

Linux on Z and LinuxONE

*Device Drivers, Features, and Commands
on Ubuntu Server 20.04.1 LTS*



Note

Before using this document, be sure to read the information in [“Notices” on page 725](#).

This edition applies to Ubuntu Server 20.04.1 and to all subsequent releases and modifications until otherwise indicated in new editions.

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Contents

Summary of changes.....	vii
About this document.....	ix
Part 1. General concepts.....	1
Chapter 1. How devices are accessed by Linux.....	3
Chapter 2. Devices in sysfs.....	7
Chapter 3. Device auto-configuration for Linux in LPAR mode.....	19
Chapter 4. Kernel and module parameters.....	23
Part 2. Booting and shutdown.....	31
Chapter 5. Console device drivers.....	33
Chapter 6. Initial program loader for IBM Z - zipl.....	55
Chapter 7. Booting Linux.....	79
Chapter 8. Shutdown actions.....	99
Chapter 9. The diag288 watchdog device driver.....	103
Chapter 10. KASLR support.....	107
Part 3. Storage.....	109
Chapter 11. DASD device driver.....	111
Chapter 12. SCSI-over-Fibre Channel device driver.....	147
Chapter 13. Storage-class memory device driver.....	191
Chapter 14. Channel-attached tape device driver.....	195
Part 4. Networking.....	205
Chapter 15. qeth device driver for OSA-Express (QDIO) and HiperSockets.....	207
Chapter 16. OSA-Express SNMP subagent support.....	271
Chapter 17. LAN channel station device driver.....	281
Chapter 18. AF_IUCV address family support.....	287
Chapter 19. SMC protocol support.....	291

Chapter 20. RDMA over Converged Ethernet.....	295
Chapter 21. Internal shared memory device driver.....	297

Part 5. System resources..... 299

Chapter 22. Managing CPUs.....	301
Chapter 23. Managing hotplug memory.....	307
Chapter 24. Persistent device configuration.....	313
Chapter 25. Huge-page support.....	327
Chapter 26. S/390 hypervisor file system.....	331
Chapter 27. TOD clock synchronization.....	337
Chapter 28. Identifying the IBM Z hardware.....	339
Chapter 29. HMC media device driver.....	341
Chapter 30. Data compression with the Integrated Accelerator for zEDC.....	345
Chapter 31. Data compression with GenWQE and zEDC Express.....	351
Chapter 32. PCI Express support.....	359

Part 6. z/VM virtual server integration.....365

Chapter 33. z/VM concepts.....	367
Chapter 34. Writing kernel APPLDATA records.....	371
Chapter 35. Writing z/VM monitor records.....	377
Chapter 36. Reading z/VM monitor records.....	381
Chapter 37. z/VM recording device driver.....	387
Chapter 38. z/VM unit record device driver.....	395
Chapter 39. z/VM DCSS device driver.....	397
Chapter 40. z/VM CP interface device driver.....	407
Chapter 41. z/VM CP special messages uevent support.....	409
Chapter 42. Cooperative memory management.....	413

Part 7. KVM virtual server integration.....415

Chapter 43. KVM virtualization on IBM Z.....	417
Chapter 44. The virtual channel subsystem.....	421

	Chapter 45. The virtio CCW transport device driver.....	425
	Chapter 46. Setting up Ubuntu Server 20.04.1 as a KVM host.....	433
	Chapter 47. Setting up a KVM host for VFIO pass-through.....	435
	Part 8. Security.....	443
	Chapter 48. Generic cryptographic device driver.....	445
	Chapter 49. Pseudorandom number generator device driver.....	467
	Chapter 50. True random-number generator device driver.....	471
	Chapter 51. Protected key device driver.....	473
	Chapter 52. Hardware-accelerated in-kernel cryptography.....	479
	Chapter 53. Instruction execution protection.....	483
	Part 9. Performance measurement using hardware facilities.....	485
	Chapter 54. Channel measurement facility.....	487
	Chapter 55. Using the CPU-measurement facilities.....	491
	Part 10. Diagnostics and troubleshooting.....	497
	Chapter 56. Logging I/O subchannel status information.....	499
	Chapter 57. Control program identification.....	501
	Chapter 58. Displaying system information.....	505
	Chapter 59. Avoiding common pitfalls.....	509
	Chapter 60. Creating a kernel dump.....	513
	Part 11. Reference.....	515
	Chapter 61. Commands for Linux on Z.....	517
	Chapter 62. Selected kernel parameters.....	697
	Chapter 63. Linux diagnose code use.....	719
	Appendix A. Accessibility.....	721
	Appendix B. Understanding syntax diagrams.....	723
	Notices.....	725
	Glossary.....	727
	Bibliography.....	737

Index..... 741

Summary of changes

This revision includes maintenance and editorial changes. Technical changes or additions to the text and illustrations are indicated by a vertical line to the left of the change.

What's new for Ubuntu Server 20.04.1 LTS

This revision reflects changes related to Ubuntu Server 20.04.1 LTS. The SC34-2784-03 revision is a maintenance refresh made in May, 2021.

Booting and shutdown

- Linux[®] in LPAR mode can now process device configuration data that is stored on the SE, see [Chapter 3, “Device auto-configuration for Linux in LPAR mode,”](#) on page 19.
- The zipl tool can now process Boot Loader Specification (BLS) snippets, see [Chapter 6, “Initial program loader for IBM Z - zipl,”](#) on page 55.
- You can control the secure boot feature with a **zipl** parameter, see [“zipl modes and syntax overview”](#) on page 56 and [“Parameter overview”](#) on page 68
- Secure boot introduces a new signature verification feature which allows the system firmware to check the authenticity of cryptographic keys to prevent the execution of kernel-space code that is not signed by a trusted key. See [“Secure boot”](#) on page 87.

Kernel

- You can now further harden Linux on Z by loading the kernel to a random location see [Chapter 10, “KASLR support,”](#) on page 107.

SCSI over Fibre-Channel

- New sysfs attributes for Fibre Channel hosts provide more information about hosts. The new attributes include `fabric_name`, which provides the name of the connected Fibre Channel fabric, see [“Displaying FCP channel and device information”](#) on page 155.
- You can now obtain diagnostic information about FCP channels, see [“Obtaining diagnostic data for FCP channels”](#) on page 161.
- You can now enable the zfcpc device driver for two modes of data consistency checking, DIF-only mode and extended mode, which includes DIF and DIX. See [“Confirming end-to-end data consistency checking”](#) on page 184.
- You can now examine which FCP connections use IBM Fibre Channel Endpoint Security, see [“Investigating IBM Fibre Channel Endpoint Security”](#) on page 185.

Network

- The OSA-Express7S network adapter is now supported, see [Chapter 15, “qeth device driver for OSA-Express \(QDIO\) and HiperSockets,”](#) on page 207
- TCP segmentation offload is now supported for OSA connections on layer 2. It is available as of z14 for OSA Express6S and newer adapters, see [“Enabling and disabling TCP segmentation offload”](#) on page 238.
- If supported by the hardware, you can now configure OSA devices with VNIC characteristics, for example for promiscuous mode, see [“Advanced packet-handling configuration”](#) on page 254.
- You can now use internal shared memory devices for fast communication between LPARs within a mainframe system, see [Chapter 21, “Internal shared memory device driver,”](#) on page 297.

System resources

- As of z15 and LinuxONE III, applications can use the Integrated Accelerator for zEnterprise[®] Data Compression, see [Chapter 30, “Data compression with the Integrated Accelerator for zEDC,”](#) on page 345.

Virtualization

- This publication now includes information for KVM guests. The numerous changes and additions include a new part, Part 7, “KVM virtual server integration,” on page 415. [“Hypervisor-specific information” on page x](#) provides some guidance about the different virtualization environments.
- You can use Ubuntu Server as a host and for guests running in secure execution mode, see [“Linux as an IBM Secure Execution host or guest” on page 419](#) and *Introducing IBM Secure Execution for Linux*

Security

- You can now create reports of cryptographic performance measurement data for cryptographic devices at specified intervals, see [“zcryptstats - Display crypto statistics” on page 693](#).
- You can now create customized cryptographic device nodes, for example, for selective assignment of device nodes to containers, see [“Creating customized device nodes” on page 452](#).
- You can now mark sets of AP queues for handling by device drivers other than zcrypt, for example in KVM guests, see [“Freeing AP queues for KVM guests” on page 462](#).
- The protected key device driver is extended to handle CCA cipher secure keys and EP11 secure keys, see [Chapter 51, “Protected key device driver,” on page 473](#).
- You can now read volatile protected key and secure key tokens from sysfs attributes, see [“Generating volatile protected keys by using the pkey device driver” on page 474](#).
- For z14 and later mainframes, CPACF provides hardware-acceleration for SHA3 cipher algorithms, see [Chapter 52, “Hardware-accelerated in-kernel cryptography,” on page 479](#).

Changed Information

- Checksum offload now supports IPv6, see [“Configuring hardware checksum offload operations” on page 236](#)
- PCIe function addresses have changed for environments that support the Alternative Routing-ID Interpretation (ARI) compatible address format, see [Chapter 32, “PCI Express support,” on page 359](#).
- The CPU Measurement Counter facility is updated to the latest version, see [“Reading CPU-measurement counters” on page 492](#).
- The z/Architecture CPU-measurement facilities support a changed format for specifying counters as raw events, see [“Reading CPU-measurement counters” on page 492](#).

This revision also includes maintenance and editorial changes.

Deleted Information

- NUMA emulation is obsolete, and the corresponding topic has been removed.
- The chapter about suspending and resuming Linux has been removed.
- The src_vipa package is deprecated, and its description has been removed.

About this document

This publication describes the device drivers, features, and commands available to Ubuntu Server 20.04.1 for the control of IBM Z® devices and attachments. Unless stated otherwise, in this book the terms *device drivers* and *features* are understood to refer to device drivers and features for Ubuntu Server 20.04.1 LTS. Some of the functionality described here requires kernel 5.4.0-45.49 or newer. This kernel update is shipped with Ubuntu Server 20.04.1 LTS.

For details about IBM tested Linux environments, see www.ibm.com/systems/z/os/linux/resources/testedplatforms.html.

Unless stated otherwise, all IBM z/VM related information in this document assumes a current z/VM version, see www.vm.ibm.com/techinfo/lpmigr/vmleos.html.

For more specific information about the device driver structure, see the documents in the kernel source tree at `linux-doc/s390`. After installing the `linux-doc` package, the absolute path is typically: `/usr/share/doc/linux-doc/s390`.

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

How this document is organized

The first part of this document contains general and overview information for the z/Architecture® specific device drivers.

Part two contains chapters about device drivers and features that are used in the context of booting and shutting down Linux.

Part three contains chapters specific to individual storage device drivers.

Part four contains chapters specific to individual network device drivers.

Part five contains chapters about device drivers and features that help to manage the resources of the real or virtual hardware.

Part six contains chapters that describe device drivers and features in support of z/VM virtual server integration.

Part seven contains chapters that describe device drivers and features in support of KVM virtual server integration. Topics cover both Linux as a KVM host and Linux as a KVM guest.

Part eight contains chapters about device drivers and features that support security aspects of Ubuntu Server 20.04.1 LTS.

Part nine contains chapters about assessing the performance of Ubuntu Server 20.04.1 LTS.

Part ten contains chapters about device drivers and features that are used in the context of diagnostics and problem solving.

Part eleven contains chapters with reference information about commands, kernel parameters, and Linux use of DIAG calls.

Who should read this document

Most of the information in this document is intended for system administrators who want to configure Ubuntu Server 20.04.1 LTS.

The following general assumptions are made about your background knowledge:

- You have an understanding of basic computer architecture, operating systems, and programs.
- You have an understanding of Linux and IBM Z terminology.

- You are familiar with Linux device driver software.
- You are familiar with the Z devices attached to your system.

Programmers: Some sections are of interest primarily to specialists who want to program extensions to the device drivers and features.

Hypervisor-specific information

This publication provides information for Linux in LPAR mode and for Linux as a guest of z/VM or KVM.

Information in this publication applies to all hypervisor environments, unless indicated otherwise. Parts and chapters that do not apply to all environments state this exception at the beginning. Lesser differences between environments are detailed within the description.

Linux in LPAR mode

Processor Resource/Systems Manager (PR/SM) technology always divides IBM Z hardware resources into one or more logical partitions (LPARs). Linux in LPAR mode runs directly in an LPAR.

Linux on z/VM

The z/VM hypervisor is an IBM Z operating system that can run in an LPAR and provide IBM Z virtual machines. Linux on z/VM runs as a guest in a z/VM guest virtual machine.

z/VM virtualizes z/Architecture and Z devices to its guests, so most of what applies to Linux in LPAR mode also applies to Linux as a z/VM guest.

Depending on your z/VM virtual machine definition and on your z/VM version and service level, a particular z/VM guest might not provide all of the described features. See ibm.com/vm/newfunction/index.html about upcoming and available new function for z/VM.

For information that exclusively applies to Linux on z/VM, see [Part 6, “z/VM virtual server integration,” on page 365](#).

Linux on KVM

Linux in LPAR mode can be set up as a KVM host that provides KVM virtual servers. Linux on KVM runs as a guest in a KVM virtual server. For information about managing KVM virtual servers, see the documentation of your KVM host distribution and *KVM Virtual Server Management*, SC34-2752.

KVM virtual servers on Z present many mainframe devices as generalized virtio devices to their guests. To Linux, these virtio devices resemble virtio devices on other hardware architectures more than the underlying mainframe devices. Therefore, entire parts and chapters of this publication do not apply to Linux on KVM.

Depending on your KVM host and on your virtual server configuration, a particular KVM guest might not provide all of the described features.

For information that exclusively applies to Linux on KVM, see [Part 7, “KVM virtual server integration,” on page 415](#).

Conventions and assumptions used in this publication

This summarizes the styles, highlighting, and assumptions used throughout this publication.

Authority

Most of the tasks described in this document require a user with root authority. In particular, writing to procs, and writing to most of the described sysfs attributes requires root authority.

Throughout this document, it is assumed that you have root authority.

Terminology

In this publication, the term *booting* is used for running boot loader code that loads the Linux operating system. *IPL* is used for issuing an IPL command to load boot loader code or a stand-alone dump utility. See also [“IPL and booting”](#) on page 79.

sysfs and procfs

In this publication, the mount point for the virtual Linux file system `sysfs` is assumed to be `/sys`. Correspondingly, the mount point for `procfs` is assumed to be `/proc`.

debugfs

This document assumes that `debugfs` has been mounted at `/sys/kernel/debug`.

To mount `debugfs`, you can use this command:

```
# mount none -t debugfs /sys/kernel/debug
```

To mount `debugfs` persistently, add the following to `/etc/fstab`:

```
debugfs /sys/kernel/debug debugfs auto 0 0
```

The Linux source tree

Useful documentation can be found in the Linux source tree. To install the kernel source, issue:

```
apt install linux-source
```

Number prefixes

In this publication, KB means 1024 bytes, MB means 1,048,576 bytes, and GB means 1,073,741,824 bytes.

Hexadecimal numbers

Mainframe publications and Linux publications tend to use different styles for writing hexadecimal numbers. Thirty-one, for example, would typically read X'1F' in a mainframe publication and 0x1f in a Linux publication.

Because the Linux style is required in many commands and is also used in some code samples, the Linux style is used throughout this publication.

Highlighting

This publication uses the following highlighting styles:

- Paths and URLs are highlighted in monospace.
- Variables are highlighted in *<italics within angled brackets>*.
- Commands in text are highlighted in **monospace bold**.
- Input and output as normally seen on a computer screen is shown

```
within a screen frame.  
Prompts are shown as hash signs:  
#
```

Part 1. General concepts

This information at an overview level describes concepts that apply across different device drivers and kernel features.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Chapter 1. How devices are accessed by Linux

Applications on Linux access character and block devices through device nodes, and network devices through network interfaces.

Device nodes and major/minor numbers

The Linux kernel represents character and block devices as pairs of numbers $\langle major \rangle : \langle minor \rangle$.

Some major numbers are reserved for particular device drivers. Other major numbers are dynamically assigned to a device driver when Linux boots. For example, major number 94 is always the major number for DASD devices while the device driver for channel-attached tape devices has no fixed major number. A major number can also be shared by multiple device drivers. See `/proc/devices` to find out how major numbers are assigned on a running Linux instance.

The device driver uses the minor number $\langle minor \rangle$ to distinguish individual physical or logical devices. For example, the DASD device driver assigns four minor numbers to each DASD: one to the DASD as a whole and the other three for up to three partitions.

Device drivers assign device names to their devices, according to a device driver-specific naming scheme (see, for example, “[DASD naming scheme](#)” on page 116). Each device name is associated with a minor number (see [Figure 1](#) on page 3).

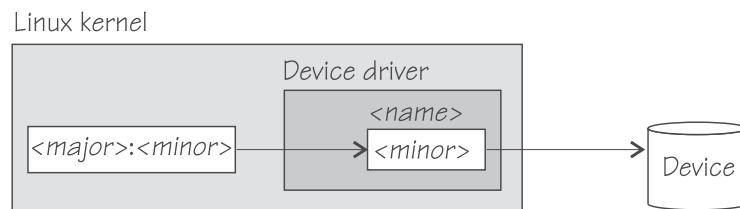


Figure 1. Minor numbers and device names

User space programs access character and block devices through *device nodes* also referred to as *device special files*. When a device node is created, it is associated with a major and minor number (see [Figure 2](#) on page 3).

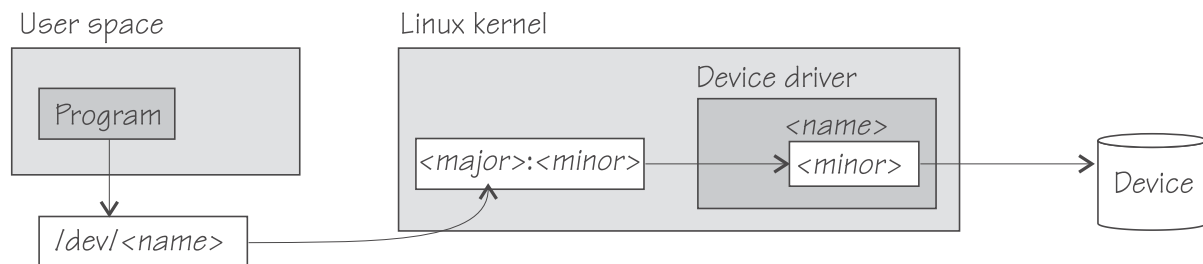


Figure 2. Device nodes

Ubuntu Server 20.04.1 uses `udev` to create device nodes for you. Standard device nodes match the device name that is used by the kernel, but different or additional nodes might be created by special `udev` rules. See the `udev` man page for more details.

Network interfaces

The Linux kernel representation of a network device is an interface.

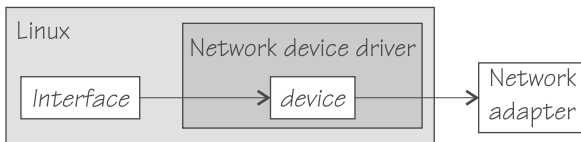


Figure 3. Interfaces

When a network device is defined, it is associated with a real or virtual network adapter (see [Figure 3 on page 4](#)). You can configure the adapter properties for a particular network device through the device representation in sysfs (see [“Device directories” on page 9](#)).

You activate or deactivate a connection by addressing the interface with **ip** or an equivalent command. All interfaces that are provided by the IBM Z specific network device drivers are interfaces for the Internet Protocol (IP).

Predictable network device names

Ubuntu Server 20.04.1 uses predictable names for network devices. These names are stable across reboots and network adapter replacements.

Predictable naming is enabled by default. In this naming scheme, a mainframe network device has a name of the following form:

```
<pf><type><bus_id>
```

For example:

```
encf5f0
```

Where:

<pf>

A two-character prefix for the network type. The type can be one of the following:

- en - Ethernet
- ww - WAN
- s1 - serial line

<type>

The device type. The device type of channel command word (CCW) devices is c. For PCIe devices, the type is s. For an introduction to mainframe devices in Linux, see [“Device categories” on page 7](#).

<bus_id>

The bus ID identifies the device within the scope of a Linux instance. For a CCW device on Ubuntu, bus IDs can take different forms, depending on the subchannel set through which the device is accessed. For subchannel set 0, the bus ID is the device number with stripped leading zeroes. For all other subchannel sets, the bus ID is the subchannel set ID followed by a dot, followed by the 4-digit device number.

Examples:

- Device number 0009 on subchannel set 0 has the bus ID 9
- Device number 0b41 on subchannel set 2 has the bus ID 2.0b41

You can use **lszdev** or **lscss -a** to obtain a list of the network devices in your system.

Matching devices with the corresponding interfaces

If you define multiple interfaces on a Linux instance, you must keep track of the interface names assigned to your network devices.

Ubuntu Server 20.04.1 uses predictable network names, which make it easy to match network devices with their interface names. The interface names are preserved across reboots.

How to keep track of the mapping differs depending on the network device driver. For qeth, you can use the **lszdev qeth** command (see [“lszdev - Display IBM Z device configurations”](#) on page 623) to obtain a mapping.

For virtio_net, which handles all network devices on a KVM guest, see [“Mapping interfaces to CCW devices”](#) on page 428.

After you set a device online (or create an IUCV device), issue **dmesg** to find the associated interface name in the messages that are issued in response to the device being set online (or created for IUCV).

For each IUCV network device and all other network devices that are online, a symbolic link of the form `/sys/class/net/<interface>/device` where `<interface>` is the interface name is created. This link points to a `sysfs` directory that represents the corresponding network device. You can read this symbolic link with **readlink** to confirm that an interface name corresponds to a particular network device.

Main steps for setting up a network interface

The main steps apply to all network devices drivers that are based on ccwgroup devices (qeth and lcs devices). How to perform a particular step can be different for the different device drivers.

The steps that follow apply to Linux on z/VM and to Linux in LPAR mode. For Linux on KVM, these steps are performed for you on the KVM host. The steps can be different for the different device drivers.

The main steps are:

1. Create a network device by combining suitable subchannels into a group device. The device driver then creates directories that represent the device in `sysfs`.
2. Configure the device through its attributes in `sysfs`. See [“Device views in sysfs”](#) on page 11. Some devices have attributes that can or must be set later when the device is online or when the connection is active.
3. Set the device online. This step associates the device with an interface name and thus makes the device known to the Linux network stack. For devices that are associated with a physical network adapter it also initializes the adapter for the network interface.
4. Configure and activate the interface. This step adds interface properties like IP addresses, netmasks, and MTU to the network interface and moves the network interface into state "up". The interface is then ready for user space (socket) programs to run connections and transfer data across it.

The preferred tool to use for device configuration is the **chzdev** command that is provided with Ubuntu Server 20.04.1, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

Chapter 2. Devices in sysfs

Most Linux device drivers create structures in sysfs. These structures hold information about individual devices and are also used to configure and control the devices.

Device categories

The `/sys/devices` directory includes several device categories that are specific to z/Architecture.

Figure 4 on page 7 illustrates a part of sysfs.

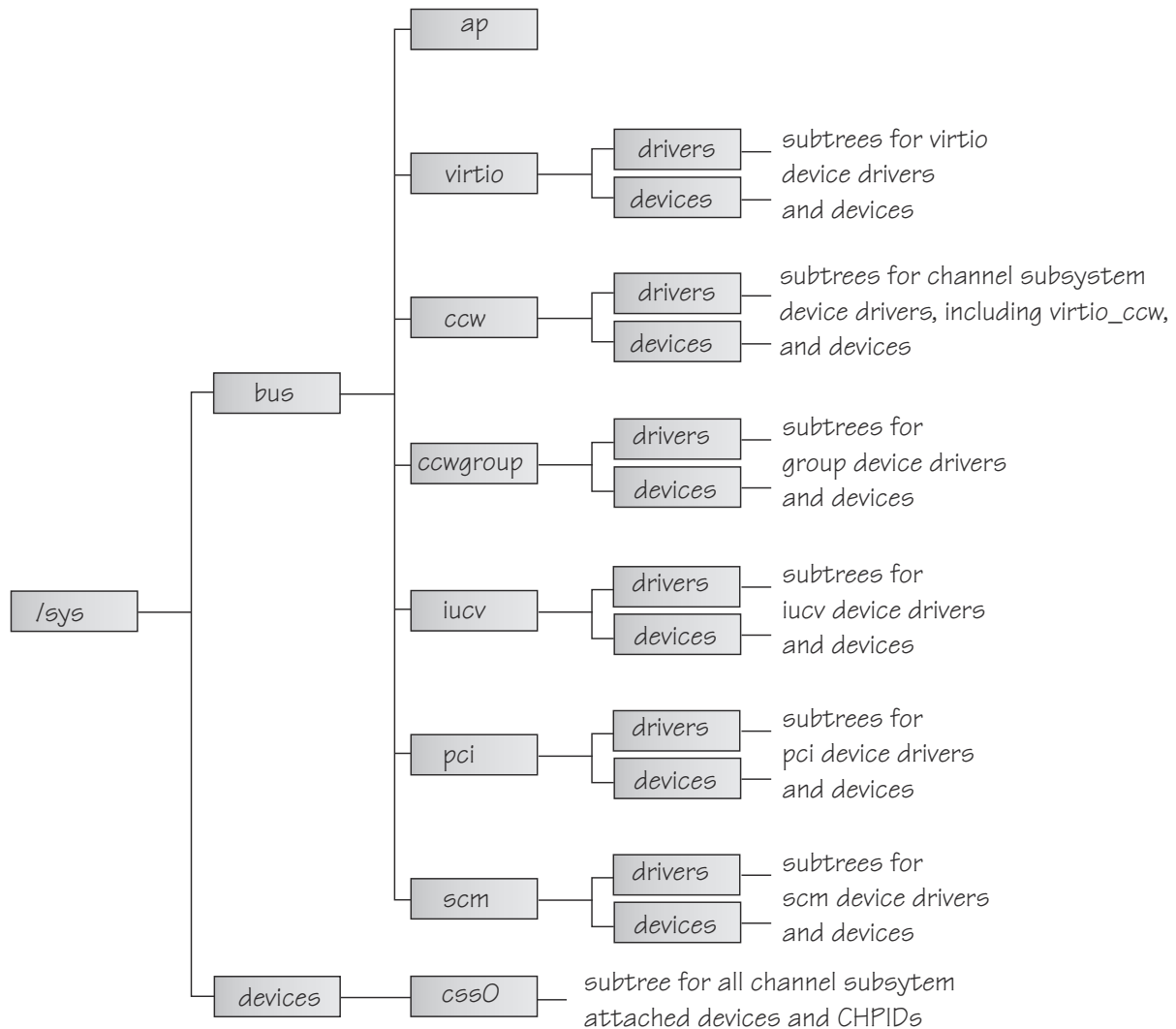


Figure 4. `sysfs`

`/sys/bus` and `/sys/devices` are common Linux directories. The directories following `/sys/bus` sort the device drivers according to the categories of devices they control. The `sysfs` branch for a particular category might be missing if there is no device for that category.

AP devices

are adjunct processors used for cryptographic operations.

virtio devices

are virtualized devices as used on KVM guests. This branch lists devices with names `virtio<n>` that represent the virtio aspects of virtio-ccw devices.

The CCW aspects of virtio-ccw devices are represented by corresponding devices in the `/sys/bus/ccw` branch, with device bus-IDs as device names. This publication uses the representation in the `/sys/bus/ccw` branch to work with virtio-ccw devices.

CCW devices

are devices that can be addressed with channel-command words (CCWs). These devices use a single subchannel on the mainframe's channel subsystem.

CCW group devices

are devices that use multiple subchannels on the mainframe's channel subsystem.

IUCV devices

are devices for virtual connections between z/VM guest virtual machines within an IBM mainframe. IUCV devices do not use the channel subsystem.

PCI devices

represent PCIe devices, for example, a 10GbE RoCE Express device. In sysfs, PCIe devices are listed in the `/pci` directory rather than the `/pcie` directory.

Table 1 on page 8 lists the z/Architecture specific device drivers that have representation in sysfs:

Device driver	Category	sysfs directories
3215 console	CCW	<code>/sys/bus/ccw/drivers/3215</code>
3270 console	CCW	<code>/sys/bus/ccw/drivers/3270</code>
DASD	CCW	<code>/sys/bus/ccw/drivers/dasd-eckd</code> <code>/sys/bus/ccw/drivers/dasd-fba</code>
SCSI-over-Fibre Channel	CCW	<code>/sys/bus/ccw/drivers/zfcp</code>
Storage class memory supporting Flash Express	SCM	<code>/sys/bus/scm/drivers/scm_block</code>
Channel-attached tape	CCW	<code>/sys/bus/ccw/drivers/tape_34xx</code> <code>/sys/bus/ccw/drivers/tape_3590</code>
Cryptographic	AP	<code>/sys/bus/ap/drivers/cex5a</code> <code>/sys/bus/ap/drivers/cex5c</code> <code>/sys/bus/ap/drivers/cex5p</code> <code>/sys/bus/ap/drivers/cex4a</code> <code>/sys/bus/ap/drivers/cex4c</code> <code>/sys/bus/ap/drivers/cex4p</code> <code>/sys/bus/ap/drivers/cex3a</code> <code>/sys/bus/ap/drivers/cex3c</code> <code>/sys/bus/ap/drivers/pcixcc</code>
virtio CCW transport device driver	CCW	<code>/sys/bus/ccw/drivers/virtio_ccw</code>
DCSS	n/a	<code>/sys/devices/dcssblk</code>
z/VM recording	IUCV	<code>/sys/bus/iucv/drivers/vmlogrdr</code>
qeth (OSA-Express features and HiperSockets)	CCW group	<code>/sys/bus/ccwgroup/drivers/qeth</code>
LCS	CCW group	<code>/sys/bus/ccwgroup/drivers/lcs</code>
10GbE RoCE Express devices for Mellanox ConnectX-3 EN (mlx4_en)	PCI	<code>sys/bus/pci/drivers/mlx4_core</code>

Table 1. Device drivers with representation in sysfs (continued)

Device driver	Category	sysfs directories
10 GbE RoCE Express2 devices for Mellanox ConnectX-4 EN (mlx5_core)	PCI	sys/bus/pci/drivers/mlx5_core
Internal Shared Memory	PCI	/sys/bus/pci/drivers/ism

Some device drivers do not relate to physical devices that are connected through the channel subsystem. Their representation in sysfs differs from the CCW and CCW group devices, for example, the Cryptographic device drivers have their own category, AP.

The following sections provide more details about devices and their representation in sysfs.

Device directories

Each device that is known to Linux is represented by a directory in sysfs.

For CCW and CCW group devices the name of the directory is a *bus ID* that identifies the device within the scope of a Linux instance. For a CCW device, the bus ID is the device's device number with a leading "0.<n>", where <n> is the subchannel set ID. For example, 0.1.0ab1.

CCW group devices are associated with multiple device numbers. For CCW group devices, the bus ID is the primary device number with a leading "0.<n>", where <n> is the subchannel set ID.

"Device views in sysfs" on page 11 tells you where you can find the device directories with their attributes in sysfs.

Device attributes

The device directories contain attributes. You control a device by setting its attributes.

Some attributes are common to all devices in a device category, other attributes are specific to a particular device driver. The following attributes are common to all CCW devices:

online

You use this attribute to set the device online or offline. To set a device online, write the value 1 to its online attribute. To set a device offline, write the value 0 to its online attribute.

cutype

specifies the control unit type and model, if applicable. This attribute is read-only.

cmb_enable

enables I/O data collection for the device. See "Enabling, resetting, and switching off data collection" on page 488 for details.

devtype

specifies the device type and model, if applicable. This attribute is read-only.

availability

indicates whether the device can be used. The following values are possible:

good

This is the normal state. The device can be used.

boxed

DASD only: The device is locked by another operating system instance and cannot be used until the lock is surrendered or the DASD is accessed by force (see "Accessing DASD by force" on page 125).

no device

Applies to disconnected devices only. The device disappears after a machine check and the device driver requests to keep the device online anyway. Changes back to "good" when the device returns after another machine check and the device driver accepts the device back.

no path

Applies to disconnected devices only. After a machine check or a logical vary off, no path remains to the device. However, the device driver keeps the device online. Changes back to "good" when the path returns after another machine check or logical vary on and the device driver accepts the device back.

modalias

contains the module alias for the device. It is of the format:

```
ccw:t<cu_type>m<cu_model>
```

or

```
ccw:t<cu_type>m<cu_model>dt<dev_type>dm<dev_model>
```

Setting attributes

Directly write to attributes or, for CCW devices, use a command to set attribute values.

About this task

Because the KVM hypervisor hides many aspects of physical devices that back virtio devices, the scope for setting device attributes for these devices on KVM guests is limited.

Procedure

- You can set a writable attribute by writing the designated value to the corresponding attribute file.
- For CCW devices, you can also use the **chzdev** or the **chccwdev** command (see [“chzdev - Configure IBM Z devices”](#) on page 531 and [“chccwdev - Set CCW device attributes”](#) on page 518) to set attributes.

With a single **chzdev** or **chccwdev** command you can:

- Set an attribute for multiple devices
- Set multiple attributes for a device, including setting the device online
- Set multiple attributes for multiple devices

Working with newly available devices

Errors can occur if you try to work with a device before its sysfs representation is completely initialized.

About this task

When new devices become available to a running Linux instance, some time elapses until the corresponding device directories and their attributes are created in sysfs. Errors can occur if you attempt to work with a device for which the sysfs structures are not present or are not complete. These errors are most likely to occur and most difficult to handle when you are configuring devices with scripts.

Procedure

Use the following steps before you work with a newly available device to avoid such errors:

1. Attach the device, for example, with a z/VM CP ATTACH command or by dynamically attaching a device to a KVM virtual server.
2. Assure that the sysfs structures for the new device are complete:

```
# echo 1 > /proc/cio_settle
```

This command returns control after all pending updates to sysfs are complete.

Tip: For CCW devices, you can omit this step if you then use **chccwdev** (see “[chccwdev - Set CCW device attributes](#)” on page 518) to work with the devices. **chccwdev** triggers `cio_settle` for you and waits for `cio_settle` to complete.

Results

You can now work with the new device. For example, you can set the device online or set attributes for the device.

Device views in sysfs

`sysfs` provides multiple views of device specific data.

The most important views are:

- “[Device driver view](#)” on page 11
- “[Device category view](#)” on page 11
- “[Device view](#)” on page 12
- “[Channel subsystem view](#)” on page 12

Many paths in `sysfs` contain device bus-IDs to identify devices. Device bus-IDs of subchannel-attached devices are of the form:

```
0.<n>.<devno>
```

where `<n>` is the subchannel set-ID and `<devno>` is the device number.

Device driver view

This view groups devices by the device drivers that control them.

The device driver view is of the form:

```
/sys/bus/<bus>/drivers/<driver>/<device_bus_id>
```

where:

<bus>

is the device category, for example, `ccw` or `ccwgroup`.

<driver>

is a name that specifies an individual device driver or the device driver component that controls the device (see [Table 1](#) on page 8).

<device_bus_id>

identifies an individual device (see “[Device directories](#)” on page 9).

Note: DCSSs are not represented in this view.

Examples

- This example shows the path for an ECKD type DASD device:
`/sys/bus/ccw/drivers/dasd-eckd/0.0.b100`
- This example shows the path for a qeth device:
`/sys/bus/ccwgroup/drivers/qeth/0.0.a100`
- This example shows the path for a cryptographic device (a CEX3A card):
`/sys/bus/ap/drivers/cex3a/card3b`

Device category view

This view groups devices by major categories that can span multiple device drivers.

The device category view does not sort the devices according to their device drivers. All devices of the same category are contained in a single directory. The device category view is of the form:

```
/sys/bus/<bus>/devices/<device_bus_id>
```

where:

<bus>

is the device category, for example, ccw or ccwgroup.

<device_bus_id>

identifies an individual device (see [“Device directories”](#) on page 9).

Notes:

- DCSSs are not represented in this view.
- /sys/bus/ccw/devices includes virtio CCW devices.

Examples

- This example shows the path for a CCW device.
/sys/bus/ccw/devices/0.0.b100
- This example shows the path for a CCW group device.
/sys/bus/ccwgroup/devices/0.0.a100
- This example shows the path for a cryptographic device:
/sys/bus/ap/devices/card3b

Device view

This view sorts devices according to their device drivers, but independent from the device category. It also includes logical devices that are not categorized.

The device view is of the form:

```
/sys/devices/<driver>/<device>
```

where:

<driver>

is a name that specifies an individual device driver or the device driver component that controls the device.

<device>

identifies an individual device. The name of this directory can be a device bus-ID or the name of a DCSS or IUCV device.

Examples

- This example shows the path for a qeth device.
/sys/devices/qeth/0.0.a100
- This example shows the path for a DCSS block device.
/sys/devices/dcssblk/mydcss

Channel subsystem view

The channel subsystem view shows the relationship between subchannels and devices.

The channel subsystem view is of the form:

```
/sys/devices/css0/<subchannel>
```

where:

<subchannel>

is a subchannel number with a leading "0.<n>.", where <n> is the subchannel set ID.

I/O subchannels show the devices in relation to their respective subchannel sets and subchannels. An I/O subchannel is of the form:

```
/sys/devices/css0/<subchannel>/<device_bus_id>
```

where:

<subchannel>

is a subchannel number with a leading "0.<n>.", where <n> is the subchannel set ID.

<device_bus_id>

is a device number with a leading "0.<n>.", where <n> is the subchannel set ID (see [“Device directories”](#) on page 9).

Examples

- This example shows a CCW device with device number 0xb100 that is associated with a subchannel 0x0001.

```
/sys/devices/css0/0.0.0001/0.0.b100
```

- This example shows a CCW device with device number 0xb200 that is associated with a subchannel 0x0001 in subchannel set 1.

```
/sys/devices/css0/0.1.0001/0.1.b200
```

- The entries for a group device show as separate subchannels. If a CCW group device uses three subchannels 0x0002, 0x0003, and 0x0004 the subchannel information could be:

```
/sys/devices/css0/0.0.0002/0.0.a100  
/sys/devices/css0/0.0.0003/0.0.a101  
/sys/devices/css0/0.0.0004/0.0.a102
```

Each subchannel is associated with a device number. Only the primary device number is used for the bus ID of the device in the device driver view and the device view.

- This example lists the information available for a non-I/O subchannel with which no device is associated:

```
ls /sys/devices/css0/0.0.ff00/  
bus driver modalias subsystem type uevent
```

Subchannel attributes

There are sysfs attributes that represent subchannel properties, including common attributes and information specific to the subchannel type.

Subchannels have two common attributes:

type

The subchannel type, which is a numerical value, for example:

- 0 for an I/O subchannel
- 1 for a CHSC subchannel
- 3 for an EADM subchannel

modalias

The module alias for the device of the form `css:t<n>`, where <n> is the subchannel type (for example, 0 or 1).

These two attributes are the only ones that are always present. Some subchannels, like I/O subchannels, might contain devices and further attributes.

Apart from the bus ID of the attached device, I/O subchannel directories typically contain these attributes:

chpids

is a list of the channel-path identifiers (CHPIDs) through with the device is connected. See also [“Channel path ID information”](#) on page 14.

pimpampom

provides the path installed, path available, and path operational masks. See *z/Architecture Principles of Operation*, SA22-7832 for details about the masks.

Channel path measurement

For Linux in LPAR mode and Linux on z/VM, a sysfs attribute controls the channel path measurement facility of the channel subsystem.

`/sys/devices/css0/cm_enable`

With the `cm_enable` attribute you can enable and disable the extended channel-path measurement facility. It can take the following values:

0

Deactivates the measurement facility and remove the measurement-related attributes for the channel paths. No action if measurements are not active.

1

Attempts to activate the measurement facility and create the measurement-related attributes for the channel paths. No action if measurements are already active.

If a machine does not support extended channel-path measurements the `cm_enable` attribute is not created.

Two sysfs attributes are added for each channel path object:

cmg

Specifies the channel measurement group or unknown if no characteristics are available.

shared

Specifies whether the channel path is shared between LPARs or unknown if no characteristics are available.

If measurements are active, two more sysfs attributes are created for each channel path object:

measurement

A binary sysfs attribute that contains the extended channel-path measurement data for the channel path. It consists of eight 32-bit values and must always be read in its entirety, or 0 will be returned.

measurement_chars

A binary sysfs attribute that is either empty, or contains the channel measurement group dependent characteristics for the channel path, if the channel measurement group is 2 or 3. If not empty, it consists of five 32-bit values.

Examples

- To turn measurements on issue:

```
# echo 1 > /sys/devices/css0/cm_enable
```

- To turn measurements off issue:

```
# echo 0 > /sys/devices/css0/cm_enable
```

Channel path ID information

All CHPIDs that are known to Linux are shown alongside the subchannels in the `/sys/devices/css0` directory.

The directories that represent the CHPIDs have the form:

```
/sys/devices/css0/chp0.<chpid>
```

where <chpid> is a two digit hexadecimal CHPID.

Example: /sys/devices/css0/chp0.4a

Setting a CHPID logically online or offline

Directories that represent CHPIDs contain a status attribute that you can use to set the CHPID logically online or offline.

Before you begin

Do not set all CHPIDs that connect a vital device offline. For example, Linux will crash if you set all CHPIDs for the root device offline.

About this task

When a CHPID has been set logically offline from a particular Linux instance, the CHPID is, in effect, offline for this Linux instance. A CHPID that is shared by multiple operating system instances can be logically online to some instances and offline to others. A CHPID can also be logically online to Linux while it has been varied off at the SE.

Procedure

Issue a command of this form:

```
# echo <value> > /sys/devices/css0/chp0.<CHPID>/status
```

where:

<CHPID>

is a two digit hexadecimal CHPID.

<value>

is either on or off.

Examples

- To set a CHPID 0x4a logically offline issue:

```
# echo off > /sys/devices/css0/chp0.4a/status
```

- To read the status attribute to confirm that the CHPID is logically offline issue:

```
# cat /sys/devices/css0/chp0.4a/status  
offline
```

- To set the same CHPID logically online issue:

```
# echo on > /sys/devices/css0/chp0.4a/status
```

- To read the status attribute to confirm that the CHPID is logically online issue:

```
# cat /sys/devices/css0/chp0.4a/status  
online
```

Configuring a CHPID on LPAR

For Linux in LPAR mode, directories that represent CHPIDs contain a configure attribute that you can use to query and change the configuration state of I/O channel-paths.

About this task

The following configuration changes are supported:

- From standby to configured ("configure")
- From configured to standby ("deconfigure")

Procedure

Issue a command of this form:

```
# echo <value> > /sys/devices/css0/chp0.<CHPID>/configure
```

where:

<CHPID>

is a two digit hexadecimal CHPID.

<value>

is either 1 or 0.

To query and set the configure value using commands, see [“chchp - Change channel path status” on page 520](#) and [“lschp - List channel paths” on page 595](#).

Examples

- To set a channel path with the ID 0x40 to standby issue:

```
# echo 0 > /sys/devices/css0/chp0.40/configure
```

This operation is equivalent to performing a Configure Channel Path Off operation on the Hardware Management Console.

- To read the configure attribute to confirm that the channel path has been set to standby issue:

```
# cat /sys/devices/css0/chp0.40/configure
0
```

- To set the same CHPID to configured issue:

```
# echo 1 > /sys/devices/css0/chp0.40/configure
```

This operation is equivalent to performing a Configure Channel Path On operation on the Hardware Management Console.

- To read the status attribute to confirm that the CHPID has been set to configured issue:

```
# cat /sys/devices/css0/chp0.40/configure
1
```

Finding the physical channel associated with a CHPID

Use the mapping of physical channel IDs (PCHID) to CHPIDs to find the hardware from the CHPID number or the CHPID numbers from the PCHID.

About this task

A CHPID is associated with either a physical port or with an internal connection defined inside the mainframe, such as HiperSockets. See [Figure 5 on page 17](#). You can determine the PCHID or internal channel ID number that is associated with a CHPID number.

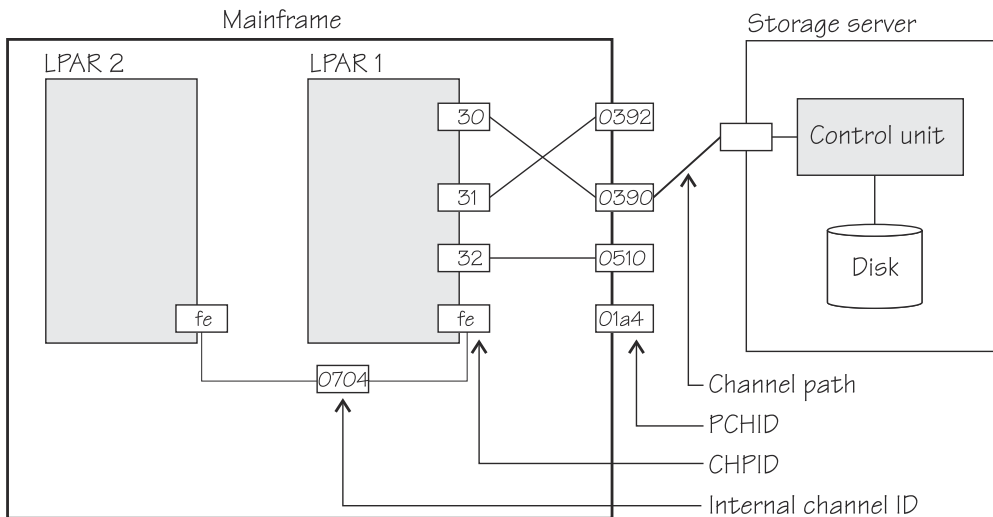


Figure 5. Relationships between CHPIDs, PCHIDs, and internal channel ID numbers.

Knowing the PCHID number can be useful in the following situations:

- When Linux indicates that a CHPID is in an error state, you can use the PCHID number to identify the associated hardware.
- When a hardware interface requires service action, the PCHID mapping can be used to determine which CHPIDs and I/O devices will be affected.

The internal channel ID number can be useful to determine which CHPIDs are connected to the same communication path, such as a HiperSockets link.

Procedure

To find the physical channel ID corresponding to a CHPID, either:

- Display the mapping of all CHPIDs to PCHIDs. Issue the **lschp** command:

```
# lschp
```

- Find the channel-ID related files for the CHPID.

These sysfs files are located under `/sys/devices/css0/chp0.<num>`, where `<num>` is the two-digit, lowercase, hexadecimal CHPID number. There are two attribute files:

chid

The channel ID number.

chid_external

A flag that indicates whether this CHPID is associated with an internal channel ID (value 0) or a physical channel ID (value 1).

The sysfs attribute files are not created when no channel ID information is available to Linux. For Linux in LPAR mode, this information is always available. For Linux on z/VM and Linux on KVM, the availability depends on the configuration and on the hypervisor version.

Example

The **lschp** command shows channel ID information in a column labeled PCHID. Internal channel IDs are enclosed in brackets. If no channel ID information is available, the column shows "-".

```
# lschp
CHPID Vary Cfg. Type Cmg Shared PCHID
=====
0.30 1 1 1b 2 1 0390
0.31 1 1 1b 2 1 0392
0.32 1 1 1b 2 1 0510
0.33 1 1 1b 2 1 0512
0.34 1 0 1b - - 0580
0.fc 1 1 24 3 1 (0702)
0.fd 1 1 24 3 1 (0703)
0.fe 1 1 24 3 1 (0704)
```

This example shows that CHPID 30 is associated with PCHID 0390, while CHPID fe is associated with internal channel ID 0704.

Alternatively, check the channel ID sysfs files, for example for CHPID 30:

```
# cat /sys/devices/css0/chp0.30/chid
0390
# cat /sys/devices/css0/chp0.30/chid_external
1
```

CCW hotplug events

A hotplug event is generated when a CCW device appears or disappears with a machine check.

The hotplug events provide the following variables:

CU_TYPE

for the control unit type of the device that appeared or disappeared.

CU_MODEL

for the control unit model of the device that appeared or disappeared.

DEV_TYPE

for the type of the device that appeared or disappeared.

DEV_MODEL

for the model of the device that appeared or disappeared.

MODALIAS

for the module alias of the device that appeared or disappeared. The module alias is the same value that is contained in `/sys/devices/css0/<subchannel_id>/<device_bus_id>/modalias` and is of the format `ccw:t<cu_type>m<cu_model>` or `ccw:t<cu_type>m<cu_model>dt<dev_type>dm<dev_model>`

Hotplug events can be used, for example, for:

- Automatically setting devices online as they appear
- Automatically loading driver modules for which devices have appeared

Chapter 3. Device auto-configuration for Linux in LPAR mode

Mainframes as of z14 can store device configuration data for Linux in LPAR mode on the Support Element (SE).

You provide this configuration data through a hardware management console (HMC) interface on mainframes or LinuxONE systems in Dynamic Partition Manager (DPM) mode. This data can then be processed automatically by Linux during the boot process.

The Ubuntu Server installer makes use of the auto-configuration data as specified on the HMC interface and enables all devices listed.

Making devices available to Linux

Devices must be configured on the hardware and in Linux before they can be used.

Defining devices to an LPAR

Typical mainframe systems run numerous operating system instances in parallel and connect to a considerable number of storage, network, and other peripheral devices. In this environment, device access must be controlled.

- Workload isolation demands selective and controlled device access.
- Operating systems expend cycles, time, and memory to manage each device. For example, on Linux, `udev` creates structures for each registered device.

Data centers with discrete host systems can use physical cabling between hosts and peripheral devices to manage device access. On mainframes with their logical partitions (LPARs), much of this cabling would need to be within the mainframe itself.

Instead of cables, the mainframe's *hardware configuration* controls which LPAR has access to which I/O device. The hardware configuration is specified in an input/output configuration data set (IOCDs). Traditionally, IOCDs are created with the hardware configuration definition (HCD) program.

DPM: The mainframe firmware automatically processes the device-configuration data you provide on the HMC interface, and creates and activates a corresponding IOCDs for you.

Controlling device availability on Linux

The mainframe configuration already limits the I/O devices that are available to a Linux instance. The `cio_ignore` feature provides another control point on Linux. With `cio_ignore`, you can create and maintain a list of devices to be ignored by Linux.

DPM: If `cio_ignore` is active, the list of devices to be ignored by Linux is automatically adjusted to accommodate all devices that are configured on the HMC interface. If available to the hardware, these devices become available to Linux and are set online.

To enforce the current `cio_ignore` list, you can use the `rd.zdev=no-auto` kernel parameter to disregard auto-configuration for devices on Linux.

Configuring devices on Linux

On a running Linux instance, you can use the `chzdev` command to configure individual devices. With the `lszdev` command you can display the device settings. These tools distinguish different types of configurations.

Active configuration

The current configuration, which might include settings that do not persist across reboots.

Persistent configuration

The configuration to be applied when the Linux instance is booted.

DPM only: Auto-configuration

The configuration as specified on the HMC interface.

chzdev provides a richer set of configuration options than the HMC interface. The active and persistent settings are often a fine-tuned version of the auto-configuration.

Overriding the auto-configuration

You can override the auto-configuration for a device with a persistent configuration.

For devices that come online early in the boot process, use the `zdev:early` device attribute to ensure that this persistent configuration is available at this early stage (see [“chzdev - Configure IBM Z devices”](#) on page 531).

Managing auto-configuration data

Use the **lszdev** and **chzdev** commands to manage auto-configuration data.

Displaying auto-configuration data

The **lszdev** command can display auto-configuration data.

Use the **lszdev** command with the `--auto-config` option to display a list of devices for which auto-configuration data is available.

Example:

```
# lszdev --auto-config
TYPE      ID          AUTO
dasd-eckd 0.0.ec30    yes
dasd-eckd 0.0.ec31    yes
```

Auto-configuration settings can be overridden with settings in the persistent configuration. Omit the `--auto-config` option to find out for which devices auto-configuration is effective:

Example:

```
# lszdev
TYPE      ID          ON  PERS  NAMES
dasd-eckd 0.0.ec30    yes yes  dasda
dasd-eckd 0.0.ec31    yes auto dasdb
dasd-eckd 0.0.ec32    yes no   dasdc
qeth      0.0.f5f0:0.0.f5f1:0.0.f5f2  yes no   enccf5f0
generic-ccw 0.0.0009    yes no
```

In the example, auto-configuration data is effective for only one device, `0.0.ec31`. Effective auto-configuration data is indicated through the value `auto` in the `PERS` column of the command output.

The **lszdev** output for detailed information about a device includes a separate column, `AUTOCONF`, for auto-configuration data, if available.

Example:

```
# lszdev -i 0.0.ec31
DEVICE dasd-eckd 0.0.ec31
Names      : -
Modules    : dasd_eckd_mod dasd_mod
Online     : no
Exists     : yes
Persistent : no
Auto-configured : yes

ATTRIBUTE          ACTIVE  PERSISTENT  AUTOCONF
cmb_enable         "0"    -           -
eer_enabled        "0"    -           -
erplog             "0"    -           -
failfast           "0"    -           -
last_known_reservation_state "none" -           -
online             "1"    -           "1"
raw_track_access   "0"    -           -
readonly           "0"    -           -
reservation_policy "ignore" -           -
use_diag           "0"    -           -
```

If the AUTOCONF column is omitted, no auto-configuration data is available for this device. You can force the column with the `--auto-config` option.

Modifying the auto-configuration

Persistent changes to the auto-configuration can be made only through the hardware interface through which the original device configuration is specified. Such changes are applied with the next reboot.

You can use **chzdev** with the `-d` and `--auto-conf` options to temporarily remove the auto-configuration for a device.

Example:

```
# chzdev -d --auto-conf 0.0.ec31
Deconfiguring devices in the auto-configuration only
ECKD DASD 0.0.ec31 deconfigured
```

Auto-configuration settings are then not applied when the device appears. These configuration changes do not remove the corresponding configuration data on the SE. The auto-configuration data for the device is restored with the next reboot.

Overriding the auto-configuration for devices that are used early in the boot process

With **chzdev**, you can override settings from the auto-configuration in the active configuration or persistently. Some persistent settings for devices that are set online early in the boot process must be included in the initial RAM disk.

Use the **chzdev** command to set the `zdev:early` device attribute for such devices.

Example:

```
# chzdev -e dasd-fba e030 zdev:early=1
FBA DASD 0.0.e030 configured
Note: The initial RAM-disk must be updated for these changes to take effect:
- FBA DASD 0.0.e030
Update initial RAM-disk now? (yes/no) yes
```

Do not indiscriminately include configuration settings in the initial RAM disk. To remove settings for a device, remove the `zdev:early` attribute from the device settings.

Example:

```
# chzdev -e dasd-fba e030 --remove-attribute zdev:early
FBA DASD 0.0.e030 configured
Note: The initial RAM-disk must be updated for these changes to take effect:
- FBA DASD 0.0.e030
Update initial RAM-disk now? (yes/no) yes
```

Use the **lszdev** command to list all devices that are configured with the `zdev:early` attribute.

Example:

```
# lszdev --by-attr zdev:early=1
TYPE      ID                                ON PERS NAMES
dasd-fba  0.0.e030                          yes yes  dasda
zfcplun   0.0.1911:0x50050763070845e3:0x4082409f00000000 no  yes
```

Chapter 4. Kernel and module parameters

Kernel and module parameters are used to configure the kernel and kernel modules.

Individual kernel parameters or module parameters are single keywords, or keyword-value pairs of the form `keyword=<value>` with no blank. Blanks separate consecutive parameters.

Kernel parameters and module parameters are encoded as strings of ASCII characters. For tape or the z/VM reader as a boot device, the parameters can also be encoded in EBCDIC.

Use *kernel parameters* to configure the base kernel and any optional kernel parts that have been compiled into the kernel image. Use *module parameters* to configure separate kernel modules. Do not confuse kernel and module parameters. Although a module parameter can have the same syntax as a related kernel parameter, kernel and module parameters are specified and processed differently.

Kernel parameters

Different methods are available to configure the base kernel and all modules that have been compiled into the kernel.

Where possible, this document describes kernel parameters with the device driver or feature to which they apply. Kernel parameters that apply to the base kernel or cannot be attributed to a particular device driver or feature are described in [Chapter 62, “Selected kernel parameters,”](#) on page 697. You can also find descriptions for most of the kernel parameters in the `kernel-parameters.txt` file, which is part of the `admin-guide` in the `linux-doc` package.

Specifying kernel parameters

There are different methods for passing kernel parameters to Linux.

- Including kernel parameters in a boot configuration
- Using a kernel parameter file
- Specifying kernel parameters when booting Linux

Kernel parameters that you specify when booting Linux are not persistent. To define a permanent set of kernel parameters for a Linux instance, include these parameters in the boot configuration.

Note: Ubuntu Server, `zipl`, or the installer; especially `preseed`, might set required kernel parameters for you. Parameters that you specify might interfere with these settings. Read `/proc/cmdline` to find out which parameters were used to start a running Linux instance.

Including kernel parameters in a boot configuration

Use the `zipl` tool to create Linux boot configurations for IBM mainframe systems.

Which sources of kernel parameters you can use depends on the mode in which you run `zipl`. See [“zipl modes and syntax overview”](#) on page 56 for details.

A boot configuration can include up to 895 characters of kernel parameters. See also [“How kernel parameters from different sources are combined”](#) on page 26.

Running `zipl` in configuration-file mode

In configuration-file mode, you issue the `zipl` command with command arguments that identify a section in a `zipl` configuration-file or a Boot Loader Specification (BLS) snippet, see [“BLS configuration snippets”](#) on page 77.

The possible sources of kernel parameters depend on where the details of the boot configuration are specified, in a `zipl` configuration-file section or in a BLS snippet.

zipl configuration-file section

Boot configurations in a zipl configuration-file section have three potential sources of kernel parameters, as illustrated in Figure 6 on page 24.

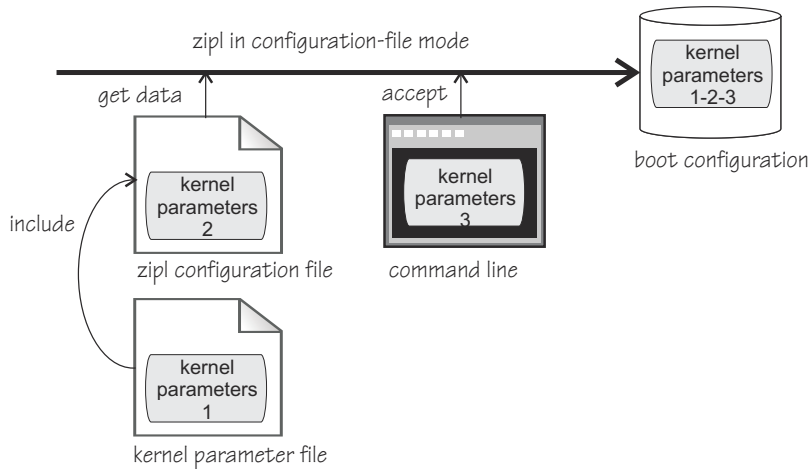


Figure 6. Sources of kernel parameters: zipl configuration-file section

zipl concatenates the kernel parameters from these sources in the following order:

1. Parameters that are specified in the kernel parameter file
2. Parameters that are specified in the **zipl** configuration-file
3. Parameters that are specified on the command line

BLS snippet

Boot configurations in a BLS snippet have two potential sources of kernel parameters, as illustrated in Figure 7 on page 24.

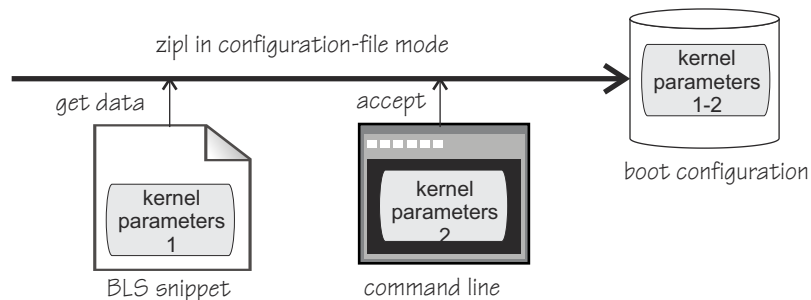


Figure 7. Sources of kernel parameters: BLS snippet

zipl concatenates the kernel parameters from these sources in the following order:

1. Parameters that are specified in the BLS snippet
2. Parameters that are specified on the command line

See “[zipl modes and syntax overview](#)” on page 56 for details about the **zipl** command modes.

Running zipl in command-line mode

In command-line mode, you specify the details about the boot configuration to be created as arguments for the **zipl** command.

As shown in [Figure 8 on page 25](#), there are two sources of kernel parameters for **zipl** in command-line mode.

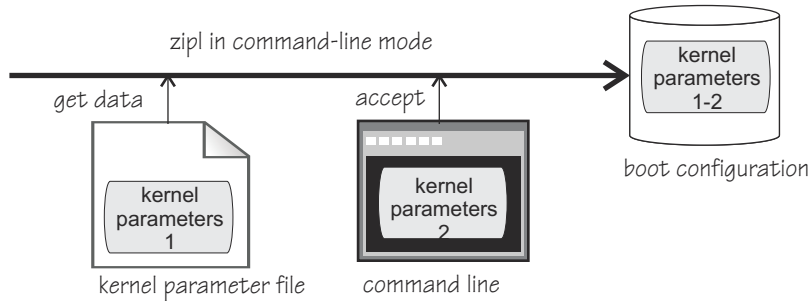


Figure 8. Sources of kernel parameters for zipl in command-line mode

In command-line mode, **zipl** concatenates the kernel parameters in the order:

1. Parameters that are specified in the kernel parameter file
2. Parameters that are specified on the command line

See [“zipl modes and syntax overview” on page 56](#) for details about the **zipl** command modes.

Using a kernel parameter file in the z/VM reader

For booting Linux from the z/VM reader, you can use a kernel parameter file in the reader.

See [“Booting from the z/VM reader” on page 93](#) for more details.

Specifying kernel parameters when booting Linux

Depending on the boot device and whether you boot Linux in a z/VM guest virtual machine or in LPAR mode, you can provide kernel parameters when you start the boot process.

zipl interactive boot menu on DASD

When booting Linux on z/VM or in LPAR mode with a zipl interactive boot menu on a DASD boot device, you can display the menu and specify kernel parameters as you select a boot configuration. See [“Example for a DASD menu configuration on z/VM” on page 91](#) and [“Example for a DASD menu configuration \(LPAR\)” on page 84](#) for details.

z/VM guest virtual machine with a CCW boot device

When booting Linux in a z/VM guest virtual machine from a CCW boot device, you can use the PARM parameter of the IPL command to specify kernel parameters. CCW boot devices include DASD, tape, and the z/VM reader.

For details, see the subsection of [“Booting Linux in a z/VM guest virtual machine” on page 89](#) that applies to your boot device.

z/VM guest virtual machine with a SCSI boot device

When booting Linux in a z/VM guest virtual machine from a SCSI boot device, you can use the SET LOADDEV command with the SCPDATA option to specify kernel parameters. See [“Booting from a SCSI device” on page 91](#) for details.

LPAR mode with a SCSI boot device

When booting Linux in LPAR mode from a SCSI boot device, you can specify kernel parameters in the **Operating system specific load parameters** field on the HMC Load panel. See [Figure 28 on page 85](#).

Kernel parameters as entered from a CMS or CP session are interpreted as lowercase on Linux.

Adding kernel parameters to a boot configuration

When booting a Linux instance, you can specify kernel parameters that are used in addition to the parameters in the boot configuration.

By default, the kernel parameters you specify when booting are concatenated to the end of the kernel parameters in your boot configuration. In total, the combined kernel parameter string that is used for booting can be up to 4096 characters.

If kernel parameters are specified in a combination of methods, they are concatenated in the following order:

1. Kernel parameters that have been included in the boot configuration with `zipl`
2. DASD only: `zipl` kernel parameters that are specified with the interactive boot menu
3. Depending on where you are booting Linux:
 - z/VM: kernel parameters that are specified with the `PARM` parameter for CCW boot devices; kernel parameters that are specified as `SCPDATA` for SCSI boot devices
 - LPAR: kernel parameters that are specified on the HMC Load panel for SCSI boot devices

If the combined kernel parameter string contains conflicting settings, the last specification in the string overrides preceding ones. Thus, you can specify a kernel parameter when booting to override an unwanted setting in the boot configuration.

Examples

- If the kernel parameters in your boot configuration include `possible_cpus=8` but you specify `possible_cpus=2` when booting, Linux uses `possible_cpus=2`.
- If the kernel parameters in your boot configuration include `resume=/dev/dasda2` to specify a disk from which to resume the Linux instance when it has been suspended, you can circumvent the resume process by specifying `noresume` when booting.

Replacing all kernel parameters in a boot configuration

Kernel parameters that you specify when booting can completely replace the kernel parameters in your boot configuration.

To replace all kernel parameters in your boot configuration, specify the new parameter string with a leading equal sign (=).

Note: This feature is intended for expert users who want to test a set of parameters. By replacing all parameters, you might inadvertently omit parameters that the boot configuration requires. Furthermore, you might omit parameters other than kernel parameters that Ubuntu Server includes in the parameter string for use by the `init` process.

Read `/proc/cmdline` to find out with which parameters a running Linux instance was started (see also [“Displaying the current kernel parameter line”](#) on page 27).

How kernel parameters from different sources are combined

If kernel parameters are specified in a combination of methods, they are concatenated in a specific order.

1. Kernel parameters that have been included in the boot configuration (see [“Including kernel parameters in a boot configuration”](#) on page 23).

The kernel parameters in the boot configuration cannot exceed 895 characters. If more than 895 characters are specified, the excessive characters are truncated.

2. LPAR or z/VM: Kernel parameters that you specify through the HMC or through z/VM interfaces (see [“Specifying kernel parameters when booting Linux”](#) on page 25).

For DASD boot devices you can specify up to 64 characters (z/VM only); for SCSI boot devices you can specify up to 3452 characters.

In total, the combined kernel parameter string that is passed to the Linux kernel for booting can be up to 4096 characters.

Multiple specifications for the same parameter

For some kernel parameters, multiple instances in the kernel parameter string are treated cumulatively. For example, multiple specifications for `cio_ignore=` are all processed and combined.

Conflicting kernel parameters

If the kernel parameter string contains kernel parameters with mutually exclusive settings, the last specification in the string overrides preceding ones. Thus, you can specify a kernel parameter when booting to override an unwanted setting in the boot configuration.

Example: If the kernel parameters in your boot configuration include `possible_cpus=8` but you specify `possible_cpus=2` when booting, Linux uses `possible_cpus=2`.

Parameters other than kernel parameters

Parameters on the kernel parameter string that the kernel does not recognize as kernel parameters are ignored by the kernel and made available to user space programs. How multiple specifications and conflicts are resolved for such parameters depends on the program that evaluates them.

Examples for kernel parameters

Typical parameters that are used for booting Ubuntu Server 20.04.1 configure the console and the root file system.

boot_image=<integer>

to specify the zipl menu section for booting.

conmode=<mode>, condev=<cuu>, console=<name>

to set up the Linux console. See [“Console kernel parameter syntax” on page 41](#) for details.

ramdisk_size=<size>

to specify the size of the initial RAM disk.

ro

to mount the root file system read-only.

root=<rootdevice>

to specify the device to be mounted as the root file system.

Displaying the current kernel parameter line

Read `/proc/cmdline` to find out with which kernel parameters a running Linux instance was booted.

About this task

Apart from kernel parameters, which are evaluated by the Linux kernel, the kernel parameter line can contain parameters that are evaluated by user space programs, for example `modprobe`.

See also [“Displaying current IPL parameters” on page 94](#) about displaying the parameters that were used to IPL and boot the running Linux instance.

Example

```
# cat /proc/cmdline
crashkernel=1G-:128M root=/dev/disk/by-path/ccw-0.0.5f50-part1 BOOT_IMAGE=0
```

Kernel parameters for rebooting

When rebooting, you can use the current kernel parameters or an alternative set of kernel parameters. By default, Linux uses the current kernel parameters for rebooting. See [“Rebooting from an alternative source” on page 96](#) about setting up Linux to use different kernel parameters for re-IPL and the associated reboot.

Module parameters

Use module parameters to configure kernel modules that are compiled as separate modules that can be loaded by the kernel.

Separate kernel modules must be loaded before they can be used. Many modules are loaded automatically by Ubuntu Server 20.04.1 when they are needed.

To keep the module parameters in the context of the device driver or feature module to which they apply, this information describes module parameters as part of the syntax you would use to load the module with `modprobe`.

To find the separate kernel modules for Ubuntu Server 20.04.1, list the contents of the subdirectories of `/lib/modules/<kernel-release>/kernel/drivers/s390` in the Linux file system. In the path, `<kernel-release>` denotes the kernel level. You can query the value for `<kernel-release>` with `uname -r`. You can combine the commands into one:

```
ls -la /lib/modules/$(uname -r)/kernel/drivers/s390
```

Specifying module parameters

You can specify module parameters with `modprobe` or on the kernel parameter line.

Specifying module parameters with `modprobe`

If you load a module explicitly with a `modprobe` command, you can specify the module parameters as command arguments.

Module parameters that are specified as arguments to `modprobe` are effective only until the module is unloaded.

Note: Parameters that you specify as command arguments might interfere with parameters that Ubuntu Server 20.04.1 sets for you.

Module parameters on the kernel parameter line

Parameters that the kernel does not recognize as kernel parameters are ignored by the kernel and made available to user space programs.

One of these user space programs is `modprobe`. `modprobe` interprets module parameters that are specified on the kernel parameter line if they are qualified with a leading module prefix and a dot.

For example, if the DASD device driver is compiled as a separate module, you can include a specification with `dasd_mod.dasd=` on the kernel parameter line. `modprobe` evaluates this specification as the `dasd=` module parameter when the `dasd_mod` module is loaded.

For some device drivers and features, the module parameters and their corresponding kernel parameters follow a naming convention that makes them effective regardless of whether the device driver or feature is compiled into the kernel or as a separate module. An example is the `zfcp.datarouter=` kernel parameter with its corresponding `datarouter=` module parameter.

If the SCSI-over-Fibre Channel device driver (`zfcp` device driver) is compiled into the kernel, `zfcp.datarouter=` is recognized as a kernel parameter. If the `zfcp` device driver is compiled as a separate module, `modprobe` interprets `zfcp.datarouter=` as the `datarouter=` parameter to be used when the `zfcp` module is loaded.

Note: Ubuntu Server 20.04.1 might set required module parameters for you. Parameters that you specify on the kernel parameter line might interfere with these settings.

Including module parameters in a boot configuration

Module parameters for modules that are required early during the boot process must be included in the boot configuration.

About this task

Ubuntu Server uses an initial RAM disk when booting.

Ubuntu Server runs **update-initramfs** and **zipl** for you when saving changes you have made.

Procedure

Perform these steps to provide module parameters for modules that are included in the initial RAM disk:

1. Make your configuration changes, for example with the **chzdev** command.
2. If Ubuntu Server does not perform this task for you, run **update-initramfs** to create an initial RAM disk that includes the module parameters.
For example:

```
# update-initramfs -k all -u
```

Tip: Use `-k all` to ensure that all kernel and initrd combinations on the system are updated.

3. If Ubuntu Server does not perform this task for you, run **zipl** to include the new RAM disk in your boot configuration.

Displaying information about the modules

Loaded modules can export module parameter settings to sysfs. Not all parameters are visible.

The parameters for modules are available as sysfs attributes of the form:

```
/sys/module/<module_name>/parameters/<parameter name>
```

Before you begin

You can display information about modules that fulfill these prerequisites:

- The module must be loaded.
- The module must export the parameters to sysfs.

Procedure

To find and display the parameters for a module, follow these steps:

1. Optional: Confirm that the module of interest is loaded by issuing a command of this form:

```
# lsmod | grep <module_name>
```

where `<module_name>` is the name of the module.

2. Optional: Get an overview of the parameters for the module by issuing a command of this form:

```
# modinfo <module_name>
```

3. Check if the module of interest exports parameters to sysfs. Issue a command of the form:

```
# ls /sys/module/<module_name>/parameters
```

4. If the previous command listed parameters, you can display the value for the parameter of interest. Issue a command of the form:

```
# cat /sys/module/<module_name>/parameters/<parameter name>
```

Example

- To list the module parameters for the `ap` module, issue:

```
# ls /sys/module/ap/parameters
domain
...
```

- To display the value of the domain parameter, issue:

```
# cat /sys/module/ap/parameters/domain
1
```

Part 2. Booting and shutdown

These device drivers and features are useful in the context of booting and shutting down instances of Ubuntu Server 20.04.1.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 5. Console device drivers

The console device drivers support terminal devices for basic Linux control, for example, for booting Linux, for troubleshooting, and for displaying Linux kernel messages.

Linux in LPAR mode

The only interface to a Linux instance in an LPAR before the boot process is completed is the Hardware Management Console (HMC), see Figure 9 on page 33. After the boot process has completed, you typically use a network connection to access Linux through a user login, for example, in an SSH session. The possible connections depend on the configuration of your particular Linux instance.

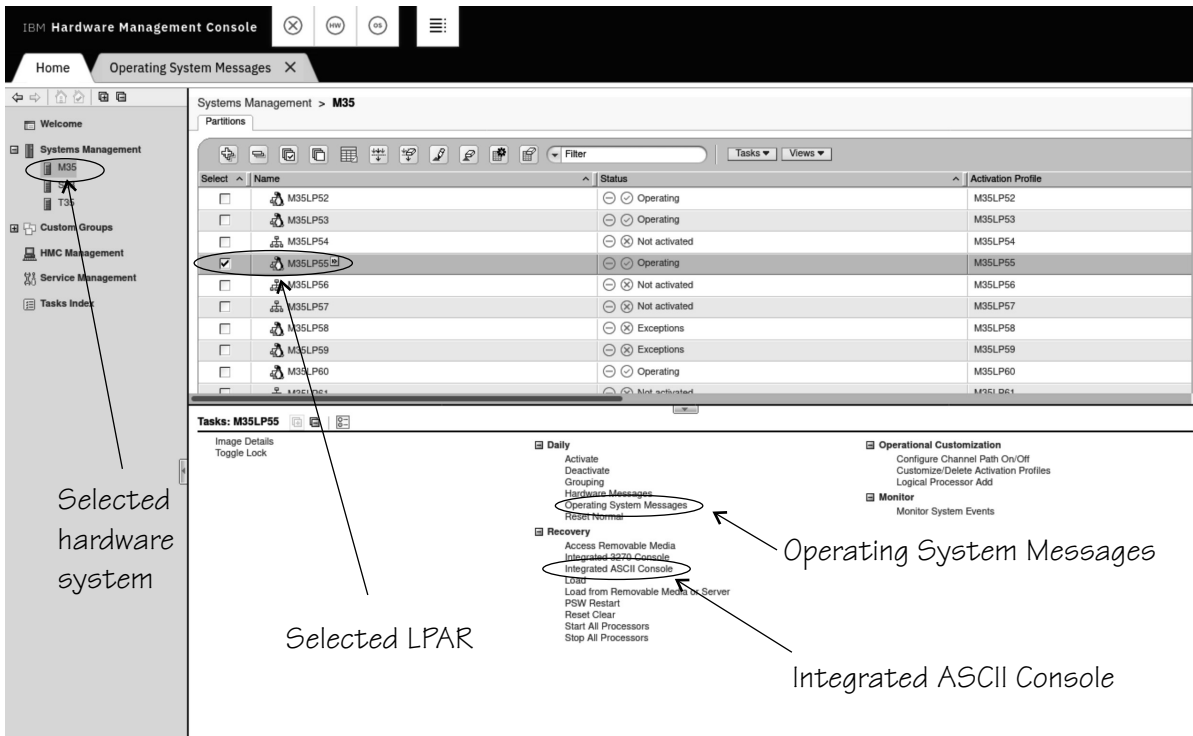


Figure 9. Hardware Management Console

Linux on z/VM

With Linux on z/VM, you typically use a 3270 terminal or terminal emulator to log in to z/VM first. From the 3270 terminal, you IPL the Linux boot device. Again, after boot you typically use a network connection to access Linux through a user login rather than a 3270 terminal.

Linux on KVM

You initiate the boot process for Linux as a KVM guest on Z when you start the KVM virtual server through a **virsh** command on the KVM host. The `--console` of the **virsh start** command option gives you access to a terminal that displays the kernel messages.

After the boot process has completed, a guest is usually accessed through a user login, for example, in an SSH session. The possible connections depend on the configuration of your particular Linux instance.

Console features

The console device drivers support several types of terminal devices.

HMC applets

You can use two applets.

Operating System Messages

This applet provides a line-mode terminal. See [Figure 10 on page 34](#) for an example.

Integrated ASCII Console

This applet provides a full-screen mode terminal. It is useful, for example, for interactive commands.

These HMC applets are accessed through the service-call logical processor (SCLP) console interface.

3270 terminal

This terminal can be based on physical 3270 terminal hardware or a 3270 terminal emulation.

z/VM can use the 3270 terminal as a 3270 device or perform a protocol translation and use it as a 3215 device. As a 3215 device it is a line-mode terminal for the United States code page (037).

The iucvconn program

You can use the iucvconn program from Linux on z/VM to access terminal devices on other Linux instances that run as guests of the same z/VM system.

For information about the iucvconn program, see *How to Set up a Terminal Server Environment on z/VM, SC34-2596*.

virsh command on the KVM host

For Linux on KVM, you can access the console through a virsh command on the KVM host. See [“Using virsh on a KVM host” on page 38](#).

The console device drivers support these terminals as output devices for Linux kernel messages.

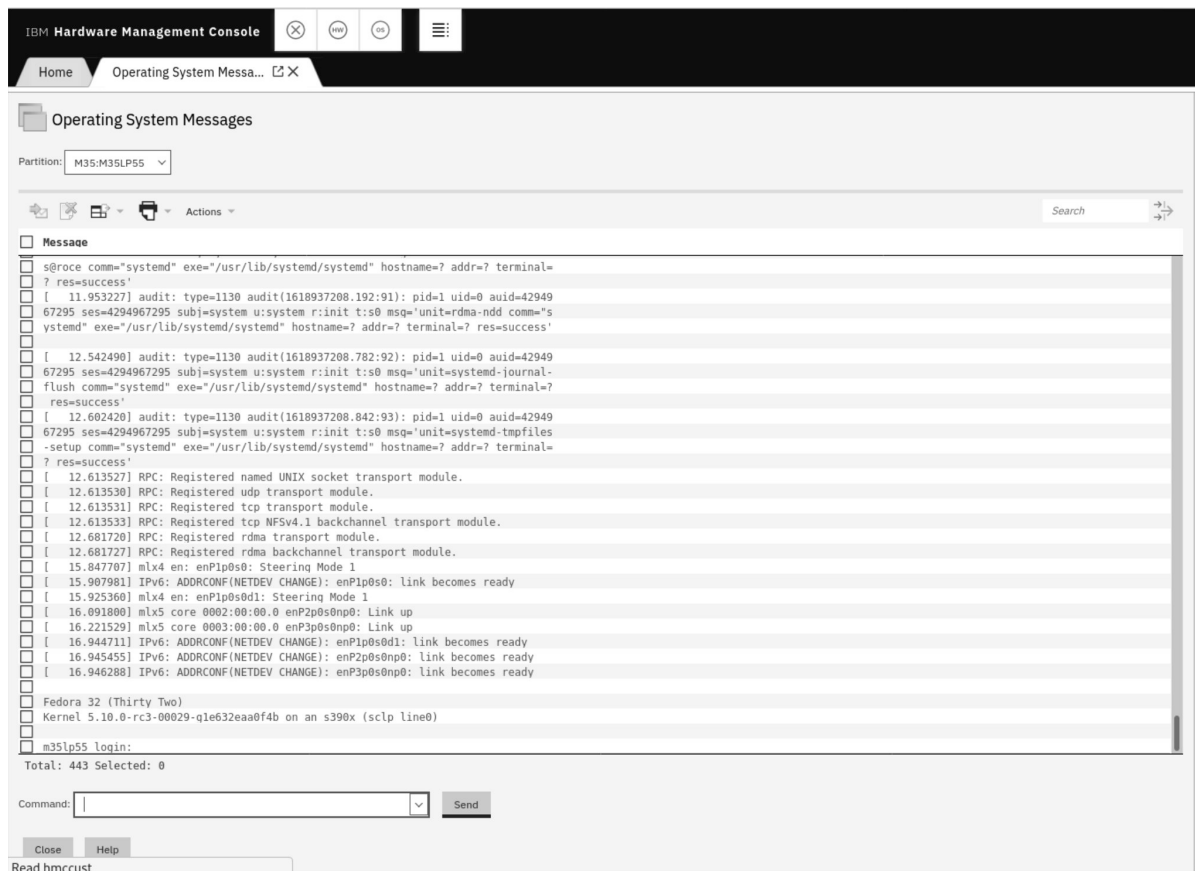


Figure 10. Linux kernel messages on the HMC Operating System Messages applet

What you should know about the console device drivers

The console concepts, naming conventions, and terminology overview help you to understand the tasks you might have to perform with console and terminal devices.

Console terminology

Terminal and *console* have special meanings in Linux.

Linux terminal

An input/output device through which users interact with Linux and Linux applications. Login programs and shells typically run on Linux terminals and provide access to the Linux system.

Linux console

An output-only device to which the Linux kernel can write kernel messages. Linux console devices can be associated with Linux terminal devices. Thus, console output can be displayed on a Linux terminal.

Mainframe terminal

Any device that gives a user access to operating systems and applications that run on a mainframe. A mainframe terminal can be a physical device such as a 3270 terminal hardware that is linked to the mainframe through a controller. It can also be a terminal emulator on a workstation that is connected through a network. For example, you access z/OS® through a mainframe terminal.

Hardware Management Console (HMC)

A device that gives a system programmer control over IBM Z hardware resources, for example, LPARs. The HMC is a web application on a web server that is connected to the support element (SE). The HMC can be accessed from the SE but more commonly is accessed from a workstation within a secure network.

On the mainframe, the Linux console and Linux terminals can both be connected to a mainframe terminal.

Before you have a Linux terminal - the zipl boot menu

Do not confuse the zipl boot menu with a Linux terminal.

Depending on your setup, a zipl boot menu might be displayed when you perform an IPL. The zipl boot menu is part of the boot loader that loads the Linux kernel and is displayed before a Linux terminal is set up. The zipl boot menu is very limited in its functions. For example, there is no way to specify uppercase letters because all input is converted to lowercase characters. For more details about booting Linux, see Chapter 7, “Booting Linux,” on page 79. For more information about the zipl boot menu, see Chapter 6, “Initial program loader for IBM Z - zipl,” on page 55.

Device and console names

Each terminal device driver can provide a single console device.

Table 2 on page 35 lists the terminal device drivers and the corresponding device names and console names.

Device driver	Device name	Console name
SCLP line-mode terminal device driver	sclp_line0	ttyS0
SCLP VT220 terminal device driver	ttysclp0	ttyS1
3215 line-mode terminal device driver	ttyS0	ttyS0
3270 terminal device driver	3270/tty1 to 3270/ tty<N>	tty3270
z/VM IUCV HVC device driver	hvc0 to hvc7	hvc0
virtio-console device driver	hvc0 to hvc<n>	hvc0

As shown in [Table 2 on page 35](#), the console with name `ttyS0` can be provided either by the SCLP console device driver or by the 3215 line-mode terminal device driver. The system environment and settings determine which device driver provides `ttyS0`. For details, see the information about the `conmode` kernel parameter in [“Console kernel parameter syntax” on page 41](#).

Of the terminal devices that are provided by the z/VM IUCV HVC device driver only `hvc0` is associated with a console.

Of the `3270/tty<N>` terminal devices only `3270/tty1` is associated with a console.

Device nodes

Applications, for example, login programs, access terminal devices by device nodes.

For example, with the default `conmode` settings, `udev` creates the following device nodes:

Device driver	On LPAR	On z/VM	On KVM
SCLP line-mode terminal device driver	<code>/dev/sclp_line0</code>	n/a	<code>/dev/sclp_line0</code>
SCLP VT220 terminal device driver	<code>/dev/ttysclp0</code>	<code>/dev/ttysclp0</code>	<code>/dev/ttysclp0</code>
3215 line-mode terminal device driver	n/a	<code>/dev/ttyS0</code>	n/a
3270 terminal device driver	<code>/dev/3270/tty1</code> to <code>/dev/3270/tty<N></code>	<code>/dev/3270/tty1</code> to <code>/dev/3270/tty<N></code>	<code>/dev/3270/tty1</code> to <code>/dev/3270/tty<N></code>
z/VM IUCV HVC device driver	n/a	<code>/dev/hvc0</code> to <code>/dev/hvc7</code>	n/a
virtio-console device driver	n/a	n/a	<code>/dev/hvc0</code> to <code>/dev/hvc<n></code>

On LPAR, the 3270 terminal device node is only created if a real terminal is available.

Terminal modes

The Linux terminals that are provided by the console device drivers include line-mode terminals, block-mode terminals, and full-screen mode terminals.

On a full-screen mode terminal, pressing any key immediately results in data being sent to the terminal. Also, terminal output can be positioned anywhere on the screen. This feature facilitates advanced interactive capability for terminal-based applications like the `vi` editor.

On a line-mode terminal, the user first types a full line, and then presses `Enter` to indicate that the line is complete. The device driver then issues a read to get the line, adds a new line, and hands over the input to the generic TTY routines. Line-mode terminals provide fewer capabilities than full-screen or block mode terminals and are intended as a backup for emergencies.

The terminal that is provided by the 3270 terminal device driver is a traditional IBM mainframe block-mode terminal. Block-mode terminals provide full-screen output support and users can type input in predefined fields on the screen. Other than on typical full-screen mode terminals, no input is passed on until the user presses `Enter`. The terminal that is provided by the 3270 terminal device driver provides limited support for full-screen applications. For example, the `ned` editor is supported, but not `vi`.

[Table 4 on page 37](#) summarizes when to expect which terminal mode.

Table 4. Terminal modes

Accessed through	Environment	Device driver	Mode
Operating System Messages applet on the HMC	LPAR	SCLP line-mode terminal device driver	Line mode
z/VM emulation of the HMC Operating System Messages applet	z/VM	SCLP line-mode terminal device driver	Line mode
Integrated ASCII Console applet on the HMC	z/VM or LPAR	SCLP VT220 terminal device driver	Full-screen mode
KVM host (for example, using the virsh console command)	KVM	SCLP line-mode terminal device driver	Line mode
KVM host (for example, using the virsh console command)	KVM	SCLP VT220 terminal device driver	Full-screen mode
3270 terminal hardware or emulation	z/VM with CONMODE=3215 or KVM	3215 line-mode terminal device driver	Line mode
3270 terminal hardware or emulation	z/VM with CONMODE=3270 or KVM	3270 terminal device driver	Block mode
iucvconn program	z/VM	z/VM IUCV HVC device driver	Full-screen mode
KVM host (for example, using the virsh console command)	KVM	virtio-console device driver	Full-screen mode

The 3270 terminal device driver provides three different views. See [“Switching the views of the 3270 terminal device driver”](#) on page 48 for details.

How console devices are accessed

How you can access console devices depends on your environment.

The diagrams in the following sections omit device drivers that are not relevant for the particular access scenario.

Using the HMC for Linux in an LPAR

You can use two applets on the HMC to access terminal devices on Linux instances that run directly in an LPAR.

[Figure 11](#) on page 38 shows the possible terminal devices for Linux instances that run directly in an LPAR.

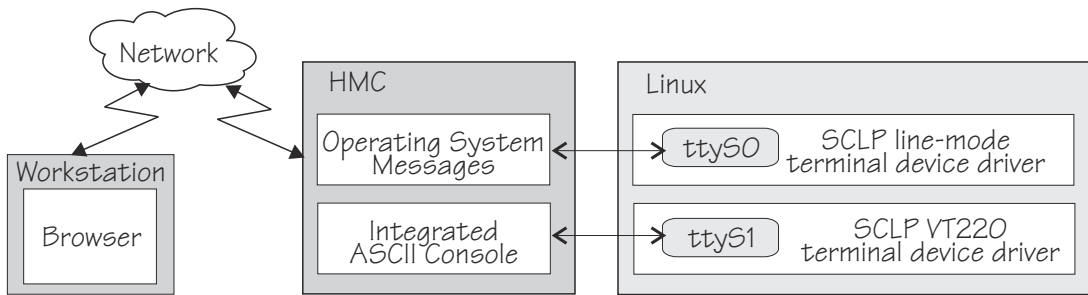


Figure 11. Accessing terminal devices on Linux in an LPAR from the HMC

The **Operating System Messages** applet accesses the device that is provided by the SCLP line-mode terminal device driver. The **Integrated ASCII console** applet accesses the device that is provided by the SCLP VT220 terminal device driver.

Using the HMC for Linux on z/VM

You can use the HMC **Integrated ASCII Console** applet to access terminal devices on Linux instances that run as z/VM guests.

While the ASCII system console is attached to the z/VM guest virtual machine where the Linux instance runs, you can access the ttyS1 terminal device from the HMC **Integrated ASCII Console** applet (see [Figure 12 on page 38](#)).

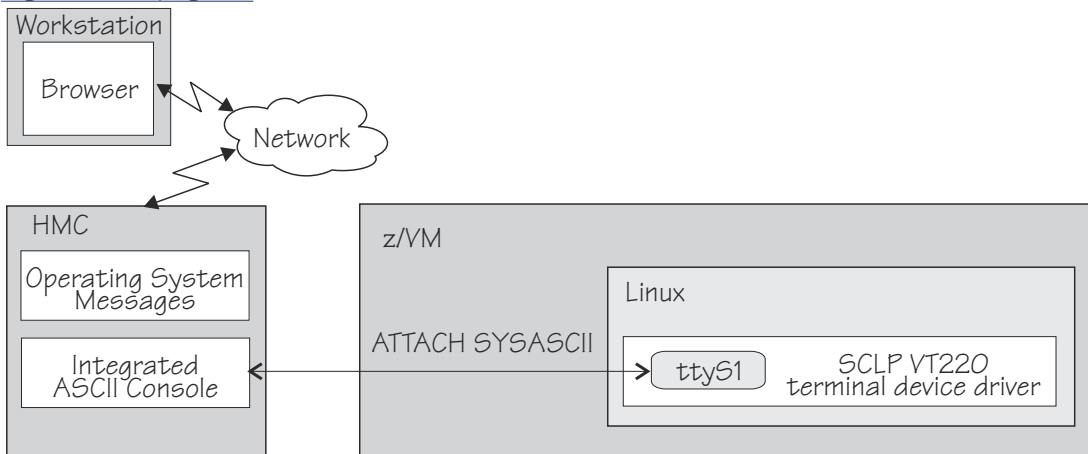


Figure 12. Accessing terminal devices from the HMC for Linux on z/VM

Use the CP ATTACH SYSASCII command to attach the ASCII system console to your z/VM guest virtual machine.

Using virsh on a KVM host

You can use the **virsh console** command on a KVM host to access an sclp or virtio based terminal on a KVM guest.

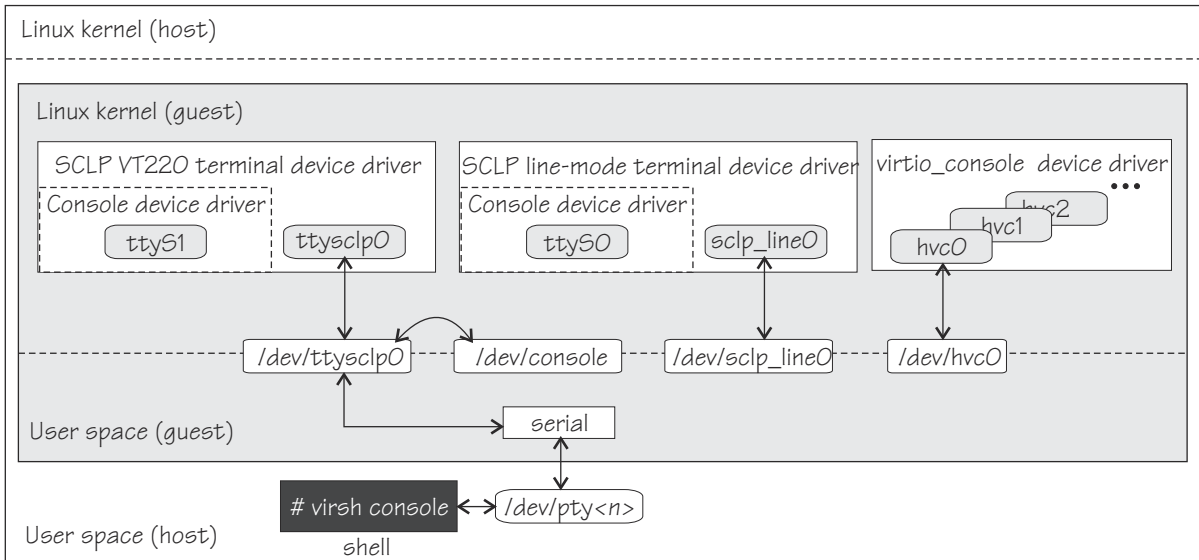


Figure 13. Using `virsh` to access a KVM guest console

Figure 13 on page 39, shows a KVM guest with three device drivers that can provide a console. The terminal that is accessed by the **virsh console** command depends on the guest configuration. For details, see *KVM Virtual Server Management*, SC34-2752.

In a common setup, the **virsh console** command opens a connection to the device that is provided by the SCLP VT220 terminal device driver. This device also becomes associated with the generic `/dev/console` device node.

Whether your Linux instance uses this device as the device to which Linux kernel messages are written depends on the Linux configuration. Use the `console=` parameter to control which devices are activated to receive Linux kernel messages (see in “Console kernel parameter syntax” on page 41).

Using a 3270 terminal emulation for Linux on z/VM

For Linux on z/VM, you can use a 3270 terminal emulation to access a console device.

Figure 14 on page 39 illustrates how z/VM can handle the 3270 communication.

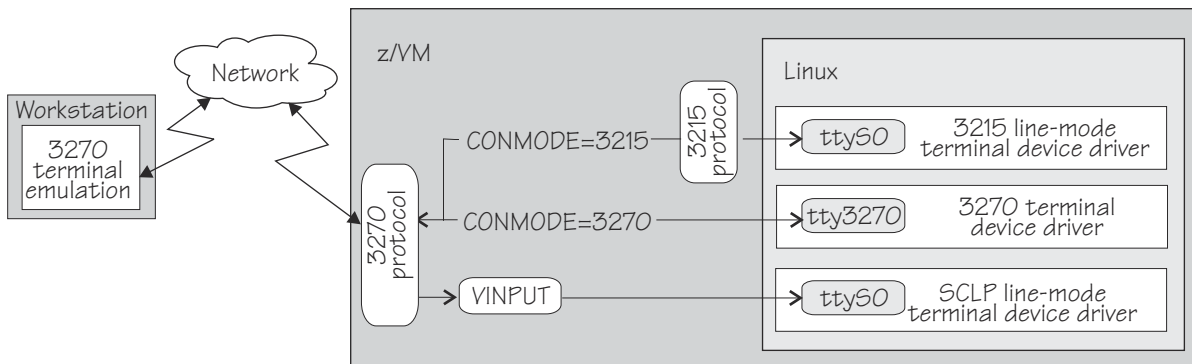


Figure 14. Accessing terminal devices from a 3270 device

Note: Figure 14 on page 39 shows two console devices with the name `ttySO`. Only one of these devices can be present at any one time.

CONMODE=3215

translates between the 3270 protocol and the 3215 protocol and connects the 3270 terminal emulation to the 3215 line-mode terminal device driver in the Linux kernel.

You can use the `conmode=` kernel parameter to make the kernel issue the corresponding z/VM CP command.

CONMODE=3270

connects the 3270 terminal emulation to the 3270 terminal device driver in the Linux kernel.

You can use the `conmode=` kernel parameter to make the kernel issue the corresponding z/VM CP command.

VINPUT

is a z/VM CP command that directs input to the `ttyS0` device provided by the SCLP line-mode terminal device driver. In a default z/VM environment, `ttyS0` is provided by the 3215 line-mode terminal device driver. You can use the `conmode=` kernel parameter to make the SCLP line-mode terminal device driver provide `ttyS0`.

The terminal device drivers continue to support 3270 terminal hardware, which, if available at your installation, can be used instead of a 3270 terminal emulation.

For information about the `conmode=` kernel parameter, see [“Console kernel parameter syntax” on page 41](#).

Using a 3270 terminal emulation for Linux on KVM

For Linux on Z as a KVM guest, you can use a 3270 terminal emulation to access a console device through the 3270 or 3215 terminal device driver.

The following figure illustrates how Linux on KVM can handle the 3270 communication.

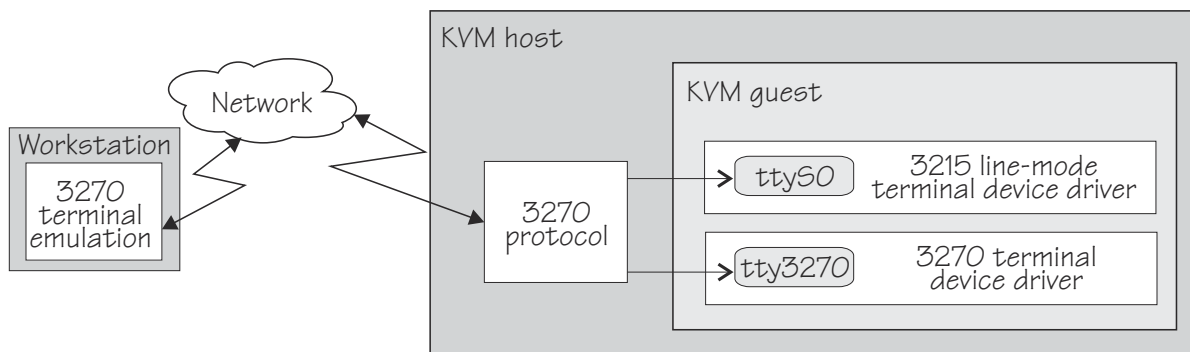


Figure 15. Accessing terminal devices from virt-manager

Using iucvconn on Linux on z/VM

On Linux on z/VM, you can access the terminal devices that are provided by the z/VM IUCV Hypervisor Console (HVC) device driver.

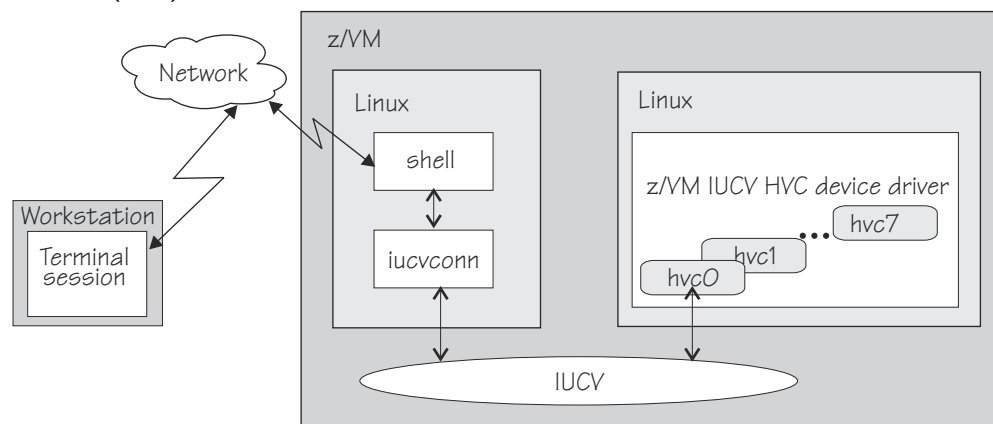


Figure 16. Accessing terminal devices from a peer Linux instance

As illustrated in Figure 16 on page 40, you access the devices with the `iucvconn` program from another Linux instance. Both Linux instances are guests of the same z/VM system. IUCV provides the

communication between the two Linux instances. With this setup, you can access terminal devices on Linux instances with no external network connection.

Note: Of the terminal devices that are provided by the z/VM IUCV HVC device driver only hvc0 can be activated to receive Linux kernel messages.

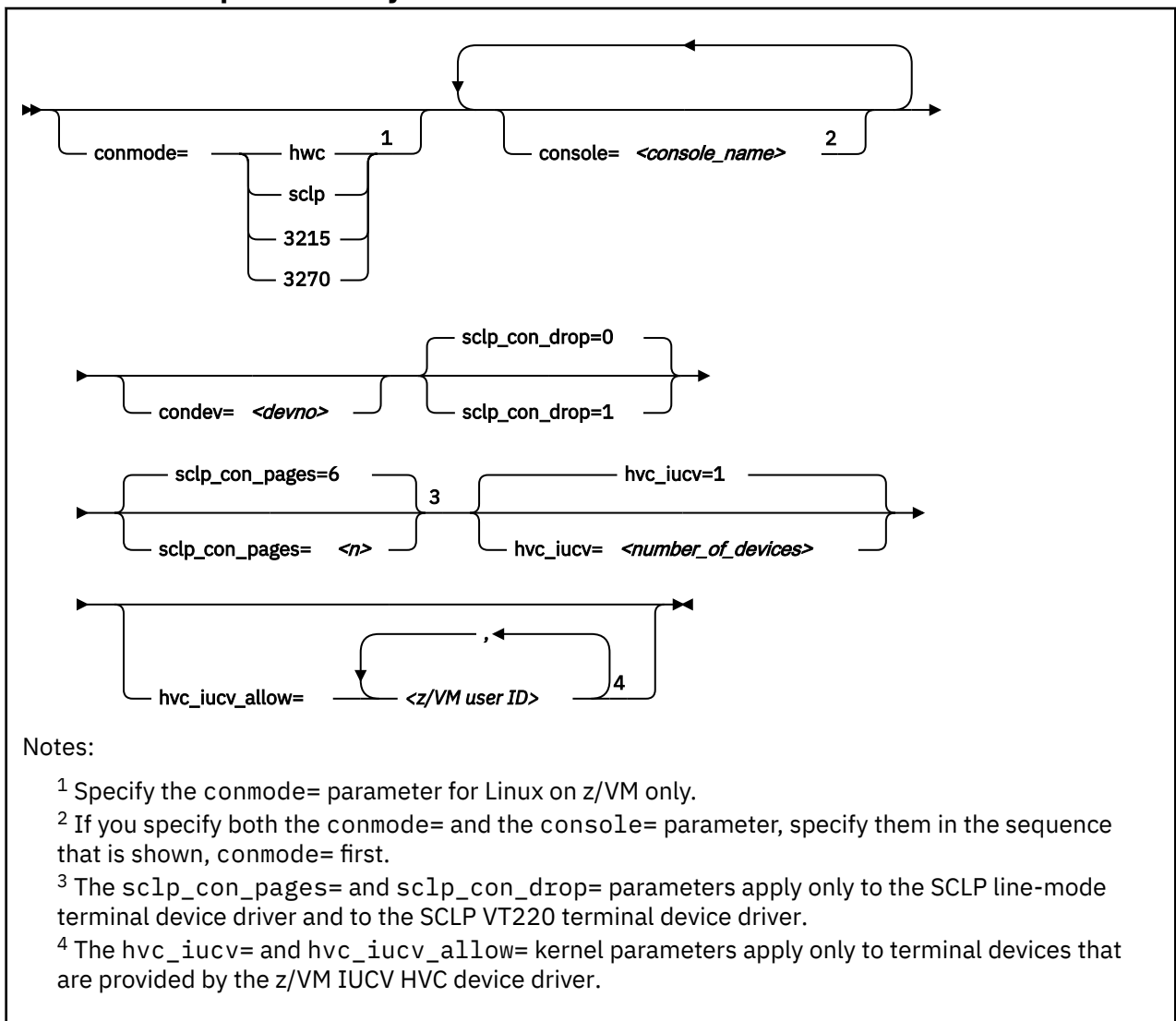
Setting up the console device drivers

You configure the console device drivers through kernel parameters. You also might have to enable user logins on terminals, and ensure suitable terminal settings.

Console kernel parameter syntax

Use the console kernel parameters to configure the console device drivers, line-mode terminals, and HVC terminal devices.

Console kernel parameter syntax



where:

conmode

specifies which one of the line-mode or block-mode terminal devices is present and provided by which device driver.

A Linux kernel might include multiple console device drivers that can provide a line-mode terminal:

- SCLP line-mode terminal device driver
- 3215 line-mode terminal device driver
- 3270 terminal device driver

On a running Linux instance, only one of these device drivers can provide a device. Table 5 on page 42 shows how the device driver that is used by default depends on the environment.

<i>Table 5. Default device driver for the line-mode terminal device</i>	
Mode	Default
LPAR	SCLP line-mode terminal device driver
z/VM	3215 line-mode terminal device driver or 3270 terminal device driver, depending on the z/VM guest's console settings (the CONMODE field in the output of #CP QUERY TERMINAL). If the device driver you specify with the conmode= kernel parameter contradicts the CONMODE z/VM setting, z/VM is reconfigured to match the specification for the kernel parameter.
KVM	SCLP line-mode terminal device driver

You can use the conmode= parameter to override the default for Linux on z/VM. Do not change the default for Linux on KVM or for Linux in LPAR mode.

sclp or hwc

specifies the SCLP line-mode terminal device driver.

You need this specification if you want to use the z/VM CP VINPUT command ([“Using a z/VM emulation of the HMC Operating System Messages applet” on page 51](#)).

3270

specifies the 3270 device driver.

3215

specifies the 3215 device driver.

console=<console_name>

specifies the console devices to be activated to receive Linux kernel messages. If present, ttyS0 is always activated to receive Linux kernel messages and, by default, it is also the *preferred* console.

The preferred console is used as an initial terminal device, beginning at the stage of the boot process when the initialization procedures run. Messages from programs that run at this stage are displayed on the preferred console only. Multiple terminal devices can be activated to receive Linux kernel messages, but only one of the activated terminal devices can be the preferred console.

If you specify conmode=3270, there is no console with name ttyS0.

If you want console devices other than ttyS0 to be activated to receive Linux kernel messages, specify a console statement for each of these other devices. The last console statement designates the preferred console.

If you specify one or more console parameters and you want to keep ttyS0 as the preferred console, add a console parameter for ttyS0 as the last console parameter. Otherwise, you do not need a console parameter for ttyS0.

<console_name> is the console name that is associated with the terminal device to be activated to receive Linux kernel messages. Of the terminal devices that are provided by the z/VM IUCV HVC device driver, only hvc0 can be activated. Specify the console names as shown in [Table 2 on page 35](#).

condev=<devno>

specifies the CCW device to be chosen from several defined 3270 consoles. By default the first device that is found is chosen. Omit this parameter if there is only one device, or if any device is acceptable.

sclp_con_drop

governs the behavior of the SCLP line-mode and VT220 terminal device driver if either of them runs out of output buffer pages. The trade-off is between slowing down Linux and losing console output. Possible values are 0 (default) and 1.

0

assures complete console output by pausing until used output buffer pages are written to an output device and can be reused without loss.

1

avoids system pauses by overwriting used output buffer pages, even if the content was never written to an output device.

You can use the `sclp_con_pages=` parameter to set the number of output buffers.

sclp_con_pages=<n>

specifies the number of 4-KB memory pages to be used as the output buffer for the SCLP line-mode and VT220 terminal. Depending on the line length, each output buffer can hold multiple lines. Use many buffer pages for a kernel with frequent phases of producing console output faster than it can be written to the output device.

Depending on the setting for the `sclp_con_drop=`, running out of pages can slow down Linux or cause it to lose console output.

The value is a positive integer. The default is 6.

hvc_iucv=<number_of_devices>

specifies the number of terminal devices that are provided by the z/VM IUCV HVC device driver. `<number_of_devices>` is an integer in the range 0 - 8. Specify 0 to switch off the z/VM IUCV HVC device driver.

hvc_iucv_allow=<z/VM user ID>, <z/VM user ID>, ...

specifies an initial list of z/VM guest virtual machines that are allowed to connect to HVC terminal devices. If this parameter is omitted, any z/VM guest virtual machine that is authorized to establish the required IUCV connection is also allowed to connect. On the running system, you can change this list with the **chiucvallow** command. See *How to Set up a Terminal Server Environment on z/VM*, SC34-2596 for more information.

Examples

- To activate `ttys1` in addition to `ttys0`, and to use `ttys1` as the preferred console, specify:

```
console=ttys1
```

- To activate `ttys1` in addition to `ttys0`, and to keep `ttys0` as the preferred console, specify:

```
console=ttys1 console=ttys0
```

- To use an emulated HMC Operating System Messages applet in a z/VM environment, specify:

```
conmode=sclp
```

- To activate `hvc0` in addition to `ttys0`, use `hvc0` as the preferred console, configure the z/VM IUCV HVC device driver to provide four devices, and limit the z/VM guest virtual machines that can connect to HVC terminal devices to `lxtserv1` and `lxtserv2`, specify:

```
console=hvc0 hvc_iucv=4 hvc_iucv_allow=lxtserv1,lxtserv2
```

- The following specification selects the SCLP line-mode terminal and configures 32 4-KB pages (128 KB) for the output buffer. If buffer pages run out, the SCLP line-mode terminal device driver does not wait for pages to be written to an output device. Instead of pausing, it reuses output buffer pages at the expense of losing content.

```
console=sclp sclp_con_pages=32 sclp_con_drop=1
```

Setting up a z/VM guest virtual machine for iucvconn

Because the `iucvconn` program uses z/VM IUCV to access Linux, you must set up your z/VM guest virtual machine for IUCV.

See [“Setting up your z/VM guest virtual machine for IUCV”](#) on page 288 for details about setting up the z/VM guest virtual machine.

For information about accessing Linux through the `iucvtty` program rather than through the z/VM IUCV HVC device driver, see *How to Set up a Terminal Server Environment on z/VM*, SC34-2596 or the man pages for the `iucvtty` and `iucvconn` commands.

Setting up a line-mode terminal

The line-mode terminals are primarily intended for booting Linux.

The preferred user access to a running instance of Ubuntu Server 20.04.1 is through a user login that runs, for example, in an SSH session. See [“Terminal modes”](#) on page 36 for information about the available line-mode terminals.

Tip: If the terminal does not provide the expected output, ensure that `dumb` is assigned to the `TERM` environment variable. For example, enter the following command:

```
# export TERM=dumb
```

Setting up a full-screen mode terminal

The full-screen terminal can be used for full-screen text editors, such as `vi`, and terminal-based full-screen system administration tools.

See [“Terminal modes”](#) on page 36 for information about the available full-screen mode terminals.

Tip: If the terminal does not provide the expected output, ensure that `linux` is assigned to the `TERM` environment variable. For example, enter the following command:

```
# export TERM=linux
```

Setting up a terminal provided by the 3270 terminal device driver

The terminal that is provided by the 3270 terminal device driver is not a line-mode terminal, but it is also not a typical full-screen mode terminal.

The terminal provides limited support for full-screen applications. For example, the `ned` editor is supported, but not `vi`.

Tip: If the terminal does not provide the expected output, ensure that `linux` is assigned to the `TERM` environment variable. For example, enter the following command:

```
# export TERM=linux
```

Enabling user logins

Use `systemd` service units to enable `terminal`s for user access.

About this task

You must explicitly enable user logins for the HVC terminals `hvc1` to `hvc7` and for any dynamically attached virtual or real 3270 terminals.

On all other terminals that are available in your environment systemd automatically enables user logins for you. In particular you do not need to enable user logins for the following terminals:

- hvc0
- 3270/tty1
- Terminals that are available in KVM guests

Enabling user logins for 3270 terminals

Instantiate getty services for terminals to allow user logins.

Procedure

Perform these steps to use a getty service for enabling user logins on any dynamically added real or virtual 3270 terminals:

1. Enable the new getty service by issuing a command of this form:

```
# systemctl enable serial-getty@<terminal>.service
```

where *<terminal>* specifies one of the 3270-tty<N> terminals and <N> is an integer greater than 1.

Note: You specify terminal 3270/tty<N> as 3270-tty<N>.

2. Optional: Start the new getty service by issuing a command of this form:

```
# systemctl start serial-getty@<terminal>.service
```

Results

At the next system start, systemd automatically starts the getty service for you.

Example

For 3270/tty2, issue:

```
# systemctl enable serial-getty@3270-tty2.service
# systemctl start serial-getty@3270-tty2.service
```

Preventing respawns for non-operational HVC terminals

If you enable user logins on a HVC terminal that is not available or not operational, systemd keeps respawning the getty program.

About this task

If user logins are enabled on unavailable HVC terminals hvc1 to hvc7, systemd might keep respawning the getty program. To be free to change the conditions that affect the availability of these terminals, use the ttyrun service to enable user logins for them. HVC terminals are operational only in a z/VM environment, and they depend on the hvc_iucv= kernel parameter (see [“Console kernel parameter syntax”](#) on page 41).

Any other unavailable terminals with enabled user login, including hvc0, do not cause problems with systemd.

Procedure

Perform these steps to use a ttyrun service for enabling user logins on a terminal:

1. Enable the ttyrun service by issuing a command of this form:

```
# systemctl enable ttyrun-getty@hvc<n>.service
```

where `hvc<n>` specifies one of the terminals `hvc1` to `hvc7`.

2. Optional: Start the new service by issuing a command of this form:

```
# systemctl start ttyrun-getty@hvc<n>.service
```

Results

At the next system start, `systemd` starts the `ttyrun` service for `hvc<n>`. The `ttyrun` service starts a `getty` only if this terminal is available.

Example

For `hvc1`, issue:

```
# systemctl enable ttyrun-getty@hvc1.service
# systemctl start ttyrun-getty@hvc1.service
```

Setting up the code page for an x3270 emulation on Linux

For accessing `z/VM` from Linux through the `x3270` terminal emulation, you must add a number of settings to the `.Xdefaults` file to get the correct code translation.

Add these settings:

```
! X3270 keymap and charset settings for Linux
x3270.charset: us-intl
x3270.keymap: circumfix
x3270.keymap.circumfix: :<key>asciicircum: Key("^)\n
```

Working with Linux terminals

You might have to work with different types of Linux terminals, and use special functions on these terminals.

- [“Using the terminal applets on the HMC” on page 46](#)
- [“Accessing terminal devices over `z/VM` IUCV” on page 47](#)
- [“Switching the views of the 3270 terminal device driver” on page 48](#)
- [“Setting a CCW terminal device online or offline” on page 48](#)
- [“Entering control and special characters on line-mode terminals” on page 49](#)
- [“Using the magic `sysrequest` feature” on page 49](#)
- [“Using a `z/VM` emulation of the HMC Operating System Messages applet” on page 51](#)
- [“Using a 3270 terminal in 3215 mode” on page 53](#)

Using the terminal applets on the HMC

You should be aware of some aspects of the line-mode and the full-screen mode terminal when using the corresponding applets on the HMC.

The following statements apply to both the line-mode terminal and the full-screen mode terminal on the HMC:

- On an HMC, you can open each applet only once.
- Within an LPAR, there can be only one active terminal session for each applet, even if multiple HMCs are used.
- A particular Linux instance supports only one active terminal session for each applet.

- Slow performance of the HMC is often due to a busy console or increased network traffic.

The following statements apply to the full-screen mode terminal only:

- Output that is written by Linux while the terminal window is closed is not displayed. Therefore, a newly opened terminal window is always blank. For most applications, like login or shell prompts, it is sufficient to press Enter to obtain a new prompt.
- The terminal window shows only 24 lines and does not provide a scroll bar. To scroll up, press Shift+PgUp; to scroll down, press Shift+PgDn.

Security hint: Always end a terminal session by explicitly logging off (for example, type "exit" and press Enter). Simply closing the applet leaves the session active and the next user to open the applet resumes the existing session without a logon.

Accessing terminal devices over z/VM IUCV

Use z/VM IUCV to access hypervisor console (HVC) terminal devices, which are provided by the z/VM IUCV HVC device driver.

About this task

For information about accessing terminal devices that are provided by the iucvttty program see *How to Set up a Terminal Server Environment on z/VM*, SC34-2596.

You access HVC terminal devices from a Linux instance where the iucvconn program is installed. The Linux instance with the terminal device to be accessed and the Linux instance with the iucvconn program must both run as guests of the same z/VM system. The two guest virtual machines must be configured such that IUCV communication is permitted between them.

Procedure

Perform these steps to access an HVC terminal device over z/VM IUCV:

1. Open a terminal session on the Linux instance where the iucvconn program is installed.
2. Enter a command of this form:

```
# iucvconn <guest_ID> <terminal_ID>
```

where:

<guest_ID>

specifies the z/VM guest virtual machine on which the Linux instance with the HVC terminal device to be accessed runs.

<terminal_ID>

specifies an identifier for the terminal device to be accessed. HVC terminal device names are of the form hvcn where *n* is an integer in the range 0-7. The corresponding terminal IDs are lnxhvcn.

Example: To access HVC terminal device hv0 on a Linux instance that runs on a z/VM guest virtual machine LXGUEST1, enter:

```
# iucvconn LXGUEST1 lnxhvc0
```

For more details and further parameters of the **iucvconn** command, see the **iucvconn** man page or *How to Set up a Terminal Server Environment on z/VM*, SC34-2596.

3. Press Enter to obtain a prompt.

Output that is written by Linux while the terminal window is closed, is not displayed. Therefore, a newly opened terminal window is always blank. For most applications, like login or shell prompts, it is sufficient to press Enter to obtain a new prompt.

Security hint

Always end terminal sessions by explicitly logging off (for example, type **exit** and press Enter). If logging off results in a new login prompt, press Control and Underscore (Ctrl+_), then press **D** to close the login window. Simply closing the terminal window for a hvC0 terminal device that was activated for Linux kernel messages leaves the device active. The terminal session can then be reopened without a login.

Switching the views of the 3270 terminal device driver

The 3270 terminal device driver provides three different views for Linux on z/VM.

Use function key 3 (PF3) to switch between the views (see [Figure 17](#) on page 48).

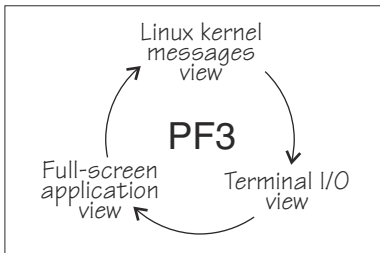


Figure 17. Switching views of the 3270 terminal device driver

The availability of the individual views depends on the configuration options that were selected when the kernel was compiled. In addition, the Linux kernel messages view is available only if the terminal device is activated for Linux kernel messages.

The full-screen application view is available only if there is an application that uses this view, for example, the ned editor. Be aware that the 3270 terminal provides only limited full-screen support. The full-screen application view of the 3270 terminal is not intended for applications that require vt220 capabilities. The application itself must create the 3270 data stream.

For the Linux kernel messages view and the terminal I/O view, you can use the PF7 key to scroll backward and the PF8 key to scroll forward. The scroll buffers are fixed at four pages (16 KB) for the Linux kernel messages view and five pages (20 KB) for the terminal I/O view. When the buffer is full and more terminal data needs to be printed, the oldest lines are removed until there is enough room. The number of lines in the history, therefore, vary. Scrolling in the full-screen application view depends on the application.

You cannot issue z/VM CP commands from any of the three views that are provided by the 3270 terminal device driver. If you want to issue CP commands, use the PA1 key to switch to the CP READ mode.

Setting a CCW terminal device online or offline

The 3270 terminal device driver uses CCW devices and provides them as CCW terminal devices.

About this task

This section applies to Linux on z/VM. A CCW terminal device can be:

- The tty3270 terminal device that can be activated for receiving Linux kernel messages.

If this device exists, it comes online early during the Linux boot process. In a default z/VM environment, the device number for this device is 0009. In sysfs, it is represented as `/sys/bus/ccw/drivers/3270/0.0.0009`. You need not set this device online and you must not set it offline.

- CCW terminal devices through which users can log in to Linux with the CP DIAL command.

These devices are defined with the CP DEF GRAF command. They are represented in sysfs as `/sys/bus/ccw/drivers/3270/0.<n>.<devno>` where `<n>` is the subchannel set ID and `<devno>` is the virtual device number. By setting these devices online, you enable them for user logins. If you set a device offline, it can no longer be used for user login.

See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for more information about the DEF GRAF and DIAL commands.

Procedure

You can use the **chccwdev** command (see “[chccwdev - Set CCW device attributes](#)” on page 518) to set a CCW terminal device online or offline. Alternatively, you can write 1 to the device's online attribute to set it online, or 0 to set it offline.

Examples

- To set a CCW terminal device 0.0.7b01 online, issue:

```
# chccwdev -e 0.0.7b01
```

Alternatively issue:

```
# echo 1 > /sys/bus/ccw/drivers/3270/0.0.7b01/online
```

- To set a CCW terminal device 0.0.7b01 offline, issue:

```
# chccwdev -d 0.0.7b01
```

Alternatively issue:

```
# echo 0 > /sys/bus/ccw/drivers/3270/0.0.7b01/online
```

Entering control and special characters on line-mode terminals

Line-mode terminals do not have a control (Ctrl) key. Without a control key, you cannot enter control characters directly.

Also, pressing the Enter key adds a newline character to your input string. Some applications do not tolerate such trailing newline characters.

Table 6 on page 49 summarizes how you can use the caret character (^) to enter some control characters and to enter strings without appended newline characters.

Table 6. Control and special characters on line-mode terminals

For the key combination	Enter	Usage
Ctrl+C	^c	Cancel the process that is running in the foreground of the terminal.
Ctrl+D	^d	Generate an end of file (EOF) indication.
Ctrl+Z	^z	Stop a process.
n/a	^n	Suppresses the automatic generation of a new line. Thus, you can enter single characters; for example, the characters that are needed for yes/no answers in some utilities.

Note: For a 3215 line-mode terminal in 3215 mode, you must use United States code page (037).

Using the magic sysrequest feature

Whether magic sysrequest functions are available and how to call them depends on your terminal.

- To call the magic sysrequest functions on the VT220 terminal or on hvc0, enter the single character Ctrl +o followed by the character for the particular function.

You can call the magic sysrequest functions from the hvc0 terminal device if it is present and is activated to receive Linux kernel messages.

- To call the magic sysrequest functions on a line-mode terminal, enter the 2 characters "^-" (caret and hyphen) followed by a third character that specifies the particular function.

Table 7 on page 50 provides an overview of the commands for the magic sysrequest functions:

Table 7. Magic sysrequest functions

On line-mode terminals, enter	On hvc0 and the VT220 terminal, enter	To
^-b	<code>Ctrl+o</code> b	Re-IPL immediately (see “lsreipl - List IPL and re-IPL settings” on page 611).
^-c	<code>Ctrl+o</code> c	Crash through a forced kernel panic.
^-s	<code>Ctrl+o</code> s	Emergency sync all file systems.
^-u	<code>Ctrl+o</code> u	Emergency remount all mounted file systems read-only.
^-t	<code>Ctrl+o</code> t	Show task info.
^-m	<code>Ctrl+o</code> m	Show memory.
^- followed by a digit (0 - 9)	<code>Ctrl+o</code> followed by a digit (0 - 9)	Set the console log level.
^-e	<code>Ctrl+o</code> e	Send the TERM signal to end all tasks except init.
^-i	<code>Ctrl+o</code> i	Send the KILL signal to end all tasks except init.
^-p	<code>Ctrl+o</code> p	See “Obtaining details about the CPU-measurement facilities” on page 495.

Note: In Table 7 on page 50 `Ctrl+o` means pressing `o` while holding down the control key.

Table 7 on page 50 lists the main magic sysrequest functions that are known to work on Ubuntu Server 20.04.1. For a more comprehensive list of functions, see `/linux-doc/html/_sources/admin-guide/sysrq.rst.txt` in the `linux-doc` package. Some of the listed functions might not work on your system.

Activating and deactivating the magic sysrequest feature

Use the `sysrq` procfs attribute to activate or deactivate the magic sysrequest feature.

Procedure

Issue the following command to activate the magic sysrequest feature:

```
# echo 1 > /proc/sys/kernel/sysrq
```

Issue the following command to deactivate the magic sysrequest feature:

```
# echo 0 > /proc/sys/kernel/sysrq
```

Triggering magic sysrequest functions from procfs

You can trigger the magic sysrequest functions through procfs.

Procedure

Write the character for the particular function to `/proc/sysrq-trigger`.

You can use this interface even if the magic `sysrequest` feature is not activated as described in [“Activating and deactivating the magic `sysrequest` feature”](#) on page 50.

Example

To set the console log level to 9, enter:

```
# echo 9 > /proc/sysrq-trigger
```

Using a z/VM emulation of the HMC Operating System Messages applet

You can use the **Operating System Messages** applet emulation; for example, if the 3215 terminal is not operational.

About this task

The preferred terminal devices for Linux instances that run as z/VM guests are provided by the 3215 or 3270 terminal device drivers.

The emulation requires a terminal device that is provided by the SCLP line-mode terminal device driver. To use the emulation, you must override the default device driver for z/VM environments (see [“Console kernel parameter syntax”](#) on page 41).

For the emulation, you use the z/VM CP `VINPUT` command instead of the graphical user interface at the Support Element or HMC. Type any input to the operating system with a leading CP `VINPUT`.

The examples in the sections that follow show the input line of a 3270 terminal or terminal emulator (for example, `x3270`). Omit the leading `#CP` if you are in CP read mode. For more information about `VINPUT`, see *z/VM: CP Commands and Utilities Reference*, SC24-6268.

Priority and non-priority commands

VINPUT commands require a `VMSG` (non-priority) or `PVMSG` (priority) specification.

Operating systems that accept this specification, process priority commands with a higher priority than non-priority commands.

The hardware console driver can accept both if supported by the hardware console within the specific machine or virtual machine.

Linux does not distinguish between priority and non-priority commands.

Example

The specifications:

```
#CP VINPUT VMSG LS -L
```

and

```
#CP VINPUT PVMSG LS -L
```

are equivalent.

Case conversion

All lowercase characters are converted by z/VM to uppercase. To compensate for this effect, the console device driver converts all input to lowercase.

For example, if you type `VINPUT VMSG echo $PATH`, the device driver gets `ECHO $PATH` and converts it into `echo $path`.

Linux and bash are case-sensitive and require some specifications with uppercase characters. To include uppercase characters in a command, use the percent sign (%) as a delimiter. The console device driver interprets characters that are enclosed by percent signs as uppercase.

This behavior and the delimiter are adjustable at build-time by editing the driver sources.

Examples

In the following examples, the first line shows the user input. The second line shows what the device driver receives after the case conversion by CP. The third line shows the command that is processed by bash.

```
#cp vinput vmsg ls -l
CP VINPUT VMSG LS -L
ls -l
...
```

- The following input would result in a bash command that contains a variable `$path`, which is not defined in lowercase:

```
#cp vinput vmsg echo $PATH
CP VINPUT VMSG ECHO $PATH
echo $path
...
```

To obtain the correct bash command enclose the uppercase string with the conversion escape character:

```
#cp vinput vmsg echo $%PATH%
CP VINPUT VMSG ECHO $%PATH%
echo $PATH
...
```

Using the escape character

The quotation mark (") is the standard CP escape character. To include the escape character in a command that is passed to Linux, you must type it twice.

Example

The following command passes a string in double quotation marks to be echoed.

```
#cp vinput pvmsg echo ""here is ""$0
CP VINPUT PVMSG ECHO "HERE IS "$0
echo "here is "$0
here is -bash
```

In the example, `$0` resolves to the name of the current process.

Using the end-of-line character

To include the end-of-line character in the command that is passed to Linux, you must specify it with a leading escape character.

If you are using the standard settings according to [“Using a 3270 terminal in 3215 mode” on page 53](#), you must specify `#` to pass `#` to Linux.

If you specify the end-of-line character without a leading escape character, z/VM CP interprets it as an end-of-line character that ends the **VINPUT** command.

Example

In this example, a number sign is intended to mark the begin of a comment in the bash command. This character is misinterpreted as the beginning of a second command.

```
#cp vinput pvmsg echo ""%N%umber signs start bash comments"" #like this one
CP VINPUT PVMSG ECHO "%N%UMBER SIGNS START BASH COMMENTS"
LIKE THIS ONE
HPCPCMD001E Unknown CP command: LIKE
...
```

The escape character prevents the number sign from being interpreted as an end-of-line character:

```
#cp vinput pvmsg echo ""%N%umber signs start bash comments"" "#like this one
VINPUT PVMSG ECHO "%N%UMBER SIGNS START BASH COMMENTS" #LIKE THIS ONE
echo "Number signs start bash comments" #like this one
Number signs start bash comments
```

Simulating the Enter and Spacebar keys

You can use the **CP VINPUT** command to simulate the Enter and Spacebar keys.

Simulate the Enter key by entering a blank followed by `\n`:

```
#CP VINPUT VMSG \n
```

Simulate the Spacebar key by entering two blanks followed by `\n`:

```
#CP VINPUT VMSG  \n
```

Using a 3270 terminal in 3215 mode

The z/VM control program (CP) defines five characters as line-editing symbols. Use the **CP QUERY TERMINAL** command to see the current settings.

The default line-editing symbols depend on your terminal emulator. You can reassign the symbols by changing the settings of `LINEND`, `TABCHAR`, `CHARDEL`, `LINEDEL`, or `ESCAPE` with the **CP TERMINAL** command. [Table 8 on page 53](#) shows the most commonly used settings:

Table 8. Line edit characters

Character	Symbol	Usage
#	LINEND	The end of line character. With this character, you can enter several logical lines at once.
	TABCHAR	The logical tab character.
@	CHARDEL	The character delete symbol deletes the preceding character.
[or ¢	LINEDEL	The line delete symbol deletes everything back to and including the previous LINEND symbol or the start of the input. "[" is common for ASCII terminals and "¢" for EBCDIC terminals.
"	ESCAPE	The escape character. With this character, you can enter a line-edit symbol as a normal character.

To enter a line-edit symbol, you must precede it with the escape character. In particular, to enter the escape character you must type it twice.

Examples

The following examples assume the settings of [Table 8 on page 53](#) with the opening square bracket character ([]) as the "delete line" character.

- To specify a tab character specify:

```
" |
```

- To specify a double quotation mark character, specify:

```
" "
```

- If you type the character string:

```
#CP HALT#CP ZIPL 190[#CP IPL 1@290 PARM vmpo:ff="MSG OP REBOOT"#IPL 290"
```

the actual commands that are received by CP are:

```
CP HALT
CP IPL 290 PARM vmpo:ff="MSG OP REBOOT"#IPL 290"
```

Chapter 6. Initial program loader for IBM Z - zipl

Use **zipl** to prepare a boot device with a Linux program loader or to prepare a dump device.

Linux on Z as a KVM guest does not support dump devices with stand-alone dump tools. Instead of preparing a dump device with the zipl tool you can also use the kdump infrastructure. To use kdump, no preparation with **zipl** is necessary. For more information about the kdump infrastructure and the dump tools that **zipl** installs, see *Using the Dump Tools*, SC33-8412.

You can simulate a **zipl** command to test a configuration before you apply the command to an actual device (see *dry-run*).

zipl supports the following devices:

- Enhanced Count Key Data (ECKD) DASDs with fixed block Linux disk layout (LDL)
- ECKD DASDs with z/OS-compliant compatible disk layout (CDL)
- Fixed Block Access (FBA) DASDs
- Magnetic tape subsystems compatible with IBM3480, IBM3490, or IBM3590 (boot and dump devices only)
- SCSI with PC-BIOS disk layout

Usage

The **zipl** tool has base functions that can be called from the command line or in configuration-file mode. There are generic parameters and parameters that are specific to particular base functions.

zipl base functions

For each base function, there is a short and a long command-line option and, with one exception, a corresponding configuration-file option.

Table 9. zipl base functions

Base function	Command line short option	Command line long option	Configuration file option	Environment
Install a boot loader See “Preparing a boot device” on page 58 for details.	-i	--image	image=	LPAR z/VM KVM
Prepare a DASD, SCSI, or tape dump device See “Preparing a DASD, SCSI, or tape dump device” on page 65 for details.	-d	--dumpto	dumpto=	LPAR z/VM
Prepare a list of ECKD volumes for a multi-volume dump See “Preparing a multi-volume dump on ECKD DASD” on page 66 for details.	-M	--mvdump	mvdump=	LPAR z/VM

Table 9. *zipl* base functions (continued)

Base function	Command line short option	Command line long option	Configuration file option	Environment
Install a menu configuration See “Installing a menu configuration” on page 67 for details.	-m	--menu	(None)	LPAR z/VM KVM

zipl modes and syntax overview

zipl can operate in command-line mode or in configuration-file mode.

Command-line mode

To run **zipl** in command-line mode, specify one of the following base functions::

- i**
see [“Preparing a boot device”](#) on page 58
- d**
see [“Preparing a DASD, SCSI, or tape dump device”](#) on page 65
- M**
see [“Preparing a multi-volume dump on ECKD DASD”](#) on page 66

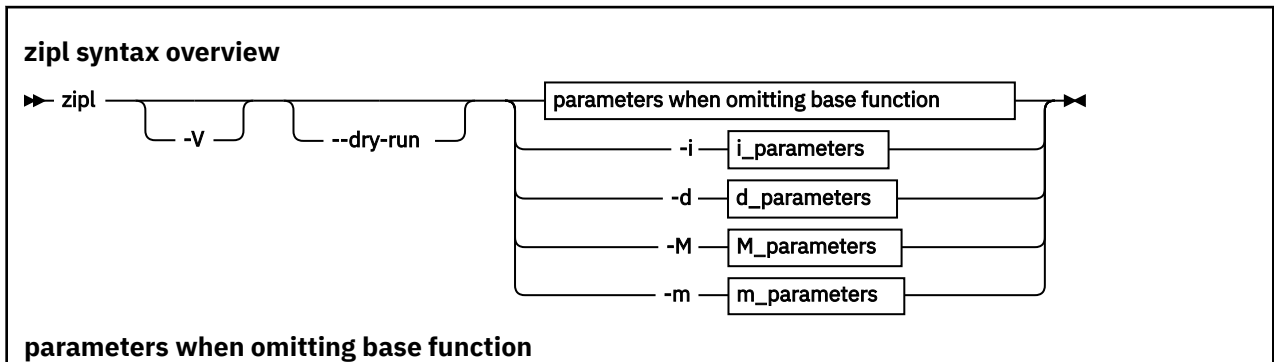
Configuration-file mode

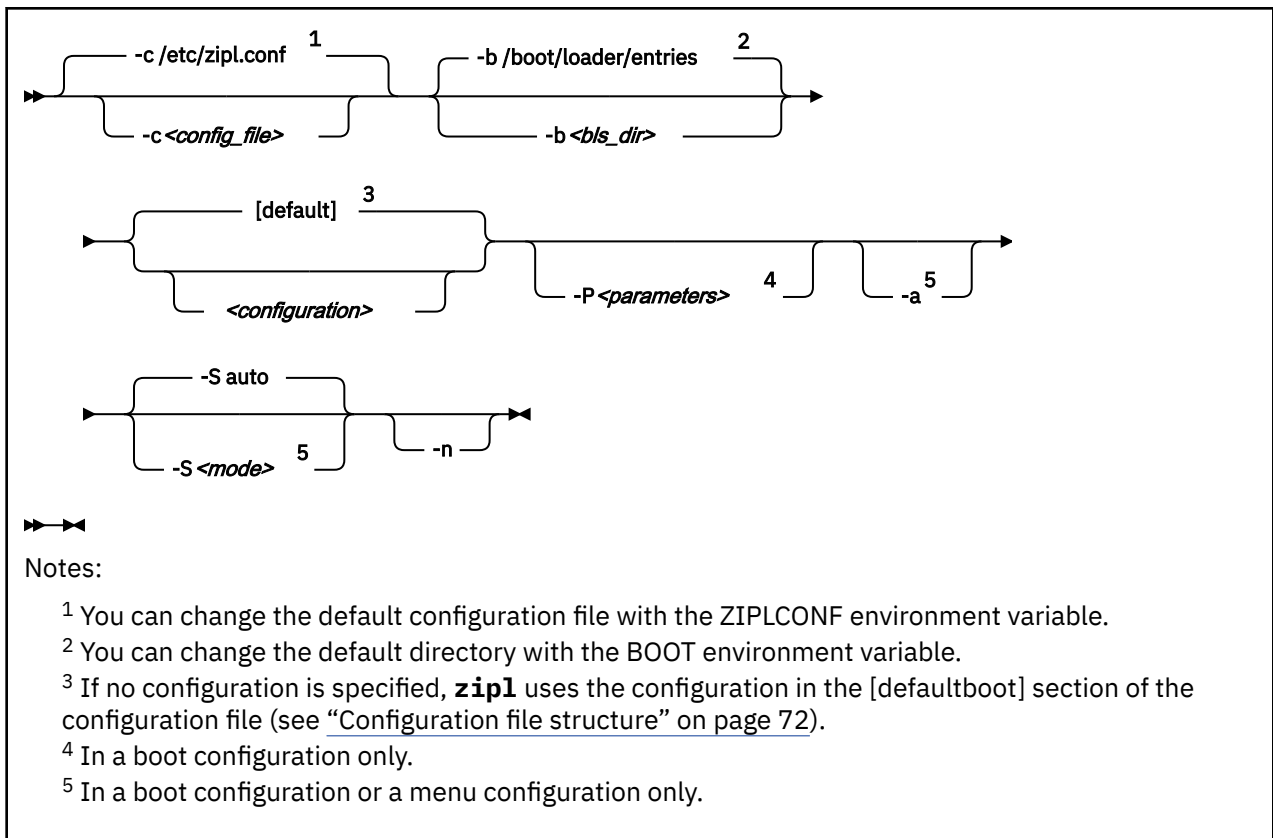
To run **zipl** in configuration-file mode, omit the base function or specify the **-m** base function (see [“Configuration file structure”](#) on page 72).

In this mode, **zipl** processes a **zipl** configuration file and, optionally, one or more Boot Loader Specification (BLS) snippets. BLS snippets are always processed as part of a menu configuration.

For more information about the **zipl** configuration file, see [“Configuration file structure”](#) on page 72.

For more information about BLS snippets, see [“BLS configuration snippets”](#) on page 77.





Where:

-c <config_file>

specifies the zipl configuration file to be used.

-b <bls_dir>

specifies a directory to be searched for files with BLS snippets.

<configuration>

identifies a particular IPL or menu configuration in a zipl configuration-file.

-P <parameters>

can optionally be used to provide kernel parameters in a boot configuration section. See [“How kernel parameters from different sources are combined”](#) on page 61 for information about how kernel parameters specified with the **-P** option are combined with any kernel parameters specified in the configuration file.

If you provide multiple parameters, separate them with a blank and enclose them within single quotation marks (') or double quotation marks (").

-a

in a boot configuration section, adds kernel image, kernel parameter file, and initial RAM disk to the bootmap file. Use this option when these files are spread across multiple disks to ensure that they are available at IPL time. Specifying this option significantly increases the size of the bootmap file that is created in the target directory.

-S <mode> or --secure <mode>

SCSI IPL disk device for LPAR only: Controls the format of the boot data that zipl writes to the IPL device. <mode> takes the following values:

auto

Uses the secure-boot enabled format if the zipl command is issued on a mainframe with secure-boot support. This is the default.

1

Enforces the secure-boot enabled format regardless of mainframe support. Use this option to prepare boot devices for systems other than the one you are working on. Disks with this format cannot be booted on machines z14 or earlier.

0

Enforces the traditional format, that does not support secure boot, regardless of mainframe support. Disks with this format can be booted on all machines but cannot be used for secure boot.

-n

suppresses confirmation prompts that require operator responses to allow unattended processing (for example, for processing DASD or tape dump configuration sections).

-v

provides verbose command output.

--dry-run

simulates a **zipl** command. Use this option to test a configuration without overwriting data on your device.

During simulation, **zipl** performs all command processing and issues error messages where appropriate. Data is temporarily written to the target directory and is cleared up when the command simulation is completed.

-v

displays version information.

-h

displays help information.

The basic functions and their parameters are described in detail in the following sections.

See “[Parameter overview](#)” on page 68 for a summary of the short and long command line options and their configuration file equivalents.

Examples

- To process the default configuration in the default configuration file (`/etc/zipl.conf`, unless specified otherwise with the environment variable `ZIPLCONF`) issue:

```
# zipl
```

- To process the default configuration in a configuration file `/etc/myxmp.conf` issue:

```
# zipl -c /etc/myxmp.conf
```

- To process a configuration [myconf] in the default configuration file issue:

```
# zipl myconf
```

- To process a configuration [myconf] in a configuration file `/etc/myxmp.conf` issue:

```
# zipl -c /etc/myxmp.conf myconf
```

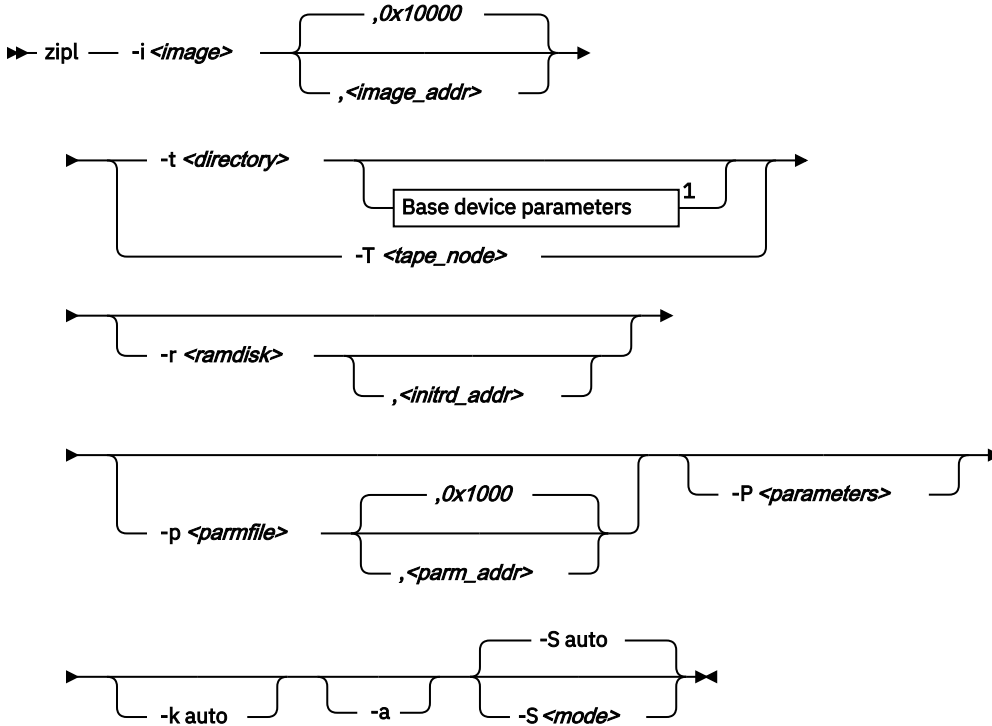
- To simulate processing a configuration [myconf] in a configuration file `/etc/myxmp.conf` issue:

```
# zipl --dry-run -c /etc/myxmp.conf myconf
```

Preparing a boot device

Use **zipl** with the **-i (--image)** command-line option or with the **image=** configuration-file option to prepare a boot device.

zipl command line syntax for preparing a boot device



Notes:

¹ Additional parameters that are used only if `-t` specifies a logical device as a target. See [“Using base device parameters”](#) on page 63.

To prepare a device as a boot device, you must specify:

The location **<image>**

of the Linux kernel image on the file system.

A target **<directory>** or **<tape_node>**

zipl installs the boot loader code on the device that contains the specified directory **<directory>** or to the specified tape device **<tape_node>**.

For KVM guests, the target device can be a virtual block device or a VFIO pass-through DASD. For details, see *KVM Virtual Server Management*, SC34-2752.

Optionally, you can also specify:

A kernel image address **<image_addr>**

to which the kernel image is loaded at IPL time. The default address is 0x10000.

The RAM disk location **<ramdisk>**

of an initial RAM disk image (initrd) on the file system.

A RAM disk image address **<initrd_addr>**

to which the RAM disk image is loaded at IPL time. If you do not specify this parameter, **zipl** investigates the location of other components and calculates a suitable address for you.

Kernel parameters

to be used at IPL time. If you provide multiple parameters, separate them with a blank and enclose them within single quotation marks (') or double quotation marks (").

You can specify parameters **<parameters>** directly on the command line. Instead or in addition, you can specify a location **<parmfile>** of a kernel parameter file on the file system. See [“How kernel parameters from different sources are combined”](#) on page 61 for a discussion of how **zipl** combines multiple kernel parameter specifications.

A parameter address *<parm_addr>*

to which the kernel parameters are loaded at IPL time. The default address is 0x1000.

An option **-k auto**

to install a kdump kernel that can be used as a stand-alone dump tool. You can IPL this kernel in an LPAR or guest virtual machine. With the IPL, you create a dump of a previously running operating system instance that was configured with a reserved memory area for kdump. For Linux, this memory area is reserved with the `crashkernel=` kernel parameter.

Note: For SCSI disks, the accumulated size of the kernel and ramdisk must not exceed 16 MB.

An option **-a**

to add the kernel image, kernel parameter file, and initial RAM disk to the bootmap file. Use this option when these files are spread across multiple disks to ensure that they are available at IPL time. This option is available on the command line only. Specifying this option significantly increases the size of the bootmap file that is created in the target directory.

An option **-S**

SCSI IPL device for LPAR only: Controls the zipl secure boot support. *<mode>* takes the following values:

auto

Uses the secure-boot enabled format if the zipl command is issued on a mainframe with secure-boot support. This is the default.

1

Enforces the secure-boot enabled format regardless of mainframe support. Use this option to prepare boot devices for systems other than the one you are working on. Disks with this format cannot be booted on machines z14 or earlier.

0

Enforces the traditional format, that does not support secure boot, regardless of mainframe support. Disks with this format can be booted on all machines but cannot be used for secure boot.

See “Parameter overview” on page 68 for a summary of the parameters. This summary includes the long options that you can use on the command line.

zipl configuration file syntax

Figure 18 on page 60 summarizes how to specify a boot configuration within a configuration file section. Required specifications are shown in bold. See “Configuration file structure” on page 72 for more details about the configuration file.

```
[<section_name>]
image=<image>, <image_addr>
ramdisk=<ramdisk>, <initrd_addr>
parmfile=<parmfile>, <parm_addr>
parameters=<parameters>
# Next line for devices other than tape only
target=<directory>
# Next line for tape devices only
tape=<tape_node>
# Next line for stand-alone kdump only
kdump=auto
# Next line for secure boot only
secure=<mode>
```

Figure 18. zipl syntax for preparing a boot device - configuration file mode

Example

The following command identifies the location of the kernel image as `/boot/mnt/image-2`, identifies the location of an initial RAM disk as `/boot/mnt/initrd`, specifies a kernel parameter file `/boot/mnt/parmfile-2`, and writes the required boot loader code to `/boot`. At IPL time, the initial RAM disk is to be

loaded to address 0x900000 rather than an address that is calculated by **zipl**. Kernel image, initial RAM disk, and the kernel parameter file are to be copied to the bootmap file on the target directory /boot rather than being referenced.

```
# zipl -i /boot/mnt/image-2 -r /boot/mnt/initrd,0x900000 -p /boot/mnt/parmf-2 -t /boot -a
```

An equivalent section in a configuration file might look like this example:

```
[boot2]
image=/boot/mnt/image-2
ramdisk=/boot/mnt/initrd,0x900000
paramfile=/boot/mnt/parmf-2
target=/boot
```

There is no configuration file equivalent for option **-a**. To use this option for a boot configuration in a configuration file, it must be specified with the **zipl** command that processes the configuration.

If the configuration file is called /etc/myxmp.conf:

```
# zipl -c /etc/myxmp.conf boot2 -a
```

How kernel parameters from different sources are combined

zipl allows for multiple sources of kernel parameters when preparing boot devices.

In command-line mode, you can use two possible sources of kernel parameters. The parameters are processed in the following order:

1. Parameters in the kernel parameter file (specified with the **-p** or **--parmf** option)
2. Parameters that are specified on the command line (specified with the **-P** or **--parameters** option)

In configuration file mode, the possible sources of kernel parameters depend on where the configuration is specified, in a **zipl** configuration-file section or in a BLS snippet. The parameters are processed in the following order:

For a **zipl** configuration-file section

1. Parameters in the kernel parameter file (specified with the **parmf**= option)
2. Parameters that are specified in the configuration section (specified with the **parameters**= option)
3. Parameters that are specified on the command line (specified with the **-P** or **--parameters** option)

For a BLS snippet

1. Parameters that are specified in the snippet (specified with the **options** option)
2. Parameters that are specified on the command line (specified with the **-P** or **--parameters** option)

Parameters from different sources are concatenated and passed to the kernel in one string. At IPL time, the combined kernel parameter string is loaded to address 0x1000, unless an alternate address is provided.

For more information about the different sources of kernel parameters, see [“Including kernel parameters in a boot configuration”](#) on page 23.

Preparing a logical device as a boot device

A *logical device* is a block device that represents one or more real devices.

If your boot directory is on a logical DASD or SCSI device, **zipl** cannot detect all required information about the underlying real device or devices and needs extra input.

Logical devices can be two DASDs combined into a logical mirror volume. Another examples are a linear mapping of a partition to a real device or a more complex mapping hierarchy. Logical devices are controlled by a device mapper.

Blocks on the logical device must map to blocks on the underlying real device or devices linearly. If two blocks on the logical device are adjacent, they must also be adjacent on the underlying real devices. This requirement excludes mappings such as *striping*.

You always boot from a real device. **zipl** must be able to write to that device, starting at block 0. In a logical device setup, starting at the top of the mapping hierarchy, the first block device that grants access to block 0 (and subsequent blocks) is the *base device*, see [Figure 19 on page 62](#).

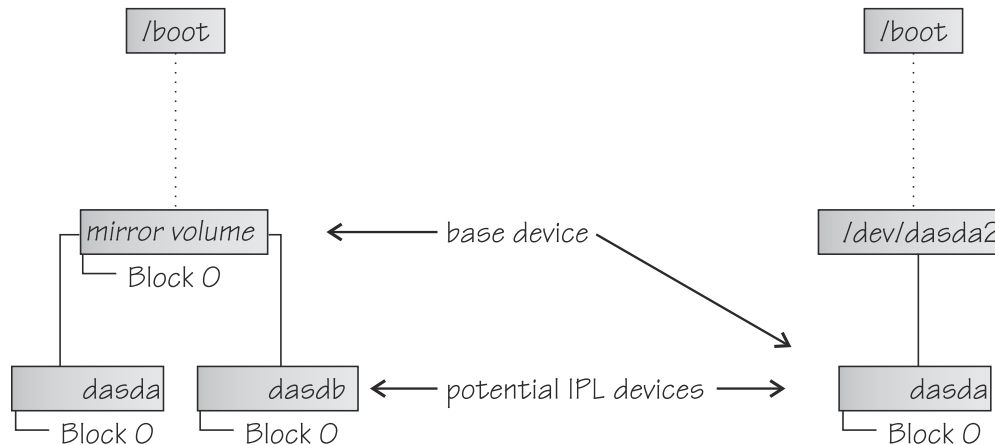


Figure 19. Definition of base device

A base device can have the following mappings:

- A mapping to a part of a real device that contains block 0
- A mapping to one complete real device
- A mapping to multiple real devices.

For a mapping to multiple real devices all the real devices must share the device characteristics and contain the same data (for example, a mirror setup). The mapping can also be to parts of the devices if these parts contain block 0. The mapping must not combine multiple devices into one large device.

The **zipl** command needs the device node of the base device and information about the physical characteristics of the underlying real devices. For most logical boot devices, a helper script automatically provides all the required information to **zipl** for you (see [“Using a helper script” on page 62](#)).

If you decide not to use the supplied helper script, or want to write your own helper script, you can use parameters to supply the base device information to **zipl**, see [“Using base device parameters” on page 63](#) and [“Writing your own helper script” on page 64](#).

Using a helper script

zipl provides a helper script, `zipl_helper.device-mapper`, that detects the required information and provides it to **zipl** for you.

The helper script is used automatically when you run **zipl** to prepare a boot device. Specify the parameters for the kernel image, parameter file, initial RAM disk, and target as usual. See [“Preparing a boot device” on page 58](#) for details about the parameters.

Assuming an example device for which the location of the kernel image is `/boot/image-5`, the location of an initial RAM disk as `/boot/initrd-5`, a kernel parameter file `/boot/parmf-5`, and which writes the required boot loader code to `/boot` and is a device mapper device, the command then becomes:

```
# zipl -i /boot/image-5 -r /boot/initrd-5 -p /boot/parmf-5 -t /boot
```

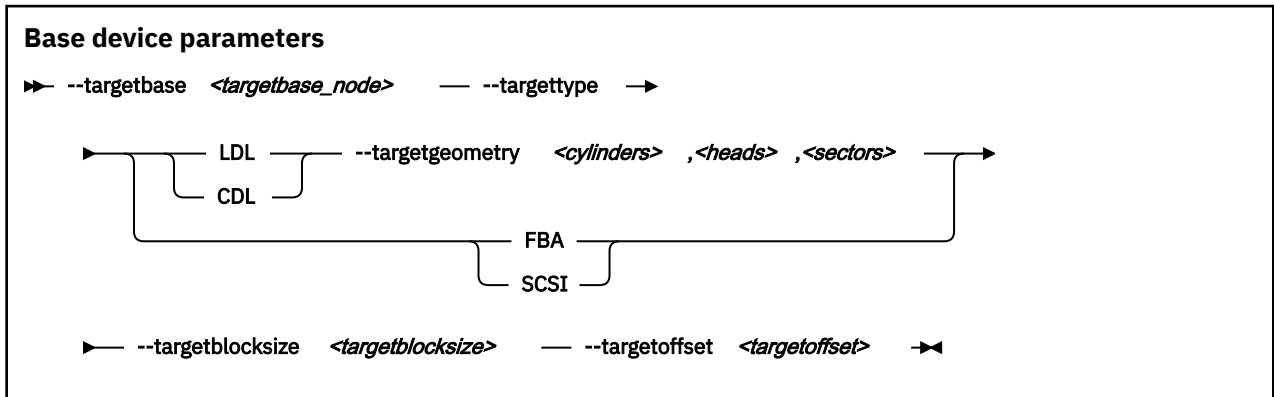
The corresponding configuration file section becomes:

```
[boot5]
image=/boot/image-5
ramdisk=/boot/initrd-5
paramfile=/boot/parmf-5
target=/boot
```

Using base device parameters

You can use parameters to supply the base device information to **zipl** directly.

The following command syntax for the base device parameters is used for logical boot devices. It extends the **zipl** syntax as shown in “Preparing a boot device” on page 58.



You must specify the following device information:

The device node `<targetbase_node>`

of the base device, either by using the standard device name or in form of the major and minor number, separated by a colon (:).

Example: The device node specification for the device might be `/dev/dm-0` and the equivalent specification as major and minor numbers might be `253:0`.

The device type

of the base device. The following specifications are valid:

LDL

for ECKD type DASD with the Linux disk layout.

CDL

for ECKD type DASD with the compatible disk layout.

FBA

for FBA type DASD.

SCSI

for FCP-attached SCSI disks.

LDL and CDL only: The disk geometry `<cylinders>`, `<heads>`, `<sectors>`

of the base device in cylinders, heads, and sectors.

The block size `<targetblocksize>`

in bytes per block of the base device.

The offset `<targetoffset>`

in blocks between the start of the physical device and the start of the topmost logical device in the mapping hierarchy.

Figure 20 on page 64 shows how to specify this information in a configuration file.

```

[<section_name>]
image=<image>, <image_addr>
ramdisk=<ramdisk>, <initrd_addr>
parmfile=<parmfile>, <parm_addr>
parameters=<parameters>
target=<directory>
targetbase=<targetbase_node>
targettype=LDL|CDL|FBA|SCSI
# Next line for target types LDL and CDL only
targetgeometry=<cylinders>, <heads>, <sectors>
targetblocksize=<targetblocksize>
targetoffset=<targetoffset>

```

Figure 20. *zipl* syntax for preparing a logical device as a boot device- configuration file mode

Example

The example command identifies the location of the kernel image as `/boot/image-5`, identifies the location of an initial RAM disk as `/boot/initrd-5`, specifies a kernel parameter file `/boot/parmf-5`, and writes the required boot loader code to `/boot`.

The command specifies the following information about the base device: the device node is `/dev/dm-3`, the device has the compatible disk layout, there are 6678 cylinders, there are 15 heads, there are 12 sectors, and the topmost logical device in the mapping hierarchy begins with an offset of 24 blocks from the start of the base device.

```

# zipl -i /boot/image-5 -r /boot/initrd-5 -p /boot/parmf-5 -t /boot --targetbase /dev/dm-3 \
# --targettype CDL --targetgeometry 6678,15,12 --targetblocksize=4096 --targetoffset 24

```

Note: Instead of using the continuation sign (`\`) at the end of the first line, you might want to specify the entire command on a single line.

An equivalent section in a configuration file might look like this example:

```

[boot5]
image=/boot/image-5
ramdisk=/boot/initrd-5
parmfile=/boot/parmf-5
target=/boot
targetbase=/dev/dm-3
targettype=CDL
targetgeometry=6678,15,12
targetblocksize=4096
targetoffset=24

```

Writing your own helper script

You can write your own helper script for device drivers that provide logical devices. The helper script must conform to a set of rules.

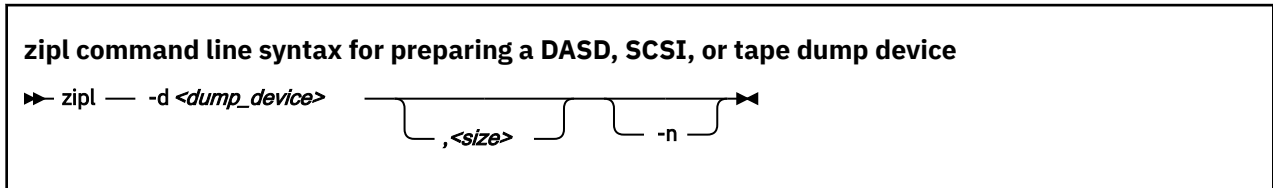
- The script must accept the name of the target directory as an argument. From this specification, it must determine a suitable base device. See [“Using base device parameters”](#) on page 63.
- The script must write the following base device `<parameter>=<value>` pairs to stdout as ASCII text. Each pair must be written on a separate line.
 - `targetbase=<targetbase_node>`
 - `targettype=<type>` where type can be LDL, CDL, FBA, or SCSI.
 - `targetgeometry=<cylinders>,<heads>,<sectors>` (For LDL and CDL only)
 - `targetblocksize=<blocksize>`
 - `targetoffset=<offset>`

See [“Using base device parameters”](#) on page 63 for the meaning of the base device parameters.

- The script must be named `zipl_helper.<device>` where `<device>` is the device name as specified in `/proc/devices`.
- The script must be in `/lib/s390-tools`.

Preparing a DASD, SCSI, or tape dump device

Use **zipl** with the `-d (--dump-to)` command-line option or with the `dump-to=` configuration-file option to prepare a DASD, SCSI, or tape dump device.



To prepare a DASD, SCSI, or tape dump device, you must specify:

The device node `<dump_device>`

of the DASD or SCSI partition, or tape device to be prepared as a dump device. **zipl** deletes all data on the partition or tape and installs the boot loader code there.

Note:

- If the dump device is an ECKD disk with fixed-block layout (LDL), a dump overwrites the dump utility. You must reinstall the dump utility before you can use the device for another dump.
- If the dump device is a tape, SCSI disk, FBA disk, or ECKD disk with the compatible disk layout (CDL), you do not need to reinstall the dump utility after every dump.

Optionally, you can also specify:

An option `-n`

to suppress confirmation prompts to allow unattended processing (for example, from a script). This option is available on the command line only.

A limit `<size>`

for the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary.

If you limit the dump size below the amount of memory that is used by the system to be dumped, the resulting dump is incomplete.

Note: For SCSI dump devices, the "size" option is not available.

DASD, SCSI, or tape dump devices are not formatted with a file system so no target directory can be specified. See *Using the Dump Tools*, SC33-8412 for details about processing these dumps.

See “Parameter overview” on page 68 for a summary of the parameters. The summary includes the long options that you can use on the command line.

Figure 21 on page 65 summarizes how to specify a DASD, SCSI, or tape dump configuration in a configuration file. See “Configuration file structure” on page 72 for a more comprehensive discussion of the configuration file.

```

[<section_name>]
dump-to=<dump_device>,<size>

```

Figure 21. *zipl* syntax for preparing a DASD, SCSI, or tape dump device - configuration file mode

-f or --force

to force that no signature checking takes place when dumping. Any data on all involved partitions is overwritten without warning.

-n

to suppress confirmation prompts to allow unattended processing (for example, from a script). This option is available on the command line only.

<size>

for the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary.

If you limit the dump size below the amount of memory that is used by the system to be dumped, the resulting dump is incomplete.

DASD or tape dump devices are not formatted with a file system so no target directory can be specified. See *Using the Dump Tools*, SC33-8412 for details about processing these dumps.

See “Parameter overview” on page 68 for a summary of the parameters. This summary includes the long options that you can use on the command line.

Figure 22 on page 67 summarizes how to specify a multi-volume DASD dump configuration in a configuration file. See “Configuration file structure” on page 72 for a more comprehensive discussion of the configuration file.

```
[<section_name>]
mvdump=<dump_device_list>,<size>
```

Figure 22. *zipl* syntax for preparing DASD devices for a multi-volume dump - configuration file mode

Example

The following command prepares two DASD partitions `/dev/dasdc1`, `/dev/dasdd1` for a multi-volume dump and suppresses confirmation prompts that require an operator response:

```
# zipl -M mvdump.conf -n
```

where the `mvdump.conf` file contains the two partitions, separated by line breaks:

```
/dev/dasdc1
/dev/dasdd1
```

An equivalent section in a configuration file might look like this example:

```
[multi_volume_dump]
mvdump=mvdump.conf
```

There is no configuration file equivalent for option `-n`. To use this option for a multi-volume DASD dump configuration in a configuration file, it must be specified with the **zipl** command that processes the configuration.

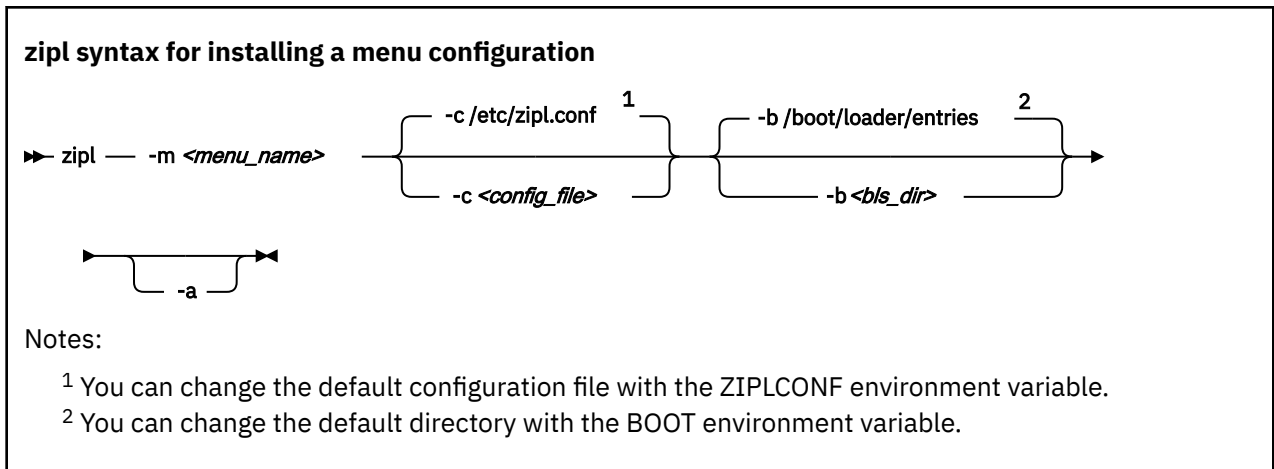
If the configuration file is called `/etc/myxmp.conf`:

```
# zipl -c /etc/myxmp.conf multi_volume_dump -n
```

Installing a menu configuration

Use **zipl** with the `-m (--menu)` command-line option to install a menu configuration.

To prepare a menu configuration, you need a configuration file that includes at least one menu section (see “Menu configurations” on page 74) or with a default section that supports an automatic menu (see “Default section” on page 73).



Where:

-m or --menu <menu_name>

specifies the menu that defines the menu configuration in the configuration file.

-c or --config <config_file>

specifies the configuration file where the menu configuration is defined. The default, `/etc/zipl.conf`, can be changed with the ZIPLCONF environment variable.

-b <bls_dir>

specifies a directory to be searched for files with BLS snippets.

-a or --add-files

adds the kernel image file, parmfile, and initial RAM disk image to the bootmap files in the respective target directories instead of referencing them. Use this option if the files are spread across disks to ensure that the files are available at IPL time. Specifying this option significantly increases the size of the bootmap file that is created in the target directory.

Example

Using the sample configuration file of Figure 23 on page 76, you could install a menu configuration with:

```
# zipl -m menu1
```

Parameter overview

You might need to know all **zipl** options and how to specify them on the command line, in the zipl configuration file, or in a BLS snippet..

Option	Explanation
Command line: -a --add-files	Causes kernel image, kernel parameter file, and initial RAM disk to be added to the bootmap file in the target directory rather than being referenced from this file. Use this option when these files are spread across multiple disks to ensure that they are available at IPL time. Specifying this option significantly increases the size of the bootmap file that is created in the target directory.

Option	Explanation
Command line: -b <bls_dir> --blsdir=<bls_dir>	Specifies the directory where zipl finds files with BLS snippets. You can change the default directory, /boot/loader/entries, with the BOOT environment variable. See “BLS configuration snippets” on page 77.
Command line: -c <config_file> --config=<config_file>	Specifies the configuration file. You can change the default configuration file /etc/zipl.conf with the environment variable ZIPLCONF.
Command line: <configuration>	Specifies a configuration section in a zipl configuration-file or a BLS snippet to be processed. A configuration section in a zipl configuration-file is specified through its section name. A BLS snippet is specified through the value of its title option within the snippet.
Command line: -d <dump_device>[,<size>] --dumpto=<dump_device>[,<size>] zipl configuration-file: dumpto=<dump_device>[,<size>]	Specifies the DASD partition, SCSI disk partition, or tape device to which a dump is to be written after IPL. The optional size specification limits the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary. If you limit the dump size below the amount of memory that is used by the system to be dumped, the resulting dump is incomplete. If no limit is provided, all of the available physical memory is dumped. See “Preparing a DASD, SCSI, or tape dump device” on page 65 and <i>Using the Dump Tools, SC33-8412</i> for details.
Command line: -h --help	Displays help information.
Command line: -i <image>[,<image_addr>] --image=<image>[,<image_addr>] zipl configuration-file: image=<image>[,<image_addr>]	Specifies the location of the Linux kernel image on the file system. In command-line mode or in a zipl configuration-file section you can optionally specify a memory location after IPL. The default memory address is 0x10000. See “Preparing a boot device” on page 58 for details.
BLS snippet: linux <image>	
Command line: -k auto --kdump=auto zipl configuration-file: kdump=auto	Installs a kdump kernel that can be used as a stand-alone dump tool. You can IPL this kernel in an LPAR or guest virtual machine to create a dump of a previously running operating system instance that has been configured with a reserved memory area for kdump. For Linux, this memory area is reserved with the crashkernel= kernel parameter. See “Preparing a boot device” on page 58 for details.

Option	Explanation
Command line: -m <menu_name> --menu=<menu_name>	Specifies the name of the menu that defines a menu configuration in the configuration file (see “Menu configurations” on page 74).
Command line: -M <dump_device_list>[,<size>] --mvdump=<dump_device_list>[,<size>] zipl configuration-file: mvdump=<dump_device_list>[,<size>]	Specifies a file with a list of DASD partitions to which a dump is to be written after IPL. The optional size specification limits the amount of memory to be dumped. The value is a decimal number that can optionally be suffixed with K for kilobytes, M for megabytes, or G for gigabytes. The value is rounded to the next megabyte boundary. If you limit the dump size below the amount of memory that is used by the system to be dumped, the resulting dump is incomplete. If no limit is provided, all of the available physical memory is dumped. See “Preparing a multi-volume dump on ECKD DASD” on page 66 and <i>Using the Dump Tools</i> , SC33-8412 for details.
Command line: -n --noninteractive	Suppresses all confirmation prompts (for example, when preparing a DASD or tape dump device).
n/a	
Command line: -p <parmfile>[,<parm_addr>] --parmfile=<parmfile>[,<parm_addr>] zipl configuration-file: parmfile=<parmfile>[,<parm_addr>]	In a boot configuration, specifies the location of a kernel parameter file. You can specify multiple sources of kernel parameters. For more information, see “How kernel parameters from different sources are combined” on page 61. The optional <parm_addr> specifies the memory address where the combined kernel parameter list is to be loaded at IPL time.
Command line: -P <parameters> --parameters=<parameters> zipl configuration-file: parameters=<parameters>	In a boot configuration, specifies kernel parameters. Individual parameters are single keywords or have the form key=value, without spaces. If you provide multiple parameters, separate them with a blank and enclose them within single quotation marks (') or double quotation marks ("). You can specify multiple sources of kernel parameters. For more information, see “How kernel parameters from different sources are combined” on page 61.
BLS snippet: options <parameters>	

Option	Explanation
<p>Command line:</p> <pre>-r <ramdisk>[,<initrd_addr>] --ramdisk=<ramdisk>[,<initrd_addr></pre> <p>zipl configuration-file:</p> <pre>ramdisk=<ramdisk>[,<initrd_addr></pre> <p>BLS snippet:</p> <pre>initrd <ramdisk></pre>	<p>Specifies the location of the initial RAM disk (initrd) on the file system.</p> <p>In command-line mode or in a zipl configuration-file section you can optionally specify a memory location after IPL.</p> <p>If you do not specify a memory address, zipl investigates the location of other components and calculates a suitable address for you.</p>
<pre>-S <mode> --secure=<mode></pre> <p>secure=auto 0 1</p>	<p>In an LPAR boot configuration, controls the format of the boot data that zipl writes to a SCSI IPL device. You can specify the following values for <i><mode></i>:</p> <p>auto Uses the secure-boot enabled format if the zipl command is issued on a mainframe with secure-boot support. This is the default.</p> <p>1 Enforces the secure-boot enabled format regardless of mainframe support. Use this option to prepare boot devices for systems other than the one you are working on. Disks with this format cannot be booted on machines z14 or earlier.</p> <p>0 Enforces the traditional format, that does not support secure boot, regardless of mainframe support. Disks with this format can be booted on all machines but cannot be used for secure boot.</p>
<p>Command line:</p> <pre>-t <directory> --target=<directory></pre> <p>zipl configuration-file:</p> <pre>target=<directory></pre>	<p>Specifies the target directory where zipl creates boot-relevant files. The boot loader is installed on the disk that contains the target directory.</p>
<p>Command line:</p> <pre>--targetbase=<targetbase_node></pre> <p>zipl configuration-file:</p> <pre>targetbase=<targetbase_node></pre>	<p>For logical boot devices, specifies the device node of the base device, either by using the standard device name or in form of the major and minor number, separated by a colon (:).</p> <p>See “Using base device parameters” on page 63 for details.</p>
<p>Command line:</p> <pre>--targetblocksize=<targetblocksize></pre> <p>zipl configuration-file:</p> <pre>targetblocksize=<targetblocksize></pre>	<p>For logical boot devices, specifies the bytes per block of the base device.</p> <p>See “Using base device parameters” on page 63 for details.</p>

Option	Explanation
Command line: -- targetgeometry=<cylin- ders>,<heads>,<sec- tors> zipl configuration-file: targetgeometry=<cylin- ders>,<heads>,<sec- tors>	For logical boot devices that map to ECKD type base devices, specifies the disk geometry of the base device in cylinders, heads, and sectors. See “Using base device parameters” on page 63 for details.
Command line: --targetoffset=<targetoffset> zipl configuration-file: targetoffset=<targetoffset>	For logical boot devices, specifies the offset in blocks between the start of the physical device and the start of the logical device. See “Using base device parameters” on page 63 for details.
Command line: --targettype=<type> zipl configuration-file: targettype=<type>	For logical boot devices, specifies the device type of the base device. See “Using base device parameters” on page 63 for details.
Command line: -T <tape_node> --tape=<tape_node> zipl configuration-file: tape=<tape_node>	Specifies the tape device where zipl installs the boot loader code.
Command line: -v --version	Prints version information.
Command line: -V --verbose	Provides more detailed command output.

If you call **zipl** in configuration file mode without specifying a configuration file, the default `/etc/zipl.conf` is used. You can change the default configuration file with the environment variable `ZIPLCONF`.

Configuration file structure

A zipl configuration file comprises a default section and one or more sections with IPL configurations. In addition, there can be sections that define menu configurations.

[defaultboot]

a default section that defines what is to be done if the configuration file is called without a section specification.

[<configuration>]

one or more sections that describe IPL configurations.

:<menu_name>

optionally, one or more menu sections that describe menu configurations.

A configuration file section consists of a section identifier and one or more option lines. Option lines are valid only as part of a section. Blank lines are permitted, and lines that begin with the number sign (#) are treated as comments and ignored. Option specifications consist of keyword=value pairs. There can but need not be blanks before and after the equal sign (=) of an option specification.

Default section

The default section consists of the section identifier, [defaultboot], followed by a single option line.

The option line specifies one of these mutually exclusive options:

default=<section_name>

where <section_name> is one of the IPL configurations described in the configuration file. If the configuration file is called without a section specification, an IPL device is prepared according to this IPL configuration.

If you specify a target parameter with this option, <section_name> is ignored and a menu with all DASD and SCSI IPL sections is built as for the defaultauto option.

defaultmenu=<menu_name>

where <menu_name> is the name of a menu configuration that is described in the configuration file. If the configuration file is called without a section specification, IPL devices are prepared according to this menu configuration. The defaultmenu option tolerates but does not require target parameters for the individual IPL sections.

defaultauto

If the configuration file is called without a section specification, a menu configuration is built. This configuration contains all DASD and SCSI IPL configurations in the configuration file. In the menu, these configurations appear in the order in which they appear in the configuration file.

The defaultauto option requires an additional option line with the target parameter. You can add further option lines with the default, prompt, and timeout parameters. These parameters have the same meaning as in “Menu configurations” on page 74.

The defaultauto option tolerates but does not require target parameters for the individual IPL sections. The resulting menu configuration is always written to the directory specified with the target parameter line within the default section.

As for configuration sections, extra parameters might be required for logical boot devices (see “Preparing a logical device as a boot device” on page 61).

Examples

- This default specification points to a boot configuration boot1 as the default.

```
[defaultboot]
default=boot1
```

- This default specification points to a menu configuration with a menu menu1 as the default.

```
[defaultboot]
defaultmenu=menu1
```

- This default specification creates a menu with all IPL sections in the configuration file. The first IPL configuration in the automatically created menu is the default.

```
[defaultboot]
defaultauto
target=/boot
default=1
```

IPL configurations

An IPL configuration has a section identifier that consists of a section name within square brackets and is followed by one or more option lines.

Each configuration includes one of the following mutually exclusive options that determine the type of IPL configuration:

image=<image>

Defines a boot configuration. See [“Preparing a boot device”](#) on page 58 for details.

dumppto=<dump_device>

Defines a DASD, SCSI, or tape dump configuration. For details, see [“Preparing a DASD, SCSI, or tape dump device”](#) on page 65.

mvdump=<dump_device_list>

Defines a multi-volume DASD dump configuration. See [“Preparing a multi-volume dump on ECKD DASD”](#) on page 66 for details.

KVM: For KVM guests, image= is the only supported option.

Additional parameters might be required for logical boot devices (see [“Preparing a logical device as a boot device”](#) on page 61).

Menu configurations

For DASD and SCSI devices, you can define a menu configuration. A menu configuration has a section identifier that consists of a menu name with a leading colon.

The identifier is followed by one or more lines with references to IPL configurations in the same zipl configuration-file or to BLS snippets. The menu configuration can also include one or more option lines.

target=<directory>

specifies a device where a boot loader is installed that handles multiple IPL configurations. For menu configurations, the target options of the referenced IPL configurations are ignored.

<i>=<configuration>

specifies a menu item. A menu includes one and more lines that specify the menu items.

<configuration> is the name of an IPL configuration that is described in the same configuration file. You can specify multiple boot configurations. For SCSI target devices, you can also specify one or more SCSI dump configurations. You cannot include DASD dump configurations as menu items.

<i> is the configuration number. The configuration number sequentially numbers the menu items, beginning with 1 for the first item. When initiating an IPL from a menu configuration, you can specify the configuration number of the menu item you want to use.

default=<n>

specifies the configuration number of one of the configurations in the menu to define it as the default configuration. If this option is omitted, the first configuration in the menu is the default configuration.

prompt=<flag>

for a DASD target device, determines whether the menu is displayed when an IPL is performed. Menus cannot be displayed for SCSI target devices.

For prompt=1 the menu is displayed, for prompt=0 it is suppressed. If this option is omitted, the menu is not displayed. Independent of this parameter, the operator can force a menu to be displayed by specifying "prompt" in place of a configuration number for an IPL configuration to be used.

If the menu of a menu configuration is not displayed, the operator can either specify the configuration number of an IPL configuration or the default configuration is used.

timeout=<seconds>

for a DASD target device and a displayed menu, specifies the time in seconds, after which the default configuration is IPLed, if no configuration has been specified by the operator. If this option is omitted or if 0 is specified as the timeout, the menu stays displayed indefinitely on the operator console and no IPL is performed until the operator specifies an IPL configuration.

secure=<mode>

In an LPAR boot configuration, controls the format of the boot data that zipl writes to a SCSI IPL device. You can specify the following values for <mode>:

auto

Uses the secure-boot enabled format if the zipl command is issued on a mainframe with secure-boot support. This is the default.

1

Enforces the secure-boot enabled format regardless of mainframe support. Use this option to prepare boot devices for systems other than the one you are working on. Disks with this format cannot be booted on machines z14 or earlier.

0

Enforces the traditional format, that does not support secure boot, regardless of mainframe support. Disks with this format can be booted on all machines but cannot be used for secure boot.

As for any configuration section, additional parameters might be required for logical boot devices (see [“Preparing a logical device as a boot device”](#) on page 61).

Example

Figure 23 on page 76 shows a sample configuration file that defines multiple configuration sections and two menu configurations.

```

[defaultboot]
defaultmenu=menu1

# First boot configuration (DASD)
[boot1]
ramdisk=/boot/initrd
parameters='root=/dev/ram0 ro'
image=/boot/image-1
target=/boot

# Second boot configuration (SCSI)
[boot2]
image=/boot/mnt/image-2
ramdisk=/boot/mnt/initrd,0x900000
parmfile=/boot/mnt/parmf-2
target=/boot

# Third boot configuration (DASD)
[boot3]
image=/boot/mnt/image-3
ramdisk=/boot/mnt/initrd
parmfile=/boot/mnt/parmf-3
target=/boot

# Configuration for dumping to tape
[dumptape]
dumpto=/dev/rtibm0

# Configuration for dumping to DASD
[dumpdasd]
dumpto=/dev/dasdc1

# Configuration for multi-volume dumping to DASD
[multi_volume_dump]
mvdump=sample_dump_conf

# Configuration for dumping to SCSI disk
[dumpscsi]
dumpto=/dev/mapper/36005076303ffd40100000000000020c0-part1

# Menu containing the SCSI boot and SCSI dump configurations
:menu1
1=dumpscsi
2=boot2
target=/boot
default=2

# Menu containing two DASD boot configurations
:menu2
1=boot1
2=boot3
target=/boot
default=1
prompt=1
timeout=30

```

Figure 23. Sample `/etc/zipl.conf` file

The following commands assume that the configuration file of the sample is the default configuration file.

- Call **zipl** to use the default configuration file settings:

```
# zipl
```

Result: **zipl** reads the default option from the `[defaultboot]` section and selects the `:menu1` section. It then installs a menu configuration with a boot configuration and a SCSI dump configuration.

- Call **zipl** to install a menu configuration (see also [“Installing a menu configuration”](#) on page 67):

```
# zipl -m menu2
```

Result: zipl selects the `:menu2` section. It then installs a menu configuration with two DASD boot configurations. “[Example for a DASD menu configuration on z/VM](#)” on page 91 and “[Example for a DASD menu configuration \(LPAR\)](#)” on page 84 illustrate what this menu looks like when it is displayed.

- Call **zipl** to install a boot loader for boot configuration `[boot2]`:

```
# zipl boot2
```

Result: zipl selects the `[boot2]` section. It then installs a boot loader that loads copies of `/boot/mnt/image-2`, `/boot/mnt/initrd`, and `/boot/mnt/parmf-2`.

- Call **zipl** to prepare a tape that can be IPLed for a tape dump:

```
# zipl dumptape
```

Result: zipl selects the `[dumptape]` section and prepares a dump tape on `/dev/rtibm0`.

- Call **zipl** to prepare a DASD dump device:

```
# zipl dumpdasd -n
```

Result: zipl selects the `[dumpdasd]` section and prepares the dump device `/dev/dasdc1`. Confirmation prompts that require an operator response are suppressed.

- Call **zipl** to prepare a SCSI dump device:

```
# zipl dumpscsi
```

Result: zipl selects the `[dumpscsi]` section and prepares the dump device. The associated dump is created in the dump partition `/dev/mapper/36005076303ffd40100000000000020c0-part1`.

BLS configuration snippets

Using Boot Loader Specification (BLS) snippets, you can add boot configurations to `zipl` without editing existing configuration files.

BLS snippets are provided as configuration files in a directory that is shared across all installed operating system instances. You add a boot configuration to `zipl` by adding a file with a BLS snippet to this directory, `/boot/loader/entries` by default.

Files that contain BLS snippets can have any name, but must have the file extension `.conf`. To avoid naming conflicts and to provide a hint about the content, a common naming convention includes the value of `/etc/machine-id`, the kernel version, and an operating system identifier in the name. For example, one such file might be `/boot/loader/entries/22be12d5d204461a9da34f3c3fd30ff9-5.5.0-10.s390.conf`.

Depending on your distribution, the Linux installation process might create a file with a BLS snippet for you.

BLS options

Table 10 on page 78 shows the subset of BLS options that are relevant to Linux on Z.

Table 10. BLS parameters and zipl equivalents

Option	Description	zipl configuration file equivalent
title	A meaningful identifier for the IPL configuration. BLS configuration file title specifications together with their zipl configuration file equivalents must be unique within the scope of a zipl command call. The title must be the first specification within a BLS configuration file.	Section name as specified within square brackets ([])
version	Specifies a version in human readable format. For example, use the output of the uname -r command. The processing order of BLS snippets is based on an alphanumeric assessment of the values of this parameter. The intention is to make the latest operating system version the default. This item is optional.	none
linux	Path to a Linux kernel.	image=
initrd	Path to an initial RAM disk. This item is optional.	ramdisk=
options	Kernel parameters. This item is optional.	parameters=

Snippet syntax

Lines start with an option keyword, followed by a blank, followed by a value. The first line must specify the **title** option. The configuration file can include empty lines and comment lines. Comment lines start with a number sign (#).

BLS snippet example

```
title linux 5.4 test kernel
#This is a comment line and is ignored
version 5.4.0-10-test
linux /boot/22be12d5d204461a9da34f3c3fd30ff9/kernels/linux-5.4.0-10
initrd /boot/22be12d5d204461a9da34f3c3fd30ff9/initrds/ramfs-5.4.0-10.im
options dasd=0.0.a01b root=/dev/dasda cio_ignore=all,!condev
```

Complementing BLS snippets through a zipl configuration file

You must use a zipl configuration file to complement the specifications in a BLS snippet with the **target=** parameter. Use the default section of the zipl configuration file to set **target=**.

Depending on your distribution, zipl might be installed with a default configuration file at **/etc/zipl.conf**, with a content similar to the following example:

```
[defaultboot]
defaultauto
prompt=1
timeout=5
target=/boot
secure=auto
```

Optionally, you can specify the **secure=** option.

Chapter 7. Booting Linux

The options and requirements you have for booting Linux depend on your platform, LPAR, z/VM, or KVM, and on your boot medium.

For details about setting up a z/VM guest virtual machine for Linux, see *z/VM: Getting Started with Linux on System z*[®], SC24-6287, the chapter about creating your first z/VM guest virtual machine for Linux and installing Linux.

For details about setting up a KVM virtual server, see *KVM Virtual Server Management*, SC34-2752.

IPL and booting

On IBM Z, you usually start booting Linux by performing an Initial Program Load (IPL) from an IPL device.

A traditional IPL device contains all data that is required to start a Z operating system or a stand-alone program. For Linux this includes a kernel image, possibly an initial RAM disk and kernel parameters, and a boot loader.

For SCSI IPL devices and generally for IPL of a KVM guest, the boot loader code is supplied by the hypervisor and not required on the IPL device.

Figure 24 on page 79 summarizes the main steps of the boot process for a traditional IPL device.

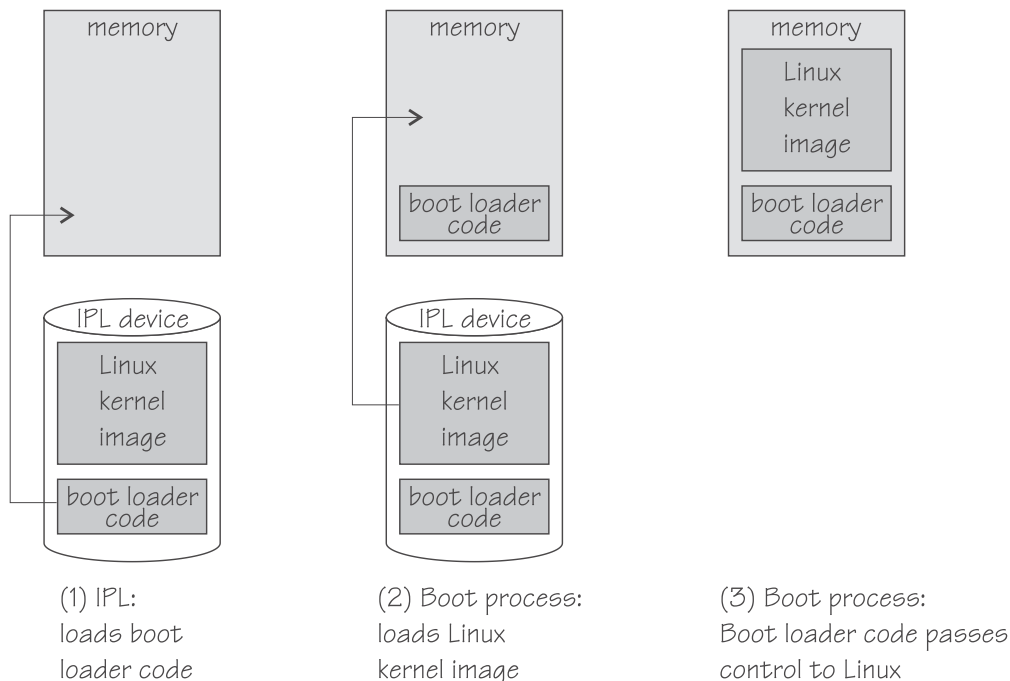


Figure 24. IPL and boot process

The IPL process accesses the IPL device and loads the Linux boot loader code to the mainframe memory. The boot loader code then gets control and loads the Linux kernel. At the end of the boot process Linux gets control.

LPAR

If your Linux instance is to run in an LPAR, you can circumvent the IPL and use the Support Element (SE) to copy the Linux kernel to the mainframe memory (see [“Loading Linux from removable media or from an FTP server”](#) on page 87).

You can use secure boot if you IPL from a SCSI device. For more information, see [“Secure boot” on page 87](#).

KVM

For Linux on Z as a KVM guest, an IPL is initiated by starting a virtual server on the KVM hypervisor.

The hypervisor first assigns resources to the virtual hardware, then it loads `s390-ccw.img` into the memory of the new virtual hardware. For KVM guests, `s390-ccw.img` takes the role of the boot loader. If needed, `s390-ccw.img` loads `s390-netboot.img` to retrieve boot data over the network.

LPAR and z/VM

An IPL can also start a dump process. See *Using the Dump Tools*, SC33-8412 for more information about dumps. You can find the latest version of this document on IBM Knowledge Center at: ibm.com/docs/en/linux-on-systems?topic=tools-upstream-kernel.

Use the **zipl** tool to prepare DASD, SCSI, and tape devices as IPL devices for booting Linux or for dumping. For more information about **zipl**, see [Chapter 6, “Initial program loader for IBM Z - zipl,” on page 55](#).

Control point and boot medium

The control point from where you can start the IPL depends on your hypervisor environment.

LPAR

For Linux in LPAR mode, the control point is the mainframe's Support Element (SE) or an attached Hardware Management Console (HMC).

z/VM

For Linux on z/VM, the control point is the control program (CP) of the hosting z/VM system.

KVM

For Linux on KVM, the control point is the KVM host.

The media that can be used as boot devices also depends on the hypervisor. [Table 11 on page 80](#) provides an overview of the possibilities:

Medium	LPAR	z/VM guest	KVM guest
DASD	✓	✓	✓
tape	✓	✓	
SCSI	✓	✓	
CD-ROM/DVD/FTP	✓		
z/VM reader		✓	
virtio block device			✓
virtio SCSI device			✓

In the table:

- A SCSI device can be an FC-attached disk device, or an FC-attached CD-ROM or DVD drive.
- CD-ROM/DVD/FTP can be the CD-ROM or DVD drive of the SE or HMC, or it can be a remote FTP server.
- A virtio block device can be backed by an ISO image in the KVM host file system or by any IPL device that was prepared with **zipl**.

Typically, booting from removable media applies to initial installation of Linux. Booting from DASD or SCSI disk devices usually applies to previously installed Linux instances.

Menu configurations

If you use **zipl** to prepare a DASD or SCSI boot device, you can define a menu configuration.

A boot device with a menu configuration can hold the code for multiple boot configurations. For SCSI devices, the menu can also include one or more SCSI system dumpers.

Each boot and dump configuration in a menu is associated with a configuration number. At IPL time, you can specify a configuration number to select the configuration to be used.

For menu configurations on DASD, you can display a menu with the configuration numbers (see “[Example for a DASD menu configuration on z/VM](#)” on page 91 and “[Example for a DASD menu configuration \(LPAR\)](#)” on page 84). For menu configurations on SCSI devices, you need to know the configuration numbers without being able to display the menus.

See “[Menu configurations](#)” on page 74 for information about defining menu configurations.

Boot data

To boot Linux, you generally need a kernel image, boot loader code, kernel parameters, and an initial RAM disk image.

For sequential I/O boot devices, z/VM reader and tape, the order in which this data is provided is significant. For random access devices, there is no required order.

On Ubuntu Server 20.04.1, kernel images are installed into the `/boot` directory and are named `vmlinuz-<version>`, where `<version>` is the same as the output of the `uname -r` command. For information about where to find the images and how to start an installation, see the *Ubuntu Installation Guide* at

<https://help.ubuntu.com/18.04/installation-guide/s390x>

Boot loader code

A kernel image is usually compiled to contain boot loader code for a particular boot device.

For example, there are Linux configuration menu options to compile boot loader code for tape or for the z/VM reader into the kernel image.

If your kernel image does not include any boot loader code or if you want to boot a kernel image from a device that does not correspond to the included boot loader code, you can provide alternate boot loader code separate from the kernel image.

You can use **zipl** to prepare boot devices with separate DASD, SCSI, or tape boot loader code. You can then boot from DASD, SCSI, or tape regardless of the boot loader code in the kernel image.

Kernel parameters

The kernel parameters are in form of an ASCII text string. If the boot device is tape or the z/VM reader, the string can also be encoded in EBCDIC.

Individual kernel parameters are single keywords or keyword/value pairs of the form `keyword=<value>` with no blank. Blanks are used to separate consecutive parameters.

If you use the **zipl** command to prepare your boot device, you can provide kernel parameters on the command line, in a parameter file, and in a **zipl** configuration file.

See [Chapter 4, “Kernel and module parameters,”](#) on page 23, [Chapter 6, “Initial program loader for IBM Z - zipl,”](#) on page 55, or the **zipl** and `zipl.conf` man pages for more details.

Initial RAM disk image

An initial RAM disk holds files, programs, or modules that are not included in the kernel image but are required for booting.

For example, booting from DASD requires the DASD device driver. If you want to boot from DASD but the DASD device driver has not been compiled into your kernel, you must provide the DASD device driver module on an initial RAM disk. If your image contains all files, programs, and modules that are needed for booting, you do not need an initial RAM disk.

Ubuntu Server provides a RAM disk in `/boot`, named `initrd.img-<version>`, where `<version>` is the same as the output of the `uname -r` command.

Rebuilding the initial RAM disk image

Configuration changes might apply to components that are required in the boot process before the root file system is mounted. For Ubuntu Server 20.04.1, such components and their configuration are provided through an initial RAM disk.

Procedure

Issue `update-initramfs -u` to update the initial RAM disk of your target kernel.

The command also updates the bootloader record.

Tip: Use the `-k all` option to ensure that all kernel and `initrd` combinations on the system are updated.

Booting Linux in LPAR mode

You can boot Linux in LPAR mode from a Hardware Management Console (HMC) or Support Element (SE).

About this task

The following description refers to an HMC, but the same steps also apply to an SE.

Booting from DASD

Use the SE or HMC to boot Linux in LPAR mode from a DASD boot device.

Before you begin

You need a boot device that is prepared with `zipl` (see [“Preparing a boot device”](#) on page 58).

Procedure

Perform these steps to boot from a DASD boot device:

1. In the navigation pane of the HMC, expand **Systems Management** and select the hardware system that you want to work with. A table of LPARs is displayed on the **Partitions** tab in the content area.
2. Select the LPAR where you want to boot Linux.
3. In the **Tasks** area, expand **Recovery** and click **Load** (see [Figure 25](#) on page 83).

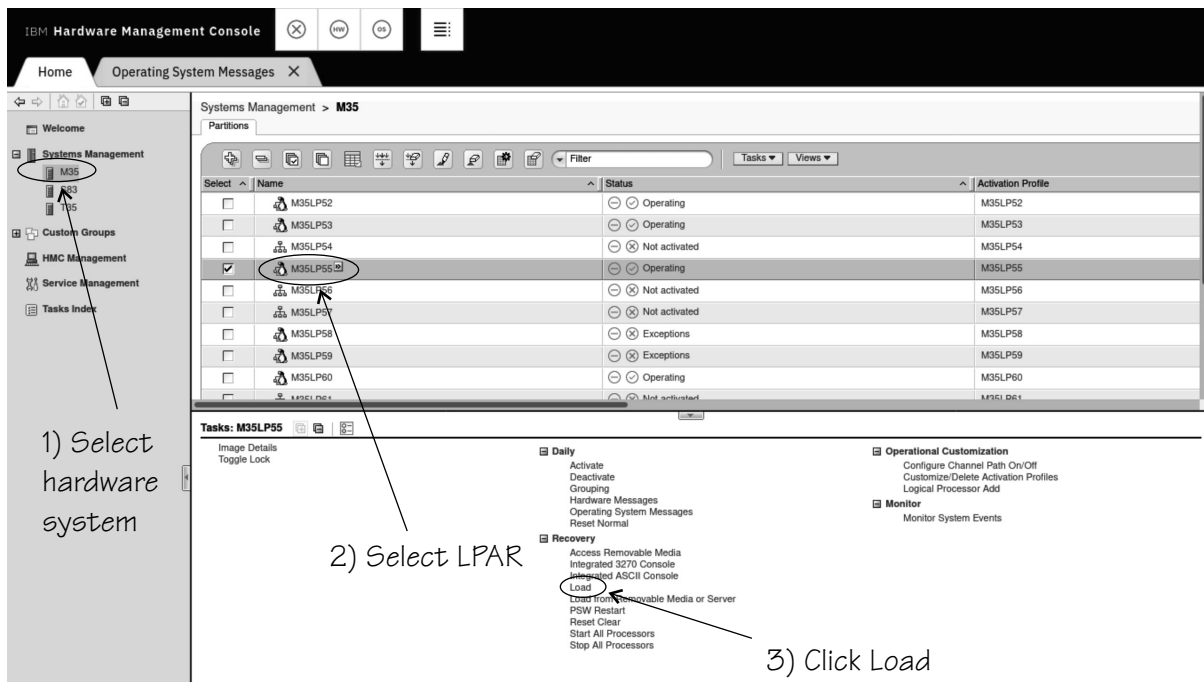


Figure 25. Load task on the HMC

4. Select load type **Standard load** as shown in Figure 26 on page 83.

Select the **Clear the main memory on this partition before loading it** check box only if you must clear memory. Memory clearing can considerably prolong the IPL procedure.

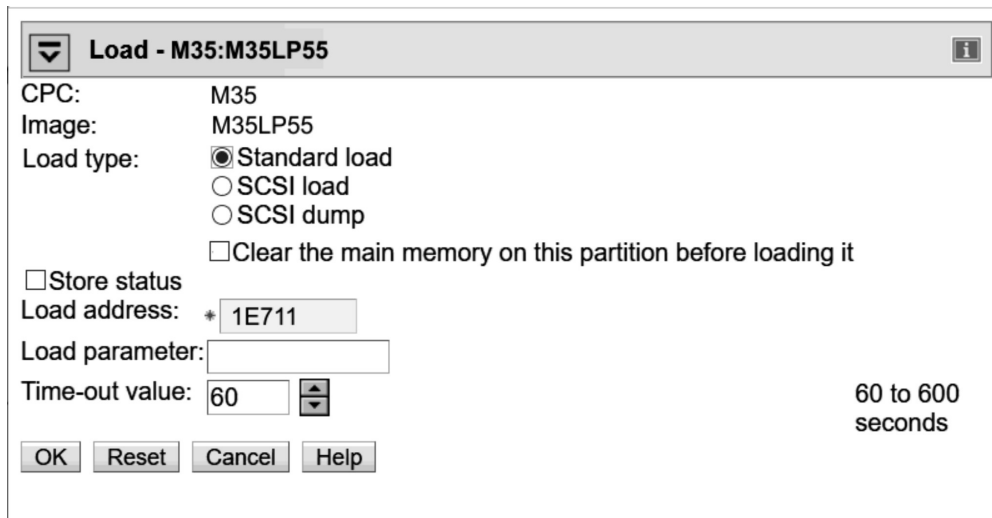


Figure 26. Load panel for booting from DASD

5. Enter the device number of the DASD boot device in the **Load address** field.

To IPL from a subchannel set other than 0, specify five digits: The subchannel set ID followed by the device number, for example 1E711.

6. If the boot configuration is part of a **zipl** created menu configuration, type the configuration number that identifies your DASD boot configuration within the menu in the **Load parameter** field.

Configuration number 0 specifies the default configuration. Depending on the menu configuration, omitting this option might display the menu or select the default configuration. Specifying "prompt" instead of a configuration number forces the menu to be displayed.

When the menu is displayed, you can specify additional kernel parameters (see "Example for a DASD menu configuration (LPAR)" on page 84). These additional kernel parameters are appended to the

parameters you might have provided in a parameter file. The combined parameter string must not exceed 895 bytes.

See “[Menu configurations](#)” on page 74 for more details about menu configurations.

7. If the boot configuration is part of a **zipl** created menu configuration, type the configuration number that identifies your DASD boot configuration within the menu in the **Load parameter** field.
8. Click **OK** to start the boot process.

Example for a DASD menu configuration (LPAR)

This example illustrates how menu2 in the sample configuration file in [Figure 23 on page 76](#) is displayed on the HMC or SE:

```
zIPL interactive boot menu
0. default (boot1)
1. boot1
2. boot3

Please choose (default will boot in 30 seconds): 2
```

You choose a configuration by specifying the configuration number. For example, to boot configuration boot3 specify 2.

You can also specify additional kernel parameters by appending them to the configuration number. For example, you can specify:

```
2 maxcpus=1
```

These parameters are concatenated to the end of the existing kernel parameters that are used by your boot configuration when booting Linux.

What to do next

Check the output on the preferred console (see “[Console kernel parameter syntax](#)” on page 41) to monitor the boot progress.

Booting from SCSI

Use the SE or HMC to boot Linux in LPAR from a SCSI boot device.

Before you begin

- You need a boot device that is prepared with **zipl** (see “[Preparing a boot device](#)” on page 58).
- You must have the SCSI IPL feature (FC9904) installed.

Procedure

Perform these steps to boot from a SCSI boot device:

1. In the navigation pane of the HMC, expand **Systems Management** and select the hardware system that you want to work with. A table of LPARs is displayed on the **Partitions** tab in the content area.
2. Select the LPAR where you want to boot Linux.
3. In the **Tasks** area, expand **Recovery** and click **Load** as shown in [Figure 27 on page 85](#).

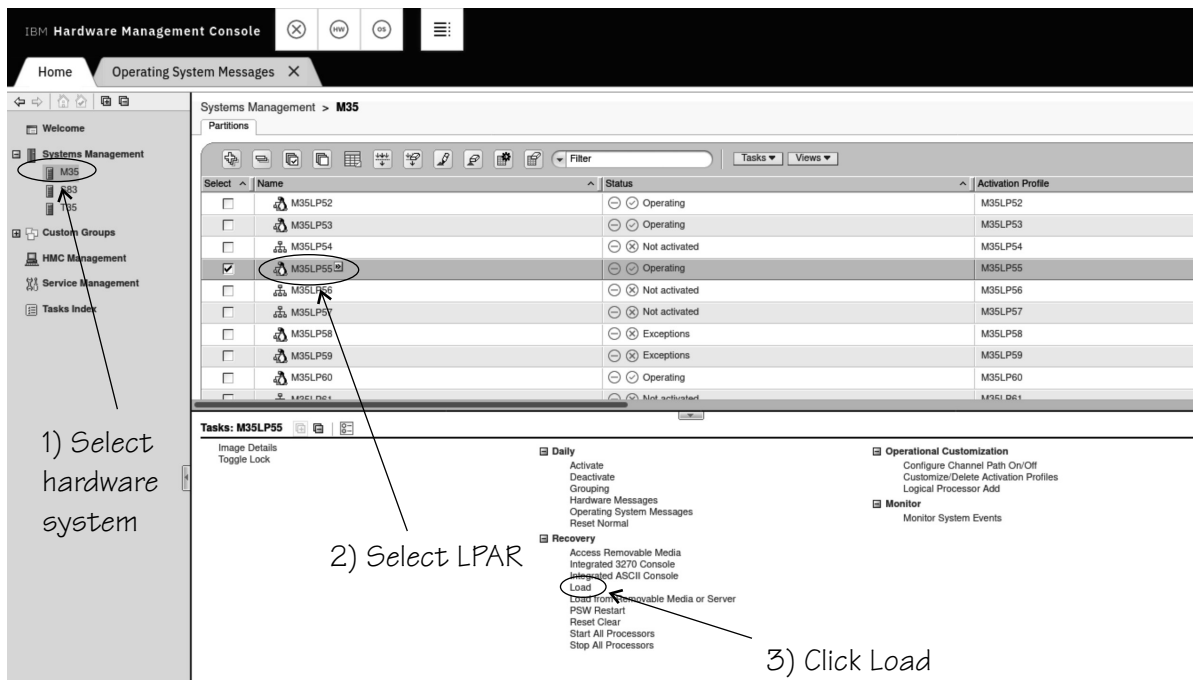


Figure 27. Load task on the HMC

4. Select load type **SCSI load** as shown in Figure 28 on page 85.
A SCSI device can be a disk or an FC-attached CD-ROM or DVD drive.

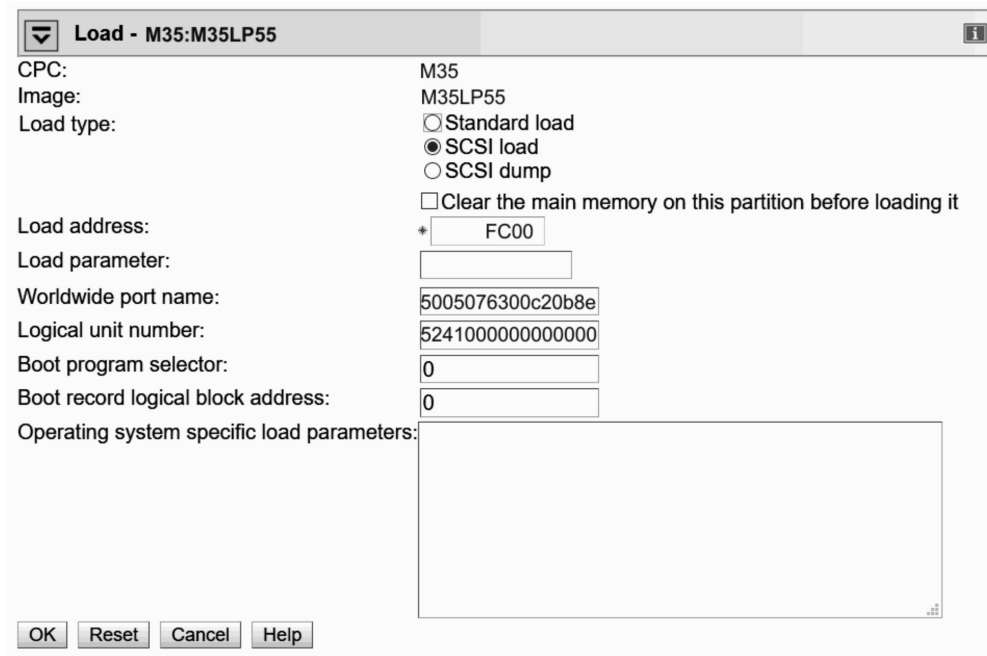


Figure 28. Load panel with SCSI feature enabled – for booting from a SCSI disk

Select the **Clear the main memory on this partition before loading it** check box only if you must clear memory. Memory clearing can considerably prolong the IPL procedure.

5. Enter the device number of the FCP channel through which the SCSI disk is accessed in the **Load address** field.
6. Enter the WWPN of the SCSI disk in the **World wide port name** field.
7. Enter the LUN of the SCSI disk in the **Logical unit number** field.
8. If the boot configuration is part of a **zipl** created menu configuration, type the configuration number that identifies your SCSI boot configuration within the menu in the **Boot program selector** field.

Configuration number 0 specifies the default configuration.

See “Menu configurations” on page 74 for more details about menu configurations.

9. Type kernel parameters in the **Operating system specific load parameters** field.

These parameters are concatenated to the end of the existing kernel parameters that are used by your boot configuration when booting Linux.

Use ASCII characters only. If you enter characters other than ASCII characters, the boot process ignores the data in the **Operating system specific load parameters** field.

10. Accept the defaults for the remaining fields.

11. Click **OK** to start the boot process.

What to do next

Check the output on the preferred console (see “Console kernel parameter syntax” on page 41) to monitor the boot progress.

Booting from tape

You can boot Linux in LPAR mode from tape.

Before you begin

You need a boot device that is prepared with **zip1** (see “Preparing a boot device” on page 58).

Procedure

Perform these steps to boot from a tape boot device:

1. In the navigation pane of the HMC, expand **Systems Management** and select the hardware system that you want to work with. A table of LPARs is displayed on the **Partitions** tab in the content area.
2. Select the LPAR where you want to boot Linux.
3. In the **Tasks** area, expand **Recovery** and click **Load** as shown in Figure 29 on page 86.

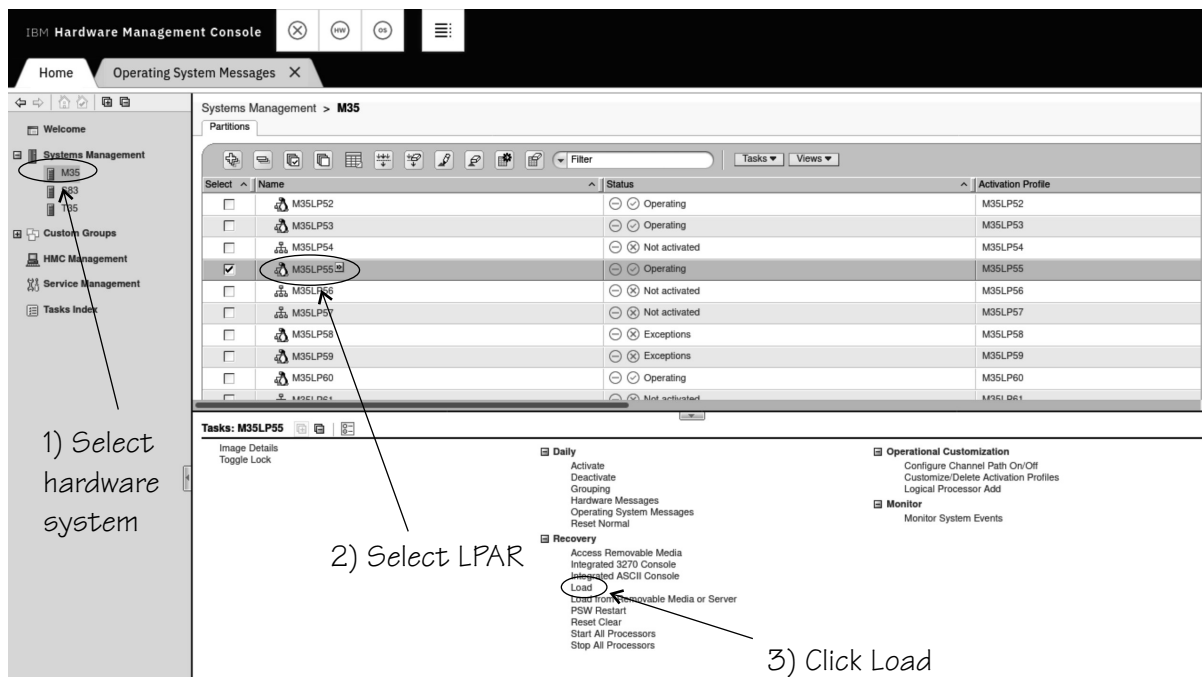


Figure 29. Load task on the HMC

4. Select the load type **Standard load** (see Figure 26 on page 83).

Select the **Clear the main memory on this partition before loading it** check box only if you must clear memory. Memory clearing can considerably prolong the IPL procedure.

5. Enter the device number of the tape boot device in the **Load address** field.
6. Click **OK** to start the boot process.

What to do next

Check the output on the preferred console (see [“Console kernel parameter syntax”](#) on page 41) to monitor the boot progress.

Secure boot

As of z15, the operating system loader verifies that components that are loaded from SCSI devices come from a trusted source. You can cancel loading for components that cannot be verified.

With secure boot enabled, an IPL fails if a component containing code is not signed or cannot be verified.

For details about how to prepare a device for secure boot, see [“zipl modes and syntax overview”](#) on page 56.

To check if a Linux instance was IPLed with secure boot, see [“Displaying current IPL parameters”](#) on page 94.

Kernel interfaces are restricted in a kernel that was IPLed with secure boot.

Loading Linux from removable media or from an FTP server

Instead of a boot loader, you can use SE functions to copy the Linux kernel image to your LPAR memory. After the Linux kernel is loaded, Linux is started using restart PSW.

Before you begin

You need installation data that includes a special file with installation information (with extension ".ins"). This file can be in different locations:

- On a disk that is inserted in the CD-ROM or DVD drive of the system where the HMC runs
- In the file system of an FTP server that you can access through FTP from your HMC system

The `.ins` file contains a mapping of the location of installation data on the disk or FTP server and the memory locations where the data is to be copied.

Procedure

Perform these steps:

1. In the navigation pane of the HMC, expand **Systems Management** and select the hardware system that you want to work with. A table of LPARs is displayed on the **Partitions** tab in the content area.
2. Select the LPAR where you want to boot Linux.
3. In the **Tasks** area, expand **Recovery** and click **Load from Removable Media or Server** (see [Figure 30](#) on page 88).

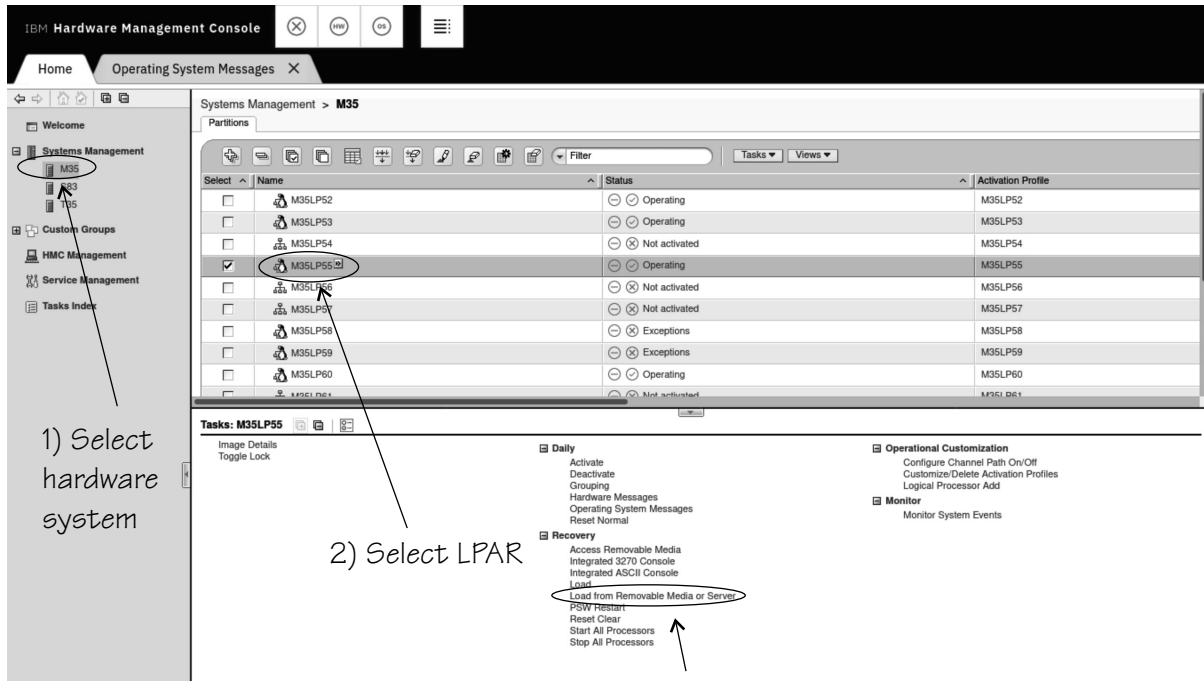


Figure 30. Load from Removable Media or Server task on the HMC

4. Specify the source of the code to be loaded.

- For loading from a CD-ROM or DVD drive
 - a. Select **Hardware Management Console removable media** (see Figure 31 on page 88).

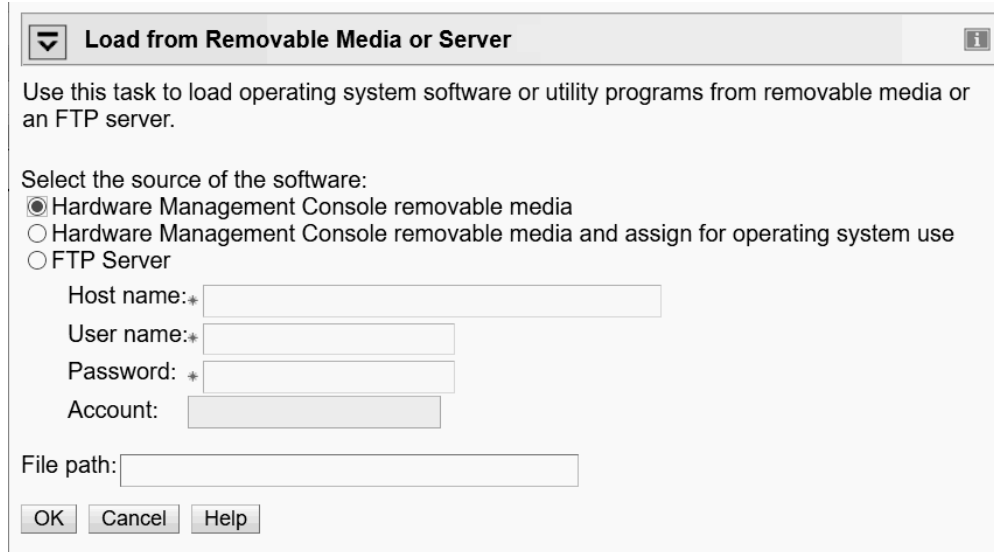


Figure 31. Load from Removable Media or Server panel

- b. Enter the path for the directory where the "ins-file" is in the **File location** field. You can leave this field blank if the "ins-file" is in the root directory of the file system on the CD-ROM or DVD.
- For an initial installation from removable media at the HMC
 - a. Select **Hardware Management Console removable media and assign for operating system use** (see Figure 31 on page 88).
 - b. Enter the path for the directory where the "ins-file" is in the **File location** field. You can leave this field blank if the "ins-file" is in the root directory of the file system on the removable media.

The installation CD or DVD must hold a distribution that supports an installation from the HMC.

- For loading from an FTP server
 - a. Select **FTP Server**.
 - b. Enter the IP address or host name of the FTP server with the installation code in the **Host name** entry field.
 - c. Enter your user ID for the FTP server in the **User name** entry field.
 - d. Enter your password for the FTP server in the **Password** entry field.
 - e. If required by your FTP server, type your account information in the **Account** entry field.
 - f. Enter the path for the directory where the "ins-file" resides in the file location entry field. You can leave this field blank if the file is in the FTP server's root directory.
- 5. Click **Continue** to display the **Select Software to Install** panel (Figure 32 on page 89).

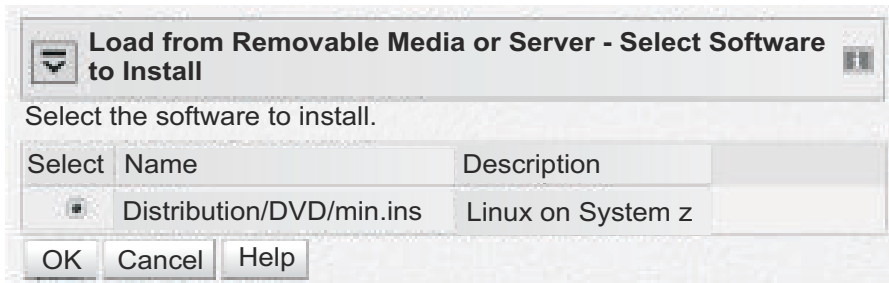


Figure 32. Select Software to Install panel

6. Select the "ins-file" to be used.
7. Click **OK** to start loading Linux.

Results

Ubuntu Server configuration scripts take over, if present.

Booting Linux in a z/VM guest virtual machine

Boot Linux in a z/VM guest virtual machine by issuing CP commands from a CMS or CP session.

For more general information about z/VM guest environments for Linux, see *z/VM: Getting Started with Linux on System z*, SC24-6287.

Booting from a tape device

Boot Linux by issuing the IPL command with a tape boot device. The boot data on the tape must be arranged in a specific order.

Before you begin

You need a tape that is prepared as a boot device. A tape boot device must contain the following items in the specified order:

1. Tape boot loader code
 - The tape boot loader code is included in the s390-tools package on developerWorks®.
2. Tape mark
3. Kernel image
4. Tape mark
5. Kernel parameters (optional)
6. Tape mark

7. Initial RAM disk (optional)
8. Tape mark
9. Tape mark

All tape marks are required even if an optional item is omitted. For example, if you do not provide an initial RAM disk image, the end of the boot information is marked with three consecutive tape marks. **zipl** prepared tapes conform to this layout.

Procedure

Perform these steps to start the boot process:

1. Establish a CMS or CP session with the z/VM guest virtual machine where you want to boot Linux.
2. Ensure that the boot device is accessible to your z/VM guest virtual machine.
3. Ensure that the correct tape is inserted and rewound.
4. Issue a command of this form:

```
#cp i <devno> clear parm <kernel_parameters>
```

where

<devno>

is the device number of the boot device as seen by the guest virtual machine.

parm <kernel_parameters>

is an optional 64-byte string of kernel parameters to be concatenated to the end of the existing kernel parameters that are used by your boot configuration (see [“Preparing a boot device” on page 58](#) for information about the boot configuration).

See also [“Specifying kernel parameters when booting Linux” on page 25](#).

Booting from a DASD

Boot Linux by issuing the IPL command with a DASD boot device. You can specify additional parameters with the IPL command.

Before you begin

You need a DASD boot device prepared with **zipl** (see [“Preparing a boot device” on page 58](#)).

Procedure

Perform these steps to start the boot process:

1. Establish a CMS or CP session with the z/VM guest virtual machine where you want to boot Linux.
2. Ensure that the boot device is accessible to your z/VM guest virtual machine.
3. Issue a command of this form:

```
#cp i <devno> clear loadparm <n> parm <kernel_parameters>
```

where:

<devno>

specifies the device number of the boot device as seen by the guest.

loadparm <n>

is applicable to menu configurations only. Omit this parameter if you are not working with a menu configuration.

Configuration number 0 specifies the default configuration. Depending on the menu configuration, omitting this option might display the menu or select the default configuration. Specifying **prompt** instead of a configuration number forces the menu to be displayed.

When the menu is displayed, you can specify additional kernel parameters (see [“Example for a DASD menu configuration on z/VM”](#) on page 91). These additional kernel parameters are appended to the parameters you might have provided in a parameter file. The combined parameter string must not exceed 895 bytes.

See [“Menu configurations”](#) on page 74 for more details about menu configurations.

parm <kernel_parameters>

is an optional 64-byte string of kernel parameters to be concatenated to the end of the existing kernel parameters used by your boot configuration (see [“Preparing a boot device”](#) on page 58 for information about the boot configuration).

See also [“Specifying kernel parameters when booting Linux”](#) on page 25.

Example for a DASD menu configuration on z/VM

Use the VI VMSG z/VM CP command to choose a boot configuration from a menu configuration.

This example illustrates how menu2 in the sample configuration file in [Figure 23 on page 76](#) is displayed on the z/VM guest virtual machine console:

```
00: zIPL interactive boot menu
00:
00: 0. default (boot1)
00:
00: 1. boot1
00: 2. boot3
00:
00: Note: VM users please use '#cp vi vmsg <input>'
00:
00: Please choose (default will boot in 30 seconds): #cp vi vmsg 2
```

You choose a configuration by specifying the configuration number. For example, to boot configuration boot3 specify

```
#cp vi vmsg 2
```

You can also specify additional kernel parameters by appending them to the configuration number. For example, you can specify:

```
#cp vi vmsg 2 maxcpus=1
```

These parameters are concatenated to the end of the existing kernel parameters that are used by your boot configuration when booting Linux.

Booting from a SCSI device

Boot Linux by issuing the IPL command with an FCP channel as the IPL device. You must specify the target port and LUN for the boot device in advance by setting the z/VM CP LOADDEV parameter.

Before you begin

You need a SCSI boot device that is prepared with **zipl** (see [“Preparing a boot device”](#) on page 58). A SCSI device can be a disk or an FC-attached CD-ROM or DVD drive.

Procedure

Perform these steps to start the boot process:

1. Establish a CMS or CP session with the z/VM guest virtual machine where you want to boot Linux.
2. Ensure that the FCP channel that provides access to the SCSI boot disk is accessible to your z/VM guest virtual machine.
3. Specify the target port and LUN of the SCSI boot disk.

Enter a command of this form:

```
#cp set loaddev portname <wwpn> lun <lun>
```

where:

<wwpn>

specifies the world wide port name (WWPN) of the target port in hexadecimal format. A blank separates the first eight digits from the final eight digits.

<lun>

specifies the LUN of the SCSI boot disk in hexadecimal format. A blank separating the first eight digits from the final eight digits.

Example: To specify a WWPN 0x5005076300c20b8e and a LUN 0x5241000000000000:

```
#cp set loaddev portname 50050763 00c20b8e lun 52410000 00000000
```

4. Optional for menu configurations: Specify the boot configuration (boot program in z/VM terminology) to be used. Enter a command of this form:

```
#cp set loaddev bootprog <n>
```

where <n> specifies the configuration number of the boot configuration. Omitting the bootprog parameter or specifying the value 0 selects the default configuration. For more information about menu configurations, see [“Menu configurations” on page 74](#).

Example: To select a configuration with configuration number 2 from a menu configuration:

```
#cp set loaddev bootprog 2
```

5. Optional: Specify kernel parameters.

```
#cp set loaddev scpdata <APPEND|NEW> '<kernel_parameters>'
```

where:

<kernel_parameters>

specifies a set of kernel parameters to be stored as system control program data (SCPDATA). When booting Linux, these kernel parameters are concatenated to the end of the existing kernel parameters that are used by your boot configuration.

<kernel_parameters> must contain ASCII characters only. If characters other than ASCII characters are present, the boot process ignores the SCPDATA.

<kernel_parameters> as entered from a CMS or CP session is interpreted as lowercase on Linux. If you require uppercase characters in the kernel parameters, run the SET LOADDEV command from a REXX script instead. In the REXX script, use the "address command" statement. See *z/VM: REXX/VM Reference*, SC24-6314 and *z/VM: REXX/VM User's Guide*, SC24-6315 for details.

Optional: APPEND

appends kernel parameters to existing SCPDATA. This is the default.

Optional: NEW

replaces existing SCPDATA.

Examples:

- To append kernel parameter novx to the current SCPDATA:

```
#cp set loaddev scpdata 'novx'
```

- To replace the current SCPDATA with the kernel parameter novx:

```
#cp set loaddev scpdata NEW 'novx'
```

For a subsequent IPL command, this kernel parameter is concatenated to the end of the existing kernel parameters in your boot configuration.

6. Start the IPL and boot process by entering a command of this form:

```
#cp i <devno>
```

where <devno> is the device number of the FCP channel that provides access to the SCSI boot disk.

Tip

You can specify the target port and LUN of the SCSI boot disk, a boot configuration, and SCPDATA all with a single SET LOADDEV command. See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for more information about the SET LOADDEV command.

Booting from the z/VM reader

Boot Linux by issuing the IPL command with the z/VM reader as the IPL device. You first must transfer the boot data to the reader.

Before you begin

You need the following files, all in record format fixed 80:

- Linux kernel image
- Kernel parameters (optional)
- Initial RAM disk image (optional)

About this task

This information is a summary of how to boot Linux from a z/VM reader. For more details, see the Redpaper *Building Linux Systems under IBM VM*, REDP-0120.

Procedure

Proceed like this to boot Linux from a z/VM reader:

1. Establish a CMS session with the guest where you want to boot Linux.
2. Transfer the kernel image, kernel parameters, and the initial RAM disk image to your guest.

You can obtain the files from a shared minidisk or use:

- The z/VM sendfile facility.
- An FTP file transfer in binary mode.

Files that are sent to your reader contain a file header that you must remove before you can use them for booting. Receive files that you obtain through your z/VM reader to a minidisk.

3. Set up the reader as a boot device.
 - a) Ensure that your reader is empty.
 - b) Direct the output of the punch device to the reader. Issue:

```
spool pun * rdr
```

- c) Use the CMS PUNCH command to transfer each of the required files to the reader.

Be sure to use the "no header" option to omit the file headers.

First transfer the kernel image.

Second transfer the kernel parameters.

Third transfer the initial RAM disk image, if present.

For each file, issue a command of this form:

```
pun <file_name> <file_type> <file_mode> (noh
```

d) Optional: Ensure that the contents of the reader remain fixed.

```
change rdr all keep nohold
```

If you omit this step, all files are deleted from the reader during the IPL that follows.

4. Issue the IPL command:

```
ipl 000c clear parm <kernel_parameters>
```

where:

0x000c

is the device number of the reader.

parm <kernel_parameters>

is an optional 64-byte string of kernel parameters to be concatenated to the end of the existing kernel parameters that are used by your boot configuration (see [“Preparing a boot device” on page 58](#) for information about the boot configuration).

See also [“Specifying kernel parameters when booting Linux” on page 25](#).

Booting Linux on KVM

You boot Linux as a KVM guest on Z from the KVM host, by starting a KVM virtual server.

About this task

For information about managing virtual servers, see *KVM Virtual Server Management*, SC34-2752.

Displaying current IPL parameters

To display the IPL parameters, use the **lsreipl** command with the **-i** option. Alternatively, a sysfs interface is available.

For more information about the **lsreipl** command, see [“lsreipl - List IPL and re-IPL settings” on page 611](#). In sysfs, information about IPL parameters is available in subdirectories of `/sys/firmware/ip1`.

`/sys/firmware/ip1/ip1_type`

The `/sys/firmware/ip1/ip1_type` file contains the device type from which the kernel was booted. The following values are possible:

ccw

The IPL device is a CCW device, for example, a DASD, the z/VM reader, or a virtio block device.

fcp

The IPL device is an FCP device.

unknown

The IPL device is not known.

Depending on the IPL type, there might be more files in `/sys/firmware/ip1/`.

If the device is a CCW device, the additional files `device` and `loadparm` are present.

device

Contains the bus ID of the CCW device that is used for IPL, for example:

```
# cat /sys/firmware/ip1/device
0.0.1234
```

loadparm

Contains up to 8 characters for the loadparm that is used for selecting from a zipl boot menu during IPL of a CCW device, for example:

```
# cat /sys/firmware/ipl/loadparm
1
```

parm

Contains additional kernel parameters that are specified with the PARM parameter when booting with the z/VM CP IPL command, for example:

```
# cat /sys/firmware/ipl/parm
novx
```

See also [“Specifying kernel parameters when booting Linux” on page 25](#).

A leading equal sign (=) indicates that the existing kernel parameters used by the boot configuration were ignored and the kernel parameters of the parm attribute were the only kernel parameters used for booting Linux. See [“Replacing all kernel parameters in a boot configuration” on page 26](#).

If the device is FCP, a number of additional files are present (also see [Chapter 12, “SCSI-over-Fibre Channel device driver,” on page 147](#) for details):

secure

Read the sysfs attribute `/sys/firmware/ipl/secure` to check whether the Linux instance was IPLed with secure boot. Issue the following command:

```
# cat /sys/firmware/ipl/secure
1
```

If the value is 1, Linux was IPLed with secure boot.

has_secure

Indicates whether the host environment supports secure boot. If the value is 1, secure boot is supported and the secure-boot enabled format can be used, see [“Secure boot” on page 87](#).

device

Contains the bus ID of the FCP device that is used for IPL, for example:

```
# cat /sys/firmware/ipl/device
0.0.50dc
```

loadparm

Contains up to 8 characters for the loadparm.

wwpn

Contains the WWPN used for IPL, for example:

```
# cat /sys/firmware/ipl/wwpn
0x5005076300c20b8e
```

lun

Contains the LUN used for IPL, for example:

```
# cat /sys/firmware/ipl/lun
0x5010000000000000
```

br_lba

Contains the logical block address of the boot record on the boot device (usually 0).

bootprog

Contains the boot program number that is used for selecting from a zipl boot menu during IPL of a SCSI disk device.

scp_data

Contains additional kernel parameters that are used when booting from a SCSI device, for example:

```
# cat /sys/firmware/ipl/scp_data
novx
```

See [“Booting from a SCSI device” on page 91](#) and [“Booting from SCSI” on page 84](#)).

A leading equal sign (=) indicates that the existing kernel parameters used by the boot configuration were ignored and the kernel parameters of the `scp_data` attribute where the only kernel parameters used for booting Linux. See [“Replacing all kernel parameters in a boot configuration” on page 26](#).

binary_parameter

Contains the information of the preceding files in binary format.

Rebooting from an alternative source

When you reboot Linux, the system conventionally boots from the last used location. However, you can configure an alternative device to be used for re-IPL instead of the last used IPL device.

Before you start:

- Linux must be compiled to support rebooting from an alternative source. This feature is built into the kernel by default.
- The IBM Z hardware must have zfcpl IPL support for re-IPL from SCSI devices.

Use the **chreipl** tool to configure the re-IPL device. For more information about the **chreipl** tool, see [“chreipl - Modify the re-IPL configuration” on page 523](#).

Alternatively, you can use a sysfs interface. In sysfs, the virtual configuration files are located under `/sys/firmware/reipl`. To configure, write strings into the configuration files. The following re-IPL types can be set with the `/sys/firmware/reipl/reipl_type` attribute:

ccw

For ccw devices such as DASDs that are attached through ESCON or FICON®, and for virtio block devices on KVM guests.

fcp

For FCP SCSI devices, including SCSI disks and CD or DVD drives (Hardware support is required.)

nss

For Named Saved Systems (z/VM only)

For each supported re-IPL type a sysfs directory is created under `/sys/firmware/reipl` that contains the configuration attributes for the device. The directory name is the same as the name of the re-IPL type.

When Linux is booted, the re-IPL attributes are set by default to the values of the boot device, which can be found under `/sys/firmware/ipl`.

Attributes for ccw

You can find the attributes for re-IPL type ccw in the `/sys/firmware/reipl/ccw` sysfs directory.

device

Device number of the re-IPL device. For example, 0.0.7412 or 0.1.5119.

loadparm

Up to eight characters for the loadparm used to select the boot configuration in the zipl menu (if available).

parm

A 64-byte string of kernel parameters that is concatenated to the boot command-line. The PARM parameter can be set only for Linux on z/VM. See also [“Specifying kernel parameters when booting Linux”](#) on page 25.

A leading equal sign (=) means that the existing kernel parameter line in the boot configuration is ignored and the boot process uses the kernel parameters in the parm attribute only. See also [“Replacing all kernel parameters in a boot configuration”](#) on page 26.

Attributes for fcp

You can find the attributes for re-IPL type fcp in the `/sys/firmware/reipl/fcp` sysfs directory.

device

Device number of the FCP device that is used for re-IPL. For example, 0.0.7412.

Note: IPL is possible only from subchannel set 0.

wwpn

World wide port number of the FCP re-IPL device.

lun

Logical unit number of the FCP re-IPL device.

bootprog

Boot program selector. Used to select the boot configuration in the zipl menu (if available).

br_lba

Boot record logical block address. Master boot record. Is always 0 for Linux.

loadparm

Up to eight characters for the loadparm.

scp_data

Kernel parameters to be used for the next FCP re-IPL. See also [“Specifying kernel parameters when booting Linux”](#) on page 25.

A leading equal sign (=) means that the existing kernel parameter line in the boot configuration is ignored and the boot process uses the kernel parameters in the scp_data attribute only. See also [“Replacing all kernel parameters in a boot configuration”](#) on page 26.

Attributes for nss

You can find the attributes for re-IPL type nss in the `/sys/firmware/reipl/nss` sysfs directory.

name

Name of the NSS. The NSS name can be one to eight characters long and must consist of alphabetic or numeric characters. The following examples are all valid NSS names: 73248734, NSSCSITE, or NSS1234.

parm

If the NSS contains a Linux instance, a 56-byte string of kernel parameters that is concatenated to the kernel parameters in the boot configuration. (Note the difference in length compared to ccw.) See also [“Specifying kernel parameters when booting Linux”](#) on page 25.

A leading equal sign (=) means that the existing kernel parameter line in the boot configuration is ignored and the boot process uses the kernel parameters in the parm attribute only. See also [“Replacing all kernel parameters in a boot configuration”](#) on page 26.

Kernel panic settings

Set the attribute `/sys/firmware/shutdown_actions/on_panic` to `reipl` to make the system re-IPL with the current re-IPL settings if a kernel panic occurs.

For Linux in LPAR mode and Linux on z/VM, you might want to trigger a system dump in response to a kernel panic. See also the description of the **dumpconf** tool in *Using the Dump Tools*, SC33-8412 on IBM Knowledge Center at:

ibm.com/docs/en/linux-on-systems?topic=tools-upstream-kernel

Examples for configuring re-IPL

Typical examples include configuring re-IPL from an FCP device and specifying parameters for re-IPL.

- To configure a DASD with bus ID 0.0.7e78 as the re-IPL device:

```
# chreipl 0.0.7e78
```

Alternatively, you can write directly to sysfs:

```
# echo 0.0.7e78 > /sys/firmware/reipl/ccw/device
```

- To configure an FCP re-IPL device 0.0.5711 with a LUN 0x1711000000000000 and a WWPN 0x5005076303004715 with an additional kernel parameter novx:

```
# chreipl 0.0.5711 0x5005076303004715 0x1711000000000000 -p "novx"
```

Alternatively, you can write directly to sysfs. For an FCP re-IPL device, additional boot parameters, as specified with the `-p` option, are stored as scp data. Therefore, the `novx` kernel parameter of the example is written to `/sys/firmware/reipl/fcp/scp_data`.

```
# echo 0.0.5711 > /sys/firmware/reipl/fcp/device
# echo 0x5005076303004715 > /sys/firmware/reipl/fcp/wwpn
# echo 0x1711000000000000 > /sys/firmware/reipl/fcp/lun
# echo 0 > /sys/firmware/reipl/fcp/bootprog
# echo 0 > /sys/firmware/reipl/fcp/br_lba
# echo "novx" > /sys/firmware/reipl/fcp/scp_data
# echo fcp > /sys/firmware/reipl/reipl_type
```

- To specify additional kernel parameters for re-IPL of an instance of Linux on z/VM:

Write the parameters to the `parm` attribute:

```
# echo "novx" > /sys/firmware/reipl/ccw/parm
```

Chapter 8. Shutdown actions

Several triggers can cause Linux to shut down. For each shutdown trigger, you can configure a specific shutdown action to be taken as a response.

Table 12. Shutdown triggers and default action overview

Trigger	Command or condition	Default shutdown action
halt	Linux shutdown -H command	stop
poff	Linux poweroff or shutdown -P command	stop
reboot	Linux reboot or shutdown -r command	reipl
restart	Depending on the hypervisor environment: LPAR A PSW restart on the HMC z/VM A CP system restart command KVM A virsh command on the KVM host	stop
panic	Linux kernel panic	stop

The available shutdown actions are summarized in [Table 13 on page 99](#).

Table 13. Shutdown actions

Action	Explanation	See also
stop	For panic or restart, enters a disabled wait state. For all other shutdown triggers, stops all CPUs. For Linux on KVM, frees the resources that were used by the Linux instance. Depending on your virtual server configuration, the memory might be preserved.	n/a
ipl	Performs an IPL according to the specifications in <code>/sys/firmware/ipl</code> .	“Displaying current IPL parameters” on page 94
reipl	Performs an IPL according to the specifications in <code>/sys/firmware/reipl</code> .	“Rebooting from an alternative source” on page 96
dump	For Linux in LPAR mode and Linux on z/VM, creates a dump according to the specifications in <code>/sys/firmware/dump</code> .	<i>Using the Dump Tools, SC33-8412</i>
dump_reipl	For Linux in LPAR mode and Linux on z/VM, performs the dump action followed by the reipl action.	<i>Using the Dump Tools, SC33-8412</i>
vmcmd	For Linux on z/VM, issues one or more z/VM CP commands according to the specifications in <code>/sys/firmware/vmcmd</code> .	“Configuring z/VM CP commands as a shutdown action” on page 100

Use **lsshut** to find out which shutdown action is configured for each shutdown trigger, see [“lsshut - List the current system shutdown actions”](#) on page 614.

Use the applicable command to configure the shutdown action for a shutdown trigger:

- For `halt`, `poff`, and `reboot` use **chshut**, see [“chshut - Control the system shutdown actions”](#) on page 527.
- For `restart` and `panic` on Linux in LPAR mode or Linux on z/VM, use **dumpconf**, see *Using the Dump Tools*, SC33-8412.

kdump for restart and panic

If `kdump` is set up for a Linux instance, `kdump` is started to create a dump, regardless of the shutdown actions that are specified for `restart` and `panic`. With `kdump`, these settings act as a backup that is used only if `kdump` fails.

Note: `kdump` is not a shutdown action that you can set as a `sysfs` attribute value for a shutdown trigger. See *Using the Dump Tools*, SC33-8412 about how to set up `kdump`.

The shutdown configuration in sysfs

The configured shutdown action for each shutdown trigger is stored in a `sysfs` attribute `/sys/firmware/shutdown_actions/on_<trigger>`.

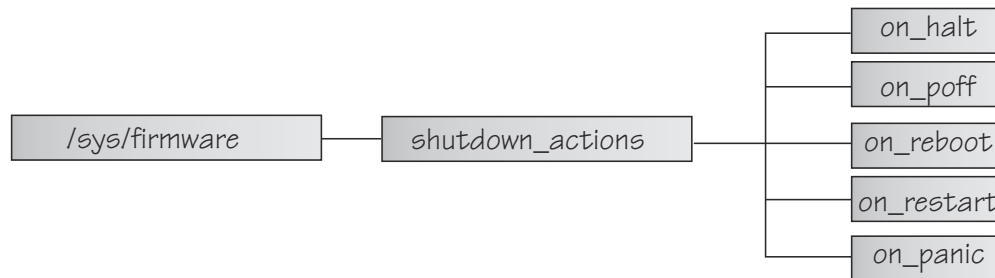


Figure 33. `sysfs` branch with shutdown action settings

The preferred way to read or change these settings is using the **lsshut**, **chshut**. For dump actions on Linux in LPAR mode or Linux on z/VM, the preferred way is the **dumpconf** command. Alternatively, you can read and write to the `/sys/firmware/shutdown_actions/on_<trigger>` attributes.

Examples

- This command reads the shutdown setting for the `poff` shutdown trigger.

```
# cat /sys/firmware/shutdown_actions/on_poff
stop
```

- This command changes the setting for the `restart` shutdown trigger to `ipl`:

```
# echo ipl > /sys/firmware/shutdown_actions/on_restart
```

Details for the `ipl`, `reipl`, `dump`, and `vmcmd` shutdown actions are contained in the corresponding subdirectories in `/sys/firmware`. For example, `/sys/firmware/ipl` contains specifications for an IPL device and other IPL parameters.

Configuring z/VM CP commands as a shutdown action

Use **chshut** and **dumpconf** to configure a CP command as a shutdown action, or directly write to the relevant `sysfs` attributes.

Before you start: This information applies to Linux on z/VM only.

In sysfs, two attributes are required to set a z/VM CP command as a shutdown action for a trigger `<trigger>`:

- `/sys/firmware/shutdown_actions/on_<trigger>` must be set to `vmcmd`.
- `/sys/firmware/vmcmd/on_<trigger>` specifies the z/VM CP command.

The values of the attributes in the `/sys/firmware/vmcmd` directory must conform to these rules:

- The value must be a valid z/VM CP command.
- The commands, including any z/VM user IDs or device numbers, must be specified with uppercase characters.
- Commands that include blanks must be delimited by double quotation marks (").
- The value must not exceed 127 characters.

You can specify multiple z/VM CP commands that are separated by the newline character `"\n"`. Each newline is counted as one character. When writing values with multiple commands, use this syntax to ensure that the newline character is processed correctly:

```
# echo -e <cmd1>\n<cmd2>... | cat > /sys/firmware/vmcmd/on_<trigger>
```

where `<cmd1>\n<cmd2>...` are two or more z/VM CP commands and `on_<trigger>` is one of the attributes in the `vmcmd` directory.

The `-e` **echo** option and redirect through **cat** are required because of the newline character.

Example for a single z/VM CP command

Issue the following command to configure the z/VM CP LOGOFF command as the shutdown action for the `poff` shutdown trigger.

```
# chshut poff vmcmd "LOGOFF"
```

Alternatively, you can issue the following commands to directly write the shutdown configuration to sysfs:

```
# echo vmcmd > /sys/firmware/shutdown_actions/on_poff
# echo LOGOFF > /sys/firmware/vmcmd/on_poff
```

[Figure 34 on page 102](#) illustrates the relationship of the sysfs attributes for this example.

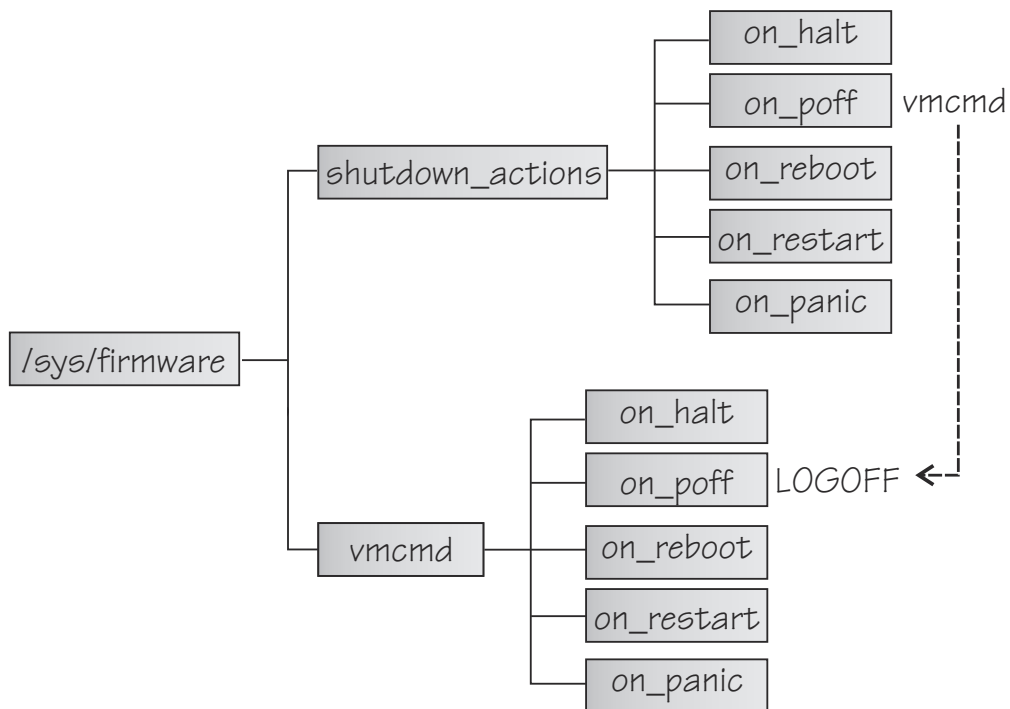


Figure 34. sysfs branch with shutdown action settings

Example for multiple z/VM CP commands

Issue the following command to configure two z/VM CP commands as the shutdown action for the `poff` shutdown trigger. First a message is sent to user OPERATOR, and then the LOGOFF command is issued.

```
# chshut poff vmcmd "MSG OPERATOR Going down" vmcmd "LOGOFF"
```

Alternatively, you can issue the following commands to directly write the shutdown configuration to sysfs:

```
# echo vmcmd > /sys/firmware/shutdown_actions/on_poff
# echo -e "MSG OPERATOR Going down\nLOGOFF" | cat > /sys/firmware/vmcmd/on_poff
```

Chapter 9. The diag288 watchdog device driver

The diag288 watchdog device driver provides Linux watchdog applications with access to the watchdog timer on IBM Z.

You can use the diag288 watchdog in these environments:

- Linux on z/VM
- Linux in LPAR mode as of z13s[®] and z13[®] with the enhancements of February 2016.
- Linux as a KVM guest.

The diag288 watchdog device driver provides the following features:

- Access to the watchdog timer on Z.
- An API for watchdog applications (see [“External programming interfaces”](#) on page 105).

Watchdog applications can be used to set up automated restart mechanisms.

For Linux in LPAR mode and for Linux on z/VM, you can alternatively use a networked heartbeat with STONITH.

Watchdog applications that communicate directly with the Z firmware, the z/VM control program (CP), or the KVM host do not require a third operating system to monitor a heartbeat.

What you should know about the diag288 watchdog device driver

The watchdog function comprises two components: a watchdog application on the Linux instance being controlled and a watchdog timer outside the Linux instance. For Linux in LPAR mode, the timer runs in the IBM Z firmware. For Linux on z/VM the timer is provided by z/VM CP. For Linux on KVM, the timer runs on the KVM host.

While the Linux instance operates satisfactorily, the watchdog application reports a positive status to the watchdog timer at regular intervals. The watchdog application uses a device node to pass these status reports to the timer ([Figure 35 on page 103](#)).

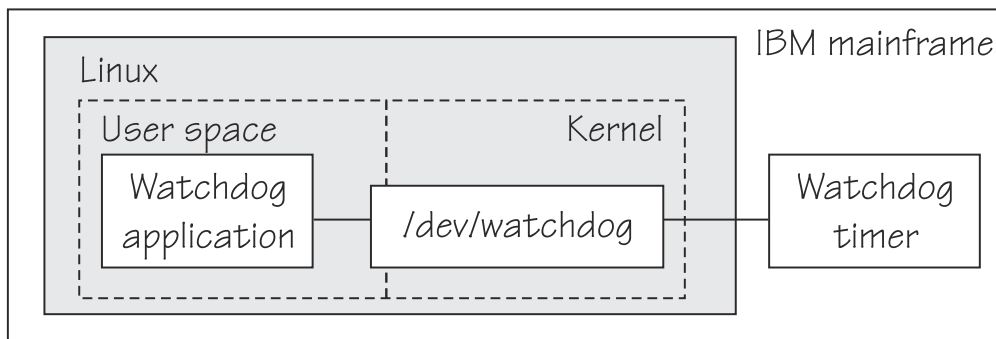


Figure 35. Watchdog application and timer for Linux in LPAR mode

The watchdog application typically derives its status by monitoring critical network connections, file systems, and processes on the Linux instance. If a specified time elapses without a positive report being received by the watchdog timer, the watchdog timer assumes that the Linux instance is in an error state. The watchdog timer then triggers a predefined action against the Linux instance. For example, Linux might be shut down or rebooted, or a system dump might be initiated see [“Setting the timeout action”](#) on page 105.

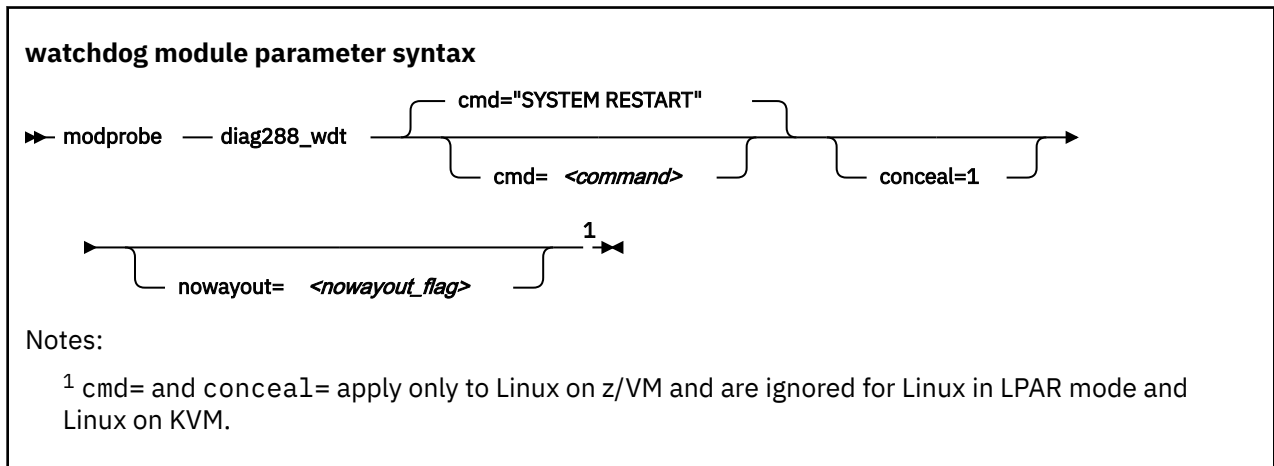
For information about setting the default timer and performing other actions, see [“External programming interfaces”](#) on page 105.

Linux on z/VM only: Loading or saving a DCSS can take a long time during which the virtual machine does not respond, depending on the size of the DCSS. As a result, a watchdog might time out and restart the guest. You are advised not to use the watchdog in combination with loading or saving DCSSs.

See also the generic watchdog documentation available from the `linux-doc` package under `linux-doc/watchdog`.

Setting up the diag288 watchdog device driver

You configure the `diag288` watchdog device driver through module parameters.



where:

<command>

configures the shutdown action to be taken if Linux on z/VM fails.

The default, "SYSTEM RESTART", configures the shutdown action that is specified for the `restart` shutdown trigger (see Chapter 8, "Shutdown actions," on page 99).

Any other specification dissociates the timeout action from the `restart` shutdown trigger. Instead, the specification is issued by CP and must adhere to these rules:

- It must be a single valid CP command
- It must not exceed 230 characters
- It must be enclosed by quotation marks if it contains any blanks or newline characters

The specification is converted from ASCII to uppercase EBCDIC.

For details about CP commands, see *z/VM: CP Commands and Utilities Reference*, SC24-6268.

On an running instance of Linux on z/VM, you can write to `/sys/module/diag288_wdt/parameters/cmd` to replace the command you specify when loading the module. Through this `sysfs` interface, you can also specify multiple commands to be issued, see "Example for Linux on z/VM" on page 105 for more details.

The preferred method for configuring a timeout action other than a system restart is to configure a different shutdown action for the `restart` shutdown trigger.

conceal=1

enables the protected application environment where the guest is protected from unexpectedly entering CP READ. Do not enable the protected environment for guests with multiprocessor configurations. The protected application facility supports only virtual uniprocessor systems.

For details, see the "SET CONCEAL" section of *z/VM: CP Commands and Utilities Reference*, SC24-6268.

<nowayout_flag>

determines what happens when the watchdog device node is closed by the watchdog application.

If the flag is set to 1, the watchdog timer keeps running and triggers an action if no positive status report is received within the specified time interval. If the character "V" is written to the device and the flag is set to 0, the watchdog timer is stopped and the Linux instance continues without the watchdog support.

Example for Linux on z/VM

The following kernel parameters determine that, on failure, the Linux instance is to be IPLed from a device with devno 0xb1a0. The protected application environment is not enabled. The watchdog application can close the watchdog device node after writing "V" to it. As a result the watchdog timer becomes ineffective and does not IPL the guest.

```
modprobe diag288_wdt cmd="ipl b1a0" nowayout=0
```

The following example shows how to specify multiple commands to be issued.

```
/bin/echo -en "MSG * WATCHDOG FIRED\nVMDUMP\nIPL" > /sys/module/diag288_wdt/parameters/cmd
```

Use the **echo** version at `/bin/echo`. The built-in **echo** command from bash might not process the newline characters as intended.

To verify that your commands have been accepted, issue:

```
# cat /sys/module/diag288_wdt/parameters/cmd
MSG * WATCHDOG FIRED
VMDUMP
IPL
```

Note: You cannot specify multiple commands as kernel parameters during boot time.

Setting the timeout action

How to configure the timeout action for the diag288 watchdog device driver depends on your hypervisor environment.

LPAR

For Linux in LPAR mode, the shutdown action is defined through the `restart` shutdown trigger (see Chapter 8, “Shutdown actions,” on page 99).

z/VM

For Linux on z/VM, the shutdown action is defined through the `restart` shutdown trigger.

You can also use the `diag288_wdt.cmd=` kernel parameter or the `cmd=` module parameter to bypass the `restart` shutdown trigger and directly specify a z/VM CP command to be issued.

KVM

For Linux on KVM, the shutdown action is defined in the virtual server configuration on the KVM hypervisor.

External programming interfaces

There is an API for applications that work with the watchdog device driver.

Application programmers: This information is intended for programmers who want to write watchdog applications that work with the watchdog device driver.

For information about the API and the supported IOCTLs, see the `linux-doc/watchdog/watchdog-api.txt.gz` file in the `linux-doc` package.

The default watchdog timeout is 30 seconds, the minimum timeout that can be set through the IOCTL `WDIOC_SETTIMEOUT` is 15 seconds.

Chapter 10. KASLR support

With kernel address space layout randomization (KASLR), the kernel is loaded to a random location in memory.

Loading the kernel to a random location can protect against attacks that rely on knowledge of the kernel addresses.

The KASLR feature is enabled by default. You can use the `nokaslr` kernel parameter to disable it, see [“nokaslr - Disable kernel randomization”](#) on page 705.

When KASLR is enabled, and the kernel is loaded to a random address, the kernel syslog can reveal kernel internal addresses. Therefore, you must prevent access to the syslog for unprivileged users by setting the `dmesg_restrict` sysctl to 1. This setting restricts access to users with `CAP_SYSLOG` privilege.

Kernel addresses can also be compromised through `/proc` and other interfaces. To prevent this, set the `kptr_restrict` sysctl to 1.

For more information about the `dmesg_restrict` and `kptr_restrict` sysctls, see the [Documentation/sysctl/kernel.txt](#) in the kernel source tree.

Part 3. Storage

Ubuntu Server 20.04.1 includes several storage device drivers that are specific to z/Architecture.

For information about storage networks and I/O to storage devices, see www.ibm.com/it-infrastructure/z/capabilities/networking

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 11. DASD device driver

Linux in any Z hypervisor environment, LPAR, z/VM, and KVM, can include direct access storage devices (DASD). For Linux on KVM, this requires a KVM host with CCW pass-through support and a KVM virtual server configuration with DASDs as pass-through devices.

The DASD device driver provides access to all real or emulated direct access storage devices (DASD) that can be attached to the channel subsystem of an IBM mainframe.

DASD devices include various physical media on which data is organized in blocks or records or both. The blocks or records in a DASD can be accessed for read or write in random order.

Traditional DASD devices are attached to a control unit that is connected to a mainframe I/O channel. Today, these real DASDs have been largely replaced by emulated DASDs. For example, emulated DASDs can be the internal disks of the IBM System Storage® DS8000® Turbo, or the volumes of the IBM System Storage DS6000™. These emulated DASD are completely virtual and the identity of the physical device is hidden.

SCSI disks that are attached through an FCP channel are not classified as DASD. They are handled by the zfcpl driver (see Chapter 12, “SCSI-over-Fibre Channel device driver,” on page 147).

Features

The DASD device driver supports a wide range of disk devices and disk functions.

- The DASD device driver has no dependencies on the adapter hardware that is used to physically connect the DASDs to the IBM Z hardware. You can use any adapter that is supported by the IBM Z hardware (see www.ibm.com/systems/support/storage/ssic/interoperability.wss for more information).
- The DASD device driver supports ESS virtual ECKD type disks
- The DASD device driver supports the control unit attached physical ECKD (Extended Count Key Data) and FBA (Fixed Block Access) devices as summarized in [Table 14 on page 111](#):

Device format	Control unit type	Device type
ECKD	1750	3380 and 3390
ECKD	2107	3380 and 3390
ECKD	2105	3380 and 3390
ECKD	3990	3380 and 3390
ECKD	9343	9345
ECKD	3880	3390
FBA	6310	9336
FBA	3880	3370

All models of the specified control units and device types can be used with the DASD device driver. This includes large devices with more than 65520 cylinders, for example, 3390 Model A. Check the storage support statement to find out what works for Ubuntu Server 20.04.1.

- The DASD device driver provides a disk format with up to three partitions per disk. See “[IBM Z compatible disk layout](#)” on page 113 for details.
- The DASD device driver provides an option for extended error reporting for ECKD devices. Extended error reporting can support high availability setups.

- The DASD device driver supports parallel access volume (PAV) and HyperPAV on storage devices that provide this feature. The DASD device driver handles dynamic PAV alias changes on storage devices. For more information about PAV and HyperPAV, see *How to Improve Performance with PAV*, SC33-8414. Use the **dasdstat** command to check whether a DASD uses PAV, see [“Scenario: Verifying that PAV and HPF are used”](#) on page 136.
- The DASD device driver supports High Performance FICON, including multitrack requests, on storage devices that provide this feature. Use the **dasdstat** command to check whether a DASD uses High Performance FICON, see [“Scenario: Verifying that PAV and HPF are used”](#) on page 136.

What you should know about DASD

The DASD device driver supports various disk layouts with different partitioning capabilities. The DASD device naming scheme helps you to keep track of your DASDs and DASD device nodes.

The IBM label partitioning scheme

Linux on Z supports the same standard DASD format that is also used by traditional mainframe operating systems, but it also supports any other Linux partition table.

The DASD device driver is embedded into the Linux generic support for partitioned disks. As a result, you can use any partition table format that is supported by Linux for your DASDs.

Traditional mainframe operating systems (such as z/OS, z/VM, and z/VSE®) expect a standard DASD format. In particular, the format of the first two tracks of a DASD is defined by this standard. These tracks include the Z IPL record, the volume label, and for some layouts VTOC records. Partitioning schemes for platforms other than Z generally do not preserve these mainframe specific records.

Ubuntu Server 20.04.1 includes the IBM label partitioning scheme that preserves the Z IPL, label, and VTOC records. With this partitioning scheme, Linux can share a disk with other mainframe operating systems. For example, a traditional mainframe operating system can handle backup and restore for a partition that is used by Linux.

The following sections describe the layouts that are supported by the IBM label partitioning scheme:

- [“IBM Z compatible disk layout”](#) on page 113
- [“Linux disk layout”](#) on page 115
- [“CMS disk layout”](#) on page 115

DASD partitions

Partitioning DASDs has the same advantages as for other disk types, but there are some prerequisites and a special tool, **fdasd**.

A DASD partition is a contiguous set of DASD blocks that is treated by Linux as an independent disk and by the traditional mainframe operating systems as a data set.

With the Linux disk layout (LDL) and the CMS disk layout, you always have a single partition only. This partition is defined by the LDL or CMS formatted area of the disk. With the compatible disk layout, you can have up to three partitions.

There are several reasons why you might want to have multiple partitions on a DASD, for example:

Limit data growth

Runaway processes or undisciplined users can consume disk space to an extent that the operating system runs short of space for essential operations. Partitions can help to isolate the space that is available to particular processes.

Encapsulate your data

If a file system gets damaged, this damage is likely to be restricted to a single partition. Partitioning can reduce the scope of data damage.

Recommendations

- Use **fdasd** to create or alter partitions on ECKD type DASDs that are formatted with the compatible disk layout. If you use another partition editor, it is your responsibility to ensure that partitions do not overlap. If they do, data damage occurs.
- Leave no gaps between adjacent partitions to avoid wasting space. Gaps are not reported as errors, and can be reclaimed only by deleting and re-creating one or more of the surrounding partitions and rebuilding the file system on them.

A disk need not be partitioned completely. You can begin by creating only one or two partitions at the start of your disk and convert the remaining space to a partition later.

There is no facility for moving, enlarging, or reducing partitions, because **fdasd** has no control over the file system on the partition. You can only delete and re-create them. Changing the partition table results in loss of data in all altered partitions. It is up to you to preserve the data by copying it to another medium.

IBM Z compatible disk layout

With the compatible disk layout, a DASD can have up to three partitions that can be accessed by traditional mainframe operating systems.

You can format only ECKD type DASD with the compatible disk layout.

Figure 36 on page 113 illustrates a DASD with the compatible disk layout.



Figure 36. Compatible disk layout

The IPL records, volume label (VOL1), and VTOC of disks with the compatible disk layout are on the first two tracks of the disks. These tracks are not intended for use by Linux applications. Using the tracks can result in data loss.

Linux can address the device as a whole as `/dev/dasd<x>`, where `<x>` can be one to four letters that identify the individual DASD (see “DASD naming scheme” on page 116).

Disks with the compatible disk layout can have one to three partitions. Linux addresses the first partition as `/dev/dasd<x>1`, the second as `/dev/dasd<x>2`, and the third as `/dev/dasd<x>3`.

You use the **dasdfmt** command (see “dasdfmt - Format a DASD” on page 556) to format a disk with the compatible disk layout. You use the **fdasd** command (see “fdasd - Partition a DASD” on page 574) to create and modify partitions.

Volume label

The volume label includes information about the disk layout, the VOLSER, and a pointer to the VTOC.

The DASD volume label is in the third block of the first track of the device (cylinder 0, track 0, block 2). This block has a 4-byte key, and an 80-byte data area with the following content:

key

for disks with the compatible disk layout, contains the four EBCDIC characters "VOL1" to identify the block as a volume label.

label identifier

is identical to the key field.

VOLSER

is a name that you can use to identify the DASD device. A volume serial number (VOLSER) can be one to six EBCDIC characters. If you want to use VOLSERS as identifiers for your DASD, be sure to assign unique VOLSERS.

You can assign VOLSERS from Linux by using the **dasdfmt** or **fdasd** command. These commands enforce that VOLSERS:

- Are alphanumeric
- Are uppercase (by uppercase conversion)
- Contain no embedded blanks
- Contain no special characters other than \$, #, @, and %

Tip: Avoid special characters altogether.

Note: The VOLSER values SCRTCH, PRIVAT, MIGRAT, or Lnnnnn (An "L" followed by 5 digits) are reserved for special purposes by other mainframe operating systems and should not be used by Linux.

These rules are more restrictive than the VOLSERS that are allowed by the traditional mainframe operating systems. For compatibility, Linux tolerates existing VOLSERS with lowercase letters and special characters other than \$, #, @, and %. Enclose VOLSERS with special characters in single quotation marks if you must specify it, for example, as a command parameter.

VTOC address

contains the address of a standard IBM format 4 data set control block (DSCB). The format is: *cylinder* (2 bytes) *track* (2 bytes) *block* (1 byte).

All other fields of the volume label contain EBCDIC space characters (code 0x40).

VTOC

Instead of a regular Linux partition table, Ubuntu Server 20.04.1 LTS, like other mainframe operating systems, uses a Volume Table Of Contents (VTOC).

The VTOC contains pointers to the location of every data set on the volume. These data sets form the Linux partitions.

The VTOC is on the second track (cylinder 0, track 1). It contains a number of records, each written in a separate data set control block (DSCB). The number of records depends on the size of the volume:

- One DSCB that describes the VTOC itself (format 4)
- One DSCB that is required by other operating systems but is not used by Linux. **fdasd** sets it to zeroes (format 5).
- For volumes with more than 65534 cylinders, 1 DSCB (format 7)
- For each partition:
 - On volumes with 65534 or less cylinders, one DSCB (format 1)
 - On volumes with more than 65534 cylinders, 1 format 8 and one format 9 DSCB

The key of the format 1 or format 8 DSCB contains the data set name, which identifies the partition to z/OS, z/VM, and z/VSE.

The VTOC can be displayed with standard IBM Z tools such as VM/DITTO. A Linux DASD with physical device number 0x0193, volume label "LNX001", and three partitions might be displayed like this example:

```

====>
VM/DITTO DISPLAY VTOC
LINE 1 OF 5
SCROLL ==> PAGE

CUU,193 ,VOLSER,LNX001 3390, WITH 100 CYLS, 15 TRKS/CYL, 58786 BYTES/TRK

--- FILE NAME --- (SORTED BY =,NAME ,) ---- EXT BEGIN-END RELTRK,
1..5...10...15...20...25...30...35...40... SQ CYL-HD CYL-HD NUMTRKS
*** VTOC EXTENT ***
0 0 1 0 1 1,1
LINUX.VLNX001.PART0001.NATIVE 0 0 2 46 11 2,700
LINUX.VLNX001.PART0002.NATIVE 0 46 12 66 11 702,300
LINUX.VLNX001.PART0003.NATIVE 0 66 12 99 14 1002,498
*** THIS VOLUME IS CURRENTLY 100 PER CENT FULL WITH 0 TRACKS AVAILABLE

PF 1=HELP 2=TOP 3=END 4=BROWSE 5=BOTTOM 6=LOCATE
PF 7=UP 8=DOWN 9=PRINT 10=RGT/LEFT 11=UPDATE 12=RETRIEVE

```

The **ls** command on Linux might list this DASD and its partitions like this example:

```

# ls -l /dev/dasda*
brw-rw---- 1 root disk 94, 0 Jan 27 09:04 /dev/dasda
brw-rw---- 1 root disk 94, 1 Jan 27 09:04 /dev/dasda1
brw-rw---- 1 root disk 94, 2 Jan 27 09:04 /dev/dasda2
brw-rw---- 1 root disk 94, 3 Jan 27 09:04 /dev/dasda3

```

where `dasda` represent the whole DASD and `dasda1`, `dasda2`, and `dasda3` represent the individual partitions.

Linux disk layout

The Linux disk layout does not have a VTOC, and DASD partitions that are formatted with this layout cannot be accessed by traditional mainframe operating systems.

You can format only ECKD type DASD with the Linux disk layout. Apart from accessing the disks as ECKD devices, you can also access them using the DASD DIAG access method. See [“Enabling the DASD device driver to use the DIAG access method”](#) on page 126 for how to enable DIAG.

[Figure 37](#) on page 115 illustrates a disk with the Linux disk layout.



Figure 37. Linux disk layout

DASDs with the Linux disk layout either have an LNX1 label or are not labeled. The first records of the device are reserved for IPL records and the volume label, and are not intended for use by Linux applications. All remaining records are grouped into a single partition. You cannot have more than a single partition on a DASD that is formatted in the Linux disk layout.

Linux can address the device as a whole as `/dev/dasd<x>`, where `<x>` can be one to four letters that identify the individual DASD (see [“DASD naming scheme”](#) on page 116). Linux can access the partition as `/dev/dasd<x>1`.

You use the **dasdfmt** command (see [“dasdfmt - Format a DASD”](#) on page 556) to format a disk with the Linux disk layout.

CMS disk layout

The CMS disk layout applies only to Linux on z/VM. The disks are formatted with z/VM tools.

Both ECKD or FBA type DASD can have the CMS disk layout. DASD partitions that are formatted with this layout cannot be accessed by traditional mainframe operating systems. Apart from accessing the disks as ECKD or FBA devices, you can also access them using the DASD DIAG access method.

Figure 38 on page 116 illustrates two variants of the CMS disk layout.



Figure 38. CMS disk layout

The first variant contains IPL records, a volume label (CMS1), and a CMS data area. Linux treats DASD like this equivalent to a DASD with the Linux disk layout, where the CMS data area serves as the Linux partition.

The second variant is a CMS reserved volume. In this variant, the DASD was reserved by a CMS RESERVE fn ft fm command. In addition to the IPL records and the volume label, DASD with the CMS disk layout also have CMS metadata. The CMS reserved file serves as the Linux partition.

For both variants of the CMS disk layout, you can have only a single Linux partition. The IPL record, volume label and (where applicable) the CMS metadata, are not intended for use by Linux applications.

Addressing the device and partition is the same for both variants. Linux can address the device as a whole as /dev/dasd<x>, where <x> can be one to four letters that identify the individual DASD (see “DASD naming scheme” on page 116). Linux can access the partition as /dev/dasd<x>1.

“Enabling the DASD device driver to use the DIAG access method” on page 126 describes how to enable DIAG.

Disk layout summary

The available disk layouts differ in their support of device formats, the DASD DIAG access method, and the maximum number of partitions.

Table 15. Disk layout summary

Disk layout	ECKD device format	FBA device format	DIAG access method support (z/VM only)	Maximum number of partitions	Formatting tool
Compatible disk layout	Yes	No	No	3	dasdfmt
Linux disk layout	Yes	No	Yes	1	dasdfmt
CMS (z/VM only)	Yes	Yes	Yes	1	z/VM tools

DASD naming scheme

The DASD naming scheme maps device names and minor numbers to whole DASDs and to partitions.

The DASD device driver uses the major number 94. For each configured device it uses four minor numbers:

- The first minor number always represents the device as a whole; including IPL, VTOC, and label records.
- The remaining three minor numbers represent the up to three partitions.

With 1,048,576 (20-bit) available minor numbers, the DASD device driver can address 262,144 devices.

The DASD device driver uses a device name of the form `dasd<x>` for each DASD. In the name, `<x>` is one to four lowercase letters. [Table 16 on page 117](#) shows how the device names map to the available minor numbers.

Table 16. Mapping of DASD names to minor numbers

Name for device as a whole		Minor number for device as a whole		Number of devices
From	To	From	To	
dasda	dasdz	0	100	26
dasdaa	dasdzz	104	2804	676
dasdaaa	dasdzzz	2808	73108	17,576
dasdaaaa	dasdnwtl	73112	1048572	243,866
Total number of devices:				262,144

The DASD device driver also uses a device name for each partition. The name of the partition is the name of the device as a whole with a 1, 2, or 3 appended to identify the first, second, or third partition. The three minor numbers that follow the minor number of the device as a whole are the minor number for the first, second, and third partition.

Examples

- "dasda" refers to the whole of the first disk in the system and "dasda1", "dasda2", and "dasda3" to the three partitions. The minor number for the whole device is 0. The minor numbers of the partitions are 1, 2, and 3.
- "dasdz" refers to the whole of the 101st disk in the system and "dasdz1", "dasdz2", and "dasdz3" to the three partitions. The minor number for the whole device is 100. The minor numbers of the partitions are 101, 102, and 103.
- "dasdaa" refers to the whole of the 102nd disk in the system and "dasdaa1", "dasdaa2", and "dasdaa3" to the three partitions. The minor number for the whole device is 104. The minor numbers of the partitions are 105, 106, and 107.

DASD device nodes

Ubuntu Server 20.04.1 uses `udev` to create multiple device nodes for each DASD that is online.

Device nodes that are based on device names

`udev` creates device nodes that match the device names that are used by the kernel. These standard device nodes have the form `/dev/<name>`.

The mapping between standard device nodes and the associated physical disk space can change, for example, when you reboot Linux. To ensure that you access the intended physical disk space, you need device nodes that are based on properties that identify a particular DASD.

`udev` creates additional devices nodes that are based on the following information:

- The bus ID of the disk
- The disk label (VOLSER)
- The universally unique identifier (UUID) of the file system on the disk
- If available: The label of the file system on the disk

Device nodes that are based on bus IDs

`udev` creates device nodes of the form

```
/dev/disk/by-path/ccw-<device_bus_id>
```

for whole DASD and

```
/dev/disk/by-path/ccw-<device_bus_id>-part<n>
```

for the <n>th partition.

Device nodes that are based on VOLSERS

udev creates device nodes of the form

```
/dev/disk/by-id/ccw-<volser>
```

for whole DASD and

```
/dev/disk/by-id/ccw-<volser>-part<n>
```

for the <n>th partition.

If you want to use device nodes that are based on VOLSER, be sure that the VOLSERS in your environment are unique (see “Volume label” on page 113).

If you assign the same VOLSER to multiple devices, Linux can still access each device through its standard device node. However, only one of the devices can be accessed through the VOLSER-based device node. Thus, the node is ambiguous and might lead to unintentional data access.

Furthermore, if the VOLSER on the device that is addressed by the node is changed, the previously hidden device is not automatically addressed instead. To reassign the node, you must reboot Linux or force the kernel to reread the partition tables from disks, for example, by issuing:

```
# blockdev --rereadpt /dev/dasdzzz
```

You can assign VOLSERS to ECKD type devices with **dasdfmt** when formatting or later with **fdasd** when creating partitions.

Device nodes that are based on file system information

udev creates device nodes of the form

```
/dev/disk/by-uuid/<uuid>
```

where <uuid> is the UUID for the file system in a partition.

If a file system label exists, udev also creates a node of the form:

```
/dev/disk/by-label/<label>
```

There are no device nodes for the whole DASD that are based on file system information.

If you want to use device nodes that are based on file system labels, be sure that the labels in your environment are unique.

Additional device nodes

/dev/disk/by-id contains additional device nodes for the DASD and partitions, that are all based on a device identifier as contained in the uid attribute of the DASD.

Note: If you want to use device nodes that are based on file system information and VOLSER, be sure that they are unique for the scope of your Linux instance. This information can be changed by a user or it can be copied, for example when backup disks are created. If two disks with the same VOLSER or UUID are online to the same Linux instance, the matching device node can point to either of these disks.

Example

For a DASD that is assigned the device name dasdzzz, has two partitions, a device bus-ID 0.0.b100 (device number 0xb100), VOLSER LNX001, and a UUID 6dd6c43d-a792-412f-a651-0031e631caed for the first and f45e955d-741a-4cf3-86b1-380ee5177ac3 for the second partition, udev creates the following device nodes:

For the whole DASD:

- /dev/dasdzzz (standard device node according to the DASD naming scheme)
- /dev/disk/by-path/ccw-0.0.b100
- /dev/disk/by-id/ccw-LNX001

For the first partition:

- /dev/dasdzzz1 (standard device node according to the DASD naming scheme)
- /dev/disk/by-path/ccw-0.0.b100-part1
- /dev/disk/by-id/ccw-LNX001-part1
- /dev/disk/by-uuid/6dd6c43d-a792-412f-a651-0031e631caed

For the second partition:

- /dev/dasdzzz2 (standard device node according to the DASD naming scheme)
- /dev/disk/by-path/ccw-0.0.b100-part2
- /dev/disk/by-id/ccw-LNX001-part2
- /dev/disk/by-uuid/f45e955d-741a-4cf3-86b1-380ee5177ac3

Accessing DASD by udev-created device nodes

Use udev-created device nodes to access a particular physical disk space, regardless of the device name that is assigned to it.

Example

The following example is based on these assumptions:

- A DASD with bus ID 0.0.b100 has two partitions.
- The standard device node of the DASD is dasdzzz.
- udev creates the following device nodes for a DASD and its partitions:

```
/dev/disk/by-path/ccw-0.0.b100
/dev/disk/by-path/ccw-0.0.b100-part1
/dev/disk/by-path/ccw-0.0.b100-part2
```

Instead of issuing:

```
# fdasd /dev/dasdzzz
```

issue:

```
# fdasd /dev/disk/by-path/ccw-0.0.b100
```

In the file system information in /etc/fstab replace the following specifications:

```
/dev/dasdzzz1 /temp1 ext3 defaults 0 0
/dev/dasdzzz2 /temp2 ext3 defaults 0 0
```

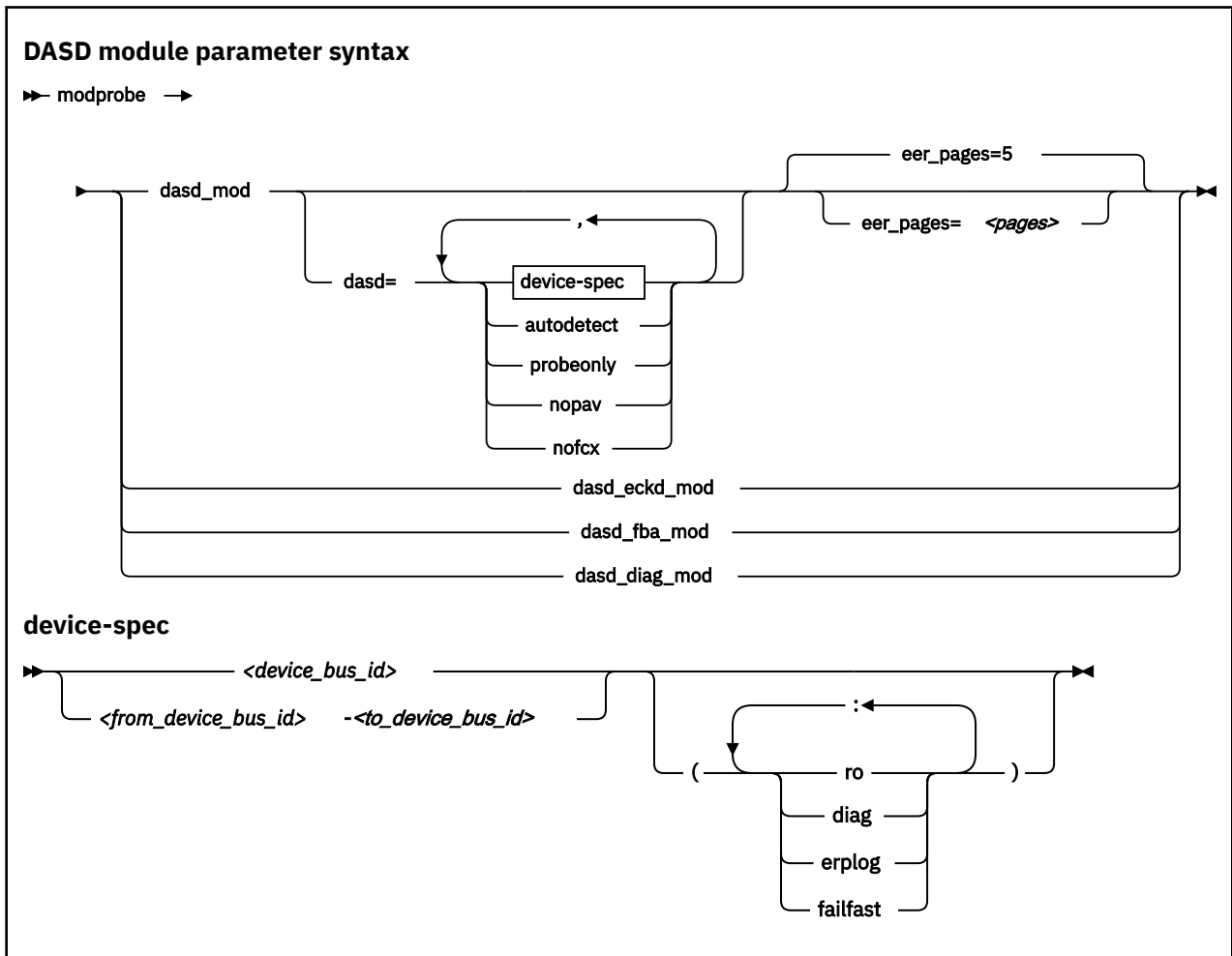
with these specifications:

```
/dev/disk/by-path/ccw-0.0.b100-part1 /temp1 ext3 defaults 0 0
/dev/disk/by-path/ccw-0.0.b100-part2 /temp2 ext3 defaults 0 0
```

You can make similar substitutions with other device nodes that udev provides for you (see [“DASD device nodes”](#) on page 117).

Setting up the DASD device driver

Unless the DASD device driver modules are loaded for you during the boot process, load and configure them with the **modprobe** command.



dasd_mod

loads the device driver base module.

When you are loading the base module, you can specify the `dasd=` parameter.

You can use the `eer_pages` parameter to determine the number of pages that are used for internal buffering of error records.

autodetect

causes the DASD device driver to allocate device names and the corresponding minor numbers to all DASD devices and set them online during the boot process. See [“DASD naming scheme” on page 116](#) for the naming scheme.

The device names are assigned in order of ascending subchannel numbers. Auto-detection can yield confusing results if you change your I/O configuration and reboot, or if your Linux instance runs as a z/VM guest because the devices might appear with different names and minor numbers after rebooting.

probeonly

causes the DASD device driver to reject any "open" syscall with EPERM.

autodetect,probeonly

causes the DASD device driver to assign device names and minor numbers as for auto-detect. All devices regardless of whether they are accessible as DASD return EPERM to any "open" requests.

nopav

suppresses parallel access volume (PAV and HyperPAV) enablement for Linux instances that run in LPAR mode. The **nopav** keyword has no effect for Linux on z/VM.

nofcx

suppresses accessing the storage server with the I/O subsystem in transport mode (also known as High Performance FICON).

<device_bus_id>

specifies a single DASD.

<from_device_bus_id>-<to_device_bus_id>

specifies the first and last DASD in a range. All DASD devices with bus IDs in the range are selected. The device bus-IDs *<from_device_bus_id>* and *<to_device_bus_id>* need not correspond to actual DASD.

(ro)

accesses the specified device or device range in read-only mode.

(diag)

forces the device driver to access the device (range) with the DIAG access method.

(erplog)

enables enhanced error recovery processing (ERP) related logging through syslogd. If **erplog** is specified for a range of devices, the logging is switched on during device initialization.

(failfast)

immediately returns "failed" for an I/O operation when the last path to a DASD is lost.



Attention: Enable immediate failure of I/O requests only in setups where a failed I/O request can be recovered outside the scope of a single DASD (see [“Enabling and disabling immediate failure of I/O requests”](#) on page 130).

dasd_eckd_mod

loads the ECKD module.

dasd_fba_mod

loads the FBA module.

dasd_diag_mod

loads the DIAG module.

If you supply a DASD kernel parameter with device specifications `dasd=<device-list1>,<device-list2> . . .`, the device names and minor numbers are assigned in the order in which the devices are specified. The names and corresponding minor numbers are always assigned, even if the device is not present, or not accessible.

If you use **autodetect** in addition to explicit device specifications, device names are assigned to the specified devices first and device-specific parameters, like **ro**, are observed. The remaining devices are handled as described for **autodetect**.

The DASD base component is required by the other modules. **modprobe** takes care of this dependency for you and ensures that the base module is loaded automatically, if necessary.

Hint: **modprobe** might return before udev has created all device nodes for the specified DASDs. If you need to assure that all nodes are present, for example in scripts, follow the **modprobe** command with:

```
# udevadm settle
```

For command details see the **modprobe** man page.

Examples

The following example specifies a range of DASD devices and two individual DASD devices:

```
modprobe dasd_mod dasd=0.0.7000-0.0.7002,0.0.7005(ro),0.0.7006
```

Table 17 on page 122 shows the resulting allocation of device names and minor numbers:

Table 17. Example mapping of device names and minor numbers to devices

Minor	Name	To access
0	dasda	device 0.0.7000 as a whole
1	dasda1	the first partition on 0.0.7000
2	dasda2	the second partition on 0.0.7000
3	dasda3	the third partition on 0.0.7000
4	dasdb	device 0.0.7001 as a whole
5	dasdb1	the first partition on 0.0.7001
6	dasdb2	the second partition on 0.0.7001
7	dasdb3	the third partition on 0.0.7001
8	dasdc	device 0.0.7002 as a whole
9	dasdc1	the first partition on 0.0.7002
10	dasdc2	the second partition on 0.0.7002
11	dasdc3	the third partition on 0.0.7002
12	dasdd	device 0.0.7005 as a whole
13	dasdd1	the first partition on 0.0.7005 (read-only)
14	dasdd2	the second partition on 0.0.7005 (read-only)
15	dasdd3	the third partition on 0.0.7005 (read-only)
16	dasde	device 0.0.7006 as a whole
17	dasde1	the first partition on 0.0.7006
18	dasde2	the second partition on 0.0.7006
19	dasde3	the third partition on 0.0.7006

The following example specifies that High Performance FICON are to be suppressed for all DASDs:

```
modprobe dasd_mod dasd=nofcx,0.0.7000-0.0.7002,0.0.7005(ro),0.0.7006
```

Working with DASDs

You might have to prepare DASDs for use, configure troubleshooting functions, or configure special device features for your DASDs.

See [“Working with newly available devices”](#) on page 10 to avoid errors when you are working with devices that have become available to a running Linux instance.

- [“Preparing an ECKD type DASD for use”](#) on page 123
- [“Preparing an FBA-type DASD for use”](#) on page 124
- [“Accessing DASD by force”](#) on page 125
- [“Enabling the DASD device driver to use the DIAG access method”](#) on page 126
- [“Using extended error reporting for ECKD type DASD”](#) on page 127
- [“Setting a DASD online or offline”](#) on page 128
- [“Enabling and disabling logging”](#) on page 130
- [“Enabling and disabling immediate failure of I/O requests”](#) on page 130

- [“Setting the timeout for I/O requests” on page 131](#)
- [“Working with DASD statistics in debugfs” on page 132](#)
- [“Accessing full ECKD tracks” on page 136](#)
- [“Handling lost device reservations” on page 138](#)
- [“Reading and resetting the reservation state” on page 139](#)
- [“Setting defective channel paths offline automatically” on page 141](#)
- [“Querying the HPF setting of a channel path” on page 142](#)
- [“Checking for access by other operating system instances” on page 140](#)
- [“Displaying DASD information” on page 143](#)

Preparing an ECKD type DASD for use

Before you can use an ECKD type DASD as a disk for Linux on Z, you must format it with a suitable disk layout. You must then create a file system or define a swap space.

Before you begin

- The base component and the ECKD component of the DASD device driver must have been compiled into the kernel or have been loaded as modules.
- The DASD device driver must have recognized the device as an ECKD type device.
- You need to know the device bus-ID for your DASD.

About this task

If you format the DASD with the compatible disk layout, you must create one, two, or three partitions. You can then use your partitions as swap areas or to create a Linux file system.

Procedure

Perform these steps to prepare the DASD:

1. Issue **lsdasd** (see [“lsdasd - List DASD devices” on page 603](#)) to find out if the device is online.

If necessary, set the device online, see [“Setting a DASD online or offline” on page 128](#).

2. Format the device with the **dasdfmt** command (see [“dasdfmt - Format a DASD” on page 556](#) for details). The formatting process can take hours for large DASDs.

If you want to use the CMS disk layout, and your DASD is already formatted with the CMS disk layout, skip this step.

Tips:

- Use the largest possible block size, ideally 4096; the net capacity of an ECKD DASD decreases for smaller block sizes. For example, a DASD formatted with a block size of 512 byte has only half of the net capacity of the same DASD formatted with a block size of 4096 byte.
- For DASDs that have previously been formatted with **dasdfmt**, use the **dasdfmt** quick format mode.
- Use the **-p** option to display a progress bar.

Example: Assuming that `/dev/dasdzzz` is a valid device node for 0.0.b100:

```
# dasdfmt -b 4096 -p /dev/dasdzzz
```

3. Proceed according to your chosen disk layout:

- If you have formatted your DASD with the Linux disk layout or the CMS disk layout, skip this step and continue with step [“4” on page 124](#). You already have one partition and cannot add further partitions on your DASD.

- If you have formatted your DASD with the compatible disk layout use the **fdasd** command to create up to three partitions (see “[fdasd - Partition a DASD](#)” on page 574 for details).

Example: To start the partitioning tool in interactive mode for partitioning a device `/dev/dasdzzz` issue:

```
# fdasd /dev/dasdzzz
```

If you create three partitions for a DASD `/dev/dasdzzz`, the device nodes for the partitions are `/dev/dasdzzz1`, `/dev/dasdzzz2`, and `/dev/dasdzzz3`.

Result: **fdasd** creates the partitions and updates the partition table (see “[VTOC](#)” on page 114).

4. Depending on the intended use of each partition, create a file system on the partition or define it as a swap space.

- Either create a file system of your choice, for example, with the Linux **mke2fs** command (see the man page for details).

Note: Do not make the block size of the file system smaller than the block size that was used for formatting the disk with the **dasdfmt** command.

Tip: Use the same block size for the file system that has been used for formatting.

Example:

```
# mke2fs -j -b 4096 /dev/dasdzzz1
```

- Or define the partition as a swap space with the **mkswap** command (see the man page for details).

5. Mount each file system to the mount point of your choice in Linux and enable your swap partitions.

Example: To mount a file system in a partition `/dev/dasdzzz1` to a mount point `/mnt` and to enable a swap partition `/dev/dasdzzz2` issue:

```
# mount /dev/dasdzzz1 /mnt
# swapon /dev/dasdzzz2
```

If a block device supports barrier requests, a journaling file systems like ext4 can use this feature to achieve better performance and data integrity. Barrier requests are supported for the DASD device driver and apply to ECKD, FBA, and the DIAG discipline.

Write barriers are used by file systems and are enabled as a file-system specific option. For example, barrier support can be enabled for an ext3 file system by mounting it with the option **-o barrier=1**:

```
# mount -o barrier=1 /dev/dasdzzz1 /mnt
```

Preparing an FBA-type DASD for use

Before you can use an FBA-type DASD as a disk for Linux on Z, you must create a file system or define a swap space.

Before you begin

- The base component and the FBA component of the DASD device driver must have been compiled into the kernel or have been loaded as modules.
- The DASD device driver must have recognized the device as an FBA device.
- You must know the device bus-ID or the device node through which the DASD can be addressed. The DASD device nodes have the form `/dev/dasd<x>`, where `<x>` can be one to four lowercase alphabetic characters.

Procedure

Perform these steps to prepare the DASD:

1. Assure that device nodes exist to address the DASD as a whole and the partition.

Example: To check if the device nodes for a DASD `dasdzy` exist, change to `/dev` and issue:

```
# ls dasdzy*
```

If necessary, create the device nodes. For example, issue:

```
# mknod -m 660 /dev/dasdzy b 94 73104
# mknod -m 660 /dev/dasdzy1 b 94 73105
```

See [Table 16 on page 117](#) for the mapping of device names and minor numbers.

2. Depending on the intended use of the partition, create a file system on it or define it as a swap space.

- Either create a file system of your choice, for example, with the Linux **mke2fs** command (see the man page for details).

Example:

```
# mke2fs -b 4096 /dev/dasdzy1
```

- Or define the partition as a swap space with the **mkswap** command (see the man page for details).

3. Mount the file system to the mount point of your choice in Linux or enable your swap partition.

Tip: Mount file systems on FBA devices that are backed by z/VM VDISKs with the `discard` mount option. This option frees memory when data is deleted from the device.

Examples:

- To mount a file system in a partition `/dev/dasdzy1`, issue:

```
# mount /dev/dasdzy1 /mnt
```

- To mount a VDISK-backed file system in a partition `/dev/dasdzzx1`, and use the `discard` option to free memory when data is deleted, issue:

```
# mount -o discard /dev/dasdzzx1 /mnt
```

What to do next

To access FBA devices, use the DIAG access method (see [“Enabling the DASD device driver to use the DIAG access method” on page 126](#) for more information).

Accessing DASD by force

A Linux instance can encounter DASDs that are locked by another system. Such a DASD is referred to as "externally locked" or "boxed". The Linux instance cannot analyze a DASD while it is externally locked.

About this task

To check whether a DASD has been externally locked, read its availability attribute. This attribute should be "good". If it is "boxed", the DASD has been externally locked. Because a boxed DASD might not be recognized as DASD, it might not show up in the device driver view in `sysfs`. If necessary, use the device category view instead (see [“Device views in `sysfs`” on page 11](#)).



CAUTION: Breaking an external lock can have unpredictable effects on the system that holds the lock.

Procedure

1. Optional: To read the availability attribute of a DASD, issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/availability
```

Example: This example shows that a DASD with device bus-ID 0.0.b110 (device number 0xb110) has been externally locked.

```
# cat /sys/bus/ccw/devices/0.0.b110/availability  
boxed
```

If the DASD is an ECKD type DASD and if you know the device bus-ID, you can break the external lock and set the device online. This means that the lock of the external system is broken with the "unconditional reserve" channel command.

2. To force a boxed DASD online, write `force` to the online device attribute. Issue a command of this form:

```
# echo force > /sys/bus/ccw/devices/<device_bus_id>/online
```

Example: To force a DASD with device number 0xb110 online issue:

```
# echo force > /sys/bus/ccw/devices/0.0.b110/online
```

Results

If the external lock is successfully broken or if the lock has been surrendered by the time the command is processed, the device is analyzed and set online. If it is not possible to break the external lock (for example, because of a timeout, or because it is an FBA-type DASD), the device remains in the boxed state. This command might take some time to complete.

For information about breaking the lock of a DASD that has already been analyzed see [“tunedasd - Adjust low-level DASD settings”](#) on page 666.

Enabling the DASD device driver to use the DIAG access method

Linux on z/VM can use the DIAG access method to access DASDs with the help of z/VM functions.

Before you begin

This section applies only to Linux instances and DASDs for which all of the following conditions are true:

- The Linux instance runs as a z/VM guest.
- The device can be of type ECKD with either LDL or CMS disk layout, or it can be a device of type FBA.
- The module for the DIAG component (`dasd_diag_mod`) must be loaded.
- The module for the component that corresponds to the DASD type (`dasd_eckd_mod` or `dasd_fba_mod`) must be loaded.
- The DASD is offline.
- The DASD does not represent a parallel access volume alias device.

About this task

You can use the DIAG access method to access both ECKD and FBA-type DASD. You use the device's `use_diag` sysfs attribute to enable or switch off the DIAG access method in a system that is online. Set the `use_diag` attribute to 1 to enable the DIAG access method. Set the `use_diag` attribute to 0 to switch off the DIAG access method (this is the default).

Alternatively, you can specify `diag` on the command line, for example during IPL, to force the device driver to access the device (range) with the DIAG access method.

Procedure

Issue a command of this form:

```
# echo <flag> > /sys/bus/ccw/devices/<device_bus_id>/use_diag
```

where `<device_bus_id>` identifies the DASD.

If the DIAG access method is not available and you set the `use_diag` attribute to 1, you cannot set the device online (see “[Setting a DASD online or offline](#)” on page 128).

Note: When switching between an enabled and a disabled DIAG access method on FBA-type DASD, first reinitialize the DASD, for example, with CMS format or by overwriting any previous content. Switching without initialization might cause data-integrity problems.

For more details about DIAG, see *z/VM: CP Programming Services*, SC24-6272.

Example

In this example, the DIAG access method is enabled for a DASD with device number 0xb100.

1. Ensure that the driver is loaded (only applicable when compiled as module):

```
# modprobe dasd_diag_mod
```

2. Identify the sysfs CCW-device directory for the device in question and change to that directory:

```
# cd /sys/bus/ccw/devices/0.0.b100/
```

3. Ensure that the device is offline:

```
# echo 0 > online
```

4. Enable the DIAG access method for this device by writing '1' to the `use_diag` sysfs attribute:

```
# echo 1 > use_diag
```

5. Use the `online` attribute to set the device online:

```
# echo 1 > online
```

Using extended error reporting for ECKD type DASD

Control the extended error reporting feature for individual ECKD type DASD through the `eer_enabled` sysfs attribute. Use the character device of the extended error reporting module to obtain error records.

Before you begin

To use the extended error reporting feature, you need ECKD type DASD.

About this task

The extended error reporting feature is disabled by default.

Procedure

To enable extended error reporting, issue a command of this form:

```
# echo 1 > /sys/bus/ccw/devices/<device_bus_id>/eer_enabled
```

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs.

When it is enabled on a device, a specific set of errors generates records and might have further side effects.

To disable extended error reporting, issue a command of this form:

```
# echo 0 > /sys/bus/ccw/devices/<device_bus_id>/eer_enabled
```

What to do next

You can obtain error records for all DASD for which extended error reporting is enabled from the character device of the extended error reporting module, `/dev/dasd_eer`. The device supports these file operations:

open

Multiple processes can open the node concurrently. Each process that opens the node has access to the records that are created from the time the node is opened. A process cannot access records that were created before the process opened the node.

close

You can close the node as usual.

read

Blocking read and non-blocking read are supported. When a record is partially read and then purged, the next read returns an I/O error -EIO.

poll

The poll operation is typically used with non-blocking read.

Setting a DASD online or offline

Use the **chzdev** command, the **chccwdev** command or the `online` sysfs attribute of the device to set DASDs online or offline.

About this task

When Linux boots, it senses your DASD. Depending on your specification for the "dasd=" parameter, it automatically sets devices online.

When you set a DASD offline, the deregistration process is synchronous, unless the device is disconnected. For disconnected devices, the deregistration process is asynchronous.

Procedure

Use the **chzdev** command ([“chzdev - Configure IBM Z devices” on page 531](#)) to set a DASD online or offline.

Alternatively, use the **chccwdev** command, or write 1 to the device's sysfs `online` attribute to set it online or 0 to set it offline. In contrast to the sysfs attribute, the **chccwdev** command triggers a `cio_settle` for you and waits for the `cio_settle` to complete.

Outstanding I/O requests are canceled when you set a device offline. To wait indefinitely for outstanding I/O requests to complete before setting the device offline, use the **chccwdev** option `--safeoffline` or the sysfs attribute `safe_offline`. The **chzdev** command uses `safe offline` (if available), unless you specify the `--force` option.

Examples

- To set a DASD with device bus-ID 0.0.b100 online, issue:


```
# chzdev -e dasd 0.0.b100
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or one of the following commands:

```
# chccwdev -e dasd 0.0.b100
```

```
# echo 1 > /sys/bus/ccw/devices/0.0.b100/online
```

- To set a DASD with device bus-ID 0.0.b100 offline, issue:

```
# chzdev -d dasd 0.0.b100
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or one of the following commands:

```
# chccwdev -d 0.0.b100
```

```
# echo 0 > /sys/bus/ccw/devices/0.0.b100/online
```

- To complete outstanding I/O requests and then set a DASD with device bus-ID 0.0.4711 offline, issue:

```
# chccwdev -s 0.0.4711
```

or

```
# echo 1 > /sys/bus/ccw/devices/0.0.4711/safe_offline
```

If an outstanding I/O request is blocked, the command might wait forever. Reasons for blocked I/O requests include reserved devices that can be released or disconnected devices that can be reconnected.

1. Try to resolve the problem that blocks the I/O request and wait for the command to complete.
2. If you cannot resolve the problem, issue **chccwdev -d** to cancel the outstanding I/O requests. The data will be lost.

Dynamic attach and detach

You can dynamically attach devices to a running instance of Linux on Z, for example, from z/VM.

When a DASD is attached, Linux attempts to initialize it according to the DASD device driver configuration (see [“Setting up the DASD device driver”](#) on page 120). You can then set the device online. You can automate setting dynamically attached devices online by using CCW hotplug events (see [“CCW hotplug events”](#) on page 18).



Attention: Do not detach a device that is still being used by Linux. Detaching devices might cause the system to hang or crash. Ensure that you unmount a device and set it offline before you detach it.

See [“Working with newly available devices”](#) on page 10 to avoid errors when working with devices that have become available to a running Linux instance.

Be careful to avoid errors when working with devices that have become available to a running Linux instance.

Enabling and disabling logging

Use the `dasd=` kernel or module parameter or use the `erplog sysfs` attribute to enable or disable error recovery processing (ERP) logging.

Procedure

You can enable and disable error recovery processing (ERP) logging on a running system. There are two methods:

- Use the `dasd=` parameter when you load the base module of the DASD device driver.

Example:

To define a device range (0.0.7000-0.0.7005) and enable logging, change the parameter line to contain:

```
dasd=0.0.7000-0.0.7005(erplog)
```

- Use the `sysfs` attribute `erplog` to turn ERP-related logging on or off.

Logging can be enabled for a specific device by writing `1` to the `erplog` attribute.

Example:

```
echo 1 > /sys/bus/ccw/devices/<device_bus_id>/erplog
```

To disable logging, write `0` to the `erplog` attribute.

Example:

```
echo 0 > /sys/bus/ccw/devices/<device_bus_id>/erplog
```

Enabling and disabling immediate failure of I/O requests

Prevent devices in mirror setups from being blocked while paths are unavailable by making I/O requests fail immediately.

About this task

By default, if all path have been lost for a DASD, the corresponding device in Linux waits for one of the paths to recover. I/O requests are blocked while the device is waiting.

If the DASD is part of a mirror setup, this blocking might cause the entire virtual device to be blocked. You can use the `failfast` attribute to immediately return I/O requests as failed while no path to the device is available.



Attention: Use this attribute with caution and only in setups where a failed I/O request can be recovered outside the scope of a single DASD.

Procedure

Use one of these methods:

- You can enable immediate failure of I/O requests when you load the base module of the DASD device driver.

Example:

To define a device range (0.0.7000-0.0.7005) and enable immediate failure of I/O requests specify:

```
dasd=0.0.7000-0.0.7005(failfast)
```

- You can use the sysfs attribute `failfast` of a DASD to enable or disable immediate failure of I/O requests.

To enable immediate failure of I/O requests, write 1 to the `failfast` attribute.

Example:

```
echo 1 > /sys/bus/ccw/devices/<device_bus_id>/failfast
```

To disable immediate failure of I/O requests, write 0 to the `failfast` attribute.

Example:

```
echo 0 > /sys/bus/ccw/devices/<device_bus_id>/failfast
```

Setting the timeout for I/O requests

DASD I/O requests can time out at two levels in the software stack.

About this task

When the DASD device driver receives an I/O request from an application, it issues one or more low-level I/O requests to the affected storage system. Both the initial I/O request from the application and the resulting low-level requests to the storage system can time out. You set the timeout values through two sysfs attributes of the DASD.

expires

specifies the maximum time, in seconds, that the DASD device driver waits for a response to a low-level I/O request from a storage server.

The default for the maximum response time depends on the type of DASD:

ECKD

uses the default that is provided by the storage server.

FBA

300 s

DIAG

50 s

If the maximum response time is exceeded, the DASD device driver cancels the request. Depending on your setup, the DASD device driver might then try the request again, possibly in combination with other recovery actions.

timeout

specifies the time interval, in seconds, within which the DASD device driver must respond to an I/O request from a software layer above it. If the specified time expires before the request is completed, the DASD device driver cancels all related low-level I/O requests to storage systems and reports the request as failed.

This setting is useful in setups where the software layer above the DASD device driver requires an absolute upper limit for I/O requests.

A value of 0 means that there is no time limit. This value is the default.

Procedure

You can use the `expires` and `timeout` attributes of a DASD to change the timeout values for that DASD.

1. To find out the current timeout values, issue commands of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/expires  
# cat /sys/bus/ccw/devices/<device_bus_id>/timeout
```

Example:

```
# cat /sys/bus/ccw/devices/0.0.7008/expires
30
# cat /sys/bus/ccw/devices/0.0.7008/timeout
0
```

In the example, a maximum response time of 30 seconds applies to the storage server for a DASD with bus ID 0.0.7008. No total time limit is set for I/O requests to this DASD.

2. To set different timeout values, issue commands of this form:

```
# echo <max_wait> > /sys/bus/ccw/devices/<device_bus_id>/expires
# echo <total_max> > /sys/bus/ccw/devices/<device_bus_id>/timeout
```

where:

<max_wait>

is the new maximum response time, in seconds, for the storage server. The value must be a positive integer.

<total_max>

is the new maximum total time in seconds. The value must be a positive integer or 0. 0 disables this timeout setting.

<device_bus_id>

is the device bus-ID of the DASD.

Example:

```
# echo 60 > /sys/bus/ccw/devices/0.0.7008/expires
# echo 120 > /sys/bus/ccw/devices/0.0.7008/timeout
```

This example sets timeout values for a DASD with bus ID 0.0.7008. The maximum response time for the storage server is set to 60 seconds and the overall time limit for I/O requests is set to 120 seconds.

Working with DASD statistics in debugfs

Gather DASD statistics and display the data with the **dasdstat** command.

Before you begin

- debugfs is required, but is mounted by default. If you unmounted the file system, remount it before continuing. See [“debugfs” on page xi](#).
- Instead of accessing raw DASD performance data in debugfs, you can use the **dasdstat** command to obtain more structured data (see [“dasdstat - Display DASD performance statistics” on page 561](#)).

About this task

The DASD performance data is contained in the following subdirectories of *<mountpoint>/dasd*, where *<mountpoint>* is the mount point of debugfs:

- A directory `global` that represents all available DASDs taken together.
- For each DASD, one directory with the name of the DASD block device with which the DASD is known to the DASD device driver (for example, `dasda`, `dasdb`, and `dasdc`).
- For each CCW device that corresponds to a DASD, a directory with the bus ID as the name.

Block devices that are not set up for PAV or HyperPAV map to exactly one CCW device and the corresponding directories contain the same statistics.

With PAV or HyperPAV, a bus ID can represent a base device or an alias device. Each base device is associated with a particular block device. The alias devices are not permanently associated with the

same block device. At any one time, a DASD block device is associated with one or more CCW devices. Statistics that are based on bus ID, therefore, show more detail for PAV and HyperPAV setups.

Each of these directories contains a file `statistics` that you can use to perform these tasks:

- Start and stop data gathering.
- Reset statistics counters.
- Read statistics.

To control data gathering at the scope of a directory in `<mountpoint>/dasd`, issue a command of this form:

```
# echo <keyword> > <mountpoint>/dasd/<directory>/statistics
```

Where:

<directory>

is one of the directories in `<mountpoint>/dasd`.

<keyword>

specifies the action to be taken:

on

to start data gathering.

off

to stop data gathering.

reset

to reset the statistics counters.

To read performance data, issue a command of this form:

```
# cat <mountpoint>/dasd/<directory>/statistics
```

Examples for gathering and reading DASD statistics in debugfs

Use the **echo** command to start and stop data gathering for individual devices or across all DASDs. Use the **cat** command to access the raw performance data.

The following examples assume that `debugfs` is mounted at `/sys/kernel/debug`.

- To start data gathering for summary data across all available DASDs:

```
# echo on > /sys/kernel/debug/dasd/global/statistics
```

- To stop data gathering for block device `dasdb`:

```
# echo off > /sys/kernel/debug/dasd/dasdb/statistics
```

- To reset the counters for CCW device `0.0.b301`:

```
# echo reset > /sys/kernel/debug/dasd/0.0.b301/statistics
```

- To read performance data for `dasda`, assuming that the `debugfs` mount point is `/sys/kernel/debug`, issue:

Linear histograms

have a series of 32 integers as the statistics data. The integers represent a histogram, with a linear scale, of the number of requests in the request queue each time a request has been queued. The first integer shows how often the request queue contained zero requests, the second integer shows how often the queue contained one request, and the n-th value shows how often the queue contained n-1 requests.

histogram_ccw_queue_length

is the histogram data for all requests, read and write.

histogram_read_ccw_queue_length

is the histogram data for read requests only.

Logarithmic histograms

have a series of 32 integers as the statistics data. The integers represent a histogram with a logarithmic scale:

- The first integer always represents all measures of fewer than 4 units
- The second integer represents measures of 4 or more but less than 8 units
- The third integer represents measures of 8 or more but less than 16 units
- The n-th integer ($1 < n < 32$) represents measures of 2^n or more but less than 2^{n+1} units
- The 32nd integer represents measures of 2^{32} ($= 4G = 4,294,967,296$) units or more.

The following rows show data for the sum of all requests, read and write:

histogram_sectors

is the histogram data for request sizes. A unit is a 512-byte sector.

histogram_io_times

is the histogram data for the total time that is needed from creating the cqr to its completion in the DASD device driver and return to the block layer. A unit is a microsecond.

histogram_io_times_weighted

is the histogram data of the total time, as measured for `histogram_io_times`, divided by the requests size in sectors. A unit is a microsecond per sector.

This metric is deprecated and there is no corresponding histogram data for read requests.

histogram_time_build_to_ssck

is the histogram data of the time that is needed from creating the cqr to submitting the request to the subchannel. A unit is a microsecond.

histogram_time_ssck_to_irq

is the histogram data of the time that is needed from submitting the request to the subchannel until an interrupt indicates that the request has been completed. A unit is a microsecond.

histogram_time_ssck_to_irq_weighted

is the histogram data of the time that is needed from submitting the request to the subchannel until an interrupt indicates that the request has been completed, divided by the request size in 512-byte sectors. A unit is a microsecond per sector.

This metric is deprecated and there is no corresponding histogram data for read requests.

histogram_time_irq_to_end

is the histogram data of the time that is needed from return of the request from the channel subsystem, until the request is returned to the block layer. A unit is a microsecond.

The following rows show data for read requests only:

histogram_read_sectors

is the histogram data for read request sizes. A unit is a 512 byte sector.

histogram_read_io_times

is the histogram data, for read requests, for the total time needed from creating the cqr to its completion in the DASD device driver and return to the block layer. A unit is a microsecond.

histogram_read_time_build_to_ssch

is the histogram data, for read requests, of the time needed from creating the cqr to submitting the request to the subchannel. A unit is a microsecond.

histogram_read_time_ssch_to_irq

is the histogram data, for read requests, of the time needed from submitting the request to the subchannel until an interrupt indicates that the request has been completed. A unit is a microsecond.

histogram_read_time_irq_to_end

is the histogram data, for read requests, of the time needed from return of the request from the channel subsystem, until the request is returned to the blocklayer. A unit is a microsecond.

Scenario: Verifying that PAV and HPF are used

Use the **dasdstat** command to display DASD performance statistics, including statistics about Parallel Access Volume (PAV) and High Performance FICON (HPF).

Procedure

1. Enable DASD statistics for the device of interest.

Example:

```
# dasdstat -e dasdc
enable statistic "/sys/kernel/debug/dasd/dasdc/statistics"
```

2. Assure that I/O requests are directed to the device.

Hints:

- Access a partition, rather than the whole device, to avoid directing the I/O request towards the first 2 tracks of a CDL formatted DASD. Requests to the first 2 tracks of a CDL formatted DASD are exceptional in that they never use High Performance FICON.
- Assure that a significant I/O load is applied to the device. PAV aliases are used only if multiple I/O requests for the device are processed simultaneously.

Example:

```
# dd if=/dev/dasdc1 of=/dev/null bs=4k count=256
```

3. Look for PAV and HPF in the statistics.

Example:

```
# dasdstat dasdc
-----
statistics data for statistic: dasdc
start time of data collection: Fri Dec 11 14:22:18 CET 2015

7 dasd I/O requests
with 4000 sectors(512B each)
3 requests used a PAV alias device
7 requests used HPF
```

In the example, dasdc uses both Parallel Access Volume and High Performance FICON.

Accessing full ECKD tracks

In raw-track access mode, the DASD device driver accesses full ECKD tracks, including record zero and the count and key data fields.

Before you begin

- This section applies to ECKD type DASD only.

- The DASD has to be offline when you change the access mode.
- The DIAG access method must not be enabled for the device.

About this task

With this mode, Linux can access an ECKD device regardless of the track layout. In particular, the device does not need to be formatted for Linux.

For example, with raw-track access mode Linux can create a backup copy of any ECKD device. Full-track access can also enable a special program that runs on Linux to access and process data on an ECKD device that is not formatted for Linux.

By default, the DASD device driver accesses only the data fields of ECKD devices. In default access mode, you can work with partitions, file systems, and files in the file systems on the DASD.

When using a DASD in raw-track access mode be aware that:

- In memory, each track is represented by 64 KB of data, even if the track occupies less physical disk space. Therefore, a disk in raw-track access mode appears bigger than in default mode.
- Programs must write and should read data in multiples of complete 64 KB tracks. Read requests for less than 64 KB are allowed, but are not optimal as the DASD device driver always reads full tracks. The minimum is a single track. The maximum is eight tracks by default but can be extended to up to 16 tracks.

The maximum number of tracks depends on the maximum number of sectors as specified in the `max_sectors_kb` sysfs attribute of the DASD. This attribute is located in the block device branch of sysfs at `/sys/block/dasd<x>/queue/max_sectors_kb`. In the path, `dasd<x>` is the device name that is assigned by the DASD device driver.

To extend the maximum beyond eight tracks, set the `max_sectors_kb` to the maximum amount of data to be processed in a single read or write operation. For example, to extend the maximum to reading or writing 16 tracks at a time, set `max_sectors_kb` to 1024 (16 x 64).

- Programs must write only valid ECKD tracks of 64 KB.
- Programs must use direct I/O to prevent the Linux block layer from splitting tracks into fragments. The DASD device driver must read a split track multiple times, which might slow down the reading process. Open the block device with option `O_DIRECT` or work with programs that use direct I/O.

For example, the options `iflag=direct` and `oflag=direct` cause **dd** to use direct I/O. When using **dd**, also specify the block size with the `bs=` option. The block size determines the number of tracks that are processed in a single I/O operation. The block size must be a multiple of 64 KB and can be up to 1024 KB. Specifying a larger block size often results in better performance. If you receive disk image data from a pipe, also use the option `iflag=fullblock` to ensure that full blocks are written to the DASD device.

Tools cannot directly work with partitions, file systems, or files within a file system. For example, **fdasd** and **dasdfmt** cannot be used.

Procedure

To change the access mode, issue a command of this form:

```
# echo <switch> > /sys/bus/ccw/devices/<device_bus_id>/raw_track_access
```

where:

<switch>

is 1 to activate raw data access and 0 to deactivate raw data access.

<device_bus_id>

identifies the DASD.

Example

The following example creates a backup of a DASD 0.0.7009 on a DASD 0.0.70a1.

The initial commands ensure that both devices are offline and that the DIAG access method is not enabled for either of them. The subsequent commands activate the raw-track access mode for the two devices and set them both online. The **lsdasd** command that follows shows the mapping between device bus-IDs and device names.

The **dd** command for the copy operation specifies direct I/O for both the input and output device and the block size of 1024 KB. After the copy operation is completed, both devices are set offline. The access mode for the original device is then set back to the default and the device is set back online.

```
#cat /sys/bus/ccw/devices/0.0.7009/online
1
# chccwdev -d 0.0.7009
# cat /sys/bus/ccw/devices/0.0.7009/use_diag
0
# cat /sys/bus/ccw/devices/0.0.70a1/online
0
# cat /sys/bus/ccw/devices/0.0.70a1/use_diag
0
# echo 1 > /sys/bus/ccw/devices/0.0.7009/raw_track_access
# echo 1 > /sys/bus/ccw/devices/0.0.70a1/raw_track_access
# chccwdev -e 0.0.7009,0.0.70a1
# lsdasd 0.0.7009 0.0.70a1
Bus-ID      Status      Name      Device Type BlkSz  Size    Blocks
=====
0.0.7009    active     dasdf     94:20  ECKD  4096   7043MB 1803060
0.0.70a1    active     dasdj     94:36  ECKD  4096   7043MB 1803060
# echo 1024 > /sys/block/dasdf/queue/max_sectors_kb
# echo 1024 > /sys/block/dasdj/queue/max_sectors_kb
# dd if=/dev/dasdf of=/dev/dasdj bs=1024k iflag=direct oflag=direct
# chccwdev -d 0.0.7009,0.0.70a1
# echo 0 > /sys/bus/ccw/devices/0.0.7009/raw_track_access
# chccwdev -e 0.0.7009
```

Handling lost device reservations

A DASD reservation by your Linux instance can be lost if another system unconditionally reserves this DASD.

About this task

This other system then has exclusive I/O access to the DASD for the duration of the unconditional reservation. Such unconditional reservations can be useful for handling error situations where:

- Your Linux instance cannot gracefully release the DASD.
- Another system requires access to the DASD, for example, to perform recovery actions.

After the DASD is released by the other system, your Linux instance might process pending I/O requests and write faulty data to the DASD. How to prevent pending I/O requests from being processed depends on the reservation policy. There are two reservation policies:

ignore

All I/O operations for the DASD are blocked until the DASD is released by the second system. When using this policy, reboot your Linux instance before the other system releases the DASD. This policy is the default.

fail

All I/O operations are returned as failed until the DASD is set offline or until the reservation state is reset. When using this policy, set the DASD offline and back online after the problem is resolved. See [“Reading and resetting the reservation state” on page 139](#) about resetting the reservation state to resume operations.

Procedure

Set the reservation policy with a command of this form:

```
# echo <policy> > /sys/bus/ccw/devices/<device_bus_id>/reservation_policy
```

where:

<device_bus_id>

specifies the DASD.

<policy>

is one of the available policies, `ignore` or `fail`.

Examples

- The command of this example sets the reservation policy for a DASD with bus ID `0.0.7009` to `fail`.

```
# echo fail > /sys/bus/ccw/devices/0.0.7009/reservation_policy
```

- This example shows a small scenario. The first two commands confirm that the reservation policy of the DASD is `fail` and that the reservation has been lost to another system. Assuming that the error that had occurred has already been resolved and that the other system has released the DASD, operations with the DASD are resumed by setting it offline and back online.

```
# cat /sys/bus/ccw/devices/0.0.7009/reservation_policy
fail
# cat /sys/bus/ccw/devices/0.0.7009/last_known_reservation_state
lost
# chccwdev -d 0.0.7009
# chccwdev -e 0.0.7009
```

Reading and resetting the reservation state

How the DASD device driver handles I/O requests depends on the `last_known_reservation_state` sysfs attribute of the DASD.

About this task

The `last_known_reservation_state` attribute reflects the reservation state as held by the DASD device driver and can differ from the actual reservation state. Use the **`tunedasd -Q`** command to find out the actual reservation state. The `last_known_reservation_state` sysfs attribute can have the following values:

none

The DASD device driver has no information about the device reservation state. I/O requests are processed as usual. If the DASD is reserved by another system, the I/O requests remain in the queue until they time out, or until the reservation is released.

reserved

The DASD device driver holds a valid reservation for the DASD and I/O requests are processed as usual. The DASD device driver changes this state if notified that the DASD is no longer reserved to this system. The new state depends on the reservation policy (see [“Handling lost device reservations” on page 138](#)).

ignore

The state is changed to none.

fail

The state is changed to lost.

lost

The DASD device driver had reserved the DASD, but subsequently another system has unconditionally reserved the DASD (see [“Handling lost device reservations” on page 138](#)). The device driver

processes only requests that query the actual device reservation state. All other I/O requests for the device are returned as failed.

When the error that led another system to unconditionally reserve the DASD is resolved and the DASD has been released by this other system, there are two methods for resuming operations.

- Setting the DASD offline and back online.
- Resetting the reservation state of the DASD.



Attention: Do not resume operations by resetting the reservation state unless your system setup maintains data integrity on the DASD despite:

- The I/O errors that are caused by the unconditional reservation
- Any changes to the DASD through the other system

You reset the reservation state by writing `reset` to the `last_known_reservation_state` sysfs attribute of the DASD. Resetting is possible only for the `fail` reservation policy (see [“Handling lost device reservations”](#) on page 138) and only while the value of the `last_known_reservation_state` attribute is `lost`.

To find out the reservation state of a DASD issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/last_known_reservation_state
```

where `<device_bus_id>` specifies the DASD.

Example

The command in this example queries the reservation state of a DASD with bus ID `0.0.7009`.

```
# cat /sys/bus/ccw/devices/0.0.7009/last_known_reservation_state
reserved
```

Checking for access by other operating system instances

Query if a DASD volume is online to another operating system instance by reading the `host_access_count` attribute.

Before you begin

To query the number of operating system instances that use the DASD device, the DASD must be online.

About this task

Storage servers that support this feature knows about the online status of the device on all attached operating system instances in an LPAR (so called hosts). If a DASD device is set online it might potentially be used on another operating system instance. This information can help to reduce the chance for outages or possible data corruption due to concurrent access to DASD volumes from different operating system instances.

Procedure

To check whether a DASD device is being used by other operating system instances, issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/host_access_count
```

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs.

For example, to query how many operating system instances have access to a device `0.0.bf45`, issue:

```
# cat /sys/bus/ccw/devices/0.0.bf45/host_access_count
13
```

In the example, 13 operating system instances have access to the device, including the current Linux instance.

What to do next

To see details for each host connected to the DASD device, use the **lsdasd** command with the `--host-access-list` option. For more information and an example, see [“lsdasd - List DASD devices”](#) on page 603.

Setting defective channel paths offline automatically

Control the removal of a defective channel path through the `path_threshold` and `path_interval` sysfs attributes. If a channel path does not work correctly, it is removed from normal operation if other channel paths are available.

About this task

A channel control check (CCC) is caused by any machine malfunction that affects channel-subsystem controls. An interface control check (IFCC) indicates that an incorrect signal occurred on the channel path. Usually, these errors can be recovered automatically. However, if IFCC or CCC errors occur frequently on a particular channel path, these errors indicate a failure of this channel path. Such a failure leads to performance degradation due to error recovery processing. If other channel paths are available, it might help the overall device performance to exclude the malfunctioning channel path from I/O.

The channel-path error recovery feature applies to devices for which multiple channel paths are operational. By default, the error threshold is 256 and the reset interval is 300 s (5 minutes). Accordingly, a channel path is set offline when the error count has reached 256. If 300 seconds elapse without an error the error count is reset to 0.

You can set different values through the `path_threshold` and `path_interval` sysfs attributes of the device.

Procedure

To exclude a channel path from I/O after a certain number of IFCC or CCC errors within a certain time frame, specify both `path_threshold` and `path_interval`.

1. To specify the number of errors that must occur before the channel path is taken offline, issue a command of this form:

```
# echo <no_of_errors> > /sys/bus/ccw/devices/<device_bus_id>/path_threshold
```

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs.

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs and `<no_of_errors>` is an integer that specifies the error threshold.

To disable detecting defective paths, and to suppress messages about IFCC or CCC errors, set `<no_of_errors>` to 0.

2. To specify the time that must elapse without errors for the counter to be reset, issue a command of this form:

```
# echo <time> > /sys/bus/ccw/devices/<device_bus_id>/path_interval
```

Example

Setting 512 for threshold and 5 minutes (300s) for interval:

```
echo 512 > /sys/bus/ccw/devices/0.0.4711/path_threshold
echo 300 > /sys/bus/ccw/devices/0.0.4711/path_interval
```

This example leads to a deactivation of the channel path after 512 IFCCs or CCCs. When 5 minutes (300s) have passed without IFCCs or CCCs after the last error and the path was not disabled, the counter is reset.

What to do next

After you repair the faulty channel path, set it online again by using the **tunedasd** command with the **-p** option. See [“tunedasd - Adjust low-level DASD settings”](#) on page 666 for details.

Querying the HPF setting of a channel path

Query the High Performance FICON (HPF) state of a channel path through the `hp \mathbb{f}` sysfs attribute. The HPF function can be lost if the device cannot provide the function, or if the channel path is not able to do HPF.

About this task

The HPF channel-path is deactivated if an HPF error occurs indicating that HPF is not available if there are other channel paths available. If no other channel paths are available, the path remains operational with HPF deactivated.

If the device loses HPF functionality, HPF is disabled for all channel paths defined for the device.

Procedure

To query the HPF function for a channel path, issue a command of this form:

```
# lsdasd -l <device_bus_id>
```

Alternatively, you can query the sysfs attribute directly:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/hp $\mathbb{f}$ 
```

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs.

Example

To query the availability of HPF for a device 0.0.4711, issue:

```
lsdasd -l 0.0.4711
0.0.4711/dasdc/94:8
  status:                active
  type:                  ECKD
  ...
  hp $\mathbb{f}$ :                  1
```

This example indicates that HPF is enabled for the device.

Alternatively, read from the `hp \mathbb{f}` sysfs attribute:

```
cat /sys/bus/ccw/devices/0.0.4712/hp $\mathbb{f}$ 
0
```

This example indicates that HPF is disabled for device 0.0.4712.

What to do next

You can now reset the paths to the device. You can use the **tunedasd** command to reset all or one channel path.

To re-validate all paths for one device and if possible reset HPF:

```
# tunedasd --path_reset_all /dev/dasdc
Resetting all chpids for device </dev/dasdc>...
Done.
```

See [“tunedasd - Adjust low-level DASD settings”](#) on page 666 for details.

You can also use sysfs to reset a path. sysfs expects a path mask. For example to reset CHPID 44, you can use **tunedasd**:

```
tunedasd -p 44 /dev/dasde
```

This would be the same as specifying the following in sysfs:

```
echo 08 > /sys/bus/ccw/devices/0.0.9330/path_reset
```

Both commands will reset CHPID 44 (path mask 08).

Displaying DASD information

Use tools to display information about your DASDs, or read the attributes of the devices in sysfs.

About this task

There are several methods to display DASD information:

- Use **lsdasd -l** (see [“lsdasd - List DASD devices”](#) on page 603) to display summary information about the device settings and the device geometry of multiple DASDs.
- Use **dasdview** (see [“dasdview - Display DASD structure”](#) on page 563) to display details about the contents of a particular DASD.
- Read information about a particular DASD from sysfs, as described in this section.

The sysfs representation of a DASD is a directory of the form `/sys/bus/ccw/devices/<device_bus_id>`, where `<device_bus_id>` is the bus ID of the DASD. This sysfs directory contains a number of attributes with information about the DASD.

Table 18. Attributes with DASD information

Attribute	Explanation
alias	<p>1 if the DASD is a parallel access volume (PAV) alias device. 0 if the DASD is a PAV base device or has not been set up as a PAV device.</p> <p>For an example about how to use PAV, see <i>How to Improve Performance with PAV</i>, SC33-8414.</p> <p>This attribute is read-only.</p>
discipline	<p>Indicates the base discipline, ECKD or FBA, that is used to access the DASD. If DIAG is enabled, this attribute might read DIAG instead of the base discipline.</p> <p>This attribute is read-only.</p>
eer_enabled	<p>1 if the DASD is enabled for extended error reporting, 0 if it is not enabled (see “Using extended error reporting for ECKD type DASD” on page 127).</p>

Table 18. Attributes with DASD information (continued)

Attribute	Explanation
erplug	1 if error recovery processing (ERP) logging is enabled, 0 if ERP logging is not enabled (see “Enabling and disabling logging” on page 130).
expires	Indicates the time, in seconds, that the DASD device driver waits for a response to an I/O request from a storage server. If this time expires, the device driver considers a request as failed and cancels it (see “Setting the timeout for I/O requests” on page 131).
failfast	1 if I/O operations are returned as failed immediately when the last path to the DASD is lost. 0 if a wait period for a path to return expires before an I/O operation is returned as failed. See “Enabling and disabling immediate failure of I/O requests” on page 130.
host_access_count	Shows how many operating system instances have access to the device. See “Checking for access by other operating system instances” on page 140.
hpf	1 if High Performance FICON is available for the device. See “Querying the HPF setting of a channel path” on page 142.
last_known_reservation_state	The reservation state as held by the DASD device driver. Values can be: none The DASD device driver has no information about the device reservation state. reserved The DASD device driver holds a valid reservation for the DASD. lost The DASD device driver had reserved the device, but this reservation has been lost to another system. See “Reading and resetting the reservation state” on page 139 for details.
online	1 if the DASD is online, 0 if it is offline (see “Setting a DASD online or offline” on page 128).
path_interval path_threshold	Control the automatic removal of defective channel path (see “Setting defective channel paths offline automatically” on page 141)
raw_track_access	1 if the DASD is in raw-track access mode, 0 if it is in default access mode (see “Accessing full ECKD tracks” on page 136).
readonly	1 if the DASD is read-only, 0 if it can be written to. This attribute is a device driver setting and does not reflect any restrictions that are imposed by the device itself. This attribute is ignored for PAV alias devices.
reservation_policy	Shows the reservation policy of the DASD. Possible values are <code>ignore</code> and <code>fail</code> . See “Handling lost device reservations” on page 138 for details.

Table 18. Attributes with DASD information (continued)

Attribute	Explanation
status	<p>Reflects the internal state of a DASD device. Values can be:</p> <p>unknown Device detection has not started yet.</p> <p>new Detection of basic device attributes is in progress.</p> <p>detected Detection of basic device attributes has finished.</p> <p>basic The device is ready for detecting the disk layout. Low-level tools can set a device to this state when changing the disk layout, for example, when formatting the device.</p> <p>unformatted The disk layout detection found no valid disk layout. The device is ready for use with low-level tools like dasdfmt.</p> <p>ready The device is in an intermediate state.</p> <p>online The device is ready for use.</p>
timeout	<p>Indicates the time, in seconds, within which the DASD device driver must respond to an I/O request from a software layer above it. If the specified time expires before the request is completed, the DASD device driver cancels all related low-level I/O requests to storage systems and reports the request as failed (see “Setting the timeout for I/O requests” on page 131).</p>
uid	<p>A device identifier of the form <code><vendor>.<serial>.<subsystem_id>.<unit_address>.<minidisk_identifier></code> where</p> <p><vendor> is the specification from the vendor attribute.</p> <p><serial> is the serial number of the storage system.</p> <p><subsystem_id> is the ID of the logical subsystem to which the DASD belongs on the storage system.</p> <p><unit_address> is the address that is used within the storage system to identify the DASD.</p> <p><minidisk_identifier> is an identifier that the z/VM system assigns to distinguish between minidisks on the DASD. This part of the uid is only present for Linux on z/VM and if the z/VM version and service level support this identifier.</p> <p>This attribute is read-only.</p>
use_diag	<p>1 if the DIAG access method is enabled, 0 if the DIAG access method is not enabled (see “Enabling the DASD device driver to use the DIAG access method” on page 126). Do not enable the DIAG access method for PAV alias devices.</p>
vendor	<p>Identifies the manufacturer of the storage system that contains the DASD.</p> <p>This attribute is read-only.</p>

There are some more attributes that are common to all CCW devices (see “[Device attributes](#)” on page 9).

Procedure

Issue a command of this form to read an attribute:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/<attribute>
```

where *<attribute>* is one of the attributes of [Table 18 on page 143](#).

Example

The following sequence of commands reads the attributes for a DASD with a device bus-ID 0.0.b100:

```
# cat /sys/bus/ccw/devices/0.0.b100/alias
0
# cat /sys/bus/ccw/devices/0.0.b100/discipline
ECKD
# cat /sys/bus/ccw/devices/0.0.b100/eeer_enabled
0
# cat /sys/bus/ccw/devices/0.0.b100/erplog
0
# cat /sys/bus/ccw/devices/0.0.b100/expires
30
# cat /sys/bus/ccw/devices/0.0.b100/failfast
0
# cat /sys/bus/ccw/devices/0.0.b100/host_access_count
1
# cat /sys/bus/ccw/devices/0.0.b100/hpf
1
# cat /sys/bus/ccw/devices/0.0.b100/last_known_reservation_state
reserved
# cat /sys/bus/ccw/devices/0.0.b100/online
1

# cat /sys/bus/ccw/devices/0.0.b100/path_interval
300
# cat /sys/bus/ccw/devices/0.0.b100/path_threshold
256
# cat /sys/bus/ccw/devices/0.0.b100/raw_track_access
0
# cat /sys/bus/ccw/devices/0.0.b100/readonly
1
# cat /sys/bus/ccw/devices/0.0.b100/reservation_policy
ignore
# cat /sys/bus/ccw/devices/0.0.b100/status
online
# cat /sys/bus/ccw/devices/0.0.b100/timeout
120
# cat /sys/bus/ccw/devices/0.0.b100/uid
IBM.75000000092461.e900.8a
# cat /sys/bus/ccw/devices/0.0.b100/use_diag
1
# cat /sys/bus/ccw/devices/0.0.b100/vendor
IBM
```

Chapter 12. SCSI-over-Fibre Channel device driver

LPAR and z/VM: The SCSI-over-Fibre Channel device driver applies to Linux in LPAR mode and to Linux on z/VM.

The SCSI-over-Fibre Channel device driver for Linux on Z (zfc device driver) supports virtual QDIO-based SCSI-over-Fibre Channel adapters (FCP devices) and attached SCSI devices (LUNs).

Z adapter hardware typically provides multiple channels, with one port each. You can configure a channel to use the Fibre Channel Protocol (FCP). This *FCP channel* is then virtualized into multiple FCP devices. Thus, an FCP device is a virtual QDIO-based SCSI-over-Fibre Channel adapter with a single port.

A single physical port supports multiple FCP devices. Using N_Port ID virtualization (NPIV) you can define virtual ports and establish a one-to-one mapping between your FCP devices and virtual ports (see “N_Port ID Virtualization for FCP channels” on page 151).

On Linux, an FCP device is represented by a CCW device that is listed under `/sys/bus/ccw/drivers/zfc`. Do not confuse FCP devices with SCSI devices. A SCSI device is identified by a LUN.

Features

The zfc device driver supports a wide range of SCSI devices, various hardware adapters, specific topologies, and specific features that depend on the Z hardware.

- Linux on Z can use various SAN-attached SCSI device types, including SCSI disks, tapes, CD-ROMs, and DVDs.
- SAN access through the following hardware adapters:
 - FICON Express16SA (as of z15)
 - FCP Express32S (LinuxONE only, as of LinuxONE II)
 - FICON Express16S+ (as of z14)
 - FICON Express16S (as of z13)

You can order hardware adapters as features for mainframe systems.

See *Fibre Channel Protocol for Linux and z/VM on IBM System z, SG24-7266* for more details about using FCP with Linux on Z.

- The zfc device driver supports switched fabric and point-to-point topologies. You can use either of these topologies, provided that it is supported by your storage server.
- The zfc device driver supports end-to-end data consistency checking.
- The zfc device driver supports the data router hardware feature to improve performance by reducing the path length.

To find out whether a combination of device and IBM mainframe is supported for your distribution, see the individual interoperability matrix for each storage device. The interoperability matrices are available at: www.ibm.com/systems/support/storage/ssic/interoperability.wss

For information about SCSI-3, the Fibre Channel Protocol, and Fibre Channel related information, see www.t10.org and www.t11.org

What you should know about zfc

The zfc device driver is a low-level driver or host-bus adapter driver that supplements the Linux SCSI stack.

[Figure 39 on page 148](#) illustrates how the device drivers work together.

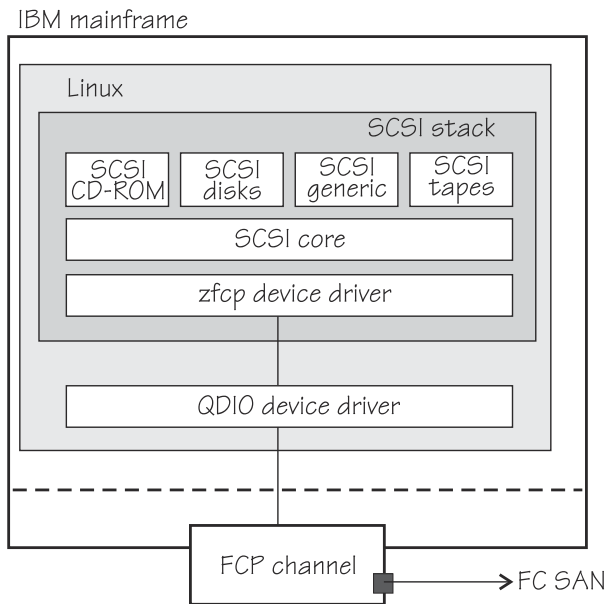


Figure 39. Device drivers that support the FCP environment

For an introduction to the concepts of Fibre Channel Protocol support, and how various SCSI devices can be configured to build an IBM mainframe FCP environment, see *Fibre Channel Protocol for Linux and z/VM on IBM System z*, SG24-7266.

sysfs structures for FCP devices and SCSI devices

FCP devices are CCW devices. In the sysfs device driver view, remote target ports with their LUNs are nested below the FCP devices.

When Linux is booted, it senses the available FCP devices and creates directories of the form:

```
/sys/bus/ccw/drivers/zfc/<device_bus_id>
```

where *<device_bus_id>* is the device bus-ID that corresponds to an FCP device. You use the attributes in this directory to work with the FCP device.

Example: `/sys/bus/ccw/drivers/zfc/0.0.3d0c`

The zfc device driver automatically adds port information when the FCP device is set online and when remote storage ports (*target ports*) are added. Each added target port extends this structure with a directory of the form:

```
/sys/bus/ccw/drivers/zfc/<device_bus_id>/<wwpn>
```

where *<wwpn>* is the worldwide port name (WWPN) of the target port. You use the attributes of this directory to work with the port.

Example: `/sys/bus/ccw/drivers/zfc/0.0.3d0c/0x500507630300c562`

With NPIV-enabled FCP devices, Linux uses automatic LUN scanning by default. The zfc sysfs branch ends with the target port entries. For FCP devices that are not NPIV-enabled, or if automatic LUN scanning is disabled, see “[Configuring SCSI devices](#)” on page 171.

Information about zfc objects and their associated objects in the SCSI stack is distributed over the sysfs tree. To ease the burden of collecting information about zfc devices, ports, units, and their associated SCSI stack objects, a command that is called **lszfc** is provided with s390-tools. See “[lszfc - List zfc devices](#)” on page 627 for more details about the command.

See also “[Mapping the representations of a SCSI device in sysfs](#)” on page 172.

SCSI device nodes

User space programs access SCSI devices through device nodes.

SCSI device names are assigned in the order in which the devices are detected. In a typical SAN environment, this can mean a seemingly arbitrary mapping of names to actual devices that can change between boots. Therefore, using standard device nodes of the form `/dev/<device_name>` where `<device_name>` is the device name that the SCSI stack assigns to a device, can be a challenge.

Ubuntu Server 20.04.1 LTS provides `udev` to create device nodes for you. Use the device nodes to identify the corresponding actual device.

Device nodes that are based on device names

`udev` creates device nodes that match the device names that are used by the kernel. These standard device nodes have the form `/dev/<name>`.

The examples in this section use standard device nodes as assigned by the SCSI stack. These nodes have the form `/dev/sd<x>` for entire disks and `/dev/sd<x><n>` for partitions. In these node names `<x>` represents one or more letters and `<n>` is an integer. For more information about the SCSI device naming scheme, see the `/linux-doc/admin-guide/devices.txt.gz` file in the `linux-doc` package.

To help you identify a particular device, `udev` creates additional device nodes that are based on the device's bus ID, the device label, and information about the file system on the device. The file system information can be a universally unique identifier (UUID) and, if available, the file system label.

Device nodes that are based on bus IDs

`udev` creates device nodes of the form

```
/dev/disk/by-path/ccw-<device_bus_id>-fc-<wwpn>-lun-<lun>
```

for whole SCSI device and

```
/dev/disk/by-path/ccw-<device_bus_id>-fc-<wwpn>-lun-<lun>-part<n>
```

for the `<n>`th partition, where `<wwpn>` is the worldwide port number of the target port and `<lun>` is the logical unit number that represents the target SCSI device.

Device nodes that are based on file system information

`udev` creates device nodes of the form

```
/dev/disk/by-uuid/<uuid>
```

where `<uuid>` is a unique file-system identifier (UUID) for the file system in a partition.

If a file system label is assigned, `udev` also creates a node of the form:

```
/dev/disk/by-label/<label>
```

There are no device nodes for the whole SCSI device that are based on file system information.

Additional device nodes

`/dev/disk/by-id` contains additional device nodes for the SCSI device and partitions that are all based on a unique SCSI identifier that is generated by querying the device.

Example

For a SCSI device that is assigned the device name `sda`, has two partitions labeled `boot` and `SWAP-sda2` respectively, a device bus-ID `0.0.3c1b` (device number `0x3c1b`), and a UUID `7eaf9c95-55ac-4e5e-8f18-065b313e63ca` for the first and `b4a818c8-747c-40a2-bfa2-acaa3ef70ead` for the second partition, `udev` creates the following device nodes:

For the whole SCSI device:

- `/dev/sda` (standard device node according to the SCSI device naming scheme)
- `/dev/disk/by-path/ccw-0.0.3c1b-fc-0x500507630300c562-lun-0x401040ea000000`
- `/dev/disk/by-id/scsi-36005076303ffc56200000000000010ea`
- `/dev/disk/by-id/wwn-0x6005076303ffc562000000000000010ea`

For the first partition:

- /dev/sda1 (standard device node according to the SCSI device naming scheme)
- /dev/disk/by-path/ccw-0.0.3c1b-fc-0x500507630300c562-lun-0x401040ea000000-part1
- /dev/disk/by-uuid/7eaf9c95-55ac-4e5e-8f18-065b313e63ca
- /dev/disk/by-label/boot
- /dev/disk/by-id/scsi-36005076303ffc56200000000000010ea-part1
- /dev/disk/by-id/wwn-0x6005076303ffc56200000000000010ea-part1

For the second partition:

- /dev/sda2 (standard device node according to the SCSI device naming scheme)
- /dev/disk/by-path/ccw-0.0.3c1b-fc-0x500507630300c562-lun-0x401040ea000000-part2
- /dev/disk/by-uuid/b4a818c8-747c-40a2-bfa2-acaa3ef70ead
- /dev/disk/by-label/SWAP-sda2
- /dev/disk/by-id/scsi-36005076303ffc56200000000000010ea-part2
- /dev/disk/by-id/wwn-0x6005076303ffc56200000000000010ea-part2

Device nodes by-uuid use a unique file-system identifier that does not relate to the partition number.

Multipath

Users of SCSI-over-Fibre Channel attached devices should always consider setting up and using redundant paths through their Fibre Channel Storage Area Network.

Path redundancy improves the availability of the LUNs. In Linux, you can set up path redundancy using the device-mapper multipath tool. For information about multipath devices and multipath partitions, see the chapter about multipathing in *How to use FC-attached SCSI devices with Linux on z Systems*, SC33-8413.

Partitioning a SCSI device

You can partition SCSI devices that are attached through an FCP channel in the same way that you can partition SCSI attached devices on other platforms.

About this task

Use the **fdisk** command to partition a SCSI disk, not **fdasd**.

udev creates device nodes for your partitions. For the SCSI disk /dev/sda, the partition device nodes are called /dev/sda1, /dev/sda2, /dev/sda3, and so on.

Example

To partition a SCSI disk with a device node /dev/sda issue:

```
# fdisk /dev/sda
```

zfcpc HBA API (FC-HBA) support

The zfcpc host bus adapter API (HBA API) provides an interface for HBA management clients that run on Z.

As shown in [Figure 40 on page 151](#), the zfcpc HBA API support includes a user space library.

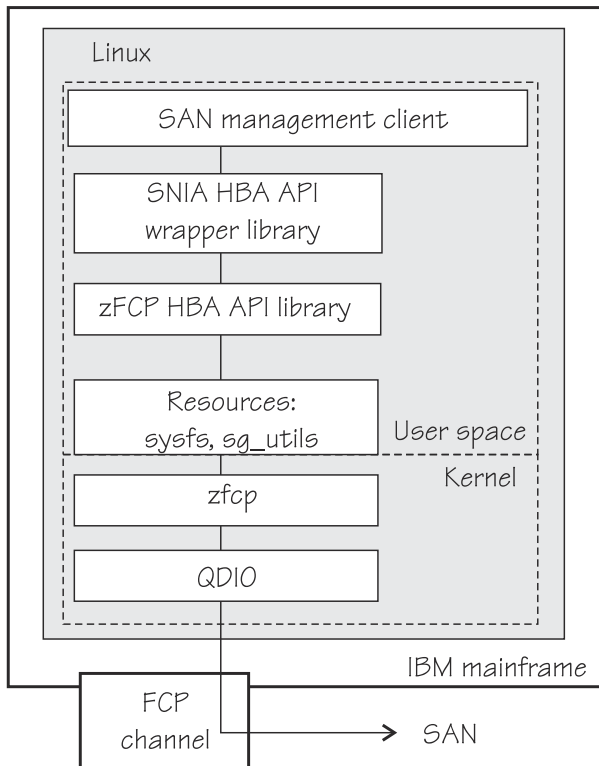


Figure 40. zfc HBA API support modules

The zFCP HBA API support uses the SNIA (Storage Networking Industry Association) library, `hbaapi_src_<x.x>.tgz`, which can be found at

hbaapi.sourceforge.net

The SNIA HBA API library offers a common entry point for applications that manage HBAs. Using the library, an application can use any HBA independently of vendor.

In a Linux on Z environment HBAs are usually virtualized and are shown as *FCP devices*. FCP devices are represented by CCW devices that are listed in `/sys/bus/ccw/drivers/zfc`. Do not confuse FCP devices with SCSI devices. A SCSI device is a disk device that is identified by a LUN.

Technically it is also possible for applications to use the zFCP HBA API library directly, however, this is not the preferred method.

For information about setting up the HBA API support, see [“API provided by the zfc HBA API support” on page 188](#).

N_Port ID Virtualization for FCP channels

Through N_Port ID Virtualization (NPIV), the sole port of an FCP channel appears as multiple, distinct ports with separate port identification.

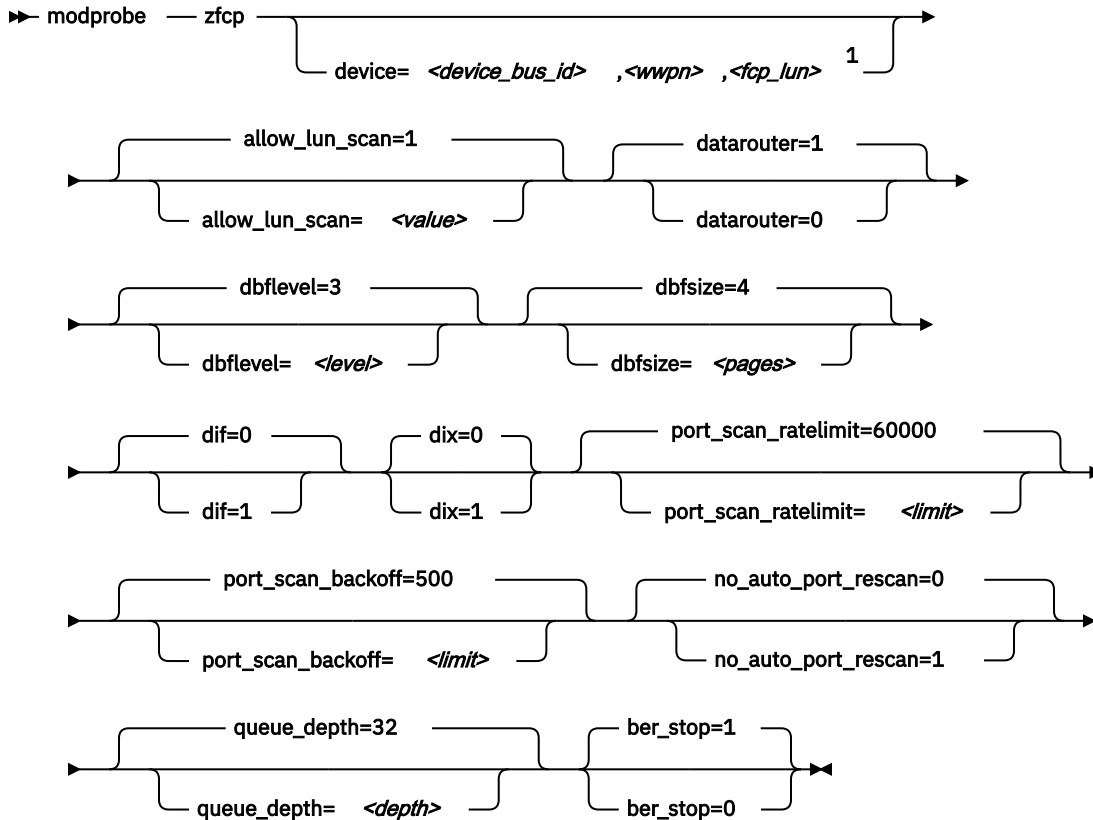
NPIV support can be configured on the SE per CHPID and LPAR for an FCP channel. The `zfc` device driver supports NPIV error messages and adapter attributes. See [“Displaying FCP channel and device information” on page 155](#) for the Fibre Channel adapter attributes.

See also the chapter on NPIV in *How to use FC-attached SCSI devices with Linux on z Systems*, SC33-8413.

Setting up the zfc device driver

Configure the `zfc` device driver through the module parameters. You might also need to install the `zfc` HBA API library.

zfcplib module parameter syntax



Notes:

¹ For experimental use only. Do not use on production systems.

where:

device=<device_bus_id>,<wwpn>,<fcp_lun>



Attention: The device= parameter is reserved for internal use. Do not use.

<device_bus_id>

specifies the FCP device through which the SCSI device is attached.

<wwpn>

specifies the target port through which the SCSI device is attached.

<fcp_lun>

specifies the LUN of the SCSI device.

allow_lun_scan=<value>

disables the automatic LUN scan for FCP devices that run in NPIV mode if set to 0, n, or N. To enable the LUN scanning set the parameter to 1, y, or Y. When the LUN scan is disabled, all LUNs must be configured through the unit_add zfcplib attribute in sysfs. LUN scan is enabled by default.

datarouter=

enables (if set to 1, y, or Y) or disables (if set to 0, n, or N) support for the hardware data routing feature. The default is 1.

Note: The hardware data routing feature becomes active only for FCP devices that are based on adapter hardware with hardware data routing support.

dbflevel=<level>

sets the initial log level of the debug feature. The value is an integer in the range 0 - 6, where greater numbers generate more detailed information. The default is 3.

dbfsize=<pages>

specifies the number of pages to be used for the debug feature.

The debug feature is available for each FCP device and the following areas:

hba

FCP device.

san

Storage Area Network.

rec

Error Recovery Process.

scsi

SCSI

The value given is used for all areas. The default is 4, that is, four pages are used for each area and FCP device. In the following example the dbfsize is increased to 6 pages:

```
dbfsize=6
```

This results in six pages being used for each area and FCP device.

dif=

turns on end-to-end data consistency checking in DIF-only mode if set to 1, y, or Y (and off if set to 0, n, or N). The default is 0.

Interface change: As of Ubuntu 19.04, the `zfc.dif=` kernel parameter enables DIF only and no longer includes DIX. Use the `zfc.dix=` kernel parameter to enable end-to-end data consistency checking in extended mode, with both DIF and DIX.

dix=

turns on end-to-end data consistency checking in extended mode if set to 1, y, or Y (and off if set to 0, n, or N). The default is 0.

Specifying `zfc.dix=1` enables both DIF and DIX. Enabling `zfc.dix=` overrides specifications for `zfc.dif=`.

Note: End-to-end data consistency checking in extended mode is experimental and can cause errors if enabled.

port_scan_ratelimit=<limit>

sets the minimum delay, in milliseconds, between automatic port scans of your Linux instance. The default value is 60000 milliseconds. To turn off the rate limit, specify 0. Use this parameter to avoid frequent scans, while you still ensure that a scan is conducted eventually.

port_scan_backoff=<delay>

sets additional random delay, in milliseconds, in which the port scans of your Linux instance are spread. The default value is 500 milliseconds. To turn off the random delay, specify 0. In an installation with multiple Linux instances, use this attribute for every Linux instance to spread scans to avoid potential multiple simultaneous scans.

no_auto_port_rescan=<value>

turns the automatic port rescan feature off (if set to 1, y, or Y) or on (if set to 0, n, or N). The default is 0. Automatic rescan is always performed when an FCP device is set online and when user-triggered writes to the sysfs attribute `port_rescan` occur.

Note: As of kernel 4.0 and the introduction of `port_scan_backoff` and `port_scan_ratelimit`, use them rather than `no_auto_port_rescan`.

queue_depth=<depth>

specifies the number of commands that can be issued simultaneously to a SCSI device. The default is 32. The value that you set here is used as the default queue depth for new SCSI devices. You can change the queue depth for each SCSI device that uses the `queue_depth` sysfs attribute, see [“Setting the queue depth” on page 179](#).

ber_stop=<value>

sets the mode of handling FCP devices for which the FCP channel reports a bit-error count in excess of its threshold.

If set to 1, y, or Y, the `zfc` device driver shuts down such FCP devices; this is the default. If set to 0, n, or N, such FCP devices keep running and might cause I/O command timeouts with an associated performance degradation.

Kernel message "All paths over this FCP device are disused because of excessive bit errors" indicates that the `zfc` device driver shut down a device because of bit errors. To resolve the problem, ensure that fibre optics on the local fibre link are clean and functional, and that all cables are properly plugged. Then recover the FCP device by writing 0 to its `failed` sysfs attribute, see [“Recovering a failed FCP device” on page 160](#). If recovery through sysfs is not possible, set the CHPID of the device offline and back online on the Support Element.

Working with FCP devices

Set an FCP device online before you attempt to perform any other tasks.

Working with FCP devices comprises the following tasks:

- [“Setting an FCP device online or offline” on page 154](#)
- [“Displaying FCP channel and device information” on page 155](#)
- [“Recovering a failed FCP device” on page 160](#)
- [“Finding out whether NPIV is in use” on page 163](#)
- [“Logging I/O subchannel status information” on page 164](#)

You have the following options for configuring FCP LUNs to attach SCSI devices:

- During installation, use the Ubuntu installer.
- On an installed system, the preferred tool to use for FCP device configuration is the **chzdev** command that is provided with Ubuntu Server 20.04.1. See [Chapter 24, “Persistent device configuration,” on page 313](#) for details.

You can always specify additional `zfc` module parameters as explained in [Chapter 4, “Kernel and module parameters,” on page 23](#).

Setting an FCP device online or offline

By default, FCP devices are offline. Set an FCP device online before you perform any other tasks.

About this task

See [“Working with newly available devices” on page 10](#) to avoid errors when you work with devices that have become available to a running Linux instance.

Important: Configuration changes can directly or indirectly affect information that is required to mount the root file system. Such changes require an update of the `initramfs`, followed by a re-write of the boot record (see [“Rebuilding the initial RAM disk image” on page 82](#)).

Setting an FCP device online registers it with the Linux SCSI stack and updates the symbolic port name for the device on the FC name server. For FCP setups that use NPIV mode, the device bus-ID and the host name of the Linux instance are added to the symbolic port name.

Setting an FCP device online also automatically runs the scan for ports in the SAN and waits for this port scan to complete.

To check if setting the FCP device online was successful, you can use a script that first sets the FCP device online and after this operation completes checks if the WWPN of a target port has appeared in sysfs.

When you set an FCP device offline, the port and LUN subdirectories are preserved. Setting an FCP device offline interrupts the communication between Linux and the FCP channel. After a timeout has expired, the port and LUN attributes indicate that the ports and LUNs are no longer accessible. The transition of the FCP device to the offline state is synchronous, unless the device is disconnected.

For disconnected devices, setting the device offline triggers an asynchronous deregistration process. When this process is completed, the device with its ports and LUNs is no longer represented in sysfs.

When the FCP device is set back online, the SCSI device names and minor numbers are freshly assigned. The mapping of devices to names and numbers might be different from what they were before the FCP device was set offline.

Procedure

For a persistent configuration, use the **chzdev** command.

For a non-persistent configuration, you can use the **chzdev** command with the `-a` option.

Examples

- To set an FCP device with bus ID 0.0.3d0c online, issue:

```
# chzdev -e zfcplib-host 0.0.3d0c
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313. To apply this setting to the running system only, use the **chzdev** command with the `-a` option:

```
# chzdev -e -a zfcplib-host 0.0.3d0c
```

- To set an FCP device with bus ID 0.0.3d0c offline, issue:

```
# chzdev -d zfcplib-host 0.0.3d0c
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313. To apply this setting to the running system only, use the **chzdev** command with the `-a` option:

```
# chzdev -d -a zfcplib-host 0.0.3d0c
```

Displaying FCP channel and device information

For each online FCP device, a number of sysfs attributes provide information about the corresponding FCP channel and FCP device.

Before you begin

The FCP device must be online for the FCP channel information to be valid.

About this task

The following tables summarize the relevant attributes.

Table 19. Attributes with FCP channel information

Attribute	Explanation
card_version	Version number that identifies a particular hardware feature. Same as model in Table 21 on page 156.
fc_security	IBM Fibre Channel Endpoint Security capabilities of the FCP channel. See “Investigating IBM Fibre Channel Endpoint Security” on page 185.
hardware_version	Number that identifies a hardware version for a particular feature. The initial hardware version of a feature is zero. This version indicator is increased only for hardware modifications of the same feature. Appending hardware_version to card_version results in a hierarchical version indication for a physical adapter. Same as hardware_version in Table 21 on page 156.
lic_version	Microcode level. Same as firmware_version in Table 21 on page 156.
peer_wwnn	WWNN of peer for a point-to-point connection.
peer_wwpn	WWPN of peer for a point-to-point connection.
peer_d_id	Destination ID of the peer for a point-to-point connection.

Table 20. Attributes with FCP device information

Attribute	Explanation
in_recovery	Shows if the FCP channel is in recovery (0 or 1).
diag_max_age	Expiration interval, in ms, for cached diagnostic data about the FCP channel (see “Obtaining diagnostic data for FCP channels” on page 161).

For the attributes availability, cmb_enable, and cutype, see “Device directories” on page 9. The status attribute is reserved.

Table 21. Relevant transport class attributes, fc_host attributes

Attribute	Explanation
fabric_name	Name of the attached fabric. The name is a 64-bit hexadecimal value. For z13 and z14 hardware with FICON Express16S or FICON Express16S+ features, this attribute contains valid fabric names only if the following minimum firmware level requirements are met. z13 FICON Express16S: MCL P08424.005, LIC version 0x00000721 z14 FICON Express16S: MCL P42611.008, LIC version 0x10200069 FICON Express16S+: MCL P42625.010, LIC version 0x10300147
firmware_version	Microcode level. Same as lic_version in Table 19 on page 156

Table 21. Relevant transport class attributes, fc_host attributes (continued)

Attribute	Explanation
hardware_version	Number that identifies a hardware version for a particular feature. The initial hardware version of a feature is zero. This version indicator is increased only for hardware modifications of the same feature. Appending hardware_version to card_version results in a hierarchical version indication for a physical adapter. Same as hardware_version in Table 19 on page 156
manufacturer	Manufacturer of the FCP channel. The value is "IBM".
maxframe_size	Maximum frame size.
model	Version number that identifies a particular hardware feature. Same as card_version in Table 19 on page 156
permanent_port_name	WWPN associated with the physical port of the FCP channel.
port_id	A unique ID (N_Port_ID) assigned by the fabric. In an NPIV setup, each virtual port is assigned a different port_id.
port_name	WWPN associated with the FCP device. If N_Port ID Virtualization is not available, the WWPN of the physical port (see permanent_port_name).
port_type	The port type indicates the topology of the port.
serial_number	The 32-byte serial number of the adapter hardware that provides the FCP channel.
speed	Speed of FC link.
supported_classes	Supported FC service class.
supported_speeds	Supported speeds.
symbolic_name	The symbolic port name that is registered with the FC name server.
tgid_bind_type	Target binding type.

Table 22. Relevant transport class attributes, fc_host statistics

Attribute	Explanation
reset_statistics	Writeable attribute to reset statistic counters.
seconds_since_last_reset	Seconds since last reset of statistic counters.
tx_frames	Transmitted FC frames.
tx_words	Transmitted FC words.
rx_frames	Received FC frames.
rx_words	Received FC words.
lip_count	Number of LIP sequences.
nos_count	Number of NOS sequences.
error_frames	Number of frames that are received in error.
dumped_frames	Number of frames that are lost because of lack of host resources.
link_failure_count	Link failure count.

Table 22. Relevant transport class attributes, fc_host statistics (continued)

Attribute	Explanation
loss_of_sync_count	Loss of synchronization count.
loss_of_signal_count	Loss of signal count.
prim_seq_protocol_err_count	Primitive sequence protocol error count.
invalid_tx_word_count	Invalid transmission word count.
invalid_crc_count	Invalid CRC count.
fc_p_input_requests	Number of FCP operations with data input.
fc_p_output_requests	Number of FCP operations with data output.
fc_p_control_requests	Number of FCP operations without data movement.
fc_p_input_megabytes	Megabytes of FCP data input.
fc_p_output_megabytes	Megabytes of FCP data output.

Procedure

Use the **cat** command to read an attribute.

- Issue a command of this form to read an attribute:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/<attribute>
```

where:

<device_bus_id>

specifies an FCP device that corresponds to the FCP channel.

<attribute>

is one of the attributes in [Table 19 on page 156](#) or [Table 20 on page 156](#).

- To read attributes of the associated Fibre Channel host use:

```
# cat /sys/class/fc_host/<host_name>/<attribute>
```

where:

<host_name>

is the ID of the Fibre Channel host.

<attribute>

is one of the attributes in [Table 21 on page 156](#).

- To read statistics attributes of the FCP channel associated with this Fibre Channel host, use:

```
# cat /sys/class/fc_host/<host_name>/statistics/<attribute>
```

where:

<host_name>

is the ID of the Fibre Channel host.

<attribute>

is one of the attributes in [Table 22 on page 157](#).

- For reading diagnostic data for FCP channels, see [“Obtaining diagnostic data for FCP channels” on page 161](#)

Examples

- In this example, information is displayed about an FCP channel that corresponds to an FCP device with bus ID 0.0.3d0c:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d0c/hardware_version
0x00000000
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d0c/lic_version
0x16500124
```

- Alternatively you can use **lszfcp** (see [“lszfcp - List zfcp devices”](#) on page 627) to display attributes of an FCP channel:

```

# lszfcp -b 0.0.3d0c -a
0.0.3d0c host0
Bus = "ccw"
  availability = "good"
  card_version = "0x0008"
  cmb_enable = "0"
  cutype = "1731/03"
  devtype = "1732/03"
  diag_max_age = "5000"
  failed = "0"
  fc_security = "Authentication, Encryption"
  hardware_version = "0x00000000"
  in_recovery = "0"
  lic_version = "0x20600112"
  modalias = "ccw:t1731m03dt1732dm03"
  online = "1"
  peer_d_id = "0x000000"
  peer_wwnn = "0x0000000000000000"
  peer_wwpn = "0x0000000000000000"
  status = "0x5400040b"
  uevent = "DRIVER=zfcp"
Class = "fc_host"
  active_fc4s = "0x00 0x00 0x01 0x00 ..."
  dev_loss_tmo = "60"
  fabric_name = "0x100000051e4a8f00"
  firmware_version = "0x20600112"
  hardware_version = "0x00000000"
  manufacturer = "IBM"
  maxframe_size = "2112 bytes"
  model = "0x0008"
  node_name = "0x5005076400c7ec87"
  permanent_port_name = "0xc05076ffd6801981"
  port_id = "0x671a29"
  port_name = "0xc05076ffd6801e10"
  port_state = "Online"
  port_type = "NPIV VPORT"
  serial_number = "IBM0200000007EC87"
  speed = "16 Gbit"
  supported_classes = "Class 2, Class 3"
  supported_fc4s = "0x00 0x00 0x01 0x00 ..."
  supported_speeds = "8 Gbit, 16 Gbit"
  symbolic_name = "IBM type serial PCHID: 0198 NPIV UlpId: 05600300 DEVNO: 0.0.3d0c NAME:
hostname.domain"
  tgid_bind_type = "wwpn (World Wide Port Name)"
Class = "scsi_host"
  active_mode = "Initiator"
  can_queue = "4096"
  cmd_per_lun = "0"
  eh_deadline = "off"
  host_busy = "0"
  megabytes = "15 0"
  proc_name = "zfcp"
  prot_capabilities = "0"
  prot_guard_type = "0"
  queue_full = "0 2357653"
  requests = "815 0 66"
  seconds_active = "11"
  sg_prot_tablesize = "0"
  sg_tablesize = "574"
  state = "running"
  supported_mode = "Initiator"
  unchecked_isa_dma = "0"
  unique_id = "6400"
  use_blk_mq = "1"
  utilization = "0 0 0"

```

Recovering a failed FCP device

Failed FCP devices are automatically recovered by the zfcp device driver. You can read the `in_recovery` attribute to check whether recovery is under way.

Before you begin

The FCP device must be online.

Procedure

Perform these steps to find out the recovery status of an FCP device and, if needed, start or restart recovery:

1. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/in_recovery
```

The value is 1 if recovery is under way and 0 otherwise. If the value is 0 for a non-operational FCP device, recovery might have failed. Alternatively, the device driver might have failed to detect that the FCP device is malfunctioning.

2. To find out whether recovery failed, read the `failed` attribute. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/failed
```

The value is 1 if recovery failed and 0 otherwise.

3. You can start or restart the recovery process for the FCP device by writing 0 to the `failed` attribute. Issue a command of this form:

```
# echo 0 > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/failed
```

Example

In the following example, an FCP device with a device bus-ID 0.0.3d0c is malfunctioning. The first command reveals that recovery is not already under way. The second command manually starts recovery for the FCP device:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d0c/in_recovery
0
# echo 0 > /sys/bus/ccw/drivers/zfcp/0.0.3d0c/failed
```

Obtaining diagnostic data for FCP channels

Diagnostic data about FCP channels is available as of z14 and FICON Express8S.

About this task

FCP channel diagnostic data is available through sysfs attributes in `/sys/bus/ccw/drivers/zfcp/<device_bus_id>/diagnostics`, where `<device_bus_id>` is the device-bus ID of the FCP device that corresponds to the FCP channel.

After the diagnostic data is retrieved from the FCP channel, it is cached for a specific expiration interval, 5 seconds by default. Reading attributes within this interval results in the cached values. If you read attributes after the cache has expired, current values are retrieved from the FCP channel. You can use the `diag_max_age` sysfs attribute of the FCP device to change the expiration interval.

The following table summarizes the available attributes with diagnostic data.

Table 23. Attributes with diagnostic data about FCP channels

Attribute	Explanation
<code>sfp_invalid</code>	Flag that indicates whether the attributes with physical properties of the FCP channel provide valid (0) or useless (1) data. These attributes are: <code>temperature</code> , <code>vcc</code> , <code>tx_bias</code> , <code>tx_power</code> , and <code>rx_power</code> .
<code>temperature</code>	Temperature of the transceiver. The value is a signed integer in units of 1/256 °C. For example, interpret 1024 as 4 °C.
<code>vcc</code>	Supply voltage of the transceiver. The value is in units of 100 µV.

Table 23. Attributes with diagnostic data about FCP channels (continued)

Attribute	Explanation
tx_bias	Bias current of the transmitter laser. The value is in units of 2 μ A.
tx_power	Coupled output power of the transmitter laser. The value is in units of 0.1 μ W.
rx_power	Optical power that is measured at the receiving element. The value is in units of 0.1 μ W.
optical_port	Flag that indicates whether the transceiver uses an optical element (1) or does not use an optical element (0).
fec_active	Flag that indicates whether forward error correction (FEC) is active (1) or inactive (0).
port_tx_type	Type of the transmitting element. Possible values are: 0 Unknown 1 Short wave 2 Long wave, LC 1310 nm 3 Long wave, LL 1550 nm
connector_type	Connector type. Possible values are: 0 Unknown 1 SFP+
b2b_credit	Number of buffers available for receiving Class 2, or Class 3 frames on the local FC port.

Procedure

- Optional: Verify the validity of the data points with physical properties of the FCP channel.

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/diagnostics/sfp_invalid
```

For valid data, the attribute value must be 0.

- Optional: Adjust the expiration interval of the cached diagnostic data.

- Read the current expiration interval from the `diag_max_age` attribute.

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/diag_max_age
```

The attribute value is the expiration interval in milliseconds.

- Write the value, in milliseconds, of the new expiration interval to the `diag_max_age` attribute.

```
# echo <expiration_interval> > /sys/bus/ccw/drivers/zfcp/<device_bus_id>/diag_max_age
```

Setting the expiration interval to 0 disables caching. The combination of short expiration intervals or disabling caching and frequent reading of diagnostic data can adversely affect performance.

- Read the data of interest.

```
# cat /sys/bus/ccw/drivers/zfcp/<device_bus_id>/diagnostics/<attribute>
```

Where *<attribute>* is one of the attributes of [Table 23 on page 161](#).

Examples

- In this example, the expiration interval for an FCP device that corresponds to bus ID 0.0.3d5c is changed from 5 seconds to 10 seconds.

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d5c/diag_max_age
5000
# echo 10000 > /sys/bus/ccw/drivers/zfcp/0.0.3d5c/diag_max_age
```

- In this example, the first command confirms that the attributes with physical properties of the FCP channel contain valid data. The next commands display data about the transceiver temperature, supply voltage, and type of the transmitting element.

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d5c/diagnostics/sfp_invalid
0
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d5c/diagnostics/temperature
7822
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d5c/diagnostics/vcc
33000
# cat /sys/bus/ccw/drivers/zfcp/0.0.3d5c/diagnostics/connector_type
1
```

The 0 returned from the first command confirms that the physical data is valid. The transceiver temperature is 30.55 °C (7822 / 256) and the supply voltage is 3.3000 V (33000 × 10⁻⁴). The `connector_type` is SFP+ (value 1).

Finding out whether NPIV is in use

The FCP setup runs in NPIV mode if the `port_type` attribute of the FCP device attribute contains the string "NPIV". Alternatively, if the applicable `permanent_port_name` and `port_name` are not the same and are not NULL.

Procedure

Read the `port_type` attribute of the FCP device.

For example:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.1940/host0/fc_host/host0/port_type
NPIV VPORT
```

Alternatively, compare the values of the `permanent_port_name` attribute and the `port_name`.

Tip: You can use **lszfcp** (see [“lszfcp - List zfcp devices” on page 627](#)) to list the FCP device attributes.

Example

```
# lszfcp -b 0.0.3d0c -a
0.0.3d0c host0
Bus = "ccw"
  availability      = "good"
  ...
Class = "fc_host"
  ...
  node_name        = "0x5005076400c829e7"
  permanent_port_name = "0xc05076ffeb001201"
  port_id          = "0x67e35d"
  port_name        = "0xc05076ffeb001b48"
  port_state       = "Online"
  port_type        = "NPIV VPORT"
  ...
  symbolic_name    = "IBM type serial PCHID: 0120 NPIV UlpId: 02600F18  DEVNO: 0.0.3d0c NAME: hostname.domain"
  ...
```

The `port_type` attribute directly indicates that NPIV is used. The example also shows that `permanent_port_name` is different from `port_name` and neither is NULL. The example also shows the `symbolic_name` attribute that shows the symbolic port name that was registered on the FC name server.

Logging I/O subchannel status information

When severe errors occur for an FCP device, the FCP device driver triggers a set of log entries with I/O subchannel status information.

The log entries are available through the SE Console Actions Work Area with the View Console Logs function. In the list of logs, these entries have the prefix 1F00. The content of the entries is intended for support specialists.

Working with target ports

You can scan for ports, display port information, recover a port, or remove a port.

Working with target ports comprises the following tasks:

- [“Scanning for ports” on page 164](#)
- [“Controlling automatic port scanning” on page 165](#)
- [“Displaying port information” on page 167](#)
- [“Recovering a failed port” on page 169](#)
- [“Removing ports” on page 169](#)

Scanning for ports

Newly available target ports are discovered. However, you might want to trigger a port scan to re-create accidentally removed port information or to assure that all ports are present.

Before you begin

The FCP device must be online.

About this task

The `zfc` device driver automatically adds port information to `sysfs` when:

- The FCP device is set online
- Target ports are added to the Fibre Channel fabric, unless the module parameter `no_auto_port_rescan` is set to 1. See [“Setting up the `zfc` device driver” on page 151](#).

Scanning for ports might take some time to complete. Commands that you issue against ports or LUNs while scanning is in progress are delayed and processed when port scanning is completed.

Use the `port_rescan` attribute if a target port was accidentally deleted from the FCP device configuration or if you are unsure whether all ports were added to `sysfs`.

Procedure

Issue a command of this form:

```
# echo 1 > /sys/bus/ccw/drivers/zfc/<device_bus_id>/port_rescan
```

where `<device_bus_id>` specifies the FCP device through which the target ports are attached.

Tip: List the contents of `/sys/bus/ccw/drivers/zfc/<device_bus_id>` to find out which ports are currently configured for the FCP device.

Example

In this example, a port with WWPN 0x500507630303c562 is already configured for an FCP device with bus ID 0.0.3d0c. An additional target port with WWPN 0x500507630300c562 is automatically configured by triggering a port scan.

```
# ls /sys/bus/ccw/drivers/zfcp/0.0.3d0c/0x*
0x500507630303c562
# echo 1 > /sys/bus/ccw/drivers/zfcp/0.0.3d0c/port_rescan
# ls /sys/bus/ccw/drivers/zfcp/0.0.3d0c/0x*
0x500507630303c562
0x500507630300c562
```

Controlling automatic port scanning

Automatic port scanning includes two zfcp parameters that improve the behaviour of Linux instances in SANs. These zfcp parameters are set to default values that work well for most installations. If needed, you can fine-tune the frequency and timing of automatic port scans with the zfcp parameters `port_scan_backoff` and `port_scan_ratelimit`. You can enable automatic port scanning with the zfcp parameter `no_auto_port_rescan=0`. This value is the default.

About this task

In a large installation, where many Linux instances receive the same notifications of SAN changes, multiple instances might trigger scans simultaneously and too frequently. See [Figure 41 on page 165](#)

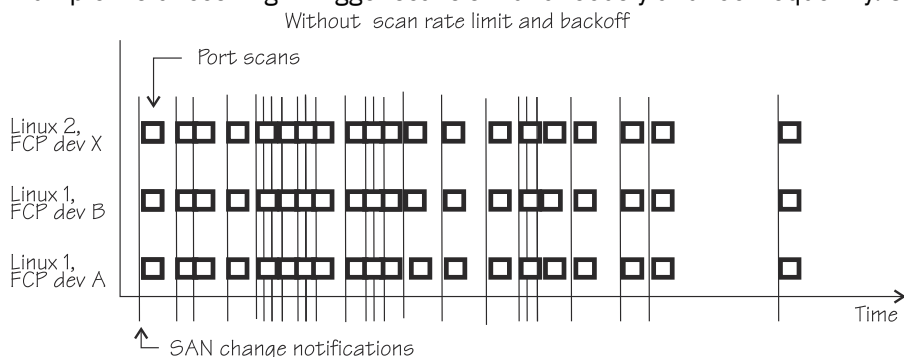


Figure 41. Numerous port scans in a Linux installation

These scans might put unnecessary load on the name server function of fabric switches and potentially result in late or inconclusive results.

You can avoid excessive scanning, yet still ensure that a port scan is eventually conducted. You can control port scanning with the zfcp parameters:

port_scan_ratelimit

sets the minimum delay, in milliseconds, between automatic port scans of your Linux instance. The default value is 60000 milliseconds. To turn off the rate limit, specify 0.

port_scan_backoff

sets an additional random delay, in milliseconds, in which the port scans of your Linux instance are spread. In an installation with multiple Linux instances, use this zfcp parameter for every Linux instance to spread scans to avoid potential multiple simultaneous scans. The default value is 500 milliseconds. To turn off the random delay, specify 0.

Use module parameters (see [“Setting up the zfcp device driver” on page 151](#)). On a running Linux system, you can also query or set these values by using the sysfs attributes with the same names.

Using `port_scan_ratelimit` reduces the number of scans, as shown in [Figure 42 on page 166](#)

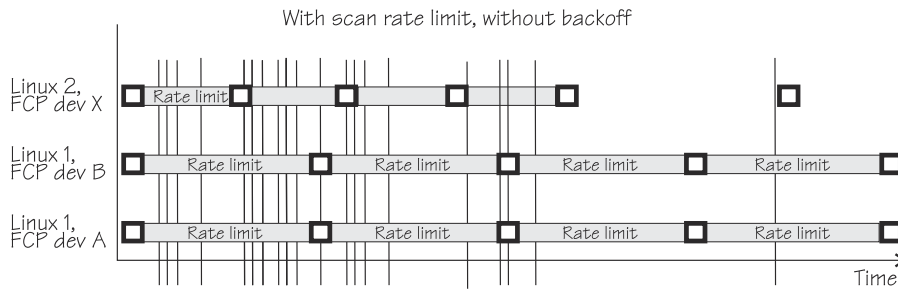


Figure 42. Port scan behavior with scan rate limit.

However, if the rate limit is set to the same value, the scans can still occur almost simultaneously, as for FCP device A and B in Linux 1.

Using `port_scan_backoff` and `port_scan_ratelimit` together delays port scans even further and avoids simultaneous scans, as shown in Figure 43 on page 166. In the figure, FCP devices A and B in Linux 1 have the same rate limit and the same backoff values. The random element in the backoff value causes the scans to occur at slightly different times.

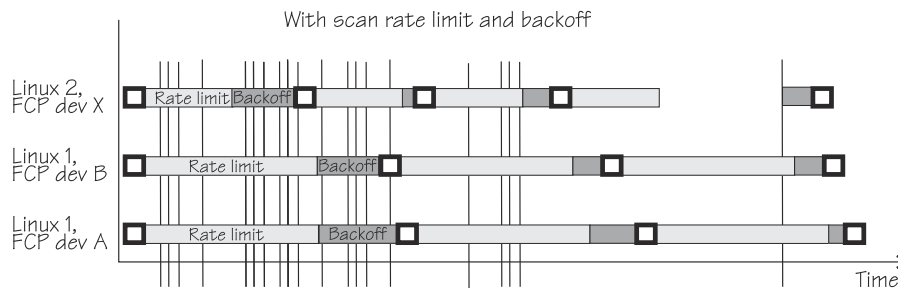


Figure 43. Port scan behavior with backoff and scan rate limit.

Procedure

Use `port_scan_backoff` and `port_scan_ratelimit` together or separately to tune the behavior of port scanning:

- To avoid too frequent scanning, set a minimum wait time between two consecutive scans for the same Linux instance. Use the `port_scan_ratelimit` sysfs attribute.

By default, `port_scan_ratelimit` is turned on and has a value of 60000 milliseconds.

For example, to specify an attribute value of 12 seconds, issue:

```
# echo 12000 > /sys/module/zfcp/parameters/port_scan_ratelimit
```

- To further spread scans over a certain time and thus avoid multiple simultaneous scans, set the `port_scan_backoff` sysfs attribute.

By default, `port_scan_backoff` is turned on and has a value of 500 milliseconds.

For example, to query the setting, issue a command of this form:

```
# cat /sys/module/zfcp/parameters/port_scan_backoff
500
```

To set the attribute to 1 second, issue:

```
# echo 1000 > /sys/module/zfcp/parameters/port_scan_backoff
```

Results

The automatic port scans are delayed by the values specified. If a SAN notification is received during the rate limit time, a port scan is conducted immediately after the delay time passed.

Setting the attributes in sysfs is a useful method on a running system where you want to make dynamic changes. If you want to make the changes persistent across IPLs, you can:

- Use the kernel or module parameter.
- Use the **chzdev** command.

Depending on the port event, one or more of the three zfc parameters are evaluated to schedule a port scan. For example, port scans that are triggered manually through sysfs are not delayed. [Table 24 on page 167](#) shows which events evaluate which zfc parameters.

Event	<code>no_auto_port_rescan</code>	<code>port_scan_backoff</code>	<code>port_scan_ratelimit</code>
FCP device resume	Yes	Yes	No
User sets FCP device online	No	Yes	No
User initiates a port scan	No	No	No
User starts FCP device recovery	Yes	Yes	Yes
Automatic FCP device recovery	Yes	Yes	Yes
SAN change notification	Yes	Yes	Yes

Displaying port information

For each target port, there is a number of read-only sysfs attributes with port information.

About this task

[Table 25 on page 167](#) and [Table 26 on page 167](#) summarize the relevant attributes.

Table 25. zfc-specific attributes with port information within the FCP device sysfs tree

Attribute	Explanation
<code>access_denied</code>	This attribute is obsolete. The value is always 0.
<code>fc_security</code>	IBM Fibre Channel Endpoint Security status of the connection between an FCP device and the port. See “Investigating IBM Fibre Channel Endpoint Security” on page 185 .
<code>in_recovery</code>	Shows if port is in recovery (0 or 1)

Table 26. Transport class attributes with port information

Attribute	Explanation
<code>node_name</code>	WWNN of the remote port (target port).
<code>port_name</code>	WWPN of the remote port.
<code>port_id</code>	Destination ID of the remote port
<code>port_state</code>	State of the remote port.
<code>roles</code>	Role of the remote port (usually FCP target).
<code>scsi_target_id</code>	Linux SCSI ID of the remote port.

Table 26. Transport class attributes with port information (continued)

Attribute	Explanation
supported_classes	Supported classes of service.

Procedure

Use the **cat** command to read an attribute.

- Issue a command of this form to read a zfcplib-specific attribute:

```
# cat /sys/bus/ccw/drivers/zfcplib/<device_bus_id>/<wwpn>/<attribute>
```

where:

<device_bus_id>

specifies the FCP device.

<wwpn>

is the WWPN of the target port.

<attribute>

is one of the attributes in [Table 25 on page 167](#).

- To read transport class attributes of the associated target port, use a command of this form:

```
# cat /sys/class/fc_remote_ports/<rport_name>/<attribute>
```

where:

<rport_name>

is the name of the remote port.

<attribute>

is one of the attributes in [Table 26 on page 167](#).

Tip: With the HBA API package installed, you can also use the **zfcplib_ping** and **zfcplib_show** commands to find out more about your ports. See [“Tools for investigating your SAN configuration” on page 190](#).

Examples

- In this example, information is displayed for a target port 0x500507630300c562 that is attached through an FCP device with bus ID 0.0.3d0c:

```
# cat /sys/bus/ccw/drivers/zfcplib/0.0.3d0c/0x500507630300c562/in_recovery
0
```

- To display transport class attributes of a target port you can use **lszfcplib**:

```
# lszfcplib -p 0x500507630300c562 -a
0.0.3d0c/0x500507630300c562 rport-0:0-0
Class = "fc_remote_ports"
  dev_loss_tmo      = "2147483647"
  fast_io_fail_tmo = "5"
  maxframe_size    = "2048 bytes"
  node_name        = "0x5005076303ffc562"
  port_id          = "0x652113"
  port_name        = "0x500507630300c562"
  port_state       = "Online"
  roles            = "FCP Target"
  scsi_target_id   = "0"
  supported_classes = "Class 2, Class 3"
```


Recovering a failed port

Failed target ports are automatically recovered by the zfcplib device driver. You can read the `in_recovery` attribute to check whether recovery is under way.

Before you begin

The FCP device must be online.

Procedure

Perform these steps to find out the recovery status of a port and, if needed, start or restart recovery:

1. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcplib/<device_bus_id>/<wwpn>/in_recovery
```

where:

<device_bus_id>

specifies the FCP device.

<wwpn>

is the WWPN of the target port.

The value is 1 if recovery is under way and 0 otherwise. If the value is 0 for a non-operational port, recovery might have failed or the device driver might have failed to detect that the port is malfunctioning.

2. To find out whether recovery failed, read the `failed` attribute. Issue a command of this form:

```
# cat /sys/bus/ccw/drivers/zfcplib/<device_bus_id>/<wwpn>/failed
```

The value is 1 if recovery failed, and 0 otherwise.

3. You can start or restart the recovery process for the port by writing 0 to the `failed` attribute. Issue a command of this form:

```
# echo 0 > /sys/bus/ccw/drivers/zfcplib/<device_bus_id>/<wwpn>/failed
```

Example

In the following example, a port with WWPN 0x500507630300c562 that is attached through an FCP device with bus ID 0.0.3d0c is malfunctioning. The first command reveals that recovery is not already under way. The second command manually starts recovery for the port:

```
# cat /sys/bus/ccw/drivers/zfcplib/0.0.3d0c/0x500507630300c562/in_recovery
0
# echo 0 > /sys/bus/ccw/drivers/zfcplib/0.0.3d0c/0x500507630300c562/failed
```

Removing ports

Removing unused ports can save FCP channel resources. Additionally setting the `no_auto_port_rescan` attribute avoids unnecessary attempts to recover unused remote ports.

Before you begin

The FCP device must be online.

About this task

List the contents of `/sys/bus/ccw/drivers/zfcplib/<device_bus_id>` to find out which ports are currently configured for the FCP device.

You cannot remove a port while SCSI devices are configured for it (see [“Configuring SCSI devices”](#) on page 171) or if the port is in use, for example, by error recovery.

Note: The next port scan will attach all available ports, including any previously removed ports. To prevent removed ports from being reattached automatically, use zoning or the `no_auto_port_rescan` module parameter, see [“Setting up the zfcplib device driver”](#) on page 151.

Procedure

Issue a command of this form:

```
# echo <wwpn> > /sys/bus/ccw/drivers/zfcplib/<device_bus_id>/port_remove
```

where:

<device_bus_id>

specifies the FCP device.

<wwpn>

is the WWPN of the port to be removed.

Example

In this example, two ports with WWPN 0x500507630303c562 and 0x500507630300c562 are configured for an FCP device with bus ID 0.0.3d0c. The port with WWPN 0x500507630303c562 is then removed.

```
# ls /sys/bus/ccw/drivers/zfcplib/0.0.3d0c/0x*  
0x500507630303c562  
0x500507630300c562  
# echo 0x500507630303c562 > /sys/bus/ccw/drivers/zfcplib/0.0.3d0c/port_remove  
# ls /sys/bus/ccw/drivers/zfcplib/0.0.3d0c/0x*  
0x500507630300c562
```

Working with SCSI devices

In an NPIV setup with auto lun scan, the SCSI devices are configured automatically. Otherwise, you must configure FCP LUNs to obtain SCSI devices. In both cases, you can configure SCSI devices, display information, and remove SCSI devices.

Working with SCSI devices comprises the following tasks:

- [“Configuring SCSI devices”](#) on page 171
- [“Mapping the representations of a SCSI device in sysfs”](#) on page 172
- [“Displaying information about SCSI devices”](#) on page 177
- [“Setting the queue depth”](#) on page 179
- [“Recovering failed SCSI devices”](#) on page 180
- [“Updating the information about SCSI devices”](#) on page 181
- [“Setting the SCSI command timeout”](#) on page 182
- [“Controlling the SCSI device state”](#) on page 182
- [“Removing SCSI devices”](#) on page 183

Configuring SCSI devices

FCP devices that use NPIV mode detect the LUNs automatically and no configuring is necessary. If needed, configure the LUN manually.

For each FCP device that uses NPIV mode and if you did not disable automatic LUN scanning (see [“Setting up the zfcplib device driver”](#) on page 151), the LUNs are configured for you. In this case, *no* FCP LUN entries are created under `/sys/bus/ccw/drivers/zfcplib/<device_bus_id>/<wwpn>`.

To find out whether an FCP device is using NPIV mode, check the `port_type` attribute. For example:

```
# cat /sys/bus/ccw/drivers/zfcplib/0.0.1901/host*/fc_host/host*/port_type
NPIV VPORT
```

To find out whether automatic LUN scanning is enabled, check the current setting of the module parameter `zfcplib.allow_lun_scan`. The example below shows automatic LUN scanning as turned on.

```
# cat /sys/module/zfcplib/parameters/allow_lun_scan
Y
```

Automatically attached SCSI devices

FCP devices that use NPIV mode detect the LUNs automatically and no configuring is necessary. In this case, *no* FCP LUN entries are created under `/sys/bus/ccw/drivers/zfcplib/<device_bus_id>/<wwpn>`.

What to do next

To check whether a SCSI device is registered, check for a directory with the name of the LUN in `/sys/bus/scsi/devices`. If there is no SCSI device for this LUN, the LUN is not valid in the storage system, or the FCP device is offline in Linux.

Manually configured FCP LUNs and their SCSI devices

For FCP devices that do not use NPIV mode, or if automatic LUN scanning is disabled, FCP LUNs must be configured manually to obtain SCSI devices.

Before you begin

You have the following options for configuring FCP LUNs to attach SCSI devices:

- During installation, use the Ubuntu installer.
- On an installed system, the preferred tool to use for SCSI device configuration is the **chzdev** command that is provided with Ubuntu Server 20.04.1. See [Chapter 24, “Persistent device configuration,”](#) on page 313 for details.

You can always specify additional zfcplib module parameters as explained in [Chapter 4, “Kernel and module parameters,”](#) on page 23

Procedure

If your FCP device does not use NPIV mode, or if you have disabled automatic LUN scanning, proceed as follows:

- Use the **chzdev** command.
To enable a zFCP LUN and create a persistent configuration, issue:

```
# chzdev -e zfcplib-lun <device_bus_id>:<wwpn>:<fcp_lun>
```

where:

<device_bus_id>

specifies the FCP device.

<wwpn>

is the WWPN of the target port.

<fcplun>

is the LUN of the SCSI device to be configured. The LUN is a 16 digit hexadecimal value padded with zeros, for example 0x4010403300000000.

For a non-persistent configuration, use the **chzdev** command with the **-a** option.

This command starts a process with multiple steps:

1. It creates a directory in `/sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>` with the LUN as the directory name. The directory is part of the list of all LUNs to configure. Without NPIV or with auto LUN scanning disabled, zfcp registers only FCP LUNs contained in this list with the Linux SCSI stack in the next step.
2. It initiates the registration of the SCSI device with the Linux SCSI stack. The FCP device must be online for this step.
3. It waits until the Linux SCSI stack registration completes successfully or returns an error. It then returns control to the shell. A successful registration creates a sysfs entry in the SCSI branch (see [“Mapping the representations of a SCSI device in sysfs” on page 172](#)).

Example

Using **chzdev**: In this example, an FCP device with bus ID 0.0.198d is enabled. The WWPN of the target port is 0x50050763070bc5e3. A SCSI device with LUN 0x4006404600000000 is added to the port.

```
# chzdev -e zfcp-lun 0.0.198d:0x50050763070bc5e3:0x4006404600000000
```

This creates a configuration that is persistent across boots. For a non-persistent configuration, use the **chzdev** command with the **-a** option.

What to do next

To check whether a SCSI device is registered for the configured LUN, check for a directory with the name of the LUN in `/sys/bus/scsi/devices`. If there is no SCSI device for this LUN, the LUN is not valid in the storage system, or the FCP device is offline in Linux.

To see which LUNs are currently configured for the port, list the contents of `/sys/bus/ccw/drivers/zfcp/<device_bus_id>/<wwpn>`.

Mapping the representations of a SCSI device in sysfs

Each SCSI device that is configured is represented by multiple directories in sysfs, in particular, within the SCSI branch. Only manually configured LUNs are also represented within the zfcp branch.

You can find the FCP device bus-ID, the target WWPN, and the FCP LUN triplet that corresponds to a SCSI device in two ways: By traversing the sysfs directory tree or by using commands.

Note: The zfcp-specific sysfs attributes `hba_id`, `wwpn`, and `fcplun` are deprecated. Use the methods described here instead to find the addressing of a SCSI device.

About this task

The directory in the sysfs SCSI branch has the following form:

```
/sys/bus/scsi/devices/<scsi_host_no>:0:<scsi_id>:<scsi_lun>
```

where:

<scsi_host_no>

is the SCSI host number that corresponds to the FCP device.

<scsi_id>

is the SCSI ID of the target port.

<scsi_lun>

is the LUN of the SCSI device.

The value for <scsi_lun> depends on the storage device. Often, it is a single-digit number, but for some storage devices it has numerous digits.

For manually configured FCP LUNs, see [“Manually configured FCP LUNs and their SCSI devices”](#) on page 171 for details about the directory in the zfcpc branch.

Before you begin

You must identify the SCSI device in sysfs. For example, use **readlink** to find the path in sysfs with all symbolic links resolved:

```
# readlink -e /sys/bus/scsi/devices/2:0:1:1074741413
/sys/devices/css0/0.0.000a/0.0.1800/host2/rport-2:0-1/target2:0:1/2:0:1:1074741413
```

Using sysfs

Note: Do not assume a stable sysfs structure. The following procedure accommodates changes in sysfs.

This example shows how you can traverse the directory tree to find the FCP device bus-ID, the target WWPN, and the FCP LUN that correspond to a SCSI device name. The example assumes:

SCSI device

2:0:1:1074741413

FCP LUN

0x40a5400f00000000

target WWPN

0x50050763030bd327

FCP device bus-ID

0.0.1800

1. Obtain the hexadecimal FCP LUN.
 - a. Start at the SCSI device directory or anywhere in the subtree below the SCSI device. Ascend the sysfs tree until you find the SCSI device. To do this, test every subdirectory for a symbolic link named "subsystem" that points to a relative directory path whose last entry is scsi. Search for the symbolic link named "subsystem":

```
# ls -dl subsystem
lrwxrwxrwx 1 root root 0 Oct 19 16:08 subsystem -> ../../../../../../../bus/scsi
```

The subsystem symbolic link points to a directory tree where the last subdirectory is scsi.

- b. Confirm that this is a SCSI device by reading the DEVTTYPE line within the uevent attribute. The value must be "scsi_device".

```
# grep "^DEVTTYPE=" uevent
DEVTTYPE=scsi_device
```

The last part of the current directory name is then the decimal SCSI LUN, for example, assuming you have found this directory:

```
# pwd
/sys/devices/css0/0.0.000a/0.0.1800/host2/rport-2:0-1/target2:0:1/2:0:1:1074741413
```

Here, the SCSI LUN is 1074741413.

c. Transform the SCSI LUN to the FCP LUN as follows:

Step	Example
Take decimal LUN in decimal notation:	1074741413
Convert to hexadecimal notation:	0x400f40a5
Pad with 0 from the left to obtain a 64-bit value:	0x00000000400f40a5
Divide into 16-bit blocks (LUN levels):	0x0000 0000 400f 40a5
Reverse the order of the blocks:	0x40a5 400f 0000 0000
The resulting hexadecimal number is the FCP LUN:	0x40a5400f00000000

The Linux kernel function `int_to_scsilun()` in `drivers/scsi/scsi_common.c` converts a decimal SCSI LUN to obtain the hexadecimal FCP LUN according to this algorithm. The conversion works in both directions.

d. Confirm that the path includes a directory `"rport-<no>"`. For example, assuming you have found this directory:

```
# pwd
/sys/devices/css0/0.0.000a/0.0.1800/host2/rport-2:0-1/target2:0:1/2:0:1:1074741413
```

If there is no `rport` directory, the transport is not fibre channel and thus not `zfc`-related. Abandon the search.

Table 27 on page 174 lists the `libudev` functions that you can use instead of manually traversing the `sysfs`.

Name	Task
<code>udev_device_get_parent()</code>	Ascend the <code>sysfs</code> tree.
<code>udev_device_get_subsystem()</code>	Retrieve subsystem name.
<code>udev_device_get_devtype()</code>	Retrieve device type.
<code>udev_device_get_syspath()</code>	Check if <code>rport</code> is a subdirectory.

2. Obtain the target WWPN.

a. Continue ascending the `sysfs` tree the same way until you find the SCSI target. To do this, test every subdirectory for a symbolic link named `"subsystem"` that points to a relative directory path whose last entry is `scsi`. Search for the symbolic link named `"subsystem"`:

```
# ls -dl subsystem
lrwxrwxrwx 1 root root 0 Oct 19 16:08 subsystem -> ../../../../../../../../../../bus/scsi
```

b. Confirm that this is a SCSI target by reading the `DEVTYPE` line within the `uevent` attribute. The value must be `"scsi_target"`.

```
# grep "^DEVTYPE=" uevent
DEVTYPE=scsi_target
```

For example, assuming you have found this directory:

```
# pwd
/sys/devices/css0/0.0.000a/0.0.1800/host2/rport-2:0-1/target2:0:1
```

- c. The SCSI target has a subdirectory `fc_transport`. Descend this subtree until you find a subdirectory that matches the SCSI target name. In this example, you would descend to `fc_transport/target2:0:1`.
- d. In the found target, read the `port_name` attribute:

```
# cat port_name
0x50050763030bd327
```

The value of the `port_name` is the target WWPN.

Name	Task
<code>udev_device_get_parent_with_subsystem_devtype(dev, "scsi", "scsi_target")</code>	Find the SCSI target.
<code>udev_device_new_from_subsystem_sysname(udev_device_get_udev(scsidev), "fc_transport", udev_device_get_sysname(targetdev))</code>	Find a matching target in the <code>fc_transport</code> branch.
<code>udev_device_get_sysattr_value()</code>	Read the <code>port_name</code> attribute.

3. Obtain the FCP device-bus ID. Keep ascending the sysfs tree. Search for the symbolic link "subsystem" that points to a relative path where the last subdirectory is `ccw`.

For example:

```
# ls -dl subsystem
lrwxrwxrwx 1 root root 0 Oct 19 16:08 subsystem -> ../../../../bus/ccw
```

Then the name of the last directory in the current path is the FCP device-bus ID, for example:

```
# pwd
/sys/devices/css0/0.0.000a/0.0.1800
```

Here, `0.0.1800` is the FCP device-bus ID.

Using commands

To map a SCSI device name to its corresponding FCP device bus-ID, target WWPN, and LUN, you can use one of the following commands. The example assumes:

SCSI device

`2:0:1:1074741413`

FCP LUN

`0x40a5400f00000000`

target WWPN

`0x50050763030bd327`

FCP device bus-ID

`0.0.1800`

- Use the **lszfc** with the `-D` option to list the FCP device-bus ID, the target WWPN, and the FCP LUN for all SCSI devices. For example:

```
lszfc -D
....
0.0.1800/0x50050763030bd327/0x40a5400f00000000 2:0:1:1074741413
....
```

For details about the **lszfc** command, see "[lszfc - List zfc devices](#)" on page 627.

- Use the **lszdev** command on device type zfcplun devices, and display the ID and ATTR:scsi_dev columns. For example:

```
# lszdev zfcplun -a -c ID,ATTR:scsi_dev
ID                               ATTR:scsi_dev
...
0.0.1800:0x50050763030bd327:0x40a5400f00000000 2:0:1:1074741413
...
```

For details about the **lszdev** command, see [“lszdev - Display IBM Z device configurations”](#) on page 623.

- Use the **lsscsi** command with the `--transport` and `--lunhex` options in verbose mode to get information about a SCSI device:

```
# lsscsi -xxtv
[2:0:1:0x40a5400f00000000] disk    fc:0x50050763030bd327,0x249900 /dev/sda
  dir: /sys/bus/scsi/devices/2:0:1:1074741413 [/sys/devices/css0/0.0.000a/0.0.1800/host2
                                             /rport-2:0-1/target2:0:1/2:0:1:1074741413]
...
```

For details about the **lsscsi** command, see the man page.

Note: The details of the command output is subject to change. Do not rely on the output always being exactly as shown.

Figure 44 on page 177 illustrates the sysfs structure of a SCSI device and how it corresponds to the **lszfcplun** command output.



Warning: Do not rely on the sysfs structure in the example. The sysfs structure changes without notice.

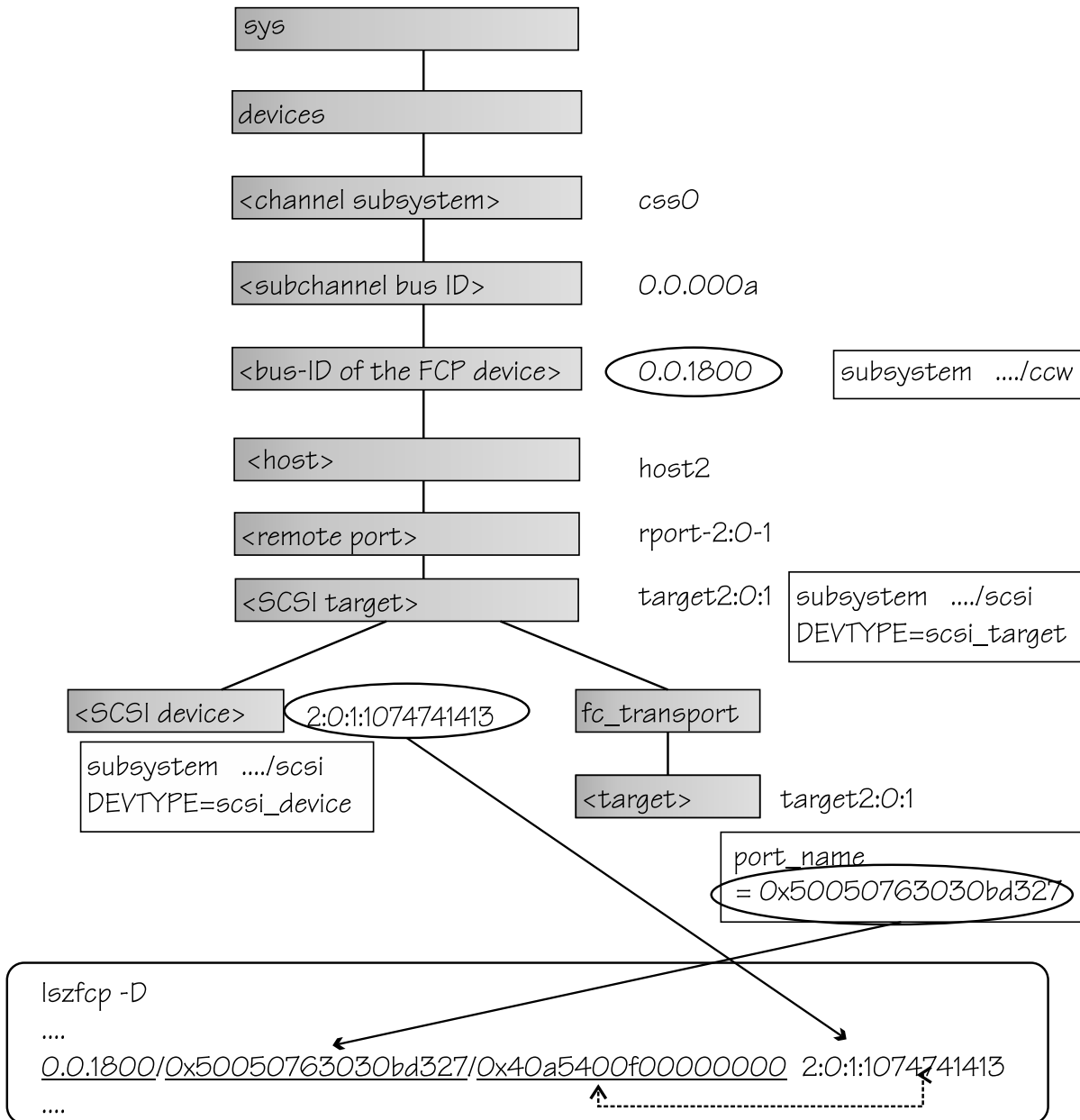


Figure 44. Example SCSI device in sysfs and command output

Displaying information about SCSI devices

For each SCSI device, there is a number of read-only attributes in sysfs that provide information for the device.

About this task

Table 29 on page 178 lists the read-only attributes for manually configured FCP LUNs, including those attributes that indicate whether the device access is restricted by access control software on the FCP channel. These attributes can be found in the zfc branch of sysfs. The path has the form:

```
/sys/bus/ccw/drivers/zfc/<device_bus_id>/<wwpn>/<fc_lun>/<attribute>
```

Table 29. Attributes of manually configured FCP LUNs with device access information

Attribute	Explanation
access_denied	Flag that indicates whether access to the device is restricted by the FCP channel. The value is 1 if access is denied and 0 if access is permitted. If access is denied to your Linux instance, confirm that your SCSI devices are configured as intended. Also, be sure that you really want to share a SCSI device. For shared access to a SCSI device, preferably use NPIV (see “ N_Port ID Virtualization for FCP channels ” on page 151). You might also use different FCP channels or target ports.
access_shared	This attribute is obsolete. The value is always 0.
access_readonly	This attribute is obsolete. The value is always 0.
in_recovery	Shows if unit is in recovery (0 or 1)

Table 30 on page 178 lists further read-only attributes with information about the SCSI device. These attributes can be found in the SCSI branch of sysfs. The path has the form:

```
/sys/class/scsi_device/<device_name>/device/<attribute>
```

Table 30. SCSI device class attributes

Attribute	Explanation
device_blocked	Flag that indicates whether the device is in blocked state (1) or not (0).
iocounterbits	The number of bits used for I/O counters.
iodone_cnt	The number of completed or rejected SCSI commands.
ioerr_cnt	The number of SCSI commands that completed with an error.
iorequest_cnt	The number of issued SCSI commands.
model	The model of the SCSI device, received from inquiry data.
rev	The revision of the SCSI device, received from inquiry data.
scsi_level	The SCSI revision level, received from inquiry data.
type	The type of the SCSI device, received from inquiry data.
vendor	The vendor of the SCSI device, received from inquiry data.
zfcplib_access_denied	Flag that indicates whether access to the device is restricted by the FCP channel. The value is 1 if access is denied and 0 if access is permitted. If access is denied to your Linux instance, confirm that your SCSI devices are configured as intended. Also, be sure that you really want to share a SCSI device. For shared access to a SCSI device, preferably use NPIV (see “ N_Port ID Virtualization for FCP channels ” on page 151). You might also use different FCP channels or target ports.
zfcplib_in_recovery	Shows if unit is in recovery (0 or 1).

Procedure

Use the **lszfcplib** command (see “[lszfcplib - List zfcplib devices](#)” on page 627) to display information about the associated SCSI device.

Alternatively, you can use `sysfs` to read the information. To read attributes of the associated SCSI device, use a command of this form:

```
# cat /sys/class/scsi_device/<device_name>/device/<attribute>
```

where:

<device_name>

is the name of the associated SCSI device.

<attribute>

is one of the attributes in [Table 30 on page 178](#).

Tip: For SCSI-attached tape devices, you can display a summary of this information by using the `lstape` command (see [“lstape - List tape devices” on page 615](#)).

Examples

- In this example, information is displayed for a manually configured FCP LUN with LUN 0x4010403200000000 that is accessed through a target port with WWPN 0x500507630300c562 and is attached through an FCP device with bus ID 0.0.3d0c. For the device access is permitted.

```
# cat /sys/bus/ccw/drivers/zfcpl/0.0.3d0c/0x500507630300c562/0x4010403200000000/access_denied
0
```

For the device to be accessible, the `access_denied` attribute of the target port, 0x500507630300c562, must also be 0 (see [“Displaying port information” on page 167](#)).

- You can use `lszfcp` to display attributes of a SCSI device. The example shows the attributes listed in [Table 30 on page 178](#) as well as other relevant attributes:

```
# lszfcp -l 0x4010403200000000 -a
0.0.3d0c/0x500507630300c562/0x4010403200000000 0:0:0:1077035024
  Class = "scsi_device"
  ...
  device_blocked      = "0"
  ...
  iocounterbits       = "32"
  iodone_cnt          = "0xbe"
  ioerr_cnt           = "0x2"
  iorequest_cnt       = "0xbe"
  ...
  model               = "2107900"
  queue_depth         = "32"
  queue_ramp_up_period = "120000"
  queue_type          = "simple"
  ...
  rev                 = ".166"
  scsi_level          = "6"
  state               = "running"
  timeout             = "30"
  type                = "0"
  uevent              = "DEVTYPE=scsi_device"
  vendor              = "IBM"
  ...
  zfcpl_access_denied = "0"
  zfcpl_failed        = "0"
  zfcpl_in_recovery   = "0"
  zfcpl_status        = "0x54000000"
```

Setting the queue depth

The Linux SCSI code automatically adjusts the queue depth as necessary. Changing the queue depth is usually a storage server requirement.

Before you begin

Check the documentation of the storage server that is used or contact your storage server support group to establish if there is a need to change this setting.

About this task

The value of the `zfcplib.queue_depth` kernel parameter or the `queue_depth` sysfs attribute (see [“Setting up the zfcplib device driver” on page 151](#)) is used as the maximum queue depth of new SCSI devices. You can query the queue depth by issuing a command of this form:

```
# cat /sys/bus/scsi/devices/<SCSI device>/queue_depth
```

Example:

```
# cat /sys/bus/scsi/devices/0:0:19:1086537744/queue_depth
16
```

You can change the maximum queue depth of each SCSI device by writing to the `queue_depth` attribute, for example:

```
# echo 8 > /sys/bus/scsi/devices/0:0:19:1086537744/queue_depth
# cat /sys/bus/scsi/devices/0:0:19:1086537744/queue_depth
8
```

This method is useful on a running system where you want to make dynamic changes. If you want to make the changes persistent across IPLs, you can:

- Use the module parameter `queue_depth` described in [“Setting up the zfcplib device driver” on page 151](#).
- Write a `udev` rule to change the setting for each new SCSI device.
- Use the **chzdev** command. See [“chzdev - Configure IBM Z devices” on page 531](#).

Linux forwards SCSI commands to the storage server until the number of pending commands exceeds the queue depth. If the server lacks the resources to process a SCSI command, Linux queues the command for a later retry and decreases the queue depth counter. Linux then waits for a defined ramp-up period. If no indications of resource problems occur within this period, Linux increases the queue depth counter until reaching the previously set maximum value. To query the current value for the queue ramp-up period in milliseconds:

```
# cat /sys/bus/scsi/devices/0:0:13:1086537744/queue_ramp_up_period
120000
```

To set a new value for the queue ramp-up period in milliseconds:

```
# echo 1000 > /sys/bus/scsi/devices/0:0:13:1086537744/queue_ramp_up_period
```

Recovering failed SCSI devices

Failed SCSI devices are automatically recovered by the zfcplib device driver. You can read the `zfcplib_in_recovery` attribute to check whether recovery is under way.

Before you begin

The FCP device must be online.

Procedure

Perform the following steps to check the recovery status of a failed SCSI device:

1. Check the value of the `zfcplib_in_recovery` attribute. Issue the **lszfcplib** command:

```
# lszfcplib -l <LUN> -a
```

where `<LUN>` is the LUN of the associated SCSI device.

Alternatively, you can issue a command of this form:

```
# cat /sys/class/scsi_device/<device_name>/device/zfcp_in_recovery
```

The value is 1 if recovery is under way and 0 otherwise. If the value is 0 for a non-operational SCSI device, recovery might have failed. Alternatively, the device driver might have failed to detect that the SCSI device is malfunctioning.

2. To find out whether recovery failed, read the `zfcp_failed` attribute. Either use the **lszfcp** command again, or issue a command of this form:

```
# cat /sys/class/scsi_device/<device_name>/device/zfcp_failed
```

The value is 1 if recovery failed, and 0 otherwise.

3. You can start or restart the recovery process for the SCSI device by writing 0 to the `zfcp_failed` attribute. Issue a command of this form:

```
# echo 0 > /sys/class/scsi_device/<device_name>/device/zfcp_failed
```

Example

In the following example, SCSI device 0:0:0:0 is malfunctioning. The first command reveals that recovery is not already under way. The second command manually starts recovery for the SCSI device:

```
# cat /sys/class/scsi_device/0:0:0:0/device/zfcp_in_recovery
0
# echo 0 > /sys/class/scsi_device/0:0:0:0/device/zfcp_failed
```

What to do next

If you manually configured an FCP LUN (see [“Manually configured FCP LUNs and their SCSI devices”](#) on page 171), but did not get a corresponding SCSI device, you can also use the corresponding FCP LUN `sysfs` attributes, `in_recovery` and `failed`, to check on recovery. See [Table 29](#) on page 178.

Updating the information about SCSI devices

Use the `rescan` attribute of the SCSI device to detect changes to a storage device on the storage server that are made after the device was discovered.

Before you begin

The FCP device must be online.

About this task

The initial information about the available SCSI devices is discovered automatically when LUNs first become available.

Procedure

To update the information about a SCSI device issue a command of this form:

```
# echo <string> > /sys/bus/scsi/devices/<scsi_host_no>:0:<scsi_id>:<scsi_lun>/rescan
```

where `<string>` is any alphanumeric string and the other variables have the same meaning as in [“Mapping the representations of a SCSI device in `sysfs`”](#) on page 172.

Example

In the following example, the information about a SCSI device 1:0:18:1086537744 is updated:

```
# echo 1 > /sys/bus/scsi/devices/1:0:18:1086537744/rescan
```

Setting the SCSI command timeout

You can change the timeout if the default is not suitable for your storage system.

Before you begin

The FCP device must be online.

About this task

There is a timeout for SCSI commands. If the timeout expires before a SCSI command completes, error recovery starts. The default timeout is 30 seconds.

To find out the current timeout, read the `timeout` attribute of the SCSI device:

```
# cat /sys/bus/scsi/devices/<scsi_host_no>:0:<scsi_id>:<scsi_lun>/timeout
```

where the variables have the same meaning as in [“Mapping the representations of a SCSI device in sysfs”](#) on page 172.

The attribute value specifies the timeout in seconds.

Procedure

To set a different timeout, enter a command of this form:

```
# echo <timeout> > /sys/bus/scsi/devices/<scsi_host_no>:0:<scsi_id>:<scsi_lun>/timeout
```

where `<timeout>` is the new timeout in seconds.

Example

In the following example, the timeout of a SCSI device 1:0:18:1086537744 is first read and then set to 45 seconds:

```
# cat /sys/bus/scsi/devices/1:0:18:1086537744/timeout
30
# echo 45 > /sys/bus/scsi/devices/1:0:18:1086537744/timeout
```

Controlling the SCSI device state

You can use the `state` attribute of the SCSI device to set a SCSI device back online if it was set offline by error recovery.

Before you begin

The FCP device must be online.

About this task

If the connection to a storage system is working but the storage system has a problem, the error recovery might set the SCSI device offline. This condition is indicated by a message like "Device offlined - not ready after error recovery".

To find out the current state of the device, read the `state` attribute:

```
# cat /sys/bus/scsi/devices/<scsi_host_no>:0:<scsi_id>:<scsi_lun>/state
```

where the variables have the same meaning as in [“Mapping the representations of a SCSI device in sysfs”](#) on page 172. The state can be:

running

The SCSI device can be used for running regular I/O requests.

cancel

The data structure for the device is being removed.

deleted

Follows the `cancel` state when the data structure for the device is being removed.

quiesce

No I/O requests are sent to the device, only special requests for managing the device. This state is used when the system is suspended.

offline

Error recovery for the SCSI device failed.

blocked

Error recovery is in progress and the device cannot be used until the recovery process is completed.

Procedure

Issue a command of this form:

```
# echo running > /sys/bus/scsi/devices/<scsi_host_no>:0:<scsi_id>:<scsi_lun>/state
```

Example

In the following example, SCSI device 1:0:18:1086537744 is offline and is then set online again:

```
# cat /sys/bus/scsi/devices/1:0:18:1086537744/state
offline
# echo running > /sys/bus/scsi/devices/1:0:18:1086537744/state
```

Removing SCSI devices

How to remove a SCSI device depends on whether your environment is set up to use NPIV.

Removing automatically attached SCSI devices

Automatically attached SCSI devices cannot be permanently removed individually.

Removing manually configured FCP LUNs and their SCSI device

Manually remove a SCSI device if your environment is not set up to use NPIV or if you disabled automatic LUN scan. For details about disabling automatic LUN scan, see [“Setting up the zfcpl device driver”](#) on page 151.

Before you begin

The preferred tool to use for SCSI device removal is the **chzdev** command that is provided with Ubuntu Server 20.04.1. See [Chapter 24, “Persistent device configuration,”](#) on page 313 for details.

Procedure

For a persistent configuration, use the **chzdev** command. Issue a command of this form:

```
chzdev -d zfcpl-lun <device_bus_id>:<wwpn>:<fcp_lun>
```

Example

The following example removes a SCSI device with LUN 0x4010403200000000, accessed through a target port with WWPN 0x500507630300c562 and is attached through an FCP device with bus ID 0.0.3d0c.

1. Remove the LUN:

For a persistent configuration, use:

```
# chzdev -d zfcplun 0.0.3d0c:0x500507630300c562:0x4010403200000000
```

For a non-persistent configuration, use the **chzdev** command with the **-a** option.

Confirming end-to-end configurations

You can confirm that specific integrity and security configurations are in place for your connections.

- [“Confirming end-to-end data consistency checking” on page 184](#)
- [“Investigating IBM Fibre Channel Endpoint Security” on page 185](#)

Confirming end-to-end data consistency checking

There are different types of end-to-end data consistency checking, with dependencies on hardware and software.

About this task

End-to-end data consistency checking is based on a data integrity field (DIF) that is added to transferred data blocks. DIF data is used to confirm that a data block originates from the expected source and was not modified during the transfer between the storage system and the FCP device. The SCSI Block Commands (T10 SBC) standard defines several types of DIF. Linux data integrity extension (DIX) builds on DIF to extend consistency checking, for example, to the operating system, middleware, or an application.

The zfcpl device driver supports the following modes of end-to-end data consistency checking:

- The FCP device calculates and checks a DIF checksum (DIF type 1)

Enable this mode with the `zfcpl.dif= kernel` or `dif= module` parameter.

Interface change: As of kernel 5.0, the `zfcpl.dif= kernel` parameter enables DIF only and no longer includes DIX. Use the `zfcpl.dix= kernel` parameter to enable end-to-end data consistency checking in extended mode, with both DIF and DIX.

- The Linux block integrity layer calculates and checks a TCP/IP checksum, which the FCP device then translates to a DIF checksum (DIX type 1 with DIF type 1)

Enable this mode with the `zfcpl.dix= kernel` or `dix= module` parameter.

Note: End-to-end data consistency checking in extended mode is experimental. SCSI disks for which this mode is enabled must be accessed with direct I/O. Direct I/O requires direct access through the block device or through a file system that fully supports end-to-end data consistency checking in extended mode. For example, XFS provides this support. Expect error messages about invalid checksums when you use other access methods.

For more information about the kernel or module parameters that control the end-to-end data consistency checking, see [“Setting up the zfcpl device driver” on page 151](#).

With end-to-end data consistency checking for SCSI disks enabled, Linux automatically discovers which FCP devices and which SCSI disks support end-to-end data consistency checking. No further setup is required.

For SCSI disks for which end-to-end data consistency checking is used, there is a `sysfs` directory

```
/sys/block/sd<x>/integrity
```

In the path, `sd<x>` is the standard name of the block device that corresponds to the SCSI disk.

End-to-end data consistency checking is used only if all of the following components support end-to-end data consistency checking:

SCSI disk

Check your storage server documentation about T10 DIF support and any restrictions.

IBM Z hardware

IBM Z FCP adapter hardware supports end-to-end data consistency checking as of FICON Express8.

Hypervisor

For Linux on z/VM, you require a z/VM version with guest support for end-to-end data consistency checking.

FCP device

Check your FCP adapter hardware documentation about the support and any restrictions. For example, end-to-end data consistency checking might be supported only for disks with 512-byte block size.

Read the `prot_capabilities` `sysfs` attribute of the SCSI host that is associated with an FCP device to find out about its end-to-end data consistency checking support. The following values are possible:

0

The FCP device does not support end-to-end data consistency checking.

1

The FCP device supports DIF type 1.

17

The FCP device supports DIX type 1 with DIF type 1.

Procedure

Issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/host<n>/scsi_host/host<n>/prot_capabilities
```

where `<device_bus_id>` identifies the FCP device and `<n>` is an integer that identifies the corresponding SCSI host.

Example

```
# cat /sys/bus/ccw/devices/0.0.1940/host0/scsi_host/host0/prot_capabilities
1
```

Investigating IBM Fibre Channel Endpoint Security

You can check whether the connections between your FCP devices and remote ports use authentication and encryption.

About this task

You can investigate two aspects of IBM Fibre Channel Endpoint Security for your connections:

- The capabilities of your FCP device, which depend on your adapter hardware with its FCP channels.
- The status of your connections between your FCP devices and remote ports.

For information about configuring IBM Fibre Channel Endpoint Security, see the Redbooks® publication *IBM Fibre Channel Endpoint Security for IBM DS8900F and IBM Z*, SG24-8455.

Procedure

Display the IBM Fibre Channel Endpoint Security information for your environment by issuing an **lszdev** command. Use command options to read the `fc_security` attributes for your Fibre Channel hosts and LUNs as shown in the following example:

```
# lszdev zfc -a -c TYPE,ID,ATTR:fc_security
TYPE      ID                                ATTR:fc_security
zfc-host  0.0.5150                          Authentication, Encryption
zfc-lun   0.0.5150:0x500507630400120c:0x4081402000000000 Authentication
zfc-lun   0.0.5150:0x500507630401120c:0x4081402000000000 Encryption
```

In the output, `zfc-host` lines show information for your FCP devices:

Authentication

The FCP device supports authentication.

Encryption

The FCP device supports encryption.

unsupported

The FCP device does not support IBM Fibre Channel Endpoint Security.

none

The FCP device does not report any IBM Fibre Channel Endpoint Security capabilities.

unknown

The IBM Fibre Channel Endpoint Security capabilities of the FCP device are not known.

In the output, `zfc-lun` lines show the current state of IBM Fibre Channel Endpoint Security of the connection between the FCP device and the FC remote port used to access the LUN:

Authentication

The connection was authenticated.

Encryption

The connection uses encryption.

unsupported

The connection does not support IBM Fibre Channel Endpoint Security because the FCP device does not support it.

none

The connection has no IBM Fibre Channel Endpoint Security.

unknown

The IBM Fibre Channel Endpoint Security state of the connection is not known.

Tip: If the output is lengthy, use the **lszdev** device selection filter to narrow the scope to the devices of interest (see [“lszdev - Display IBM Z device configurations”](#) on page 623).

Alternatively, you can use the **lszfc** command with the `-a` option to display the IBM Fibre Channel Endpoint Security information for FCP devices. Use the **lszfc** command with the `-m` option to display the information for your connections (see [“lszfc - List zfc devices”](#) on page 627). For example, issue the following command:

```
# lszfc -HPam
```

Instead of using commands, you can read the information directly from `sysfs`. For example, for an FCP channel that provides an FCP device with device-bus ID `0.0.5150`:

```
# cat /sys/bus/ccw/drivers/zfc/0.0.5150/fc_security
Authentication, Encryption
```

For a remote port `0x500507630401120c` that is connected through this FCP device:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5150/0x500507630401120c/fc_security
Encryption
```

Both sysfs attributes are read-only.

Scenario for finding available LUNs

There are several steps from setting an FCP device online to listing the available LUNs.

Procedure

1. Check for available FCP devices of type 1732/03:

```
# lscss -t 1732/03
Device   Subchan.  DevType CU Type Use  PIM PAM POM  CHPIDs
-----
0.0.3c02 0.0.0015  1732/03 1731/03    80  80  ff  36000000 00000000
```

Another possible type would be, for example, 1732/04.

2. Set the FCP device online:

```
# chccwdev 0.0.3c02 --online
```

A port scan is performed automatically when the FCP device is set online.

3. Optional: Confirm that the FCP device is available and online:

```
# lszfcp -b 0.0.3c02 -a
0.0.3c02 host0
Bus = "ccw"
  availability      = "good"
...
  failed            = "0"
...
  in_recovery       = "0"
...
  online            = "1"
...
```

4. Optional: List the available ports:

```
# lszfcp -P
0.0.3c02/0x50050763030bc562 rport-0:0-0
0.0.3c02/0x500507630310c562 rport-0:0-1
0.0.3c02/0x500507630040727b rport-0:0-10
0.0.3c02/0x500507630e060521 rport-0:0-11
...
```

5. Scan for available LUNs on FCP device 0.0.3c02, port 0x50050763030bc562:

```
# lsluns -c 0.0.3c02 -p 0x50050763030bc562
Scanning for LUNs on adapter 0.0.3c02
  at port 0x50050763030bc562:
    0x4010400000000000
    0x4010400100000000
    0x4010400200000000
    0x4010400300000000
    0x4010400400000000
    0x4010400500000000
    0x4010400600000000
    ...
```

API provided by the zfcphbaapi support

You require the zFCP HBA API library for developing and running HBA management client applications. To develop applications, you need the sub-package `zfcphbaapi-dev`. To run applications, you need the `libzfcphbaapi0` sub-package.

Programmers: This information is intended for programmers who want to write HBA management clients that run on Linux on Z.

Developing applications

To develop applications, you must install the development version of the zFCP HBA API provided by the `zfcphbaapi-dev` package, and link your application against the library.

Procedure

1. Install the development package for the zFCP HBA API.
Use, for example, **apt-get**:

```
# apt-get install zfcphbaapi-dev
```

The development package `zfcphbaapi-dev` provides the necessary header files and `.so` symbolic links needed to program against the zFCP HBA API.

2. Add the command-line option `-lzfcphbaapi` during the linker step of the build process to link your application against the zFCP HBA API library.
3. In the application, issue the **HBA_LoadLibrary()** call as the first call to initialize the library.

Functions provided

The zfcphbaapi implements Fibre Channel - HBA API (FC-HBA) functions as defined in the FC-HBA specification.

You can find the FC-HBA specification at www.t11.org. The following functions are available:

- `HBA_CloseAdapter()`
- `HBA_FreeLibrary()`
- `HBA_GetAdapterAttributes()`
- `HBA_GetAdapterName()`
- `HBA_GetAdapterPortAttributes()`
- `HBA_GetDiscoveredPortAttributes()`
- `HBA_GetEventBuffer()`
- `HBA_GetFcpTargetMapping()`
- `HBA_GetFcpTargetMappingV2()`
- `HBA_GetNumberOfAdapters()`
- `HBA_GetRNIDMgmtInfo()`
- `HBA_GetVersion()`
- `HBA_LoadLibrary()`
- `HBA_OpenAdapter()`
- `HBA_RefreshAdapterConfiguration()`
- `HBA_RefreshInformation()`
- `HBA_RegisterForAdapterAddEvents()`
- `HBA_RegisterForAdapterEvents()`
- `HBA_RegisterForAdapterPortEvents()`

- HBA_RegisterForAdapterPortStatEvents()
- HBA_RegisterForLinkEvents()
- HBA_RegisterForTargetEvents()
- HBA_RegisterLibrary()
- HBA_RegisterLibraryV2()
- HBA_RemoveCallback()
- HBA_SendCTPassThru()
- HBA_SendCTPassThruV2()
- HBA_SendLIRR()
- HBA_SendReadCapacity()
- HBA_SendReportLUNs()
- HBA_SendReportLUNsV2()
- HBA_SendRNID()
- HBA_SendRNIDV()
- HBA_SendRPL()
- HBA_SendRPS()
- HBA_SendScsiInquiry()
- HBA_SendSRL()
- HBA_SetRNIDMgmtInfo()

All other FC-HBA functions return status code HBA_STATUS_ERROR_NOT_SUPPORTED where possible.

Note: ZFCP HBA API for Linux 5.04 can access only FCP devices, ports, and units that are configured in the operating system.

Getting ready to run applications

To run an application, you must install the zFCP HBA API library that is provided by the `libzfcphbaapi0` package. You can set environment variables to log any errors in the library, and use tools to investigate the SAN configuration.

Before you begin

To use the HBA API support, you need the zFCP HBA API library, `libzfcphbaapi0`. Installing `libzfcphbaapi0` automatically installs all dependent packages.

The application must be developed to use the zFCP HBA API library, see [“Developing applications” on page 188](#).

Procedure

Follow these steps to access the library from a client application:

1. Install the `libzfcphbaapi0` package with **apt-get**.
For example:

```
# apt-get install libzfcphbaapi0
```

2. Optional: Set the environment variables for logging errors.

The zfcphba HBA API support uses the following environment variables to log errors in the zfcphba HBA API library:

LIB_ZFCP_HBAAPI_LOG_LEVEL

specifies the log level. If not set or set to zero, there is no logging (default). If set to an integer value greater than 1, logging is enabled.

LIB_ZFCP_HBAAPI_LOG_FILE

specifies a file for the logging output. If not specified, stderr is used.

What to do next

You can use the **zfcplib** and **zfcplib** commands to investigate your SAN configuration. These commands are available with the `zfcplib-hbaapi-utils` package.

Tools for investigating your SAN configuration

The HBA API package `zfcplib-hbaapi-utils` includes the following tools that can help you to investigate your SAN configuration and to solve configuration problems.

zfcplib

to probe a port in the SAN.

zfcplib

to retrieve information about the SAN topology and details about the SAN components.

See *How to use FC-attached SCSI devices with Linux on z Systems*, SC33-8413 for details.

Chapter 13. Storage-class memory device driver

LPAR only: The storage-class memory device driver applies to Linux in LPAR mode only.

Storage-class memory (SCM) is a class of data storage devices that combines properties of both storage and memory.

SCM can be implemented as Flash Express or as Virtual Flash Memory.

What you should know about storage-class memory

Storage-class memory (SCM) is accessed, in chunks called *increments*, through extended asynchronous data mover (EADM) subchannels.

The LPAR on which your Linux instance runs must be configured to provide SCM.

- At least one EADM subchannel must be available to the LPAR. Because SCM supports multiple concurrent I/O requests, it is advantageous to configure multiple EADM subchannels. A typical number of EADM subchannels is 64.
- One or more SCM increments must be added to the I/O configuration of the LPAR.

In Linux, each increment is represented as a block device. You can use the block device with standard Linux tools as you would use any other block device. Commonly used tools that work with block devices include: **fdisk**, **mkfs**, and **mount**.

Storage-class memory device nodes

Applications access storage-class memory devices by device nodes. Normally, Ubuntu Server 20.04.1 creates a device node for each storage increment. Alternatively, use the **mknod** command to create one.

The device driver uses a device name of the form `/dev/scm<x>` for an entire block device. In the name, `<x>` is one or two lowercase letters.

You can partition a block device into up to seven partitions. If you use partitions, the device driver numbers them from 1 - 7. The partitions then have device nodes of the form `/dev/scm<x><n>`, where `<n>` is a number in the range 1 - 7, for example `/dev/scma1`.

The following example shows two block devices, `scma` and `scmb`, where `scma` has one partition, `scma1`.

```
# lsblk
NAME      MAJ:MIN RM  SIZE RO MOUNTPOINT
scma      252:0   0   16G  0
`-scma1   252:1   0   16G  0
scmb      252:8   0   16G  0
```

You must load the module before you check for the device node.

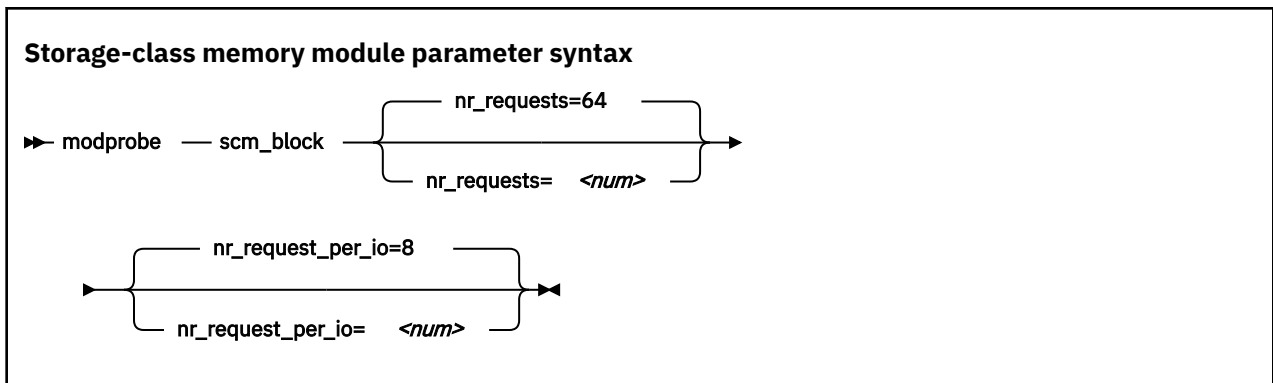
To check whether there already is a node, use for example, **lsblk** to list all block devices and look for "scm" entries.

To create storage-class memory device nodes issue commands of the form:

```
# mknod /dev/scma1 b <major> 1
# mknod /dev/scma2 b <major> 2
# mknod /dev/scma3 b <major> 3
...
```

Setting up the storage-class memory device driver

Configure the storage-class memory device driver by using the module parameters.



where

nr_requests

specifies the number of parallel I/O requests. Set this number to the number of EADM subchannels. The default is 64.

nr_request_per_io

submits more concurrent I/O requests than the current limit, which is based on the number of available EADM subchannels (64). Valid values are 1 - 64. Increasing the requests increases the number of I/O requests per second, especially for requests with a small block size. The default number of requests is 8. Depending on the workload, this setting might improve the throughput of the `scm_block` driver.

Working with storage-class memory increments

You can list storage-class memory increments and EADM subchannels.

- [“Displaying EADM subchannels” on page 192](#)
- [“Listing storage-class memory increments” on page 193](#)
- [“Combining SCM devices with LVM” on page 193](#)

Displaying EADM subchannels

Use the `lscss` command to list EADM subchannels.

About this task

The extended asynchronous data mover (EADM) subchannels are used to transfer data to and from the storage-class memory. At least one EADM subchannel must be available to the LPAR.

Procedure

To list EADM subchannels, issue:

```
# lscss --eadm
Device  Subchan.
-----
n/a     0.0.ff00
n/a     0.0.ff01
n/a     0.0.ff02
n/a     0.0.ff03
n/a     0.0.ff04
n/a     0.0.ff05
n/a     0.0.ff06
n/a     0.0.ff07
```

For more information about the `lscss` command, see [“lscss - List subchannels” on page 600](#).

Listing storage-class memory increments

Use the **lsscm** command to see the status and attributes of storage-class memory increments.

About this task

Each storage-class memory increment can be accessed as a block device through a device node `/dev/scm<x>`. Optionally, you can partition a storage-class memory increment in up to seven partitions.

You can also use the **lsblk** command to list all block devices.

Procedure

To list all storage-class memory increments, their status, and attributes, issue:

```
# lsscm
SCM Increment      Size      Name  Rank D_state O_state Pers ResID
-----
0000000000000000 16384MB scma   1    2      1    2    1
0000000040000000 16384MB scmb   1    2      1    2    1
```

See [“lsscm - List storage-class memory increments”](#) on page 612 for details about the **lsscm** command.

Combining SCM devices with LVM

You can use LVM to combine multiple SCM block devices into an arbitrary sized LVM device.

Example

Configure SCM as any other block devices in LVM. If your version of LVM does not accept SCM devices as valid LVM device types and issues an error message, add the SCM devices to the LVM configuration file `/etc/lvm/lvm.conf`. Add the following line to the section labeled "devices":

```
types = [ "scm", 8 ]
```

Chapter 14. Channel-attached tape device driver

LPAR and z/VM: The channel-attached tape device driver applies to Linux in LPAR mode and to Linux on z/VM.

The Linux on Z tape device driver supports channel-attached tape devices.

SCSI tape devices that are attached through an FCP channel are handled by the `zfc` device driver (see Chapter 12, “SCSI-over-Fibre Channel device driver,” on page 147).

Features

The tape device driver supports a range of channel-attached tape devices and functions of these devices.

- The tape device driver supports channel-attached tape drives that are compatible with IBM 3480, 3490, 3590, and 3592 magnetic tape subsystems. Various models of these device types are handled (for example, the 3490/10).
3592 devices that emulate 3590 devices are recognized and treated as 3590 devices.
- Logical character devices for non-rewinding and rewinding modes of operation (see [“Tape device modes and logical devices”](#) on page 195)
- Control operations through `mt` (see [“Using the mt command”](#) on page 197)
- Message display support (see [“tape390_display - Display messages on tape devices and load tapes”](#) on page 664)
- Encryption support (see [“tape390_crypt - Manage tape encryption”](#) on page 660)
- Up to 128 physical tape devices

What you should know about channel-attached tape devices

A naming scheme helps you to keep track of your tape devices, their modes of operation, and the corresponding device nodes.

Tape device modes and logical devices

The tape device driver supports up to 128 physical tape devices. Each physical tape device can be used as a character device in non-rewinding or in rewinding mode.

In non-rewinding mode, the tape remains at the current position when the device is closed. In rewinding mode, the tape is rewound when the device is closed. The tape device driver treats each mode as a separate logical device.

Both modes provide sequential (traditional) tape access without any caching done in the kernel.

You can use a channel-attached tape device in the same way as any other Linux tape device. You can write to it and read from it using standard Linux facilities such as GNU `tar`. You can perform control operations (such as rewinding the tape or skipping a file) with the standard tool `mt`.

Tape naming scheme

The tape device driver assigns minor numbers along with an index number when a physical tape device comes online.

The naming scheme for tape devices is summarized in [Table 31 on page 196](#).

Table 31. Tape device names and minor numbers

Device	Names	Minor numbers
Non-rewinding character devices	ntibm<n>	2×<n>
Rewinding character devices	rtibm<n>	2×<n>+1

where <n> is the index number that is assigned by the device driver. The index starts from 0 for the first physical tape device, 1 for the second, and so on. The name space is restricted to 128 physical tape devices, so the maximum index number is 127 for the 128th physical tape device.

The index number and corresponding minor numbers and device names are not permanently associated with a specific physical tape device. When a tape device goes offline, it surrenders its index number. The device driver assigns the lowest free index number when a physical tape device comes online. An index number with its corresponding device names and minor numbers can be reassigned to different physical tape devices as devices go offline and come online.

Tip: Use the **lstape** command (see “[lstape - List tape devices](#)” on page 615) to determine the current mapping of index numbers to physical tape devices.

When the tape device driver is loaded, it dynamically allocates a major number to channel-attached character tape devices. A different major number might be used when the device driver is reloaded, for example when Linux is rebooted.

For online tape devices directories provide information about the major/minor assignments. The directories have the form:

- /sys/class/tape390/ntibm<n>
- /sys/class/tape390/rtibm<n>

Each of these directories has a dev attribute. The value of the dev attribute has the form <major>:<minor>, where <major> is the major number for the device and <minor> is the minor number specific to the logical device.

Example

In this example, four physical tape devices are present, with three of them online. The TapeNo column shows the index number and the BusID column indicates the associated physical tape device. In the example, no index number is allocated to the tape device in the last row. The device is offline and, currently, no names and minor numbers are assigned to it.

```
# lstape --ccw-only
TapeNo BusID CuType/Model DevType/DevMod BlkSize State Op MedState
0 0.0.01a1 3490/10 3490/40 auto UNUSED --- UNLOADED
1 0.0.01a0 3480/01 3480/04 auto UNUSED --- UNLOADED
2 0.0.0172 3590/50 3590/11 auto IN_USE --- LOADED
N/A 0.0.01ac 3490/10 3490/40 N/A OFFLINE --- N/A
```

Table 32 on page 196 summarizes the resulting names and minor numbers.

Table 32. Example names and minor numbers

Bus ID	Index (TapeNo)	Device	Device name	Minor number
0.0.01a1	0	non-rewind	ntibm0	0
		rewind	rtibm0	1
0.0.01a0	1	non-rewind	ntibm1	2
		rewind	rtibm1	3

Table 32. Example names and minor numbers (continued)

Bus ID	Index (TapeNo)	Device	Device name	Minor number
0.0.0172	2	non-rewind	ntibm2	4
		rewind	rtibm2	5
0.0.01ac	not assigned	n/a	n/a	not assigned

For the online devices, the major/minor assignments can be read from their respective representations in `/sys/class`:

```
# cat /sys/class/tape390/ntibm0/dev
254:0
# cat /sys/class/tape390/rtibm0/dev
254:1
# cat /sys/class/tape390/ntibm1/dev
254:2
# cat /sys/class/tape390/rtibm1/dev
254:3
# cat /sys/class/tape390/ntibm2/dev
254:4
# cat /sys/class/tape390/rtibm2/dev
254:5
```

In the example, the major number is 254. The minor numbers are as expected for the respective device names.

Tape device nodes

Applications access tape devices by device nodes. Ubuntu Server 20.04.1 uses `udev` to create two device nodes for each tape device.

The device nodes have the form `/dev/<name>`, where `<name>` is the device name according to [“Tape naming scheme”](#) on page 195.

For example, if you have two tape devices, `udev` creates the device nodes that are shown in [Table 33](#) on page 197:

Table 33. Tape device nodes

Node for	non-rewind device	rewind device
First tape device	<code>/dev/ntibm0</code>	<code>/dev/rtibm0</code>
Second tape device	<code>/dev/ntibm1</code>	<code>/dev/rtibm1</code>

Using the `mt` command

There are differences between the MTIO interface for channel-attached tapes and other tape drives. Correspondingly, some operations of the `mt` command are different for channel-attached tapes.

The `mt` command handles basic tape control in Linux. See the man page for general information about `mt`.

setdensity

has no effect because the recording density is automatically detected on channel-attached tape hardware.

drvbuffer

has no effect because channel-attached tape hardware automatically switches to unbuffered mode if buffering is unavailable.

lock and unlock

have no effect because channel-attached tape hardware does not support media locking.

setpartition and mkpartition

have no effect because channel-attached tape hardware does not support partitioning.

status

returns a structure that, aside from the block number, contains mostly SCSI-related data that does not apply to the tape device driver.

load

does not automatically load a tape but waits for a tape to be loaded manually.

offline and rewoffl and eject

all include expelling the currently loaded tape. Depending on the stacker mode, it might attempt to load the next tape (see [“Loading and unloading tapes”](#) on page 202 for details).

Loading the tape device driver

There are no module parameters for the tape device driver. You must load the required device driver module before you can use it.

Use the **modprobe** command to load the modules.

Tape module syntax



See the **modprobe** man page for details about **modprobe**.

Working with tape devices

Typical tasks for working with tape devices include displaying tape information, controlling compression, and loading and unloading tapes.

For information about working with the channel measurement facility, see [Chapter 54, “Channel measurement facility,”](#) on page 487.

For information about displaying messages on a tape device's display unit, see [“tape390_display - Display messages on tape devices and load tapes”](#) on page 664.

See [“Working with newly available devices”](#) on page 10 to avoid errors when working with devices that have become available to a running Linux instance.

- [“Setting a tape device online or offline”](#) on page 198
- [“Displaying tape information”](#) on page 200
- [“Enabling compression”](#) on page 202
- [“Loading and unloading tapes”](#) on page 202

Setting a tape device online or offline

Set a tape device online or offline with the **chccwdev** command or through the `online` sysfs attribute of the device.

About this task

Setting a physical tape device online makes both corresponding logical devices accessible:

- The non-rewind character device
- The rewind character device

At any time, the device can be online to a single Linux instance only. You must set the tape device offline to make it accessible to other Linux instances in a shared environment.

Procedure

Use the **chzdev** command (see [“chzdev - Configure IBM Z devices” on page 531](#)) to set a tape online or offline.

Alternatively, use the **chccwdev** command, or you can write 1 to the online attribute of the device to set it online; or write 0 to set it offline.

Results

When a physical tape device is set online, the device driver assigns an index number to it. This index number is used in the standard device nodes (see [“Tape device nodes” on page 197](#)) to identify the corresponding logical devices. The index number is in the range 0 - 127. A maximum of 128 physical tape devices can be online concurrently.

If you are using the standard device nodes, you must find out which index number the tape device driver has assigned to your tape device. This index number, and consequently the associated standard device node, can change after a tape device was set offline and back online.

Ubuntu Server 20.04.1 uses udev to create alternative device nodes that distinguish devices by the physical device's bus ID instead of the index number. If you are using such device nodes, you do not need to know the index number.

If you need to know the index number, issue a command of this form:

```
# lstape --ccw-only <device_bus_id>
```

where *<device_bus_id>* is the device bus-ID that corresponds to the physical tape device. The index number is the value in the TapeNo column of the command output. For more information about the **lstape** command, see [“lstape - List tape devices” on page 615](#).

Examples

- To set a physical tape device with device bus-ID 0.0.015f online, first load the module if you have not already done so:

```
# modprobe tape_3590
```

Then issue:

```
# chzdev -e tape 015f
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,” on page 313](#).

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or one of the following commands:

```
# chccwdev -e 0.0.015f
```

or

```
# echo 1 > /sys/bus/ccw/devices/0.0.015f/online
```

To find the index number that the tape device driver assigned to the device, issue:

```
# lstape 0.0.015f --ccw-only
TapeNo  BusID      CuType/Model  DevType/Model  BlkSize  State  Op      MedState
2        0.0.015f    3480/01       3480/04        auto     UNUSED ---     LOADED
```

In the example, the assigned index number is 2. The standard device nodes for working with the device until it is set offline are then:

- /dev/ntibm2 for the non-rewinding device
- /dev/rtibm2 for the rewinding device

- To set a physical tape device with device bus-ID 0.0.015f offline, issue:

```
# chzdev -d tape 015f
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the -a option or one of the following commands:

```
# chccwdev -d 0.0.015f
```

or

```
# echo 0 > /sys/bus/ccw/devices/0.0.015f/online
```

Displaying tape information

Use the **lstape** command to display summary information about your tape devices, or read tape information from sysfs.

Each physical tape device is represented in a sysfs directory of the form

```
/sys/bus/ccw/devices/<device_bus_id>
```

where *<device_bus_id>* is the device bus-ID that corresponds to the physical tape device. This directory contains a number of attributes with information about the physical device. The attributes: blocksize, state, operation, and medium_state, might not show the current values if the device is offline.

Table 34. Tape device attributes

Attribute	Explanation
online	1 if the device is online or 0 if it is offline (see “Setting a tape device online or offline” on page 198)
cmb_enable	1 if channel measurement block is enabled for the physical device or 0 if it is not enabled (see Chapter 54, “Channel measurement facility,” on page 487)
cutype	Type and model of the control unit
devtype	Type and model of the physical tape device
blocksize	Currently used record size in bytes or 0 for auto

Table 34. Tape device attributes (continued)

Attribute	Explanation
state	<p>State of the physical tape device, either of:</p> <p>UNUSED The device is not in use and is available to any operating system image in a shared environment.</p> <p>IN_USE The device is being used by a process on this Linux instance.</p> <p>OFFLINE The device is offline.</p> <p>NOT_OP Device is not operational.</p>
operation	<p>The current tape operation, for example:</p> <p>---</p> <p>No operation</p> <p>WRI Write operation</p> <p>RFO Read operation</p> <p>MSN Medium sense</p> <p>Several other operation codes exist, for example, for rewind and seek.</p>
medium_state	<p>The current state of the tape cartridge:</p> <p>1 Cartridge is loaded into the tape device</p> <p>2 No cartridge is loaded</p> <p>0 The tape device driver does not have information about the current cartridge state</p>

Procedure

Issue a command of this form to read an attribute:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/<attribute>
```

where *<attribute>* is one of the attributes of [Table 34 on page 200](#).

Example

The following **lstape** command displays information about a tape device with bus ID 0.0.015f:

```
# lstape 0.0.015f --ccw-only
TapeNo  BusID      CuType/Model  DevType/Model  BlkSize  State  Op      MedState
2        0.0.015f    3480/01       3480/04        auto     UNUSED ---     LOADED
```

This sequence of commands reads the same information from sysfs:

```
# cat /sys/bus/ccw/devices/0.0.015f/online
1
# cat /sys/bus/ccw/devices/0.0.015f/cmb_enable
0
# cat /sys/bus/ccw/devices/0.0.015f/cutype
3480/01
# cat /sys/bus/ccw/devices/0.0.015f/devtype
3480/04
# cat /sys/bus/ccw/devices/0.0.015f/blocksize
0
# cat /sys/bus/ccw/devices/0.0.015f/state
UNUSED
# cat /sys/bus/ccw/devices/0.0.015f/operation
---
# cat /sys/bus/ccw/devices/0.0.015f/medium_state
1
```

Enabling compression

Control Improved Data Recording Capability (IDRC) compression with the **mt** command provided by the package `mt-st`.

About this task

Compression is off after the tape device driver is loaded.

Procedure

To enable compression, issue:

```
# mt -f <node> compression
```

or

```
# mt -f <node> compression 1
```

where `<node>` is the device node for a character device, for example, `/dev/ntibm0`.

To disable compression, issue:

```
# mt -f <tape> compression 0
```

Any other numeric value has no effect, and any other argument disables compression.

Example

To enable compression for a tape device with a device node `/dev/ntibm0` issue:

```
# mt -f /dev/ntibm0 compression 1
```

Loading and unloading tapes

Unload tapes with the **mt** command. How to load tapes depends on the stacker mode of your tape hardware.

Procedure

Unload tapes with a command of this form:

```
# mt -f <node> unload
```

where `<node>` can be a device node for the non-rewinding device or for the rewinding device.

Whether you can load tapes from your Linux instance depends on the stacker mode of your tape hardware. There are three possible modes:

manual

Tapes must always be loaded manually by an operator. You can use the **tape390_display** command (see [“tape390_display - Display messages on tape devices and load tapes”](#) on page 664) to display a short message on the tape device's display unit when a new tape is required.

automatic

If there is another tape present in the stacker, the tape device automatically loads a new tape when the current tape is expelled. You can load a new tape from Linux by expelling the current tape with the **mt** command.

system

The tape device loads a tape when instructed from the operating system. From Linux, you can load a tape with the **tape390_display** command (see [“tape390_display - Display messages on tape devices and load tapes”](#) on page 664). You cannot use the **mt** command to load a tape.

Example

To expel a tape from a tape device that can be accessed through a device node `/dev/ntibm0`, issue:

```
# mt -f /dev/ntibm0 unload
```

Assuming that the stacker mode of the tape device is `system` and that a tape is present in the stacker, you can load a new tape by issuing:

```
# tape390_display -l "NEW TAPE" /dev/ntibm0
```

"NEW TAPE" is a message that is displayed on the display unit of the tape device until the tape device receives the next tape movement command.

Part 4. Networking

Ubuntu Server 20.04.1 includes several network device drivers that are specific to z/Architecture.

For information about high-performing, secure networking and connectivity, see www.ibm.com/it-infrastructure/z/capabilities/networking

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Example

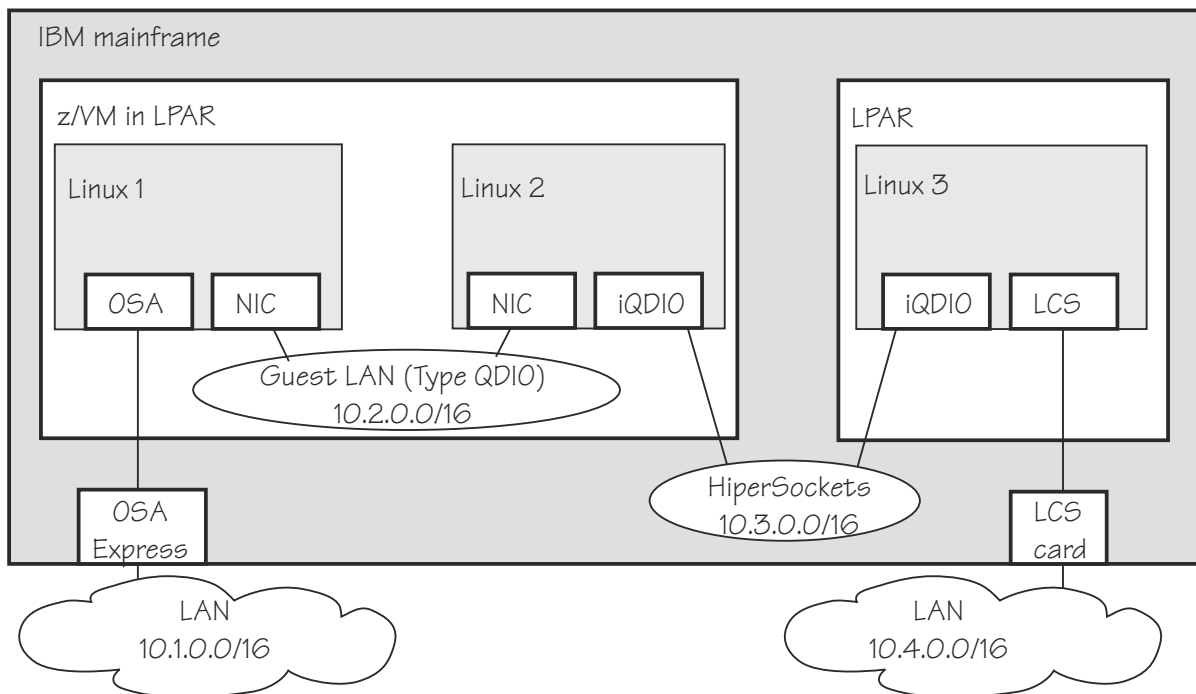


Figure 45. Networking example

In the example there are three Linux instances; two of them run as z/VM guests in one LPAR and a third Linux instance runs in another LPAR. Within z/VM, Linux instances can be connected through a guest LAN or VSWITCH. Within and between LPARs, you can connect Linux instances through HiperSockets. OSA-Express cards running in either non-QDIO mode (called LCS here) or in QDIO mode can connect the mainframe to an external network.

Table 35 on page 206 lists which control units and device type combinations are supported by the network device drivers.

Device type	Control unit	Device driver	Comment
1732/01	1731/01	qeth	OSA configured as OSD
1732/02	1731/02	qeth	OSA configured as OSX
1732/05	1731/05	qeth	HiperSockets
0000/00	3088/1f	lcs	2216 Nways Multiaccess Connector
0000/00	3088/60	lcs	OSA configured as OSE (non-QDIO)

Chapter 15. qeth device driver for OSA-Express (QDIO) and HiperSockets

LPAR and z/VM: The qeth device driver applies to Linux in LPAR mode and to Linux on z/VM.

The qeth device driver supports a multitude of network connections, for example, connections through Open Systems Adapters (OSA), HiperSockets, guest LANs, and virtual switches.

Real connections that use OSA-Express

An IBM mainframe uses OSA-Express adapters, which are real LAN-adapter hardware, see [Figure 46](#) on [page 207](#). These adapters provide connections to the outside world, but can also connect virtual systems (between LPARs or between z/VM guest virtual machines) within the mainframe. The qeth driver supports these adapters if they are defined to run in queued direct I/O (QDIO) mode (defined as OSD or OSX in the hardware configuration). OSD-devices are the standard IBM Z LAN-adapters. For details about OSA-Express in QDIO mode, see *Open Systems Adapter-Express Customer's Guide and Reference*, SA22-7935.

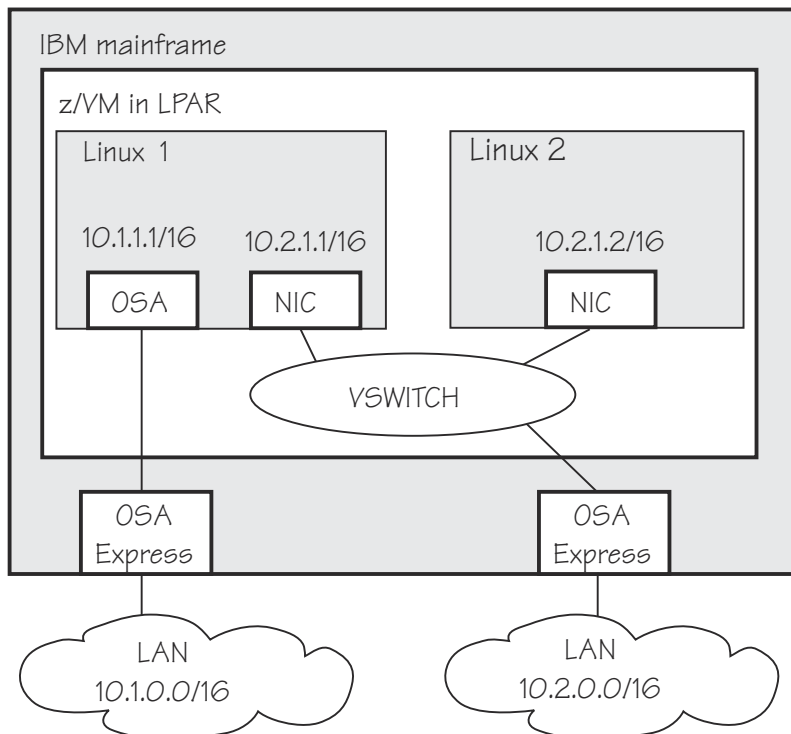


Figure 46. OSA-Express adapters are real LAN-adapter hardware

The OSA-Express LAN adapter can serve as a Network Control Program (NCP) adapter for an internal ESCON/CDLC interface to another mainframe operating system. This feature is used by the IBM Communication Controller for Linux (CCL). The OSA CHPID type does not support any additional network functions and its only purpose is to provide a bridge between the CDLC and QDIO interfaces to connect to the Linux NCP. For more details, see the *IBM Communication Controller Migration Guide*, SG24-6298.

The qeth device driver supports CHPIDs of type OSD and OSX:

OSD

provides connectivity as the standard IBM Z LAN adapter type, running in either layer 3 or layer 2 mode. When running in layer 3 mode, only TCP/IP traffic is supported, using IP addresses. When running in layer 2 mode, the traffic is protocol-independent, using MAC addresses.

OSX

provides connectivity to and access control for the intraensemble data network (IEDN), which is managed by Unified Resource Manager functions. A zEnterprise CPC and zBX within an ensemble are connected through the IEDN. See *zEnterprise System Introduction to Ensembles*, GC27-2609 and *zEnterprise System Ensemble Planning and Configuring Guide*, GC27-2608 for more details.

HiperSockets

An IBM mainframe uses internal connections that are called *HiperSockets*. These simulate QDIO network adapters and provide high-speed TCP/IP communication for operating system instances within and across LPARs. For details about HiperSockets, see *HiperSockets Implementation Guide*, SG24-6816.

Virtual connections for Linux on z/VM

z/VM offers virtualized LAN-adapters that enable connections between z/VM guest virtual machines and the outside world. It allows definitions of simulated network interface cards (NICs) attached to certain z/VM guests. The NICs can be connected to a simulated LAN segment called *guest LAN* for z/VM internal communication between z/VM guest virtual machines, or they can be connected to a virtual switch called *VSWITCH* for external LAN connectivity.

Guest LAN

Guest LANs represent a simulated LAN segment that can be connected to simulated network interface cards. There are three types of guest LANs:

- Simulated OSA in layer 3 mode
- Simulated HiperSockets (layer 3) mode
- Simulated OSA in layer 2 mode

Each guest LAN is isolated from other guest LANs on the same system (unless some member of one LAN group acts as a router to other groups). See [Figure 47 on page 208](#).

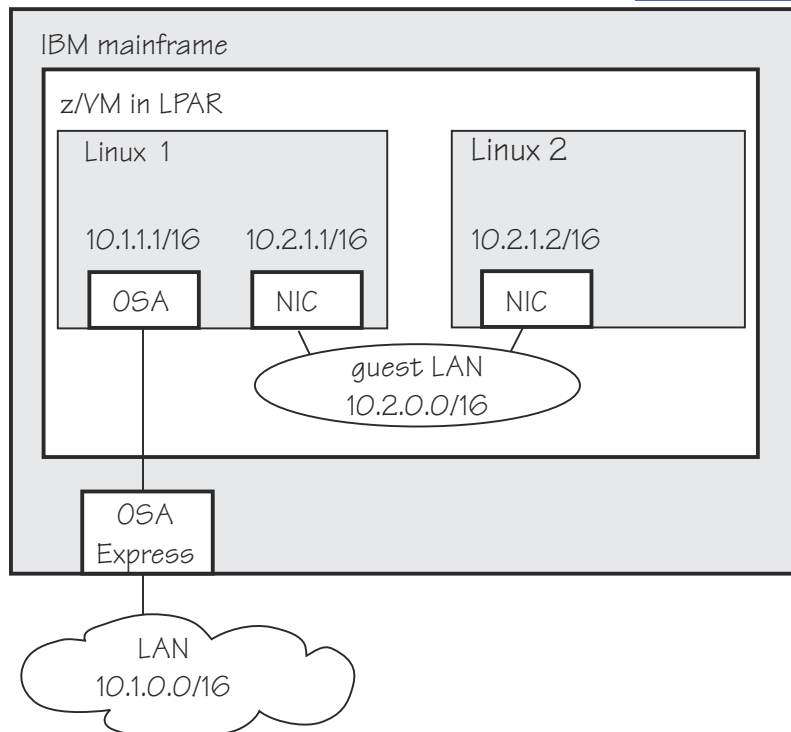


Figure 47. Guest LAN

Virtual switch

A virtual switch (VSWITCH) is a special-purpose guest LAN that provides external LAN connectivity through an additional OSA-Express device served by z/VM without the need for a routing virtual machine, see [Figure 48 on page 209](#).

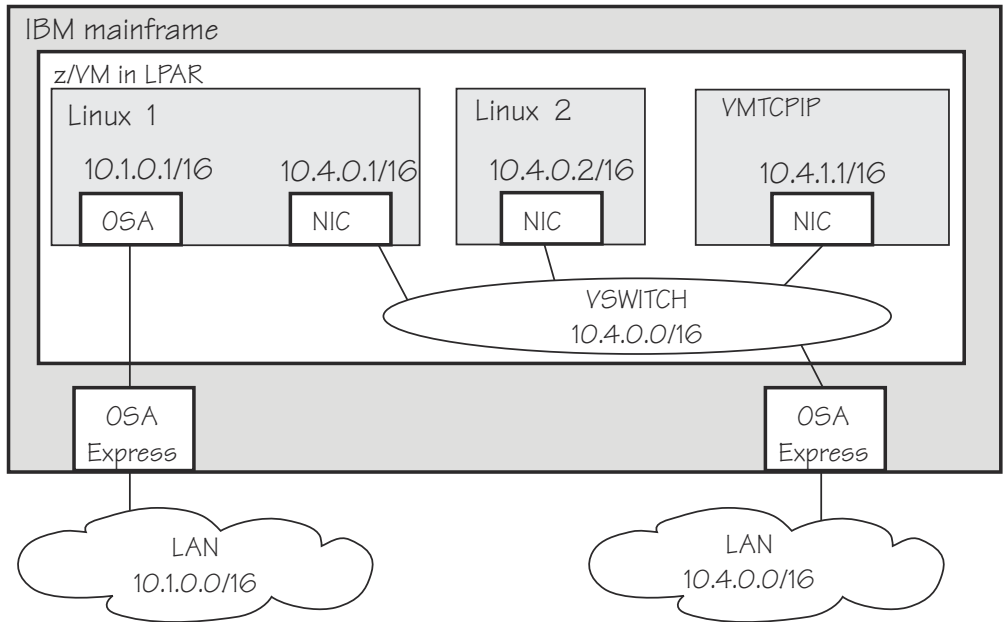


Figure 48. Virtual switch

A dedicated OSA adapter can be an option, but is not required for a VSWITCH.

The geth device driver distinguishes between virtual NICs in QDIO mode or HiperSockets mode. It cannot detect whether the virtual network is a guest LAN or a VSWITCH.

HiperSockets bridge port

A HiperSockets bridge port connects a network defined by a virtual switch to a HiperSockets LAN. The two networks are combined into one logical network. If the VSWITCH is connected to an external Ethernet LAN, the HiperSockets LAN can then communicate outside the CEC as shown in Figure 49 on page 209. You can thus connect a HiperSockets LAN to an external LAN without using a router.

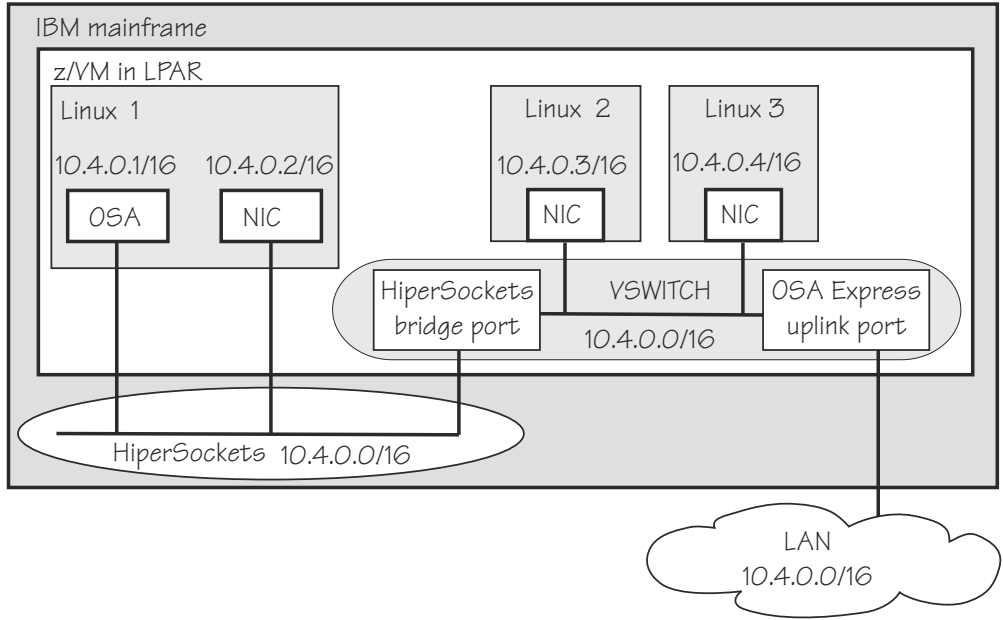


Figure 49. HiperSockets bridge port in z/VM

Linux can use a bridge port, for example, to connect an OSA or HiperSockets port to a Linux bridge. For more information, see “Layer 2 promiscuous mode” on page 218, and Figure 53 on page 219.

For information about guest LANs, virtual switches, HiperSockets bridge ports and virtual HiperSockets, see *z/VM: Connectivity*, SC24-6267.

Device driver functions

The qeth device driver supports many networking transport protocol functions, as well as offload functions and problem determination functions.

The qeth device driver supports functions that are listed in [Table 36 on page 210](#) and [Table 37 on page 211](#).

<i>Table 36. Real connections</i>				
Function	OSA Layer 2	OSA Layer 3	HiperSockets Layer 2	HiperSockets Layer 3
Basic device or protocol functions				
IPv4/multicast/broadcast	Yes/Yes/Yes	Yes/Yes/Yes	Yes/Yes/Yes	Yes/Yes/Yes
IPv6/multicast	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Non-IP traffic	Yes	Yes	Yes	No
VLAN IPv4/IPv6/non IP	sw/sw/sw	hw/sw/sw	sw/sw/sw	hw/hw/No
Linux ARP	Yes	No (hw ARP)	Yes	No
Linux neighbor solicitation	Yes	Yes	Yes	No
Unique MAC address	Yes (random for LPAR)	No	Yes	Yes
Change MAC address	Yes	No	Yes	No
Promiscuous mode	Yes. Bridgeport (once per card) or VNIC characteristics flooding and learning.	No	Yes. Bridgeport (once per card) or VNIC characteristics flooding and learning.	<ul style="list-style-type: none"> • Yes (for sniffer=1) • No (for sniffer=0)
MAC headers send/receive	Yes/Yes	faked/faked	Yes/Yes	faked/faked
ethtool support	Yes	Yes	Yes	Yes
Bonding	Yes	No	Yes	No
Priority queueing	Yes	Yes	No	No
Bridge port	Yes	No	Yes	No
Offload features				
TCP segmentation offload (TSO)	Yes	Yes	No	No
Inbound (rx) checksum	Yes	Yes	No	No
Outbound (tx) checksum	Yes	Yes	No	No
OSA/QETH specific features				
Special device driver setup for VIPA	No	required	No	Yes

Table 36. Real connections (continued)

Function	OSA Layer 2	OSA Layer 3	HiperSockets Layer 2	HiperSockets Layer 3
Basic device or protocol functions				
Special device driver setup for proxy ARP	No	required	No	Yes
Special device driver setup for IP takeover	No	required	No	Yes
Special device driver setup for routing IPv4/IPv6	No/No	required/ required	No/No	Yes/Yes
Receive buffer count	Yes	Yes	Yes	Yes
Direct connectivity to z/OS	Yes by HW	Yes	no	Yes
SNMP support	Yes	Yes	No	No
Multiport support	Yes	Yes	No	No
Data connection isolation	Yes	Yes	No	No
Problem determination				
Hardware trace	No	Yes	No	No
Legend: No - Function not supported or not required. Yes - Function supported. hw - Function performed by hardware. sw - Function performed by software. faked - Function will be simulated. required - Function requires special setup.				

Table 37. Virtual NICs coupled to a z/VM VSWITCH or guest LAN

Function	Emulated OSA Layer 2	Emulated OSA Layer 3	Emulated HiperSockets Layer 3
Basic device or protocol features			
IPv4/multicast/broadcast	Yes/Yes/Yes	Yes/Yes/Yes	Yes/Yes/Yes
IPv6/multicast	Yes/Yes	Yes/Yes	No/No
Non-IP traffic	Yes	No	No
VLAN IPv4/IPv6/non IP	sw/sw/sw	hw/sw/No	hw/No/No
Linux ARP	Yes	No (hw ARP)	No
Linux neighbor solicitation	Yes	Yes	No
Unique MAC address	Yes	Yes	Yes
Change MAC address	Yes	No	No
Promiscuous mode	Yes	Yes	No
MAC headers send/receive	Yes/Yes	faked/faked	faked/faked

Table 37. Virtual NICs coupled to a z/VM VSWITCH or guest LAN (continued)

Function	Emulated OSA Layer 2	Emulated OSA Layer 3	Emulated HiperSockets Layer 3
Basic device or protocol features			
ethtool support	Yes	Yes	Yes
Bonding	Yes	No	No
Priority queueing	Yes	Yes	No
Offload features	No	No	No
OSA/QETH specific features			
Special device driver setup for VIPA	No	required	required
Special device driver setup for proxy ARP	No	required	required
Special device driver setup for IP takeover	No	required	required
Special device driver setup for routing IPv4/IPv6	No/No	required/required	required/required
Receive buffer count	Yes	Yes	Yes
Direct connectivity to z/OS	No	Yes	Yes
SNMP support	No	No	No
Multiport support	No	No	No
Data connection isolation	No	No	No
Problem determination			
Hardware trace	No	No	No
Legend: No - Function not supported or not required. Yes - Function supported. hw - Function performed by hardware. sw - Function performed by software. faked - Function will be simulated. required - Function requires special setup.			

What you should know about the qeth device driver

Interface names are assigned to qeth group devices, which map to subchannels and their corresponding device numbers and device bus-IDs. An OSA-Express adapter can handle both IPv4 and IPv6 packets.

Layer 2 and layer 3

The qeth device driver consists of a common core and two device disciplines: layer 2 and layer 3.

In layer 2 mode, OSA routing to the destination is based on MAC addresses. A local MAC address is assigned to each interface of a Linux instance and registered in the OSA Address Table. These MAC addresses are unique and different from the MAC address of the OSA adapter. See [“MAC headers in layer 2 mode”](#) on page 215 for details.

In layer 3 mode, all interfaces of all Linux instances share the MAC address of the OSA adapter. OSA routing to the destination Linux instance is based on IP addresses. See [“MAC headers in layer 3 mode”](#) on page 216 for details.

The layer 2 discipline (qeth_l2)

The layer 2 discipline supports:

- OSA devices and z/VM virtual NICs that couple to VSWITCHes or QDIO guest LANs running in layer 2 mode
- HiperSockets devices
- OSX (OSA-Express for zBX) devices for IEDN

The layer 2 discipline is the default setup for OSA. On HiperSockets the default continues to be layer 3. See [“Setting the layer2 attribute”](#) on page 226 for details.

The network device in Linux must use the same layer as the VSWITCH or QDIO guest LAN in z/VM. By default, the qeth device driver uses layer 2. If the coupled VSWITCH or QDIO guest LAN uses layer 3, you must adapt the layer setting in Linux.

For z/VM NICs that are coupled to a guest LAN or VSWITCH, the qeth device driver detects the required layer and configures it automatically. If a qeth device is created before the NIC is coupled, the qeth device driver defaults to layer 2.

The layer 3 discipline (qeth_l3)

The layer 3 discipline supports:

- OSA devices and z/VM virtual NICs that couple to VSWITCHes or QDIO guest LANs running in layer 3 mode (with faked link layer headers)
- HiperSockets and HiperSockets guest LAN devices that are running in layer 3 mode (with faked link layer headers)
- OSX (OSA-Express for zBX) devices for IEDN

This discipline supports those devices that are not capable of running in layer 2 mode. Not all Linux networking features are supported and others need special setup or configuration. See [Table 43](#) on page 223. Some performance-critical applications might benefit from being layer 3.

Layer 2 and layer 3 interfaces cannot communicate within a HiperSockets LAN or within a VSWITCH or guest LAN. However, a shared OSA adapter can convert traffic between layer 2 and layer 3 networks.

qeth group devices

The qeth device driver requires three I/O subchannels for each HiperSockets CHPID or OSA-Express CHPID in QDIO mode. One subchannel is for control reads, one for control writes, and the third is for data.

The qeth device driver uses the QDIO protocol to communicate with the HiperSockets and OSA-Express adapter (see [Figure 50](#) on page 213).

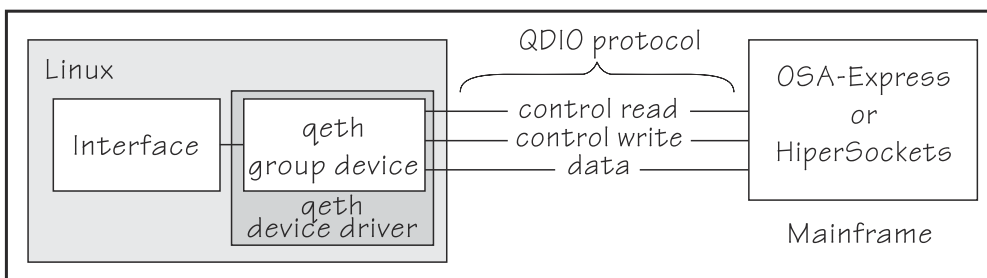


Figure 50. I/O subchannel interface

The three device bus-IDs that correspond to the subchannel triplet are grouped as one qeth group device. The following rules apply for the device bus-IDs:

read

no specific rules.

write

must be the device bus-ID of the read subchannel plus one.

data

can be any free device bus-ID on the same CHPID.

You can configure different triplets of device bus-IDs on the same CHPID differently. For example, if you have two triplets on the same CHPID they can have different attribute values for priority queueing.

Overview of the steps for setting up a qeth group device

You must perform several steps before user-space applications on your Linux instance can use a qeth group device.

Before you begin

Find out how the hardware is configured and which qeth device bus-IDs are on which CHPID, for example by looking at the IOCDS. Identify the device bus-IDs that you want to group into a qeth group device. The three device bus-IDs must be on the same CHPID.

Procedure

Perform these steps to allow user-space applications on your Linux instance to use a qeth group device:

1. Create the qeth group device.

After booting Linux, each qeth device bus-ID is represented by a subdirectory in `/sys/bus/ccw/devices/`. These subdirectories are then named with the bus IDs of the devices.

For example, a qeth device with bus IDs 0.0.fc00, 0.0.fc01, and 0.0.fc02 is represented as `/sys/bus/ccw/drivers/qeth/0.0.fc00`

2. Configure the device.
3. Set the device online.
4. Activate the device and assign an IP address to it.

What to do next

These tasks and the configuration options are described in detail in [“Working with qeth devices”](#) on page 221.

qeth interface names and device directories

Ubuntu Server 20.04.1 automatically assigns interface names to the qeth group devices. The qeth device driver creates the corresponding sysfs structures.

While an interface is online, it is represented in sysfs as:
`/sys/class/net/<interface>`

The mapping between interface names and the device bus-ID that represents the qeth group device in sysfs is preserved when a device is set offline and back online.

[“Finding out the interface name of a qeth group device”](#) on page 233 and [“Finding out the bus ID of a qeth interface”](#) on page 234 provide information about mapping device bus-IDs and interface names.

Support for IP Version 6 (IPv6)

The qeth device driver supports IPv6 in many network setups.

IPv6 is supported on:

- Ethernet interfaces of the OSA-Express adapter that runs in QDIO mode.

- HiperSockets layer 2 and layer 3 interfaces.
- z/VM guest LANs running in QDIO mode or HiperSockets layer 3 mode.
- z/VM virtual NIC interfaces (VSWITCHES and guest LANs) running in layer 2 mode.

IPv6 is not supported on the ATM feature.

There are noticeable differences between the IP stacks for versions 4 and 6. Some concepts in IPv6 are different from IPv4, such as neighbor discovery, broadcast, and Internet Protocol security (IPsec). IPv6 uses a 16-byte address field, while the addresses under IPv4 are 4 bytes in length.

Stateless autoconfiguration generates unique IP addresses for all Linux instances, even if they share an OSA-Express adapter with other operating systems.

Be aware of the IP version when you specify IP addresses and when you use commands that return IP version-specific output (such as **qetharp**).

MAC headers in layer 2 mode

In LAN environments, data packets find their destination through Media Access Control (MAC) addresses in their MAC header.

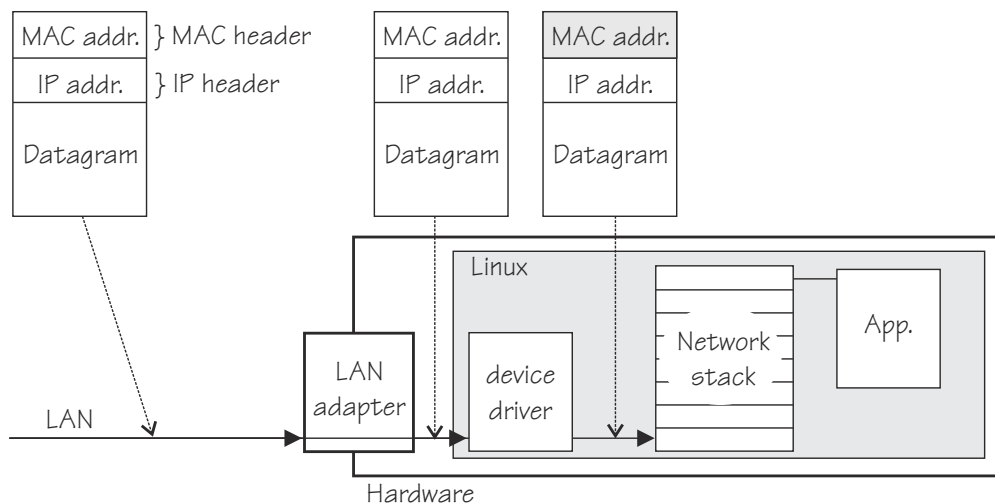


Figure 51. Standard IPv4 processing

MAC address handling as shown in [Figure 51](#) on page 215 applies to non-mainframe environments and a mainframe environment with an OSA-Express adapter where the `layer2` option is enabled.

The `layer2` option keeps the MAC addresses on incoming packets. Incoming and outgoing packets are complete with a MAC header at all stages between the Linux network stack and the LAN as shown in [Figure 51](#) on page 215. This layer2-based forwarding requires unique MAC addresses for all concerned Linux instances.

In layer 2 mode, the Linux TCP/IP stack has full control over the MAC headers and the neighbor lookup. The Linux TCP/IP stack does not configure IPv4 or IPv6 addresses into the hardware, but requires a unique MAC address for the card.

For Linux as a z/VM guest, the `qeth` device driver obtains a MAC address for each L2 device from the z/VM host. No configuration is necessary.

For Linux in LPAR mode with a directly attached OSA adapter in QDIO mode, assign a unique MAC address. You can set a MAC address by issuing the command:

```
ip link set addr <MAC address> dev <interface>
```

Note: Be sure not to assign the MAC address of the OSA-Express adapter to your Linux instance.

For OSX CHPIDs, you cannot set your own MAC addresses. Linux uses the MAC addresses defined by the Unified Resource Manager.

For HiperSockets connections, a MAC address is generated.

MAC headers in layer 3 mode

A qeth layer 3 mode device driver is an Ethernet offload engine for IPv4, and a partial Ethernet offload engine for IPv6. Hence, there are some special things to understand about the layer 3 mode.

To support IPv6 and protocols other than IPv4, the device driver registers a layer 3 card as an Ethernet device to the Linux TCP/IP stack.

In layer 3 mode, the OSA-Express adapter in QDIO mode removes the MAC header with the MAC address from incoming IPv4 packets. It uses the registered IP addresses to forward a packet to the recipient TCP/IP stack. See [Figure 52 on page 216](#). Thus the OSA-Express adapter is able to deliver IPv4 packets to the correct Linux instances. Apart from broadcast packets, a Linux instance can get packets only for IP addresses it configured in the stack and registered with the OSA-Express adapter.

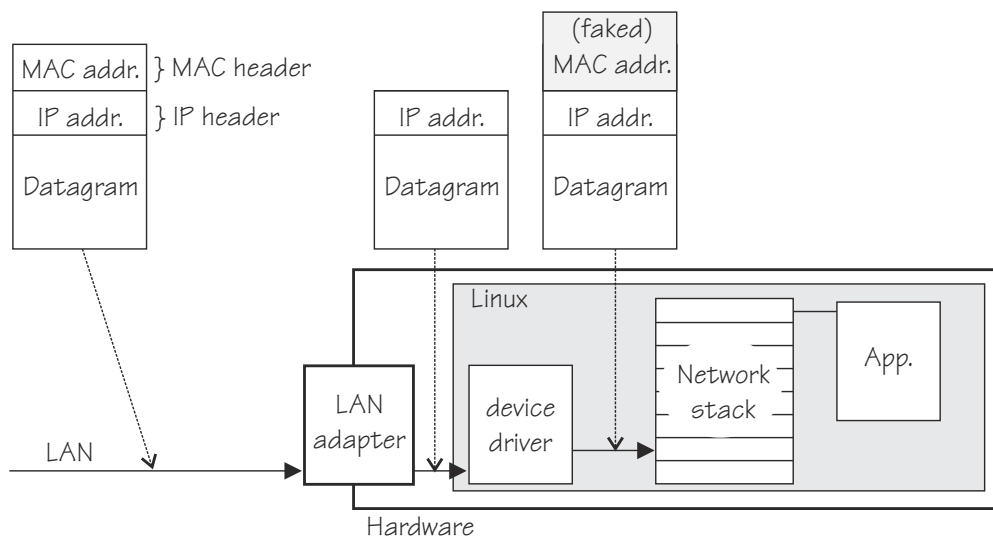


Figure 52. MAC address handling in layer3 mode

The OSA-Express QDIO microcode builds MAC headers for outgoing IPv4 packets and removes them from incoming IPv4 packets. Thus, the operating systems' network stacks send and receive only IPv4 packets without MAC headers.

This lack of MAC headers can be a problem for applications that expect MAC headers. For examples of how such problems can be resolved, see [“Setting up for DHCP with IPv4” on page 265](#).

Outgoing frames

The qeth device driver registers the layer 3 card as an Ethernet device. Therefore, the Linux TCP/IP stack will provide complete Ethernet frames to the device driver.

If the hardware does not require the Ethernet frame (for example, for IPv4) the driver removes the Ethernet header prior to sending the frame to the hardware. If necessary information like the Ethernet target address is not available (because of the offload functionality) the value is filled with the hardcoded address FAKELL.

Frame	Destination address	Source address
IPv4	FAKELL	Real device address
IPv6	Real destination address	Real device address

<i>Table 38. Ethernet addresses of outgoing frames (continued)</i>		
Frame	Destination address	Source address
Other packets	Real destination address	Real device address

Incoming frames

The device driver provides Ethernet headers for all incoming frames.

If necessary information like the Ethernet source address is not available (because of the offload functionality) the value is filled with the hardcoded address FAKELL.

<i>Table 39. Ethernet addresses of incoming frames</i>		
Frame	Destination address	Source address
IPv4	Real device address	FAKELL
IPv6	Real device address	FAKELL
Other packets	Real device address	Real source address

Note that if a source or destination address is a multicast or broadcast address the device driver can provide the corresponding (real) Ethernet multicast or broadcast address even when the packet was delivered or sent through the offload engine. Always providing the link layer headers enables packet socket applications like **tcpdump** to work properly on a qeth layer 3 device without any changes in the application itself (the patch for libpcap is no longer required).

While the faked headers are syntactically correct, the addresses are not authentic, and hence applications requiring authentic addresses will not work. Some examples are given in [Table 40 on page 217](#).

<i>Table 40. Applications that react differently to faked headers</i>		
Application	Support	Reason
tcpdump	Yes	Displays only frames, fake Ethernet information is displayed.
iptables	Partially	As long as the rule does not deal with Ethernet information of an IPv4 frame.
dhcp	Yes	Is non-IPv4 traffic. (Note that DHCP does not work for Layer 3 HiperSockets.)

IP addresses

The network stack of each operating system that shares an OSA-Express adapter in QDIO mode registers all its IP addresses with the adapter.

Whenever IP addresses are deleted from or added to a network stack, the device drivers download the resulting IP address list changes to the OSA-Express adapter.

For the registered IP addresses, the OSA-Express adapter off-loads various functions, in particular also:

- Handling MAC addresses and MAC headers
- ARP processing

ARP

The OSA-Express adapter in QDIO mode responds to Address Resolution Protocol (ARP) requests for all registered IPv4 addresses.

ARP is a TCP/IP protocol that translates 32-bit IPv4 addresses into the corresponding hardware addresses. For example, for an Ethernet device, the hardware addresses are 48-bit Ethernet Media Access Control (MAC) addresses. The mapping of IPv4 addresses to the corresponding hardware

addresses is defined in the ARP cache. When it needs to send a packet, a host consults the ARP cache of its network adapter to find the MAC address of the target host.

If there is an entry for the destination IPv4 address, the corresponding MAC address is copied into the MAC header and the packet is added to the appropriate interface's output queue. If the entry is not found, the ARP functions retain the IPv4 packet, and broadcast an ARP request asking the destination host for its MAC address. When a reply is received, the packet is sent to its destination.

Note:

1. On an OSA-Express adapter in QDIO mode, do not set the NO_ARP flag on the Linux Ethernet device. The device driver disables the ARP resolution for IPv4. Because the hardware requires no neighbor lookup for IPv4, but neighbor solicitation for IPv6, the NO_ARP flag is not allowed on the Linux Ethernet device.
2. On HiperSockets, which is a full Ethernet offload engine for IPv4 and IPv6 and supports no other traffic, the device driver sets the NO_ARP flag on the Linux Ethernet interface. Do not remove this flag from the interface.

Layer 2 promiscuous mode

OSA and HiperSockets ports that operate in layer 2 mode can be set up to receive all frames that are addressed to unknown MAC addresses.

On most architectures, traffic between operating systems and networks is handled by Ethernet Network Interface Controllers (NICs). NICs usually filter incoming traffic to admit only frames with destination MAC addresses that are registered with the NIC.

However, a NIC can also be configured to receive and pass to the operating system all Ethernet frames that reach it, regardless of the destination MAC address. This mode of operation is known as "promiscuous mode". Promiscuous mode is a prerequisite for configuring a NIC as a member of a Linux software bridge.

For more information about how to set up a software bridge, see the documentation that is provided by Ubuntu Server, or the bridging how-to available at <http://www.tldp.org/HOWTO/BRIDGE-STP-HOWTO>.

On IBM Z, you can realize a promiscuous mode for Ethernet traffic through a bridge port configuration or through Virtual Network Interface Controller (VNIC) characteristics. Depending on the hardware level, OSA and HiperSockets devices can be configured as bridge ports or they can be configured with VNIC characteristics. The same OSA or HiperSockets device cannot simultaneously be configured as a bridge port and with VNIC characteristics.

VNIC characteristics

With (VNIC) characteristics, you can set and fine-tune a promiscuous mode for HiperSockets devices, (see "[Advanced packet-handling configuration](#)" on page 254).

Bridge ports

Linux can assign a bridge port *role* to a logical port, and the HiperSockets or OSA adapter assigns an active *state* to one of the logical ports to which a role was assigned. A local port in active bridge port state receives all Ethernet frames with unknown destination MAC addresses.

[Figure 53 on page 219](#) shows a setup with a HiperSockets bridge port and an OSA bridge port.

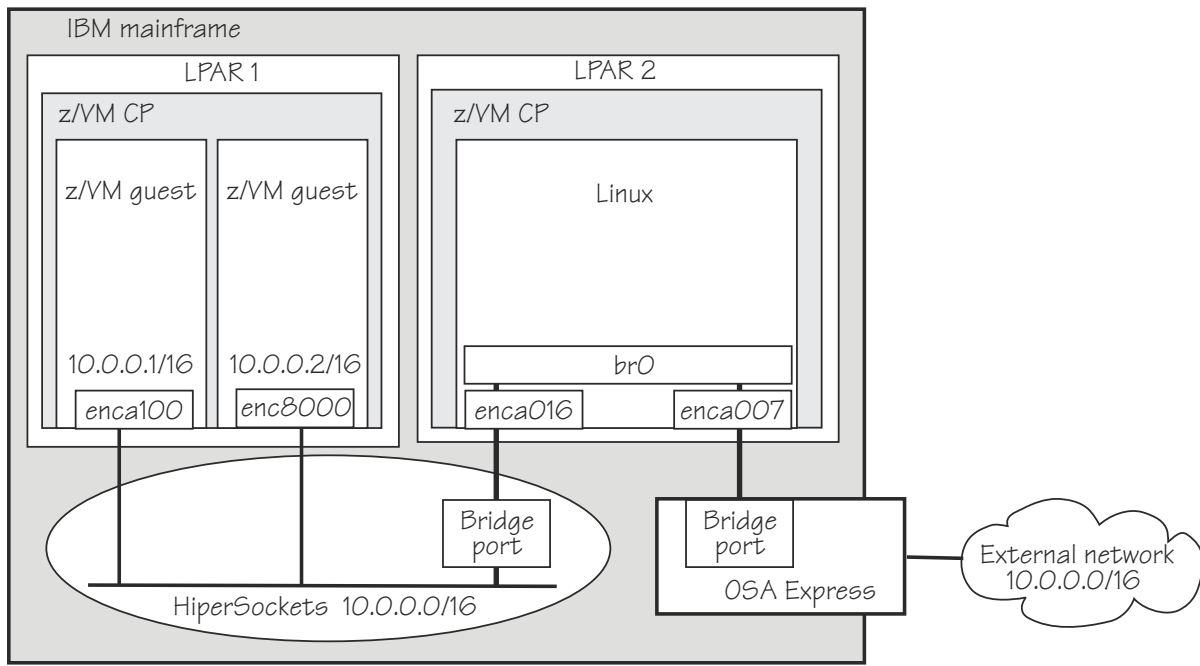


Figure 53. HiperSockets and OSA bridge port in Linux

Differences between promiscuous mode and bridge-port roles

Making a logical port of an OSA or HiperSockets adapter an active bridge port is similar to enabling promiscuous mode on a non-mainframe NIC that is connected to a real Ethernet switch. However, there are important differences:

Number of ports in promiscuous mode

- Real switches: Any number of interfaces that are connected to a real switch can be turned to promiscuous mode, and all of them then receive frames with unknown destination addresses.
- Bridge ports on Z: Although you can assign the bridge-port role to multiple ports of a single OSA or HiperSockets adapter, only one port is active and receives traffic to unknown destinations.

Monitoring traffic to other systems

- Real switches: A port of a real switch can be configured to receive frames with both known and unknown destinations. If a NIC in promiscuous mode is connected to the port, the corresponding host receives a copy of all traffic that passes through the switch. This includes traffic that is destined to other hosts connected to this switch.
- Bridge ports on Z: Only frames with unknown destinations are passed to the operating system. It is not possible to monitor traffic addressed to systems connected to other ports of the same OSA or HiperSockets adapter.
- On Z: The HiperSockets network traffic analyzer (see [“Setting up a HiperSockets network traffic analyzer”](#) on page 266) or z/VM guest LAN sniffer can be used to monitor traffic that is destined to other ports.

Limitation by the source of traffic (OSA bridge port only)

- Real switches and HiperSockets bridge-port LAN: Frames with unknown destination MAC addresses are delivered to the promiscuous interfaces regardless of the port through which the frames enter the switch or HiperSockets adapter.
- OSA bridge port only: An active bridge port *learns* which MAC addresses need to be routed to the owning system by analyzing ARP and other traffic. Incoming frames are routed to the active bridge port if their destination MAC address:
 - Matches an address that is learned or registered with the bridge port

- Is not learned or registered with any of the local ports of the OSA adapter, but arrived from the physical Ethernet port

Bridge port roles

Linux can assign a primary or secondary role to a logical port of an OSA or a HiperSockets adapter. Only one logical port of such an adapter can be assigned the primary role, but multiple other logical ports can be assigned secondary role. When one or more logical ports of an adapter are assigned primary or secondary role, the hardware ensures that exactly one of these ports is active. The active port receives frames with unknown destination. When a port with primary role is present, it always becomes active. When only ports with secondary role are present, the hardware decides which one becomes active. Changes in the ports' state are reported to Linux user space through udev events.

You can set a bridge port role either directly by using the **bridge_role** attribute or indirectly by using the **bridge_reflect_promisc** attribute. See [“Configuring a network device as a member of a Linux bridge” on page 252](#).

Setting up the qeth device driver

No kernel or module parameters exist for the qeth device driver. qeth devices are set up using sysfs.

Loading the qeth device driver modules

Load the qeth device driver before you work with qeth devices.

Use the **modprobe** command to load the qeth device driver, and to automatically load all required additional modules in the correct order:



where:

qeth

is the core module that contains common functions that are used for both layer 2 and layer 3 disciplines.

qeth_l2

is the module that contains layer 2 discipline-specific code.

qeth_l3

is the module that contains layer 3 discipline-specific code.

When a qeth device is configured for a particular discipline, the driver tries to automatically load the corresponding discipline module. Automatic loading requires that automatic kernel module loading is enabled in the distribution.

Switching the discipline of a qeth device

To switch the discipline of a device, the network interface must be shut down and the device must be offline.

Some devices can only run in one discipline, see [“Layer 2 and layer 3” on page 212](#). The device driver rejects any request to switch the discipline of these devices.

If the new discipline is accepted by the device driver, the old network interface is deleted. When the new discipline is set online the first time, the new network interface is created.

Removing the modules

Removing a module is not possible if there are cross dependencies between the discipline modules and the core module.

To release the dependencies from the core module to the discipline module, all devices of this discipline must be ungrouped. Now the discipline module can be removed. If all discipline modules are removed, the core module can be removed.

Working with qeth devices

Typical tasks for working with qeth devices include creating group devices, finding out the type of a network adapter, and setting a device online or offline.

About this task

To make the changes persistent across IPLs, use the **chzdev** command. If you want to make dynamic changes to the running system only, use sysfs.

Table 41 on page 221, Table 42 on page 222, and Table 43 on page 223 serve as both a task overview and a summary of the attributes and the possible values you can write to them. Underlined values are defaults.

Tip: Use the **chzdev** command to configure devices instead of using the attributes directly (see “chzdev - Configure IBM Z devices” on page 531). You can also use the **znetconf** command for network devices.

Not all attributes are applicable to each device. Some attributes apply only to HiperSockets or only to OSA-Express CHPIDs in QDIO mode, other attributes are applicable to IPv4 interfaces only. See the task descriptions for the applicability of each attribute.

Table 41. qeth tasks and attributes common to layer2 and layer3

Task	Corresponding attributes	Possible attribute values
“Setting the layer2 attribute” on page 226	layer2	0, 1, or <u>-1</u> see “Layer 2 and layer 3” on page 212 ¹
“Using priority queueing” on page 227	priority_queueing	prio_queueing_vlan prio_queueing_skb prio_queueing_prec <u>no_prio_queueing</u> no_prio_queueing:0 no_prio_queueing:1 no_prio_queueing:2 no_prio_queueing:3
“Specifying the number of inbound buffers” on page 229	buffer_count	integer in the range 8 - 128. The default is <u>64</u> for OSA devices and <u>128</u> for HiperSockets devices
“Finding out the maximum frame size” on page 230	inbuf_size	n/a, read-only
“Specifying the relative port number” on page 230	portno	integer, either 0 or 1, the default is <u>0</u>
“Finding out the type of your network adapter” on page 231	card_type	n/a, read-only
“Setting a device online or offline” on page 232	online	<u>0</u> or 1

Table 41. *qeth* tasks and attributes common to layer2 and layer3 (continued)

Task	Corresponding attributes	Possible attribute values
“Finding out the interface name of a qeth group device” on page 233	if_name	n/a, read-only
“Finding out the bus ID of a qeth interface” on page 234	none	n/a
“Activating an interface” on page 234	none	n/a
“Deactivating an interface” on page 235	none	n/a
“Recovering a device” on page 236	recover	1
“Configuring the receive checksum offload feature” on page 237	none	n/a
“Configuring the transmit checksum offload feature” on page 237	none	n/a
“Isolating data connections” on page 238	isolation	none, drop, forward
“Displaying and resetting QETH performance statistics” on page 241	performance_stats	0 or 1
“Capturing a hardware trace” on page 241	hw_trap	arm disarm
“Enabling and disabling TCP segmentation offload” on page 238	none	n/a

¹A value of -1 means that the layer is not set and that the default layer setting is used when the device is set online.

Table 42. *qeth* functions and attributes in layer 2 mode

Function	Corresponding attributes	Possible attribute values
“Configuring a network device as a member of a Linux bridge” on page 252	bridge_role bridge_state bridge_hostnotify	primary, secondary, <u>none</u> active, standby, <u>inactive</u> 0 or 1
“Advanced packet-handling configuration” on page 254	vnicc/bridge_invisible vnicc/flooding vnicc/learning vnicc/mcast_flooding vnicc/rx_bcast vnicc/takeover_learning vnicc/takeover_setvmac vnicc/learning_timeout	0 or 1 0 or 1 0 or 1 0 or 1 0 or <u>1</u> 0 or 1 0 or 1 integer in the range 60 - 86400 the default is <u>600</u>

Table 43. qeth tasks and attributes in layer 3 mode

Task	Corresponding attributes	Possible attribute values
“Setting up a Linux router” on page 242	route4 route6	primary_router secondary_router primary_connector secondary_connector multicast_router <u>no_router</u>
“Enabling and disabling TCP segmentation offload” on page 238	none	n/a
“Faking broadcast capability” on page 245	fake_broadcast ¹	<u>0</u> or 1
“Taking over IP addresses” on page 246	ipa_takeover/enable ipa_takeover/add4 ipa_takeover/add6 ipa_takeover/del4 ipa_takeover/del6 ipa_takeover/invert4 ipa_takeover/invert6	<u>0</u> or 1 or toggle IPv4 or IPv6 IP address and mask bits <u>0</u> or 1 or toggle
“Configuring a device for proxy ARP” on page 249	rxip/add4 rxip/del4	IPv4 IP address
Configuring a device for Neighbor Discovery Protocol (NDP) proxy	rxip/add6 rxip/del6	IPv6 IP address
“Configuring a device for virtual IP address (VIPA)” on page 250	vipa/add4 vipa/add6 vipa/del4 vipa/del6	IPv4 or IPv6 IP address
“Configuring a HiperSockets device for AF_IUCV addressing” on page 251	hsuid	1 to 8 characters
“Setting up a HiperSockets network traffic analyzer” on page 266	sniffer	<u>0</u> or 1

¹ not valid for HiperSockets

Tip: Use the **qethconf** command instead of using the attributes for IPA, proxy ARP, and VIPA directly (see [“qethconf - Configure qeth devices” on page 644](#)).

sysfs provides multiple paths through which you can access the qeth group device attributes. For example, if a device with bus ID 0.0.a100 corresponds to interface enca100:

```
/sys/bus/ccwgroup/drivers/qeth/0.0.a100
/sys/bus/ccwgroup/devices/0.0.a100
/sys/devices/qeth/0.0.a100
/sys/class/net/enca100/device
```

all lead to the attributes for the same device. For example, the following commands are all equivalent and return the same value:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/if_name
enca100
# cat /sys/bus/ccwgroup/devices/0.0.a100/if_name
enca100
# cat /sys/devices/qeth/0.0.a100/if_name
enca100
# cat /sys/class/net/enca100/device/if_name
enca100
```

The path through `/sys/class/net` becomes available when the device is first set online and the interface is created. The path persists until the device is ungrouped.

Tips:

- Work through one of the paths that are based on the device bus-ID.
- Using Ubuntu Server 20.04.1 LTS, you set qeth attributes using **chzdev**. Ubuntu Server creates udev configuration files with names of the form `/etc/udev/rules.d/41-qeth-<device_bus-ID>.rules`.

The following sections describe the tasks in detail.

Enabling a qeth device

Use the **chzdev** command to create a group device, configure it, and set it online. Alternatively, for a non-persistent configuration, you can use the **znetconf** command or `sysfs`.

Before you begin

You must know the device bus-ID that corresponds to the read subchannel of your OSA-Express CHPID in QDIO mode or HiperSockets CHPID as defined in the IOCDS of your mainframe.

If you are using simulated NICs to couple to a z/VM virtual switch (VSWITCH) or a guest LAN, you need to know the virtual device addresses that were used in z/VM to define the simulated NIC.

Procedure

To enable a QETH device and create a persistent configuration, issue a command of the form:

```
# chzdev --enable qeth <read>
```

For example, if the read subchannel has a device bus-ID of 0.0.a000:

```
# chzdev --enable qeth 0.0.a000
```

This configures the read subchannel 0.0.a000, the write subchannel 0.0.a001, and the data subchannel 0.0.a002

Results

The **chzdev** command creates a group device in `sysfs` and sets a number of attributes for it, including the `layer2` attribute. The command also sets the group device online. For more information about the attributes, see the corresponding sections.

For example, to see the attributes set for device 0.0.a000, that has been assigned device name `enca000`, use the **lsqeth** command:


```
# lsqeth enca000
Device name           : enca000
-----
card_type             : OSD_1000
cdev0                 : 0.0.a000
cdev1                 : 0.0.a001
cdev2                 : 0.0.a002
chpid                 : 76
online                : 1
portname              : no portname required
portno                : 0
route4                : no
route6                : no
state                 : UP (LAN ONLINE)
priority_queueing     : always queue 0
fake_broadcast        : 0
buffer_count          : 64
layer2                : 0
isolation             : none
sniffer               : 0
switch_attrs          : unknown
```

Example

In this example (see Figure 54 on page 225), a single OSA-Express CHPID in QDIO mode is used to connect a Linux instance to a network.

Mainframe configuration:

IBM mainframe

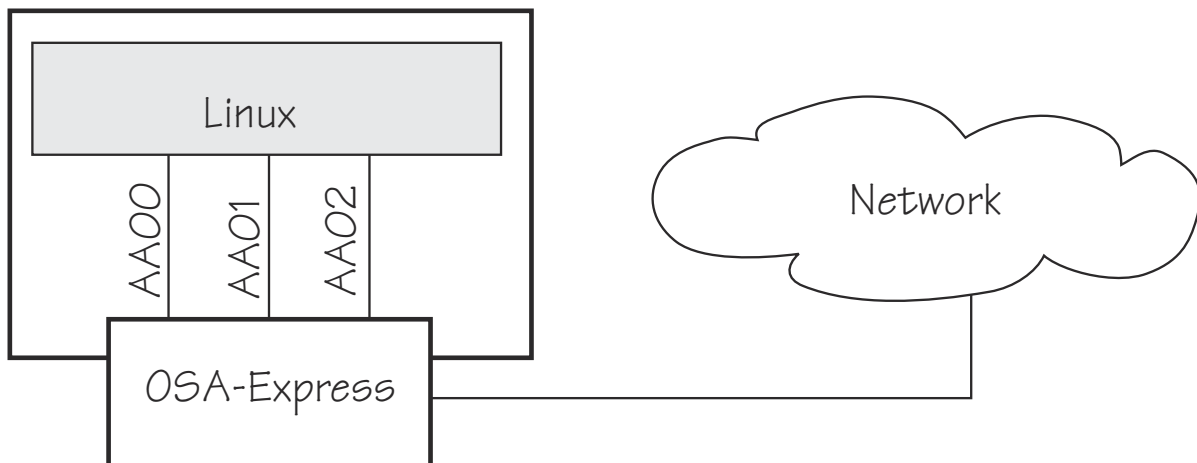


Figure 54. Mainframe configuration

Linux configuration:

Assuming that 0.0.aa00 is the device bus-ID that corresponds to the read subchannel:

```
# chzdev --enable qeth 0.0.a000
```

This command results in the creation of the following directories in sysfs:

- /sys/bus/ccwgroup/drivers/qeth/0.0.aa00
- /sys/bus/ccwgroup/devices/0.0.aa00
- /sys/devices/qeth/0.0.aa00

Both the command and the resulting directories would be the same for a HiperSockets CHPID.

What to do next

To change an attribute, or to set another attribute, issue a command of the form:

```
chzdev <device_type> <device_bus_ID> <attribute>=<value>
```

For example, to set the device 0.0.a000 offline, issue:

```
chzdev qeth 0.0.a000 online=0
```

To remove a qeth group device, use the ungroup attribute. For example, to ungroup the device you just created, issue:

```
chzdev qeth 0.0.a000 ungroup=1
```

Setting the layer2 attribute

If the detected hardware always runs in a specific discipline, the corresponding discipline module is automatically requested.

Before you begin

- To change a configured layer2 attribute, the network interface must be shut down and the device must be set offline.
- If you are using the layer2 option within a QDIO-based VSWITCH or guest LAN environment, avoid defining a VLAN with ID 1. Some switch vendors use ID 1 as the default value.
- IQD channels that in the IOCDs are defined as "external-bridged" must be configured to use layer 2.

About this task

The qeth device driver attempts to load the layer 3 discipline for HiperSockets devices and layer 2 for non-HiperSockets devices.

You can use the layer 2 mode for almost all device types, however, note the following about layer 2 to layer 3 conversion:

real OSA-Express

Hardware is able to convert layer 2 to layer 3 traffic and vice versa and thus there are no restrictions.

HiperSockets

There is no support for layer 2 to layer 3 conversion and, thus, no communication is possible between HiperSockets layer 2 interfaces and HiperSockets layer 3 interfaces. Do not include HiperSockets layer 2 interfaces and HiperSockets layer 3 interfaces in the same LAN.

z/VM VSWITCH or guest LAN

The qeth device driver detects the mode of the VSWITCH or LAN to which the NIC is coupled, and sets this mode on the device. The z/VM definition "Ethernet mode" is available for VSWITCHes and for guest LANs of type QDIO.

Procedure

The qeth device driver separates the configuration options in sysfs according to the device discipline. Hence the first configuration action after you group the device must be the configuration of the discipline.

To set the discipline, issue a command of the form:

```
chzdev <device_bus_id> layer2=<integer>
```

where <integer> is

- 0 to turn off the layer2 attribute; this results in the layer 3 discipline (default for HiperSockets).
- 1 to turn on the layer2 attribute; this results in the layer 2 discipline (default for network devices other than HiperSockets).

If the `layer2` attribute has a value of -1 (default), the layer was not set and the device drivers attempts to detect the correct layer setting. This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `layer2`:

```
echo <integer> > /sys/devices/qeth/<device_bus_id>/layer2
```

Results

If you configured the discipline successfully, more configuration attributes are shown (for example, `route4` for the layer 3 discipline) and can be configured. If an OSA device is not configured for a discipline but is set online, the device driver assumes that it is a layer 2 device. It then tries to load the layer 2 discipline.

For information about `layer2`, see:

- *Open Systems Adapter-Express Customer's Guide and Reference*, SA22-7935
- *OSA-Express Implementation Guide*, SG24-5948
- *Networking Overview for Linux on zSeries*, REDP-3901
- *z/VM: Connectivity*, SC24-6267

Using priority queueing

An OSA-Express CHPID in QDIO mode has up to four output queues (queues 0 - 3). The priority queueing feature gives these queues different priorities (queue 0 having the highest priority). The four output queues are available only if multiple priority is enabled for queues on the OSA-Express CHPID in QDIO mode.

Before you begin

- Priority queueing applies to OSA-Express CHPIDs in QDIO mode only.
- If more than 160 TCP/IP stacks per OSA-Express CHPID are defined in the IOCDs, priority queueing is disabled.
- The device must be offline while you set the queueing options.

About this task

Queueing is relevant mainly in high traffic situations. When there is little traffic, queueing has no impact on processing. The `qeth` device driver can put data on one or more of the queues. By default, the driver uses queue 2 for all data.

Procedure

You can determine how outgoing IP packages are assigned to queues by setting a value for the `priority_queueing` attribute of your `qeth` device.

Issue a command of the form:

```
# chzdev <device_bus_id> priority_queueing=<method>
```

where `<method>` can be any of these values:

prio_queueing_vlan

to base the queue assignment on the two most significant bits in the priority code point in the IEEE 802.1Q header as used in VLANs. This value affects only traffic with VLAN headers, and hence works only with `qeth` devices in layer 2 mode.

You can set the priority code point in the IEEE 802.1Q headers of the traffic based on `skb->priority` by using a command of the form:

```
ip link add link <link> name <name> type vlan id <vlan-id> egress-qos-map <mapping>
```

Note: Enabling this option makes all traffic default to queue 3.

prio_queueing_skb

to base the queue assignment on the priority flag of the skbs. An skb, or socket buffer, is a Linux kernel-internal structure that represents network data. The mapping to the priority queues is as follows:

Table 44. Mapping of flag value to priority queues

Priority flag of the skb	Priority queue
0-1	3
2-3	2
4-5	1
≥6	0

You can use `prio_queueing_skb` for any network setups, including conventional LANs.

Use either `sockopt SO_PRIORITY` or an appropriate **iptables** command to adjust the priority flag of the skb (`skb->priority`).

Note: The priority flag of the skbs defaults to 0, hence enabling this option makes all traffic default to queue 3.

prio_queueing_prec

to base the queue assignment on the two most significant bits of each packet's IP header precedence field. To set the precedence field, use `sockopt IP_TOS` (for IPv4) or `IPV6_TCLASS` (for IPv6).

Note: Enabling this option makes all traffic default to queue 3.

no_prio_queueing

causes the qeth device driver to use queue 2 for all packets. This value is the default.

no_prio_queueing:0

causes the qeth device driver to use queue 0 for all packets.

no_prio_queueing:1

causes the qeth device driver to use queue 1 for all packets.

no_prio_queueing:2

causes the qeth device driver to use queue 2 for all packets. This value is equivalent to the default.

no_prio_queueing:3

causes the qeth device driver to use queue 3 for all packets.

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `priority_queueing`:

```
# echo <method> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/priority_queueing
```

Example

To read what is set for priority queueing for device 0.0.a110, issue:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a110/priority_queueing
```

Possible results are:

by VLAN headers

if `prio_queueing_vlan` is set.

by skb-priority

if `prio_queueing_skb` is set.

by precedence

if `prio_queueing_prec` is set.

by type of service

if `prio_queueing_tos` is set.

always queue <x>

otherwise.

To configure queueing by `skb->priority` setting for device `0.0.a110` persistently, issue:

```
# chzdev 0.0.a110 priority_queueing=prio_queueing_skb
```

For the current configuration only, use **chzdev -a** or `sysfs`:

```
# echo prio_queueing_skb > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/priority_queueing
```

Specifying the number of inbound buffers

Depending on the amount of available storage and the amount of traffic, you can assign 8 - 128 inbound buffers for each qeth group device.

Before you begin

The device must be offline while you specify the number of buffers for inbound traffic.

About this task

By default, the qeth device driver assigns 64 inbound buffers to OSA devices and 128 to HiperSockets devices.

The Linux memory usage for inbound data buffers for the devices is: (number of buffers) × (buffer size).

The buffer size is equivalent to the frame size. See [“Finding out the maximum frame size” on page 230](#) for details.

Procedure

Set the `buffer_count` attribute to the number of inbound buffers you want to assign.

Issue a command of the form:

```
# chzdev <device_type> <device_bus_id> buffer_count=<number>
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,” on page 313](#).

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `buffer_count`:

```
# echo <number> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/buffer_count
```

Example

In this example, 64 inbound buffers are assigned to device `0.0.a000` persistently:

```
# chzdev qeth 0.0.a000 buffer_count=64
```

For the current configuration only, use **chzdev -a** or **sysfs**:

```
# echo 64 > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/buffer_count
```

Finding out the maximum frame size

The `inbuf_size` attribute returns the maximum frame size (MFS) in KB. To find out the MFS, read the `inbuf_size` attribute of the devices.

About this task

An OSA-Express CHPID in QDIO mode allows packing of data, and always runs with an MFS of 64 KB.

HiperSockets CHPIDs do not pack data and run with a frame size that matches their definition in the hardware configuration (IOCP CHPARM specification). On HiperSockets, the MFS maps to corresponding maximum transmission unit (MTU) sizes, see [Table 45 on page 230](#).

inbuf_size value	MFS	MTU
16k	16 KB	8 KB
24k	24 KB	16 KB
40k	40 KB	32 KB
64k	64 KB	56 KB

Procedure

Issue a command of this form to get a list of all attributes and find the `inbuf_size` attribute:

```
# lszdev qeth <device_bus_id> --info --info |grep inbuf_size
```

Alternatively, use **sysfs**:

```
# cat /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/inbuf_size
```

Example

To find the `inbuf_size` of a device 0.0.a100 issue:

```
# lszdev qeth 0.0.a100 --info --info | grep inbuf_size
inbuf_size "64k"
```

or:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/inbuf_size
64k
```

Specifying the relative port number

Use the `portno` attribute to specify the relative port number.

Before you begin

- This description applies to network adapters that, per CHPID, show more than one port to Linux.

- The device must be offline while you specify the relative port number.

Procedure

By default, the qeth group device uses port 0.

To use a different port, issue a command of the form:

```
# chzdev <device_bus_id> portno=<integer>
```

Where *<integer>* is either 0 or 1. This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or the sysfs attribute portno:

```
# echo <integer> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/portno
```

Example

In this example, port 1 is assigned to the qeth group device.

```
# chzdev 0.0.a000 portno=1
```

or, using sysfs:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a000/portno
```

Finding out the type of your network adapter

Use the `card_type` attribute to find out the type of the network adapter through which your device is connected.

Procedure

You can find out the type of the network adapter through which your device is connected. To find out the type, read the device's `card_type` attribute.

To list all attributes, issue a command of the form:

```
# lsdev <device_type> <device_bus_id> --info --info
```

or, using sysfs:

```
# cat /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/card_type
```

The `card_type` attribute gives information about both the type of network adapter and the type of network link (if applicable) available at the card's ports. See [Table 46 on page 232](#) for details.

Table 46. Possible values of `card_type` and what they mean

Value of <code>card_type</code>	Adapter type	Link type
OSD_25GIG	OSA card in OSD mode	25 Gigabit Ethernet
OSD_10GIG		10 Gigabit Ethernet
OSD_1000		Gigabit Ethernet, 1000BASE-T
OSD_100		Fast Ethernet
OSD_GbE_LANE		Gigabit Ethernet, LAN Emulation
OSD_FE_LANE		Fast Ethernet, LAN Emulation
OSD_Express		Unknown
OSX	OSA-Express for zBX	10 Gigabit Ethernet
HiperSockets	HiperSockets, CHPID type IQD	N/A
Virtual NIC QDIO	VSWITCH or guest LAN based on OSA	N/A
Virtual NIC Hiper	Guest LAN based on HiperSockets	N/A
Unknown	Other	

Example

To find the `card_type` of a device 0.0.a100 issue:

```
# lsdev qeth 0.0.a100 --info --info
...
READONLY    ACTIVE
card_type   "OSD_1000"
....
```

or, using `sysfs`:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/card_type
OSD_1000
```

Setting a device online or offline

Use the online device group attribute to set a device online or offline.

Procedure

To set a `qeth` group device online, set the online device group attribute to 1. To set a `qeth` group device offline, set the online device group attribute to 0.

Issue a command of the form:

```
# chzdev <device_bus_id> online=<flag>
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `online`:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/online
```


Results

Setting a device online associates it with an interface name (see “Finding out the interface name of a qeth group device” on page 233). When you set a device successfully online or offline, a change uevent is created.

Setting a device offline closes this network device. If IPv6 is active, you lose any IPv6 addresses set for this device. After you set the device online, you can restore lost IPv6 addresses only by issuing the **ip** or an equivalent command again.

Example

To set a qeth device with bus ID 0.0.a100 online persistently, issue:

```
# chzdev 0.0.a100 online=1
```

or, for the running configuration only using sysfs:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/online
```

To set the same device offline issue:

```
# chzdev 0.0.a100 online=0
```

or, for the running configuration only using sysfs:

```
# echo 0 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/online
```

Finding out the interface name of a qeth group device

When a qeth group device is set online, an interface name is assigned to it.

Procedure

To find the interface name of a qeth group device, either:

- Obtain a list of all attributes for a device by issuing the **lszdev** command for the device.

Issue a command of the form:

```
# lszdev qeth <device_bus_id> --info --info
```

- Obtain a mapping for all qeth interfaces and devices by issuing the **lsqeth -p** command.
- Find out the interface name of a qeth group device for which you know the device bus-ID by reading the group device's `if_name` attribute.

Issue a command of the form:

```
# cat /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/if_name
```

Example

```
# lszdev qeth 0.0.a100 --info --info
...
if_name  "enca100"
....
```

or, using sysfs:

```
# cat /sys/bus/ccwgroup/drivers/qeth/0.0.a100/if_name
enca100
```

Finding out the bus ID of a qeth interface

Use the **lsqeth -p** command to obtain a mapping for all qeth interfaces and devices. Alternatively, you can use sysfs.

Procedure

To find the device bus-ID that corresponds to an interface, either:

- Use the **lsqeth -p** command.
- Use the readlink command.

For each network interface, there is a directory in sysfs under `/sys/class/net/`, for example, `/sys/class/net/enca100` for interface enca100. This directory contains a symbolic link "device" to the corresponding device in `/sys/devices`. Read this link to find the device bus-ID of the device that corresponds to the interface.

Example

To find out which device bus-ID corresponds to an interface enca100 issue, for example:

```
# readlink /sys/class/net/enca100/device
../../../../../0.0.a100
```

In this example, enca100 corresponds to the device bus-ID 0.0.a100.

Activating an interface

Use the **ip** command or equivalent to activate an interface.

Before you begin

- You must know the interface name of the qeth group device (see [“Finding out the interface name of a qeth group device”](#) on page 233).
- You must know the IP address that you want to assign to the device.

About this task

The MTU size defaults to the correct settings for HiperSockets devices. For OSA-Express CHPIDs in QDIO mode, the default MTU size depends on the device mode, layer 2 or layer 3.

- For layer 2, the default MTU is 1500 bytes.
- For layer 3, the default MTU is 1492 bytes.

In most cases, these defaults are well suited for OSA-Express CHPIDs in QDIO mode. If your network is laid out for jumbo frames, increase the MTU size to a maximum of 9000 bytes for layer 2, or to 8992 bytes for layer 3. See *Open Systems Adapter-Express Customer's Guide and Reference*, SA22-7935 for more details about MTU size.

For HiperSockets, the maximum MTU size is restricted by the maximum frame size as announced by the Licensed Internal Code (LIC). The maximum MTU is equal to the frame size minus 8 KB. Hence, the possible frame sizes of 16 KB, 24 KB, 40 KB, or 64 KB result in maximum corresponding MTU sizes of 8 KB, 16 KB, 32 KB, or 56 KB.

Procedure

You activate or deactivate network devices with **ip** or an equivalent command. For details of the **ip** command, see the **ip** man page.

Examples

- This example activates a HiperSockets CHPID with broadcast address 192.168.100.255:

```
# ip addr add 192.168.100.10/24 dev enca1c0
# ip link set dev enca1c0 up
```

- This example activates an OSA-Express CHPID in QDIO mode with broadcast address 192.168.100.255:

```
# ip addr add 192.168.100.11/24 dev encf500
# ip link set dev encf500 up
```

- This example reactivates an interface that was already activated and subsequently deactivated:

```
# ip link set dev encf500 up
```

Confirming that an IP address has been set under layer 3

There may be circumstances that prevent an IP address from being set, most commonly if another system in the network has set that IP address already.

About this task

The Linux network stack design does not allow feedback about IP address changes. If **ip** or an equivalent command fails to set an IP address on an OSA-Express network CHPID, a query with **ip** shows the address as being set on the interface although the address is not actually set on the CHPID.

There are usually failure messages about not being able to set the IP address or duplicate IP addresses in the kernel messages. You can find these messages in the output of the **dmesg** command.

If you are not sure whether an IP address was set properly or experience a networking problem, check the messages or logs to see if an error was encountered when setting the address. This also applies in the context of HiperSockets and to both IPv4 and IPv6 addresses. It also applies to whether an IP address has been set for IP takeover, for VIPA, or for proxy ARP.

Duplicate IP addresses

The OSA-Express adapter in QDIO mode recognizes duplicate IP addresses on the same OSA-Express adapter or in the network using ARP and prevents duplicates.

About this task

Several setups require duplicate addresses:

- To perform IP takeover you need to be able to set the IP address to be taken over. This address exists prior to the takeover. See [“Taking over IP addresses” on page 246](#) for details.
- For proxy ARP you need to register an IP address for ARP that belongs to another Linux instance. See [“Configuring a device for proxy ARP” on page 249](#) for details.
- For VIPA you need to assign the same virtual IP address to multiple devices. See [“Configuring a device for virtual IP address \(VIPA\)” on page 250](#) for details.

You can use the **qethconf** command (see [“qethconf - Configure qeth devices” on page 644](#)) to maintain a list of IP addresses that your device can take over, a list of IP addresses for which your device can handle ARP, and a list of IP addresses that can be used as virtual IP addresses, regardless of any duplicates on the same OSA-Express adapter or in the LAN.

Deactivating an interface

You can deactivate an interface with **ip** or an equivalent command or by setting the network device offline.

About this task

Setting a device offline involves actions on the attached device, but deactivating a device only stops the interface logically within Linux.

Procedure

To deactivate an interface with **ip**, issue a command of the form:

```
# ip link set dev <interface_name> down
```

Example

To deactivate encf500 issue:

```
# ip link set dev encf500 down
```

Recovering a device

You can use the `recover` attribute of a `qeth` group device to recover it in case of failure.

About this task

For example, error messages from the `qeth`, `qdio`, or `cio` kernel modules might inform you of a malfunctioning device.

Setting the `recover` attribute schedules recovery synchronously, however the recovery itself might take some time.

Procedure

Issue a command of the form:

```
# chzdev <device_bus_id> -a recover=1
```

Alternatively, use the `sysfs` attribute `recover`:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/recover
```

Example

```
# chzdev 0.0.a100 -a recover=1
```

Alternatively, using `sysfs`:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/recover
```

| Configuring hardware checksum offload operations

| Some CPU-intensive operations can be offloaded to the OSA adapter, thus reducing the load on the host CPU.

The `qeth` device driver supports offloading for the following operations on both layer 2 and layer 3:

- Inbound (receive) and outbound (transmit) checksum calculations for TCP and UDP network packets
- TCP segmentation, see [“Enabling and disabling TCP segmentation offload”](#) on page 238.

VLAN interfaces inherit offload settings from their base interface.

You can set the offload operations with the Linux **ethtool** command. See the **ethtool** man page for details. The following abbreviated example shows some of the offload settings:

```
# ethtool -k encf500
Features for encf500:
rx-checksumming: on
tx-checksumming: on
    tx-checksum-ipv4: on
    tx-checksum-ip-generic: off [fixed]
    tx-checksum-ipv6: on
    tx-checksum-fcoe-crc: off [fixed]
    tx-checksum-sctp: off [fixed]
scatter-gather: on
    tx-scatter-gather: on
    tx-scatter-gather-fraglist: off [fixed]
tcp-segmentation-offload: on
    tx-tcp-segmentation: on
    tx-tcp-ecn-segmentation: off [fixed]
    tx-tcp6-segmentation: on
udp-fragmentation-offload: off [fixed]
generic-segmentation-offload: off [requested on]
generic-receive-offload: on
large-receive-offload: off [fixed]
...
```

Configuring the receive checksum offload feature

A checksum calculation is a form of redundancy check to protect the integrity of data.

Procedure

To enable or disable checksum calculations by the OSA feature, issue a command of this form:

```
# ethtool -K <interface_name> rx <value>
```

where *<value>* is on or off.

Examples

- To let the OSA feature calculate the inbound checksum for network device encf500, issue

```
# ethtool -K encf500 rx on
```

- To let the host CPU calculate the inbound checksum for network device encf500, issue

```
# ethtool -K encf500 rx off
```

Configuring the transmit checksum offload feature

The qeth device driver supports offloading outbound (transmit) checksum calculations to the OSA feature.

About this task

You can enable or disable the OSA feature calculating the transmit checksums by using the **ethtool** command.

Procedure

Issue a command of the form:

```
# ethtool -K <interface_name> tx <value>
```

where *<value>* is on or off.

Example

- To let the OSA feature calculate the outbound checksum for network device encf500, issue

```
# ethtool -K encf500 tx on
```

- To let the host CPU calculate the outbound checksum for network device encf500, issue

```
# ethtool -K encf500 tx off
```

Enabling and disabling TCP segmentation offload

Offloading the TCP segmentation operation from the Linux network stack to the adapter can lead to enhanced performance for interfaces with predominately large outgoing packets.

About this task

TCP segmentation offload is supported for OSA connections on layer 3. On layer 2 it is available as of z14 for OSA Express6S and newer adapters. Use the **ethtool -k** (see example in [“Configuring hardware checksum offload operations”](#) on page 236) to check whether your system supports it.

Procedure

Outbound (TX) checksumming and scatter gather are prerequisites for TCP segmentation offload (TSO). You must turn on scatter gather and outbound checksumming before configuring TSO.

All three options can be turned on or off with a single **ethtool** command of the form:

```
# ethtool -K <interface_name> tx <value> sg <value> tso <value>
```

where *<value>* is either on or off. For more information about TX checksumming, see [“Configuring the transmit checksum offload feature”](#) on page 237.

Attention: When TCP segmentation is offloaded, the OSA feature performs the calculations. Offloaded calculations are supported only for packets that go out to the LAN.

Examples

- To enable TSO for a network device eth0 issue:

```
# ethtool -K eth0 tx on sg on tso on
```

- To disable TSO for a network device eth0 issue:

```
# ethtool -K eth0 tx off sg off tso off
```

Isolating data connections

You can restrict communications between operating system instances that share an OSA port on an OSA adapter.

About this task

A Linux instance can configure the OSA adapter to prevent any direct package exchange between itself and other operating system instances that share an OSA adapter. This configuration ensures a higher degree of isolation than VLANs.

QDIO data connection isolation is configured as a policy. The policy is implemented as a sysfs attribute called `isolation`. The attribute appears in sysfs regardless of whether the hardware supports the feature. The policy can take the following values:

none

No isolation. This value is the default.

drop

Specifies the ISOLATION_DROP policy. All packets from guests that share an OSA adapter to guests that have this policy configured are dropped automatically. The same holds for all packets that are sent by the guest with this policy configured to guests on the same OSA card. All packets to or from the isolated guest must have a target that is not hosted on the OSA card. You can accomplish this by a router hosted on a separate machine or a separate OSA adapter.

For example, assume that three Linux instances share an OSA adapter, but only one instance (Linux A) must be isolated. Then Linux A declares its OSA adapter (QDIO Data Connection to the OSA adapter) to be isolated. Any packet sent to or from Linux A must pass at least the physical switch to which the shared OSA adapter is connected. Linux A cannot communicate with other instances that share the OSA adapter, here B or C. The two other instances can still communicate directly through the OSA adapter without the external switch in the network path (see [Figure 55 on page 239](#)).

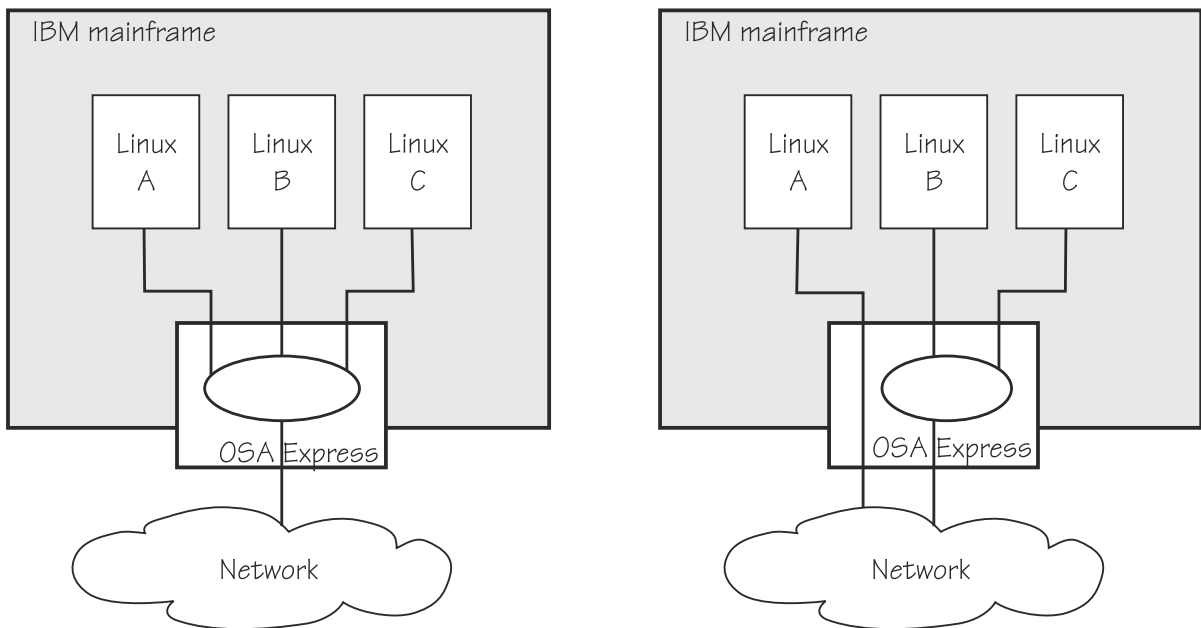


Figure 55. Linux instance A is isolated from instances B and C

forward

Specifies the ISOLATION_FORWARD policy. All packets are passed through a switch. The ISOLATION_FORWARD policy requires a network adapter in VEPA mode with an adjacent switch port configured for reflective relay mode.

To check whether the switch of the adapter is in reflective relay mode, read the sysfs attribute `switch_attrs`. The attribute lists all supported forwarding modes, with the currently active mode enclosed in square brackets. For example:

```
lszdev qeth 0.0.f5f0 --info --info
...
READONLY      ACTIVE
...
switch_attrs: "802.1 [rr]"
```

Or, using sysfs to query the attribute directly:

```
cat /sys/devices/qeth/0.0.f5f0/switch_attrs
802.1 [rr]
```

The example indicates that the adapter supports both 802.1 forwarding mode and reflective relay mode, and reflective relay mode is active.

Using a network adapter in VEPA mode achieves further isolation. VEPA mode forces traffic from the Linux guests to be handled by the external switch. For example, Figure 56 on page 240 shows instances A and B with ISOLATION_FORWARD specified for the policy. All traffic between A and B goes through the external switch. The rule set of the switch now determines which connections are possible. The graphic assumes that A can communicate with B, but not with C.

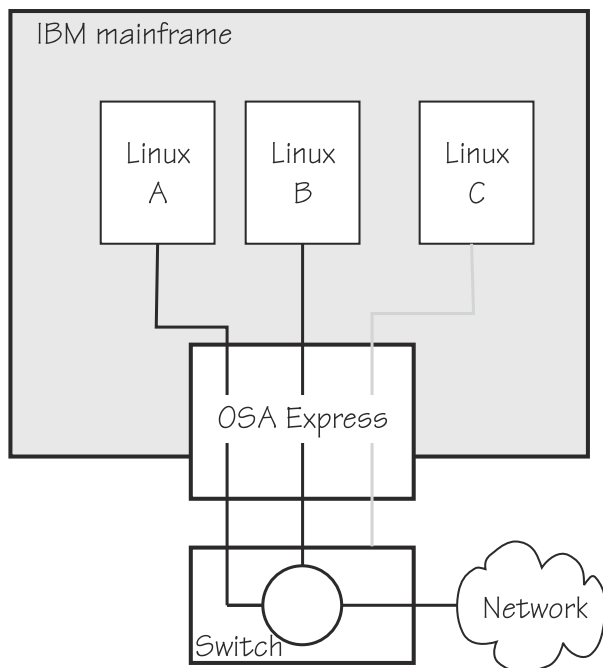


Figure 56. Traffic from Linux instance A and B is forced through an external switch

If the ISOLATION_FORWARD policy was enforced successfully, but the switch port later loses the reflective-relay capability, the device is set offline to prevent damage.

You can configure the policy regardless of whether the device is online. If the device is online, the policy is configured immediately. If the device is offline, the policy is configured when the device comes online.

Examples

- To check the current isolation policy:

```
# cat /sys/devices/qeth/0.0.f5f0/isolation
```

- To set the isolation policy to ISOLATION_DROP:

```
# chzdev qeth 0.0.f5f0 isolation=drop
```

Or, using sysfs:

```
# echo drop > /sys/devices/qeth/0.0.f5f0/isolation
```

- To set the isolation policy to ISOLATION_FORWARD:

```
# chzdev qeth 0.0.f5f0 isolation=forward
```

Or, using sysfs:

```
# echo forward > /sys/devices/qeth/0.0.f5f0/isolation
```


If the switch is not capable of VEPA support, or VEPA support is not configured on the switch, then you cannot set the isolation attribute value to 'forward' while the device is online. If the switch does not support VEPA and you set the isolation value 'forward' while the device is offline, then the device cannot be set online until the isolation value is set back to 'drop' or 'none'.

- To set the isolation policy to none:

```
# chzdev qeth 0.0.f5f0 isolation=none
```

Or, using sysfs:

```
# echo none > /sys/devices/qeth/0.0.f5f0/isolation
```

When you use vNICs, VEPA mode must be enabled on the respective VSWITCH. See *z/VM: Connectivity*, SC24-6267 for information about setting up data connection isolation on a VSWITCH.

Displaying and resetting QETH performance statistics

Use the **ethtool** to display the QETH performance statistics and the `performance_stats` sysfs attribute to reset the statistic values.

About this task

Ubuntu Server continuously gathers QETH performance data.

Procedure

1. Use the **ethtool** command to display the statistics. For details, see the **ethtool** man page.
2. Optional: Reset the statistic values to 0 by writing 1 to the `performance_stats` sysfs attribute of the QETH device.
For example:

```
# chzdev -a <device_bus_id> performance_stats=1
```

or, using sysfs:

```
echo 1 > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/performance_stats
```

Capturing a hardware trace

Hardware traces are intended for use by the IBM service organization. Hardware tracing is turned off by default. Turn on the hardware-tracing feature only when instructed to do so by IBM service.

Before you begin

- The OSA-Express adapter must support the hardware-tracing feature.
- The qeth device must be online to return valid values of the `hw_trap` attribute.

About this task

When errors occur on an OSA-Express adapter, both software and hardware traces must be collected. Instructions for software traces depend on a case-by-case basis and are communicated as part of the service process. The hardware-tracing feature requests a hardware trace if an error is detected. This feature makes it possible to correlate the hardware trace with the device driver trace. If the hardware-tracing feature is activated, traces are captured automatically, but you can also start the capturing yourself.

Procedure

To activate or deactivate the hardware-tracing feature, issue a command of the form:

```
# chzdev <device_bus_id> -a hw_trap=<value>
```

Where <value> can be:

arm

If the hardware-tracing feature is supported, write `arm` to the `hw_trap` sysfs attribute to activate it. If the hardware-tracing feature is present and activated, the `hw_trap` sysfs attribute has the value `arm`.

disarm

Write `disarm` to the `hw_trap` sysfs attribute to turn off the hardware-tracing feature. If the hardware-tracing feature is not present or is turned off, the `hw_trap` sysfs attribute has the value `disarm`. This setting is the default.

trap

(Write only) Capture a hardware trace. Hardware traces are captured automatically, but if asked to do so by IBM service, you can start the capturing yourself by writing `trap` to the `hw_trap` sysfs attribute. The hardware trap function must be set to `arm`.

Examples

In this example the hardware-tracing feature is activated and started for qeth device 0.0.a000:

```
# chzdev 0.0.a000 -a hw_trap=arm
# chzdev 0.0.a000 -a hw_trap=trap
```

Alternatively, using sysfs directly:

1. Check that the `hw_trap` sysfs attribute is set to `arm`:

```
# cat /sys/devices/qeth/0.0.a000/hw_trap
arm
```

2. Start the capture:

```
# echo trap > /sys/devices/qeth/0.0.a000/hw_trap
```

Working with qeth devices in layer 3 mode

Tasks you can perform on qeth devices in layer 3 mode include setting up a router, configuring TCP segmentation offload, and taking over IP addresses.

Use the layer 2 attribute to set the mode. See [“Setting the layer2 attribute” on page 226](#) about setting the mode. See [“Layer 2 and layer 3” on page 212](#) for general information about the layer 2 and layer 3 disciplines.

Setting up a Linux router

By default, your Linux instance is not a router. Depending on your IP version, IPv4 or IPv6 you can use the `route4` or `route6` attribute of your qeth device to define it as a router.

Before you begin

- A suitable hardware setup must be in place that enables your Linux instance to act as a router.
- The Linux instance is set up as a router. To configure Linux running as a z/VM guest or in an LPAR as a router, IP forwarding must be enabled in addition to setting the `route4` or `route6` attribute.

For IPv4, enable IP forwarding by issuing:

```
# sysctl -w net.ipv4.conf.all.forwarding=1
```

For IPv6, enable IP forwarding by issuing:

```
# sysctl -w net.ipv6.conf.all.forwarding=1
```

About this task

You can set the `route4` or `route6` attribute dynamically, while the `qeth` device is online.

The same values are possible for `route4` and `route6` but depend on the type of CHPID, as shown in [Table 47 on page 243](#).

Router specification	OSA-Express CHPID in QDIO mode	HiperSockets CHPID
<code>primary_router</code>	Yes	No
<code>secondary_router</code>	Yes	No
<code>primary_connector</code>	No	Yes
<code>secondary_connector</code>	No	Yes
<code>multicast_router</code>	Yes	Yes
<code>no_router</code>	Yes	Yes

Both types of CHPIDs accept:

multicast_router

causes the `qeth` driver to receive all multicast packets of the CHPID. For a unicast function for HiperSockets see [“HiperSockets Network Concentrator” on page 261](#).

no_router

is the default. You can use this value to reset a router setting to the default.

An OSA-Express CHPID in QDIO mode accepts the following values:

primary_router

to make your Linux instance the principal connection between two networks.

secondary_router

to make your Linux instance a backup connection between two networks.

A HiperSockets CHPID accepts the following values, if the microcode level supports the feature:

primary_connector

to make your Linux instance the principal connection between a HiperSockets network and an external network (see [“HiperSockets Network Concentrator” on page 261](#)).

secondary_connector

to make your Linux instance a backup connection between a HiperSockets network and an external network (see [“HiperSockets Network Concentrator” on page 261](#)).

Example

In this example (see [Figure 57 on page 244](#)), two Linux instances, "Linux P" and "Linux S", running on an IBM mainframe use OSA-Express to act as primary and secondary routers between two networks. IP forwarding must be enabled for Linux in an LPAR or as a z/VM guest to act as a router. IP forwarding is configured in `procs` or in a configuration file; see the Ubuntu Server 20.04.1 manuals for details.

Mainframe configuration:

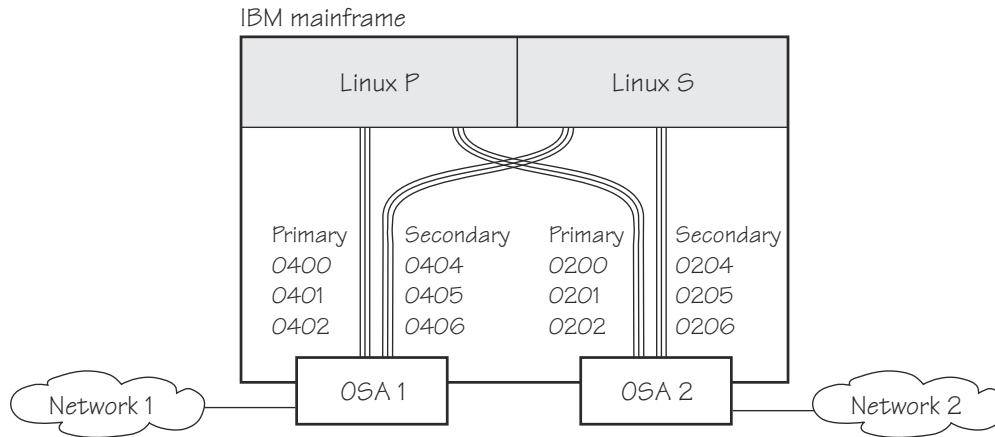


Figure 57. Mainframe configuration

It is assumed that both Linux instances are configured as routers in their LPARs or in z/VM.

Linux P configuration:

To create the qeth group devices:

```
# chzdev --enable qeth 0.0.0400,0.0.0401,0.0.0402
# chzdev --enable qeth 0.0.0200,0.0.0201,0.0.0202
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or the **sysfs** attribute group:

```
# echo 0.0.0400,0.0.0401,0.0.0402 > /sys/bus/ccwgroup/drivers/qeth/group
# echo 0.0.0200,0.0.0201,0.0.0202 > /sys/bus/ccwgroup/drivers/qeth/group
```

To make Linux P a primary router for IPv4:

```
# chzdev qeth 0.0.0400 route4=primary_router
# chzdev qeth 0.0.0200 route4=primary_router
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or the **sysfs** attribute **route4**:

```
# echo primary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0400/route4
# echo primary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0200/route4
```

Linux S configuration:

To create the qeth group devices:

```
# chzdev --enable qeth 0.0.0404,0.0.0405,0.0.0406
# chzdev --enable qeth 0.0.0204,0.0.0205,0.0.0206
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or the **sysfs** attribute group:

```
# echo 0.0.0404,0.0.0405,0.0.0406 > /sys/bus/ccwgroup/drivers/qeth/group
# echo 0.0.0204,0.0.0205,0.0.0206 > /sys/bus/ccwgroup/drivers/qeth/group
```

To make Linux S a secondary router for IPv4:

```
# chzdev qeth 0.0.0400 route4=secondary_router
# chzdev qeth 0.0.0200 route4=secondary_router
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or the **sysfs** attribute **route4**:

```
# echo secondary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0404/route4
# echo secondary_router > /sys/bus/ccwgroup/drivers/qeth/0.0.0204/route4
```

In this example, qeth device 0.0.1510 is defined as a primary router for IPv6:

```
# chzdev --enable qeth 0.0.1510,0.0.1511,0.0.1512
# chzdev qeth 0.0.1510 route6=primary_router
# lsudev 1510 -i | grep route6
primary router
```

Alternatively, using **sysfs** attributes:

```
/sys/bus/ccwgroup/drivers/qeth # cd 0.0.1510
# echo 1 > online
# echo primary_router > route6
# cat route6
primary router
```

See [“HiperSockets Network Concentrator”](#) on page 261 for further examples.

Faking broadcast capability

It is possible to fake the broadcast capability for devices that do not support broadcasting.

Before you begin

- You can fake the broadcast capability only on devices that do not support broadcast.
- The device must be offline while you enable faking broadcasts.

About this task

For devices that support broadcast, the broadcast capability is enabled automatically.

To find out whether a device supports broadcasting, use the **ip** command. If the resulting list shows the **BROADCAST** flag, the device supports broadcast. This example shows that the device **encf500** supports broadcast:

```
# ip -s link show dev encf500
3: encf500: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1492 qdisc pfifo_fast qlen 1000
    link/ether 00:11:25:bd:da:66 brd ff:ff:ff:ff:ff:ff
    RX: bytes    packets  errors  dropped overrun mcast
       236350    2974    0       0       0       9
    TX: bytes    packets  errors  dropped carrier collsns
       374443    1791    0       0       0       0
```

Some processes, for example, the *gated* routing daemon, require the devices' broadcast capable flag to be set in the Linux network stack.

Procedure

To set the broadcast capable flag for devices that do not support broadcast, set the `fake_broadcast` attribute of the `qeth` group device to 1. To reset the flag, set it to 0.

Issue a command of the form:

```
# chzdev <device_bus_id> fake_broadcast=<flag>
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `fake_broadcast`:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/fake_broadcast
```

Example

In this example, a device 0.0.a100 is instructed to pretend that it can broadcast.

```
# chzdev 0.0.a100 fake_broadcast=1
```

Or, for the running configuration using `sysfs`:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a100/fake_broadcast
```

Taking over IP addresses

You can configure IP takeover if the `layer2` option is not enabled. If you enabled the `layer2` option, you can configure for IP takeover as you would in a distributed server environment.

About this task

For information about the `layer2` option, see [“MAC headers in layer 2 mode”](#) on page 215.

Taking over an IP address overrides any previous allocation of this address to another LPAR. If another LPAR on the same CHPID already registered for that IP address, this association is removed.

An OSA-Express CHPID in QDIO mode can take over IP addresses from any IBM Z operating system. IP takeover for HiperSockets CHPIDs is restricted to taking over addresses from other Linux instances in the same Central Electronics Complex (CEC).

IP address takeover between multiple CHPIDs requires ARP for IPv4 and Neighbor Discovery for IPv6. OSA-Express handles ARP transparently, but not Neighbor Discovery.

There are three stages to taking over an IP address:

- Stage 1: Ensure that your `qeth` group device is enabled for IP takeover
- Stage 2: Activate the address to be taken over for IP takeover
- Stage 3: Issue a command to take over the address

Stage 1: Enabling a `qeth` group device for IP takeover

For OSA-Express and HiperSockets CHPIDs, both the `qeth` group device that is to take over an IP address and the device that surrenders the address must be enabled for IP takeover.

Procedure

By default, qeth devices are not enabled for IP takeover. To enable a qeth group device for IP address takeover set the enable device group attribute to 1. To switch off the takeover capability set the enable device group attribute to 0.

In sysfs, the enable attribute is located in a subdirectory `ipa_takeover`. Issue a command of the form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/ipa_takeover/enable
```

Example

In this example, a device 0.0.a500 is enabled for IP takeover:

```
# echo 1 > /sys/bus/ccwgroup/drivers/qeth/0.0.a500/ipa_takeover/enable
```

Stage 2: Activating and deactivating IP addresses for takeover

The qeth device driver maintains a list of IP addresses that qeth group devices can take over or surrender. To enable Linux to take over an IP-address or to surrender an address, the address must be added to this list.

Procedure

Use the **qethconf** command to add IP addresses to the list.

- To display the list of IP addresses that are activated for IP takeover issue:

```
# qethconf ipa list
```

- To activate an IP address for IP takeover, add it to the list.

Issue a command of the form:

```
# qethconf ipa add <ip_address>/<mask_bits> <interface_name>
```

- To deactivate an IP address delete it from the list.

Issue a command of the form:

```
# qethconf ipa del <ip_address>/<mask_bits> <interface_name>
```

In these commands, `<ip_address>/<mask_bits>` is the range of IP addresses to be activated or deactivated. See [“qethconf - Configure qeth devices” on page 644](#) for more details about the **qethconf** command.

IPv4 example

In this example, there is only one range of IP addresses (192.168.10.0 to 192.168.10.255) that can be taken over by HiperSockets device `enca1c10`.

List the range of IP addresses (192.168.10.0 to 192.168.10.255) that can be taken over by HiperSockets device `enca1c10`.

```
# qethconf ipa list  
ipa add 192.168.10.0/24 enca1c10
```

The following command adds a range of IP addresses that can be taken over by device `encf500`.

```
# qethconf ipa add 192.168.11.0/24 encf500  
qethconf: Added 192.168.11.0/24 to /sys/class/net/encf500/device/ipa_takeover/add4.  
qethconf: Use "qethconf ipa list" to check for the result
```

Listing the activated IP addresses now shows both ranges of addresses.

```
# qethconf ipa list
ipa add 192.168.10.0/24 enca1c0
ipa add 192.168.11.0/24 encf500
```

The following command deletes the range of IP addresses that can be taken over by device encf500.

```
# qethconf ipa del 192.168.11.0/24 encf500
qethconf: Deleted 192.168.11.0/24 from /sys/class/net/encf500/device/ipa_takeover/del4.
qethconf: Use "qethconf ipa list" to check for the result
```

IPv6 example

The following command adds one range of IPv6 addresses, fec0:0000:0000:0000:0000:0000:0000:0000 to fec0:0000:0000:0000:FFFF:FFFF:FFFF:FFFF, that can be taken over by OSA device encd300.

Add a range of IP addresses:

```
qethconf ipa add fec0::/64 encd300
qethconf: Added fec0:0000:0000:0000:0000:0000:0000:0000/64 to
  sysfs entry /sys/class/net/encd300/device/ipa_takeover/add6.
qethconf: For verification please use "qethconf ipa list"
```

Listing the activated IP addresses now shows the range of addresses:

```
qethconf ipa list
...
ipa add fec0:0000:0000:0000:0000:0000:0000:0000/64 encd300
```

The following command deletes the IPv6 address range that can be taken over by encd300:

```
qethconf ipa del fec0:0000:0000:0000:0000:0000:0000:0000/64 encd300:
qethconf: Deleted fec0:0000:0000:0000:0000:0000:0000:0000/64 from
  sysfs entry /sys/class/net/encd300/device/ipa_takeover/del6.
qethconf: For verification please use "qethconf ipa list"
```

Stage 3: Issuing a command to take over the address

To complete taking over a specific IP address and remove it from the CHPID or LPAR that previously held it, issue the **ip addr** command.

Before you begin

- Both the device that is to take over the IP address and the device that is to surrender the IP address must be enabled for IP takeover. This rule applies to the devices on both OSA-Express and HiperSockets CHPIDs. (See [“Stage 1: Enabling a qeth group device for IP takeover”](#) on page 246).
- The IP address to be taken over must have been activated for IP takeover (see [“Stage 2: Activating and deactivating IP addresses for takeover”](#) on page 247).

About this task

Be aware of the information in [“Confirming that an IP address has been set under layer 3”](#) on page 235 when using IP takeover.

Examples

IPv4 example:

To make a HiperSockets device enca1c0 take over IP address 192.168.10.22 issue:


```
# ip addr add 192.168.10.22/24 dev enca1c0
```

For IPv4, the IP address you are taking over must be different from the one that is already set for your device. If your device already has the IP address it is to take over, you must issue two commands: First remove the address to be taken over if it is already there. Then add the IP address to be taken over.

For example, to make a HiperSockets device enca1c0 take over IP address 192.168.10.22 if enca1c0 is already configured to have IP address 192.168.10.22 issue:

```
# ip addr del 192.168.10.22/24 dev enca1c0  
# ip addr add 192.168.10.22/24 dev enca1c0
```

IPv6 example:

To make a OSA device encd300 take over fec0::111:25ff:febd:d9da/64 issue:

```
ip addr add fec0::111:25ff:febd:d9da/64 nodad dev encd300
```

For IPv6, setting the **nodad** (no duplicate address detection) option ensures that the encd300 interface uses the IP address fec0::111:25ff:febd:d9da/64. Without the **nodad** option, the previous owner of the IP address might prevent the takeover by responding to a duplicate address detection test.

The IP address you are taking over must be different from the one that is already set for your device. If your device already has the IP address it is to take over you must issue two commands: First remove the address to be taken over if it is already there. Then add the IP address to be taken over.

For example, to make a device encd300 take over IP address fec0::111:25ff:febd:d9da/64 when encd300 is already configured to have that particular IP address issue:

```
ip addr del fec0::111:25ff:febd:d9da/64 nodad dev encd300  
ip addr add fec0::111:25ff:febd:d9da/64 nodad dev encd300
```

Configuring a device for proxy ARP

You can configure a device for proxy ARP if the layer2 option is not enabled. If you enabled the layer2 option, you can configure for proxy ARP as you would in a distributed server environment.

Before you begin

Configure only qeth group devices that are set up as routers for proxy ARP.

About this task

For information about the layer2 option, see [“MAC headers in layer 2 mode”](#) on page 215.

The qeth device driver maintains a list of IP addresses for which a qeth group device handles ARP and issues gratuitous ARP packets. For more information about proxy ARP, see

<http://www.cisco.com/c/en/us/support/docs/ip/dynamic-address-allocation-resolution/13718-5.html>

Use the **qethconf** command to display this list or to change the list by adding and removing IP addresses (see [“qethconf - Configure qeth devices”](#) on page 644).

Be aware of the information in [“Confirming that an IP address has been set under layer 3”](#) on page 235 when you work with proxy ARP.

Example

[Figure 58 on page 250](#) shows an environment where proxy ARP is used.

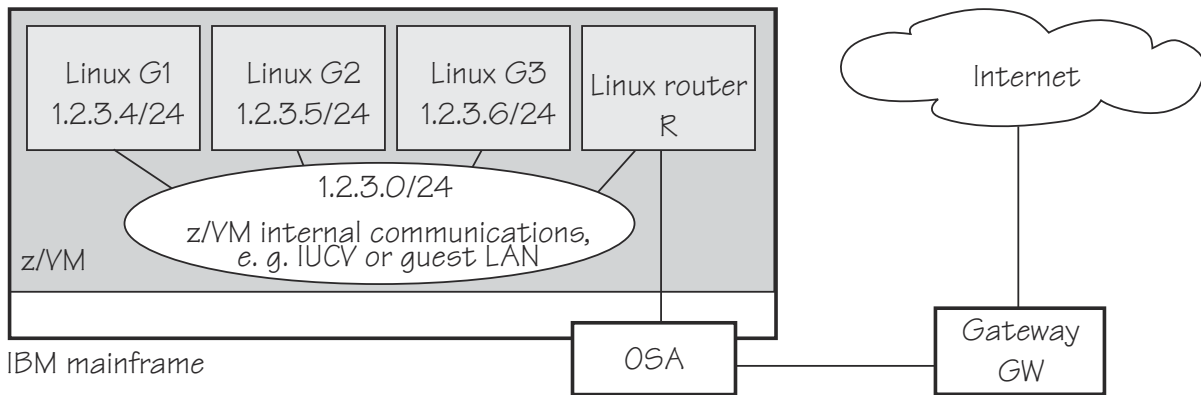


Figure 58. Example of proxy ARP usage

G1, G2, and G3 are instances of Linux on z/VM (connected, for example, through a guest LAN to a Linux router R), reached from GW (or the outside world) through R. R is the ARP proxy for G1, G2, and G3. That is, R agrees to take care of packets that are destined for G1, G2, and G3. The advantage of using proxy ARP is that GW does not need to know that G1, G2, and G3 are behind a router.

To receive packets for 1.2.3.4, so that it can forward them to G1 1.2.3.4, R would add 1.2.3.4 to its list of IP addresses for proxy ARP for the interface that connects it to the OSA adapter.

```
# qethconf parp add 1.2.3.4 encf500
qethconf: Added 1.2.3.4 to /sys/class/net/encf500/device/ixip/add4.
qethconf: Use "qethconf parp list" to check for the result
```

After issuing similar commands for the IP addresses 1.2.3.5 and 1.2.3.6 the proxy ARP configuration of R would be:

```
# qethconf parp list
parp add 1.2.3.4 encf500
parp add 1.2.3.5 encf500
parp add 1.2.3.6 encf500
```

Configuring a device for virtual IP address (VIPA)

You can configure a device for VIPA if the layer2 option is not enabled. If you enabled the layer2 option, you can configure for VIPA as you would in a distributed server environment.

About this task

For information about the layer2 option, see [“MAC headers in layer 2 mode”](#) on page 215.

IBM Z use VIPAs to protect against certain types of hardware connection failure. You can assign VIPAs that are independent from particular adapter. VIPAs can be built under Linux using *dummy* devices (for example, "dummy0" or "dummy1").

The qeth device driver maintains a list of VIPAs that the OSA-Express adapter accepts for each qeth group device. Use the **qethconf** utility to add or remove VIPAs (see [“qethconf - Configure qeth devices”](#) on page 644).

For an example of how to use VIPA, see [“Scenario: VIPA – minimize outage due to adapter failure”](#) on page 257.

Be aware of [“Confirming that an IP address has been set under layer 3”](#) on page 235 when you work with VIPAs.

Configuring a HiperSockets device for AF_IUCV addressing

Use the `hsuid` attribute of a HiperSockets device in layer 3 mode to identify it to the AF_IUCV addressing family support.

Before you begin

- Support for AF_IUCV based connections through real HiperSockets requires Completion Queue Support.
- The device must be set up for AF_IUCV addressing (see [“Setting up HiperSockets devices for AF_IUCV addressing”](#) on page 288).

Procedure

To set an identifier, issue a command of this form:

```
# chzdev qeth 0.0.a007 hsuid=<value>
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `hsuid`:

```
# echo <value> > /sys/bus/ccwgroup/drivers/qeth/0.0.a007/hsuid
```

The identifier is case-sensitive and must adhere to these rules:

- It must be 1 - 8 characters.
- It must be unique across your environment.
- It must not match any z/VM user ID in your environment. The AF_IUCV addressing family support also supports z/VM IUCV connections.

Example

In this example, MYHOST01 is set as the identifier for a HiperSockets device with bus ID 0.0.a007.

```
# chzdev qeth 0.0.a007 hsuid=MYHOST01
```

Or, for the running configuration only using `sysfs`:

```
# echo MYHOST01 > /sys/bus/ccwgroup/drivers/qeth/0.0.a007/hsuid
```

Working with qeth devices in layer 2 mode

Tasks that you can perform on qeth devices in layer 2 mode include setting up an OSA or HiperSockets bridge port and tuning packet handling for an OSA or HiperSockets device with VNIC characteristics.

VNIC characteristics and the bridge port role are mutually exclusive.

Use the `layer2` attribute to set the mode. See [“Setting the layer2 attribute”](#) on page 226 about setting the mode. See [“Layer 2 and layer 3”](#) on page 212 for general information about the layer 2 and layer 3 disciplines.

Configuring a network device as a member of a Linux bridge

You can define an OSA or HiperSockets device to be a bridge port, which allows it to act as a member of a Linux software bridge. Use the `bridge_role` attribute of a network device in layer 2 to make it receive all traffic with unknown destination MAC addresses.

Alternatively, use VNIC characteristics to configure a layer 2 network device to receive all unknown traffic (see [“Advanced packet-handling configuration”](#) on page 254).

Before you begin

To use the bridging support, you need OSA or HiperSockets hardware that supports layer 2 SETBRIDGEPORT functionality.

You can have one active bridge port per Internal Queued Direct Communication (IQD) or OSA channel. You can have either only secondary bridge ports, or one primary and several secondary bridge ports per OSA or HiperSockets channel.

Devices for which VNIC characteristics are configured cannot also be configured as bridge ports.

On z13 and older mainframes: HiperSockets bridge ports only bridge traffic to and from HiperSockets ports in z/VM guests. On z14 and later HiperSockets bridge ports bridge traffic to and from all layer 2 HiperSockets ports that are not configured as "bridge_invisible", see [“Advanced packet-handling configuration”](#) on page 254.

HiperSockets only: On IQDX channels permission to configure ports as bridge ports must be granted in IBM zEnterprise Unified Resource Manager (zManager). On machines in PR/SM mode, bridge ports can only be configured on IQD channels that are defined as "external-bridged" in the IOCDs. On machines in DPM mode, bridge ports can be configured on any IQD channel.

For more information about the bridge port concept, see [“Layer 2 promiscuous mode”](#) on page 218.

About this task

The following sysfs attributes control the bridge port functions. The attributes can be found in the `/sys/bus/ccwgroup/drivers/qeth/<device_bus_id>` directory.

bridge_role

Read-write attribute that controls the role of the port. Valid values are:

primary

Assigns the port the primary bridge port role.

secondary

Assigns the port a secondary bridge port role.

none

Revokes existing bridge port roles and indicates that no role is assigned.

Assigning a role directly to a port prevents use of the **bridge_reflect_promisc** attribute.

bridge_state

Read-only attribute that shows the state of the port. Valid values are:

active

The port is assigned a bridge port role and is switched into active state by the adapter. The device receives frames that are addressed to unknown MAC addresses.

standby

The port is assigned a bridge port role, but is not currently switched into active state by the adapter. The device does not receive frames that are destined to unknown MAC addresses.

inactive

The port is not assigned a bridge port role.

bridge_hostnotify

HiperSockets only: Read-write attribute that controls the sending of notifications for the port. When you enable notifications (even if notifications were already enabled), udev events are emitted for all currently connected communication peers in quick succession. After that, a udev event is emitted every time a communication peer is connected, or a previously connected peer is disconnected. Any user space program that monitors these events must repopulate its list of registered peers every time the status of the bridge port device changes to enable notifications.

Valid values are:

1

The port is set to send notifications.

0

Notifications are turned off.

Notifications about the change of the state of bridge ports, and (if enabled) about registration and deregistration of communication peers on the LAN are delivered as udev events. The events are described in the file `linux-doc/s390/qeth.txt`.

bridge_reflect_promisc

Read-write attribute that, when set, makes the bridge-port role of the port follow ("reflect") the promiscuity flag (`IFF_PROMISC`) of the corresponding Linux network interface. You can specify the following values:

none

Setting and resetting the promiscuous mode on the network interface has no effect on the bridge-port role of the underlying port.

primary

Setting or resetting the promiscuous mode on the network interface that is served by this device causes the driver to attempt assigning (or resetting) the primary role to the port. If a port with the primary role exists, assignment fails.

secondary

Setting or resetting the promiscuous mode on the network interface that is served by this device causes the driver to attempt assigning (or resetting) the secondary role to the port.

Setting **bridge_reflect_promisc** to anything but **none** causes the **bridge_role** attribute to become read-only. The role of a port changes as a result of setting or unsetting the promiscuity flag (`IFF_PROMISC`) of the corresponding network interface. You can check the currently assigned role by reading the **bridge_role** attribute.

Procedure

1. To configure a network device as a bridge, issue a command of this form:

```
# chzdev <device_bus_id> bridge_role=<value>
```

This setting persists across re-boots. For more details, see [Chapter 24, "Persistent device configuration,"](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the `-a` option or the `sysfs` attribute `bridge_role`:

```
# echo <value> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/bridge_role
```

Setting the **bridge_role** attribute requires the **bridge_reflect_promisc** attribute to be **none**. Alternatively, to make the bridge-port role of the port follow the promiscuity flag (`IFF_PROMISC`) of the corresponding Linux network interface, issue a command of the following form:

```
# chzdev <device_bus_id> bridge_reflect_promisc=<value>
```

This setting persists across re-boots. For more details, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

To apply this setting to the running system only, use the **chzdev** command with the **-a** option or the sysfs attribute `bridge_reflect_promisc`:

```
# echo <value> > /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/bridge_reflect_promisc
```

where valid values are:

- primary
- secondary
- none

2. Check the state of the bridge port by reading the `bridge_state` attribute. Issue a command of this form:

```
# lszdev qeth <device_bus_id> --info --info
```

Alternatively, use the sysfs attribute `bridge_state` directly:

```
# cat /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/bridge_state
```

where displayed values could be:

- active
- standby
- inactive

Example

In this example, a network device with bus ID `0.0.a007` is defined as a primary bridge port.

```
# chzdev 0.0.a007 bridge_role=primary
```

Or, for the running configuration only using sysfs:

```
# echo primary > /sys/bus/ccwgroup/drivers/qeth/0.0.a007/bridge_role
# cat /sys/bus/ccwgroup/drivers/qeth/a007/bridge_state
active
```

What to do next

You can specify up to four secondary bridge ports together with one primary bridge port. If the primary bridge port fails, one of these bridge ports takes over. For each secondary bridge port, set `bridge_role` to secondary.

Advanced packet-handling configuration

Use VNIC characteristics to control how OSA or HiperSockets devices in layer 2 mode handle special scenarios, for example, packets with unknown MAC addresses, address takeover, or traffic with bridge ports.

Before you begin

- See your Z hardware documentation about support for VNIC characteristics. Support might differ for OSA and HiperSockets devices.
- VNIC characteristics are supported for layer 2 mode only.
- VNIC characteristics cannot be configured on devices that are configured as bridge ports.

About this task

You can configure and fine-tune a promiscuous mode for incoming packets. You can configure the device to receive all packets regardless of the MAC address, or you can reject incoming multicast packets, or broadcast packets, or both.

For Linux instances that host multiple guest operating systems with different MAC addresses, you can configure the device to learn and handle these MAC addresses. The device then provides functions similar to a switch or to a software bridge.

The VNIC characteristics also include settings that can protect the MAC address of the device from being taken over by another device. You can deny takeover, or you can explicitly permit takeover to facilitate migration, for example in a recovery situation.

The VNIC characteristics of a qeth device are represented by sysfs attributes in `/sys/devices/qeth/<device_bus_id>/vnicc:`

flooding

With flooding enabled, the device receives packets to any unknown destination MAC address. Valid values are 0 for disabled and 1 for enabled. By default, flooding is disabled.

For a shared OSA adapter, flooding applies to traffic between the physical port and the OSA interfaces, but not to communication between the interfaces that share the adapter. Enable learning to configure bridge-like behavior of shared OSA adapters.

An OSA Express adapter can support a maximum of 64 devices with flooding enabled.

mcast_flooding

With multicast flooding enabled, the device receives packets to any multicast MAC address. Valid values are 0 for disabled and 1 for enabled. By default, multicast flooding is disabled and the device receives only packets to multicast MAC addresses to which it has previously registered.

rx_bcast

With broadcast receiving enabled, the device receives packets with the broadcast destination MAC address. Valid values are 0 for disabled and 1 for enabled. By default, the device is enabled to receive broadcast packets.

learning

With learning enabled, the device assembles a list of source MAC addresses of outgoing packets. The device then receives incoming packets to any MAC address in the list. Valid values are 0 for disabled and 1 for enabled. By default, learning is disabled.

A MAC address is added to the list unless it has been explicitly assigned to another device on the same channel. An exception are addresses of devices on which the `takeover_learning` characteristic is set. Such devices surrender their address to a learning device. If an address is already listed by a different learning device on the same channel, the address is removed from that learning device's list. Explicitly configuring a MAC address on a different device removes the address from the learning device list.

A learned MAC address is dropped from the list of learned MAC addresses unless packets with this MAC address are sent within a specific timeout period. The default timeout period is 600 s. You can specify a different timeout period with the `learning_timeout` attribute.

takeover_setvmac

With this option enabled, the device's MAC address can be configured on a different device, without notification. Valid values are 0 for disabled and 1 for enabled. By default, this option is disabled and the MAC address cannot be configured on a different device on the same channel.

takeover_learning

With takeover by learning enabled, the MAC address of this device can be learned on a different device on the same channel and, thus, taken over by this other device, without notification. Valid values are 0 for disabled and 1 for enabled. By default, takeover by learning is disabled.

bridge_invisible

With bridge-port invisible enabled, packets are not transferred between the device and any other device that is configured as a bridge port. Valid values are 0 for disabled and 1 for enabled. By default, this option is disabled and, thus, traffic to and from bridge ports is permitted.

This characteristic applies to HiperSockets devices only.

learning_timeout

With learning enabled, this attribute specifies a timeout period, in seconds. A MAC address is dropped from the list of learned MAC addresses if this timeout period expires without any packets with this MAC address being received.

You can set this timeout period by writing a value in the range 60 - 86400 to the attribute. The default is 600. The timeout must be set before learning is enabled on the device.

Procedure

1. Optional: To read a VNIC characteristic setting from sysfs, issue a command of this form:

```
# cat /sys/devices/qeth/<device_bus_id>/vnicc/<attribute>
```

where *<device_bus_id>* is the device-bus ID of the qeth device and *<attribute>* is one of the attributes that represent the VNIC characteristics.

Example:

```
# cat /sys/devices/qeth/0.0.a016/vnicc/learning
0
```

Tip: For an overview of all VNIC characteristics of the device, find the interface name of the device, then use the **lsqeth** command.

Example:

```
# cat /sys/devices/qeth/0.0.a016/if_name
eth0
# lsqeth eth0 | grep vnicc
vnicc/bridge_invisible : 0
vnicc/flooding         : 0
vnicc/learning         : 0
vnicc/learning_timeout : 600
vnicc/mcast_flooding   : 1
vnicc/rx_bcast         : 1
vnicc/takeover_learning : 0
vnicc/takeover_setvmac : 0
```

2. To set a VNIC characteristic issue a command of this form:

```
# chzdev <device_bus_id> vnicc/<attribute>=<value>
```

where *<device_bus_id>* is the device-bus ID of the qeth device, *<attribute>* is one of the attributes that represent the VNIC characteristics, and *<value>* is the value to be set.

This setting persists across re-boots. For more details, see Chapter 24, “Persistent device configuration,” on page 313. To apply this setting to the running system only, use the **chzdev** command with the **-a** option or use the corresponding sysfs attribute.

Example: In this example, learning is enabled for a device with bus-ID 0.0.a016.

```
# chzdev 0.0.a016 vnicc/learning=1
```

or, using sysfs:

```
# echo 1 > /sys/devices/qeth/0.0.a016/vnicc/learning
```


Example

This example shows a typical configuration for a bridge-like behavior of the device.

```
# lsqeth eth0 | grep vnicc
vnicc/bridge_invisible : 0
vnicc/flooding         : 1
vnicc/learning         : 1
vnicc/learning_timeout : 600
vnicc/mcast_flooding   : 1
vnicc/rx_bcast         : 1
vnicc/takeover_learning : 1
vnicc/takeover_setvmac : 1
```

Scenario: VIPA – minimize outage due to adapter failure

Using VIPA you can assign IP addresses that are not associated with a particular adapter. VIPA thus minimizes outage that is caused by adapter failure.

This scenario uses standard VIPA, which is sufficient for applications, such as web servers, that do *not* open connections to other nodes.

Note:

1. See the information in [“Confirming that an IP address has been set under layer 3” on page 235](#) concerning possible failure when you set IP addresses for OSA-Express features in QDIO mode (qeth device driver).

Setting up standard VIPA

To set up VIPA you must create a dummy device, ensure that your service listens to the IP address, and set up routing to it.

Procedure

Follow these main steps to set up VIPA in Linux:

1. Create a dummy device with a virtual IP address.
2. Ensure that your service (for example, the Apache web server) listens to the virtual IP address assigned in step [“1” on page 257](#).
3. Set up routes to the virtual IP address, on clients or gateways. To do so, you can use either:
 - Static routing (shown in the example of [Figure 59 on page 258](#)).
 - Dynamic routing. For details of how to configure routes, you must see the documentation that is delivered with your routing daemon (for example, zebra or gated).

Adapter outage

If outage of an adapter occurs, you must switch adapters.

Procedure

- Under static routing:
 - a) Delete the route that was set previously.
 - b) Create an alternative route to the virtual IP address.
- Under dynamic routing, see the documentation that is delivered with your routing daemon for details.

Example of how to set up standard VIPA

This example shows you how to configure VIPA under static routing, and how to switch adapters when an adapter outage occurs.

About this task

Figure 59 on page 258 shows the network adapter configuration that is used in the example.

IBM mainframe

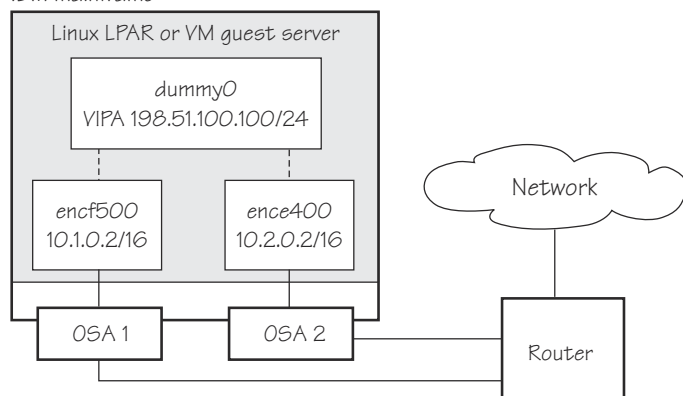


Figure 59. Example of using Virtual IP Address (VIPA)

Procedure

1. Define the real interfaces.

```
[server]# ip addr add 10.1.0.2/16 dev encf500
[server]# ip link set dev encf500 up
[server]# ip addr add 10.2.0.2/16 dev ence400
[server]# ip link set dev ence400 up
```

2. If the dummy component was not compiled into the kernel, ensure that the dummy module was loaded.

If necessary, load it by issuing:

```
[server]# modprobe dummy
```

3. Create a dummy interface with a virtual IP address 198.51.100.100 and a netmask 255.255.255.0:

```
[server]# ip addr add 198.51.100.100/24 dev dummy0
[server]# ip link set dev dummy0 up
```

4. Enable the network devices for this VIPA so that it accepts packets for this IP address.

- IPv4 example:

```
[server]# qethconf vipa add 198.51.100.100 encf500
qethconf: Added 198.51.100.100 to /sys/class/net/encf500/device/vipa/add4.
qethconf: Use "qethconf vipa list" to check for the result
[server]# qethconf vipa add 198.51.100.100 ence400
qethconf: Added 198.51.100.100 to /sys/class/net/ence400/device/vipa/add4.
qethconf: Use "qethconf vipa list" to check for the result
```

- For IPv6, the address is specified in IPv6 format:

```
[server]# qethconf vipa add 2002::1235:5678 encf500
qethconf: Added 2002:0000:0000:0000:0000:0000:1235:5678 to /sys/class/net/encf500/device/vipa/add6.
qethconf: Use "qethconf vipa list" to check for the result
[server]# qethconf vipa add 2002::1235:5678 ence400
qethconf: Added 2002:0000:0000:0000:0000:0000:1235:5678 to /sys/class/net/ence400/device/vipa/add6.
qethconf: Use "qethconf vipa list" to check for the result
```

5. Ensure that the addresses are set:

```
[server]# qethconf vipa list
vipa add 198.51.100.100 encf500
vipa add 198.51.100.100 ence400
```

6. Ensure that your service (such as the Apache web server) listens to the virtual IP address.
7. Set up a route to the virtual IP address (static routing) so that VIPA can be reached through the gateway with address 10.1.0.2.

```
[router]# ip route add 198.51.100.100 via 10.1.0.2
```

What to do next

Now assume that an adapter outage occurs. You must then:

1. Delete the previously created route.

```
[router]# ip route del 198.51.100.100
```

2. Create the alternative route to the virtual IP address.

```
[router]# ip route add 198.51.100.100 via 10.2.0.2
```

Introduction to VLANs

Use VLANs to increase traffic flow and reduce latency. With VLANs, you can organize your network by traffic patterns rather than by physical location.

In a conventional network topology, such as that shown in Figure 60 on page 259, devices communicate across LAN segments in different broadcast domains by using routers. Although routers add latency by delaying transmission of data while they are using more of the data packet to determine destinations, they are preferable to building a single broadcast domain. A single domain can easily be flooded with traffic.

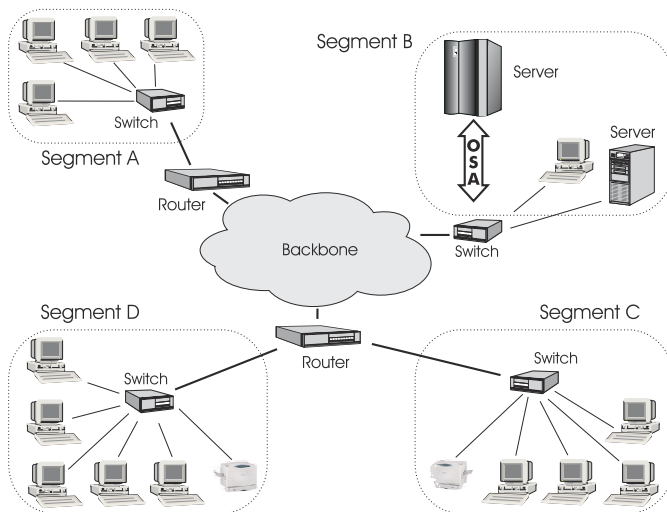


Figure 60. Conventional routed network

By organizing the network into VLANs by using Ethernet switches, distinct broadcast domains can be maintained without the latency that is introduced by multiple routers. As Figure 61 on page 260 shows, a single router can provide the interfaces for all VLANs that appeared as separate LAN segments in the previous figure.

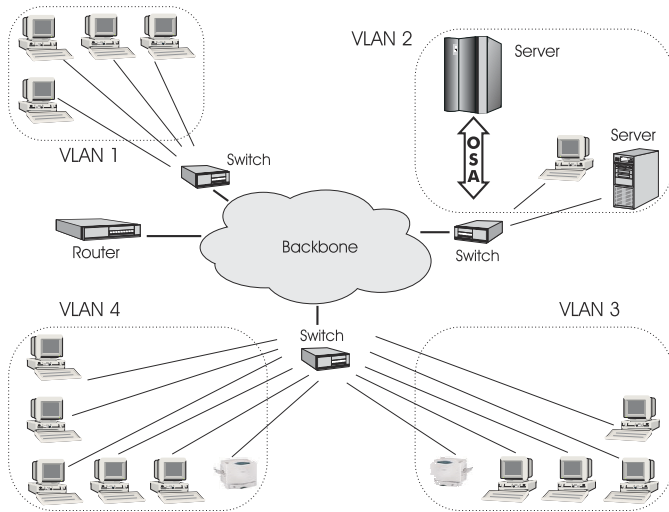


Figure 61. Switched VLAN network

Figure 62 on page 260 shows how VLANs can be organized logically, according to traffic flow, rather than being restricted by physical location. If workstations 1-3 communicate mainly with the small server, VLANs can be used to organize only these devices in a single broadcast domain that keeps broadcast traffic within the group. This setup reduces traffic both inside the domain and outside, on the rest of the network.

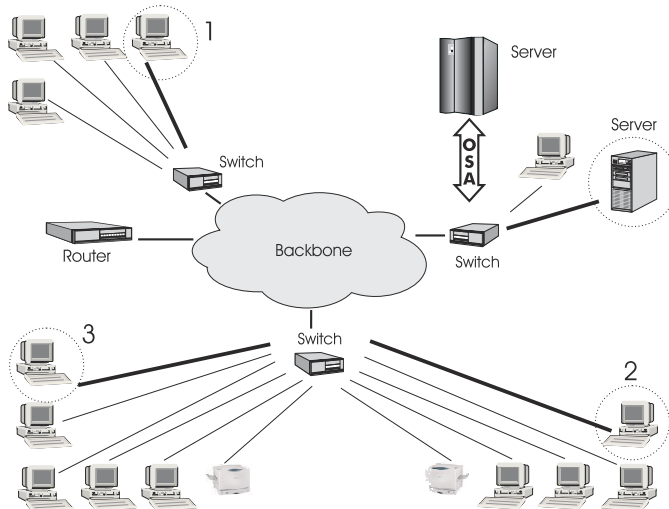


Figure 62. VLAN network organized for traffic flow

Configuring VLAN devices

Configure VLANs with the **ip link add** command. See the **ip-link** man page for details.

About this task

Information about the current VLAN configuration is available by listing the files in

```
/proc/net/vlan/*
```

with **cat** or more. For example:

```
bash-2.04# cat /proc/net/vlan/config
VLAN Dev name | VLAN ID
Name-Type: VLAN_NAME_TYPE_RAW_PLUS_VID_NO_PAD bad_proto_recvd: 0
encd300.100 | 100 | encd300
encd300.200 | 200 | encd300
```

```

encd300.300 | 300 | encd300
bash-2.04# cat /proc/net/vlan/encd300.300
encd300.300 VID: 300 REORDER_HDR: 1 dev->priv_flags: 1
    total frames received: 10914061
    total bytes received: 1291041929
Broadcast/Multicast Rcvd: 6

    total frames transmitted: 10471684
    total bytes transmitted: 4170258240
    total headroom inc: 0
    total encap on xmit: 10471684
Device: encd300
INGRESS priority mappings: 0:0 1:0 2:0 3:0 4:0 5:0 6:0 7:0
EGRESS priority Mappings:
bash-2.04#

```

Example: Creating two VLANs

VLANs are allocated in an existing interface that represents a physical Ethernet LAN.

The following example creates two VLANs, one with ID 3 and one with ID 5.

```

ip addr add 198.51.160.23/19 dev ence400
ip link set dev ence400 up
ip link add dev ence400.3 link ence400 type vlan id 3
ip link add dev ence400.5 link ence400 type vlan id 5

```

The **ip link add** commands added interfaces "ence400.3" and "ence400.5", which you can then configure:

```

ip addr add 1.2.3.4/24 dev ence400.3
ip link set dev ence400.3 up
ip addr add 10.100.2.3/16 dev ence400.5
ip link set dev ence400.5 up

```

The traffic that flows out of ence400.3 is in the VLAN with ID=3. This traffic is not received by other stacks that listen to VLANs with ID=4.

The internal routing table ensures that every packet to 1.2.3.x goes out through ence400.3, and everything to 10.100.x.x through ence400.5. Traffic to 198.51.1xx.x flows through ence400 (without a VLAN tag).

To remove one of the VLAN interfaces:

```

ip link set dev ence400.3 down
ip link delete ence400.3 type vlan

```

HiperSockets Network Concentrator

You can configure a HiperSockets Network Concentrator on a QETH device in layer 3 mode.

Before you begin: The instructions that are given apply to IPv4 only. The HiperSockets Network Concentrator connector settings are available in layer 3 mode only.

The HiperSockets Network Concentrator connects systems to an external LAN within one IP subnet that uses HiperSockets. HiperSockets Network Concentrator connected systems look as if they were directly connected to the LAN. This simplification helps to reduce the complexity of network topologies that result from server consolidation.

Without changing the network setup, you can use HiperSockets Network Concentrator to port systems:

- From the LAN into an Z server environment
- From systems that are connected by a different HiperSockets Network Concentrator into an Z server environment

Thus, HiperSockets Network Concentrator helps to simplify network configuration and administration.

Design

A connector Linux system forwards traffic between the external OSA interface and one or more internal HiperSockets interfaces. The forwarding is done via IPv4 forwarding for unicast traffic and via a particular bridging code (xcec_bridge) for multicast traffic.

A script named `ip_watcher.pl` observes all IP addresses registered in the HiperSockets network and sets them as Proxy ARP entries (see [“Configuring a device for proxy ARP”](#) on page 249) on the OSA interfaces. The script also establishes routes for all internal systems to enable IP forwarding between the interfaces.

All unicast packets that cannot be delivered in the HiperSockets network are handed over to the connector by HiperSockets. The connector also receives all multicast packets to bridge them.

Setup

The setup principles for configuring the HiperSockets Network Concentrator on a mainframe Linux system are as follows:

leaf nodes

The leaf nodes do not require a special setup. To attach them to the HiperSockets network, their setup should be as if they were directly attached to the LAN. They do not have to be Linux systems.

connector systems

In the following, HiperSockets Network Concentrator IP refers to the subnet of the LAN that is extended into the HiperSockets net.

- If you want to support forwarding of all packet types, define the OSA interface for traffic into the LAN as a multicast router (see [“Setting up a Linux router”](#) on page 242).

If only unicast packages are to be forwarded, there is also the possibility not to identify the OSA interface as multicast router: add the interface name to the `start_hsnrc` script and only unicast packets are forwarded.

- All HiperSockets interfaces that are involved must be set up as connectors: set the `route4` attributes of the corresponding devices to `"primary_connector"` or to `"secondary_connector"`. Alternatively, you can add the OSA interface name to the `start` script as a parameter. This option results in HiperSockets Network Concentrator ignoring multicast packets, which are then not forwarded to the HiperSockets interfaces.
- IP forwarding must be enabled for the connector partition. Enable the forwarding either manually with the command

```
sysctl -w net.ipv4.ip_forward=1
```

Alternatively, you can enable IP forwarding in the `/etc/sysctl.conf` configuration file to activate IP forwarding for the connector partition automatically after booting.

- The network routes for the HiperSockets interface must be removed. A network route for the HiperSockets Network Concentrator IP subnet must be established through the OSA interface. To establish a route, assign the IP address 0.0.0.0 to the HiperSockets interface. At the same time, assign an address that is used in the HiperSockets Network Concentrator IP subnet to the OSA interface. These assignments set up the network routes correctly for HiperSockets Network Concentrator.
- To start HiperSockets Network Concentrator, run the script `start_hsnrc.sh`. You can specify an interface name as optional parameter. The interface name makes HiperSockets Network Concentrator use the specified interface to access the LAN. There is no multicast forwarding in that case.
- To stop HiperSockets Network Concentrator, use the command `killall ip_watcher.pl` to remove changes that are caused by running HiperSockets Network Concentrator.

Availability setups

If a connector system fails during operation, it can simply be restarted. If all the startup commands are run automatically, it will instantaneously be operational again after booting. Two common availability setups are mentioned here:

One connector partition and one monitoring system

As soon as the monitoring system cannot reach the connector for a specific timeout (for example, 5 seconds), it restarts the connector. The connector itself monitors the monitoring system. If it detects (with a longer timeout than the monitoring system, for example, 15 seconds) a monitor system failure, it restarts the monitoring system.

Two connector systems monitoring each other

In this setup, there is an active and a passive system. As soon as the passive system detects a failure of the active connector, it takes over operation. To take over operation, it must reset the other system to release all OSA resources for the multicast_router operation. The failed system can then be restarted manually or automatically, depending on the configuration. The passive backup HiperSockets interface can either switch into primary_connector mode during the failover, or it can be set up as secondary_connector. A secondary_connector takes over the connecting function, as soon as there is no active primary_connector. This setup has a faster failover time than the first one.

Hints

- The MTU of the OSA and HiperSockets link should be of the same size. Otherwise, multicast packets that do not fit in the link's MTU are discarded as there is no IP fragmentation for multicast bridging. Warnings are printed to syslog.
- The script `ip_watcher.pl` prints error messages to the standard error descriptor of the process.
- `xcec-bridge` logs messages and errors to syslog.
- Registering all internal addresses with the OSA adapter can take several seconds for each address.
- To shut down the HiperSockets Network Concentrator function, issue `killall ip_watcher.pl`. This script removes all routing table and Proxy ARP entries added during the use of HiperSockets Network Concentrator.

Note:

1. Broadcast bridging is active only on OSA or HiperSockets hardware that can handle broadcast traffic without causing a bridge loop. If you see the message "Setting up broadcast echo filtering for ... failed" in the message log when you set the qeth device online, broadcast bridging is not available.
2. Unicast packets are routed by the common Linux IPv4 forwarding mechanisms. As bridging and forwarding are done at the IP Level, the IEEE 802.1q VLAN and the IPv6 protocol are not supported.
3. To use HiperSockets Network Concentrator, the `s390-tools` package from developerWorks is required.

Examples for setting up a network concentrator

An example of a network environment with a network concentrator.

[Figure 63 on page 264](#) shows a network environment where a Linux instance C acts as a network concentrator that connects other operating system instances on a HiperSockets LAN to an external LAN.

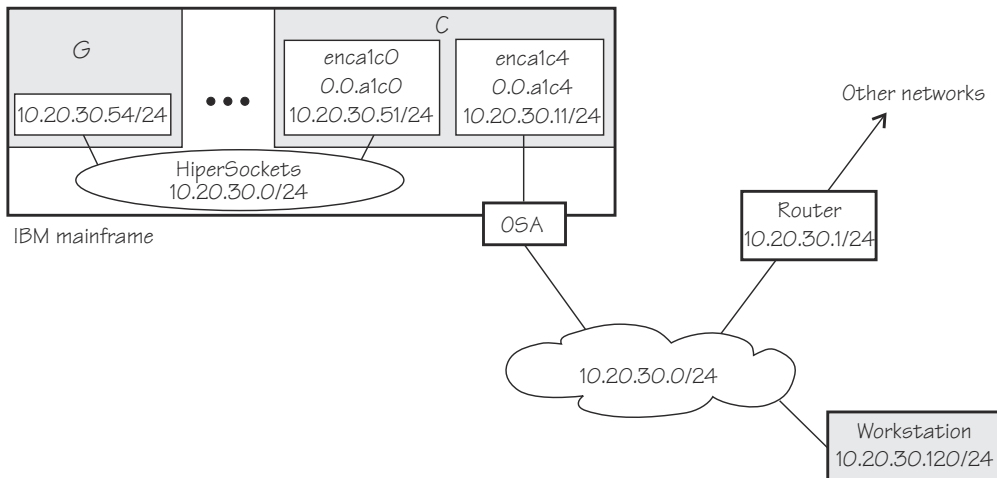


Figure 63. HiperSockets network concentrator setup

Setup for the network concentrator C:

The HiperSockets interface enca1c0 (device bus-ID 0.0.a1c0) has IP address 10.20.30.51/24. The default gateway is 10.20.30.1.

Issue:

```
# echo primary_connector > /sys/bus/ccwgroup/drivers/qeth/0.0.a1c0/route4
```

The OSA-Express CHPID in QDIO mode interface enca1c4 (with device bus-ID 0.0.a1c4) has IP address 10.20.30.11/24. The default gateway is 10.20.30.1.

Issue:

```
# echo multicast_router > /sys/bus/ccwgroup/drivers/qeth/0.0.a1c4/route4
```

To enable IP forwarding issue:

```
# sysctl -w net.ipv4.ip_forward=1
```

Tip: See Ubuntu Server 20.04.1 information about using configuration files to automatically enable IP forwarding when Linux boots.

To remove the network routes for the HiperSockets interface issue:

```
# ip route del 10.20.30/24
```

To start the HiperSockets network concentrator, run the script start_hsync.sh. Issue:

```
# start_hsync.sh &
```

Setup for G:

No special setup required. The HiperSockets interface has IP address 10.20.30.54/24. The default gateway is 10.20.30.1.

Setup for workstation:

No special setup required. The network interface IP address is 10.20.30.120/24. The default gateway is 10.20.30.1.

Figure 64 on page 265 shows the example of Figure 63 on page 264 with an additional mainframe. On the second mainframe a Linux instance D acts as a HiperSockets network concentrator.

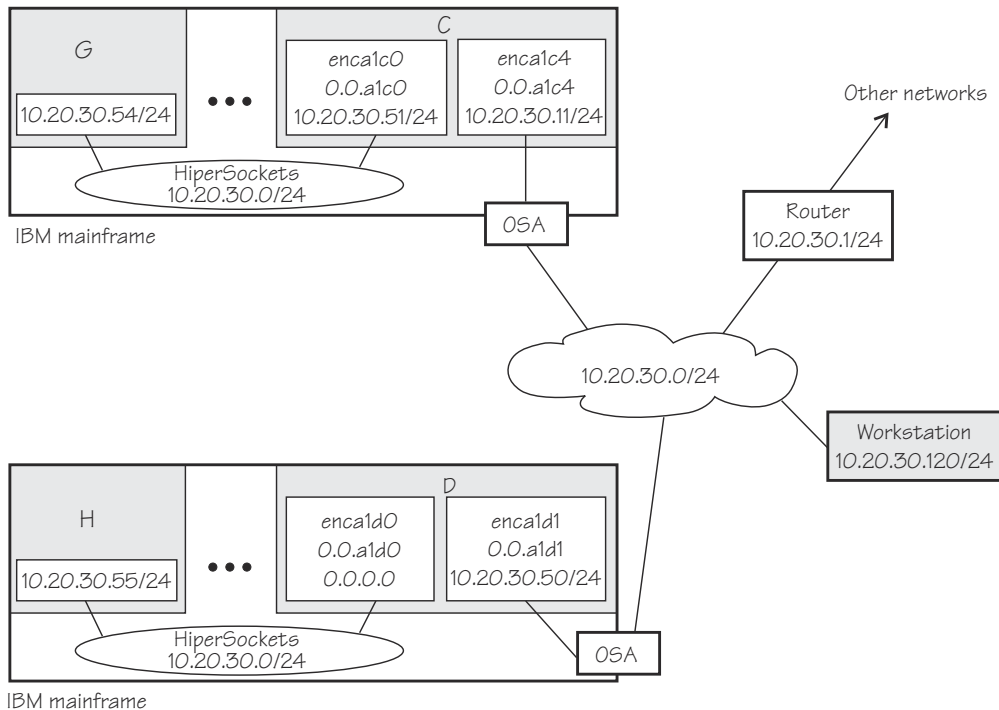


Figure 64. Expanded HiperSockets network concentrator setup

The configuration of C, G, and the workstation remain the same as for [Figure 63 on page 264](#).

Setup for the network concentrator D:

The HiperSockets interface `enca1d0` has the corresponding device-bus ID `0.0.enca1d0` and IP address `0.0.0.0`. Issue:

```
# echo primary_connector > /sys/bus/ccwgroup/drivers/qeth/0.0.a1d0/route4
```

The OSA-Express CHPID in QDIO mode interface `enca1d1` has IP address `10.20.30.50/24`. The default gateway is `10.20.30.1`.

D is not configured as a multicast router, it therefore forwards only unicast packets.

To enable IP forwarding issue:

```
# sysctl -w net.ipv4.ip_forward=1
```

Tip: See [Ubuntu Server 20.04.1](#) information about using configuration files to automatically enable IP forwarding when Linux boots.

To start the HiperSockets network concentrator, run the script `start_hsync.sh`. Issue:

```
# start_hsync.sh &
```

Setup for H:

No special setup required. The HiperSockets interface has IP address `10.20.30.55/24`. The default gateway is `10.20.30.1`.

Setting up for DHCP with IPv4

For connections through an OSA-Express adapter in QDIO mode configured with the layer 3 discipline, the OSA-Express adapter offloads ARP, MAC header, and MAC address handling.

For information about MAC headers, see [“MAC headers in layer 3 mode” on page 216](#).

Because a HiperSockets connection configured with the layer 3 discipline does not go out on a physical network, there are no ARP, MAC headers, and MAC addresses for packets in a HiperSockets LAN. The resulting problems for DHCP are the same in both cases and the fixes for connections through the OSA-Express adapter also apply to HiperSockets.

Dynamic Host Configuration Protocol (DHCP) is a TCP/IP protocol that allows clients to obtain IP network configuration information (including an IP address) from a central DHCP server. The DHCP server controls whether the address it provides to a client is allocated permanently or is leased temporarily. DHCP specifications are described by RFC 2131 "Dynamic Host Configuration Protocol" and RFC 2132 "DHCP options and BOOTP Vendor Extensions", which are available on the Internet at

www.ietf.org

Two types of DHCP environments must be taken into account:

- DHCP through OSA-Express adapters in QDIO mode
- DHCP in a z/VM VSWITCH or guest LAN

For information about setting up DHCP for a Linux instance in a z/VM VSWITCH or guest LAN environment, see Redpaper *Linux on IBM eServer™ zSeries and S/390: TCP/IP Broadcast on z/VM Guest LAN*, REDP-3596 at

www.ibm.com/redbooks

The programs *dhclient* and *dhcp* are examples of a DHCP client and a DHCP server you can use. Ubuntu Server might provide different DHCP client and server programs.

Required options for using dhcpcd with layer3

You must configure the DHCP client program *dhclient* to use it on Linux on Z with layer3.

- Run the DHCP client with an option that instructs the DHCP server to broadcast its response to the client.

Because the OSA-Express adapter in QDIO mode forwards packets to Linux based on IP addresses, a DHCP client that requests an IP address cannot receive the response from the DHCP server without this option.

- Run the DHCP client with an option that specifies the client identifier string.

By default, the client uses the MAC address of the network interface. Hence, without this option, all Linux instances that share the OSA-Express adapter in QDIO mode would also have the same client identifier.

See the documentation for *dhcpcd* about selecting these options.

You need no special options for the DHCP server program, *dhcp*.

Setting up Linux as a LAN sniffer

You can set up a Linux instance to act as a LAN sniffer, for example, to make data on LAN traffic available to tools like **tcpdump** or Wireshark.

The LAN sniffer can be:

- A HiperSockets Network Traffic Analyzer for LAN traffic between LPARs
- A LAN sniffer for LAN traffic between z/VM guest virtual machines, for example, through a z/VM virtual switch (VSWITCH)

Setting up a HiperSockets network traffic analyzer

A HiperSockets network traffic analyzer (NTA) runs in an LPAR and monitors LAN traffic between LPARs.

Before you begin

- Your Linux instance must run in LPAR mode.
- On the SE, the LPARs must be authorized for analyzing and being analyzed.

Tip: Do any authorization changes before you configure the NTA device. If you must activate the NTA after SE authorization changes, set the qeth device offline, set the sniffer attribute to 1, and set the device online again.

- You need a traffic-dumping tool such as **tcpdump**.
- You need a mainframe system that supports HiperSockets network traffic analyzer.

About this task

The HiperSockets NTA is available to trace both layer 3 and layer 2 network traffic, but the analyzing device itself must be configured as a layer 3 device. The analyzing device is a dedicated NTA device and cannot be used as a regular network interface.

Procedure

Perform the following steps:

- Linux setup:
 - a) Configure a HiperSockets interface dedicated to analyzing with the `layer2 sysfs` attribute set to 0 and the `sniffer sysfs` attribute set to 1.

For example, assuming the HiperSockets interface is `enca1c0` with device bus-ID `0.0.a1c0`:

```
# chzdev qeth -e -a a1c0 layer2=0 sniffer=1
```

The **chzdev** command also sets the device online. To make the change persistent across reboots, omit the `-a` option. For more information about **chzdev**, see [“chzdev - Configure IBM Z devices” on page 531](#).

Alternatively, for the running configuration only:

```
# znetconf -a a1c0 layer2=0 sniffer=1
```

The **znetconf** command also sets the device online. For more information about **znetconf**, see [“znetconf - List and configure network devices” on page 685](#).

The qeth device driver automatically sets the `buffer_count` attribute to 128 for the analyzing device.

- b) Activate the device (no IP address is needed):

```
# ip link set enca1c0 up
```

- c) Switch the interface into promiscuous mode:

```
# tcpdump -i enca1c0
```

Results

The device is now set up as a HiperSockets network traffic analyzer.

Hint: A HiperSockets network traffic analyzer with no free empty inbound buffers might have to drop packets. Dropped packets are reflected in the "dropped counter" of the HiperSockets network traffic analyzer interface and reported by **tcpdump**.

Example:

```
# ip -s link show dev enca1c0
...
RX: bytes  packets  errors  dropped  overrun  mcast
223242    6789    0       5        0        176
...
# tcpdump -i enca1c0
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on enca1c0, link-type EN10MB (Ethernet), capture size 96 bytes
...
5 packets dropped by kernel
```

Setting up a z/VM guest LAN sniffer

You can set up a guest LAN sniffer on a virtual NIC that is coupled to a z/VM VSWITCH or guest LAN.

Before you begin

- You need class B authorization on z/VM.
- The Linux instance to be set up as a guest LAN sniffer must run as a guest of the same z/VM system as the guest LAN you want to investigate.

About this task

If a virtual switch connects to a VLAN that includes nodes outside the z/VM system, these external nodes are beyond the scope of the sniffer.

For information about VLANs and z/VM VSWITCHes, see *z/VM: Connectivity*, SC24-6267.

Procedure

- Set up Linux.

Ensure that the qeth device driver has been compiled into the Linux kernel or that the qeth device driver has been loaded as a module.

- Set up z/VM.

Ensure that the z/VM guest virtual machine on which you want to set up the guest LAN sniffer is authorized for the switch or guest LAN and for promiscuous mode.

For example, if your virtual NIC is coupled to a z/VM VSWITCH, perform the following steps on your z/VM system:

- a) Check if the z/VM guest virtual machine already has the required authorizations. Enter a CP command of this form:

```
q vswitch <switchname> promisc
```

where *<switchname>* is the name of the virtual switch. If the output lists the z/VM guest virtual machine as authorized for promiscuous mode, no further setup is required.

- b) If the output from step “1” on page 268 does not list the guest virtual machine, check if the guest is authorized for the virtual switch. Enter a CP command of this form:

```
q vswitch <switchname> acc
```

where *<switchname>* is the name of the virtual switch.

If the output lists the z/VM guest virtual machine as authorized, you must temporarily revoke the authorization for the switch before you can grant authorization for promiscuous mode. Enter a CP command of this form:

```
set vswitch <switchname> revoke <userid>
```

where *<switchname>* is the name of the virtual switch and *<userid>* identifies the z/VM guest virtual machine.

- c) Authorize the Linux instance for the switch and for promiscuous mode. Enter a CP command of this form:

```
set vswitch <switchname> grant <userid> promisc
```

where *<switchname>* is the name of the virtual switch and *<userid>* identifies the z/VM guest virtual machine.

For details about the CP commands used in this section and for commands you can use to check and assign authorizations for other types of guest LANs, see *z/VM: CP Commands and Utilities Reference*, SC24-6268.

Chapter 16. OSA-Express SNMP subagent support

LPAR and z/VM: The SNMP subagent support applies to Linux in LPAR mode and to Linux on z/VM.

The OSA-Express Simple Network Management Protocol (SNMP) subagent (osasnmpd) supports management information bases (MIBs) for the OSA-Express features.

This subagent capability through the OSA-Express features is also called *Direct SNMP* to distinguish it from another method of accessing OSA SNMP data through OSA/SF, a package for monitoring and managing OSA features that does not run on Linux.

See [“osasnmpd – Start OSA-Express SNMP subagent”](#) on page 641 for information about the **osasnmpd** command itself.

To use the osasnmpd subagent, you need:

- An OSA-Express feature that runs in QDIO mode with the latest textual MIB file for the appropriate LIC level (recommended)
- The qeth device driver for OSA-Express (QDIO)
- The osasnmpd subagent from s390-tools
- net-snmp package 5.1.x or higher

What you should know about osasnmpd

The osasnmpd subagent requires a master agent to be installed on a Linux system.

You get the master agent from either the net-snmp package. The subagent uses the Agent eXtensibility (AgentX) protocol to communicate with the master agent.

net-snmp is an open source project that is owned by the Open Source Development Network, Inc. (OSDN). For more information on net-snmp visit:

net-snmp.sourceforge.net

When the master agent (snmpd) is started on a Linux system, it binds to a port (default 161) and awaits requests from SNMP management software. Subagents can connect to the master agent to support MIBs of special interest (for example, OSA-Express MIB). When the osasnmpd subagent is started, it retrieves the MIB objects of the OSA-Express features currently present on the Linux system. It then registers with the master agent the object IDs (OIDs) for which it can provide information.

An OID is a unique sequence of dot-separated numbers (for example, .1.3.6.1.4.1.2) that represents a particular information. OIDs form a hierarchical structure. The longer the OID, that is the more numbers it is made up of, the more specific is the information that is represented by the OID. For example, .1.3.6.1.4.1.2 represents all IBM-related network information while ..1.3.6.1.4.1.2.6.188 represents all OSA-Express-related information.

A MIB corresponds to a number of OIDs. MIBs provide information on their OIDs including textual representations the OIDs. For example, the textual representation of .1.3.6.1.4.1.2 is .iso.org.dod.internet.private.enterprises.ibm.

The structure of the MIBs might change when updating the OSA-Express licensed internal code (LIC) to a newer level. If MIB changes are introduced by a new LIC level, you must download the appropriate MIB file for the LIC level (see [“Downloading the IBM OSA-Express MIB”](#) on page 273). You do not need to update the subagent. Place the updated MIB file in a directory that is searched by the master agent.

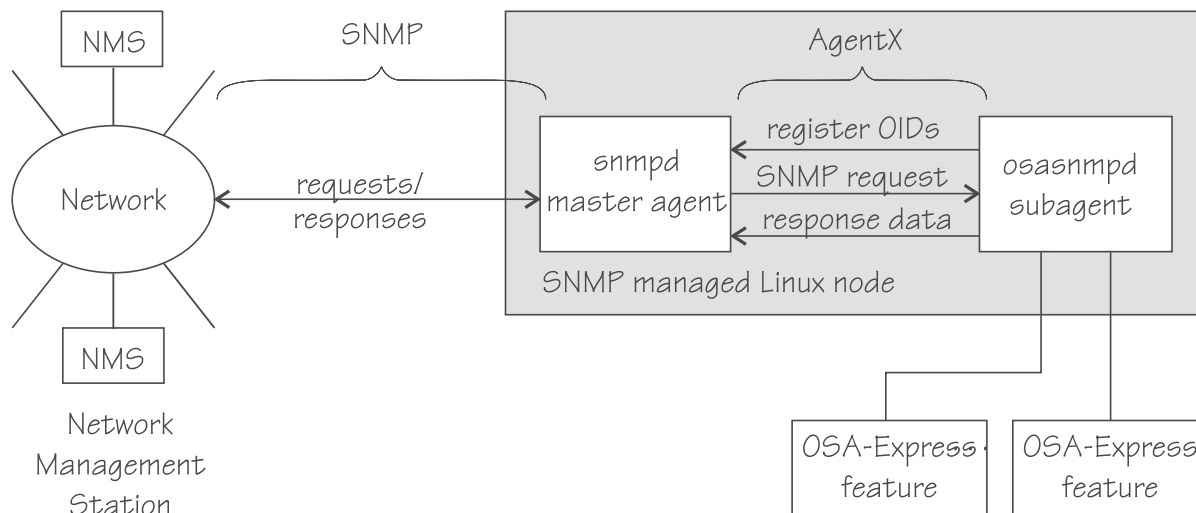


Figure 65. OSA-Express SNMP agent flow

Figure 65 on page 272 illustrates the interaction between the snmpd master agent and the osasnmppd subagent.

Example: This example shows the processes that run after the snmpd master agent and the osasnmppd subagent are started. In the example, PID 687 is the SNMP master agent and PID 729 is the OSA-Express SNMP subagent process:

```
ps -ef | grep snmp
USER      PID      1  0  11:57 pts/1    00:00:00 snmpd
root      687
root      729     659  0  13:22 pts/1    00:00:00 osasnmppd
```

When the master agent receives an SNMP request for an OID that is registered by a subagent, the master agent uses the subagent to collect any requested information and to perform any requested operations. The subagent returns any requested information to the master agent. Finally, the master agent returns the information to the originator of the request.

Setting up osasnmppd

You can set up osasnmppd by installing the snmpd, snmp, and osasnmppd packages.

About this task

Ubuntu Server 20.04.1 provides the package s390-tools-osasnmppd that contains osasnmppd.

Procedure

To install the osasnmppd package and the prerequisite snmp and snmpd packages, issue:

```
# apt-get install snmpd snmp s390-tools-osasnmppd
```

What to do next

Continue with the following setup tasks:

- [“Installing MIBs” on page 273](#)
- [“Downloading the IBM OSA-Express MIB” on page 273](#)
- [“Configuring access control” on page 273](#)

Installing MIBs

Install support for management information bases (MIBs) before installing the IBM OSA-Express MIB.

Procedure

1. Install the `snmp-mibs-downloader` package using `apt`:

```
# apt-get install snmp-mibs-downloader
```

2. Download the latest MIB modules:

```
# download-mibs
```

3. Edit the `/etc/snmp/snmp.conf` configuration file to deactivate the line that starts with the word "mibs".

Downloading the IBM OSA-Express MIB

Keep your MIB file up to date by downloading the latest version.

About this task

Perform the following steps to download the IBM OSA-Express MIB. The MIB file is valid only for hardware that supports the OSA-Express adapter.

Procedure

1. Go to www.ibm.com/servers/resourcelink
 - A user ID and password are required. If you do not yet have one, you can apply for a user ID.
2. Sign in.
3. Select **Library** from the navigation area.
4. Under **Library shortcuts**, select **Open Systems Adapter (OSA) Library**.
5. Follow the link for **OSA-Express Direct SNMP MIB module**.
6. Select and download the MIB for your LIC level.
7. Rename the MIB file to the name specified in the MIBs definition line and use the extension `.txt`.

Example: If the definition line in the MIB looks like this:

```
==>IBM-OSA-MIB DEFINITIONS ::= BEGIN
```

Rename the MIB to `IBM-OSA-MIB.txt`.

8. Place the MIB into `/usr/share/snmp/mibs`.

If you want to use a different directory, be sure to specify the directory in the `snmp.conf` configuration file.

Results

You can now make the OID information from the MIB file available to the master agent. You can then use textual OIDs instead of numeric OIDs when using master agent commands.

See also the FAQ (How do I add a MIB to the tools?) for the master agent package at

```
net-snmp.sourceforge.net/FAQ.html
```

Configuring access control

To start successfully, the subagent requires at least read access to the standard MIB-II on the local node.

About this task

During subagent startup or when network interfaces are added or removed, the subagent must query OIDs from the interfaces group of the standard MIB-II.

Given here is an example of how to use the `snmpd.conf` and `snmp.conf` configuration files to assign access rights by using the View-Based Access Control Mechanism (VACM). The following access rights are assigned on the local node:

- General read access for the scope of the standard MIB-II
- Write access for the scope of the OSA-Express MIB
- Public local read access for the scope of the interfaces MIB

The example is intended for illustration purposes only. Depending on the security requirements of your installation, you might need to define your access differently. See the `snmpd` man page for a more information about assigning access rights to `snmpd`.

Procedure

1. Ubuntu Server 20.04.1 creates a sample `snmpd.conf` file in `/etc/snmp` when you install `snmpd`.
2. Open `/etc/snmp/snmpd.conf` with your preferred text editor.
3. Map a community name to a security name:

```
com2sec <security-name> <source> <community-name>
```

where:

<security-name>

is given access rights through further specifications within `snmpd.conf`.

<source>

is the IP address or DNS name of the accessing system, typically a Network Management Station.

<community-name>

is the community string used for basic SNMP password protection.

Example:

```
#      sec.name      source      community
com2sec osasec      default    osacom
com2sec pubsec      localhost  public
```

4. Use the security name to define a group with different versions of the master agent for which you want to grant access rights.

Include a line of this form for each master agent version:

```
group <group-name> <security-model> <security-name>
```

where:

<group-name>

is a group name of your choice.

<security-model>

is the security model of the SNMP version.

<security-name>

is the same as in step “3” on page 274.

Example:

```
#      groupName      securityModel      securityName
group  osagroup        v1                 osasec
group  osagroup        v2c                osasec
group  osagroup        usm                osasec
group  osasnmpd       v2c                pubsec
```

Group "osasnmpd" with community "public" is required by osasnmpd to determine the number of network interfaces.

5. Define your views. A view is a subset of all OIDs. Include lines of this form:

```
view <view-name> <included|excluded> <scope>
```

where:

<view-name>

is a view name of your choice.

<included|excluded>

indicates whether the following scope is an inclusion or an exclusion statement.

<scope>

specifies a subtree in the OID tree.

Example:

```
# name incl/excl subtree mask(optional)
view allview included .1
view osaview included .1.3.6.1.4.1.2
view ifmibview included .1.3.6.1.2.1.2
view ifmibview included .1.3.6.1.2.1.1
```

View "allview" encompasses all OIDs while "osaview" is limited to IBM OIDs. The numeric OID provided for the subtree is equivalent to the textual OID ".iso.org.dod.internet.private.enterprises.ibm" View "ifmibview" is required by osasnmpd to determine the number of network interfaces.

Tip: Specifying the subtree with a numeric OID leads to better performance than using the corresponding textual OID.

6. Define access rights. Include lines of this form:

```
access <group-name> "" any noauth exact <read-view> <write-view> none
```

where:

<group-name>

is the group you defined in step "4" on page 274.

<read-view>

is a view for which you want to assign read-only rights.

<write-view>

is a view for which you want to assign read-write rights.

Example:

```
# group context sec.model sec.level prefix read write notif
access osagroup "" any noauth exact allview osaview none
access osasnmpd "" v2c noauth exact ifmibview none none
```

The access line of the example gives read access to the "allview" view and write access to the "osaview". The second access line gives read access to the "ifmibview".

7. Also include the following line to enable the AgentX support:

```
master agentx
```

AgentX support is compiled into the net-snmp master agent.

8. Save and close snmpd.conf.

Example of an snmpd.conf file:

```
# sec.name source community
com2sec osasec default osacom
com2sec pubsec localhost public
```

```
#      groupName      securityModel securityName
group  osagroup          v1             osasec
group  osagroup          v2c            osasec
group  osagroup          usm            osasec
group  osasnmppd        v2c            pubsec
#      name            incl/excl      subtree        mask(optional)
view   allview           included       .1
view   osaview           included       .1.3.6.1.4.1.2
view   ifmibview        included       .1.3.6.1.2.1.2
view   ifmibview        included       .1.3.6.1.2.1.1
#      group          context        sec.model      sec.level      prefix read      write      notif
access osagroup           ""            any            noauth        exact allview   osaview   none
access osasnmppd        ""            v2c            noauth        exact ifmibview none      none
master agentx
```

9. Open `snmp.conf` with your preferred text editor.

Tip: See `man snmp.conf` for possible locations of `snmp.conf`.

10. Include a line of this form to specify the directory to be searched for MIBs:

```
mibdirs +<mib-path>
```

Example:

```
mibdirs +/usr/share/snmp/mibs
```

11. Include a line of this form to make the OSA-Express MIB available to the master agent:

```
mibs +<mib-name>
```

where `<mib-name>` is the stem of the MIB file name you assigned in [“Downloading the IBM OSA-Express MIB”](#) on page 273.

Example: `mibs +IBM-OSA-MIB`

12. Define defaults for the version and community to be used by the `snmp` commands. Add lines of this form:

```
defVersion <version>
defCommunity <community-name>
```

where `<version>` is the SNMP protocol version and `<community-name>` is the community that you defined in step “3” on page 274.

Example:

```
defVersion 2c
defCommunity osacom
```

These default specifications simplify issuing master agent commands.

13. Save and close `snmp.conf`.

Working with the `osasnmppd` subagent

Working with the `osasnmppd` subagent includes starting it, checking the log file, issuing queries, and stopping the subagent.

Working with `osasnmppd` comprises the following tasks:

- [“Starting the `osasnmppd` subagent”](#) on page 276
- [“Checking the log file”](#) on page 277
- [“Issuing queries”](#) on page 277
- [“Stopping `osasnmppd`”](#) on page 278

Starting the `osasnmppd` subagent

Use the `osasnmppd` command to start the `osasnmppd` subagent.

Procedure

1. Start the snmpd daemon by using the command:

```
# systemctl start snmpd.service
```

2. Start the osasmpd subagent with the **osasmpd** command:

```
# osasmpd
```

The osasmpd subagent starts a daemon that is called osasmpd.

For command options see [“osasmpd – Start OSA-Express SNMP subagent”](#) on page 641.

If you restart the master agent, you must also restart the subagent. When the master agent is started, it does not look for already running subagents. Any running subagents must also be restarted to be register with the master agent.

Checking the log file

Warnings and messages are written to the log file of either the master agent or the OSA-Express subagent. It is good practice to check these files at regular intervals.

Example

This example assumes that the default subagent log file is used. The lines in the log file show the messages after a successful OSA-Express subagent initialization.

```
# cat /var/log/osasmpd.log
IBM OSA-E NET-SNMP 5.1.x subagent version 1.3.0
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.2.1.10.7.2.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.1.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.3.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.4.
Jul 14 09:28:41 registered Toplevel OID .1.3.6.1.4.1.2.6.188.1.8.
OSA-E microcode level is 611 for interface encf500
Initialization of OSA-E subagent successful...
```

Issuing queries

You can issue queries against your SNMP setup.

Before you begin

The **snmpget** and **snmpwalk** commands require the snmp package. To install it, issue:

```
# apt-get install snmp
```

About this task

Examples of what SNMP queries might look like are given here. For more comprehensive information about the master agent commands see the **snmpcmd** man page.

The commands can use either numeric or textual OIDs. While the numeric OIDs might provide better performance, the textual OIDs are more meaningful and give a hint on which information is requested.

Examples

The query examples assume an interface, encf500, for which the CHPID is 6B. You can use the **lsqeth** command to find the mapping of interface names to CHPIDs.

- To list the ifIndex and interface description relation (on one line):

```
# snmpget -v 2c -c osacom localhost interfaces.ifTable.ifEntry.ifDescr.6
interfaces.ifTable.ifEntry.ifDescr.6 = encf500
```

Using this GET request you can see that encf500 has the ifIndex 6 assigned.

- To find the CHPID numbers for your OSA devices:

```
# snmpwalk -OS -v 2c -c osacom localhost .1.3.6.1.4.1.2.6.188.1.1.1.1
IBM-OSA-MIB::ibmOSAExpChannelNumber.6 = Hex-STRING: 00 6B
IBM-OSA-MIB::ibmOSAExpChannelNumber.7 = Hex-STRING: 00 7A
IBM-OSA-MIB::ibmOSAExpChannelNumber.8 = Hex-STRING: 00 7D
```

The first line of the command output, with index number 6, corresponds to CHPID 0x6B of the encf500 example. The example assumes that the community osacom is authorized as described in [“Configuring access control” on page 273](#).

If you provided defaults for the SNMP version and the community (see step [“12” on page 276](#)), you can omit the -v and -c options:

```
# snmpwalk -OS localhost .1.3.6.1.4.1.2.6.188.1.1.1.1
IBM-OSA-MIB::ibmOSAExpChannelNumber.6 = Hex-STRING: 00 6B
IBM-OSA-MIB::ibmOSAExpChannelNumber.7 = Hex-STRING: 00 7A
IBM-OSA-MIB::ibmOSAExpChannelNumber.8 = Hex-STRING: 00 7D
```

You can obtain the same output by substituting the numeric OID .1.3.6.1.4.1.2.6.188.1.1.1.1 with its textual equivalent:

```
.iso.org.dod.internet.private.enterprises.ibm.ibmProd.ibmOSAMib.ibmOSAMibObjects.ibmOSAExpChannelTable.ibmOSAExpChannelEntry.ibmOSAExpChannelNumber
```

You can shorten this unwieldy OID to the last element, `ibmOsaExpChannelNumber`:

```
# snmpwalk -OS localhost ibmOsaExpChannelNumber
IBM-OSA-MIB::ibmOSAExpChannelNumber.6 = Hex-STRING: 00 6B
IBM-OSA-MIB::ibmOSAExpChannelNumber.7 = Hex-STRING: 00 7A
IBM-OSA-MIB::ibmOSAExpChannelNumber.8 = Hex-STRING: 00 7D
```

- To find the port type for the interface with index number 6:

```
# snmpwalk -OS localhost .1.3.6.1.4.1.2.6.188.1.4.1.2.6
IBM-OSA-MIB::ibmOsaExpEthPortType.6 = INTEGER: fastEthernet(81)
```

fastEthernet(81) corresponds to card type OSD_100.

Using the short form of the textual OID:

```
# snmpwalk -OS localhost ibmOsaExpEthPortType.6
IBM-OSA-MIB::ibmOsaExpEthPortType.6 = INTEGER: fastEthernet(81)
```

Specifying the index, 6 in the example, limits the output to the interface of interest.

Stopping osasnmppd

The subagent can be stopped by sending either a SIGINT or SIGTERM signal to the thread.

About this task

Avoid stopping the subagent with **kill -9** or with **kill -SIGKILL**. These commands do not allow the subagent to unregister the OSA-Express MIB objects from the SNMP master agent. This can cause problems when restarting the subagent.

If you saved the subagent PID to a file when you started it, you can consult this file for the PID (see [“osasnmppd – Start OSA-Express SNMP subagent” on page 641](#)). Otherwise, you can issue a **ps** command to find it out.

Example

The osasnmppd subagent starts a daemon that is called osasnmppd. To stop osasnmppd, issue the **kill** command for either the daemon or its PID:

```
# ps -ef | grep snmp
USER      PID      1  0 11:57 pts/1    00:00:00 snmpd
root      729    659  0 13:22 pts/1    00:00:00 osasnmppd
# killall osasnmppd
```


Chapter 17. LAN channel station device driver

LPAR and z/VM: The LCS device driver applies to Linux in LPAR mode and to Linux on z/VM.

The LAN channel station device driver (LCS device driver) supports Open Systems Adapters (OSA) features in non-QDIO mode up to OSA-Express4S.

The LCS device driver supports OSA-Express features for the IBM Z mainframes that are relevant to Ubuntu Server 20.04.1 as shown in [Table 48 on page 281](#).

Table 48. The LCS device driver supported OSA features

Feature	z15	z14	z13 and z13s
OSA-Express7S	1000Base-T Ethernet	Not supported	Not supported
OSA-Express6S	1000Base-T Ethernet	1000Base-T Ethernet	Not supported
OSA-Express5S	1000Base-T Ethernet	1000Base-T Ethernet	1000Base-T Ethernet
OSA-Express4S	1000Base-T Ethernet	1000Base-T Ethernet	1000Base-T Ethernet
OSA-Express3	1000Base-T Ethernet	Not supported	Not supported

The LCS device driver supports automatic detection of Ethernet connections. The LCS device driver can be used for Internet Protocol, version 4 (IPv4) only.

What you should know about LCS

Interface names are assigned to LCS group devices, which map to subchannels and their corresponding device numbers and device bus-IDs.

LCS group devices

The LCS device driver requires two I/O subchannels for each LCS interface, a read subchannel and a write subchannel. The corresponding bus IDs must be configured for control unit type 3088.

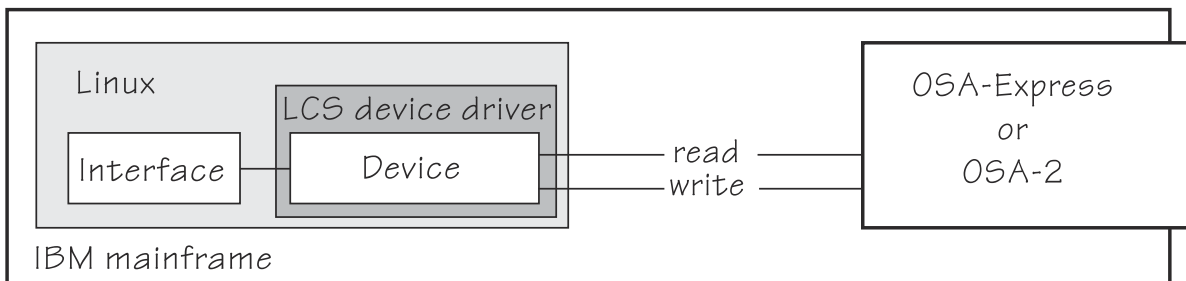


Figure 66. I/O subchannel interface

The device bus-IDs that correspond to the subchannel pair are grouped as one LCS group device. The following rules apply for the device bus-IDs:

read

must be even.

write

must be the device bus-ID of the read subchannel plus one.

Setting up the LCS device driver

There are no module parameters for the LCS device driver.

Ubuntu Server 20.04.1 loads the device driver module for you when a device becomes available.

You can also load the lcs module with the **modprobe** command:

```
# modprobe lcs
```

Working with LCS devices

Working with LCS devices includes tasks such as creating an LCS group device, specifying a timeout, or activating an interface.

- [“Creating an LCS group device” on page 282](#)
- [“Removing an LCS group device” on page 283](#)
- [“Specifying a timeout for LCS LAN commands” on page 283](#)
- [“Setting an LCS group device online or offline” on page 283](#)
- [“Activating and deactivating an interface” on page 284](#)
- [“Recovering an LCS group device” on page 285](#)

Creating an LCS group device

Use the group attribute to create an LCS group device.

Before you begin

You must know the device bus-IDs that corresponds to the read and write subchannel of your OSA card. The subchannel is defined in the IOCDS of your mainframe.

Procedure

To define an LCS group device, write the device bus-IDs of the subchannel pair to `/sys/bus/ccwgroup/drivers/lcs/group`.

Issue a command of this form:

```
# echo <read_device_bus_id>,<write_device_bus_id> > /sys/bus/ccwgroup/drivers/lcs/group
```

Results

The lcs device driver uses the device bus-ID of the read subchannel to create a directory for a group device:

```
/sys/bus/ccwgroup/drivers/lcs/<read_device_bus_id>
```

This directory contains a number of attributes that determine the settings of the LCS group device. The following sections describe how to use these attributes to configure an LCS group device.

Example

Assuming that 0.0.d000 is the device bus-ID that corresponds to a read subchannel:

```
# echo 0.0.d000,0.0.d001 > /sys/bus/ccwgroup/drivers/lcs/group
```

This command results in the creation of the following directories in sysfs:

- `/sys/bus/ccwgroup/drivers/lcs/0.0.d000`
- `/sys/bus/ccwgroup/devices/0.0.d000`
- `/sys/devices/lcs/0.0.d000`

Removing an LCS group device

Use the `ungroup` attribute to remove an LCS group device.

Before you begin

The device must be set offline before you can remove it.

Procedure

To remove an LCS group device, write `1` to the `ungroup` attribute.

Issue a command of the form:

```
# echo 1 > /sys/bus/ccwgroup/drivers/lcs/<device_bus_id>/ungroup
```

Example

This command removes device `0.0.d000`:

```
# echo 1 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/ungroup
```

Specifying a timeout for LCS LAN commands

Use the `lancmd_timeout` attribute to set a timeout for an LCS LAN command.

About this task

You can specify a timeout for the interval that the LCS device driver waits for a reply after issuing a LAN command to the LAN adapter. For older hardware, the replies can take a longer time. The default is 5 s.

Procedure

To set a timeout, issue a command of this form:

```
# echo <timeout> > /sys/bus/ccwgroup/drivers/lcs/<device_bus_id>/lancmd_timeout
```

where `<timeout>` is the timeout interval in seconds in the range 1 - 60.

Example

In this example, the timeout for a device `0.0.d000` is set to 10 s.

```
# echo 10 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/lancmd_timeout
```

Setting an LCS group device online or offline

Use the `online` device group attribute to set an LCS device online or offline.

About this task

Setting a device online associates it with an interface name. Setting the device offline preserves the interface name.

You must know the interface name to activate the network interface. To determine the assigned interface name, use the `lszdev --existing` command. For each online interface, the interface name is shown in the Name column. Alternatively, to determine the assigned interface name issue a command of the form:

```
# ls /sys/devices/lcs/<device_bus_id>/net/
```

Procedure

To set an LCS group device online, set the online device group attribute to 1. To set an LCS group device offline, set the online device group attribute to 0.

Issue a command of this form:

```
# echo <flag> > /sys/bus/ccwgroup/drivers/lcs/<device_bus_id>/online
```

Example

To set an LCS device with bus ID 0.0.d000 online issue:

```
# echo 1 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/online
```

The interface name that was assigned to the LCS group device in the example is encd000. To confirm that this name is correct for the group device issue:

```
# lsudev --existing
TYPE      ID                                ON  PERS  NAMES
...
lcs       0.0.d000:0.0.d001                yes  no    encd000
...
```

or

```
# ls /sys/devices/lcs/0.0.d000/net/
encd000
...
```

The interface name that was assigned to the LCS group device in the example is encd000.

For each online interface, there is a symbolic link of the form `/sys/class/net/<interface_name>/device` in `sysfs`. You can confirm that you found the correct interface name by reading the link:

```
# readlink /sys/class/net/encd000/device
../../../../0.0.d000
```

To set the device offline issue:

```
# echo 0 > /sys/bus/ccwgroup/drivers/lcs/0.0.d000/online
```

Activating and deactivating an interface

Use the **ip** command or equivalent to activate or deactivate an interface.

About this task

Before you can activate an interface, you must set the group device online and found out the interface name that is assigned by the LCS device driver. See [“Setting an LCS group device online or offline”](#) on page 283.

You activate or deactivate network devices with **ip** or an equivalent command. For details of the **ip** command, see the **ip** man page.

Examples

- This example activates an Ethernet interface:

```
# ip addr add 192.168.100.10/24 dev encf500
# ip link set dev encf500 up
```

- This example deactivates the Ethernet interface:

```
# ip link set dev encf500 down
```

- This example reactivates an interface that was already activated and subsequently deactivated:

```
# ip link set dev encf500 up
```

Recovering an LCS group device

You can use the recover attribute of an LCS group device to recover it in case of failure.

Procedure

Issue a command of the form:

```
# echo 1 > /sys/bus/ccwgroup/drivers/lcs/<device_bus_id>/recover
```

Example

```
# echo 1 > /sys/bus/ccwgroup/drivers/lcs/0.0.d100/recover
```

Chapter 18. AF_IUCV address family support

LPAR and z/VM: The AF_IUCV address family support applies to Linux in LPAR mode and to Linux on z/VM.

The AF_IUCV address family provides an addressing mode for communications between applications that run on Z.

This addressing mode can be used for connections through real HiperSockets and through the z/VM Inter-User Communication Vehicle (IUCV).

Support for AF_IUCV based connections through real HiperSockets requires Completion Queue Support.

HiperSockets devices facilitate connections between applications across LPARs within an IBM Z. In particular, an application that runs on an instance of Linux on Z can communicate with:

- Itself
- Other applications that run on the same Linux instance
- An application on an instance of Linux on Z in another LPAR

IUCV facilitates connections between applications across z/VM guest virtual machines within a z/VM system. In particular, an application that runs on Linux on z/VM can communicate with:

- Itself
- Other applications that run on the same Linux instance
- Applications running on other instances of Linux on z/VM, within the same z/VM system
- Applications running on a z/VM guest other than Linux, within the same z/VM system
- The z/VM control program (CP)

The AF_IUCV address family supports stream-oriented sockets (SOCK_STREAM) and connection-oriented datagram sockets (SOCK_SEQPACKET). Stream-oriented sockets can fragment data over several packets. Sockets of type SOCK_SEQPACKET always map a particular socket write or read operation to a single packet.

Features

The AF_IUCV address family provides socket connections for HiperSockets and IUCV.

For all instances of Linux on Z, the AF_IUCV address family provides the following features:

- Multiple outgoing socket connections for real HiperSockets
- Multiple incoming socket connections for real HiperSockets

For instances of Linux on z/VM, the AF_IUCV address family also provides the following features:

- Multiple outgoing socket connections for IUCV
- Multiple incoming socket connections for IUCV
- Socket communication with applications that use the CMS AF_IUCV support

Setting up the AF_IUCV address family support

You must authorize your LPAR or z/VM guest virtual machine and load those components that were compiled as separate modules.

There are no module parameters for the AF_IUCV address family support.

Setting up HiperSockets devices for AF_IUCV addressing

In AF_IUCV addressing mode, HiperSockets devices in layer 3 mode are identified through their `hsuid` `sysfs` attribute.

You set up a HiperSockets device for AF_IUCV by assigning a value to this attribute (see [“Configuring a HiperSockets device for AF_IUCV addressing”](#) on page 251).

Setting up your z/VM guest virtual machine for IUCV

You must specify suitable IUCV statements for your z/VM guest virtual machine.

For details and for general IUCV setup information for z/VM guest virtual machines, see *z/VM: CP Programming Services*, SC24-6272 and *z/VM: CP Planning and Administration*, SC24-6271.

Granting IUCV authorizations

Use the IUCV statement to grant the necessary authorizations.

IUCV ALLOW

allows any other z/VM virtual machine to establish a communication path with this z/VM virtual machine. With this statement, no further authorization is required in the z/VM virtual machine that initiates the communication.

IUCV ANY

allows this z/VM guest virtual machine to establish a communication path with any other z/VM guest virtual machine.

IUCV <user ID>

allows this z/VM guest virtual machine to establish a communication path to the z/VM guest virtual machine with the z/VM user ID <user ID>.

You can specify multiple IUCV statements. To any of these IUCV statements you can append the `MSGLIMIT <limit>` parameter. <limit> specifies the maximum number of outstanding messages that are allowed for each connection that is authorized by the statement. If no value is specified for `MSGLIMIT`, AF_IUCV requests 65 535, which is the maximum that is supported by IUCV.

Setting a connection limit

Use the `OPTION` statement to limit the number of concurrent connections.

OPTION MAXCONN <maxno>

<maxno> specifies the maximum number of IUCV connections that are allowed for this virtual machine. The default is 64. The maximum is 65 535.

Example

These sample statements allow any z/VM guest virtual machine to connect to your z/VM guest virtual machine with a maximum of 10 000 outstanding messages for each incoming connection. Your z/VM guest virtual machine is permitted to connect to all other z/VM guest virtual machines. The total number of connections for your z/VM guest virtual machine cannot exceed 100.

```
IUCV ALLOW MSGLIMIT 10000
IUCV ANY
OPTION MAXCONN 100
```

Loading the IUCV modules

Ubuntu Server 20.04.1 loads the `af_iucv` module when an application requests a socket with the AF_IUCV addressing mode.

You can also use the **modprobe** command to load the AF_IUCV address family support module `af_iucv`:

```
# modprobe af_iucv
```

Addressing AF_IUCV sockets in applications

To use AF_IUCV sockets in applications, you must code a special AF_IUCV `sockaddr` structure.

Application programmers: This information is intended for programmers who want to use connections that are based on AF_IUCV addressing in their applications.

The primary difference between AF_IUCV sockets and TCP/IP sockets is how communication partners are identified (for example, how they are named). To use the AF_IUCV support in an application, code a `sockaddr` structure with AF_IUCV as the socket address family and with AF_IUCV address information. For more information, see the `af_iucv` man page.

Chapter 19. SMC protocol support

The shared memory communication (SMC) protocol is an addition to TCP/IP and can be used transparently for shared memory communications.

The SMC protocol can be used for connections through:

- Shared Memory Communications over RDMA (SMC-R) with RoCE devices.
- Shared Memory Communications Direct (SMC-D) with ISM devices

If both variants are available for a connection, SMC-D is used.

Prerequisites

SMC connections are initiated through TCP/IP. Hence, the communication partners must be able to reach each other through TCP/IP. Also, SMC is not routable and thus both communication partners must be in the same IP subnet.

An SMC connection requires both communication partners to support SMC. Unless both partners support SMC, the connection falls back to TCP/IP.

The SMC-R protocol requires a system with a RoCE Express adapter. See [Chapter 20, “RDMA over Converged Ethernet,”](#) on page 295.

The SMC-D protocol requires:

- A system with an Internal Shared Memory (ISM) device. For more information about ISM devices, see [Chapter 21, “Internal shared memory device driver,”](#) on page 297. ISM devices are supported for Linux in LPAR mode and for Linux on z/VM.
- The communication partners must be running on the same CPC.

To use SMC on Linux, a socket application must use the AF_SMC address family. For AF_SMC support in existing applications without code changes, the SMC-Tools package provides a preload library and the **smc_run** command. For more information about these tools and how to convert socket applications from AF_INET or AF_INET6 to AF_SMC, see [“Setting up the SMC support”](#) on page 291.

Features

The AF_SMC address family provides RDMA communication. Benefits include:

- Transparency to existing TCP/IP applications with the preload library and **smc_run**
- Low latency
- Lower CPU usage compared to native TCP/IP

Setting up the SMC support

SMC traffic requires a mapping of the OSA or HiperSockets network interfaces to the RoCE adapters or ISM devices.

Physical network (PNET) IDs provide this mapping. If a network interface and a RoCE or ISM device have the same PNET ID, they are connected to the same physical network and can be used together for SMC.

LPAR and z/VM

For Linux in LPAR mode and for Linux on z/VM you can assign PNET IDs to OSA, HiperSockets, RoCE, and ISM devices through the IOCDs.

[Figure 67 on page 292](#) illustrates how the IOCDs assigns the PNETID NET1 to an ISM device and a network interface for an Ethernet device. In Linux, the matching PNETID associates the ISM device with an Ethernet device.

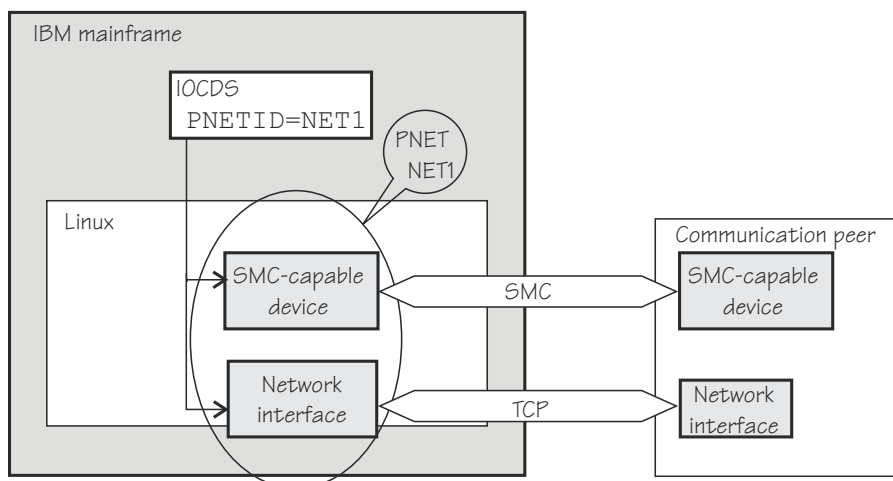


Figure 67. PNET ID and ISM device association

As a fallback, you can also use a software PNET table that maps network interfaces to RoCE adapters. For details, see the KVM information that follows.

KVM

For SMC on Linux on KVM, you need a software PNET table that maps network interfaces to RoCE adapters or ISM devices. Use the `smc_pnet` command to create a physical network (PNET) table with this mapping.

Note: z/OS does not support the RoCE Express adapter as an Ethernet device, and therefore uses OSA adapters for the initial handshake for SMC-R connections. Linux has no such constraint.

Network device settings

On the network device associated with the IB (RoCE) device you want to use for SMC traffic, check the settings with the `ethtool` command and ensure that pause settings are turned on.

For example, if `enP2s13` is the network device associated with the desired IB device port:

```
# ethtool -a enP2s13
Pause parameters for enP2s13:
Autonegotiate: off
RX: on
TX: on
```

Sysctl settings

The TCP port must not be shared by IPv4 and IPv6 connections. Use the following sysctl call to ensure that an IPv6 socket binds only to IPv6 addresses:

```
# sysctl -w net.ipv6.bindv6only=1
```

SMC requires contiguous memory. The minimum is 16 KB, and the maximum is 512 MB. The SMC implementation selects a value as follows:

- Some socket applications define the socket send- and receive buffer sizes with a `setsockopt` call, whose upper limits are defined in `net.core.wmem_max` and `net.core.rmem_max`.
- If `setsockopt` `SO_SNDBUF` is not used, the socket send buffer size is taken from the value of `net.ipv4.tcp_wmem`.
- If `setsockopt` `SO_RCVBUF` is not used, the socket receive buffer is taken from the value of `net.ipv4.tcp_rmem`, rounded to the next higher power of 2.

Make an existing application use SMC

Use the preload library to make the unmodified socket application use SMC. Existing TCP/IP applications can benefit from the SMC protocol without recompiling, if they are invoked with the SMC preload library `ld_pre_smc.so`. See “[smc_run - Run a TCP socket program with the SMC protocol using a preloaded library](#)” on page 655, which makes an existing TCP/IP socket program use SMC.

Converting an application to use SMC

Alternatively, if you need to, you can convert an application. To convert an application from TCP/IP to SMC sockets, change the `socket()` function call from `AF_INET` to `AF_SMC` with protocol "0" and from `AF_INET6` to `AF_SMC` with protocol "1". For example, change:

```
sd = socket(AF_INET, SOCK_STREAM, 0);
```

to:

```
sd = socket(AF_SMC, SOCK_STREAM, 0);
```

and

```
sd = socket(AF_INET6, SOCK_STREAM, 0);
```

to:

```
sd = socket(AF_SMC, SOCK_STREAM, 1);
```

Use the `sockets.h` header file from the `glibc-header` package. For more programming information, see the `af_smc(7)` man page.

Investigating PNET IDs

You can find the PNET IDs for PCIe devices and for CCW group devices in `sysfs`.

PCIe devices

The PNET IDs of PCI devices can be read, in EBCDIC format, as the value of the `util_string` attribute of the device in `sysfs`. If the PCIe device is connected through a RoCE adapter, the contents of the `util_string` attribute depends on the adapter:

- On RoCE Express adapters, the attribute contains two PNET IDs as fixed 16-character blocks in sequence.
- On RoCE Express2 adapters have one PCI device per port, and the attribute contains a single PNET ID.

You can use a command of the following form to read PNET IDs and convert them to ASCII:

```
# cat /sys/devices/pci<function_name>/<function_address>/util_string | iconv -f IBM-1047 -t ASCII
```

In the command, `/sys/devices/pci<function_name>/<function_address>` represents the PCI device in `sysfs`.

Alternatively, use the `smc_rnics` command that is part of the `smc-tools` package.

Example:

```
# cat /sys/devices/pci0000:00/0000:00:00.0/util_string | iconv -f IBM-1047 -t ASCII  
NET1
```

The PNET ID of the example is `NET1`. If there is no command output or if the output is blank, no PNET ID is assigned to the device.

Alternatively, using `smc_rnics`:

```
# smc_nics
  FID  Power  PCI_ID          PCHID  Type          PPrt  PNET_ID          Net-Dev
-----
  8ca  1        0002:00:00.0    01c8   RoCE_Express2  0     NET1             enP2p0s0np0
  8ea  1        0003:00:00.0    01c8   RoCE_Express2  1     NET2             enP3p0s0np0
  ...
```

CCW group devices

The PNET IDs of CCW group devices can be read, in EBCDIC format, as the value of the `util_string` of the corresponding channel path ID in `sysfs`. For adapters with multiple ports, the PNET IDs are given in sequential 16-character blocks corresponding to the ports. To find the channel path ID of a CCW group device, read its `chpid` attribute in `sysfs`.

Example:

```
# cat /sys/bus/ccwgroup/devices/0.0.b1f0/chpid
4a
```

To find the PNET IDs issue a command of this form:

```
# cat /sys/devices/css0/chp0.<chpid>/util_string | iconv -f IBM-1047 -t ASCII
```

where `<chpid>` is the channel path ID.

Example:

```
# cat /sys/devices/css0/chp0.4a/util_string | iconv -f IBM-1047 -t ASCII
NET1
```

The PNET ID of the example is `NET1`. If there is no command output or if the output is blank, no PNET ID is assigned to the device.

Tips

- The output of the `iconv` command does not have a trailing line break, so displayed PNET IDs are followed by a command prompt. Pipe the output to a suitable `sed` command, for example `sed 's/$/\n/'`, to display the PNET IDs on a separate line.
- Use the following command to display a list of all CCW devices and their PNET IDs:

```
# for device in `ls -1 /sys/bus/ccwgroup/devices`; do
chpid=`cat /sys/bus/ccwgroup/devices/$device/chpid | tr [A-F] [a-f]`;
pnetid=`cat /sys/devices/css0/chp0.$chpid/util_string | iconv -f IBM-1047 -t ASCII | sed 's/^/ /'`;
echo " device: $device chpid: $chpid pnetID: $pnetid";
done
```

Chapter 20. RDMA over Converged Ethernet

Linux on Z supports RDMA over Converged Ethernet (RoCE) in the form of RoCE Express features.

Ubuntu Server supports RoCE features as shown in [Table 49 on page 295](#). Note that the mapping of ports to function keys depend on the adapter hardware.

Table 49. Support for RDMA over Converged Ethernet features

Feature	z15	z14 and z14 ZR1	z13 and z13s
RoCE Express ^{®2}			Not supported
Two adapter ports, different function IDs	10 Gigabit Ethernet 25 Gigabit Ethernet	10 Gigabit Ethernet 25 Gigabit Ethernet	
RoCE Express			
Two adapter ports, same function ID	10 Gigabit Ethernet	10 Gigabit Ethernet	10 Gigabit Ethernet

The RoCE support requires PCI Express support, see [Chapter 32, “PCI Express support,” on page 359](#).

Using a RoCE device for SMC-R

SMC-R requires RoCE devices that are associated with network devices of TCP networks through a PNET ID, for example through statements in the IOCDs.

The following figure illustrates how a RoCE device and a Ethernet device are associated by a matching PNET ID. A communication peer has a similarly associated pair of an RoCE device and Ethernet device. With this setup, the TCP connection can switch over to an SMC-R connection over the SMC protocol. The communication peer can but need not be on the same CPC.

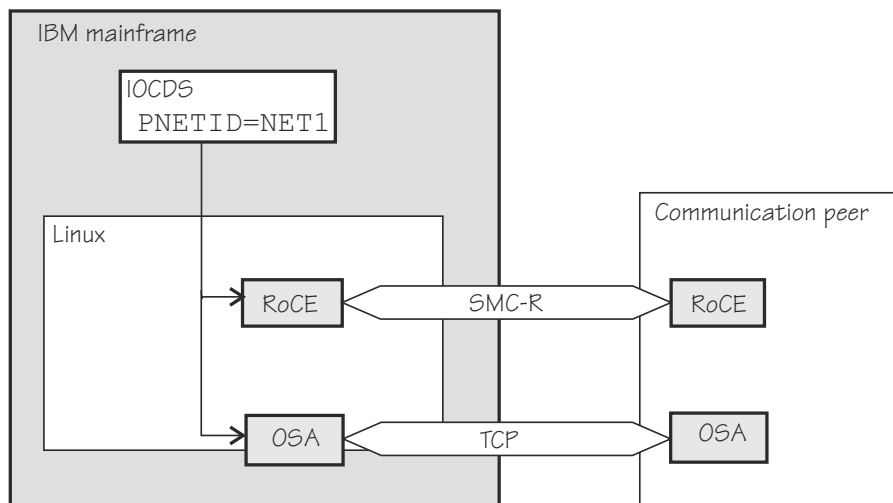


Figure 68. A matching PNET ID associates RoCE devices and Ethernet device

For more information about PNET IDs, see [“Setting up the SMC support” on page 291](#).

Working with the RoCE support

Because the 10 GBE RoCE Express feature hardware physically consists of a Mellanox adapter, you must ensure that the following prerequisites are fulfilled before you can work with it.

Procedure

1. Ensure that PCIe support is enabled and the PCI card is active on your system. See “[Setting up the PCIe support](#)” on page 359 and “[Using PCIe hotplug on LPAR](#)” on page 360.
2. Use the appropriate Mellanox device driver:
 - If you want to use TCP/IP, you need the `mlx4_core` module and `mlx4_en` or `mlx5_core` module. If it is not compiled into the kernel or already loaded, load it using for example, **`modprobe`**.
 - If you also want to use RDMA with InfiniBand (that is, using reliable datagram sockets, RDS), you need the `mlx4_ib` or `mlx5_ib` module. If it is not compiled into kernel or already loaded, load it using for example, **`modprobe`**. To use RDS, you also need the `rds` module and the `rds_rdma` module, see `Documentation/networking/rds.txt` in the Linux source tree and the `rds` and `rds-rdma` man pages.
3. Activate the network interface.

You need to know the network interface name, which you can find under:

- `/sys/bus/pci/drivers/mlx4_core/<pci_slot>/net/<interface>` for RoCE Express.
- `/sys/bus/pci/drivers/mlx5_core/<pci_slot>/net/<interface>` for RoCE Express 2.

Use the **`ip`** command or equivalent to activate the interface. See the `dev_port sysfs` attribute of the interface name to ensure that you are working with the correct port.

What to do next

For further information about Mellanox, see:

- http://www.mellanox.com/page/products_dyn?product_family=27&mtag=linux_driver
- http://www.mellanox.com/page/products_dyn?product_family=79&mtag=roce

Enabling debugging

The `mlx4` and `mlx5` device drivers can be configured for debugging with a `sysfs` parameter.

Procedure

- For `mlx4`: Load the `mlx4` module with the `sysfs` parameter `debug_level=1` to write debug messages to the `syslog`.

Check the value of the `debug_level` parameter . If the parameter is set to 0, you can set it to 1 with the following command:

```
echo 1 > /sys/module/mlx4_core/parameters/debug_level
```

- For `mlx5`: Load the `mlx5` module with the `sysfs` parameter `debug_mask=1` to write debug messages to the `syslog`.

Check the value of the `debug_mask` parameter . If the parameter is set to 0, you can set it to 1 with the following command:

```
echo 1 > /sys/module/mlx5_core/parameters/debug_mask
```


Chapter 21. Internal shared memory device driver

LPAR and z/VM: The ISM device driver applies to Linux in LPAR mode and to Linux on z/VM.

The internal shared memory (ISM) device driver provides virtual PCI devices for shared memory communications direct (SMC-D).

ISM devices are defined in the IOCDs. Each ISM definition includes a physical network ID (PNET ID) to associate the ISM device with Ethernet devices.

The following figure illustrates how an ISM device and a HiperSockets device are associated by a matching PNET ID. A communication peer on the same CPC has a similarly associated pair of an ISM device and HiperSockets device. With this setup, the TCP connection can switch over to an SMC-D connection over the SMC protocol.

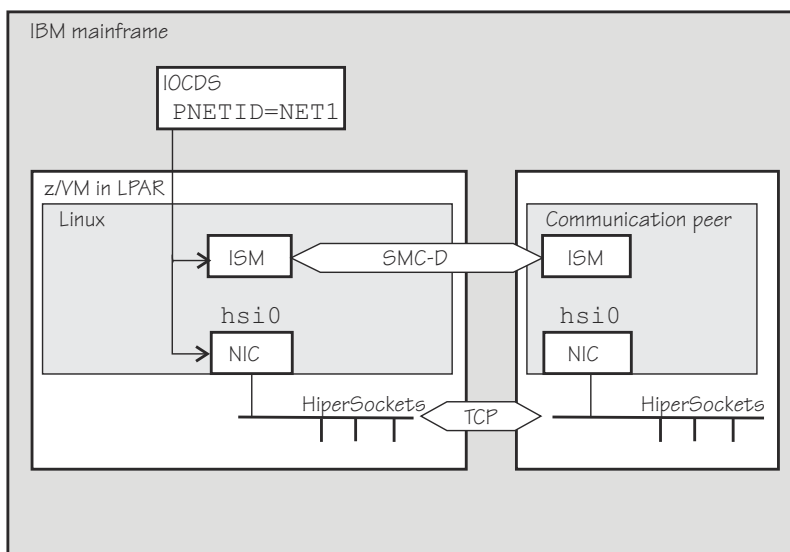


Figure 69. A matching PNET ID associates ISM devices and Ethernet devices

For information about how to find the PNET ID of PCI devices from your Linux instance, see [“Investigating PNET IDs” on page 293](#).

For more information on SMC and SMC-D, see [Chapter 19, “SMC protocol support,” on page 291](#).

Loading the ISM device driver

If the ISM device driver is compiled as a separate module, you must load it before you can use ISM devices.

Load the `ism` module with the `modprobe` command. The `ism` module has no module parameters.

```
# modprobe ism
```

Listing ISM devices

Because ISM devices are PCI devices, you can list them with the `lspci` command.

Example

```
# lspci -v
0001:00:00.0 Non-VGA unclassified device: IBM Internal Shared Memory (ISM) virtual PCI device
Physical Slot: 000002e1
Flags: bus master, fast devsel, latency 0, IRQ 8
Memory at 8001000000000000 (64-bit, prefetchable) [size=256T]
Memory at 8002000000000000 (64-bit, prefetchable) [size=256]
Capabilities: [40] MSI: Enable+ Count=1/32 Maskable- 64bit+
Kernel driver in use: ism
Kernel modules: ism
```

Part 5. System resources

These device drivers and features help you to manage the resources of your real or virtual hardware.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 22. Managing CPUs

You can control the online status, check the capability, and, for LPAR mode, examine the topology of CPUs.

Use the **lscpu** and **chcpu** commands to manage CPUs. These commands are part of the util-linux package. For details, see the man pages. Alternatively, you can manage CPUs through the attributes of their entries in sysfs.

Some attributes that govern CPUs are available in sysfs under:

```
/sys/devices/system/cpu/cpu<N>
```

where <N> is the number of the logical CPU. Both the sysfs interface and the **lscpu** and **chcpu** commands manage CPUs through their logical representation in Linux.

You can obtain a mapping of logical CPU numbers to physical CPU addresses by issuing the **lscpu** command with the **-e** option.

Example:

```
# lscpu -e
CPU NODE DRAWER BOOK SOCKET CORE L1d:L1i:L2d:L2i ONLINE CONFIGURED POLARIZATION ADDRESS
0 1 0 0 0 0 0:0:0:0 yes yes horizontal 0
1 1 0 0 0 0 1:1:1:1 yes yes horizontal 1
2 1 0 0 0 1 2:2:2:2 yes yes horizontal 2
3 1 0 0 0 1 3:3:3:3 yes yes horizontal 3
4 1 0 0 0 2 4:4:4:4 yes yes horizontal 4
5 1 0 0 0 2 5:5:5:5 yes yes horizontal 5
6 1 0 0 0 3 6:6:6:6 yes yes horizontal 6
7 1 0 0 0 3 7:7:7:7 yes yes horizontal 7
8 0 1 1 1 4 8:8:8:8 yes yes horizontal 8
...
```

The logical CPU numbers are shown in the CPU column and the physical address in the ADDRESS column of the output table.

Alternatively, you can find the physical address of a CPU in the sysfs address attribute of a logical CPU.

Example:

```
# cat /sys/devices/system/cpu/cpu0/address
0
```

Simultaneous multithreading

Linux in LPAR mode can use the simultaneous multithreading technology on mainframes.

IBM z13 introduced the simultaneous multithreading technology to the mainframe. In Linux terminology, simultaneous multithreading is also known as SMT or Hyper-Threading.

With multithreading enabled, a single *core* on the hardware is mapped to multiple logical CPUs on Linux. Thus, multiple threads can issue instructions to a core simultaneously during each cycle.

To find out whether multithreading is enabled for a particular Linux instance, compare the number of cores with the number of threads that are available in the LPAR. You can use the **hyptop** command to obtain this information.

Simultaneous multithreading is designed to enhance performance. Whether this goal is achieved strongly depends on the available resources, the workload, and the applications that run on a particular Linux instance. Depending on these conditions, it might be advantageous to not make full use of multithreading or to disable it completely. Use the **hyptop** command to obtain utilization data for threads while Linux runs with multithreading enabled.

You can use the `smt=` and `nosmt` kernel parameters to control multithreading. By default, Linux in LPAR mode uses multithreading if it is provided by the hardware.

CPU capability change

When the CPUs of a mainframe heat or cool, the Linux kernel generates a `uevent` for all affected online CPUs.

You can read the CPU capability from the `Capability` and, if present, `Secondary Capability` fields in `/proc/sysinfo`.

The capability values are unsigned integers as defined in the system information block (SYSIB) 1.2.2 (see *z/Architecture Principles of Operation*, SA22-7832). A smaller value indicates a proportionally greater CPU capacity. Beyond that, there is no formal description of the algorithm that is used to generate this value. The value is used as an indication of the capability of the CPU relative to the capability of other CPU models.

Changing the configuration state of CPUs

A CPU on an LPAR can be in a `configured`, `standby`, or `reserved` state. You can change the state of standby CPUs to `configured` state and vice versa.

Before you begin

- You can change the configuration state of CPUs for Linux in LPAR mode only. For Linux on z/VM, CPUs are always in a `configured` state.
- Daemon processes like `cpuplugd` can change the state of any CPU at any time. Such changes can interfere with manual changes.

About this task

When Linux is booted, only CPUs that are in a `configured` state are brought online and used. The kernel does not detect CPUs in `reserved` state.

Procedure

Issue a command of this form to change the configuration state of a CPU:

```
# chcpu -c|-g <N>
```

where

<N>

is the number of the logical CPU.

-c

changes the configuration state of a CPU from `standby` to `configured`.

-g

changes the configuration state of a CPU from `configured` to `standby`. Only offline CPUs can be changed to the `standby` state.

Alternatively, you can write `1` to the `configure` `sysfs` attribute of a CPU to set its configuration state to `configured`, or `0` to change its configuration state to `standby`.

Examples:

- The following `chcpu` command changes the state of the logical CPU with number 2 from `standby` to `configured`:

```
# chcpu -c 2
```

The following command achieves the same results by writing 1 to the `configure sysfs` attribute of the CPU.

```
# echo 1 > /sys/devices/system/cpu/cpu2/configure
```

- The following **chcpu** command changes the state of the logical CPU with number 2 from `configured` to `standby`:

```
# chcpu -g 2
```

The following command achieves the same results by writing 0 to the `configure sysfs` attribute of the CPU.

```
# echo 0 > /sys/devices/system/cpu/cpu2/configure
```

Setting CPUs online or offline

Use the **chcpu** command or the `online sysfs` attribute of a logical CPU to set a CPU online or offline.

Before you begin

- Daemon processes like **cpuplugd** can change the state of any CPU at any time. Such changes can interfere with manual changes.

Procedure

1. Optional: Rescan the CPUs to ensure that Linux has a current list of configured CPUs.

To initiate a rescan, issue the **chcpu** command with the **-r** option.

```
# chcpu -r
```

Alternatively, you can write 1 to `/sys/devices/system/cpu/rescan`.

You might need a rescan for Linux on z/VM after one or more CPUs have been added to the z/VM guest virtual machine by the z/VM hypervisor. Linux in LPAR mode automatically detects newly available CPUs.

2. Change the online state of a CPU by issuing a command of this form:

```
# chcpu -e|-d <N>
```

where

<N>

is the number of the logical CPU.

-e

sets an offline CPU online. Only CPUs that are in the configuration state `configured` can be set online. For Linux on z/VM, all CPUs are in the `configured` state.

-d

sets an online CPU offline.

Alternatively, you can write 1 to the `online sysfs` attribute of a CPU to set it online, or 0 to set it offline.

Examples:

- The following **chcpu** commands force a CPU rescan, and then set the logical CPU with number 2 online.

```
# chcpu -r
# chcpu -e 2
```

The following commands achieve the same results by writing 1 to the `online` sysfs attribute of the CPU.

```
# echo 1 > /sys/devices/system/cpu/rescan
# echo 1 > /sys/devices/system/cpu/cpu2/online
```

- The following **chcpu** command sets the logical CPU with number 2 offline.

```
# chcpu -d 2
```

The following command achieves the same results by writing 0 to the `online` sysfs attribute of the CPU.

```
# echo 0 > /sys/devices/system/cpu/cpu2/online
```

Examining the CPU topology

Depending on your hardware support, sysfs provides information about the CPU topology of an LPAR.

Before you begin

Meaningful CPU topology information is available only to Linux in LPAR mode.

About this task

The Linux scheduler uses this topology information to optimize decisions about which process to schedule to which CPU. Depending on the workload, this optimization might increase cache hits and, therefore, overall performance.

By default, CPU topology support is enabled and default assumptions are used if no topology information is available. You can override these defaults if they are not suitable for your workload, see [“Overriding topology default assumptions”](#) on page 305.

The following sysfs attributes provide information about the CPU topology:

```
/sys/devices/system/cpu/cpu<N>/topology/thread_siblings
/sys/devices/system/cpu/cpu<N>/topology/core_siblings
/sys/devices/system/cpu/cpu<N>/topology/book_siblings
/sys/devices/system/cpu/cpu<N>/topology/drawer_siblings
```

where `<N>` specifies a particular logical CPU number. These attributes contain masks that specify sets of CPUs.

Because the mainframe hardware is evolving over time, the terms *drawer*, *book*, *core*, and *thread* do not necessarily correspond to fixed hardware entities. What matters for the Linux scheduler is the levels of relatedness that these terms signify, not the physical embodiment of the levels. In this context, more closely related means sharing more resources, like caches.

The `thread_siblings`, `core_siblings`, `book_siblings`, and `drawer_siblings` attribute each contain a mask that specifies the CPU and its peers at a particular level of relatedness.

1. The `thread_siblings` attribute covers the CPU and its closely related peers.
2. The `core_siblings` attribute covers all CPUs of the `thread_siblings` attribute and peers related at the core level.
3. The `book_siblings` attribute covers all CPUs of the `core_siblings` attribute and peers related at the book level.

4. The `drawer_siblings` attribute covers all CPUs of the `book_siblings` attribute and peers related at the drawer level.

If a machine reconfiguration causes the CPU topology to change, change uevents are created for each online CPU.

If the kernel also supports standby CPU activation and deactivation (see “Changing the configuration state of CPUs” on page 302), the masks also contains the CPUs that are in a configured, but offline state. Updating the masks after a reconfiguration might take some time.

Overriding topology default assumptions

Use the `topology=` kernel parameter to override default assumptions about the CPU topology.

By default, CPU topology support is enabled in the Linux kernel. If no topology information is available, a topology is assumed where the CPUs share least resources, that is, each CPU is assumed to be on a different drawer.

Use the `topology=off` kernel parameter to override these defaults if they are not suitable for your workload.

Format



off

Disables CPU topology support.

on

If no topology information is available, assumes that all CPUs are core siblings. If topology information is available, this setting is ignored.

Example

```
topology=off
```

Dynamic changes

On a running Linux instance, you can read the current topology setting from `/proc/sys/s390/topology`. You can also write to `/proc/sys/s390/topology` to change the setting.

The value 1 corresponds to `topology=on`, and 0 corresponds to `topology=off`.

Example

```
# echo 0 > /proc/sys/s390/topology
```

CPU polarization

You can modify the operation of a vertical SMP environment by adjusting the SMP factor based on the workload demands.

Before you begin

CPU polarization is relevant only to Linux in LPAR mode.

Warning: Turning on vertical CPU polarization without careful configuration can result in significant performance degradation. See [Configuration note](#) for details.

About this task

Horizontal CPU polarization means that the PR/SM hypervisor dispatches each virtual CPU of an LPAR for the same amount of time.

With vertical CPU polarization, the PR/SM hypervisor dispatches certain CPUs for a longer time than others. For example, if an LPAR has three virtual CPUs, each of them with a share of 33%, then in case of vertical CPU polarization, all of the processing time would be combined to a single CPU. This CPU would run most of the time while the other two CPUs would get nearly no time.

There are three types of vertical CPUs: high, medium, and low. Low CPUs hardly get any real CPU time, while high CPUs get a full real CPU. Medium CPUs get something in between.

Configuration note: Switching to vertical CPU polarization usually results in a system with different types of vertical CPUs. Running a system with different types of vertical CPUs can result in significant performance degradation. If possible, use only one type of vertical CPUs. Set all other CPUs offline and deconfigure them.

Procedure

To change the polarization, issue a command of this form:

```
# chcpu -p horizontal|vertical
```

Alternatively, you can write a 0 for horizontal polarization (the default) or a 1 for vertical polarization to `/sys/devices/system/cpu/dispatching`.

Example: The following `chcpu` command sets the polarization to vertical.

```
# chcpu -p vertical
```

You can achieve the same results by issuing the following command:

```
# echo 1 > /sys/devices/system/cpu/dispatching
```

What to do next

You can issue the `lscpu` command with the `-e` option to find out the polarization of your CPUs. For more detailed information for a particular CPU, read the `polarization` attribute of the CPU in `sysfs`.

```
# cat /sys/devices/system/cpu/cpu<N>/polarization
```

The polarization can have one of the following values:

- `horizontal` - each of the guests' virtual CPUs is dispatched for the same amount of time.
- `vertical:high` - full CPU time is allocated.
- `vertical:medium` - medium CPU time is allocated.
- `vertical:low` - very little CPU time is allocated.
- `unknown` - temporary value following a polarization change until the change is completed and the kernel has established the new polarization of each CPU.

Chapter 23. Managing hotplug memory

LPAR and z/VM: Hotplug memory can be used by Linux in LPAR mode and by Linux on z/VM.

You can dynamically increase or decrease the memory for your running Linux instance.

To make memory available as hotplug memory, you must define it to your LPAR or z/VM. Hotplug memory is supported by z/VM 5.4 with the PTF for APAR VM64524 and by later z/VM versions.

For more information about memory hotplug, see `linux-doc/memory-hotplug.txt.gz` in the `linux-doc` package.

What you should know about memory hotplug

Hotplug memory is represented in `sysfs`. After rebooting Linux, all hotplug memory is offline.

Hotplug memory management overhead

Linux requires 64 bytes of memory to manage a 4-KB page of hotplug memory.

Use the following formula to calculate the total amount of initial memory that is consumed to manage your hotplug memory:

```
<hotplug memory> / 64
```

Example: 4.5 TB of hotplug memory consume $4.5 \text{ TB} / 64 = 72 \text{ GB}$.

For large amounts of hotplug memory, you might have to increase the initial memory that is available to your Linux instance. Otherwise, booting Linux might fail with a kernel panic and a message that there is not enough free memory.

How memory is represented in `sysfs`

Both the core memory of a Linux instance and the available hotplug memory are represented by directories in `sysfs`.

The memory with which Linux is started is the *core memory*. On the running Linux system, additional memory can be added as *hotplug memory*. The Linux kernel requires core memory to allocate its own data structures.

In `sysfs`, both the core memory of a Linux instance and the available hotplug memory are represented in form of memory blocks of equal size. Each block is represented as a directory of the form `/sys/devices/system/memory/memory<n>`, where `<n>` is an integer. You can find out the block size by reading the `/sys/devices/system/memory/block_size_bytes` attribute.

In the naming scheme, the memory blocks with the lowest address ranges are assigned the lowest integer numbers. The core memory always begins with `memory0`. The hotplug memory blocks follow the core memory blocks.

You can calculate where the hotplug memory begins. To find the number of core memory blocks, divide the base memory by the block size.

Example:

- With a core memory of 512 MB and a block size of 128 MB, the core memory is represented by four blocks, `memory0` through `memory3`. Therefore, first hotplug memory block on this Linux instance is `memory4`.
- Another Linux instance with a core memory of 1024 MB and access to the same hotplug memory, represents this first hotplug memory block as `memory8`.

The hotplug memory is available to all operating system instances within the z/VM system or LPAR to which it was defined. The `state sysfs` attribute of a memory block indicates whether the block is in use by your own Linux system. The `state` attribute does not indicate whether a block is in use by another operating system instance. Attempts to add memory blocks that are already in use fail.

Hotplug memory and reboot

The original core memory is preserved as core memory and hotplug memory is freed when rebooting a Linux instance.

When you perform an IPL after shutting down Linux, always use **`ipl clear`** to preserve the original memory configuration.

Memory zones

The Linux kernel divides memory into memory zones. On a mainframe, three zones are used: DMA, Normal, and Movable.

- Memory in the DMA zone is below 2 GB, and some I/O operations require that memory buffers are located in this zone.
- Memory in the Normal zone is above 2 GB, and it can be used for all memory allocations that do not require zone DMA.
- Memory in the Movable zone cannot be used for arbitrary kernel allocations, but only for memory buffers that can easily be moved by the kernel, such as user memory allocations and page cache memory. Memory in the Movable zone can more easily be taken offline than memory in other zones.

The zones that are available to a memory block are listed in the `valid_zones sysfs` attribute. For more information, see [“Adding memory”](#) on page 310.

Setting up hotplug memory

Before you can use hotplug memory on your Linux instance, you must define this memory as hotplug memory on your physical or virtual hardware.

Defining hotplug memory to an LPAR

You use the Hardware Management Console (HMC) to define hotplug memory as *reserved storage* on an LPAR.

For information about defining reserved storage for your LPAR, see the *Processor Resource/Systems Manager Planning Guide*, SB10-7041 for your mainframe.

Defining hotplug memory to z/VM

In z/VM, you define hotplug memory as *standby storage*.

There is also *reserved storage* in z/VM, but other than reserved memory defined for an LPAR, reserved storage that is defined in z/VM is not available as hotplug memory.

Always align the z/VM guest storage with the Linux memory block size. Otherwise, memory blocks might be missing or impossible to set offline in Linux.

For information about defining standby memory for z/VM guests see the "DEFINE STORAGE" section in *z/VM: CP Commands and Utilities Reference*, SC24-6268.

Performing memory management tasks

Typical memory management tasks include finding out the memory block size, adding memory, and removing memory.

- [“Finding out the memory block size”](#) on page 309

- [“Listing the available memory blocks” on page 309](#)
- [“Adding memory” on page 310](#)
- [“Removing memory” on page 311](#)

Finding out the memory block size

On an IBM Z mainframe, memory is provided to Linux as memory blocks of equal size.

Procedure

- Use the **lsmem** command to find out the size of your memory blocks.

Example:

```
# lsmem
Address range                               Size (MB)  State    Removable  Device
=====
0x0000000000000000-0x000000000fffffff     256  online   no         0
0x0000000010000000-0x000000002fffffff     512  online   yes        1-2
0x0000000030000000-0x000000003fffffff     256  online   no         3
0x0000000040000000-0x000000006fffffff     768  online   yes        4-6
0x0000000070000000-0x00000000fffffff     2304  offline  -         7-15

Memory device size : 256 MB
Memory block size  : 256 MB
Total online memory : 1792 MB
Total offline memory: 2304 MB
```

In the example, the block size is 256 MB.

- Alternatively, you can read `/sys/devices/system/memory/block_size_bytes`. This sysfs attribute contains the block size in byte in hexadecimal notation.

Example:

```
# cat /sys/devices/system/memory/block_size_bytes
10000000
```

This hexadecimal value corresponds to 256 MB.

Listing the available memory blocks

List the available memory to find out how much memory is available and which memory blocks are online.

Procedure

- Use the **lsmem** command to list your memory blocks.

Example:

```
# lsmem -a
Address range                               Size (MB)  State    Removable  Device
=====
0x0000000000000000-0x000000000fffffff     256  online   no         0
0x0000000010000000-0x000000001fffffff     256  online   no         1
0x0000000020000000-0x000000002fffffff     256  online   no         2
0x0000000030000000-0x000000003fffffff     256  online   yes        3
0x0000000040000000-0x000000004fffffff     256  online   yes        4
0x0000000050000000-0x000000005fffffff     256  offline  -         5
0x0000000060000000-0x000000006fffffff     256  offline  -         6
0x0000000070000000-0x000000007fffffff     256  offline  -         7

Memory device size : 256 MB
Memory block size  : 256 MB
Total online memory : 1280 MB
Total offline memory: 786 MB
```

- Alternatively, you can list the available memory blocks by listing the contents of `/sys/devices/system/memory`. Read the state attributes of each memory block to find out whether it is online or offline.

Example: The following command results in an overview for all available memory blocks.

```
# grep -r --include="state" "line" /sys/devices/system/memory/
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
/sys/devices/system/memory/memory4/state:online
/sys/devices/system/memory/memory5/state:offline
/sys/devices/system/memory/memory6/state:offline
/sys/devices/system/memory/memory7/state:offline
```

Note

Online blocks are in use by your Linux instance. An offline block can be free to be added to your Linux instance but it might also be in use by another Linux instance.

Adding memory

You can add memory to your Linux instance by setting unused memory blocks online.

Procedure

- Use the **chmem** command with the **-e** parameter to set memory online. You can specify the amount of memory you want to add with the command without specifying particular memory blocks. If there are enough eligible memory blocks to satisfy your request, the tool finds them for you and sets the most suitable blocks online. For information about the **chmem** command, see the man page. The **chmem** command is part of the `util-linux` package.
- Alternatively, you can write to the `state` sysfs attribute of an unused memory block. Issue a command of the form:

```
# echo online_value > /sys/devices/system/memory/memory<n>/state
```

where *online_value* is one of:

online

sets the memory block online to the default zone. The default zone is the first zone listed in the `valid_zones` sysfs attribute.

online_movable

sets the memory block online to the Movable zone. Setting the block online fails if the Movable zone is not listed in the `valid_zones` sysfs attribute.

online_kernel

sets the memory block online to the first non-Movable zone listed in the `valid_zones` directory. Setting the block online fails if the Movable zone is the only zone listed in the `valid_zones` sysfs attribute.

`<n>` is an integer that identifies the memory unit.

Results

Adding the memory block fails if the memory block is already in use. The state attribute changes to online when the memory block has been added successfully.

Removing memory

You can remove memory from your Linux instance by setting memory blocks offline.

About this task

Avoid removing core memory. The Linux kernel requires core memory to allocate its own data structures.

Procedure

- Use the **chmem** command with the **-d** parameter to set memory offline.
You can specify the amount of memory you want to remove with the command without specifying particular memory blocks. The tool finds eligible memory blocks for you and sets the most suitable blocks offline.
For information about the **chmem** command, see the man page. The **chmem** command is part of the `util-linux` package.
- Alternatively, you can write `offline` to the `sysfs state` attribute of an unused memory block.
Issue a command of the form:

```
# echo offline > /sys/devices/system/memory/memory<n>/state
```

where `<n>` is an integer that identifies the memory unit.

Results

The hotplug memory functions first relocate memory pages to free the memory block and then remove it. The `state` attribute changes to `offline` when the memory block has been removed successfully.

The memory block is not removed if it cannot be freed completely.

Chapter 24. Persistent device configuration

Use the **chzdev** command to persistently configure your devices and device drivers and the **lszdev** command to view your configuration.

You can manage the device configuration with **lszdev** and **chzdev** within all hypervisor environments, LPAR, z/VM, and KVM. For KVM guests, this applies mainly to pass-through devices. For virtio devices, the virtual server definition on the KVM host and the KVM virtualization limit the scope for configuration on the KVM guest.

Mainframe-specific devices, such as DASDs, FCP devices, and network devices require special configuration steps before they can be used. Tools are available that configure devices, for example **chccwdev** and **znetconf**, but this type of configuration is not preserved across reboots.

The **chzdev** command facilitates persistent configuration. The command performs all configuration steps that are required to make devices operational, for example, as a block device, a character device, or a network interface.

The following device types are supported:

- FICON-attached direct access storage devices (DASDs)
- SCSI-over-Fibre Channel (FCP) devices and SCSI devices
- OSA-Express and HiperSockets network devices
- LAN-Channel-Station (LCS) network devices
- Channel command word (CCW) devices that are not covered by any other device type, for example the 3215 console, 3270 terminal devices, z/VM reader and puncher devices, and CCW tape devices.

The **chzdev** and **lszdev** commands are included in the s390-tools package. **chzdev** configures the devices and device drivers in two ways:

- In the currently running configuration, called the *active configuration*
- In configuration files such as udev rules, called the *persistent configuration*

The **lszdev** command displays configuration information about devices and device drivers. For details, see [“lszdev - Display IBM Z device configurations” on page 623](#).

For details about the **chzdev** command, see [“chzdev - Configure IBM Z devices” on page 531](#).

Note: Using tools that are not aligned with **lszdev** and **chzdev** can result in conflicting configuration settings.

Device ID

The **chzdev** and **lszdev** commands use *device IDs* to identify devices. For CCW devices and CCW group devices, this device ID is the device bus-ID.

The device bus-ID is of the format 0.<*subchannel_set_ID*>.<*devno*>, for example, 0.0.8000.

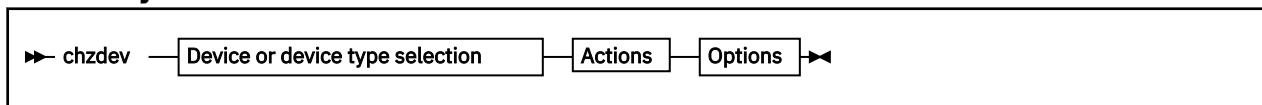
Tip: For device bus-IDs with a leading "0.0", you can shorten the specification to just the device number (*devno*). For example, you can shorten 0.0.0b10 to 0b10.

Other device categories can have different IDs. For example, SCSI devices have a triplet device ID that consists of a device number, a WWPN, and a LUN.

Configuring device drivers

You can use the **chzdev** command to modify device driver attributes, for example module parameters such as DASD's `eer_pages`. You select a device driver, rather than a device, by using the `--type` option. Device drivers can be selected by type or subtype, for example DASDs are of type `dasd`, but have the subtypes `dasd-fba` and `dasd-eckd`.

chzdev syntax overview



Where the different command sections have these meanings:

Device or device type selection

Select devices by device ID, device state, or function. Select device types by specifying a device type and the `--type` option. For details about selecting devices or device types, see [“Selecting devices and device drivers” on page 314](#).

Actions

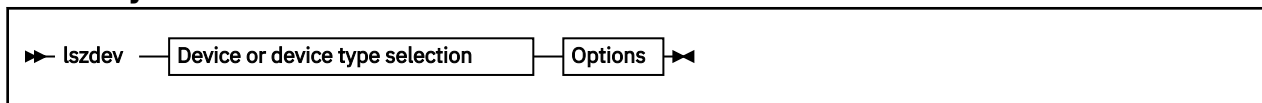
Act on the selected devices. For details about these actions, see:

- [“Enabling and disabling a device” on page 317](#)
- [“Changing device or device driver settings” on page 322](#)
- [“Importing and exporting configuration data” on page 324](#)

Options

Choose how to apply the command, for example as a test run, as applying to the persistent configuration only, or as running in quiet mode. Options include `--dry-run`, `--verbose`, `--quiet`, and `--yes`. For the complete list of options, see [“chzdev - Configure IBM Z devices” on page 531](#)

lszdev syntax overview



Where the different command sections have these meanings:

Device or device type selection

Select devices to display by device ID, device state, or function. For details about selecting devices, see [“Selecting devices and device drivers” on page 314](#). If no selection is made, all existing and configured devices are displayed.

Options

Choose the configuration information, and how to display it.

- To display a list with information about all devices, specify only **lszdev** without options. You can restrict output to a single device, a device type, or a range of devices. You can control what information is included by specifying output columns.
- To display details about a single device, specify the device and the `--info` option.

For details on and examples of displaying information, see [“Viewing the configuration” on page 319](#). For the complete list of options, see [“lszdev - Display IBM Z device configurations” on page 623](#).

Selecting devices and device drivers

You can select devices by type and ID, by state, by path, or by network interface name.

About this task

You can select either devices or device drivers.

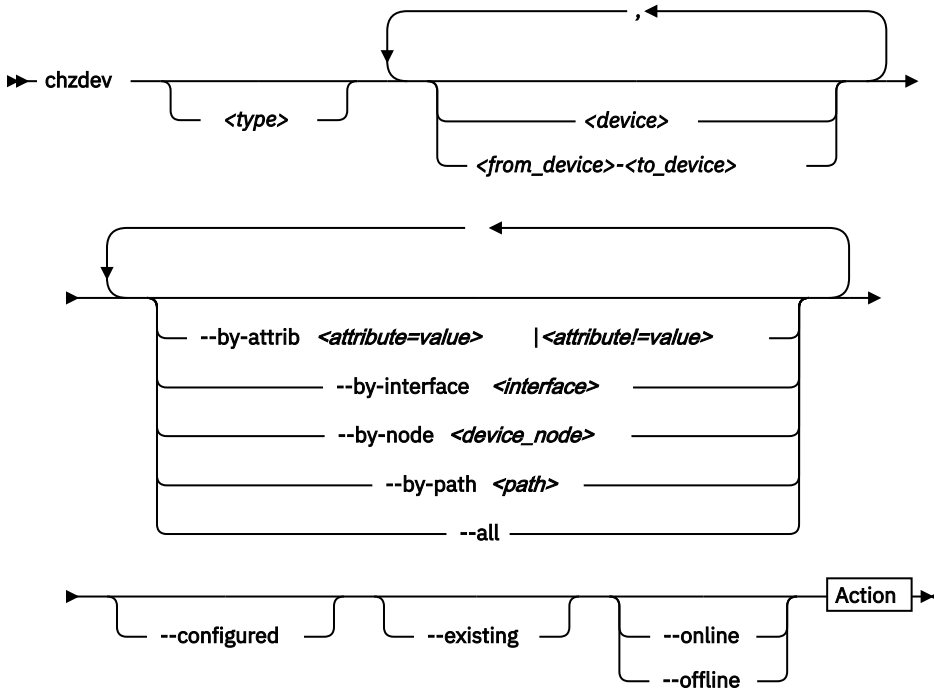
To select a device driver, specify the `--type` option and a `<type>` without a device ID. For details, see the description of `<type>` and the `--type` option.

Selecting a device driver

► chzdev — <type> — --type — Action ◄◄

Select devices by device ID, by attribute, interface, node, or path. Then restrict your choice to the devices with a particular configuration state. For details see the descriptions for the --configured, --existing, --online, and --offline options. To select all devices, specify --all.

Selecting a device



Device driver selection:

<type>

restricts the scope of an action to the specified device type. Specify a device type together with the --type option to manage the configuration of the device driver itself.

-t <device_type> or --type <device_type>

selects a device type as target for a configuration or query action. For example: dasd-eckd, zfcp, or geth.

Device selection:

<type>

restricts the scope of an action to the specified device type. Specify a device type and optionally a device ID to only work on devices with matching type and ID

Note:

As a precaution, use the most specific device type when configuring a device by ID. Otherwise the same device ID might accidentally match other devices of a different sub-type. To get a list of supported device types, use the --list-types option.

<device>

selects a single device or a range of devices by device ID. Separate multiple IDs or ranges with a comma (.). To select a range of devices, specify the ID of the first and the last device in the range separated by a hyphen (-).

--all

selects all existing and configured devices.

--by-attr *<attrib=value>* | *<attrib!=value>*

selects devices with a specific attribute, *<attrib>* that has a value of *<value>*. When specified as *<attrib>!=<value>*, selects all devices that do not provide an attribute named *<attrib>* with a value of *<value>*.

Tip: You can use the `--list-attributes` option to display a list of available attributes and the `--help-attribute` to get more detailed information about a specific attribute.

--by-interface *<interface>*

selects devices by network interface, for example, `encf500`. *<interface>* must be the name of an existing networking interface.

--by-node *<device_node>*

selects devices by device node, for example, `/dev/sda`. *<device_node>* must be the path to the device node for a block device or character device.

Note: If *<device_node>* is the device node for a logical device (such as a device mapper device), **lszdev** tries to resolve the corresponding physical device nodes. The **lsblk** tool must be available for this resolution to work.

--by-path *<path>*

selects devices by file-system path, for example, `/usr`. The *<path>* parameter can be the mount point of a mounted file system, or a path on that file system.

Note: If the file system that provides *<path>* is stored on multiple physical devices (such as supported by `btrfs`), **lszdev** tries to resolve the corresponding physical device nodes. The **lsblk** tool must be available and the file system must provide a valid UUID for this resolution to work.

Restrict selection to configuration state:**--configured**

narrows the selection to those devices for which a persistent configuration exists.

--existing

narrows the selection to all devices that are present in the active configuration.

--configured --existing

specifying both `--configured` and `--existing` narrows the selection to devices that are present in both configurations, persistent and active.

--online

narrows the selection to devices that are enabled in the active configuration.

--offline

narrows the selection to devices that are disabled in the active configuration.

Action

performs an action on the selected device, for details see:

- [“Enabling and disabling a device” on page 317](#)
- [“Changing device or device driver settings” on page 322](#)
- [“Importing and exporting configuration data” on page 324](#)

Examples

In the following examples the `enable` and `disable` actions are used when illustrating the different methods of selecting devices.

- To enable device `0.0.8000` by type and ID, issue:

```
# chzdev dasd-fba 0.0.8000 --enable
FBA DASD 0.0.8000 configured
```

- To select a device by ID only, issue the following command to disable device 0.0.8000. In this case **chzdev** automatically determines the associated type:

```
# chzdev 0.0.8000 --disable
FBA DASD 0.0.8000 deconfigured
```

Note: This addressing mode might result in multiple devices being selected. For example, if an FBA DASD is part of the persistent configuration, but you have disabled it and defined a new ECKD DASD 0.0.8000 that is active, and you enable 0.0.8000, both the FBA and the ECKD device will be enabled. The same is true if you specify only "dasd" and not "dasd-fba".

Tip: To ensure that you enable the correct device, include the most specific type, for example dasd-eckd instead of just dasd.

- To select multiple devices by range, specify the beginning of the range, a hyphen, and the end of the range:

```
# chzdev dasd-eckd 0.0.3000-0.0.4000 --enable
ECKD DASD 0.0.3718 configured
ECKD DASD 0.0.3719 configured
ECKD DASD 0.0.371a configured
ECKD DASD 0.0.37b8 configured
ECKD DASD 0.0.37b9 configured
ECKD DASD 0.0.37be configured
ECKD DASD 0.0.37bf configured
```

- To narrow the selection by configuration state, for example "online", use the `--online` option. This example configures all devices that are enabled in the active configuration persistently:

```
# chzdev --persistent --online --enable
Configuring devices in the persistent configuration only
ECKD DASD 0.0.3718 configured
ECKD DASD 0.0.3719 configured
ECKD DASD 0.0.371a configured
ECKD DASD 0.0.37b8 configured
ECKD DASD 0.0.37b9 configured
ECKD DASD 0.0.37be configured
ECKD DASD 0.0.37bf configured
FBA DASD 0.0.8000 configured
FCP device 0.0.1940 configured
Note: NPIV mode disabled - LUNs must be configured manually
zFCP LUN 0.0.1940:0x500507630508c1ae:0x402140ac00000000 configured
QETH device 0.0.f5f0:0.0.f5f1:0.0.f5f2 configured
Generic CCW device 0.0.0009 configured
```

- To select devices by specifying a file system path that is located on the target device, use the `--by-path` option:

```
# chzdev --persistent --by-path /mnt --enable
Configuring devices in the persistent configuration only
ECKD DASD 0.0.3718 configured
```

Note: If the file system that provides the PATH is stored on multiple physical devices or on a sub-volume (such as supported by btrfs), **lszdev** tries to resolve the corresponding physical device nodes. For the resolution to work, the **lsblk** and **findmnt** tools must be available, and if there are multiple physical devices the file system must provide a valid UUID.

- To select a device by specifying a device node that refers to a block or character device:

```
# chzdev --persistent --by-node /dev/dasda1 --enable
Configuring devices in the persistent configuration only
ECKD DASD 0.0.3718 configured
```

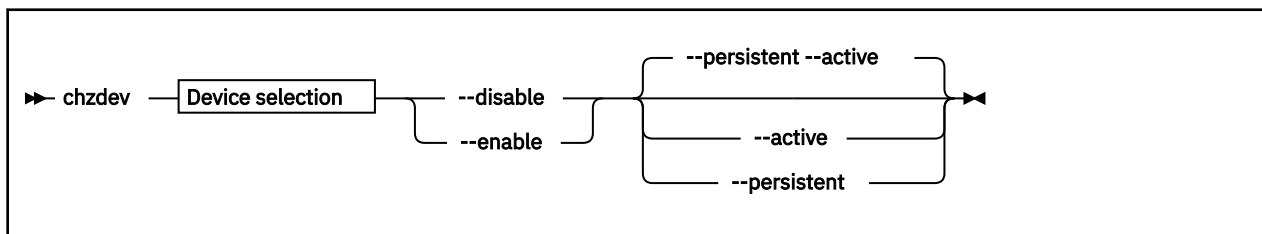
Enabling and disabling a device

You can use the **chzdev** command to enable or disable a device, both in the active and in the persistent configuration.

About this task

Any steps necessary for the device to function are automatically taken. If a `cio_ignore` device exclusion list is active, **chzdev** removes the specified device ID from the list.

Note: If a SCSI device is enabled and its FCP device taken off the `cio_ignore` exclusion list, all devices defined to the FCP device might come online automatically, see “Configuring SCSI devices” on page 171.



where:

-d or --disable

disables the selected devices.

Active configuration

Disables the selected devices by reverting the configuration steps necessary to enable them.

Persistent configuration

Removes configuration files and settings associated with the selected devices.

-e or --enable

enables the selected devices. Any steps necessary for the devices to function are taken, for example: create a CCW group device, remove a device from the CIO exclusion list, or set a CCW device online.

Active configuration

Performs all setup steps required for a device to become operational, for example, as a block device or as a network interface.

Persistent configuration

Creates configuration files and settings associated with the selected devices.

-a or --active

applies changes to the active configuration only. The persistent configuration is not changed unless you also specify `--persistent`.

Note: Changes to the active configuration are effective immediately. They are lost on reboot, when a device driver is unloaded, or when a device becomes unavailable.

-p or --persistent

applies changes to the persistent configuration only. The persistent configuration takes effect when the system boots, when a device driver is loaded, or when a device becomes available.

Examples

- To enable an ECKD DASD with bus ID 0.0.3718 in both the active and the persistent configuration, specify the device ID and its type to the **chzdev** command, together with the `--enable` option:

```
# chzdev dasd-eckd 0.0.3718 --enable
ECKD DASD 0.0.3718 configured
```

This command sets ECKD DASD 0.0.3718 online and creates udev rules to automatically bring it online at the next boot.

- To restrict the scope of the configuration actions to either the active or persistent configuration, specify `--active` or `--persistent`. The following command creates udev rules to automatically bring device 0.0.3718 online at the next boot:

```
# chzdev dasd-eckd 0.0.3718 --enable --persistent
Configuring devices in the persistent configuration only
ECKD DASD 0.0.3718 configured
```

- To disable a device, specify its device type and ID together with the `--disable` option:

```
# chzdev dasd-eckd 0.0.3718 --disable
ECKD DASD 0.0.3718 deconfigured
```

- To enable an FCP device and create a persistent configuration, issue:

```
# chzdev --enable zfcplun 0.0.198d:0x50050763070bc5e3:0x4006404600000000
```

- To enable an FCP device without creating a persistent configuration, issue:

```
# chzdev --enable --active zfcplun 0.0.198d:0x50050763070bc5e3:0x4006404600000000
```

- To enable a QETH device and create a persistent configuration, issue:

```
# chzdev --enable qeth 0.0.a000:0.0.a001:0.0.a002
```

- To enable a QETH device without creating a persistent configuration, issue:

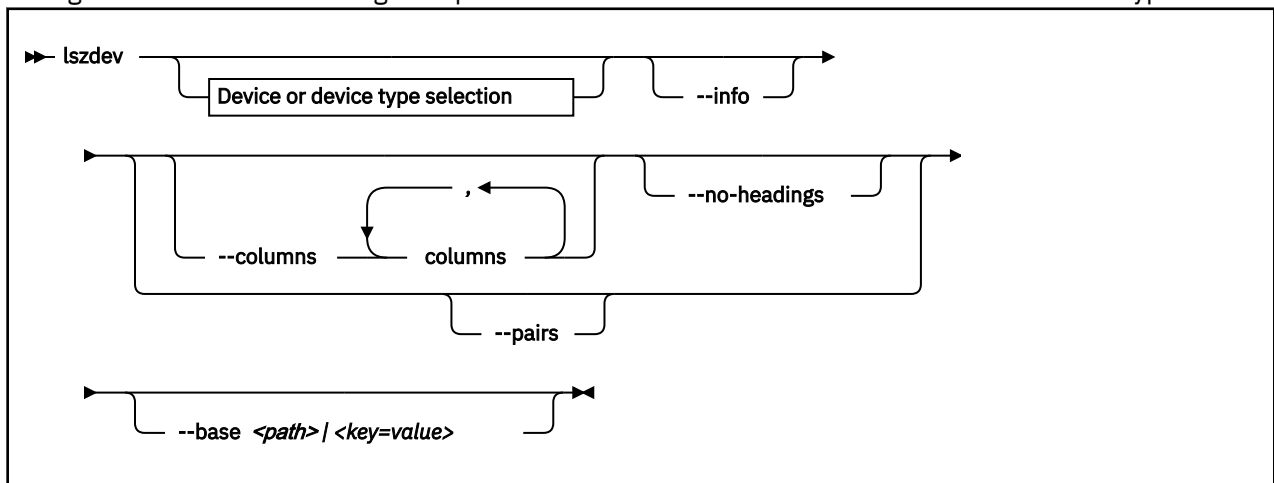
```
# chzdev --enable --active qeth 0.0.a000:0.0.a001:0.0.a002
```

Viewing the configuration

Use the **lszdev** command to list information about device drivers, devices, device types, and attributes.

About this task

The **lszdev** command provides options for extracting information from the active and persistent system configuration. You can list and get help on available device attributes and list available device types.



where:

-i or --info

displays detailed information about the configuration of the selected device or device type.

-c <columns> or --columns <columns>

specifies a comma-separated list of columns to display.

Example:

```
# lszdev --columns TYPE,ID
```

Tip: To get a list of supported column names, use the `--list-columns` option.

-n or --no-headings

suppresses column headings for list output.

--pairs

produces output in `<key="value">` format. Use this option to generate output in a format more suitable for processing by other programs. In this format, column values are prefixed with the name of the corresponding column. Values are enclosed in double quotation marks. The **lszdev** command automatically escapes quotation marks and slashes that are part of the value string.

--base <path> | <key=value>

changes file system paths that are used to access files. If `<path>` is specified without an equal sign (=), it is used as base path for accessing files in the active and persistent configuration. If the specified parameter is in `<key=value>` format, only those paths that begin with `<key>` are modified. For these paths, the initial `<key>` portion is replaced with `<value>`.

Example:

```
# lszdev --persistent --base /etc=/mnt/etc
```

Examples

- To list devices with their status, use the **lszdev** command, issue:

```
# lszdev
TYPE          ID                      ON PERS  NAMES
dasd-eckd     0.0.0190                no no
dasd-eckd     0.0.3718                yes yes  dasda dasda1
dasd-eckd     0.0.3719                no no
dasd-eckd     0.0.371a                yes yes  dasdb dasdb1 dasdb2 dasdb3
dasd-fba      0.0.8000                no no
zfcpl-host    0.0.1940                no no
zfcpl-host    0.0.1941                no no
qeth          0.0.a000:0.0.a001:0.0.a002 no no
qeth          0.0.a003:0.0.a004:0.0.a005 no no
qeth          0.0.f500:0.0.f501:0.0.f502 no no
qeth          0.0.f503:0.0.f504:0.0.f505 no no
qeth          0.0.f5f0:0.0.f5f1:0.0.f5f2 yes yes  encf5f0
generic-ccw   0.0.0009                yes no
generic-ccw   0.0.000c                no no
generic-ccw   0.0.000d                no no
generic-ccw   0.0.000e                no no
```

- To restrict output to a single device type, issue:

```
# lszdev qeth
TYPE          ID                      ON PERS  NAMES
qeth          0.0.a000:0.0.a001:0.0.a002 no no
qeth          0.0.a003:0.0.a004:0.0.a005 no no
qeth          0.0.f500:0.0.f501:0.0.f502 no no
qeth          0.0.f503:0.0.f504:0.0.f505 no no
qeth          0.0.f5f0:0.0.f5f1:0.0.f5f2 yes yes  encf5f0
```

- To list output in machine-readable format, use the `--pairs` option, issue:

```
# lszdev qeth --pairs
TYPE="qeth" ID="0.0.a000:0.0.a001:0.0.a002" ON="no" PERS="no" NAMES=""
TYPE="qeth" ID="0.0.a003:0.0.a004:0.0.a005" ON="no" PERS="no" NAMES=""
TYPE="qeth" ID="0.0.f500:0.0.f501:0.0.f502" ON="no" PERS="no" NAMES=""
TYPE="qeth" ID="0.0.f503:0.0.f504:0.0.f505" ON="no" PERS="no" NAMES=""
TYPE="qeth" ID="0.0.f5f0:0.0.f5f1:0.0.f5f2" ON="yes" PERS="yes" NAMES="encf5f0"
```

- To list all columns that you can display, use the `--list-columns` option:


```
# lszdev --list-columns
COLUMN  DESCRIPTION
TYPE    Device type
ID      Device identifier
ON      Device is online in the active configuration
EXISTS  Device exists in the active configuration
PERS    Device is configured persistently
NAMES   Associated Linux device names
BLOCKDEVS Associated block devices
CHARDEVS Associated character devices
NETDEVS Associated network interfaces
MODULES Required kernel modules
ATTR:   Value of specific attribute, e.g. ATTR:online
```

- To display specific columns only, use the `--columns` option with the names of the columns as a comma-separated list:

```
# lszdev qeth --columns ID,NAMES,ATTR:layer2
ID          NAMES          ATTR:layer2
0.0.a000:0.0.a001:0.0.a002      0
0.0.a003:0.0.a004:0.0.a005      0
0.0.f500:0.0.f501:0.0.f502      1
0.0.f503:0.0.f504:0.0.f505      0
0.0.f5f0:0.0.f5f1:0.0.f5f2      encf5f0      1
```

- To get a list of supported device types, use the `--list-types` option:

```
# lszdev --list-types
TYPE      DESCRIPTION
dasd      FICON-attached Direct Access Storage Devices (DASDs)
dasd-eckd Enhanced Count Key Data (ECKD) DASDs
dasd-fba  Fixed Block Architecture (FBA) DASDs
zfcpc    SCSI-over-Fibre Channel (FCP) devices and SCSI devices
zfcpc-host FCP devices
zfcpc-lun zfcpc-attached SCSI devices
qeth      OSA-Express and HiperSockets network devices
ctc       Channel-To-Channel (CTC) and CTC-MPC network devices
lcs       LAN-Channel-Station (LCS) network devices
generic-ccw Generic Channel-Command-Word (CCW) devices
```

Some device types are related. For example, specifying the "dasd" device type will select both "dasd-eckd" and "dasd-fba" devices.

- To list configuration details for a device, use the `--info` option:

```
# lszdev --info --by-interface encf5f0
DEVICE qeth 0.0.f5f0:0.0.f5f1:0.0.f5f2
Names      : encf5f0
Modules    : qeth
Online     : yes
Exists     : yes
Persistent : yes

ATTRIBUTE      ACTIVE      PERSISTENT
buffer_count   "64"      -
hw_trap        "disarm"  -
isolation      "none"    -
layer2         "1"       "1"
online         "1"       "1"
performance_stats "0"      -
portname       ""        -
portno         "0"       -
priority_queueing "always queue 0" -
```

- To list configuration details for a device driver, use the `--type` and a device-type name:

```
# lszdev --type dasd
DEVICE TYPE dasd
Description : FICON-attached Direct Access Storage Devices (DASDs)
Modules     : dasd_mod dasd_eckd_mod dasd_fba_mod
Active      : yes
Persistent  : no
ATTRIBUTE          ACTIVE          PERSISTENT
autodetect         "0"              -
dasd                -                -
eer_pages          "5"              -
nofcx              "0"              -
nopav              "0"              -
probeonly          "0"              -
```

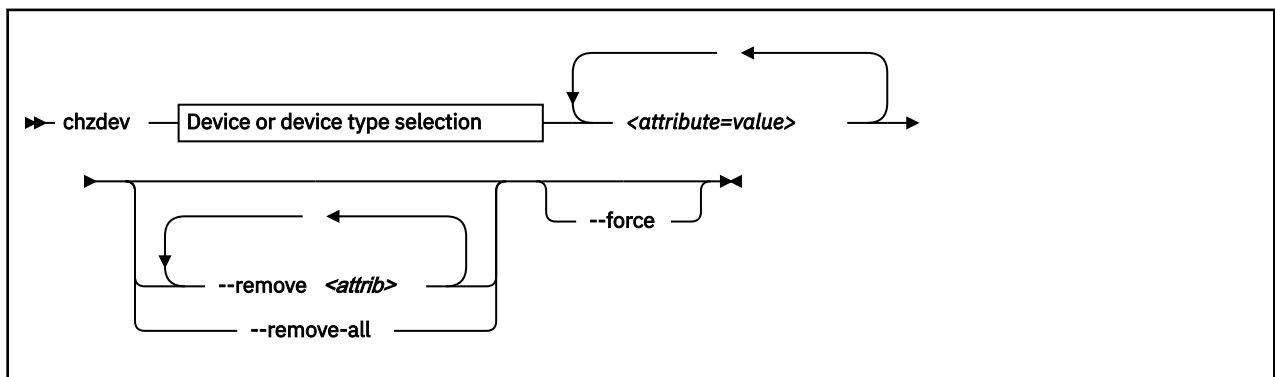
Changing device or device driver settings

Use the **chzdev** command to change both device and device driver settings.

About this task

Some devices provide named attributes. You can change the value of the attributes by using the **chzdev** command with a `<attribute=value>` assignment.

You can also use the **chzdev** command to modify device driver attributes, for example module parameters such as the DASD module parameter `eer_pages`. You select a device driver, rather than a device, by specifying the `--type` option. Device drivers can be selected by type or sub-type, for example DASDs are of type `dasd`, but have the sub-types `dasd-fba` and `dasd-eckd`.



where:

<attribute=value>

specifies a device attribute and its value. To specify multiple attributes, separate attribute-value pairs with a blank.

You can use the `--list-attributes` option to display a list of available attributes and the `--help-attribute` to get more detailed information about a specific attribute.

Tip: To specify an attribute that is not known to **chzdev**, use the `--force` option.

-r <attrib> or --remove <attrib>

removes the setting for attribute `<attrib>`.

Active configuration

For attributes that maintain a list of values, clears all values for that list.

Persistent configuration

Removes any setting for the specified attribute. When the device or device driver is configured again, the attribute is set to its default value.

Some attributes cannot be removed.

-R or --remove-all

removes the settings for all attributes of the selected device or device driver.

Active configuration

For attributes that maintain a list of values, clears all values for that list.

Persistent configuration

Removes all attribute settings that can be removed. When the device or device driver is configured again, the attribute is set to its default value.

Some attributes cannot be removed.

-f or --force

overrides safety checks and confirmation questions, including:

- More than 256 devices selected
- Configuring unknown attributes
- Combining apparently inconsistent settings

Examples for changing device settings

- To set the `use_diag` attribute for device 0.0.8000, issue:

```
# chzdev dasd-fba 0.0.8000 use_diag=1 --persistent --verbose
Configuring devices in the persistent configuration only
FBA DASD 0.0.8000 configured
Changes: use_diag=1
Block devices: /dev/dasda /dev/dasda1
```

- To list available attributes, specify the device type together with the `--list-attributes` option:

```
# chzdev dasd-fba --list-attributes
NAME                DESCRIPTION
online              Activate a device
cmb_enable          Enable the Channel measurement facility
failfast           Modify error recovery in no-path scenario
readonly           Inhibit write access to DASD
erplog             Enable logging of Error Recovery Processing
use_diag           Activate z/VM hypervisor assisted I/O processing
eer_enabled        Enable Extended Error Reporting
expires            Modify I/O operation timeout
retries            Modify I/O operation retry counter
timeout            Modify I/O request timeout
reservation_policy  Modify lost device reservation behavior
last_known_reservation_state  Display and reset driver device reservation view
safe_offline       Deactivate DASD after processing outstanding I/Os
```

- To display more details about an attribute, use the `--help-attribute` option:

```
# chzdev dasd-fba --help-attribute use_diag
ATTRIBUTE use_diag

DESCRIPTION
  Control I/O access mode for a DASD:
    0: I/O is performed using standard channel programs
    1: I/O is performed using the z/VM DIAGNOSE X'250' interface

Note that the DIAGNOSE X'250' access mode only works when running
Linux as z/VM guest, and only for devices formatted with consistent
block sizes such as ECKD DASDs with LDL or CMS format, or FBA
devices.

DEFAULT VALUE
  The default value is '0'.
ACCEPTED VALUES
  - Numbers 0 to 1 in decimal notation
```

- To remove a setting from a persistent configuration, use the `--remove` and `--persistent` options:

```
# chzdev dasd 8000 --persistent --remove use_diag --verbose
Configuring devices in the persistent configuration only
FBA DASD 0.0.8000 configured
Changes: -use_diag
Block devices: /dev/dasda /dev/dasda1
```


- To export this configuration data to a file called config.txt, issue:

```
# chzdev --by-interface enca000 --persistent --export config.txt
```

- To apply data in this format to a system's configuration, use the --import option:

```
# chzdev --import config.txt
Importing configuration data from config.txt
QETH device 0.0.a000:0.0.a001:0.0.a002 configured
```

- To create a persistent configuration for an ECKD DASD 0.0.1000 and write it to a new Linux system that is mounted under /mnt/etc, issue:

```
# chzdev dasd-eckd 1000 -e -p --base /etc=/mnt/etc
```

- To display a configuration that was written to /mnt/etc, issue:

```
# lsudev --persistent --base /etc=/mnt/etc
```

- To copy the persistent configuration to /mnt/etc, issue:

```
# chzdev --all --persistent --export - | chzdev --import - --base /etc=/mnt/etc
Exporting configuration data to standard output
Importing configuration data from Standard input
ECKD DASD 0.0.1234 configured
FCP device 0.0.190d configured
FCP device 0.0.194d configured
```

Configuring the root device

Changing the configuration of the device that provides the root file system might require additional configuration steps.

About this task

For what steps are required to persistently apply root device configurations, see the Ubuntu documentation available from

```
https://help.ubuntu.com/
```

Example

The following example shows a change made to an Ubuntu Linux instance. The example shows that changes have been made that might require rebuilding the RAM disk:

```
# chzdev --by-path / eplog=1
ECKD DASD 0.0.ca00 configured
Note: Some of the changes affect devices providing the root file system:
- ECKD DASD 0.0.ca00
Additional steps such as rebuilding the RAM-disk might be required.
```

For more information about rebuilding the RAM disk, see [“Rebuilding the initial RAM disk image”](#) on page 82.

Chapter 25. Huge-page support

Note: Across the IT industry, *huge pages* and *large pages* are used synonymously for memory pages that exceed 4 KB. In keeping with the more commonly used term in the context of Linux, this publication uses *huge pages*.

Huge-page support entails support for the Linux hugetlbfs file system.

This virtual file system is backed by larger memory pages than the usual 4 K pages; for IBM Z the hardware page size is 1 MB.

To check whether 1 MB huge pages are supported in your environment, issue the command:

```
# grep edat /proc/cpuinfo
features : esan3 zarch stfle msa ldisp eimm dfp edat etf3eh highgprs te
```

An output line that lists `edat` as a feature indicates 1 MB huge-page support.

Applications that use huge-page memory save a considerable amount of page table memory. Another benefit from the support might be an acceleration in the address translation and overall memory access speed.

You can also configure 2 GB huge pages if Linux is running on an LPAR or as a KVM guest. See [“Pre-allocating 2 GB huge pages”](#) on page 328.

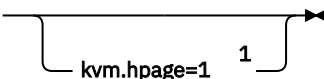
Ubuntu Server 20.04.1 also supports transparent hugepages. For more information, see the `transhuge.txt` file, available in the `linux-doc` package. You can find it, for example, by issuing the following command:

```
# find / -type f -iname "*transhuge*" 2> /dev/null
/usr/share/doc/linux-doc/vm/transhuge.txt.gz
```

Setting up hugetlbfs huge-page support

You configure hugetlbfs huge-page support by adding the `hugepages=` parameter to the kernel parameter line.

Huge-page support kernel parameter syntax

►► `hugepages= <number>` 

Notes:

¹ Relevant only to KVM hosts.

where:

number

is the number of huge pages to be allocated at boot time.

kvm.hpage=

enables KVM hosts to back the memory of their guests with huge pages. For more information about `kvm` module parameters, including the corresponding parameter for `kvm` as a separate module, see [Chapter 46, “Setting up Ubuntu Server 20.04.1 as a KVM host,”](#) on page 433

Note: If you specify more pages than available, Linux reserves as many as possible. As a likely result, too few general pages remain for the boot process, and your system stops with an out-of-memory error.

Pre-allocating 2 GB huge pages

If Linux is running in an LPAR or as a KVM guest, you can use 2 GB huge pages.

Before you can use 2 GB huge pages, you must pre-allocate them to the kernel page pool. To pre-allocate 2 GB pages, precede the **hugepages=** parameter with the page size selection parameter, **hugepagesz=2G**.

Tip: Memory quickly becomes fragmented after booting, and new 2 GB huge pages cannot be allocated. Use kernel boot parameters to allocate 2 GB huge pages to avoid the memory fragmentation problem.

To pre-allocate a number of pages of 2 GB size and also set the default size to 2 GB:

```
default_hugepagesz=2G hugepagesz=2G hugepages=<number>
```

Setting up multiple huge-page pools

You can allocate multiple huge-page pools and use them simultaneously. To allocate multiple huge-page pools, specify the **hugepagesz=** parameter several times, each time followed by a corresponding **hugepages=** parameter.

For example, to specify two pools, one with 1 MB pages and one with 2 GB pages, specify:

```
hugepagesz=1M hugepages=8 hugepagesz=2G hugepages=2
```

This creates a sysfs attribute for each pool, `/sys/kernel/mm/hugepages/hugepages-<size>kB/nr_hugepages`, where *<size>* is the page size in KB. For the example given, the following attributes are created:

```
/sys/kernel/mm/hugepages/hugepages-1024kB/nr_hugepages
/sys/kernel/mm/hugepages/hugepages-2097152kB/nr_hugepages
```

Huge pages and hotplug memory

Hotplug memory that is added to a running Linux instance is movable and can be allocated to movable resources only.

By default, huge pages are not movable and cannot be allocated from movable memory. You can enable allocation from movable memory with the sysctl setting `hugepages_treat_as_movable`.

To enable allocation of huge pages from movable hotplug memory, issue:

```
# echo 1 > /proc/sys/vm/hugepages_treat_as_movable
```

Although this setting makes huge pages eligible for allocation through movable memory, it does not make huge pages movable. As a result, the allocated hotplug memory cannot be set offline until all huge pages are released from that memory.

To disable allocation of huge pages from movable hotplug memory, issue:

```
# echo 0 > /proc/sys/vm/hugepages_treat_as_movable
```

Working with hugetlbfs huge-page support

Typical tasks for working with hugetlbfs huge-page support include reading the current number of huge pages, changing the number of huge pages, and display information about available huge pages.

About this task

The huge-page memory can be used through `mmap()` or SysV shared memory system calls. More detailed information, including implementation examples, can be found in the `hugetlbpage.txt` file, available in the `linux-doc` package.

Your database product might support huge-page memory. See your database documentation to find out if and how it can be configured to use huge-page memory.

Depending on your version of Java™, you might require specific options to make a Java program use the huge-page feature. For IBM SDK, Java Technology Edition 7 and 8, specify the **-Xlp** option. If you use the SysV shared memory interface, which includes **java -Xlp**, you must adjust the shared memory allocation limits to match the workload requirements. Use the following `sysctl` attributes:

/proc/sys/kernel/shmall

Defines the global maximum amount of shared memory for all processes, specified in number of 4 KB pages.

/proc/sys/kernel/shmmax

Defines the maximum amount of shared memory per process, specified in number of Bytes.

For example, the following commands would set both limits to 20 GB:

```
# echo 5242880 > /proc/sys/kernel/shmall
# echo 21474836480 > /proc/sys/kernel/shmmax
```

Procedure

- Specify the `hugepages=` kernel parameter with the number of huge pages to be allocated at boot time. To read the current number of huge pages, issue:

```
# cat /proc/sys/vm/nr_hugepages
```

- To change the number of huge pages dynamically during runtime, write to `procfs`:

```
# echo 12 > /proc/sys/vm/nr_hugepages
```

If there is not enough contiguous memory available to fulfill the request, the maximum possible number of huge pages are reserved.

- To obtain information about the number of huge pages currently available and the huge-page size, issue:

```
# cat /proc/meminfo
...
HugePages_Total: 20
HugePages_Free: 14
HugePages_Rsvd: 0
HugePages_Surp: 0
...
Hugepagesize: 1024 KB
...
```

- To adjust characteristics of a huge-page pool, when more than one pool exists, use the `sysfs` attributes of the pool.

These can be found under

```
/sys/kernel/mm/hugepages/hugepages-<size>/nr_hugepages
```

Where *<size>* is the page size in KB.

Example

To allocate 2 GB huge pages:

1. Specify 2 GB huge pages and pre-allocate them to the page pool at boot time. Use the following kernel boot parameters:

```
default_hugepagesz=2G hugepagesz=2G hugepages=4
```

2. After booting, read `/proc/meminfo` to see information about the amount of huge pages currently available and the huge-page size:

```
cat /proc/meminfo
...
HugePages_Total: 4
HugePages_Free: 4
HugePages_Rsvd: 0
HugePages_Surp: 0
Hugepagesize: 2097152 kB
...
```

Chapter 26. S/390 hypervisor file system

The S/390® hypervisor file system (hypfs) provides a mechanism to access LPAR and z/VM hypervisor data.

Directory structure

When the hypfs file system is mounted, the accounting information is retrieved and a file system tree is created. The tree contains a full set of attribute files with the hypervisor information.

By convention, the mount point for the hypervisor file system is `/sys/hypervisor/s390`.

LPAR directories and attributes

There are hypfs directories and attributes with hypervisor information for Linux in LPAR mode.

Figure 70 on page 331 illustrates the file system tree that is created for LPAR.

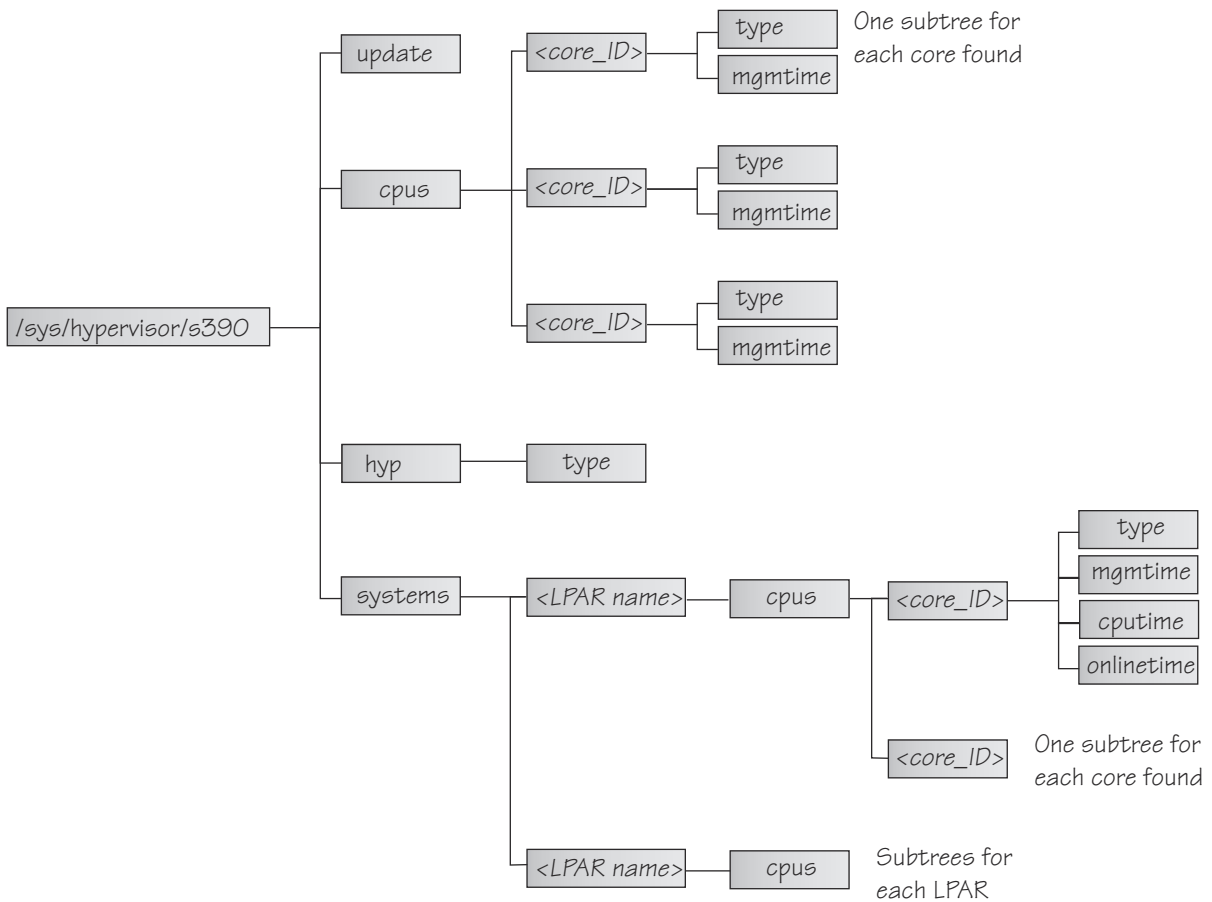


Figure 70. The hypervisor file system for LPAR

update

Write-only file to trigger an update of all attributes.

cpus/

Directory for all physical cores.

cpus/<core_ID>

Directory for one physical core. <core_ID> is the logical (decimal) core number.

type

Type of the physical core, such as CP or IFL.

mgmtime

Physical-LPAR-management time in microseconds (LPAR overhead).

hyp/

Directory for hypervisor information.

hyp/type

Type of hypervisor (LPAR hypervisor).

systems/

Directory for all LPARs.

systems/<lpar name>/

Directory for one LPAR.

systems/<lpar name>/cpus/<core_ID>/

Directory for the virtual cores for one LPAR. The <core_ID> is the logical (decimal) core number.

type

Type of the logical core, such as CP or IFL.

mgmtime

LPAR-management time. Accumulated number of microseconds during which a physical core was assigned to the logical core and the core time was consumed by the hypervisor and was not provided to the LPAR (LPAR overhead).

cputime

Accumulated number of microseconds during which a physical core was assigned to the logical core and the core time was consumed by the LPAR.

onlinetime

Accumulated number of microseconds during which the logical core has been online.

Note: For LPARs with multithreading enabled, the entities in the cpus directories represent hardware cores, not threads.

Note: For older machines, the onlinetime attribute might be missing. Generally, it is advantageous for applications to tolerate missing attributes or new attributes that are added to the file system. To check the content of the files, you can use tools such as **cat** or **less**.

z/VM directories and attributes

There are hypfs directories and attributes with hypervisor information for Linux on z/VM.

update

Write-only file to trigger an update of all attributes.

cpus/

Directory for all physical CPUs.

cpus/count

Total current CPUs.

hyp/

Directory for hypervisor information.

hyp/type

Type of hypervisor (z/VM hypervisor).

systems/

Directory for all z/VM guest virtual machines.

systems/<guest name>/

Directory for one guest virtual machine.

systems/<guest name>/onlinetime_us

Time in microseconds that the guest virtual machine has been logged on.

systems/<guest name>/cpus/

Directory for the virtual CPUs for one guest virtual machine.

capped

Flag that shows whether CPU capping is on for the guest virtual machine (0 = off, 1 = soft, 2 = hard).

count

Total current virtual CPUs in the guest virtual machine.

cputime_us

Number of microseconds where the guest virtual CPU was running on a physical CPU.

dedicated

Flag that shows if the guest virtual machine has at least one dedicated CPU (0 = no, 1 = yes).

weight_cur

Current share of guest virtual machine (1-10000); 0 for ABSOLUTE SHARE guests.

weight_max

Maximum share of guest virtual machine (1-10000); 0 for ABSOLUTE SHARE guests.

weight_min

Number of operating CPUs. Do not be confused by the attribute name, which suggests a different meaning.

systems/<guest name>/samples/

Directory for sample information for one guest virtual machine.

cpu_delay

Number of CPU delay samples that are attributed to the guest virtual machine.

cpu_using

Number of CPU using samples attributed to the guest virtual machine.

idle

Number of idle samples attributed to the guest virtual machine.

mem_delay

Number of memory delay samples that are attributed to the guest virtual machine.

other

Number of other samples attributed to the guest virtual machine.

total

Number of total samples attributed to the guest virtual machine.

systems/<guest name>/mem/

Directory for memory information for one guest virtual machine.

max_KiB

Maximum memory in KiB (1024 bytes).

min_KiB

Minimum memory in KiB (1024 bytes).

share_KiB

Guest estimated core working set size in KiB (1024 bytes).

used_KiB

Resident memory in KiB (1024 bytes).

To check the content of the files, you can use tools such as **cat** or **less**.

Setting up the S/390 hypervisor file system

To use the file system, it must be mounted. You can mount the file system with the mount command or with an entry in `/etc/fstab`.

To mount the file system manually, issue the following command:

```
# mount none -t s390_hypfs <mount point>
```

where *<mount point>* is where you want the file system mounted. Preferably, use `/sys/hypervisor/s390`.

To mount hypfs by using `/etc/fstab`, add the following line:

```
none <mount point> s390_hypfs defaults 0 0
```

If your z/VM system does not support DIAG 2fc, the `s390_hypfs` is not activated and it is not possible to mount the file system. Instead, an error message like this is issued:

```
mount: unknown filesystem type 's390_hypfs'
```

To get data for all z/VM guests, privilege class B is required for the guest where hypfs is mounted. For non-class B guests, data is provided only for the local guest.

To get data for all LPARs, select the **Global performance data control** check box in the HMC or SE security menu of the LPAR activation profile. Otherwise, data is provided only for the local LPAR.

Working with the S/390 hypervisor file system

Typical tasks that you must perform when working with the S/390 hypervisor file system include defining access permissions and updating hypfs information.

- [“Defining access permissions” on page 334](#)
- [“Updating hypfs information” on page 335](#)

Defining access permissions

The root user usually has access to the hypfs file system. It is possible to explicitly define access permissions.

About this task

If no mount options are specified, the files and directories of the file system get the uid and gid of the user who mounted the file system (usually root). You can explicitly define uid and gid using the mount options `uid=<number>` and `gid=<number>`.

Example

You can define `uid=1000` and `gid=2000` with the following mount command:

```
# mount none -t s390_hypfs -o "uid=1000,gid=2000" <mount point>
```

Alternatively, you can add the following line to the `/etc/fstab` file:

```
none <mount point> s390_hypfs uid=1000,gid=2000 0 0
```

The first mount defines uid and gid. Subsequent mounts automatically have the same uid and gid setting as the first one.

The permissions for directories and files are as follows:

- Update file: 0220 (`--w--w----`)
- Regular files: 0440 (`-r--r-----`)
- Directories: 0550 (`dr-xr-x---`)

Updating hypfs information

You trigger the update process by writing something into the update attribute at the top-level hypfs directory.

Procedure

With hypfs mounted at `/sys/hypervisor/s390`, you can trigger the update process by issuing the following command:

```
# echo 1 > /sys/hypervisor/s390/update
```

During the update, the entire directory structure is deleted and rebuilt. If a file was open before the update, subsequent reads return the old data until the file is opened again. Within 1 second only one update can be done. If multiple updates are triggered within a second, only the first update is performed and subsequent write system calls return `-1` and `errno` is set to `EBUSY`.

Applications can use the following procedure to ensure consistent data:

1. Read the modification time through `stat(2)` from the update attribute.
2. If the data is too old, write to the update attribute and start again with step 1.
3. Read data from the file system.
4. Read the modification time of the update attribute again and compare it with first timestamp. If the timestamps do not match, return to step 2.

Chapter 27. TOD clock synchronization

Your Linux instance might be part of an extended remote copy (XRC) setup that requires synchronization of the Linux time-of-day (TOD) clock with a timing network.

Ubuntu Server 20.04.1 in LPAR mode supports system time protocol (STP) based TOD synchronization. For information about STP, see

www.ibm.com/systems/z/advantages/pso/stp.html



Attention: To avoid hanging I/O operations on XRC-enabled DASD, be sure that a reliable timing signal is available before enabling clock synchronization. Linux expects regular timing signals and might stop indefinitely to wait for such signals if it does not receive them.

Enabling clock synchronization when booting

Use the `stp=` kernel parameter to enable clock synchronization when booting.

You can use kernel parameters to set up synchronization for your Linux TOD clock. These kernel parameters specify the initial synchronization settings. On a running Linux instance, you can change these settings through attributes in `sysfs` (see “Enabling and disabling clock synchronization” on page 337).

Enabling and disabling clock synchronization

Use the STP `sysfs` attribute `online` to enable or disable clock synchronization.

Procedure

To enable clock synchronization, set `/sys/devices/system/stp/online` to 1. To disable clock synchronization, set this attribute to 0.

Example

To disable clock synchronization, enter:

```
# echo 0 > /sys/devices/system/stp/online
```

Chapter 28. Identifying the IBM Z hardware

In installations with several IBM Z mainframes, you might need to identify the particular hardware system on which a Linux instance is running.

On Linux in LPAR mode, two attributes in `/sys/firmware/ocf` can help you to identify the hardware.

cpc_name

contains the name that is assigned to the central processor complex (CPC). This name identifies the mainframe system on a Hardware Management Console (HMC).

hmc_network

contains the name of the HMC network to which the mainframe system is connected.

The two attributes contain the empty string if the Linux instance runs as a guest of a hypervisor that does not support the operations command facility (OCF) communication parameters interface.

Use the **cat** command to read these attributes.

Example:

```
# cat /sys/firmware/ocf/cpc_name
Z05
# cat /sys/firmware/ocf/hmc_network
SNA00
```


Chapter 29. HMC media device driver

LPAR and z/VM: The HMC media device driver applies to Linux in LPAR mode and to Linux on z/VM.

You use the HMC media device driver to access files on removable media at a system that runs the Hardware Management Console (HMC).

Before you begin: You must log in to the HMC on the system with the removable media and assign the media to the LPAR.

The HMC media device driver supports the following removable media:

- A DVD in the DVD drive of the HMC system
- A CD in the DVD drive of the HMC system
- USB-attached storage that is plugged into the HMC system

The most commonly used removable media at the HMC is a DVD.

The HMC media device driver uses the `/dev/hmcdrv` device node to support these capabilities:

- List the media contents with the `lshmc` command (see [“lshmc - List media contents in the HMC media drive”](#) on page 606).
- Mount the media contents as a file system with the `hmcdrvfs` command (see [“hmcdrvfs - Mount a FUSE file system for remote access to media in the HMC media drive”](#) on page 582).

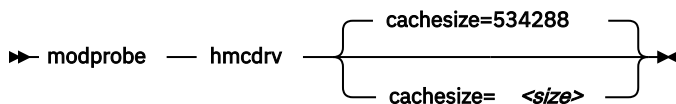
Installers on suitably prepared installation DVDs can use these capabilities to install Linux in an LPAR.

Module parameters

You can set the cache size for the HMC media device driver.

Before you can work with the HMC media device driver and with the dependent `lshmc` and `hmcdrvfs` commands, you must load the `hmcdrv` kernel module.

hmcdrv module parameter syntax



where `<size>` is the cache size in bytes. The specification must be a multiple of 2048. Specify 0 to not cache any media content. By default, the cache size is 534288 bytes (0.5 MB).

Loading the `hmcdrv` module creates a device node at `/dev/hmcdrv`.

Example

To specify a cache size of 150 K, issue:

```
# modprobe hmcdrv cachesize=153600
```

Working with the HMC media

You can list files on media that are inserted into the HMC system and you can mount the media content on the Linux file system.

- [“Assigning the removable media of the HMC to an LPAR”](#) on page 342
- [“Listing files on the removable media at the HMC”](#) on page 342

- [“Mounting the content of the removable media at the HMC” on page 343](#)

Assigning the removable media of the HMC to an LPAR

Use the HMC to assign the removable media to the LPAR where your Linux instance runs.

Before you begin

- You need access to the HMC, and you must be authorized to use the **Access Removable Media** task for the LPAR to which you want to assign the media.
- For Linux on z/VM, the z/VM guest virtual machine must have at least privilege class B.
- For Linux in LPAR mode, the LPAR activation profile must allow issuing SCLP requests.

About this task

You can list files on the removable media at the HMC without having to first mount the contents on the Linux file system.

Procedure

1. Insert the removable media into the HMC system.
2. Use the **Access Removable Media** task on your HMC to assign the removable media to the LPAR where your Linux instance runs.

For Linux on z/VM, this is the LPAR where the z/VM hypervisor runs that provides the guest virtual machine to your Linux instance.

For details, see the HMC documentation for the HMC at your installation.

Results

You can now access the removable media from your Linux instance.

Listing files on the removable media at the HMC

Use the **lshmc** command to list files on the removable media at the HMC.

Before you begin

Your Linux instance must have access to the removable media at the HMC (see [“Assigning the removable media of the HMC to an LPAR” on page 342](#)).

About this task

You can list files on the removable media at the HMC without having to first mount the contents on the Linux file system.

Procedure

Issue a command of this form:

```
# lshmc <filepath>
```

where *<filepath>* is an optional specification for a particular path and file. Path specifications are interpreted as relative to the root directory of the removable media. You can use the asterisk (*) and question mark (?) as wildcards. If you omit *<filepath>*, all files in the root directory of the media are listed.

Example: The following command lists all `.html` files in the `www` subdirectory of the media.

```
# lshmc www/*.html
```

For more information about the **lshmc** command, see [“lshmc - List media contents in the HMC media drive”](#) on page 606.

Mounting the content of the removable media at the HMC

Use the **hmcdrvfs** command to mount the content of the removable media at the HMC.

Before you begin

Your Linux instance must have access to the removable media of the HMC (see [“Assigning the removable media of the HMC to an LPAR”](#) on page 342).

About this task

You can mount the content of the removable media at the HMC in read-only mode on the Linux file system.

Procedure

1. Optional: Confirm that you are accessing the intended content by issuing the **lshmc** command.
2. Mount the media content by issuing a command of this form:

```
# hmcdrvfs <mountpoint>
```

where *<mountpoint>* is the mount point on the Linux file system.

Example: The following command mounts the media content at `/mnt/hmc`:

```
# hmcdrvfs /mnt/hmc
```

Results

You can now access the files on the media in read-only mode through the Linux file system.

What to do next

When you no longer need access to the media content, unmount the media with the **umount** command.

Chapter 30. Data compression with the Integrated Accelerator for zEDC

Hardware dependency: The Integrated Accelerator for zEnterprise Data Compression (zEDC) is available on IBM Z and LinuxONE hardware as of z15 and LinuxONE III.

The Integrated Accelerator for zEDC replaces hardware-acceleration through zEDC Express as available for earlier hardware, see [Chapter 31, “Data compression with GenWQE and zEDC Express,”](#) on page 351.

The Integrated Accelerator for zEDC provides on-chip hardware-acceleration for data compression and decompression.

The prerequisites for using the Integrated Accelerator for zEDC depend on your virtualization environment.

Linux in LPAR mode

The on-chip accelerator is always available if the hardware provides it.

Linux as a guest of KVM or z/VM

The hypervisor must run on hardware that provides the on-chip accelerator, it must support the z15 CPU model and provide it to the guest.

Linux container

The on-chip accelerator must be available to the Linux instance that runs the container. The requirements for the image are the same as for the user space of any Linux instance.

Tip: Read `/proc/cpuinfo`. If the features line includes `df1t`, your real or virtual hardware provides the on-chip accelerator.

For technical resources related to the Integrated Accelerator for zEDC, see www.ibm.com/support/z-content-solutions/compression.

Features

Acceleration with the on-chip Integrated Accelerator for zEDC is available to applications that use zlib or gzip in user space and to the kernel zlib.

Acceleration for applications in user space

Applications can use the on-chip accelerator through zlib and gzip. Ubuntu Server 20.04.1 includes the required versions.

For Linux containers, the image must contain the required versions of zlib and gzip. You can search the zlib and gzip binaries for "DFLTCC" to verify that you have the required versions, as in the following example:

```
# strings /usr/bin/gzip | grep DFLTCC$
DFLTCC
# strings /usr/lib/s390x-linux-gnu/libz.so | grep DFLTCC$
DFLTCC
```

Acceleration for Java workloads

Support for Java workloads depends on your Java platform implementation.

Java implementations that use the system zlib, for example OpenJDK, support the on-chip accelerator if the system zlib supports it.

The IBM SDK for Java includes a zlib library, so its support of the on-chip accelerator is independent of the system zlib. As of IBM SDK for Java 8 SR6, the included zlib supports the on-chip accelerator.

Acceleration for the kernel

The kernel zlib can use the on-chip accelerator.

Compression levels and defaults

The *compression level* is a measure of the compression quality. It is expressed as an integer in the range 1 - 9.

Compression quality and performance are conflicting goals. Compression level 1 provides best performance at the expense of quality. Compression level 9 provides the best quality at the expense of performance. The compression level that is provided by the Integrated Accelerator for zEDC is approximately equivalent to level 1.

Acceleration defaults

The following defaults apply to both on-chip acceleration for gzip and zlib in user space and for the kernel zlib:

- By default, decompression is accelerated.
- By default, compression is accelerated only if compression level 1 is requested.

Expanding the scope of compression acceleration

Configure software with a configurable compression level to request level 1 to enable on-chip compression.

For other types of software you must configure the on-chip accelerator.

- Software that hardcodes a compression level other than 1.
- Software that neither requests a particular level nor provides an option to configure a level. Such software requests level 6 by default.

If level 1 compression is acceptable for your purposes, use overrides to apply on-chip compression to any requested compression level:

- For applications in user space, including Java workloads, see [“Overrides for applications” on page 347](#).
- For the kernel, see [“Overrides for the kernel zlib” on page 349](#).

Confirming that the on-chip accelerator is used

Expect a significant performance gain when using the Integrated Accelerator for zEDC for data compression and decompression workloads, especially when processing large files.

Before you begin

Ensure that your workload is configured to request compression level 1. For software that is hardcoded to request a level other than 1, use the techniques that are described in [“Overriding the defaults” on page 347](#) to force compression with the on-chip accelerator.

Procedure

- Confirm by comparison.

Run the same workload twice: once with the on-chip accelerator enabled and once with the on-chip accelerator off. Compare the results to assess the effect of the on-chip accelerator.

By default, the on-chip accelerator is enabled for workloads in both user space and the kernel. Use the applicable control to turn off the on-chip accelerator for the reference run:

User space

Set the environment variable DFLTCC to 0.

Kernel

Restart Linux with the kernel parameter setting `dfltcc=off`.

- Confirm through hardware counters.

Evaluate hardware counters to directly confirm that the on-chip accelerator is active. For example, you can evaluate the counters with the following symbolic names:

DFLT_ACCESS

Cycles CPU spent obtaining access to Deflate unit.

DFLT_CYCLES

Cycles CPU is using Deflate unit.

DFLT_CC

Increments by one for every DEFLATE CONVERSION CALL instruction executed that ended in Condition Codes 0, 1, or 2.

Issue the **lscpumf** command with the `-C` option to find out how these names map to the counter numbers on your Z hardware. In the edition of *IBM The CPU-Measurement Facility Extended Counters Definition for z10, z196/z114, zEC12/zBC12, z13/z13s, z14, and z15, SA23-2261* for your hardware model, the counters are listed by counter number.

For information about working with hardware counters, see [Chapter 55, “Using the CPU-measurement facilities,”](#) on page 491.

Overriding the defaults

You can override the defaults for compression and decompression with the Integrated Accelerator for zEDC.

Overrides for applications

Use the `DFLTCC` and `DFLTCC_LEVEL_MASK` environment variables to override the defaults for Java applications and, generally, for applications that use `zlib` or `gzip` in user space.

For Linux containers, specify these environment variables with the command that instantiates the container. For example, if you manage your containers with **podman**, use the `-e` option of the **podman run** command.

Turning off acceleration

Set the `DFLTCC` environment variable to 0 to turn off on-chip compression and decompression with the Integrated Accelerator for zEDC.

The `DFLTCC` environment variable can take the following values:

- 1**
turns on-chip acceleration on. This is the default.
- 0**
turns on-chip acceleration off.

Configuring accelerated compression for any compression level

By default, software that requests compression level 1 uses the on-chip accelerator if it is enabled. Use the `DFLTCC_LEVEL_MASK` environment variable to configure on-chip acceleration for any combination of compression levels.

The values of the `DFLTCC_LEVEL_MASK` environment variable are 4-digit hexadecimal numbers in the range `0x0000 - 0x03ff`. Of the ten corresponding binary digits that can be 1, each represents a compression level. The least significant bit represents an assumed level 0, the most significant bit represents level 9.

The following examples demonstrate how the mask works:

0x0000

The bits for all compression levels are off. No on-chip compression is performed. This setting has the same effect on compression as setting the DFLTCC environment variable to 0.

0x0001

The bit for the assumed compression level 0 is on and overrides the default behavior for level 0. Instead of transferring data into a compressed format without a size reduction, data is actually compressed, which can have unintended consequences.

Note: Do not set this bit unless you are a compression expert who understands the implications and wants to experiment with this setting.

0x0002

The bit for compression level 1 is on; all other bits are off. On-chip compression is performed only for software that requests compression level 1.

This is the default.

0x0006

The bits for compression level 1 and 2 are on; the other bits are off. On-chip compression is performed for software that requests compression level 1 or 2.

0x000e

The bits for compression level 1, 2, and 3 are on; the other bits are off. On-chip compression is performed for software that requests compression level 1, 2, or 3.

0x007e

The bits for compression level 1 - 6 are on; the bits for level 0, 7, 8, and 9 are off. On-chip compression is performed for software that requests a compression level in the range 1 - 6. Level 6 is the default for software that does not request a particular compression level.

0x01fe

The bits for compression level 1 - 8 are on; the bits for level 0 and 9 are off. On-chip compression is performed for software that requests a compression level in the range 1 - 8.

Note: On-chip compression with the Integrated Accelerator for zEDC is approximately equivalent to compression level 1. Forcing On-chip compression for software that requests a higher compression level can result in a larger compressed data volume than intended by the author of the software.

You can set the environment variable for all users, programs and system services of a Linux instance by writing the setting to `/etc/environment`.

```
# echo DFLTCC_LEVEL_MASK=0x1fe >> /etc/environment
```

The following examples take a more cautious approach by limiting the scope of the setting:

- Use **env** to limit the setting to an individual command call:

```
# env DFLTCC_LEVEL_MASK=0x2fe <command>
```

- Use an entry in your `~/.bashrc` for the scope of your bash sessions:

```
# echo DFLTCC_LEVEL_MASK=0x1fe >> ~/.bashrc
```

- Use a systemd unit override for a service `<your_service>` for the scope of that systemd service:

```
# printf "[Service]\nEnvironment=DFLTCC_LEVEL_MASK=0x2fe\n" > \
/etc/systemd/system/<your_service>.service.d/dfltcc.conf
```

- Use an override in the global systemd configuration file for the scope of all systemd services:

```
# printf "[Manager]\nDefaultEnvironment=DFLTCC_LEVEL_MASK=0x2fe\n" > \
/etc/systemd/system.conf.d/dfltcc.conf
```

Overrides for the kernel zlib

Use the `dfltcc=` kernel parameter to override the defaults for the kernel zlib.

Format



on

enables on-chip acceleration for compression level 1 and for decompression. This is the default.

off

turns off on-chip acceleration for both compression and decompression.

def_only

enables on-chip acceleration for compression on level 1 but not for decompression.

inf_only

enables on-chip acceleration for decompression only.

always

enables on-chip acceleration for decompression and for compression regardless of the requested compression level.

Note: On-chip compression with the Integrated Accelerator for zEDC is approximately equivalent to compression level 1. Forcing On-chip compression for software that requests a higher compression level can result in a larger compressed data volume than intended by the author of the software.

Examples

```
dfltcc=inf_only
```

Accelerating btrfs

If the kernel zlib is compiled with support for the Integrated Accelerator for zEDC, you can enable it for btrfs through a mount option.

By default, btrfs requests compression level 3, but the Integrated Accelerator for zEDC provides compression level 1. If compression level 1 is acceptable for your purposes, mount your instance of btrfs with the `compress=zlib:1` option.

Chapter 31. Data compression with GenWQE and zEDC Express

LPAR and z/VM: Data compression with GenWQE and zEDC Express applies to Linux in LPAR mode and to Linux on z/VM.

Generic Work Queue Engine (GenWQE) supports hardware-accelerated data compression and decompression through zEDC Express, a PCIe-attached Field Programmable Gate Array (FPGA) acceleration adapter.

zEDC Express was introduced with zEC12 and is available for later IBM Z and LinuxONE hardware up to z14 and LinuxONE II. As of z15 and LinuxONE III, zEDC hardware acceleration is available through on-chip compression and decompression, see [Chapter 30, “Data compression with the Integrated Accelerator for zEDC,”](#) on page 345.

zEDC hardware-acceleration is available for both Linux and z/OS. For more information about zEDC on z/OS and about setting up zEDC Express, see *Reduce Storage Occupancy and Increase Operations Efficiency with IBM zEnterprise Data Compression*, SG24-8259. You can obtain this publication from the IBM Redbooks website at www.redbooks.ibm.com/abstracts/sg248259.html.

Features

GenWQE supports hardware-accelerated data compression and decompression with common standards.

- GenWQE implements the `zlib` API.
- GenWQE adheres to the following RFCs:
 - RFC 1950 (`zlib`)
 - RFC 1951 (`deflate`)
 - RFC 1952 (`gzip`)

These standards ensure compatibility among different `zlib` implementations.

- Data that is compressed with GenWQE can be decompressed through a `zlib` software library.
- Data that is compressed through a software `zlib` software library can be decompressed with GenWQE.
- GenWQE supports the following PCIe FPGA acceleration hardware:
 - zEDC Express

What you should know about GenWQE

Learn about the GenWQE components, how to enable GenWQE accelerated `zlib` for user applications, and device representation in Linux.

The GenWQE accelerated `zlib`

The GenWQE accelerated `zlib` can replace a `zlib` software library.

For data compression and decompression tasks, Ubuntu Server 20.04.1 includes software libraries. The `zlib` library, which provides the `zlib` API, is one of the most commonly used libraries for data compression and decompression. For information about `zlib`, see www.zlib.net.

Because the GenWQE accelerated `zlib` offers the `zlib` API, applications can use it instead of the default `zlib` software library. The GenWQE hardware-accelerated `zlib` is designed to enhance performance by offloading tasks to a hardware accelerator.

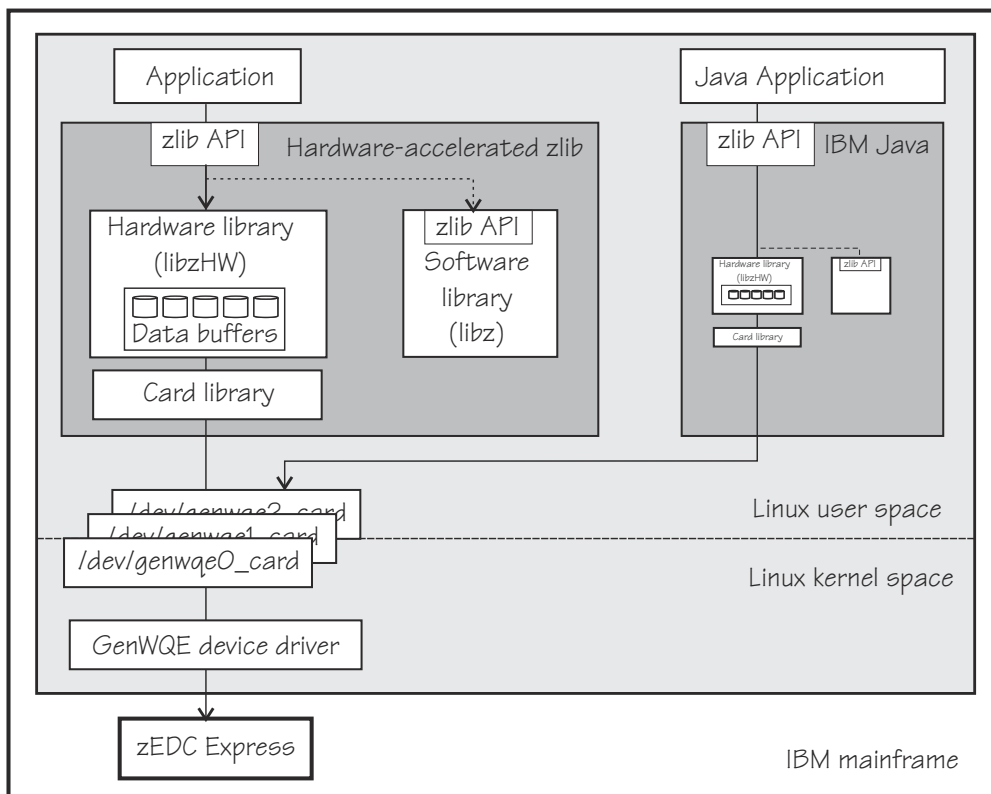


Figure 71. GenWQE accelerated zlib

Applications

You can make the user space components of the GenWQE hardware-accelerated zlib available to applications that request data compression functions through the zlib API. Ubuntu Server 20.04.1 provides these user space components with the `libzadc1` package.

A second package, `genwqe`, provides tools that use the GenWQE hardware-accelerated zlib.

IBM Java version 7.1 or later includes components of the GenWQE hardware-accelerated zlib. Through these components, it can directly address the GenWQE device nodes. With the required environment variables in place, it uses hardware-acceleration if it is available (see [“GenWQE hardware-acceleration for IBM Java”](#) on page 356).

Hardware-accelerated zlib

The hardware-accelerated zlib is a zlib implementation that acts as a wrapper for two included libraries:

libzHW

a hardware library that prepares requests for processing by the hardware accelerator. The hardware library is intended to handle the bulk of the requests.

This library also manages data buffers for optimized hardware compression.

libz

a software implementation of the zlib interface. Because it provides the same interface as its wrapper library, it can handle any requests unmodified.

The hardware-accelerated zlib arbitrates between the two included libraries. It uses the software library as a backup if no hardware accelerator is available. It also evaluates the expected performance gain against the extra processing for channeling requests to the accelerator. For small or fragmented data, software processing might be advantageous, especially for decompression. The evaluation takes available resources, such as buffer space, into account.

Card library

The card library, `libcard`, mediates between the hardware-accelerated `zlib` library and the GenWQE device driver. It provides recovery features and can move jobs between available accelerators.

Device driver

The GenWQE device driver is the kernel part of GenWQE. It serializes requests to an accelerator in form of device driver control blocks (DDCBs), and it enables multi-process and multi-thread usage.

GenWQE device nodes

GenWQE user space components use device nodes to exchange data with the GenWQE device driver.

Ubuntu Server 20.04.1 automatically loads the GenWQE device driver module when it is required. It also creates a device node of the form `/dev/genwqe<n>_card` for each available virtual acceleration card. `<n>` is an index number that identifies an individual virtual card. Node `/dev/genwqe0_card` is assigned to the first card that is detected, `/dev/genwqe1_card` to the second card, and so on.

Do not directly use these device nodes. The nodes are intended to be used by the user space components of the GenWQE hardware-accelerated `zlib` and by IBM Java.

Virtual accelerators

Each physical accelerator card can provide up to 15 virtual cards. In PCIe terminology, these virtual cards are called virtual functions.

GenWQE accelerator cards, as detected by Linux on Z, are virtual cards. Which and how many cards are available to a particular Linux instance depends on the mainframe configuration and, if applicable, the hypervisor configuration.

As for most mainframe devices, availability can be enhanced by assigning virtual accelerator cards from different physical cards.

A degree of load distribution can be achieved by unevenly distributing accelerator cards among different Linux instances.

Tradeoff between best compression and speed

A minimum size of compressed data and fast compression are conflicting goals.

For hardware-accelerated compression with GenWQE, the compression ratio is roughly equivalent to **`gzip --fast`**.

Data that was compressed with GenWQE hardware-acceleration might have a different size from data that was compressed in software. The data compression standards are not violated by this difference. Despite possible differences in size of the compressed data, data that is compressed with GenWQE hardware-acceleration can be decompressed in software and vice versa.

Setting up GenWQE hardware acceleration

Install the GenWQE components and understand how environment variables can override default settings.

Installing the GenWQE hardware-accelerated `zlib`

Install the `libzadc4` and `genwqe-tools` packages that are included in Ubuntu Server 20.04.1 with the **`apt`** command.

To install the `genwqe-tools` package, issue:

```
apt install genwqe-tools
```

This command automatically installs the required `libzadc4` library.

The `libzadc4` package includes the user space components of the GenWQE hardware-accelerated zlib.

The `genwqe-tools` package provides the following tools:

- **genwqe_gzip** and **genwqe_gunzip**, which are GenWQE versions of **gzip** and **gunzip** (see [“Examples for using GenWQE”](#) on page 355).

These tools can be used for most purposes, but they do not implement all of the more unusual options of their common code counterparts. See the man pages to find out which options are supported.

- **genwqe_echo**, a tool to confirm the availability of accelerator hardware through the GenWQE accelerated zlib. See [“Confirming that the accelerator hardware can be reached”](#) on page 357 for details.

Environment variables

You can set environment variables to control the GenWQE hardware-accelerated zlib.

The GenWQE hardware-accelerated zlib uses defaults that correspond to the following environment variable settings:

```
ZLIB_ACCELERATOR=GENWQE
ZLIB_CARD=-1
ZLIB_TRACE=0x0
ZLIB_DEFLATE_IMPL=0x41
ZLIB_INFLATE_IMPL=0x41
```

You can override these defaults by setting the following environment variables:

ZLIB_ACCELERATOR

Sets the accelerator type. For zEDC Express, the type is GENWQE.

ZLIB_CARD

-1, uses all accelerators that are available to the Linux instance. Failed requests are retried on alternative accelerators.

You can specify the ID of a particular virtual accelerator card to be used. The ID is the index number that makes the nodes unique. All other cards are ignored, and no retry on alternative cards is performed if the specified card fails. Specify an ID only if you want to test a particular card.

0 uses the first card that is found by the device driver. As for specifying an individual card, all other cards are ignored.

ZLIB_TRACE

Sets tracing bits:

0x1

General trace.

0x2

Hardware trace.

0x4

Software trace.

0x8

Trace summary at the end of a process.

Tracing requires extra processing and incurs a performance penalty. The least performance impact is to be expected from the trace summary. By default, tracing is off.

ZLIB_DEFLATE_IMPL

0x01 and 0x41 enable hardware compression, where 0x41 adds an optimization setting. 0x00 forces software compression and is intended for experimentation, for example, for gathering performance data with and without hardware acceleration.

ZLIB_INFLATE_IMPL

0x01 and 0x41 enable hardware decompression, where 0x41 adds an optimization setting. 0x00 forces software decompression and is intended for experimentation, for example, for gathering performance data with and without hardware acceleration.

You can find more details about the environment variables in the GenWQE wiki on GitHub at [github.com/ibm-genwqe/genwqe-user/wiki/Environment Variables](https://github.com/ibm-genwqe/genwqe-user/wiki/Environment-Variables).

Examples for using GenWQE

You can use the GenWQE hardware-accelerated zlib through GenWQE tools.

Activating the GenWQE hardware-accelerated zlib for an application

Whether and how you can make an application use the GenWQE hardware-accelerated zlib depends on how the application links to `libz.so`.

Examine the application for links to `libz.so`, for example with the `ldd` tool.

- If the application does not link to `libz.so` or if it statically links to `libz.so`, it would require recompilation, and possibly code changes, to make acceleration through GenWQE possible.
- If an application dynamically links to `libz.so`, you might be able to redirect the library calls from the default implementation to the GenWQE hardware-accelerated `zlib`.

Some applications require `zlib` features that are not available from the GenWQE hardware-accelerated `zlib`. Such applications fail if a global redirect is put in place. The following technique redirects calls for the scope of a particular application.

Specify the `LD_PRELOAD` environment variable to load the GenWQE hardware-accelerated `zlib`. Set the variable with the `start` command for your application.

Example:

```
# LD_PRELOAD=/lib/s390x-linux-gnu/genwqe/libz.so.1 <application_start_cmd>
```

Compressing data with `genwqe_gzip`

GenWQE provides two tools, `genwqe_gzip` and `genwqe_gunzip` that can be used in place of the common code `gzip` and `gunzip` tools. The GenWQE versions of the tools use hardware acceleration if it is available.

Procedure

Run the `genwqe_gzip` command with the `-AGENWQE` parameter to compress a file.

```
# genwqe_gzip -AGENWQE <file>
```

The `-AGENWQE` parameter ensures that the correct, PCIe-attached, accelerator card is used. Also use this option when decompressing data with the `genwqe_gunzip` command. See the man pages for other options.

Running tar with GenWQE hardware-acceleration

You can make `tar` use `genwqe_gzip` in place of the common code `gzip`.

About this task

If called with the `z` option, the `tar` utility uses the first `gzip` tool in the search path, which is usually the common code version. By inserting the path to the GenWQE version of the `gzip` tool at the beginning of the `PATH` variable, you can make the `tar` utility use hardware acceleration.

The acceleration is most marked for a single large text file. The example that follows compresses a directory with the Linux source code.

Procedure

1. Run the **tar** command as usual to use software compression. To obtain performance data, specify the **tar** command as an argument to the **time** command.

```
# time tar cfz linux-src.sw.tar.gz linux-src
real 0m22.329s
user 0m22.147s
sys 0m0.849s
```

2. Run the **tar** command with an adjusted PATH variable to use GenWQE hardware acceleration. Again, use the **time** command to obtain performance data.

```
# time PATH=/usr/lib/genwqe:$PATH \
tar cfz linux-src.hw.tar.gz linux-src
real 0m1.323s
user 0m0.242s
sys 0m1.023s
```

Results

In the example, the accelerated operation is significantly faster. The hardware-compressed data is slightly larger than the software-compressed version of the same data

GenWQE hardware-acceleration for IBM Java

IBM Java version 7.1 or later can use the GenWQE hardware-accelerated zlib.

To activate the GenWQE hardware-accelerated zlib for IBM Java, you must set environment parameters. See the documentation for your Java version to find out which settings are required.

Note: Any values that you set for the environment variables override the default settings for the GenWQE user space components (see [“Environment variables”](#) on page 354).

Exploring the GenWQE setup

You might want to ensure that your GenWQE setup works as intended.

- [“Listing your GenWQE accelerator cards”](#) on page 356
- [“Checking the GenWQE device driver setup”](#) on page 357
- [“Confirming that the accelerator hardware can be reached”](#) on page 357

Listing your GenWQE accelerator cards

Use the **lspci** command to list the available GenWQE accelerator cards.

Procedure

1. Issue the **lspci** command and look for GenWQE.

Example:

```
# lspci |grep GenWQE
0002:00:00.0 Processing accelerators: IBM GenWQE Accelerator Adapter
```

2. Issue the **lspci** command with the verbose option to display details about a particular card.

Example:

```
# lspci -vs 0002:00:00.0
0002:00:00.0 Processing accelerators: IBM GenWQE Accelerator Adapter
Subsystem: IBM GenWQE Accelerator Adapter
Physical Slot: 000000ff
Flags: bus master, fast devsel, latency 0, IRQ 3
Memory at 8002000000000000 (64-bit, prefetchable) [disabled] [size=128M]
Capabilities: [50] MSI: Enable+ Count=1/1 Maskable- 64bit+
Capabilities: [80] Express Endpoint, MSI 00
Capabilities: [100] Alternative Routing-ID Interpretation (ARI)
Kernel driver in use: genwqe
Kernel modules: genwqe_card
```

Checking the GenWQE device driver setup

Perform these tasks if GenWQE does not work as expected.

Procedure

1. Confirm that the device driver is loaded.

```
# lsmod | grep genwqe
genwqe_card 88997 0
crc_itu_t 1910 1 genwqe_card
```

If the `genwqe_card` module is not listed in the command output, load it with **modprobe**.

```
# modprobe genwqe_card
```

The `genwqe_card` module does not have module parameters.

2. Confirm that GenWQE device nodes exist and that the nodes have the required permissions.

The nodes must grant read and write permissions to all users, for example:

```
# ls -l /dev/genwqe*
crw-rw-rw 1 root root 249, 0 Jun 30 10:01 /dev/genwqe0_card
crw-rw-rw 1 root root 248, 0 Jun 30 10:01 /dev/genwqe1_card
```

If the permissions are not `crw-rw-rw`, create a file `/etc/udev/rules.d/52-genwqedevice.rules` with this rule as its content:

```
KERNEL=="genwqe*", MODE="0666"
```

The new rule takes effect next time the GenWQE device driver is loaded.

Tip: Use the **chmod** command to temporarily set the permissions.

What to do next

You can find debug information in the Linux source tree at `/sys/kernel/debug/genwqe` and at `/sys/class/genwqe`.

Confirming that the accelerator hardware can be reached

The `genwqe_echo` command is similar to a **ping** command.

Before you begin

The `genwqe_echo` command is included in the `genwqe` package (see [“Installing the GenWQE hardware-accelerated zlib”](#) on page 353).

Procedure

Issue a command of this form to confirm that you can reach the accelerator hardware.

```
# genwqe_echo -AGENWQE -C <n> -c <m>
```

In the command, <n> is the index number of the card and <m> is a positive integer that specifies how many requests are sent to the card. The -AGENWQE parameter ensures that the correct, PCIe-attached, accelerator card is used.

Example: The following command sends four requests to the card with device node /dev/genwqe1_card:

```
# genwqe_echo -AGENWQE -C 1 -c 4
1 x 33 bytes from UNIT #1: echo_req time=37.0 usec
1 x 33 bytes from UNIT #1: echo_req time=19.0 usec
1 x 33 bytes from UNIT #1: echo_req time=23.0 usec
1 x 33 bytes from UNIT #1: echo_req time=18.0 usec
--- UNIT #1 echo statistics ---
4 packets transmitted, 4 received, 0 lost, 0% packet loss
```

See the **genwqe_echo** man page for other command options.

External programming interfaces

The GenWQE hardware-accelerated zlib implements a large subset of the original software zlib.

For information about programming against the GenWQE hardware-accelerated zlib, see the section about implemented zlib functions in *Accelerated Data Compressing using the GenWQE Linux Driver and Corsica FPGA PCIe card*.

To obtain this document, go to the developerWorks website at www.ibm.com/developerworks/community/files/app and search for "genwqe".

Chapter 32. PCI Express support

The Peripheral Component Interconnect Express (PCIe) device driver supports various PCI devices, including but not limited to devices that implement the SMC network protocol. For more information about RoCE, see [Chapter 20, “RDMA over Converged Ethernet,” on page 295](#). For more information about ISM, see [Chapter 21, “Internal shared memory device driver,” on page 297](#).

PCIe functions are seen by Linux as devices, hence devices is used here synonymously. You can assign PCIe devices to LPARs in the IOCDs.

PCIe function addresses

The function addresses uniquely identifies a PCIe function within a Linux instance. Function addresses adhere to this format: `<domain>:<bus>:<slot>.<function>`. For Linux on Z, the address components have the following values:

<domain>

UID as specified for the PCI function in the hardware configuration (IOCDs). UIDs are unique hexadecimal values in the range 1 - FFFF. For example, with a UID of 0x318, `<domain>` would be: 0318.

UIDs are available only if supported by the hardware and if the LPAR is enabled for UID checking. If your environment does not support UIDs for PCIe functions, consecutive numbers, starting from 0000, are assigned to the functions. The mapping of assigned numbers and physical functions does not persist across reboots.

<bus>

Two zeros: 00.

<slot>.<function>

Interface change: As of Ubuntu 20.04.1, `<slot>.<function>` represents the PCIe Routing-ID (RID) if your environment supports the Alternative Routing-ID Interpretation (ARI) compatible address format.

The previous constant value, 00.0, is used as a fallback for environments that do not support the ARI compatible address format. You can force this previous value with the `pci=nomio` kernel parameter (see [“Setting up the PCIe support” on page 359](#)).

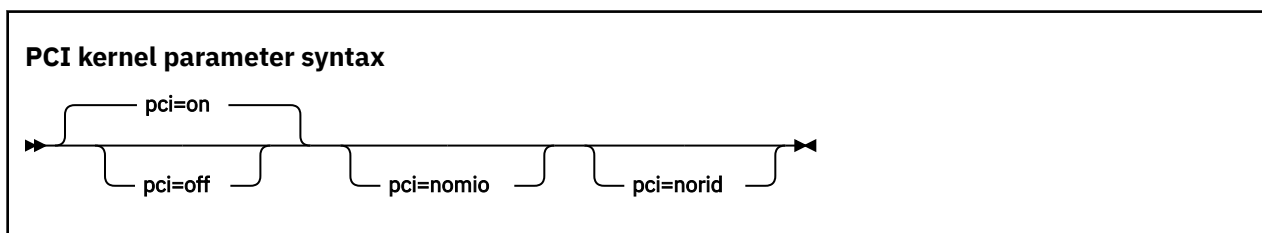
To list PCIe devices, use the `lspci` command. For more information about `lspci`, see the man page.

Setting up the PCIe support

Configure the PCIe support through the `pci=` kernel parameter.

PCIe devices are automatically configured during the system boot process. In contrast to most IBM Z devices, all PCIe devices that are in a configured state are automatically set online. PCIe devices that are in stand-by state are not automatically enabled.

Scanning of PCIe devices is enabled by default. To disable use of PCI devices, set the kernel command line parameter `pci=off`.



where:

pci=

off

disables automatic scanning of PCIe devices.

on

enables automatic scanning of PCIe devices (default).

pci=nomio

if available, PCIe uses enhanced instructions as introduced with z15. Specify this kernel parameter to use the previous instructions.

pci=norid

as of Ubuntu 20.04.1, PCI function addresses follow an Alternative Routing-ID Interpretation (ARI) conform format if it is supported by the system environment. Specify this kernel parameter to use the previous format.



Attention: Other PCI kernel parameters do not apply to IBM Z and might have adverse effects on your system.

Using PCIe hotplug on LPAR

Use PCIe hotplug to change the availability of a shared PCIe device.

About this task

Only one LPAR can access a PCIe device. Other LPARs can be candidates for access. Use the HMC or SE to define which LPAR is connected and which LPARs are on the candidate list. A PCIe device that is defined, but not yet used, is shown as a PCIe slot in Linux.

On Linux, you use the `power` sysfs attribute of a PCIe slot to connect the device to the LPAR where Linux runs. While a PCIe device is connected to one LPAR, it is in the reserved state for all other LPARs that are in the candidates list. A reserved PCIe device is invisible to the operating system. The slot is removed from sysfs.

Procedure

The `power` attribute of a slot contains 0 if a PCIe device is in stand-by state, or 1 if the device is configured and usable.

1. Locate the slot for the card you want to work with.

To locate the slot, read the `function_id` attribute of the PCIe device from sysfs.

For example, to read the `/sys/bus/pci/devices/0000:00:00.0/function_id` issue:

```
# cat /sys/bus/pci/devices/0000:00:00.0/function_id
0x00000011
```

where 00000011 is the slot. Alternatively, you can use the `lspci -v` command to find the slot.

2. Write the value that you want to the `power` attribute:

- Write 1 to `power` to connect the PCIe device to the LPAR in which your Linux instance is running. Linux automatically scans the device, registers it, and brings it online. For example:

```
echo 1 > /sys/bus/pci/slots/00000011/power
```

- Write 0 to `power` to stop using the PCIe device. The device state changes to stand-by. The PCIe device is set offline automatically. For example:

```
echo 0 > /sys/bus/pci/slots/00000011/power
```

A PCIe device in standby is also in the standby state to all other LPARs in the candidates list. A standby PCIe device appears as a slot, but without a PCIe device.

Recovering a PCIe device

Use the `recover sysfs` attribute to recover a PCIe device.

About this task

A kernel message is displayed when a PCIe device enters the error state. It is not possible to automatically relieve the PCIe device from this state.

Procedure

1. Find out which PCIe device is in an error state by issuing the `lspci` command.
In the following example, the device in error state can be identified by the trailing "(rev ff)" in the output line.

```
# lspci
0000:00:00.0 Ethernet controller: Mellanox Technologies MT27710 Family [ConnectX-4 Lx Virtual Function] (rev ff)
0001:00:00.0 Ethernet controller: Mellanox Technologies MT27710 Family [ConnectX-4 Lx Virtual Function]
0002:00:00.0 Non-VGA unclassified device: IBM Internal Shared Memory (ISM) virtual PCI device
```

2. Find the PCIe device directory in `sysfs`.
PCIe device directories are of the form `/sys/bus/pci/devices/<function_address>`, where `<function_address>` identifies the PCIe device.
For example: `/sys/bus/pci/devices/0000:00:00.0`.
3. Write 1 to the `recover` attribute of the PCIe device.
For example:

```
# echo 1 > /sys/bus/pci/devices/0000:00:00.0/recover
```

After a successful recovery, the PCI device is de-registered and reprobbed.

Reporting defective PCIe devices

For Linux in LPAR mode or Linux on z/VM, use the `zpcictl` command to report defective PCIe devices to the Support Element (SE). Such devices might require physical repair actions.

Before you begin

- You need to know the function address of the defective PCIe device or a device node that represents the device.
- To send diagnostic data with the error report you need to install the `smartmontools` package. Whether data is collected and which data is available depends on the PCI device type. For example, S.M.A.R.T. data is gathered for NVMe devices.

Procedure

Issue a command of this form to report a device with function address `0000:00:00.0` to the SE:

```
# zpcictl --report-error <device>
```

where `<device>` is the device's function address or a device node that represents the device.

Example:

```
# zpcictl --report-error 0000:00:00.0
```

Displaying PCIe information

For each online PCIe device, there is a number of read-only attributes in sysfs that provide information about the device.

About this task

The sysfs representation of a PCIe device or slot is a directory of the form `/sys/bus/pci/devices/<function_address>`, where `<function_address>` identifies the PCIe device. This sysfs directory contains a number of attributes with information about the PCIe device.

Table 50. Read-only attributes with PCIe device information

Attribute	Explanation
<code>function_handle</code>	Eight-character, hexadecimal PCI-function (device) handle.
<code>function_id</code>	Eight-character, hexadecimal PCI-function (device) ID. The ID identifies the PCIe device within the processor configuration. This value specifies the slot at <code>/sys/bus/pci/slots</code> .
<code>pchid</code>	Four-character, hexadecimal, physical channel ID. Specifies the slot of the PCIe adapter in the I/O drawer. Thus identifies the adapter that provides the device.
<code>pfgid</code>	Two-character, hexadecimal, physical function group ID.
<code>pfip/segment0</code> <code>/segment1</code> <code>/segment2</code> <code>/segment3</code>	Two-character, hexadecimal, PCI-function internal path. Provides an abstract indication of the path that is used to access the PCI function. This can be used to compare the paths used by two or more PCI functions, to give an indication of the degree of isolation between them.
<code>uid</code>	Up to eight-character, hexadecimal, user-defined identifier.
<code>vfn</code>	Four-character, hexadecimal, number that identifies the virtual function within the adapter.
<code>util_string</code>	Type-specific information about the device. For RoCE devices and ISM devices, it contains the PNET ID if a PNET ID has been assigned in the I/O configuration.

Procedure

Issue a command of this form to read an attribute:

```
# cat /sys/bus/pci/devices/<function_address>/<attribute>
```

where `<attribute>` is one of the attributes of [Table 50 on page 362](#).

Reading statistics for a PCIe device

Use the `statistics` attribute file to see measurement data for a PCIe device.

About this task

All PCIe devices collect measurement data by default. You can read the data in a sysfs attribute file in the debug file system, by default mounted at `/sys/kernel/debug`.

You can turn data collection on and off. To switch off measurement data collecting for the current session, write "0" to the statistics attribute. To enable data collection again, write "1" to the statistics attribute.

Example

To read measurement data for a (RoCE) function named 0000:00:00.0 use:

```
# cat /sys/kernel/debug/pci/0000:00:00.0/statistics
```

The statistics attribute file might look similar to this example:

```
FMB @ 0000000078cd8000
Update interval: 4000 ms
Samples: 14373
Last update TOD: cefa44fa50006378
  Load operations:      1002780
  Store operations:    1950622
Store block operations: 0
  Refresh operations:  0
  Received bytes:      0
  Received packets:    0
  Transmitted bytes:   0
  Transmitted packets: 0
  Allocated pages:     9104
  Mapped pages:        16633
  Unmapped pages:      2337
```

Part 6. z/VM virtual server integration

I z/VM only: This part applies to Linux on z/VM only.

These device drivers and features help you to effectively run and manage a z/VM-based virtual Linux server farm.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 33. z/VM concepts

z/VM only: This chapter applies to Linux on z/VM only.

The z/VM performance monitoring and cooperative memory management concepts help you to understand how the different components interact with Linux.

Performance monitoring for z/VM guest virtual machines

You can monitor the performance of z/VM guest virtual machines and their guest operating systems with performance monitoring tools on z/VM or on Linux.

These tools can be your own, IBM tools such as the Performance Toolkit for VM, or third-party tools. The guests being monitored require agents that write monitor data.

Monitoring on z/VM

z/VM monitoring tools must read performance data. For monitoring Linux instances, this data is APPLDATA monitor records.

Linux instances must write these records for the tool to read, as shown in [Figure 72 on page 367](#).

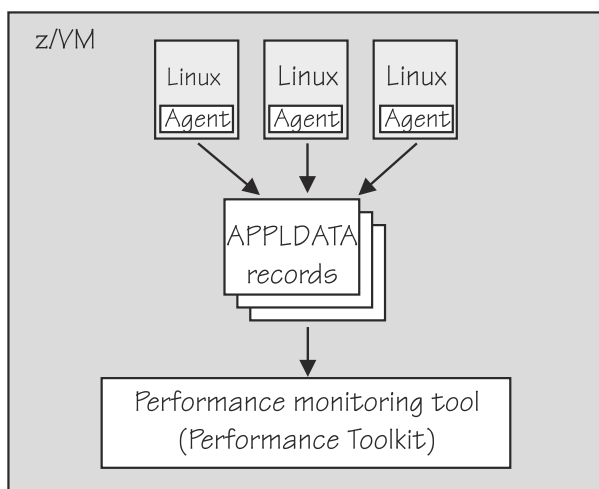


Figure 72. Linux instances write APPLDATA records for performance monitoring tools

Both user space applications and the Linux kernel can write performance data to APPLDATA records. Applications use the monwriter device driver to write APPLDATA records. The Linux kernel can be configured to collect system level data such as memory, CPU usage, and network-related data, and write it to data records.

For file system size data, there is a command, **mon_fsstatd**. This user space tool uses the monwriter device driver to write file system size information as defined records.

For process data, there is a command, **mon_procd**. This user space tool uses the monwriter device driver to write system information as defined records.

In summary, Ubuntu Server 20.04.1 LTS supports writing and collecting performance data as follows:

- The Linux kernel can write z/VM monitor data for Linux instances, see [Chapter 34, “Writing kernel APPLDATA records,”](#) on page 371.
- Linux applications that are running on z/VM guests can write z/VM monitor data, see [Chapter 35, “Writing z/VM monitor records,”](#) on page 377.

- You can collect monitor file system size information, see [“mon_fsstatd – Monitor z/VM guest file system size”](#) on page 629.
- You can collect system information about up to 100 concurrently running processes, see [“mon_procd – Monitor Linux on z/VM”](#) on page 634.

Monitoring on Linux

A Linux instance can read the monitor data by using the monreader device driver.

Figure 73 on page 368 illustrates a Linux instance that is set up to read the monitor data. You can use an existing monitoring tool or write your own software.

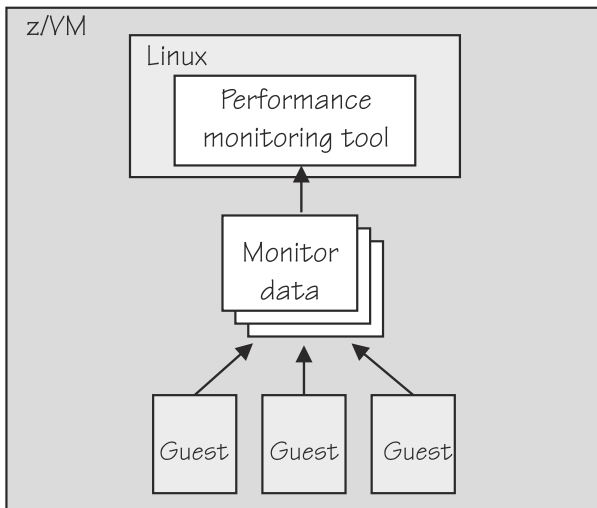


Figure 73. Performance monitoring using monitor DCSS data

In summary, Ubuntu Server 20.04.1 LTS supports reading performance data in the form of read access to z/VM monitor data for Linux instances. See [Chapter 36, “Reading z/VM monitor records,”](#) on page 381 for more details.

Further information

Several z/VM publications include information about monitoring.

- See *z/VM: Getting Started with Linux on System z*, SC24-6287, the chapter on monitoring performance for information about using the CP Monitor and the Performance Toolkit for VM.
- See *z/VM: Saved Segments Planning and Administration*, SC24-6322 for general information about DCSSs (z/VM keeps monitor records in a DCSS).
- See *z/VM: Performance*, SC24-6301 for information about creating a monitor DCSS.
- See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about the CP commands that are used in the context of DCSSs and for controlling the z/VM monitor system service.
- For the layout of the monitor records, visit www.ibm.com/vm/pubs/ctlblk.html and see [Chapter 34, “Writing kernel APPLDATA records,”](#) on page 371.
- For more information about performance monitoring on z/VM, visit

www.ibm.com/vm/perf

Cooperative memory management background

Cooperative memory management (CMM, or “cmm1”) dynamically adjusts the memory available to Linux.

For information about setting up CMM, see [Chapter 42, “Cooperative memory management,”](#) on page 413.

In a virtualized environment it is common practice to give the virtual machines more memory than is actually available to the hypervisor. Linux tends to use all of its available memory. As a result, the hypervisor (z/VM) might start swapping.

To avoid excessive z/VM swapping, the memory available to Linux can be reduced. CMM allocates pages to page pools that make the pages unusable to Linux. There are two such page pools as shown in [Figure 74 on page 369](#).

z/VM memory

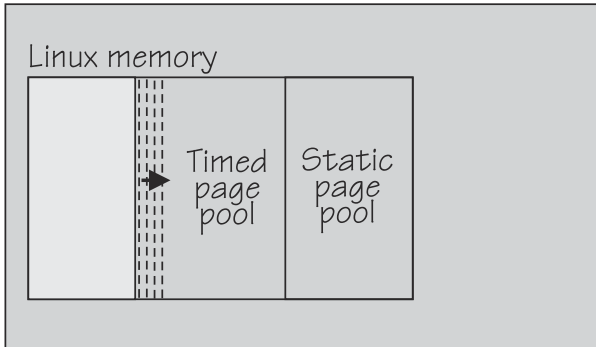


Figure 74. Page pools

There are two page pools:

A static page pool

The page pool is controlled by a resource manager that changes the pool size at intervals according to guest activity as well as overall memory usage on z/VM (see [Figure 75 on page 369](#)).

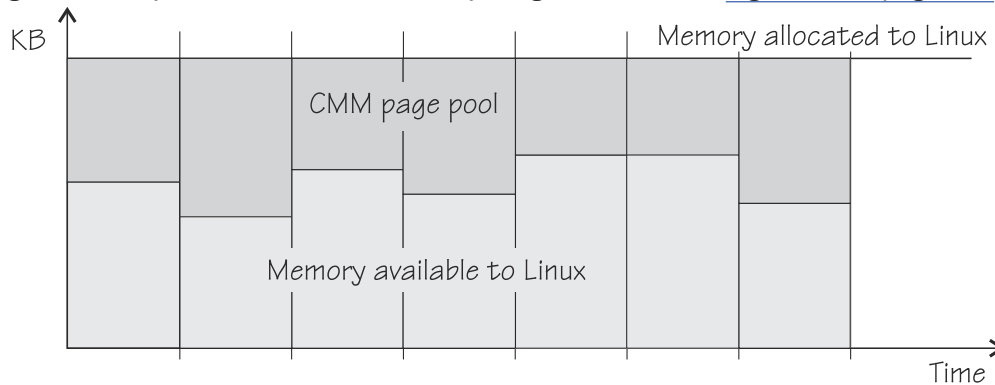


Figure 75. Static page pool

A timed page pool

Pages are released from this pool at a speed that is set in the *release rate* (see [Figure 76 on page 370](#)). According to guest activity and overall memory usage on z/VM, a resource manager adds pages at intervals. If no pages are added and the release rate is not zero, the pool empties.

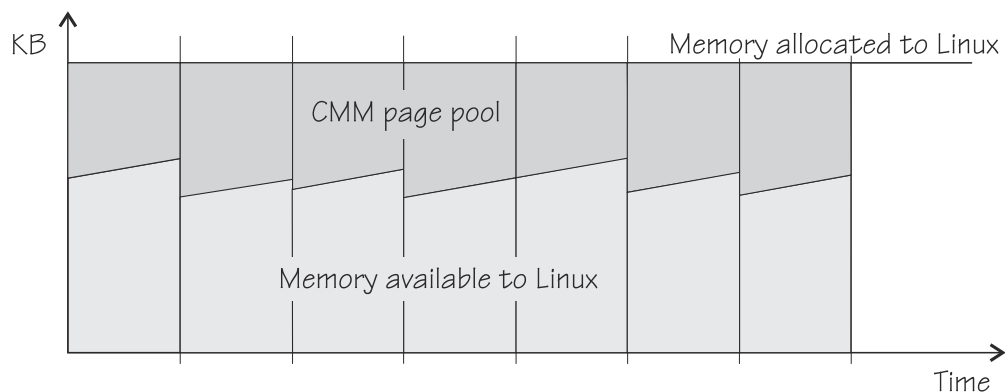


Figure 76. Timed page pool

The external resource manager that controls the pools can be the z/VM resource monitor (VMRM) or a third-party systems management tool.

VMRM controls the pools over a message interface. Setting up the external resource manager is beyond the scope of this information. For more details, see the chapter about VMRM in *z/VM: Performance*, SC24-6301.

Third-party tools can provide a Linux daemon that receives commands for the memory allocation through TCP/IP. The daemon, in turn, uses the procfs-based interface. You can use the procfs interface to read the pool sizes. These values are useful diagnostic data.

Linux guest relocation

Information about guest relocations is stored in the s390 debug feature (s390dbf).

You can access this information in a kernel dump or from a running Linux instance. For more information, see *Using the Dump Tools*, SC33-8412.

Chapter 34. Writing kernel APPLDATA records

z/VM only: APPLDATA records apply to Linux on z/VM only.

z/VM is a convenient point for collecting z/VM guest performance data and statistics for an entire server farm. Linux instances can export such data to z/VM by using APPLDATA monitor records.

z/VM regularly collects these records. The records are then available to z/VM performance monitoring tools.

A virtual CPU timer on the Linux instance to be monitored controls when data is collected. The timer accounts for only busy time to avoid unnecessarily waking up an idle guest. The APPLDATA record support comprises several modules. A base module provides an intra-kernel interface and the timer function. The intra-kernel interface is used by *data gathering modules* that collect actual data and determine the layout of a corresponding APPLDATA monitor record (see “APPLDATA monitor record layout” on page 373).

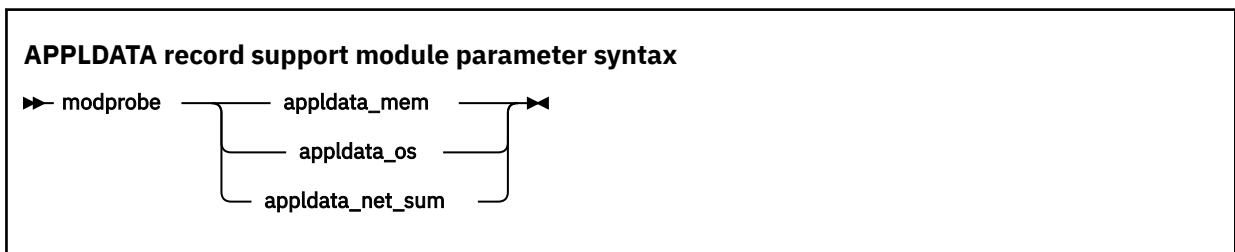
For an overview of performance monitoring support, see “Performance monitoring for z/VM guest virtual machines” on page 367.

Setting up the APPLDATA record support

You must enable your z/VM guest virtual machine for data gathering and load the APPLDATA record support modules.

Procedure

1. On z/VM, ensure that the user directory of the guest virtual machine includes the option APPLMON.
2. On Linux, use the **modprobe** command to load any required modules.



where `appldata_mem`, `appldata_os`, and `appldata_net_sum` are the modules for gathering memory-related data, operating system-related data, and network-related data.

See the **modprobe** man page for command details.

Generating APPLDATA monitor records

You can set the timer interval and enable or disable data collection.

You control the monitor stream support through the `procfs`. APPLDATA monitor records are produced if both a particular data-gathering module and the monitoring support in general are enabled.

Enabling or disabling the support

Use the `procfs` `timer` attribute to enable or disable the monitoring support.

Procedure

To read the current setting, issue:

```
# cat /proc/sys/appldata/timer
```

To enable the monitoring support, issue:

```
# echo 1 > /proc/sys/appldata/timer
```

To disable the monitoring support, issue:

```
# echo 0 > /proc/sys/appldata/timer
```

Activating or deactivating individual data-gathering modules

Each data-gathering module has a `procfs` entry that contains a value 1 if the module is active and 0 if the module is inactive.

About this task

The following `procfs` entries control the data-gathering modules:

`/proc/sys/appldata/mem` for the memory data-gathering module

`/proc/sys/appldata/os` for the CPU data-gathering module

`/proc/sys/appldata/net_sum` for the net data-gathering module

To check whether a module is active, look at the content of the corresponding `procfs` entry.

Procedure

Issue a command of this form:

```
# echo <flag> > /proc/sys/appldata/<data_type>
```

where `<data_type>` is one of `mem`, `os`, or `net_sum`.

Note: An active data-gathering module produces APPLDATA monitor records only if the monitoring support is enabled (see [“Enabling or disabling the support”](#) on page 371).

Example

To find out whether memory data-gathering is active, issue:

```
# cat /proc/sys/appldata/mem
0
```

In the example, memory data-gathering is off. To activate memory data-gathering, issue:

```
# echo 1 > /proc/sys/appldata/mem
```

To deactivate the memory data-gathering module, issue:

```
# echo 0 > /proc/sys/appldata/mem
```

Setting the sampling interval

You can set the time that lapses between consecutive data samples.

About this task

The time that you set is measured by the virtual CPU timer. Because the virtual timer slows down as the guest idles, the sampling interval in real time can be considerably longer than the value you set.

The value in `/proc/sys/appldata/interval` is the sample interval in milliseconds. The default sample interval is 10 000 ms.

Procedure

To read the current value, issue:

```
# cat /proc/sys/appldata/interval
```

To set the sample interval to a different value, write the new value (in milliseconds) to `/proc/sys/appldata/interval`. Issue a command of this form:

```
# echo <interval> > /proc/sys/appldata/interval
```

where `<interval>` is the new sample interval in milliseconds. The specification must be in the range 1 - 2147483647, where $2,147,483,647 = 2^{31} - 1$.

Example

To set the sampling interval to 20 s (20000 ms), issue:

```
# echo 20000 > /proc/sys/appldata/interval
```

APPLDATA monitor record layout

Each of the data-gathering modules writes a different type of record.

- Memory data (see [Table 51 on page 373](#))
- Processor data (see [Table 52 on page 374](#))
- Networking (see [Table 53 on page 375](#))

z/VM can identify the records by their unique product ID. The product ID is an EBCDIC string of this form: "LINUXKRNL<record ID>260100". The `<record ID>` is treated as a byte value, not a string.

The records contain data of the following types:

u32

unsigned 4-byte integer.

u64

unsigned 8-byte integer.

Offset (Decimal)	Offset (Hex)	Type	Name	Description
0	0x0	u64	timestamp	TOD time stamp that is generated on the Linux side after record update
8	0x8	u32	sync_count_1	After z/VM collected the record data, sync_count_1 and sync_count_2 must be the same. Otherwise, the record was updated on the Linux side while z/VM was collecting the data. As a result, the data might be inconsistent.
12	0xC	u32	sync_count_2	See sync_count_1.

Table 51. APPLDATA_MEM_DATA record (Record ID 0x01) (continued)

Offset (Decimal)	Offset (Hex)	Type	Name	Description
16	0x10	u64	pgpggin	Data that was read from disk (in KB)
24	0x18	u64	pgpggout	Data that was written to disk (in KB)
32	0x20	u64	pswpin	Pages that were swapped in
40	0x28	u64	pswpout	Pages that were swapped out
48	0x30	u64	sharedram	Shared RAM in KB
56	0x38	u64	totalram	Total usable main memory size in KB
64	0x40	u64	freeram	Available memory size in KB
72	0x48	u64	totalhigh	Total high memory size in KB
80	0x50	u64	freehigh	Available high memory size in KB
88	0x58	u64	bufferram	Memory that was reserved for raw disk blocks, corresponding to "Buffers" from /proc/meminfo, in KB
96	0x60	u64	cached	Size of used cache, including "Cached" and "SwapCached" from /proc/meminfo, in KB
104	0x68	u64	totalswap	Total swap space size in KB
112	0x70	u64	freeswap	Free swap space in KB
120	0x78	u64	pgalloc	Page allocations
128	0x80	u64	pgfault	Page faults (major+minor)
136	0x88	u64	pgmajfault	Page faults (major only)

Table 52. APPLDATA_OS_DATA record (Record ID 0x02)

Offset (Decimal)	Offset (Hex)	Type (size)	Name	Description
0	0x0	u64	timestamp	TOD time stamp that is generated on the Linux side after record update
8	0x8	u32	sync_count_1	After z/VM collected the record data, sync_count_1 and sync_count_2 must be the same. Otherwise, the record was updated on the Linux side while z/VM was collecting the data. As a result, the data might be inconsistent.
12	0xC	u32	sync_count_2	See sync_count_1.
16	0x10	u32	nr_cpus	Number of virtual CPUs.
20	0x14	u32	per_cpu_size	Size of the per_cpu_data for each CPU (= 36).
24	0x18	u32	cpu_offset	Offset of the first per_cpu_data (= 52).
28	0x1C	u32	nr_running	Number of runnable threads.
32	0x20	u32	nr_threads	Number of threads.

Table 52. APPLDATA_OS_DATA record (Record ID 0x02) (continued)

Offset (Decimal)	Offset (Hex)	Type (size)	Name	Description
36	0x24	3 × u32	avenrun[3]	Average number of running processes during the last 1 (first value), 5 (second value) and 15 (third value) minutes. These values are "fake fix-point". Each value is composed of a 10-bit integer and an 11-bit fractional part. See note "1" on page 375 at the end of this table.
48	0x30	u32	nr_iowait	Number of blocked threads (waiting for I/O).
52	0x34	See note "2" on page 375.	per_cpu_data	Time spent in user, kernel, idle, nice, etc for every CPU. See note "3" on page 375 at the end of this table.
52	0x34	u32	per_cpu_user	Timer ticks that were spent in user mode.
56	0x38	u32	per_cpu_nice	Timer ticks that were spent with modified priority.
60	0x3C	u32	per_cpu_system	Timer ticks that were spent in kernel mode.
64	0x40	u32	per_cpu_idle	Timer ticks that were spent in idle mode.
68	0x44	u32	per_cpu_irq	Timer ticks that were spent in interrupts.
72	0x48	u32	per_cpu_softirq	Timer ticks that were spent in softirqs.
76	0x4C	u32	per_cpu_iowait	Timer ticks that were spent while waiting for I/O.
80	0x50	u32	per_cpu_steal	Timer ticks "stolen" by the hypervisor.
84	0x54	u32	cpu_id	The number of this CPU.

Note:

1. The following C-Macros are used inside Linux to transform these into values with two decimal places:

```
#define LOAD_INT(x) ((x) >> 11)
#define LOAD_FRAC(x) LOAD_INT(((x) & ((1 << 11) - 1)) * 100)
```

2. nr_cpus * per_cpu_size
3. per_cpu_user through cpu_id are repeated for each CPU

Table 53. APPLDATA_NET_SUM_DATA record (Record ID 0x03)

Offset (Decimal)	Offset (Hex)	Type	Name	Description
0	0x0	u64	timestamp	TOD time stamp that is generated on the Linux side after record update
8	0x8	u32	sync_count_1	After z/VM collected the record data, sync_count_1 and sync_count_2 must be the same. Otherwise, the record was updated on the Linux side while z/VM was collecting the data. As a result, the data might be inconsistent.
12	0xC	u32	sync_count_2	See sync_count_1.
16	0x10	u32	nr_interfaces	Number of interfaces being monitored

Table 53. APPLDATA_NET_SUM_DATA record (Record ID 0x03) (continued)

Offset (Decimal)	Offset (Hex)	Type	Name	Description
20	0x14	u32	padding	Unused. The next value is 64-bit aligned, so these 4 bytes would be padded out by compiler
24	0x18	u64	rx_packets	Total packets that were received
32	0x20	u64	tx_packets	Total packets that were transmitted
40	0x28	u64	rx_bytes	Total bytes that were received
48	0x30	u64	tx_bytes	Total bytes that were transmitted
56	0x38	u64	rx_errors	Number of bad packets that were received
64	0x40	u64	tx_errors	Number of packet transmit problems
72	0x48	u64	rx_dropped	Number of incoming packets that were dropped because of insufficient space in Linux buffers
80	0x50	u64	tx_dropped	Number of outgoing packets that were dropped because of insufficient space in Linux buffers
88	0x58	u64	collisions	Number of collisions while transmitting

Programming interfaces

The monitor stream support base module exports two functions.

- `appldata_register_ops()` to register data-gathering modules
- `appldata_unregister_ops()` to undo the registration of data-gathering modules

Both functions receive a pointer to a struct `appldata_ops` as parameter. Additional data-gathering modules that want to plug into the base module must provide this data structure. You can find the definition of the structure and the functions in `arch/s390/appldata/appldata.h` in the Linux source tree.

See “APPLDATA monitor record layout” on page 373 for an example of APPLDATA data records that are to be sent to z/VM.

Tip: Include the timestamp, `sync_count_1`, and `sync_count_2` fields at the beginning of the record as shown for the existing APPLDATA record formats.

Chapter 35. Writing z/VM monitor records

z/VM only: z/VM monitor records apply to Linux on z/VM only.

Applications can use the monitor stream application device driver to write z/VM monitor APPLDATA records to the z/VM *MONITOR stream.

For an overview of performance monitoring support, see [“Performance monitoring for z/VM guest virtual machines”](#) on page 367.

The monitor stream application device driver interacts with the z/VM monitor APPLDATA facilities for performance monitoring. A better understanding of these z/VM facilities might help when you are using this device driver. See *z/VM: Performance*, SC24-6301 for information about monitor APPLDATA.

The monitor stream application device driver provides the following functions:

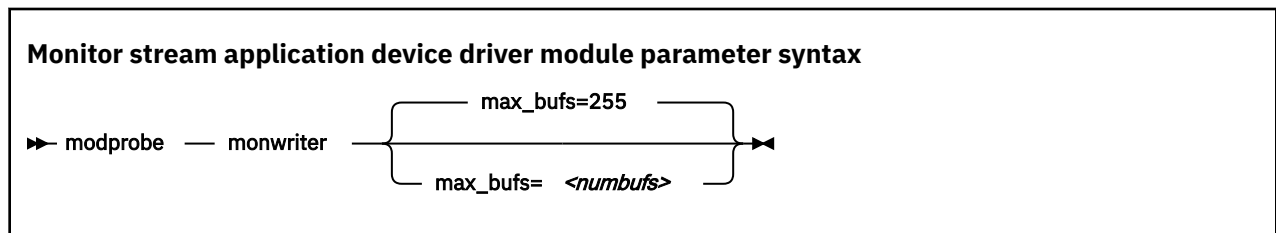
- An interface to the z/VM monitor stream.
- A means of writing z/VM monitor APPLDATA records.

Setting up the z/VM *MONITOR record writer device driver

On Linux, configure the z/VM *MONITOR record writer device driver through kernel or module parameters. You also must set up your guest virtual machine for monitor records on z/VM.

Loading the module

You can configure the monitor stream application device driver when you load the device driver module, `monwriter`.



where `<numbufs>` is the maximum number of monitor sample and configuration data buffers that can exist in the Linux guest at one time. The default is 255.

Example

If you have compiled the monitor stream application device driver as a separate module, you must load it before you can work with it. To load the `monwriter` module and set the maximum number of buffers to 400, use the following command:

```
# modprobe monwriter max_bufs=400
```

Setting up the user z/VM guest virtual machine

You must enable your z/VM guest virtual machine to write monitor records and configure the z/VM system to collect these records.

Procedure

Perform these steps:

1. Set this option in the z/VM user directory entry of the virtual machine in which the application that uses this device driver is to run:
 - OPTION APPLMON
2. Issue the following CP commands to have CP collect the respective types of monitor data:
 - MONITOR SAMPLE ENABLE APPLDATA ALL
 - MONITOR EVENT ENABLE APPLDATA ALL

You can log in to the z/VM console to issue the CP commands. These commands must be preceded with #CP. Alternatively, you can use the **vmcp** command for issuing CP commands from your Linux instance.

See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about the CP MONITOR command.

Working with the z/VM *MONITOR record writer

The monitor stream application device driver uses the z/VM CP instruction DIAG X'DC' to write to the z/VM monitor stream. Monitor data must be preceded by a data structure, `monwrite_hdr`.

See *z/VM: CP Programming Services*, SC24-6272 for more information about the DIAG X'DC' instruction and the different monitor record types (sample, config, event).

The application writes monitor data by passing a `monwrite_hdr` structure that is followed by monitor data. The only exception is the STOP function, which requires no monitor data. The `monwrite_hdr` structure, as described in `monwriter.h`, is filled in by the application. The structure includes the DIAG X'DC' function to be performed, the product identifier, the header length, and the data length.

All records that are written to the z/VM monitor stream begin with a product identifier. This device driver uses the product ID. The product ID is a 16-byte structure of the form `ppppppffnvvrrmm`, where:

ppppppp

is a fixed ASCII string, for example, LNXAPPL.

ff

is the application number (hexadecimal number). This number can be chosen by the application. You can reduce the chance of conflicts with other applications, by requesting an application number from the IBM z/VM Performance team at

www.ibm.com/vm/perf

n

is the record number as specified by the application.

vv, rr, and mm

can also be specified by the application. A possible use is to specify version, release, and modification level information, allowing changes to a certain record number when the layout is changed, without changing the record number itself.

The first 7 bytes of the structure (LNXAPPL) are filled in by the device driver when it writes the monitor data record to the CP buffer. The last 9 bytes contain information that is supplied by the application on the `write()` call when writing the data.

The `monwrite_hdr` structure that must be written before any monitor record data is defined as follows:

```
/* the header the app uses in its write() data */
struct monwrite_hdr {
    unsigned char mon_function;
    unsigned short applid;
    unsigned char record_num;
    unsigned short version;
    unsigned short release;
    unsigned short mod_level;
    unsigned short datalen;
}
```

```
    unsigned char hdrLen;  
}__attribute__((packed));
```

The following function code values are defined:

```
/* mon_function values */  
#define MONWRITE_START_INTERVAL 0x00 /* start interval recording */  
#define MONWRITE_STOP_INTERVAL 0x01 /* stop interval or config recording */  
#define MONWRITE_GEN_EVENT      0x02 /* generate event record */  
#define MONWRITE_START_CONFIG   0x03 /* start configuration recording */
```

Writing data and stopping data-writing

Applications use the `open()`, `write()`, and `close()` calls to work with the z/VM monitor stream.

Before an application can write monitor records, it must issue `open()` to open the device driver. Then, the application must issue `write()` calls to start or stop the collection of monitor data and to write any monitor records to buffers that CP can access.

When the application has finished writing monitor data, it must issue `close()` to close the device driver.

Using the `monwrite_hdr` structure

The structure `monwrite_hdr` is used to pass DIAG x'DC' functions and the application-defined product information to the device driver on `write()` calls.

When the application calls `write()`, the data it is writing consists of one or more `monwrite_hdr` structures. Each structure is followed by monitor data. The only exception is the STOP function, which is not followed by data.

The application can write to one or more monitor buffers. A new buffer is created by the device driver for each record with a unique product identifier. To write new data to an existing buffer, an identical `monwrite_hdr` structure must precede the new data on the `write()` call.

The `monwrite_hdr` structure also includes a field for the header length, which is useful for calculating the data offset from the beginning of the header. There is also a field for the data length, which is the length of any monitor data that follows. See `/usr/include/asm-s390/monwriter.h` for the definition of the `monwrite_hdr` structure.

Chapter 36. Reading z/VM monitor records

z/VM only: z/VM monitor records apply to Linux on z/VM only.

Monitoring software on Linux can access z/VM guest data through the z/VM *MONITOR record reader device driver.

z/VM uses the z/VM monitor system service (*MONITOR) to collect monitor records from agents on its guests. z/VM writes the records to a discontinuous saved segment (DCSS). The z/VM *MONITOR record reader device driver uses IUCV to connect to *MONITOR and accesses the DCSS as a character device.

For an overview of performance monitoring support, see [“Performance monitoring for z/VM guest virtual machines”](#) on page 367.

The z/VM *MONITOR record reader device driver supports the following devices and functions:

- Read access to the z/VM *MONITOR DCSS.
- Reading *MONITOR records.
- Access to *MONITOR records as described on

www.ibm.com/vm/pubs/ct1blk.html

- Access to the kernel APPLDATA records from the Linux monitor stream (see [Chapter 34, “Writing kernel APPLDATA records,”](#) on page 371).

What you should know about the z/VM *MONITOR record reader device driver

The data that is collected by *MONITOR depends on the setup of the monitor stream service.

The z/VM *MONITOR record reader device driver only reads data from the monitor DCSS; it does not control the system service.

z/VM supports only one monitor DCSS. All monitoring software that requires monitor records from z/VM uses the same DCSS to read *MONITOR data. Usually, a DCSS called MONDCSS is already defined and used by existing monitoring software.

If a monitor DCSS is already defined, you must use it. To find out whether a monitor DCSS exists, issue the following CP command from a z/VM guest virtual machine with privilege class E:

```
q monitor
```

The command output also shows the name of the DCSS.

Device node

Ubuntu Server 20.04.1 creates a device node, `/dev/monreader`, that you can use to access the monitor DCSS.

Further information

- See *z/VM: Saved Segments Planning and Administration*, SC24-6322 for general information about DCSSs.
- See *z/VM: Performance*, SC24-6301 for information about creating a monitor DCSS.
- See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about the CP commands that are used in the context of DCSSs and for controlling the z/VM monitor system service.

- For the layout of the monitor records, go to www.ibm.com/vm/pubs/ctlblk.html and click the link to the monitor record format for your z/VM version. Also, see [Chapter 34, “Writing kernel APPLDATA records,” on page 371.](#)

Setting up the z/VM *MONITOR record reader device driver

You must set up a Linux instance and the z/VM guest virtual machine for accessing an existing monitor DCSS with the z/VM *MONITOR record reader device driver.

Before you begin

Some of the CP commands you use for setting up the z/VM *MONITOR record reader device driver require class E authorization.

Setting up the monitor system service and the monitor DCSS on z/VM is beyond the scope of this information. See [“What you should know about the z/VM *MONITOR record reader device driver” on page 381](#) for documentation about the monitor system service, DCSS, and related CP commands.

Providing the required z/VM user directory statements

The z/VM guest virtual machine where your Linux instance is to run must be permitted to establish an IUCV connection to the z/VM *MONITOR system service.

Procedure

Ensure that the guest entry in the user directory includes the following statement:

```
IUCV *MONITOR
```

If the DCSS is restricted, you also need this statement:

```
NAMESAVE <dcss>
```

where <dcss> is the name of the DCSS that is used for the monitor records. You can find out the name of an existing monitor DCSS by issuing the following CP command from a z/VM guest virtual machine with privilege class E:

```
q monitor
```

Assuring that the DCSS is addressable for your Linux instance

The DCSS address range must not overlap with the storage of your z/VM guest virtual machine.

Procedure

To find out the start and end address of the DCSS, issue the following CP command from a z/VM guest virtual machine with privilege class E:

```
q nss map
```

The output gives you the start and end addresses of all defined DCSSs in units of 4-kilobyte pages. For example:

```
00: FILE FILENAME FILETYPE MINSIZE BEGPAG ENDPAG TYPE CL #USERS PARMREGS VMGROUP
...
00: 0011 MONDCSS CPDCSS N/A 09000 097FF SC R 00003 N/A N/A
...
```

What to do next

If the DCSS overlaps with the guest storage, follow the procedure in [“Avoiding overlaps with your guest storage”](#) on page 399.

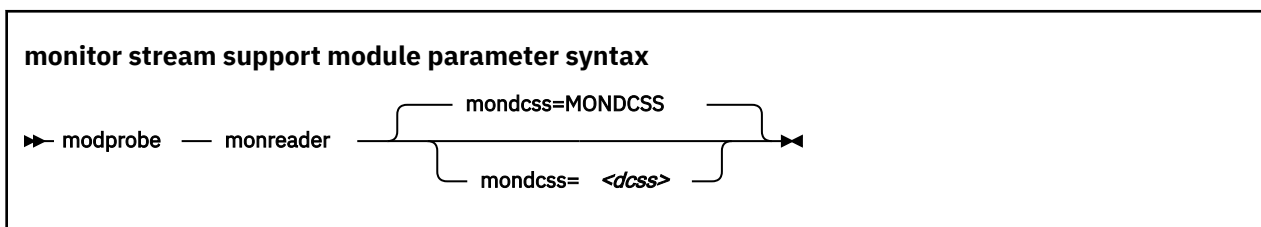
Specifying the monitor DCSS name

Specify the DCSS name as a module parameter when you load the device driver module.

About this task

By default, the z/VM *MONITOR record reader device driver assumes that the monitor DCSS on z/VM is called MONDCSS. If you want to use a different DCSS name, you must specify it.

Load the monitor read support module with **modprobe** to assure that any other required modules are also loaded. You need IUCV support if you want to use the monitor read support.



where `<dcss>` is the name of the DCSS that z/VM uses for the monitor records. The value is automatically converted to uppercase.

Example

To load the monitor read support module and specify MYDCSS as the DCSS, issue:

```
modprobe monreader mondcss=mydcss
```

Working with the z/VM *MONITOR record reader support

You can open the z/VM *MONITOR record character device to read records from it.

This section describes how to work with the monitor read support.

- [“Opening and closing the character device”](#) on page 383
- [“Reading monitor records”](#) on page 384

Opening and closing the character device

Only one user can open the character device at any one time. Once you have opened the device, you must close it to make it accessible to other users.

About this task

The open function can fail (return a negative value) with one of the following values for errno:

EBUSY

The device has already been opened by another user.

EIO

No IUCV connection to the z/VM MONITOR system service could be established. An error message with an IPUSER SEVER code is printed into syslog. See *z/VM: Performance*, SC24-6301 for details about the codes.

Once the device is opened, incoming messages are accepted and account for the message limit. If you keep the device open indefinitely, expect to eventually reach the message limit (with error code EOVERFLOW).

Reading monitor records

You can either read in non-blocking mode with polling, or you can read in blocking mode without polling.

About this task

Reading from the device provides a 12-byte monitor control element (MCE), followed by a set of one or more contiguous monitor records (similar to the output of the CMS utility MONWRITE without the 4 K control blocks). The MCE contains information about:

- The type of the following record set (sample/event data)
- The monitor domains contained within it
- The start and end address of the record set in the monitor DCSS

The start and end address can be used to determine the size of the record set. The end address is the address of the last byte of data. The start address is needed to handle "end-of-frame" records correctly (domain 1, record 13), that is, it can be used to determine the record start offset relative to a 4 K page (frame) boundary.

See "Appendix A: *MONITOR" in *z/VM: Performance*, SC24-6301 for a description of the monitor control element layout. The layout of the monitor records can be found on

www.ibm.com/vm/pubs/ctlblk.html

The layout of the data stream that is provided by the monreader device is as follows:

```
...
<0 byte read>
<first MCE>
<first set of records>  \
                        |...   |- data set
...
<last MCE>
<last set of records>  /
<0 byte read>
...
```

There might be more than one combination of MCE and a corresponding record set within one data set. The end of each data set is indicated by a successful read with a return value of 0 (0 byte read). Received data is not to be considered valid unless a complete record set is read successfully, including the closing 0-Byte read. You are advised to always read the complete set into a user space buffer before processing the data.

When designing a buffer, allow for record sizes up to the size of the entire monitor DCSS, or use dynamic memory allocation. The size of the monitor DCSS will be printed into syslog after loading the module. You can also use the (Class E privileged) CP command Q **NSS MAP** to list all available segments and information about them (see "[Assuring that the DCSS is addressable for your Linux instance](#)" on page 382).

Error conditions are indicated by returning a negative value for the number of bytes read. For an error condition, the errno variable can be:

EIO

Reply failed. All data that was read since the last successful read with 0 size is not valid. Data is missing. The application must decide whether to continue reading subsequent data or to exit.

EFAULT

Copy to user failed. All data that was read since the last successful read with 0 size is not valid. Data is missing. The application must decide whether to continue reading subsequent data or to exit.

EAGAIN

Occurs on a non-blocking read if there is no data available at the moment. No data is missing or damaged, retry or use polling for non-blocking reads.

EOVERFLOW

The message limit is reached. The data that was read since the last successful read with 0 size is valid, but subsequent records might be missing. The application must decide whether to continue reading subsequent data or to exit.

Chapter 37. z/VM recording device driver

z/VM only: The z/VM recording device driver applies to Linux on z/VM only.

The z/VM recording device driver enables Linux on z/VM to read from the CP recording services and, thus, act as a z/VM wide control point.

The z/VM recording device driver uses the z/VM CP RECORDING command to collect records and IUCV to transmit them to the Linux instance.

For general information about CP recording system services, see *z/VM: CP Programming Services*, SC24-6272.

Features

With the z/VM recording device driver, you can read from several CP services and collect records.

In particular, the z/VM recording device driver supports:

- Reading records from the CP error logging service, *LOGREC.
- Reading records from the CP accounting service, *ACCOUNT.
- Reading records from the CP diagnostic service, *SYMPTOM.
- Automatic and explicit record collection (see [“Starting and stopping record collection”](#) on page 389).

What you should know about the z/VM recording device driver

You can read records from different recording services, one record at a time.

The z/VM recording device driver is a character device driver that is grouped under the IUCV category of device drivers (see [“Device categories”](#) on page 7). There is one device for each recording service. The device nodes are created for you. If the z/VM recording device driver is compiled as a separate module, the device nodes are created when the module is loaded.

z/VM recording device nodes

Each recording service has a fixed minor number and a name that corresponds to the name of the service.

[Table 54 on page 387](#) shows the mapping of names and minor numbers.

Table 54. Device names and minor numbers

z/VM recording service	Standard device name	Minor number
*LOGREC	logrec	0
*ACCOUNT	account	1
*SYMPTOM	symptom	2

About records

Records for different services are different in details, but follow the same overall structure.

The read function returns one record at a time. If there is no record, the read function waits until a record becomes available.

Each record begins with a 4-byte field that contains the length of the remaining record. The remaining record contains the binary z/VM data followed by the four bytes X'454f5200' to mark the end of the record. These bytes build the zero-terminated ASCII string "EOR", which is useful as an eye catcher.

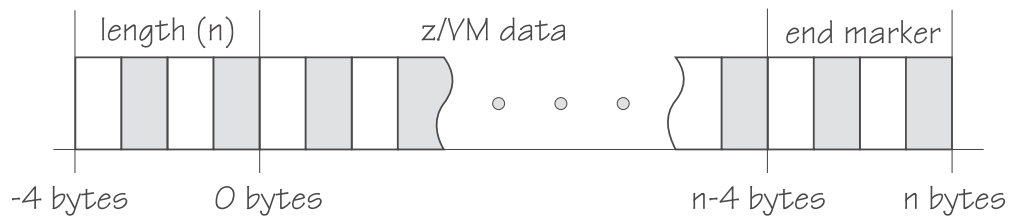


Figure 77. Record structure

Figure 77 on page 388 illustrates the structure of a complete record as returned by the device. If the buffer assigned to the read function is smaller than the overall record size, multiple reads are required to obtain the complete record.

The format of the z/VM data (*LOGREC) depends on the record type that is described in the common header for error records HDRREC.

For more information about the z/VM record layout, see the *CMS and CP Data Areas and Control Blocks* documentation at www.ibm.com/vm/pubs/ctlblk.html.

Setting up the z/VM recording device driver

Before you can collect records, you must authorize your z/VM guest virtual machine and load the device driver module.

About this task

This section provides information about the guest authorization that is required for collecting records and about how to load the device driver if it was compiled as a module.

Procedure

1. Authorize the z/VM guest virtual machine on which your Linux instance runs to:
 - Use the z/VM CP RECORDING command.
 - Connect to the IUCV services to be used: one or more of *LOGREC, *ACCOUNT, and *SYMPTOM.
2. Load the vmlogrdr module.

Use the **modprobe** command to ensure that any other required modules are loaded in the correct order:

```
# modprobe vmlogrdr
```

There are no module parameters for the z/VM recording device driver.

Working with z/VM recording devices

Typical tasks that you perform with z/VM recording devices include starting and stopping record collection, purging records, and opening and closing devices.

- [“Starting and stopping record collection” on page 389](#)
- [“Purging existing records” on page 389](#)
- [“Querying the z/VM recording status” on page 390](#)
- [“Opening and closing devices” on page 391](#)

Starting and stopping record collection

By default, record collection for a particular z/VM recording service begins when the corresponding device is opened and stops when the device is closed.

About this task

You can use a device's `autorecording` attribute to be able to open and close a device without also starting or stopping record collection. You can use a device's `recording` attribute to start and stop record collection regardless of whether the device is opened or not.

You cannot start record collection if a device is open and records already exist. Before you can start record collection for an open device, you must read or purge any existing records for this device (see [“Purging existing records”](#) on page 389).

Procedure

To be able to open a device without starting record collection and to close a device without stopping record collection write `0` to the device's `autorecording` attribute. To restore the automatic starting and stopping of record collection, write `1` to the device's `autorecording` attribute. Issue a command of this form:

```
# echo <flag> > /sys/bus/iucv/drivers/vmlogrdr/<device>/autorecording
```

where `<flag>` is either `0` or `1`, and `<device>` is one of: `logrec`, `symptom`, or `account`.

To explicitly turn on record collection, write `1` to the device's `recording` attribute. To explicitly turn off record collection, write `0` to the device's `recording` attribute. Issue a command of this form:

```
# echo <flag> > /sys/bus/iucv/drivers/vmlogrdr/<device>/recording
```

where `<flag>` is either `0` or `1`, and `<device>` is one of: `logrec`, `symptom`, or `account`.

You can read both the `autorecording` and the `recording` attribute to find the current settings.

Examples

- In this example, first the current setting of the `autorecording` attribute of the `logrec` device is checked, then automatic recording is turned off:

```
# cat /sys/bus/iucv/drivers/vmlogrdr/logrec/autorecording
1
# echo 0 > /sys/bus/iucv/drivers/vmlogrdr/logrec/autorecording
```

- In this example, record collection is started explicitly and later stopped for the `account` device:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdr/account/recording
...
# echo 0 > /sys/bus/iucv/drivers/vmlogrdr/account/recording
```

To confirm whether recording is on or off, read the `recording_status` attribute as described in [“Querying the z/VM recording status”](#) on page 390.

Purging existing records

By default, existing records for a particular z/VM recording service are purged automatically when the corresponding device is opened or closed.

About this task

You can use a device's `autopurge` attribute to prevent records from being purged when a device is opened or closed. You can use a device's `purge` attribute to purge records for a particular device at any time without having to open or close the device.

Procedure

To be able to open or close a device without purging existing records write `0` to the device's `autopurge` attribute. To restore automatic purging of existing records, write `1` to the device's `autopurge` attribute. You can read the `autopurge` attribute to find the current setting. Issue a command of this form:

```
# echo <flag> > /sys/bus/iucv/drivers/vmlogrdx/<device>/autopurge
```

where `<flag>` is either `0` or `1`, and `<device>` is one of: `logrec`, `symptom`, or `account`.

To purge existing records for a particular device without opening or closing the device write `1` to the device's `purge` attribute. Issue a command of this form:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdx/<device>/purge
```

where `<device>` is one of: `logrec`, `symptom`, or `account`.

Examples

- In this example, the setting of the `autopurge` attribute for the `logrec` device is checked first, then automatic purging is switched off:

```
# cat /sys/bus/iucv/drivers/vmlogrdx/logrec/autopurge
1
# echo 0 > /sys/bus/iucv/drivers/vmlogrdx/logrec/autopurge
```

- In this example, the existing records for the `symptom` device are purged:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdx/symptom/purge
```

Querying the z/VM recording status

Use the `recording_status` attribute of the z/VM recording device driver representation in `sysfs` to query the z/VM recording status.

Example

This example runs the z/VM CP command `QUERY RECORDING` and returns the complete output of that command. This list does not necessarily have an entry for all three services and there might also be entries for other guests.

```
# cat /sys/bus/iucv/drivers/vmlogrdx/recording_status
```

This command results in output similar to the following example:

RECORDING	COUNT	LMT	USERID	COMMUNICATION
EREP ON	00000000	002	EREP	ACTIVE
ACCOUNT ON	00001774	020	DISKACNT	INACTIVE
SYMPTOM ON	00000000	002	OPERSYMP	ACTIVE
ACCOUNT OFF	00000000	020	LINUX31	INACTIVE

where the lines represent:

- The service

- The recording status
- The number of queued records
- The number of records that result in a message to the operator
- The guest that is or was connected to that service and the status of that connection

A detailed description of the QUERY RECORDING command can be found in the *z/VM: CP Commands and Utilities Reference*, SC24-6268.

Opening and closing devices

You can open, read, and release the device. You cannot open the device multiple times. Each time the device is opened it must be released before it can be opened again.

About this task

You can use a device's `autorecord` attribute (see [“Starting and stopping record collection”](#) on page 389) to enable automatic record collection while a device is open.

You can use a device's `autopurge` attribute (see [“Purging existing records”](#) on page 389) to enable automatic purging of existing records when a device is opened and closed.

Scenario: Connecting to the *ACCOUNT service

A typical sequence of tasks is autorecording, turning autorecording off, purging records, and starting recording.

Procedure

1. Query the status of z/VM recording. As root, issue the following command:

```
# cat /sys/bus/iucv/drivers/vmlogrdx/recording_status
```

The results depend on the system, and look similar to the following example:

RECORDING	COUNT	LMT	USERID	COMMUNICATION
EREK ON	00000000	002	EREK	ACTIVE
ACCOUNT ON	00001812	020	DISKACNT	INACTIVE
SYMPTOM ON	00000000	002	OPERSYMP	ACTIVE
ACCOUNT OFF	00000000	020	LINUX31	INACTIVE

2. Open `/dev/account` with an appropriate application.

This action connects the guest to the *ACCOUNT service and starts recording. The entry for *ACCOUNT on guest LINUX31 changes to ACTIVE and ON:

```
# cat /sys/bus/iucv/drivers/vmlogrdx/recording_status
```

RECORDING	COUNT	LMT	USERID	COMMUNICATION
EREK ON	00000000	002	EREK	ACTIVE
ACCOUNT ON	00001812	020	DISKACNT	INACTIVE
SYMPTOM ON	00000000	002	OPERSYMP	ACTIVE
ACCOUNT ON	00000000	020	LINUX31	ACTIVE

3. Switch autopurge and autorecord off:

```
# echo 0 > /sys/bus/iucv/drivers/vmlogrdx/account/autopurge
```

```
# echo 0 > /sys/bus/iucv/drivers/vmlogrdx/account/autorecording
```

4. Close the device by ending the application that reads from it and check the recording status.

While the connection is INACTIVE, RECORDING is still ON:

```
# cat /sys/bus/iucv/drivers/vmlogrdᄁ/recording_status
RECORDING    COUNT    LMT    USERID    COMMUNICATION
EREᄁ ON      00000000 002    EREᄁ      ACTIVE
ACCOUNT ON    00001812 020    DISKACNT  INACTIVE
SYMPTOM ON   00000000 002    OPERSYMP  ACTIVE
ACCOUNT ON   00000000 020    LINUX31   INACTIVE
```

5. The next status check shows that some event created records on the *ACCOUNT queue:

```
# cat /sys/bus/iucv/drivers/vmlogrdᄁ/recording_status
RECORDING    COUNT    LMT    USERID    COMMUNICATION
EREᄁ ON      00000000 002    EREᄁ      ACTIVE
ACCOUNT ON    00001821 020    DISKACNT  INACTIVE
SYMPTOM ON   00000000 002    OPERSYMP  ACTIVE
ACCOUNT ON    00000009 020    LINUX31   INACTIVE
```

6. Switch recording off:

```
# echo 0 > /sys/bus/iucv/drivers/vmlogrdᄁ/account/recording
```

```
# cat /sys/bus/iucv/drivers/vmlogrdᄁ/recording_status
RECORDING    COUNT    LMT    USERID    COMMUNICATION
EREᄁ ON      0000000000 002    EREᄁ      ACTIVE
ACCOUNT ON    00001821 020    DISKACNT  INACTIVE
SYMPTOM ON   00000000 002    OPERSYMP  ACTIVE
ACCOUNT OFF    00000009 020    LINUX31   INACTIVE
```

7. Try to switch it on again, and check whether it worked by checking the recording status:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdᄁ/account/recording
```

```
# cat /sys/bus/iucv/drivers/vmlogrdᄁ/recording_status
RECORDING    COUNT    LMT    USERID    COMMUNICATION
EREᄁ ON      0000000000 002    EREᄁ      ACTIVE
ACCOUNT ON    00001821 020    DISKACNT  INACTIVE
SYMPTOM ON   00000000 002    OPERSYMP  ACTIVE
ACCOUNT OFF    00000009 020    LINUX31   INACTIVE
```

Recording did not start, in the message logs you might find a message:

```
vmlogrdᄁ: recording response: HCPCRC8087I Records are queued for user LINUX31 on the
*ACCOUNT recording queue and must be purged or retrieved before recording can be turned on.
```

This kernel message has priority 'debug' so it might not be written to any of your log files.

8. Now remove all the records on your *ACCOUNT queue either by starting an application that reads them from /dev/account or by explicitly purging them:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdᄁ/account/purge
```

```
# cat /sys/bus/iucv/drivers/vmlogrdᄁ/recording_status
RECORDING    COUNT    LMT    USERID    COMMUNICATION
EREᄁ ON      0000000000 002    EREᄁ      ACTIVE
ACCOUNT ON    00001821 020    DISKACNT  INACTIVE
SYMPTOM ON   00000000 002    OPERSYMP  ACTIVE
ACCOUNT OFF   00000000 020    LINUX31   INACTIVE
```

9. Now start recording and check status again:

```
# echo 1 > /sys/bus/iucv/drivers/vmlogrdᄁ/account/recording
```



```
# cat /sys/bus/iucv/drivers/vmlogrdt/recording_status
RECORDING      COUNT      LMT      USERID      COMMUNICATION
EREP ON        00000000  002      EREP        ACTIVE
ACCOUNT ON     00001821  020      DISKACNT    INACTIVE
SYMPTOM ON     00000000  002      OPERSYMP    ACTIVE
ACCOUNT ON     00000000      020      LINUX31     INACTIVE
```

Chapter 38. z/VM unit record device driver

z/VM only: The z/VM unit record device driver applies to Linux on z/VM only.

The z/VM unit record device driver provides Linux on z/VM with access to virtual unit record devices. Unit record devices comprise punch card readers, card punches, and line printers.

Linux access is limited to virtual unit record devices with default device types (2540 for reader and punch, 1403 for printer).

To write Linux files to the virtual punch or printer (that is, to the corresponding spool file queues) or to receive z/VM reader files (for example CONSOLE files) to Linux files, use the **vmur** command that is part of the s390-tools package (see [“vmur - Work with z/VM spool file queues”](#) on page 672).

What you should know about the z/VM unit record device driver

The z/VM unit record device driver is compiled as a separate module, **vmur**. When the **vmur** module is loaded, it registers a character device.

When a unit record device is set online, **udev** creates a device node for it. The default **udev** rules create the following device nodes:

- Reader: `/dev/vmrdx-0.0.<device_number>`
- Punch: `/dev/vmpun-0.0.<device_number>`
- Printer: `/dev/vmprt-0.0.<device_number>`

Working with z/VM unit record devices

After loading the z/VM unit record device driver, set the required virtual unit record devices online.

Procedure

1. Load the virtual record device module with the **modprobe** command.

```
# modprobe vmur
```

There are no module parameters for the **vmur** device driver.

2. Set the devices that you want to work with online.

For example, to set the devices with device bus-IDs 0.0.000c, 0.0.000d, and 0.0.000e online, issue the following command:

```
# chzdev -e 0.0.000c-0.0.000e
```

What to do next

You can now use the **vmur** command to work with the devices ([“vmur - Work with z/VM spool file queues”](#) on page 672).

If you want to unload the **vmur** module, close all unit record device nodes. Attempting to unload the module while a device node is open results in error message `Module vmur is in use`. You can unload the **vmur** module, for example, by issuing `modprobe -r`.

Serialization is implemented per device; only one process can open a particular device node at any one time.

Chapter 39. z/VM DCSS device driver

z/VM only: The z/VM DCSS device driver applies to Linux on z/VM only.

The z/VM discontinuous saved segments (DCSS) device driver provides disk-like fixed block access to z/VM discontinuous saved segments.

Through DCSSs, you can implement shared read-write RAM disks for Linux instances that run as guests of the same z/VM system. Such RAM disks can provide shared file systems.

For information about DCSS, see *z/VM: Saved Segments Planning and Administration*, SC24-6322.

Removed information: References to execute-in-place technology have been removed because changed dependencies make this technology experimental.

What you should know about DCSSs

The DCSS device names and nodes adhere to a naming scheme. There are different modes and options for mounting a DCSS.

Important: DCSSs occupy spool space. Be sure that you have enough spool space available (multiple times the DCSS size).

DCSS naming scheme

The standard device names are of the form `dcssblk<n>`, where `<n>` is the corresponding minor number.

The first DCSS device that is added is assigned the name `dcssblk0`, the second `dcssblk1`, and so on. When a DCSS device is removed, its device name and corresponding minor number are free and can be reassigned. A DCSS device that is added always receives the lowest free minor number.

DCSS device nodes

User space programs access DCSS devices by device nodes. Ubuntu Server 20.04.1 creates standard DCSS device nodes for you.

Standard DCSS device nodes have the form `/dev/<device_name>`, for example:

```
/dev/dcssblk0  
/dev/dcssblk1  
...
```

Accessing a DCSS in exclusive-writable mode

You must access a DCSS in exclusive-writable mode, for example, to create or update the DCSS.

To access a DCSS in exclusive-writable mode at least one of the following conditions must apply:

- The DCSS fits below the maximum definable address space size of the z/VM guest virtual machine.

For large read-only DCSS, you can use suitable guest sizes to restrict exclusive-writable access to a specific z/VM guest virtual machine with a sufficient maximum definable address space size.

- The z/VM user directory entry for the z/VM guest virtual machine includes a `NAMESAVE` statement for the DCSS. See *z/VM: CP Planning and Administration*, SC24-6271 for more information about the `NAMESAVE` statement.
- The DCSS was defined with the `LOADNSHR` operand.

See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about the `LOADNSHR` operand.

See “DCSS options” on page 398 about saving DCSSs with the LOADNSHR operand or with other optional properties.

DCSS options

The z/VM DCSS device driver always saves DCSSs with default properties. Any previously defined options are removed.

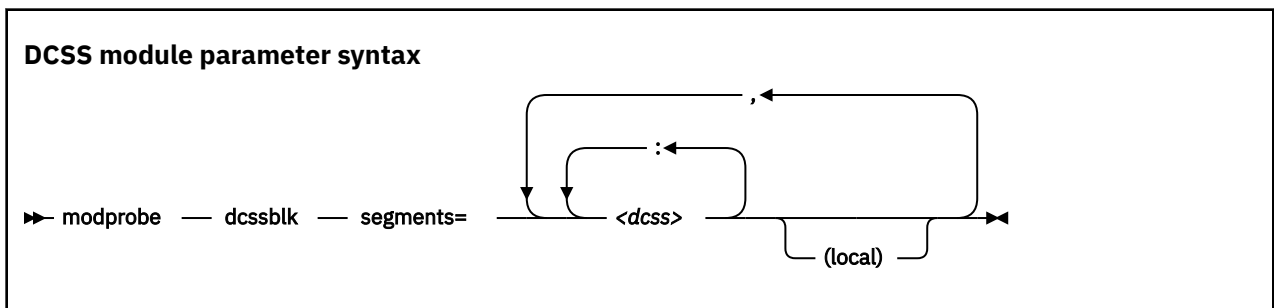
For example, a DCSS that was defined with the LOADNSHR operand loses this property when it is saved with the z/VM DCSS device driver.

To save a DCSS with optional properties, you must unmount the DCSS device, then use the CP DEFSEG and SAVESEG commands to save the DCSS. See “Workaround for saving DCSSs with optional properties” on page 403 for an example.

See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about DCSS options.

Setting up the DCSS device driver

Before you can load and use DCSSs, you must load the DCSS block device driver. Use the segments module parameter to load one or more DCSSs when the DCSS device driver is loaded.



<dcss>

specifies the name of a DCSS as defined on the z/VM hypervisor. The specification for <dcss> is converted from ASCII to uppercase EBCDIC.

:

the colon (:) separates DCSSs within a set of DCSSs to be mapped to a single DCSS device. You can map a set of DCSSs to a single DCSS device if the DCSSs in the set form a contiguous memory space.

You can specify the DCSSs in any order. The name of the first DCSS you specify is used to represent the device under `/sys/devices/dcssblk`.

(local)

sets the access mode to exclusive-writable after the DCSS or set of DCSSs are loaded.

,

the comma (,) separates DCSS devices.

Examples

The following command loads the DCSS device driver and three DCSSs: DCSS1, DCSS2, and DCSS3. DCSS2 is accessed in exclusive-writable mode.

```
# modprobe dcssblk segments="dcss1,dcss2(local),dcss3"
```

The following command loads the DCSS device driver and four DCSSs: DCSS4, DCSS5, DCSS6, and DCSS7. The device driver creates two DCSS devices. One device maps to DCSS4. The other device maps to the combined storage space of DCSS5, DCSS6, and DCSS7 as a single device.

```
# modprobe dcssblk segments="dcss4,dcss5:dcss6:dcss7"
```

Avoiding overlaps with your guest storage

Ensure that your DCSSs do not overlap with the memory of your z/VM guest virtual machine (guest storage).

About this task

To find the start and end addresses of the DCSSs, enter the following CP command; this command requires privilege class E:

```
#cp q nss map
```

the output gives you the start and end addresses of all defined DCSSs in units of 4-kilobyte pages:

```
00: FILE FILENAME FILETYPE MINSIZE BEGPAG ENDPAG TYPE CL #USERS PARMREGS VMGROUP
...
00: 0011 MONDCSS CPDCSS N/A 09000 097FF SC R 00003 N/A N/A
...
```

If all DCSSs that you intend to access are located above the guest storage, you do not need to take any action.

Procedure

If any DCSS that you intend to access with your guest machine overlaps with the guest storage, redefine the guest storage. Define two or more discontinuous storage extents such that the storage gap with the lowest address range covers the address ranges of all your DCSSs.

Note:

- You cannot place a DCSS into a storage gap other than the storage gap with the lowest address range.
- A z/VM guest that was defined with one or more storage gaps cannot access a DCSS above the guest storage.

From a CMS session, use the DEF STORE command to define your guest storage as discontinuous storage extents. Ensure that the storage gap between the extents covers all your DCSSs' address ranges. Issue a command of this form:

```
DEF STOR CONFIG 0.<storage_gap_begin> <storage_gap_end>.<storage above gap>
```

where:

<storage_gap_begin>

is the lower limit of the storage gap. This limit must be at or below the lowest address of the DCSS with the lowest address range.

Because the lower address ranges are needed for memory management functions, make the lower limit at least 128 MB. The lower limit for the DCSS increases with the total memory size. Although 128 MB is not an exact value, it is an approximation that is sufficient for most cases.

<storage_gap_end>

is the upper limit of the storage gap. The upper limit must be above the upper limit of the DCSS with the highest address range.

<storage above gap>

is the amount of storage above the storage gap. The total guest storage is <storage_gap_begin> + <storage above gap>.

All values can be suffixed with M to provide the values in megabyte. See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for more information about the DEF STORE command.

Example

To make a DCSS that starts at 144 MB and ends at 152 MB accessible to a z/VM guest with 512 MB guest storage:

```
DEF STORE CONFIG 0.140M 160M.372M
```

This specification is one example of how a suitable storage gap can be defined. In this example, the storage gap covers 140 - 160 MB and, thus, the entire DCSS range. The total guest storage is 140 MB + 372 MB = 512 MB.

Working with DCSS devices

Typical tasks for working with DCSS devices include mapping DCSS representations in z/VM and Linux, adding and removing DCSSs, and accessing and updating DCSS contents.

- [“Adding a DCSS device” on page 400](#)
- [“Listing the DCSSs that map to a particular device” on page 401](#)
- [“Finding the minor number for a DCSS device” on page 401](#)
- [“Setting the access mode” on page 402](#)
- [“Saving updates to a DCSS or set of DCSSs” on page 403](#)
- [“Workaround for saving DCSSs with optional properties” on page 403](#)
- [“Removing a DCSS device” on page 404](#)

Adding a DCSS device

Storage gaps or overlapping storage ranges can prevent you from adding a DCSS.

Before you begin

- You must have set up one or more DCSSs on z/VM and know their names on z/VM.
- If you use the watchdog device driver, turn off the watchdog before adding a DCSS device. Adding a DCSS device can result in a watchdog timeout if the watchdog is active.
- You cannot concurrently access overlapping DCSSs.
- You cannot access a DCSS that overlaps with your guest virtual storage (see [“Avoiding overlaps with your guest storage” on page 399](#)).
- On z/VM guest virtual machines with one or more storage gaps, you cannot add a DCSS that is above the guest storage.
- On z/VM guest virtual machines with multiple storage gaps, you cannot add a DCSS unless it fits in the storage gap with the lowest address range.

Procedure

To add a DCSS device enter a command of this form:

```
# echo <dcss-list> > /sys/devices/dcscblk/add
```

<dcss-list>

the name, as defined on z/VM, of a single DCSS or a colon (:) separated list of names of DCSSs to be mapped to a single DCSS device. You can map a set of DCSSs to a single DCSS device if the DCSSs in the set form a contiguous memory space. You can specify the DCSSs in any order. The name of the first DCSS you specify is used to represent the device under `/sys/devices/dcscblk`.

Examples

To add a DCSS called "MYDCSS" enter:

```
# echo MYDCSS > /sys/devices/dcscblk/add
```

To add three contiguous DCSSs "MYDCSS1", "MYDCSS2", and "MYDCSS3" as a single device, enter:

```
# echo MYDCSS2:MYDCSS1:MYDCSS3 > /sys/devices/dcscblk/add
```

In sysfs, the resulting device is represented as `/sys/devices/dcscblk/MYDCSS2`.

Listing the DCSSs that map to a particular device

Read the `seglist` sysfs attribute to find out how DCSS devices in Linux map to DCSSs as defined in z/VM.

Procedure

To list the DCSSs that map to a DCSS device, issue a command of this form:

```
# cat /sys/devices/dcscblk/<dcsc-name>/seglist
```

where `<dcsc-name>` is the DCSS name that represents the DCSS device.

Examples

In this example, DCSS device MYDCSS maps to a single DCSS, "MYDCSS".

```
# cat /sys/devices/dcscblk/MYDCSS/seglist
MYDCSS
```

In this example, DCSS device MYDCSS2 maps to three contiguous DCSSs, "MYDCSS1", "MYDCSS2", and "MYDCSS3".

```
# cat /sys/devices/dcscblk/MYDCSS2/seglist
MYDCSS2
MYDCSS1
MYDCSS3
```

Finding the minor number for a DCSS device

When you add a DCSS device, a minor number is assigned to it.

About this task

Unless you use dynamically created device nodes as provided by udev, you might need to know the minor device number that has been assigned to the DCSS (see [“DCSS naming scheme”](#) on page 397).

When you add a DCSS device, a directory of this form is created in sysfs:

```
/sys/devices/dcscblk/<dcsc-name>
```

where `<dcsc-name>` is the DCSS name that represents the DCSS device.

This directory contains a symbolic link, block, that helps you to find out the device name and minor number. The link is of the form `../../../../block/dcscblk<n>`, where `dcscblk<n>` is the device name and `<n>` is the minor number.

Example

To find out the minor number assigned to a DCSS device that is represented by the directory `/sys/devices/dcssblk/MYDCSS` issue:

```
# readlink /sys/devices/dcssblk/MYDCSS/block
../../../../block/dcssblk0
```

In the example, the assigned minor number is 0.

Setting the access mode

You might want to access the DCSS device with write access to change the content of the DCSS or set of DCSSs that map to the device.

About this task

There are two possible write access modes to the DCSS device:

shared

In the shared mode, changes to DCSSs are immediately visible to all z/VM guests that access them. Shared is the default.

Note: Writing to a shared DCSS device bears the same risks as writing to a shared disk.

exclusive-writable

In the exclusive-writable mode you write to private copies of DCSSs. A private copy is writable, even if the original DCSS is read-only. Changes that you make to a private copy are invisible to other guests until you save the changes (see [“Saving updates to a DCSS or set of DCSSs”](#) on page 403).

After saving the changes to a DCSS, all guests that open the DCSS access the changed copy. z/VM retains a copy of the original DCSS for those guests that continue accessing it, until the last guest stops using it.

To access a DCSS in the exclusive-writable mode, the maximum definable storage size of your z/VM virtual machine must be above the upper limit of the DCSS. Alternatively, suitable authorizations must be in place (see [“Accessing a DCSS in exclusive-writable mode”](#) on page 397).

For either access mode the changes are volatile until they are saved (see [“Saving updates to a DCSS or set of DCSSs”](#) on page 403).

Procedure

Issue a command of this form:

```
# echo <flag> > /sys/devices/dcssblk/<dcss-name>/shared
```

where `<dcss-name>` is the DCSS name that represents the DCSS device.

You can read the shared attribute to find out the current access mode.

Example

To find out the current access mode of a DCSS device represented by the DCSS name "MYDCSS":

```
# cat /sys/devices/dcssblk/MYDCSS/shared
1
```

1 means that the current access mode is shared. To set the access mode to exclusive-writable, issue:

```
# echo 0 > /sys/devices/dcssblk/MYDCSS/shared
```

Saving updates to a DCSS or set of DCSSs

Use the save sysfs attribute to save DCSSs that were defined without optional properties.

Before you begin

- Saving a DCSS as described in this section results in a default DCSS, without optional properties. For DCSSs that were defined with options (see “DCSS options” on page 398), see “Workaround for saving DCSSs with optional properties” on page 403.
- If you use the watchdog device driver, turn off the watchdog before saving updates to DCSSs. Saving updates to DCSSs can result in a watchdog timeout if the watchdog is active.
- Do not place save requests before you have accessed the DCSS device.

Procedure

Issue a command of this form:

```
# echo 1 > /sys/devices/dcssblk/<dcss-name>/save
```

where <dcss-name> is the DCSS name that represents the DCSS device.

Saving is delayed until you close the device.

You can check if a save request is waiting to be performed by reading the contents of the save attribute.

You can cancel a save request by writing 0 to the save attribute.

Examples

To check whether a save request exists for a DCSS device that is represented by the DCSS name "MYDCSS":

```
# cat /sys/devices/dcssblk/MYDCSS/save  
0
```

The 0 means that no save request exists. To place a save request issue:

```
# echo 1 > /sys/devices/dcssblk/MYDCSS/save
```

To purge an existing save request issue:

```
# echo 0 > /sys/devices/dcssblk/MYDCSS/save
```

Workaround for saving DCSSs with optional properties

If you need a DCSS that is defined with special options, you must use a workaround to save the DCSSs.

Before you begin

Important: This section applies to DCSSs with special options only. The workaround in this section is error-prone and requires utmost care. Erroneous parameter values for the described CP commands can render a DCSS unusable. Use this workaround only if you really need a DCSS with special options.

Procedure

Perform the following steps to save a DCSS with optional properties:

1. Unmount the DCSS.

Example: Enter this command to unmount a DCSS with the device node /dev/dcssblk0:

```
# umount /dev/dcssblk0
```

2. Use the CP DEFSEG command to newly define the DCSS with the required properties.

Example: Enter this command to newly define a DCSS, mydcss, with the range 80000-9ffff, segment type sr, and the loadnshr operand:

```
# vmcp defseg mydcss 80000-9ffff sr loadnshr
```

Note: If your DCSS device maps to multiple DCSSs as defined to z/VM, you must perform this step for each DCSS. Be sure to specify the command correctly with the correct address ranges and segment types. Incorrect specifications can render the DCSS unusable.

3. Use the CP SAVESEG command to save the DCSS.

Example: Enter this command to save a DCSS mydcss:

```
# vmcp saveseg mydcss
```

Note: If your DCSS device maps to multiple DCSSs as defined to z/VM, you must perform this step for each DCSS. Omitting this step for individual DCSSs can render the DCSS device unusable.

Reference

See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for details about the DEFSEG and SAVESEG CP commands.

Removing a DCSS device

Use the `remove sysfs` attribute to remove a DCSS from Linux.

Before you begin

A DCSS device can be removed only when it is not in use.

Procedure

You can remove the DCSS or set of DCSSs that are represented by a DCSS device from your Linux system by issuing a command of this form:

```
# echo <dcss-name> > /sys/devices/dcssblk/remove
```

where `<dcss-name>` is the DCSS name that represents the DCSS device.

Example

To remove a DCSS device that is represented by the DCSS name "MYDCSS" issue:

```
# echo MYDCSS > /sys/devices/dcssblk/remove
```

What to do next

If you have created your own device nodes, you can keep the nodes for reuse. Be aware that the major number of the device might change when you unload and reload the DCSS device driver. When the major number of your device has changed, existing nodes become unusable.

Scenario: Changing the contents of a DCSS

Before you change the contents of a DCSS, you must add the DCSS to Linux, access it in a writable mode, and mount the file system on it.

About this task

The scenario that follows is based on these assumptions:

- The Linux instance runs as a z/VM guest with class E user privileges.
- A DCSS was set up and can be accessed in exclusive-writable mode by the Linux instance.
- The DCSS does not overlap with the guest's main storage.
- There is only a single DCSS named "MYDCSS".
- The DCSS block device driver is set up and ready to be used.

The description in this scenario can readily be extended to changing the content of a set of DCSSs that form a contiguous memory space. The only change to the procedure would be mapping the DCSSs in the set to a single DCSS device in step "1" on page 405. The assumptions about the set of DCSSs would be:

- The contiguous memory space that is formed by the set does not overlap with the guest storage.
- Only the DCSSs in the set are added to the Linux instance.

Procedure

Perform the following steps to change the contents of a DCSS:

1. Add the DCSS to the block device driver.

```
# echo MYDCSS > /sys/devices/dcssblk/add
```

2. Ensure that there is a device node for the DCSS block device.

If it is not created for you, for example by udev, create it yourself.

- a) Find out the major number that is used for DCSS block devices. Read `/proc/devices`:

```
# cat /proc/devices
..
Block devices
..
254 dcssblk
..
```

The major number in the example is 254.

- b) Find out the minor number that is used for MYDCSS.

If MYDCSS is the first DCSS to be added, the minor number is 0. To be sure, you can read a symbolic link that is created when the DCSS is added.

```
# readlink /sys/devices/dcssblk/MYDCSS/block
../../../../block/dcssblk0
```

The trailing 0 in the standard device name `dcssblk0` indicates that the minor number is, indeed, 0.

- c) Create the node with the **mknod** command:

```
# mknod /dev/dcssblk0 b 254 0
```

3. Set the access mode to exclusive-write.

```
# echo 0 > /sys/devices/dcssblk/MYDCSS/shared
```

4. Mount the file system in the DCSS on a spare mount point.

```
# mount /dev/dcssblk0 /mnt
```

5. Update the data in the DCSS.
6. Create a save request to save the changes.

```
# echo 1 > /sys/devices/dcssblk/MYDCSS/save
```

7. Unmount the file system.

```
# umount /mnt
```

The changes to the DCSS are now saved. When the last z/VM guest stops accessing the old version of the DCSS, the old version is discarded. Each guest that opens the DCSS accesses the updated copy.

8. Remove the device.

```
# echo MYDCSS > /sys/devices/dcssblk/remove
```

9. Optional: If you have created your own device node, you can clean it up.

```
# rm -f /dev/dcssblk0
```

Chapter 40. z/VM CP interface device driver

z/VM only: The z/VM CP interface device driver applies to Linux on z/VM only.

Using the z/VM CP interface device driver (vmcp), you can send control program (CP) commands to the z/VM hypervisor and display the response.

The vmcp device driver works only for Linux on z/VM.

What you should know about the z/VM CP interface

The z/VM CP interface driver (vmcp) uses the CP diagnose X'08' to send commands to CP and to receive responses. The behavior is similar but not identical to #CP on a 3270 or 3215 console.

Using the z/VM CP interface

There are two ways of using the z/VM CP interface device driver:

- As a device node (usually /dev/vmcp)
- As a user space tool (see [“vmcp - Send CP commands to the z/VM hypervisor”](#) on page 670)

Differences between vmcp and a 3270 or 3215 console

Most CP commands behave identically with vmcp and on a 3270 or 3215 console. However, some commands show a different behavior:

- Diagnose X'08' (see *z/VM: CP Programming Services*, SC24-6272) requires you to specify a response buffer with the command. Because the response size is not known in advance, the default response buffer of vmcp might be too small and the response truncated.
- On a 3270 or 3215 console, the CP command is executed on virtual CPU 0. The vmcp device driver uses the CPU that is scheduled by the Linux kernel. For CP commands that depend on the CPU number (like trace), specify the CPU, for example: `cpu 3 trace count`.
- Some CP commands do not return specific error or status messages through diagnose X'08'. These messages are returned only on a 3270 or 3215 console. For example, the command `vmcp link user1 1234 123 mw` might return the message `DASD 123 LINKED R/W` in a 3270 or 3215 console. This message is not displayed if the CP command is issued with vmcp. For details, see the z/VM help system or *z/VM: CP Commands and Utilities Reference*, SC24-6268.

Using the device node

You can send a command to z/VM CP by writing to the vmcp device node.

Observe the following rules for writing to the device node:

- Omit the newline character at the end of the command string. For example, use `echo -n` if you are writing directly from a terminal session.
- Write the command in the same case as required on z/VM.
- Escape characters that need escaping in the environment where you issue the command.

Example

The following command attaches a device to your z/VM guest virtual machine. The asterisk (*) is escaped to prevent the command shell from interpreting it.

```
# echo -n ATTACH 1234 \* > /dev/vmcp
```

Application programmers

You can also use the vmcp device node directly from an application using open, write (to issue the command), read (to get the response), ioctl (to get and set status), and close. The following ioctls are supported:

Name	Code definition	Description
VMCP_GETCODE	_IOR (0x10, 1, int)	Queries the return code of z/VM.
VMCP_SETBUF	_IOW(0x10, 2, int)	Sets the buffer size (the device driver has a default of 4 KB; vmcp calls this ioctl to set it to 8 KB instead).
VMCP_GETSIZE	_IOR(0x10, 3, int)	Queries the size of the response.

Chapter 41. z/VM CP special messages uevent support

z/VM only: The z/VM CP special messages uevent support applies to Linux on z/VM only.

The `smsgiucv_app` kernel device driver receives z/VM CP special messages (SMSG) and delivers these messages to user space as udev events (uevents).

The device driver receives only messages that start with APP. The generated uevents contain the message sender and content as environment variables (see Figure 78 on page 409).

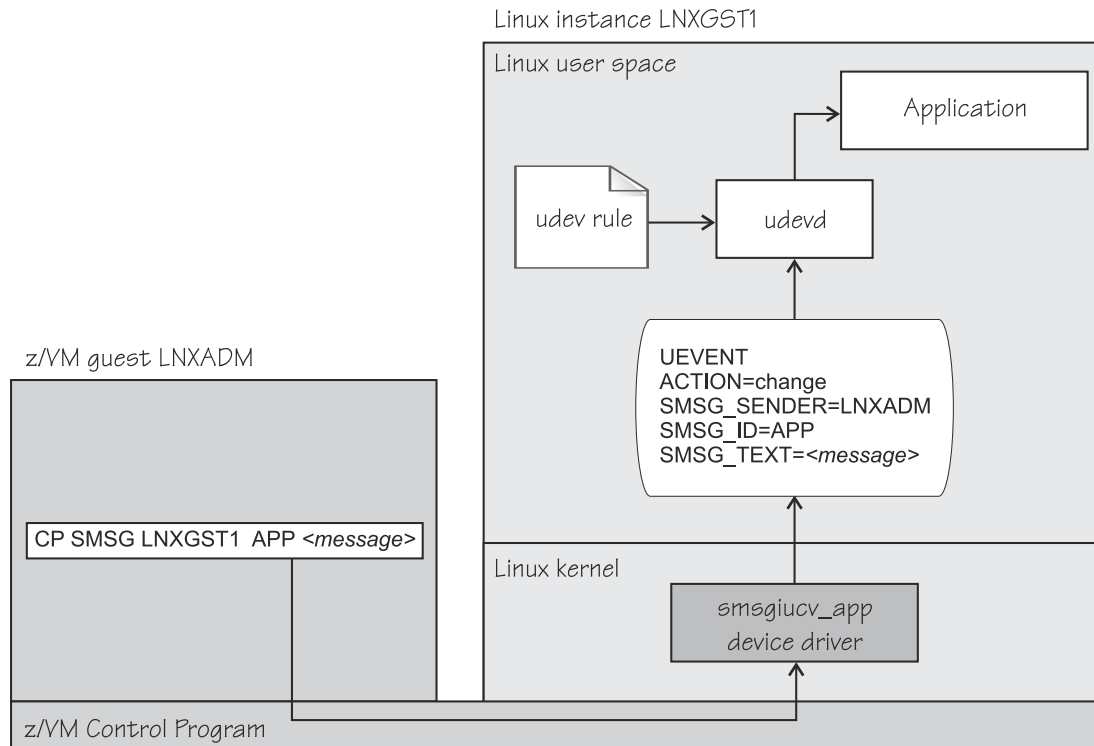


Figure 78. CP special messages as uevents in user space

You can restrict the received special messages to a particular z/VM user ID. CP special messages are discarded if the specified sender does not match the sender of the CP special message.

Setting up the CP special message device driver

Configure the CP special message device driver when you load the device driver module.

The z/VM user ID does not require special authorizations to receive CP special messages. CP special messages can be issued from the local z/VM guest virtual machine or from other guest virtual machines. You can issue special messages from Linux or from a CMS or CP session.

Load the device driver module with the **modprobe** command.

```

smsgiucv_app syntax
▶▶ modprobe — smsgiucv_app — sender= <user_ID>
    
```

Where:

sender = <user_ID>

permits CP special messages from the specified z/VM user ID only. CP special messages are discarded if the specified sender does not match the sender of the CP special message. If the **sender** option is empty or not set, CP special messages are accepted from any z/VM user ID.

Lowercase characters are converted to uppercase.

To receive messages from several user IDs leave the `sender=` parameter empty, or do not specify it, and then filter with udev rules (see [“Example udev rule”](#) on page 411).

Working with CP special messages

You might have to send, access, or respond to CP special messages.

- [“Sending CP special messages”](#) on page 410
- [“Accessing CP special messages through uevent environment variables”](#) on page 410
- [“Writing udev rules for handling CP special messages”](#) on page 410

Sending CP special messages

Issue a CP SMSG command from a CP or CMS session or from Linux to send a CP special message.

Procedure

To send a CP special message to LXGUEST1 from Linux, enter a command of the following form:

```
# vmcp SMSG LXGUEST1 APP "<message text>"
```

To send a CP special message to LXGUEST1, enter the following command from a CP or CMS session:

```
#CP SMSG LXGUEST1 APP <message text>
```

The special messages cause uevents to be generated. See [“Writing udev rules for handling CP special messages”](#) on page 410 for information about handling the uevents.

Accessing CP special messages through uevent environment variables

A uevent for a CP special message contains environment variables that you can use to access the message.

SMSG_ID

Specifies the message prefix. The SMSG_ID environment variable is always set to APP, which is the prefix that is assigned to the `msgiucv_app` device driver.

SMSG_SENDER

Specifies the z/VM user ID that sent the CP special message.

Use SMSG_SENDER in udev rules for filtering the z/VM user ID if you want to accept CP special messages from different senders. All alphabetic characters in the z/VM user ID are uppercase characters.

SMSG_TEXT

Contains the message text of the CP special message. The APP prefix and leading white spaces are removed.

Writing udev rules for handling CP special messages

When using the CP special messages device driver, CP special messages trigger uevents.

change events

The `smsgiucv_app` device driver generates change uevents for each CP special message that is received.

For example, the special message:

```
#CP SMSG LXGUEST1 APP THIS IS A TEST MESSAGE
```

might trigger the following uevent:

```
UEVENT[1263487666.708881] change /devices/iucv/smsgiucv_app (iucv)
ACTION=change
DEVPATH=/devices/iucv/smsgiucv_app
SUBSYSTEM=iucv
SMSG_SENDER=MAINT
SMSG_ID=APP
SMSG_TEXT=THIS IS A TEST MESSAGE
DRIVER=SMSGIUCV
SEQNUM=1493
```

add and remove events

In addition to the change event for received CP special messages, generic add and remove events are generated when the module is loaded or unloaded, for example:

```
UEVENT[1263487583.511146] add /module/smsgiucv_app (module)
ACTION=add
DEVPATH=/module/smsgiucv_app
SUBSYSTEM=module
SEQNUM=1487

UEVENT[1263487583.514622] add /devices/iucv/smsgiucv_app (iucv)
ACTION=add
DEVPATH=/devices/iucv/smsgiucv_app
SUBSYSTEM=iucv
DRIVER=SMSGIUCV
SEQNUM=1488

UEVENT[1263487628.955149] remove /devices/iucv/smsgiucv_app (iucv)
ACTION=remove
DEVPATH=/devices/iucv/smsgiucv_app
SUBSYSTEM=iucv
SEQNUM=1489

UEVENT[1263487628.957082] remove /module/smsgiucv_app (module)
ACTION=remove
DEVPATH=/module/smsgiucv_app
SUBSYSTEM=module
SEQNUM=1490
```

With the information from the uevents, you can create custom udev rules to trigger actions that depend on the settings of the `SMSG_*` environment variables (see [“Accessing CP special messages through uevent environment variables”](#) on page 410).

In your udev rules, use the add and remove uevents to initialize and clean up resources. To handle CP special messages, write udev rules that match change uevents. For more information about writing udev rules, see the udev man page.

Example udev rule

The udev rules that process CP special messages identify particular messages and define one or more specific actions as a response.

The following example shows how to process CP special messages by using udev rules. The example contains rules for actions, one for all senders and one for the MAINT, OPERATOR, and LNXADM senders only.

The rules are contained in a block that matches uevents from the `smsgiucv_app` device driver. If there is no match, processing ends:

```

#
# Sample udev rules for processing CP special messages.
#
#
DEVPATH!="*/smsgiucv_app", GOTO="smsgiucv_app_end"

# ----- Rules for CP messages go here -----

LABEL="smsgiucv_app_end"

```

The example uses the **vmur** command. If the vmur kernel module has been compiled as a separate module, this module must be loaded first. Then, the z/VM virtual punch device is activated.

```

# --- Initialization ---

# load vmur and set the virtual punch device online
SUBSYSTEM=="module", ACTION=="add", RUN+="/sbin/modprobe --quiet vmur"
SUBSYSTEM=="module", ACTION=="add", RUN+="/sbin/chccwdev -e d"

```

The following rule accepts messages from all senders. The message text must match the string UNAME. If it does, the output of the **uname** command (the node name and kernel version of the Linux instance) is sent back to the sender.

```

# --- Rules for all senders ----

# UNAME: tell the sender which kernel is running
ACTION=="change", ENV{SMSG_TEXT}=="UNAME", \
    PROGRAM=="/bin/uname -n -r", \
    RUN+="/sbin/vmcp msg $env{SMSG_SENDER} '$result'"

```

In the following example block rules are defined to accept messages from certain senders only. If no sender matches, processing ends. The message text must match the string DMESG. If it does, the environment variable PATH is set and the output of the **dmesg** command is sent into the z/VM reader of the sender. The name of the spool file is LINUX.DMESG.

```

# --- Special rules available for particular z/VM user IDs ---

ENV{SMSG_SENDER}!="MAINT|OPERATOR|LNxADM", GOTO="smsgiucv_app_end"

# DMESG: punch dmesg output to sender
ACTION=="change", ENV{SMSG_TEXT}=="DMESG", \
    ENV{PATH}="/bin:/sbin:/usr/bin:/usr/sbin", \
    RUN+="/bin/sh -c 'dmesg |fold -s -w 74 |vmur punch -r -t -N LINUX.DMESG -u $env{SMSG_SENDER}'"

```

Chapter 42. Cooperative memory management

z/VM only: Cooperative memory management applies to Linux on z/VM only.

Cooperative memory management (CMM, or "cmm1") can reduce the memory that is available to an instance of Linux on z/VM.

CMM allocates pages to page pools that are not available to Linux. A diagnose code indicates to z/VM that the pages in the page pools are out of use. z/VM can then immediately reuse these pages for other z/VM guests.

To set up CMM, you must set up a resource management tool that controls the page pools. This tool can be the z/VM resource monitor (VMRM) or a third-party systems management tool.

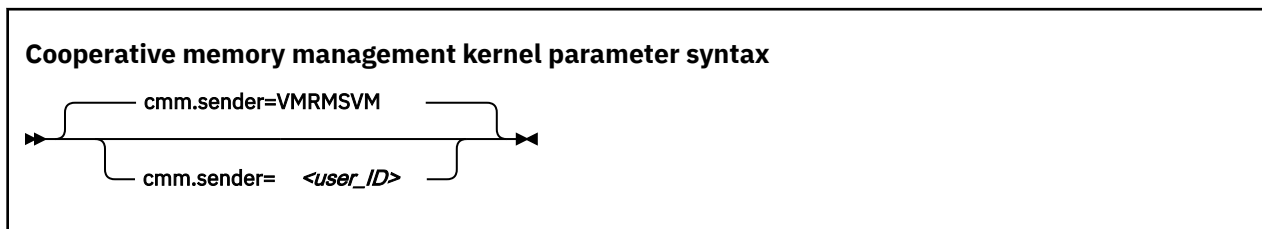
This chapter describes how to set up CMM. For background information about CMM, see [“Cooperative memory management background”](#) on page 368.

You can also use the **cpuplugd** command to define rules for cmm behavior, see [“cpuplugd - Control CPUs and memory”](#) on page 547.

For information about setting up the external resource manager, see the chapter on VMRM in *z/VM: Performance*, SC24-6301.

Setting up cooperative memory management

Setup Linux on z/VM to participate in cooperative memory management by adding the `cmm.sender=` parameter to the kernel parameter line.



where `<user_ID>` specifies the z/VM guest virtual machine that is permitted to send messages to the module through the special messages interface. The default z/VM user ID is VMRMSVM, which is the default for the VMRM service machine.

Lowercase characters are converted to uppercase.

Working with cooperative memory management

After it has been set up, CMM works through the resource manager. No further actions are necessary. You might want to read the sizes of the page pools for diagnostic purposes.

To reduce the Linux memory size, CMM allocates pages to page pools that make the pages unusable to Linux. There are two such page pools, a static pool and a timed pool. You can use the `procf`s interface to read the sizes of the page pools.

Reading the size of the static page pool

You can read the current size of the static page pool from `procf`s.

Procedure

Issue this command:

```
# cat /proc/sys/vm/cmm_pages
```

Reading the size of the timed page pool

You can read the current size of the timed page pool from `proctfs`.

Procedure

Issue this command:

```
# cat /proc/sys/vm/cmm_timed_pages
```

Part 7. KVM virtual server integration

KVM and LPAR: This part describes both Linux as a KVM guest and Linux as a KVM host.

These device drivers and features help you to effectively run and manage a KVM-based virtual Linux server farm.

Depending on your KVM host and on your virtual server configuration, a particular KVM guest might not provide all of the described features.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 43. KVM virtualization on IBM Z

KVM only: This chapter applies to Linux on KVM only.

Ubuntu Server 20.04.1 can run on the mainframe environment as virtualized by the KVM hypervisor.

Figure 79 on page 417 illustrates how the KVM hypervisor virtualizes the IBM Z resources for Linux on KVM.

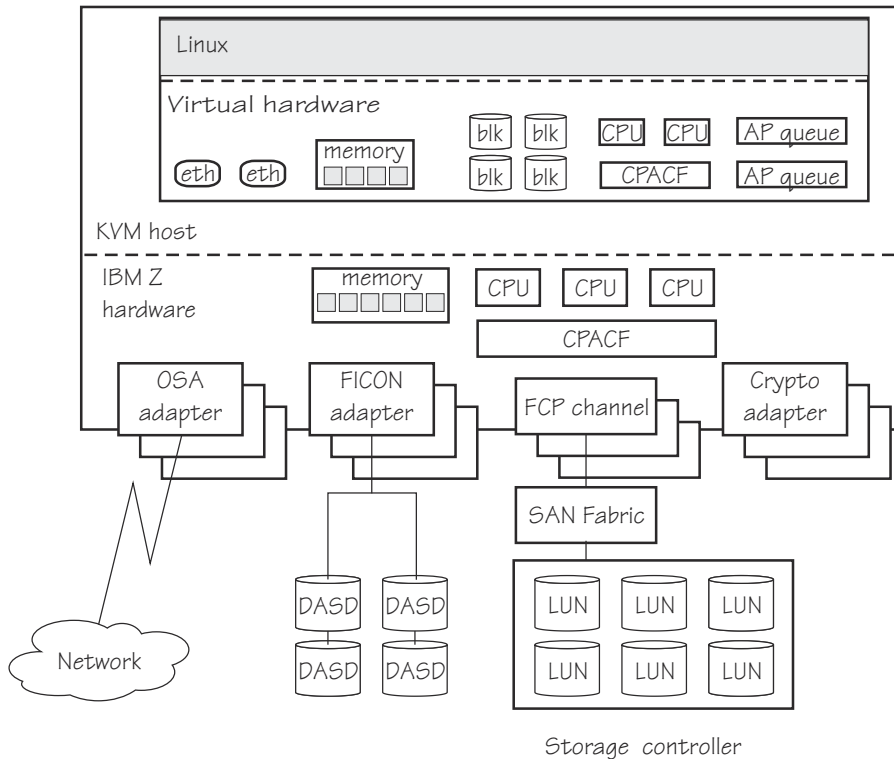


Figure 79. KVM virtualization

The KVM hypervisor defines the CPUs, memory, and virtual devices that are available to an instance of Linux on KVM when it is booted. It also specifies the host resources that back these guest resources.

The device virtualization hides most of the physical device aspects from the guest. A virtio-net network device could be backed on the host, for example, by a physical OSA device or an Open vSwitch configuration. Disk devices can be virtio-blk devices, although DASDs can also be pass-through devices with DASD attributes exposed to the KVM guest.

Both virtio-blk and virtio-net devices use the virtio framework. The virtio CCW transport device driver provides the interface to this framework and uses channel command words (CCW) to establish the virtio infrastructure.

Figure 80 on page 418 illustrates the virtio stack for Linux as a KVM guest on Z.

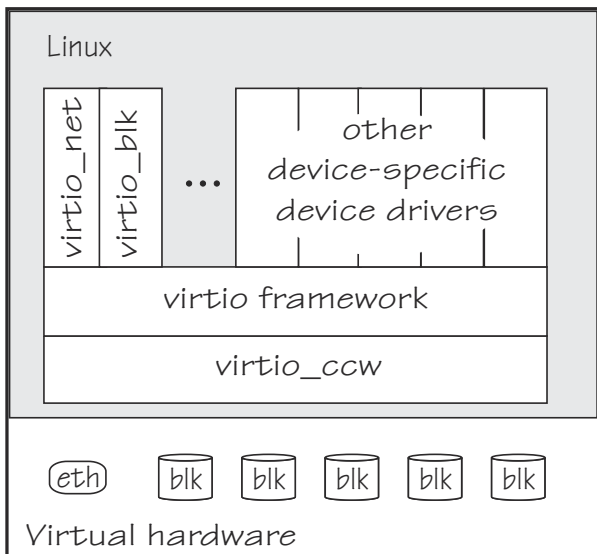


Figure 80. virtio stack

The hypervisor can dynamically add or remove devices. These changes result in hotplug events on the guest.

Linux on KVM versus Linux on z/VM or Linux in LPAR mode

If you are familiar with Linux on z/VM or with Linux in LPAR mode, you will observe some differences when working with Linux on Z as a KVM guest.

Starting and stopping Linux

The KVM hypervisor is the control point for IPL of Linux on KVM. You can initiate a reIPL from a running instance of Linux on KVM.

System dump

As for Linux in LPAR mode and for Linux on z/VM, you can use `kdump` as a dump tool.

Alternatively, you can initiate a dump on the host. These hypervisor-driven dumps are analogous to using `VMDUMP` for Linux on z/VM.

You cannot use the stand-alone dump tools to create a dump for Linux on KVM.

For more details, see [“Creating a kernel dump of a KVM guest” on page 513](#).

Responsibilities

Some of the administrative powers and responsibilities for the hardware that backs devices or provides access to devices are offloaded from the guest to the host.

Virtual channel subsystem

The KVM hypervisor provides a virtualized channel subsystem with virtual channel paths to its guests. CHPID 00 on this virtual channel subsystem is shared by all virtio-ccw devices, including virtio-net and virtio-blk devices. See [Chapter 44, “The virtual channel subsystem,” on page 421](#).

Storage devices

Expect to find generic block devices, which can be backed on the KVM host by SCSI disks, DASD, or even files in the host file system.

For these generic block devices, you cannot and need not configure any adapter hardware or physical disk devices. This preparation is done for you by the host.

There are no storage-class memory increments.

Network devices

Instead of groups of subchannels for various types of network devices, there are virtio-net devices for Ethernet interfaces.

You cannot and need not group subchannels into CCW group devices, configure network devices, or configure any adapter hardware. This setup is done for you by the host.

Linux as a KVM guest on Z versus distributed systems

If you are familiar with Linux as KVM guests on workstations, you will observe some differences when working with Linux as a KVM guest on Z.

Device drivers and the channel subsystem

All I/O to storage and network devices is handled by a virtual IBM Z channel subsystem and the virtio CCW transport device driver. Do not expect to find all device types that are common on workstations. For example, you will not find USB devices.

Cryptographic support

Linux as a KVM guest on Z can use the IBM Z CP Assist for Cryptographic Function (CPACF). If configured for your KVM virtual server, you can also use IBM Z cryptographic adapters (see [Part 8, “Security,” on page 443](#)).

Pass-through CCW devices

Linux as a KVM guest on Z might include CCW devices that the KVM hypervisor passes to the KVM guest with device characteristics exposed. For example, you might have one or more DASD, see [Chapter 11, “DASD device driver,” on page 111](#).

Live guest migration

In a live guest migration, the system programmer relocates a KVM virtual server with a running Linux instance from one KVM host to another without significantly disrupting operations.

Live guest migrations can help, for example, to avoid downtime during maintenance activities. A live guest migration can succeed only if both KVM hosts have access to equivalent resources. The hosts can but need not run on the same mainframe. The system programmer, who also initiates the migration, ensures that all preconditions are met.

If live migration is used at your installation, be sure not to block the migration. In particular:

- The virtual server configuration must not include any vfio_ap devices, which provide access to AP queues on cryptographic adapters.
- CCW and PCI pass-through devices must be detached before live migration.
- All tape device nodes must be closed and online tape drives must be unloaded.
- No program must be in a prolonged uninterruptible sleep state. Programs can assume this state while waiting for an outstanding I/O request to complete. Most I/O requests complete fast and do not compromise live guest migration. An example of an I/O request that can take too long to complete is rewinding a tape.

Linux as an IBM Secure Execution host or guest

IBM Secure Execution for Linux was introduced with IBM z15™ and LinuxONE III.

As a KVM host, Ubuntu Server can host KVM guests in IBM Secure Execution mode. As a KVM guest, Ubuntu Server itself can run in IBM Secure Execution mode.

You can create encrypted Ubuntu Server images that can run on a public, private or hybrid cloud with their in-use memory and state protected. This type of protection is more generally known as protection of data in-use.

You can modify a Linux instance to be able to act as an IBM Secure Execution host by booting it with the `prot_virt=1` kernel parameter. An IBM Secure Execution host must run in LPAR mode.

For details about setting up a KVM host and guests for secure execution, see *Introducing IBM Secure Execution for Linux*.

Chapter 44. The virtual channel subsystem

KVM only: The virtual channel subsystem is specific to Linux on KVM.

The KVM hypervisor provides a virtual channel subsystem with a subchannel, CHPID 00, for paravirtualized CCW devices.

This virtual channel subsystem connects paravirtualized CCW devices and pass-through CCW devices to the virtual server. In the virtual channel subsystem:

- All paravirtualized CCW devices have control unit type 3832/<nn>, where <nn> is a two-digit hexadecimal number that indicates the device type.
- All paravirtualized CCW devices use a single virtual channel path with CHPID 00. The availability of all paravirtualized CCW devices depends on this channel path being operational.

For general information about the channel subsystem, see *z/Architecture Principles of Operation*, SA22-7832.

Listing devices with lscss

The particulars of the channel subsystem view of a guest become visible when you list devices with **lscss**.

Example

```
# lscss
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs
-----
0.0.0042 0.0.0000 0000/00 3832/01 yes 80 80 ff 00000000 00000000
0.0.0815 0.0.0001 0000/00 3832/02 yes 80 80 ff 00000000 00000000
0.0.9999 0.0.0002 0000/00 3832/03 yes 80 80 ff 00000000 00000000
0.1.abcd 0.1.0000 0000/00 3832/05 yes 80 80 ff 00000000 00000000
...
0.1.6196 0.1.36e2 3390/0c 3990/e9 yes fc fc ff 32333435 40410000
...
```

As illustrated in the example, the output, typically, shows numerous paravirtualized CCW devices. The output columns DevType, PIM, PAM, POM, and CHPIDs show identical values for these devices. These values result from the virtualization and carry no information that is characteristic for a particular device.

The output of the example also includes a pass-through DASD, with device type 3390/0c, for which all fields provide device-characteristic information.

The following columns contain meaningful device information for paravirtualized CCW devices:

Device

is the device bus-ID that uniquely identifies a device to the guest and to the KVM hypervisor.

Use device bus-IDs to identify devices to the KVM hypervisor administrator. The KVM hypervisor defines these bus-IDs with prefix fe instead of 0. For example, 0.0.0042 on the guest is specified as fe.0.0042 in the virtual server configuration on the KVM hypervisor.

Device bus-IDs are persistent across reboots and change only if the device definitions are changed in the KVM hypervisor.

Subchan.

shows the current assignment of a subchannel to the device.

In contrast to the persistent device bus-IDs, subchannel assignments to devices might change across reboots or as a result of hotplug events.

CU Type

has a two-digit suffix that identifies the device type.

For example, 01 in 3832/01 identifies a network device and 02 in 3832/02 identifies a block device. For more information, see [“Types of paravirtualized CCW devices” on page 422](#).

Use

indicates whether the device is online.

Types of paravirtualized CCW devices

For Linux as a KVM guest on Z, paravirtualized CCW devices can represent various real and virtual devices, including block devices, network devices, and devices that are attached through a virtual SCSI HBA.

Table 56 on page 422 explains the values that are shown in the CU Type column of the **lscss** command. Which of these devices are present on a particular KVM guest depends on the virtual server configuration on the KVM hypervisor.

<i>Table 56. Types of CCW devices</i>	
CU Type/Model	Explanation
3832/01	<p>Network device</p> <p>The corresponding device bus-ID represents a network interface on the guest. The details of the interface are hidden by the KVM hypervisor. On the KVM hypervisor, this interface might be based on a MacVTap interface or a virtual switch.</p> <p>Network devices are handled by the <code>virtio_net</code> device driver module. See “Virtual network devices” on page 428 for details.</p>
3832/02	<p>Block device</p> <p>The corresponding device bus-ID represents a persistent storage space to the guest. The details of the block device are hidden by the KVM hypervisor. To the KVM hypervisor, this storage space might be a SCSI LUN or a DASD, but it might also be a file in the file system of the host or any other block device.</p> <p>Block devices are handled by the <code>virtio_blk</code> device driver module. See “Virtual block devices” on page 426 for details.</p>
3832/03	<p>Character device for console output. See “Using virsh on a KVM host” on page 38.</p>
3832/04	<p>Random number generator device</p> <p>Depending on the configuration of your virtual server by the KVM hypervisor, this device might be backed by IBM Z cryptographic hardware.</p> <p>This device provides sufficient random numbers of good quality only if the random device of KVM host does so. In particular, this devices provides true random numbers only if it is backed by a true random number generator on the KVM host.</p> <p>This device is provided by the <code>virtio_rng</code> device driver module.</p>
3832/05	<p>Balloon device for memory management.</p> <p>The preferred memory management technology is Collaborative Memory Management Assist (CMTA). See “cmta - Reduce hypervisor paging I/O overhead” on page 702.</p>

Table 56. Types of CCW devices (continued)

CU Type/Model	Explanation
3832/08	<p>Virtual SCSI HBA</p> <p>SCSI devices can be attached through a virtual SCSI host bus adapter (HBA) and are then handled by the <code>virtio_scsi</code> device driver module. For example, the following devices are attached through a virtual SCSI HBA:</p> <ul style="list-style-type: none"> • SCSI tapes (see “Virtual SCSI-attached tape devices” on page 429) • Virtual CD/DVD drives (see “Virtual SCSI-attached CD/DVD drives” on page 431) <p>Host devices need not necessarily be attached through a virtual SCSI HBA. For example, SCSI-attached disks are usually virtualized as block devices and handled by the <code>virtio_blk</code> device driver module.</p>
3832/10	<p>Virtual graphics processing unit (GPU). Supports remote access to graphical user interfaces. GPU devices are handled by the <code>virtio_gpu</code> device driver module.</p>
3832/12	<p>Virtual human interface devices, like a virtual keyboard and a virtual mouse, as remote input devices for graphical user interfaces. These devices are handled by the <code>virtio_input</code> device driver module.</p>

Listing channel paths with `lschp`

Linux as a KVM guest on Z includes a channel path, with CHPID 00, for paravirtualized CCW devices.

The virtual channel subsystem always provides the same single channel path for all paravirtualized CCW devices to the guest. The following sample output for `lschp` shows this channel path:

```
# lschp
CHPID Vary Cfg. Type Cmg Shared PCHID
=====
0.00 1 - 32 - 0 -
```



Attention: Setting this channel path logically offline would make all paravirtualized CCW devices inaccessible to the guest. As a consequence, the system is likely to crash.

Depending on the presence of pass-through CCW devices, there can also be output lines for other devices.

Chapter 45. The virtio CCW transport device driver

KVM only: The virtio CCW transport device driver applies to Linux on KVM only.

The virtio CCW transport device driver handles the virtual channel command word (CCW) devices that are provided by the KVM hypervisor.

Virtual CCW devices are accessed through a virtual channel subsystem, see [Chapter 44, “The virtual channel subsystem,”](#) on page 421.

The virtio CCW transport device driver is part of a module stack that also includes device drivers for handling particular device types. If a module is not loaded automatically, you must load it before you can work with the corresponding devices. Loading a supporting module with the **modprobe** command automatically loads the base module if needed.

Virtio devices

The KVM hypervisor hides some of the specifics of the devices it virtualizes. For example, the hypervisor can virtualize both disk devices and plain files in the host file system as block devices. The KVM guest cannot differentiate block devices according to their nature on the host.

As a user of Linux on KVM, you must work with the virtual devices at the abstraction level with which they are presented. You cannot perform all actions against virtual devices that you can perform against real devices.

Setting CCW devices offline or online

By default, all virtio CCW devices are online after an instance of Linux as a KVM guest on Z is booted.

About this task

If the KVM hypervisor defines unnecessary devices to your Linux instance, you can set them offline.

Tip: You can also use the `cio_ignore=` kernel parameter to prevent unnecessary devices from being sensed in the first place (see [“cio_ignore - List devices to be ignored”](#) on page 698).

Procedure

Use the **chccwdev** command to set block devices offline or online.

For example, to set a block device with bus ID `0.0.0815` offline, issue:

```
# chccwdev -d 0.0.0815
```

To set this device back online, issue:

```
# chccwdev -e 0.0.0815
```

Alternatively, you can write `0` (offline) or `1` (online) to the `online` sysfs attribute of the device.

Example

To set the device offline, issue:

```
# echo 0 > /sys/bus/ccw/drivers/virtio_ccw/0.0.0815/online
```

Virtual block devices

On Linux as a KVM guest on Z, you can use generic virtual block devices, for example, paravirtualized DASDs or SCSI LUNs.

These virtual block devices are handled by the `virtio_blk` device driver module. This module is loaded automatically by Ubuntu Server 20.04.1 during the boot process.

A virtual block device might be backed by a disk device, but it might also be backed by a file on the hypervisor. Do not perform operations that require knowledge of the specific hardware that backs a virtual block device. For example, do not attempt to run a low-level formatting operation on a virtual block device.

Block device naming-scheme

Applications access block devices through device nodes. The `virtio-blk` device driver uses 16 device nodes for each block device: one for the block device itself and 15 for partitions.

The standard device nodes are of the form:

- `/dev/vd<x>` for the block device
- `/dev/vd<x><n>` for partitions

where

<x>

represents one or more alphabetic characters; `vd<x>` matches the device name that is used by the `virtio-blk` device driver.

<n>

is an integer in the range 1-15.

All of these nodes use the same major number. You can find the major number by issuing the following command:

```
# cat /proc/devices | grep virtblk
```

Table 57. Naming scheme for virtio block devices

Name that is used by the device driver	Standard device node	Minor number	Description
vda vda1 vda2 ... vda15	/dev/vda /dev/vda1 /dev/vda2 ... /dev/vda15	0 1 2 ... 15	First block device and up to 15 partitions
vdb vdb1 vdb2 ... vdb15	/dev/vdb /dev/vdb1 /dev/vdb2 ... /dev/vdb15	16 17 18 ... 31	Second block device and up to 15 partitions
vd<x> vd<x>1 vd<x>2 ... vd<x>15	/dev/vd<x> /dev/vd<x>1 /dev/vd<x>2 ... /dev/vd<x>15	(<m>-1)×16 (<m>-1)×16+1 (<m>-1)×16+2 ... (<m>-1)×16+15	<m>-th block device with up to 15 partitions

With 1,048,576 (20-bit) available minor numbers, the `virtio-blk` device driver can address 65,536 block devices and their partitions. For the first 26 devices, `<x>` is one alphabetic character (vda-vdz). The next devices use first two (vdAA-vdZZ) and then more alphabetic characters.

The mapping of standard device nodes to bus-IDs can change when Linux is rebooted or when hotplug events occur. Your distribution might provide udev rules that create other nodes to attain a persistent mapping between device nodes and bus-IDs.

Mapping block devices to CCW devices

For each virtual block device, there is a corresponding online CCW device.

To list the device nodes for your block devices, issue:

```
# ls /sys/block
```

The command output is a list of symbolic links that match the device names of the block devices.

Example:

```
# ls /sys/block
vda      vdb      vdc
```

These links contain several attributes, including another symbolic link, `device`. To find the bus ID for a particular block device, issue a command according to the following example:

Example:

```
# ls -l /sys/block/vdb/device/../../ | head -1
0.0.1111
```

Tip: For an overview of the mapping, issue this command:

```
# ls -d /sys/devices/css0/*/*/virtio*/block/*
```

Example:

```
# ls -d /sys/devices/css0/*/*/virtio*/block/*
/sys/devices/css0/0.0.0000/0.0.10b1/virtio3/block/vda
/sys/devices/css0/0.0.0001/0.0.1111/virtio4/block/vdb
/sys/devices/css0/0.0.0002/0.0.11ab/virtio5/block/vdc
```

You can pipe the output to **awk** to obtain a more compact view:

```
# ls -d /sys/devices/css0/*/*/virtio*/block/* | awk -F "/" '{print $9 "\t" $6}'
vda      0.0.10b1
vdb      0.0.1111
vdc      0.0.11ab
```

Partitioning virtual block devices

How to partition a block device depends on how the device is backed on the host, DASD or other.

Before you begin: Virtual block devices must be partitioned from the KVM host. From the guest, you cannot find out how a block device is backed on the host.

DASD backed block devices

Use the **fdasd** command to create up to 3 partitions. For details, see [“fdasd - Partition a DASD” on page 574](#) or the **fdasd** man page

All other block devices

Use the common code **fdisk** command to create up to 15 partitions. For details, see the **fdisk** man page.

Alternatively, you can use the **parted** command to create partitions. The **parted** command can handle both DASD-backed and other block devices. For details, see the **parted** man page.

The partitions of a block device are represented as subdirectories of the device representation in `/sys/block`. For example, you can list the existing partitions of a block device `/sys/block/vda` by issuing:

```
# ls /sys/block/vda
```

Virtual network devices

On Linux as a KVM guest on Z, you use generic network devices for Ethernet interfaces.

Interface names

Ubuntu Server 20.04.1 uses interface names of the form `eth<n>`, where `<n>` is an index number that identifies an individual interface.

Tip: Use `ip link` to display a summary of your interfaces.

Mapping interfaces to CCW devices

If you define multiple interfaces on a Linux instance, you need to keep track of the interface names assigned to your CCW network devices.

After setting a device online, read `/var/log/messages` or issue `dmesg` to find the associated interface name in the messages that are issued in response to the device being set online.

To list the network interfaces, issue:

```
# ls /sys/class/net
```

The command output is a list of symbolic links that match the interface names. There is an interface for each network device that is online.

Example:

```
# ls /sys/class/net
eth0    eth1
```

For each network device that is online, there is a symbolic link of the form `/sys/class/net/<interface>/device` where `<interface>` is the interface name. To find the device bus-ID for a particular interface, issue a command according to the following example:

Example:

```
# ls -l /sys/class/net/eth0/device/../../ | head -1
0.0.f500
```

Tip: Issue the following command to obtain a mapping of network devices to interface names.

```
# ls -d /sys/devices/css0/*/*/virtio*/net/*
```

Example:

```
# ls -d /sys/devices/css0/*/*/virtio*/net/*
/sys/devices/css0/0.0.0001/0.0.f500/virtio0/net/eth0
/sys/devices/css0/0.0.0002/0.0.1ed0/virtio1/net/eth1
```

You can pipe the command output to `awk` to obtain a more compact view:

```
# ls -d /sys/devices/css0/*/*/virtio*/net/* | awk -F "/" '{print $9 "\t" $6}'
eth0    0.0.f500
eth1    0.0.1ed0
```

Activating an interface

Use **ip** or an equivalent command to activate an interface.

Example:

```
# ip addr 192.0.2.5 dev eth0 peer 192.0.2.6
```

Virtual SCSI-attached tape devices

The representation of virtual SCSI-attached tape and medium changer devices on Linux as a KVM guest on Z depends on your device driver.

st

The **st** device driver for SCSI tape drives is included in the Linux kernel source from kernel.org.

For each device, **st** provides device nodes of the form `/dev/st<i><x>` and `/dev/nst<i><x>` where the latter is for non-rewinding devices, where

<x>

is an alphabetic character that specifies a tape property, for example, compression or encryption.

<i>

identifies an individual device.

The identifier, `<i>`, is assigned when Linux is booted or when a device is set online. As a result, there is no fixed mapping between a physical tape device and the tape device nodes. For details, see the **st** man page.

ch

The **ch** device driver for SCSI medium changers is included in the Linux kernel source from kernel.org.

For each device, **ch** provides device nodes of the form `/dev/sch<i>` where `<i>` identifies an individual device.

The identifier, `<i>`, is assigned when Linux is booted or when a device is set online. As a result, there is no fixed mapping between physical media changer devices and the media changer device nodes. For details, see `Documentation/scsi/scsi-changer.txt` in the Linux source code.

lin_tape

The **lin_tape** device driver is available from the IBM Fix Central site at www.ibm.com/support/fixcentral. For details about downloading the device driver, see Technote 1428656.

The device nodes that it provides include characteristics of the physical tape drive or medium changer and are persistent across reboots and after setting a tape device offline and back online. For details, see *IBM Tape Device Drivers Installation and User's Guide*, GC27-2130.

Listing your tape devices

Use the **lsscsi** command with the `-v` option to list all your SCSI-attached devices, including SCSI-attached tape and medium changer devices. You can also use the **lstape** command to list tape and medium changer devices.

Example:

```
# lsscsi -v
[0:0:0:0] tape IBM ULT3580-TD6 H990 /dev/st0
dir: /sys/bus/scsi/devices/0:0:0:0 \
[/sys/devices/css0/0.0.0000/0.0.0003/virtio2/host0/target0:0:0/0:0:0:0]
[0:0:0:1] mediumx IBM 3573-TL E.80 /dev/sch0
dir: /sys/bus/scsi/devices/0:0:0:1 \
[/sys/devices/css0/0.0.0000/0.0.0003/virtio2/host0/target0:0:0/0:0:0:1]
[0:0:1:0] tape IBM ULT3580-TD6 H990 /dev/st1
dir: /sys/bus/scsi/devices/0:0:1:0 \
[/sys/devices/css0/0.0.0000/0.0.0003/virtio2/host0/target0:0:1/0:0:1:0]
[0:0:1:1] mediumx IBM 3573-TL E.80 /dev/sch1
dir: /sys/bus/scsi/devices/0:0:1:1 \
[/sys/devices/css0/0.0.0000/0.0.0003/virtio2/host0/target0:0:1/0:0:1:1]
[1:0:0:0] tape IBM ULT3580-TD6 H990 /dev/st3
dir: /sys/bus/scsi/devices/1:0:0:0 \
[/sys/devices/css0/0.0.0001/0.0.0004/virtio5/host1/target1:0:0/1:0:0:0]
[1:0:0:1] mediumx IBM 3573-TL E.80 /dev/sch3
dir: /sys/bus/scsi/devices/1:0:0:1 \
[/sys/devices/css0/0.0.0001/0.0.0004/virtio5/host1/target1:0:0/1:0:0:1]
[1:0:1:0] tape IBM ULT3580-TD6 H990 /dev/st2
dir: /sys/bus/scsi/devices/1:0:1:0 \
[/sys/devices/css0/0.0.0001/0.0.0004/virtio5/host1/target1:0:1/1:0:1:0]
[1:0:1:1] mediumx IBM 3573-TL E.80 /dev/sch2
dir: /sys/bus/scsi/devices/1:0:1:1 \
[/sys/devices/css0/0.0.0001/0.0.0004/virtio5/host1/target1:0:1/1:0:1:1]
```

The output includes the device node as used by the `st` or `ch` device driver and the SCSI device name of the form `<scsi_host_no>:<scsi_id>:<scsi_lun>`, `0:0:0:0` for `/dev/st0` in the example.

If the devices are handled by `lin_tape` instead of `st` or `ch`, `lsscsi` cannot determine the device node name and displays "-" instead.

The sysfs path in the output includes two bus IDs:

- The first bus ID, from left to right, applies to the subchannel
- The second bus ID applies to the virtual SCSI host bus adapter (HBA)

The two bus IDs can but do not need to be the same. In the example, the HBA device bus-ID for `/dev/st0` is `0.0.0003`.

The following `lstape` output for the same device setup assumes that the devices are managed by the `lin_tape` device driver instead of `st` and `ch`. The `lstape` output also shows the generic device name, `sg<x>`, that is assigned by the SCSI generic device driver, `sg`.

```
# lstape --verbose
FICON/ESCON tapes (found 0):
TapeNo BusID CuType/Model DevType/Model BlkSize State Op MedState
SCSI tape devices (found 8):
Generic Device Target Vendor Model Type State
sg0 IBMtape0 0:0:0:0 IBM ULT3580-TD6 tapedrv running
0.0.0003 N/A 10WT037733
sg1 IBMchanger0 0:0:0:1 IBM 3573-TL changer running
0.0.0003 N/A 00L4U78W6497_LL0
sg3 IBMtape1 0:0:1:0 IBM ULT3580-TD6 tapedrv running
0.0.0003 N/A 10WT037701
sg2 IBMchanger1 0:0:1:1 IBM 3573-TL changer running
0.0.0003 N/A 00L4U78W6497_LL0
sg6 IBMtape3 1:0:0:0 IBM ULT3580-TD6 tapedrv running
0.0.0004 N/A 10WT037733
sg7 IBMchanger3 1:0:0:1 IBM 3573-TL changer running
0.0.0004 N/A 00L4U78W6497_LL0
sg4 IBMtape2 1:0:1:0 IBM ULT3580-TD6 tapedrv running
0.0.0004 N/A 10WT037701
sg5 IBMchanger2 1:0:1:1 IBM 3573-TL changer running
0.0.0004 N/A 00L4U78W6497_LL0
```

Use the SCSI device name and the device bus-ID to communicate about the devices with the hypervisor administrator.

Virtual SCSI-attached CD/DVD drives

The KVM hypervisor might provide virtual SCSI-attached CD/DVD drives to your KVM guest.

Virtual SCSI-attached CD/DVD drives have device nodes of the form `/dev/sr<n>`, where `<n>` is an integer that identifies an individual device. The node for the first drive is `/dev/sr0`.

Issue the following command to list all device nodes for CD/DVD drives:

```
# ls /dev/sr*
```

You can also use the **lsscsi** command to list all your SCSI-attached devices, including SCSI-attached CD/DVD drives.

```
# lsscsi
[0:0:0:0]    cd/dvd  QEMU      QEMU CD-ROM    2.3.  /dev/sr0
```

You can use the **isoinfo** command with the `-i` option to find out if a drive contains media.

Example:

```
# isoinfo -i /dev/sr0
```

This command returns an error if no media is present.

You can use the **mount** command to mount the content of media in the drive on the file system.

Example:

```
# mount /dev/sr0 /mnt/media
```

Unmount the content of the media to release it.

Example:

```
# umount /dev/sr0
```

You depend on the KVM hypervisor to eject and insert media.

Chapter 46. Setting up Ubuntu Server 20.04.1 as a KVM host

LPAR or KVM: KVM hosts can run in LPAR mode or they can be nested hosts that run as KVM guests. A KVM host has hardware and user space requirements.

Hardware

The real or virtual hardware must provide the Start Interpretive Execution (SIE) feature (see [“Check whether the Linux instance can be a hypervisor”](#) on page 507).

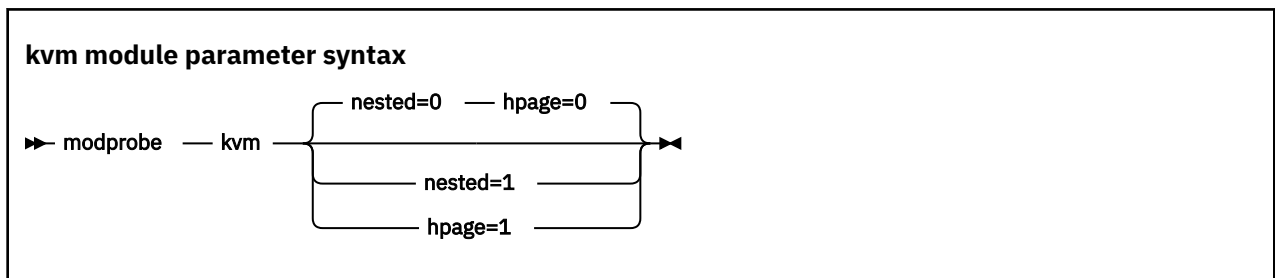
User space

You must install the packages for QEMU and libvirt. For example, use apt:

```
$ apt install qemu-kvm libvirt-daemon-system libvirt-clients
```

Module parameters

Configure the KVM host support with module parameters.



nested=

If set to "1", passes the SIE capability on to its guests. Thus, the guests can be hosts for higher-level guests.

Nested KVM hosts are intended for test environments and not for production systems.

hpage=

If set to "1", supports guest-configurations with huge-page memory backing.

Enough 1 MB huge pages must be set up to satisfy the needs of the guests. For details about setting up huge pages, see [Chapter 25, “Huge-page support,”](#) on page 327.

Consider making this setting persistent, for example, through a modprobe configuration file or by specifying `kvm.hpage=1` on the kernel parameter line.

Nested hosts cannot back their guests with huge pages. You cannot set both `nested=` and `hpage=` to 1.

Chapter 47. Setting up a KVM host for VFIO pass-through

LPAR or KVM: KVM hosts can run in LPAR mode or they can be nested hosts that run as KVM guests.

KVM hosts can use the Virtual Function I/O (VFIO) framework and the VFIO mediated device framework to pass host devices with their attributes through to their KVM guests.

For general information about VFIO and VFIO mediated devices, see `Documentation/vfio.txt` and `Documentation/vfio-mediated-device.txt` in the Linux kernel source. You can also find this information by searching for "vfio" at www.kernel.org/doc/html/latest/search.html.

What you should know about VFIO

Depending on the device type, Linux handles devices with specific device drivers.

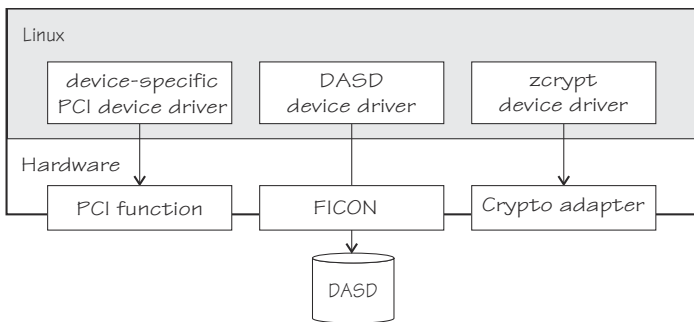


Figure 81. Device drivers on Linux

For Linux on KVM, QEMU provides virtual VFIO pass-through devices that preserve the host-device attributes. Therefore, Linux on KVM accesses a pass-through device with the same device driver that the host would use to access the corresponding host resource. For example, Linux in LPAR mode uses the DASD device driver to access DASDs. Correspondingly, Linux on KVM uses the DASD device driver to access VFIO pass-through DASDs.

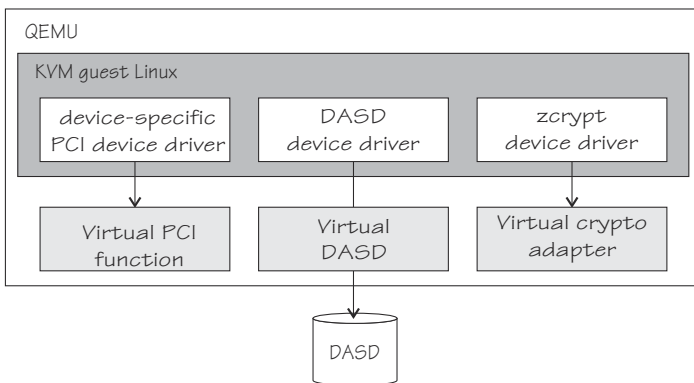


Figure 82. Device drivers for VFIO pass-through devices

To avoid contention, a KVM host must relinquish direct control of the host resource that backs a VFIO pass-through device. For these host resources, the VFIO framework substitutes the default device drivers on the KVM host with device-specific VFIO device drivers. These substitute device drivers reserve host resources for guest use and provide access to these resources on behalf of the guest.

On Z, the KVM hypervisor supports the following types of pass-through devices:

- PCIe

- CCW (DASD)
- Cryptographic adapter resources (AP queues)

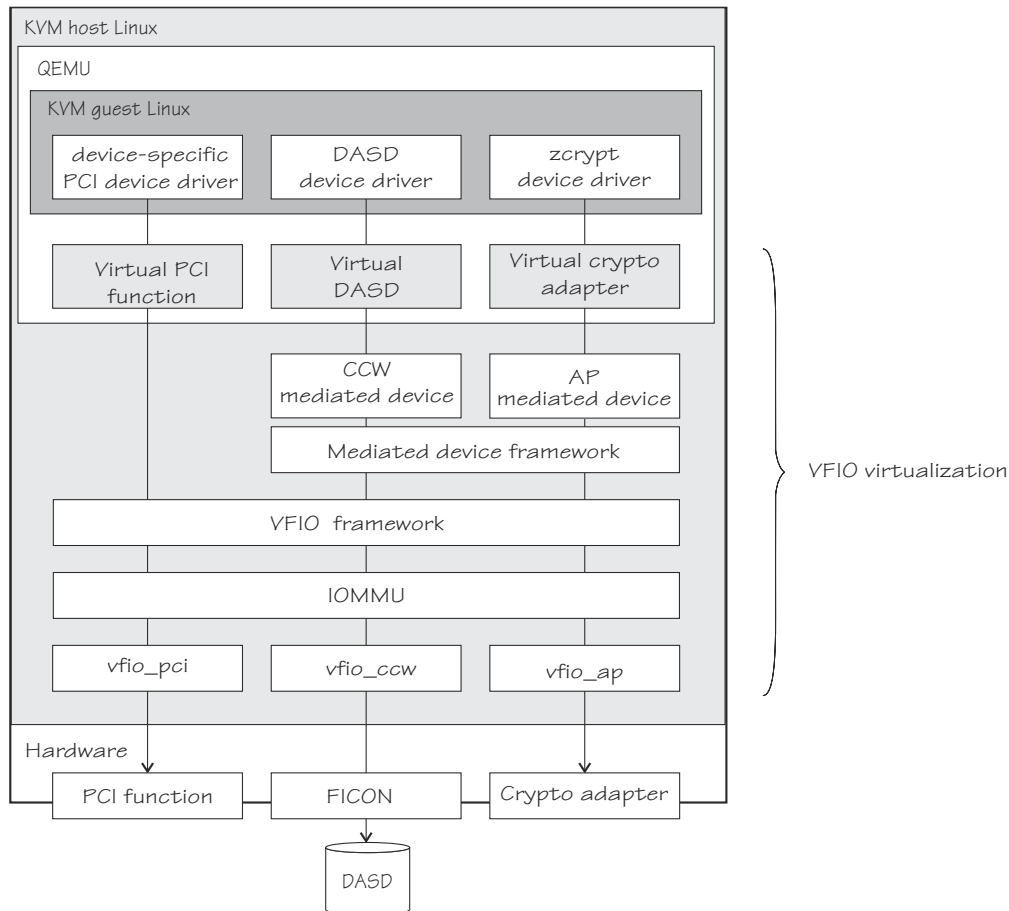


Figure 83. VFIO virtualization

On the host, you must define the resources that back a VFIO pass-through device and associate these resources with the applicable VFIO device driver. The necessary configuration steps depend on the device type. For pass-through DASD and pass-through cryptographic adapter resources, you must create specific VFIO mediated devices. The KVM hypervisor then uses VFIO mediated devices as a source for pass-through devices.

For configuration details, see [“Host setup for VFIO pass-through devices”](#) on page 436.

Host setup for VFIO pass-through devices

You must ensure that a VFIO device driver controls the resource on the host.

About this task

The VFIO device driver reserves the pass-through device for KVM guests and accesses the corresponding host resource on behalf of the guest.

Procedure

Although the details differ considerably by device type, the following main steps apply to all VFIO pass-through devices:

1. Free the resource from control of the default device driver ([“Freeing host resources from the default device drivers”](#) on page 437).
2. Associate the resource with the corresponding VFIO device driver. See:

- [“Assigning DASDs to vfio_ccw” on page 438](#)
- [“Assigning PCI devices to vfio_pci” on page 439](#)
- [“Assigning cryptographic adapter resources to vfio_ap” on page 439](#)

What to do next

After completing the host setup for a VFIO pass-through device, you can configure the device for a KVM guest (see *KVM Virtual Server Management*, SC34-2752).

Freeing host resources from the default device drivers

Proceed according to your type of pass-through device.

DASD

Write the bus ID of the DASD to the `unbind` attribute of its device driver module. Then, write the bus ID of the subchannel to the `unbind` attribute the subchannel device driver.

```
# echo <device_bus_id> > /sys/bus/ccw/drivers/dasd-eckd/unbind
# echo <subchannel_bus_id> > /sys/bus/css/devices/<subchannel_bus_id>/driver/unbind
```

Tip: Use the `lscss` command to obtain a mapping of device bus IDs and subchannel IDs.

Example: In this example, a DASD with bus ID `0.0.3000` is freed from the `dasd-eckd` device driver.

```
# lscss -d 0.0.3000
Device   Subchan.  DevType CU Type Use PIM PAM POM CHPIDs
-----
0.0.3000 0.0.0004 3390/0A 3990/E9 YES C0 C0 FF 34400000 00000000
# echo 0.0.3000 > /sys/bus/ccw/drivers/dasd-eckd/unbind
# echo 0.0.0004 > /sys/bus/css/devices/0.0.0004/driver/unbind
```

PCIe devices

Before you begin: PCI devices can be configured for automatic management by libvirt (see the information about configuring VFIO pass-through devices in *KVM Virtual Server Management*, SC34-2752). This management includes a dynamic host preparation. Perform the steps that follow only for devices that are not managed by libvirt.

Write the function address of the PCIe device to the `unbind` attribute of its device driver.

```
# echo <function_address> > /sys/bus/pci/drivers/<pci_device_driver>/unbind
```

Tip: Issue `lspci -v` to find out which device driver controls the device of interest.

Example:

```
~]# lspci -v
0001:00:00.0 Ethernet controller: Mellanox Technologies MT27500 Family [ConnectX-3]
Subsystem: Mellanox Technologies Device 048d
Physical Slot: 00000015
...
Kernel driver in use: mlx4_core
Kernel modules: mlx4_core
# echo 0001:00:00.0 > /sys/bus/pci/drivers/mlx4_core/unbind
```

Cryptographic adapter resources

Cryptographic adapter resources are managed as AP queues (see [“Cryptographic domains” on page 447](#)). Two 256-bit masks, one for adapters and the other for domains, rule which AP queues are controlled by the `zcrypt` device driver.

Taking a crude approach, you could issue one of the following commands or both to free all AP queues from direct host control.

```
# echo 0x0 > /sys/bus/ap/apmask
# echo 0x0 > /sys/bus/ap/aqmask
```

After issuing these commands, all AP queues that were originally available to the host are now eligible for KVM guest use and the host can no longer use them.

For information about handling AP queues more selectively, see [“Kernel parameters” on page 449](#) and [“Freeing AP queues for KVM guests” on page 462](#).

Assigning DASDs to vfio_ccw

Create a VFIO CCW mediated device for the subchannel to which the DASD is attached.

Before you begin

You must know the subchannel bus ID of the DASD and the DASD must be free from control of the default DASD and channel device drivers (see [“Freeing host resources from the default device drivers” on page 437](#)).

Procedure

1. Ensure that the `vfio_ccw` device driver and the `vfio_mdev` modules are loaded. If either module is compiled as a separate module, you might have to load it yourself.

```
# modprobe vfio_ccw
# modprobe vfio_mdev
```

2. Assign the DASD's subchannel to the `vfio_ccw` device driver by writing the subchannel bus-ID to `/sys/bus/css/drivers/vfio_ccw/bind`.

Example: This example assigns subchannel `0.0.0004` to `vfio_ccw`.

```
# echo 0.0.0004 > /sys/bus/css/drivers/vfio_ccw/bind
```

3. Create a new VFIO CCW mediated device by writing a universally unique identifier (UUID) to `/sys/bus/css/devices/<subchannel_bus_id>/mdev_supported_types/vfio_ccw-io/create`, where `<subchannel_bus_id>` is the subchannel of the DASD.

Tip: Use the `uuidgen` command to generate a UUID.

Example: This example creates a CCW mediated device for subchannel `0.0.0004`.

```
# uuidgen
18e124fb-b2fc-47f6-a407-f256b6c49767
# echo 18e124fb-b2fc-47f6-a407-f256b6c49767 > \
/sys/bus/css/devices/0.0.0004/mdev_supported_types/vfio_ccw-io/create
```

4. Optional: Display subchannel information for the mediated device, by issuing `lscss` with the `--vfio` option.

Example:

```
$ lscss --vfio
MDEV                               Subchan.  PIM PAM POM  CHPIDs
-----
18e124fb-b2fc-47f6-a407-f256b6c49767 0.0.0004  c0  c0  ff 0  5020000 00000000
```

Assigning PCI devices to vfiopci

Set up the vfiopci device driver to control a particular PCIe card type by specifying the card's vendor code and device code.

After setting up the vfiopci device driver for one or more PCIe card types, all eligible cards of these types get associated with the vfiopci device driver ([“Freeing host resources from the default device drivers” on page 437](#)). Free a card from control of its card-specific default device driver to make it eligible for the vfiopci device driver.

Tip: Issue `lspci -n` to display the vendor and device codes for your PCIe devices in the format `<vendor_code>:<device_code>`.

Module parameter

You can use the `ids=` module parameter to specify the PCIe card types.

vfiopci module parameter syntax

```
modprobe vfiopci ids= <vendor_code>:<device_code>
```

Example: In this example, a PCIe device with function address `0001:000:000:0`, vendor code `15b3`, and device code `1003` is available on the host. The specification for the `ids=` module parameter makes the card type eligible for the vfiopci device driver.

```
# lspci -n
0001:000:000:0 15b3:1003
# modprobe vfiopci ids=15b3:1003
```

sysfs interface

On a running host, you can use the `/sys/bus/pci/drivers/vfiopci/new_id` sysfs attribute to enable the vfiopci device driver to control a particular PCIe card type. Write the vendor code and device code, separated by a blank, to the attribute.

Example: This example, makes cards with vendor code `15b3` and device code `1003` eligible for the vfiopci device driver.

```
# echo 15b3 1003 > /sys/bus/pci/drivers/vfiopci/new_id
```

Assigning cryptographic adapter resources to vfio_ap

Create a VFIO AP mediated device and assign cryptographic adapter resources to the device.

Cryptographic adapter resources are managed as AP queues (see [“Cryptographic domains” on page 447](#)). An AP queue corresponds to a specific cryptographic domain on a specific cryptographic adapter. AP queues are assigned indirectly through assignments of domains and adapters. As a consequence, AP queues are not assigned independently, but in the form of a matrix of queues. A queue is in the matrix if both its adapter and its domain are specified.

Load the modules

Ensure that the vfio_ap and vfio_mdev device drivers are loaded.

```
# modprobe vfio_ap
# modprobe vfio_mdev
```

Create a mediated device

Associate a new VFIO mediated device with the `vfio_ap` device driver by writing a universally unique identifier (UUID) to `/sys/devices/vfio_ap/matrix/mdev_supported_types/vfio_ap-passthrough/create`.

Tip: Use the `uuidgen` command to generate a UUID.

Example: This example creates a VFIO AP mediated device.

```
# uuidgen
4b0518fd-9237-493f-93c8-c5597f8006a3
# echo 4b0518fd-9237-493f-93c8-c5597f8006a3 \
> /sys/devices/vfio_ap/matrix/mdev_supported_types/vfio_ap-passthrough/create
```

Configure the mediated device

The sysfs representations of VFIO AP mediated devices are subdirectories of `/sys/devices/vfio_ap/matrix`. The directory names match the UUIDs that identify the mediated devices. Use the attributes in a device directory to configure the device and to obtain information about the device.

Attribute	Explanation
<code>assign_adapter</code>	Write adapter IDs to this attribute to assign adapters to the mediated device. Specify the adapter IDs in decimal or hexadecimal notation. For hexadecimal notation, use the prefix "0x". Example: <pre># echo 0x0a > assign_adapter</pre>
<code>assign_control_domain</code>	Write domain IDs to this attribute to assign control domains to the mediated device. Assign a control domain for each domain that you assign to the mediated device, so that you can manage your domains from the guest that uses the mediated device. Specify the domain IDs in decimal or hexadecimal notation. For hexadecimal notation, use the prefix "0x". Example: <pre># echo 0x001b > assign_control_domain</pre>
<code>assign_domain</code>	Write domain IDs to this attribute to assign usage domains to the mediated device. Specify the domain IDs in decimal or hexadecimal notation. For hexadecimal notation, use the prefix "0x". Example: <pre># echo 0x001b > assign_domain</pre>
<code>control_domains</code>	Read this attribute to list the assigned control domains. Example: <pre># cat control_domains 001b</pre>

Table 58. sysfs attributes of VFIO mediated devices for cryptographic adapter resources (continued)

Attribute	Explanation
matrix	Read this attribute to list the assigned AP queues that result from the adapter and domain assignments. Example: <pre># cat matrix 0a.001b</pre>
mdev_type	Symbolic link that points to the vfio_ap-passthrough directory.
remove	Write 1 to this attribute to remove the mediated device. Example: <pre># echo 1 > remove</pre>
subsystem	Symbolic link that points to the matrix bus
unassign_adapter	Write adapter IDs to this attribute to remove adapters from the mediated device. Specify the adapter IDs in decimal or hexadecimal notation. For hexadecimal notation, use the prefix "0x". Example: <pre># echo 0x0a > unassign_adapter</pre>
unassign_control_domain	Write domain IDs to this attribute to remove control domains from the mediated device. Specify the domain IDs in decimal or hexadecimal notation. For hexadecimal notation, use the prefix "0x". Example: <pre># echo 0x001b > unassign_control_domain</pre>
unassign_domain	Write domain IDs to this attribute to remove usage domains from the mediated device. Specify the domain IDs in decimal or hexadecimal notation. For hexadecimal notation, use the prefix "0x". Example: <pre># echo 0x001b > unassign_domain</pre>

Scenario

This scenario assumes a KVM host on which 8 AP queues have been freed from control of the zcrypt device driver. A matrix of two of these queues are to be assigned to a mediated device.

1. Load the required modules.

```
# modprobe vfio_ap  
# modprobe vfio_mdev
```

2. List the eligible AP queues. AP queues are eligible only if they are controlled by the vfio_ap device driver.

```
# lszcrypt -V | grep vfio
00.0001 CEX7A Accelerator online 0 0 13 08 -MC-A-NF- vfio_ap
00.0002 CEX7A Accelerator online 0 0 13 08 -MC-A-NF- vfio_ap
00.0004 CEX7A Accelerator online 0 0 13 08 -MC-A-NF- vfio_ap
00.001b CEX7A Accelerator online 0 0 13 08 -MC-A-NF- vfio_ap
0a.0001 CEX7P EP11-Coproc online 0 0 13 08 ----XNF- vfio_ap
0a.0002 CEX7P EP11-Coproc online 0 0 13 08 ----XNF- vfio_ap
0a.0004 CEX7P EP11-Coproc online 0 0 13 08 ----XNF- vfio_ap
0a.001b CEX7P EP11-Coproc online 0 0 13 08 ----XNF- vfio_ap
```

The output shows that 8 AP queues are eligible. The eight queues correspond to a matrix of two adapters, 0x00 and 0x0a and four domains, 0x0001, 0x0002, 0x0004, and 0x001b. These adapters and domains are the only ones that you can assign to the mediated device.

3. Create a mediated device.

```
# uuidgen
4b0518fd-9237-493f-93c8-c5597f8006a3
# echo 4b0518fd-9237-493f-93c8-c5597f8006a3 \
> /sys/devices/vfio_ap/matrix/mdev_supported_types/vfio_ap-passthrough/create
```

4. Add adapters 0x00 and 0x0a to the device.

```
# echo 0x00 > /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/assign_adapter
# echo 0x0a > /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/assign_adapter
# cat /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/matrix
00.
0a.
```

Reading the `matrix` attribute does not yield any AP queues. To assign AP queues both adapters and domains must be added.

5. Add domain 0x001b.

```
# echo 0x001b > /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/assign_domain
# cat /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/matrix
00.001b
0a.001b
# cat /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/control_domains
```

The content of the `matrix` attribute shows that two AP queues are assigned to the mediated device. The two queues correspond to a matrix of two adapters, 0x00 and 0x0a and one domain, 0x001b. Reading the `control_domains` attribute shows that no control domain is configured.

6. Add domain 0x001b to the control domains.

```
# echo 0x001b > /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/
assign_control_domain
# cat /sys/devices/vfio_ap/matrix/4b0518fd-9237-493f-93c8-c5597f8006a3/control_domains
001b
```

Part 8. Security

These device drivers and features support security aspects of Ubuntu Server 20.04.1 LTS.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 48. Generic cryptographic device driver

The generic cryptographic device driver (zcrypt) supports cryptographic coprocessor and accelerator hardware. Cryptographic coprocessors provide secure key cryptographic operations for the IBM Common Cryptographic Architecture (CCA) and the Enterprise PKCS#11 feature (EP11).

Some cryptographic processing in Linux can be offloaded from the processor and performed by CCA or EP11 coprocessors or accelerators. Several of these CCA or EP11 coprocessors and accelerators are available offering a range of features. The generic cryptographic device driver (zcrypt) is required to use any available cryptographic hardware.

Features

The cryptographic device driver supports a range of hardware and software functions.

Supported cryptographic adapters

The cryptographic hardware feature might contain one or two cryptographic adapters. Each adapter can be configured either as a CCA coprocessor or as an accelerator. The CEX7S, CEX6S, CEX5S, and CEX4S cryptographic adapters can also be configured as EP11 coprocessors.

The following types of cryptographic adapters are supported:

- Crypto Express7S (EP11) Coprocessor (CEX7P)
- Crypto Express7S (CCA) Coprocessor (CEX7C)
- Crypto Express7S Accelerator (CEX7A)
- Crypto Express6S (EP11) Coprocessor (CEX6P)
- Crypto Express6S (CCA) Coprocessor (CEX6C)
- Crypto Express6S Accelerator (CEX6A)
- Crypto Express5S Accelerator (CEX5A)
- Crypto Express5S (CCA) Coprocessor (CEX5C)
- Crypto Express5S (EP11) Coprocessor (CEX5P)
- Crypto Express4S Accelerator (CEX4A)
- Crypto Express4S (CCA) Coprocessor (CEX4C)
- Crypto Express4S (EP11) Coprocessor (CEX4P)
- Crypto Express3 Accelerator (CEX3A)
- Crypto Express3 Coprocessor (CEX3C)

For information about setting up your cryptographic environment on Linux under z/VM, see *z/VM: Secure Configuration Guide*, SG24-6323 and *Security for Linux on System z*, SG24-7728.

Supported facilities

The cryptographic device driver supports several cryptographic accelerators as well as CCA and EP11 coprocessors.

Cryptographic accelerators support clear key cryptographic algorithms. In particular, they provide fast RSA encryption and decryption for any key size in the range 1024 - 4096 bit.

Cryptographic coprocessors act as a hardware security module (HSM) and provide secure key cryptographic operations for the IBM Common Cryptographic Architecture (CCA) and the Enterprise PKCS#11 feature (EP11).

Cryptographic CCA coprocessors also provide clear key RSA operations for 1024-bit, 2048-bit, and 4096-bit keys, and a true random number generator for `/dev/hwrng`. The EP11 coprocessor supports only secure key operations.

For more information about CCA, see *Secure Key Solution with the Common Cryptographic Architecture Application Programmer's Guide*, SC33-8294. You can obtain this publication at ibm.com/docs/en/linux-on-systems?topic=overview-secure-key-solution-cca-application-programmers-guide.

For more information about EP11, see *Exploiting Enterprise PKCS #11 using openCryptoki*, SC34-2713. You can obtain this publication at ibm.com/docs/en/linux-on-systems?topic=security-cryptographic-hardware-support.

Hardware and software prerequisites

Support for the Crypto Express features depends on the IBM Z hardware model.

Table 59 on page 446 lists the support for the cryptographic adapters.

Cryptographic adapters	Mainframe support
CEX7A, CEX7C, and CEX7P	z15
CEX6A, CEX6C, and CEX6P	z14
CEX5A, CEX5C, and CEX5P	z14, z13 and z13s

Table 60 on page 446 lists the required software by function.

Software required	Function that is supported by the software
The CCA library	For the secure key cryptographic functions on CEX6C, CEX5C, CEX4C, or CEX3C features. For information about CEX6C, CEX5C, CEX4C, and CEX3C adapter coexistence and how to use CCA functions, see <i>Secure Key Solution with the Common Cryptographic Architecture Application Programmer's Guide</i> , SC33-8294. You can obtain it at www.ibm.com/developerworks/linux/linux390/documentation_ubuntu.html .
The EP11 library	For the secure key cryptographic functions on EP11 coprocessors. See <i>Exploiting Enterprise PKCS #11 using openCryptoki</i> , SC34-2713. You can obtain this publication at www.ibm.com/developerworks/linux/linux390/documentation_ubuntu.html .
The libica library	For the clear key cryptographic functions. See <i>libica Programmer's Reference</i> , SC34-2602. You can obtain this publication at www.ibm.com/developerworks/linux/linux390/documentation_dev.html .
APAR VM65942	To support z14 hardware and the CEX6S adapter for Linux on z/VM. To support ECC with a shared cryptographic adapter in coprocessor mode for Linux on z/VM 6.4.
APARs VM66428 and VM66206	To support z15 hardware and the CEX7S adapter for Linux on z/VM.

What you should know about the cryptographic device driver

Your use of the cryptographic device driver and the cryptographic hardware might require additional software. There are special considerations for Linux on z/VM, for performance, and for specific cryptographic operations.

Functions provided by the cryptographic device driver

The cryptographic device driver handles cryptographic accelerator, CCA coprocessor, and EP11 coprocessor adapters. The functions that the device driver provides depend on the adapter.

For both accelerators and CCA coprocessors, it provides Rivest-Shamir-Adleman (RSA) encryption and RSA decryption functions using clear keys. RSA operations are supported in both the modulus-exponent and the Chinese-Remainder Theorem (CRT) variants for any key size in the range 57 - 4096 bit.

For CCA coprocessors, the device driver also provides a function to pass CCA requests to the cryptographic coprocessor and an access to the true random number generator of the CCA coprocessor.

For EP11 coprocessors, the device driver provides functionality to pass EP11 requests to the cryptographic coprocessor.

Adapter discovery

Cryptographic adapters are detected automatically when the module is loaded. They are reprobbed periodically, and following any hardware problem.

Depending on what adapters were detected, the cryptographic device driver might provide two misc device nodes, one for cryptographic requests, and one for a device from which random numbers can be read.

Upon detection of a cryptographic adapter, the device driver presents a Linux misc device, `z90crypt`, to user space. A user space process can open the misc device to submit cryptographic requests to the adapter through IOCTLs.

If at least one of the detected cryptographic adapters is a CCA coprocessor, an additional misc device, `hwrng`, is created from which random numbers can be read.

You can set cryptographic adapters online or offline in the device driver. The cryptographic device driver ignores adapters that are configured offline even if the hardware is detected. The online or offline configuration is independent of the hardware configuration.

Request processing

Cryptographic adapters process requests asynchronously.

The device driver detects request completion either by standard polling, a special high-frequency polling thread, or by hardware interrupts. If hardware interrupt support is available, the device driver does not use polling to detect request completion.

All requests to either of the two misc devices are routed to a cryptographic adapter using a crypto request scheduling function that, for each adapter, takes into account:

- The supported functions
- The number of pending requests
- A speed rating

Cryptographic domains

Crypto Express hardware adapters are divided into multiple domains, also called *cryptographic domains* or *AP domains*.

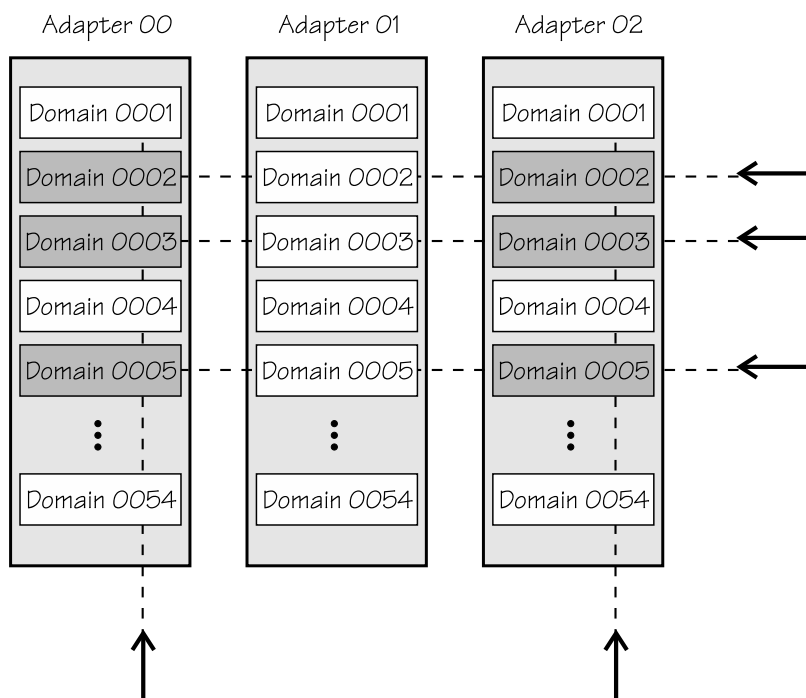
Each domain acts as an independent cryptographic device with its own state, including its own master key. Two domains in the same Crypto Express adapter are completely isolated and cannot access each

other's states. The maximum number of domains depends on the mainframe model and is the same for all Crypto Express adapters in that mainframe. For example, a z13 supports up to 85 domains (with hexadecimal domain IDs 0000 to 0054).

The device driver uses at least one domain for all adapters. If none is given, the kernel selects a default domain. Alternatively, you can select the default domain using a module parameter (see “Kernel parameters” on page 449).

Cryptographic devices on LPARs

When you assign adapters and domains to an LPAR on the HMC or SE, you indirectly assign virtual cryptographic devices.



For example, assigning adapter ID 00 and 02 as well as domains 0002, 0003, and 0005 to an LPAR implicitly assigns six virtual cryptographic devices to the LPAR: (00,0002), (00,0003), (00,0005), (02,0002), (02,0003), and (02,0005).

You can choose between two types of access to a cryptographic domain:

To use cryptographic functions.

A domain that is assigned to an LPAR for usage access is called a *usage domain* of that LPAR on the HMC or SE.

To manage or control the domain, including the management of the master keys.

A domain that is assigned to an LPAR for management (control) access is called a *control domain* of that LPAR on the HMC or SE.

Every usage domain of an LPAR must also be a control domain of that LPAR.

The list of usage domains and the list of adapter IDs define the list of virtual cryptographic devices that are assigned to an LPAR. For example, if 00 is an adapter ID and 0002 is a usage domain ID, then the virtual cryptographic device (00,0002) is assigned to the LPAR.

Cryptographic devices on z/VM

In z/VM, the virtual cryptographic devices available to a guest are defined by using the CRYPTO directory statement:

- The `CRYPTO APDEDICATE` statement assigns domain IDs and adapter IDs to the guest. This assignment implicitly defines a list of dedicated virtual cryptographic devices. All virtual cryptographic devices that are determined by an ID from the adapter list of that guest and an ID from the domain list of that guest are assigned to the guest.
- The `CRYPTO APVIRT` statement assigns one virtual cryptographic device that can be shared among multiple guests with a guest-specific virtualized adapter ID and a virtualized domain ID.

Virtual cryptographic devices in z/VM can be either shared or dedicated, but not both.

Linux on z/VM with access to a shared cryptographic accelerator can either observe an accelerator or a CCA coprocessor.

For shared cryptographic CCA coprocessors, the following functions are available to the Linux instance:

- Random number functions
- Clear-key RSA functions
- If APAR VM65942 has been installed: Clear-key ECC functions

Other requests are rejected by z/VM. For more information about supported functions, see the z/VM publications.

Cryptographic devices on Linux

In Linux, virtual cryptographic devices are called *AP queues*. The name of an AP queue consists of two parts, the adapter ID and the domain ID, both in hexadecimal notation. For example, if cryptographic adapters with the IDs 00 and 02 are selected, and the domain IDs 0002, 0003 and 0005 have been configured on the cryptographic adapter, then the following AP queues are defined to Linux:

```
/sys/devices/ap/card00/00.0002
/sys/devices/ap/card00/00.0003
/sys/devices/ap/card00/00.0005
/sys/devices/ap/card02/02.0002
/sys/devices/ap/card02/02.0003
/sys/devices/ap/card02/02.0005
```

Setting up the cryptographic device driver

Configure the cryptographic device driver through the `ap.domain=` and the `ap.poll_thread=` kernel parameters. You might also have to set up libraries and create a device node.

The cryptographic device driver consists of multiple, separate modules:

zcrypt

Cryptographic Coprocessor interface, Cryptographic Coprocessor message type 6, Cryptographic Coprocessor message type 50. Support for message type 6 includes secure key and RNG requests. Support for message type 50 includes RSA requests for both modulus-exponent and Chinese-Remainder Theorem variants.

zcrypt_cex4

device driver for CEX7S, CEX6S, CEX5S, and CEX4S adapters.

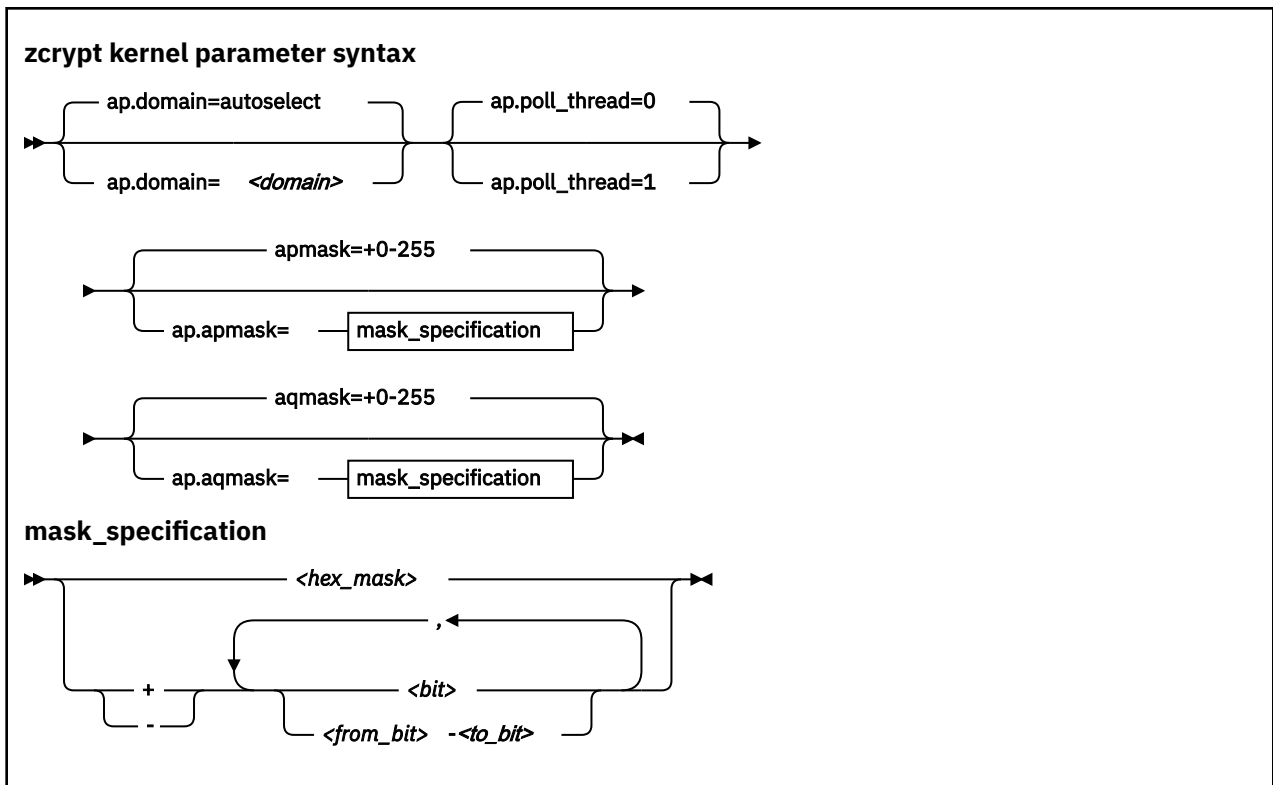
zcrypt_cex2a

device driver for CEX3A adapters.

For information about setting up cryptographic hardware on your mainframe system, see *zSeries Crypto Guide Update*, SG24-6870.

Kernel parameters

You configure the cryptographic device driver by adding parameters to the kernel parameter line.



where

<domain>

is an integer that identifies the default cryptographic domain for the Linux instance. You define cryptographic domains in the LPAR activation profile on the HMC or SE.

The default value (**ap.domain=autoselect**) causes the device driver to choose one of the available domains automatically.

Important: Be sure to enter an existing domain. The Trusted Key Entry (TKE) workstation does not find the cryptographic adapters if a non-existing domain is entered here. All CCA applications use the default domain, and do not work correctly if the specified domain does not exist.

<poll_thread>

is an integer argument and enables a polling thread to tune cryptographic performance. Valid values are 1 (enabled) or 0 (disabled, this value is the default). For details, see [“Setting the polling thread” on page 459](#).

Note: All mainframes supported by Ubuntu Server 20.04.1 use AP interrupts instead of the polling thread. The polling thread is disabled when AP interrupts are available. See [“Using AP adapter interrupts” on page 460](#).

ap.apmask= and ap.aqmask=

are two 256-bit masks that specify which AP queues are controlled by the zcrypt device driver and which are available to alternative device drivers, like `vfiopap`.

If your Linux instance is a KVM host, the `vfiopap` device driver controls AP queues on behalf of KVM guests (see [Chapter 47, “Setting up a KVM host for VFIO pass-through,” on page 435](#)). While `vfiopap` is the only eligible alternative device driver, freeing an AP queue from zcrypt makes it available to `vfiopap`.

Each bit of the `ap.apmask=` mask addresses a cryptographic adapter. The leftmost bit corresponds to the adapter with ID `0x00`. Generally, the bit number in the mask corresponds to the decimal value of the adapter ID. If an adapter bit is set to 0, all AP queues for this adapter are available to alternative device drivers, across all domains.

Each bit of the `ap.apmask=` mask addresses a cryptographic domain. The leftmost bit corresponds to domain `0x0000`. Generally, the bit number in the mask corresponds to the decimal value of the domain ID. If a domain bit is set to 0, all AP queues with this domain are available to alternative device drivers, across all adapters.

AP queues are controlled by the `zcrypt` device driver if both the bit for its adapter and for its domain are set to 1. An AP queue is available to alternative device drivers if the bit for its adapter, or its domain, or both are set to 0.

By default, all bits in both masks are 1. Therefore, `zcrypt` is the default device driver for all AP queues.

<hex_mask>

specifies a replacement for the default mask. Valid values are `0x` followed by 1 - 64 hexadecimal digits. If fewer than 64 digits are specified, the specification is padded with 0s on the right. The value is big-endian. The hexadecimal representation is mapped to the 256-digit binary mask.

<bit>

specifies an individual bit number. 0 specifies the leftmost bit. With the plus sign (+) prefix, the bit is set to 1. With the minus sign (-) prefix, the bit is set to 0.

<from_bit>-<to_bit>

specifies the range of bits from bit number `<from_bit>` to bit number `<to_bit>`. With the plus sign (+) prefix, all bits in the range are set to 1. With the minus sign (-) prefix, all bits in the range are set to 0.

Bit numbers can be in decimal or hexadecimal notation. Hexadecimal numbers must be prefixed with `0x`. You can specify a comma-separated list of bits and ranges. Such lists are processed left to right.

The hexadecimal representations of the masks are available in `sysfs`. Using `sysfs`, you can change the masks on a running Linux instance, see [“Freeing AP queues for KVM guests” on page 462](#).

Examples

- The following kernel parameter line specification makes the `zcrypt` device driver operate within the default cryptographic domain "7" with `ap.poll_thread=` enabled:

```
ap.domain=7 ap.poll_thread=1
```

- The following specification makes all AP queues on adapter `0x00` and any adapters with IDs greater than `0x07` and all AP queues with domain ID, `0x0007`, `0x0008`, `0x0009`, `0x000a`, and `0x000b` available to the `vfio_ap` device driver.

```
ap.apmask=0x7F ap.aqmask=-7-11
```

The following specification with hexadecimal notation for the queue range is equivalent:

```
ap.apmask=0x7F ap.aqmask=-0x7-0xb
```

Accessing cryptographic devices

The cryptographic device driver registers as a misc device and provides a default device node to user space.

In Ubuntu Server 20.04.1 `udev` creates the device node `/dev/z90crypt` for you. The device node `z90crypt` is assigned to the miscellaneous devices.

The `/dev/z90crypt` device node provides unrestricted user space access to a device that represents all AP queues that are available to the Linux instance.

You can create customized device nodes that represent subsets of AP queues and functions, see [“Creating customized device nodes” on page 452](#).

Creating customized device nodes

The cryptographic device driver can provide and maintain multiple zcrypt device nodes. These nodes can be restricted in terms of cryptographic adapters, domains, and available IOCTLs.

About this task

You can create device nodes with access to a subset of the AP queues that are available to the Linux instance and that can perform a subset of the functions. Such a device node can be used for access control to cryptographic resources:

- Selective assignment of device nodes to Linux containers.
- Linux file permissions for the device nodes can be used to restrict the access for users and groups.

Procedure

1. Create a new device node by issuing a **zcryptctl** command of this form:

```
# zcryptctl create <name>
```

where *<name>* is a unique device name. A device node `/dev/<name>` and a device directory `/sys/devices/virtual/zcrypt/<name>` are created in sysfs.

For more information about **zcryptctl**, see [“zcryptctl - Control access to AP queues and functions” on page 689](#).

Example:

```
# zcryptctl create node_1
```

The example creates a device node `/dev/node_1` and a device directory `/sys/devices/virtual/zcrypt/node_1` in sysfs.

2. Set the adapters for the new device node. Issue a **zcryptctl** command of this form:

```
# zcryptctl addap <name> <adapter_id_1>,<adapter_id_2>,<adapter_id_3>,...
```

where *<adapter_id_n>* specifies an adapter to which you want this node to have access. You can use the hexadecimal adapter IDs or their equivalent decimal values. Hexadecimal specifications must be prefixed with `0x`.

Example:

```
# zcryptctl addap node_1 0x05,0x06,0x07,0x0a
```

Using decimal notation this command would be:

```
# zcryptctl addap node_1 5,6,7,10
```

3. Set the domains for the new device node. Issue a **zcryptctl** command of this form:

```
# zcryptctl adddom <name> <dom_1>,<dom_2>,<dom_3>,...
```

where *<dom_n>* is a domain to which you want this node to have access. You can use the hexadecimal domain IDs or their equivalent decimal values. Hexadecimal specifications must be prefixed with `0x`.

Example:

```
# zcryptctl adddom node_1 0x0006
```

4. Set the IOCTLs for the new device node. Issue a **zcryptctl** command of this form:

```
# zcryptctl addioctl <name> <ioctl_1>,<ioctl_2>,<ioctl_3>,...
```

Set IOCTLS according to the functions you want to support. The following table lists the IOCTLS that are required by the CCA, EP11, and libica library.

Library	Functions	Required IOCTLS
CCA	Secure key cryptographic functions on CCA coprocessors.	ZSESEND CPRB
EP11	Secure key cryptographic functions on EP11 coprocessors.	ZSENDEP11 CPRB
libica	Clear key cryptographic functions.	ICARSAMODEXPO, ICARSACRT, ZSESEND CPRB

The available IOCTLS are listed in `arch/s390/include/uapi/asm/zcrypt.h` in the Linux source tree.

Example:

```
# zcryptctl addioctl node_1 ZSESEND CPRB
```

5. Optional: Secure the device node through suitable settings for the file owner and group, and through access permissions for user, group, and others.

Results

Changes to the masks are instantly applied and affect all applications with an open file descriptor for this `zcrypt` node immediately.

Example

To create and define a `zcrypt` device node for CCA requests on adapters `0x05`, `0x06`, `0x07`, `0x0a` and domain `0x0006` using the `zcryptctl` command:

```
# zcryptctl create node_1
# zcryptctl addap node_1 0x05,0x06,0x07,0x0a
# zcryptctl adddom node_1 0x0006
# zcryptctl addioctl node_1 ZSESEND CPRB
```

It is equivalent to using the `zcryptctl config` command with the following configuration file entry:

```
# node 1 for CCA requests on domain 6 - hexadecimal notation
node = node_1
aps = 0x05,0x06,0x07,0x0a
doms = 0x0006
ioctls = ZSESEND CPRB
```

The following equivalent configuration file uses decimal notation for adapters and domains:

```
# node 1 for CCA requests on domain 6 - decimal notation
node = node_1
aps = 5,6,7,10
doms = 6
ioctls = ZSESEND CPRB
```

Alternatively, you can use `sysfs` attributes to obtain the same results:

```
# echo node_1 > /sys/class/zcrypt/create
# echo +0x05,+0x06,+0x07,+0x0a > /sys/devices/virtual/zcrypt/node_1/apmask
# echo +0x0006 > /sys/devices/virtual/zcrypt/node_1/aqmask
# echo +0x81 > /dev/node_1/ioctlmask
```

The `apmask` and `aqmask` attributes in the node directory follow the same syntax as the `apmask` and `aqmask` attributes at `/sys/bus/ap` (see “Freeing AP queues for KVM guests” on page 462). Relative values require a plus (+) or minus (-) prefix, can use decimal or hexadecimal notation, and can address individual bits or ranges. You can also specify the complete hexadecimal mask as an absolute value. The `sysfs` interface requires numeric values for the IOCTLS as listed in `arch/s390/include/uapi/asm/zcrypt.h`.

What to do next

You can delete the device node with `zcryptctl destroy <name>`.

Displaying information about the AP bus

Use the `lszcrypt -b` command to display status information about the AP bus; alternatively, you can use `sysfs`.

About this task

For information about `lszcrypt -b`, see “[lszcrypt - Display zcrypt devices](#)” on page 619.

The AP bus is represented in `sysfs` as a directory of the form

```
/sys/bus/ap
```

The `sysfs` directory contains a number of attributes with information about the AP bus.

Table 62. AP bus attributes

Attribute	Explanation
<code>ap_domain</code>	Read-write attribute that represents the default domain selected by the kernel. Alternatively, you can select the domain using a kernel parameter, or a module parameter during module load. See “ Kernel parameters ” on page 449.
<code>ap_max_domain_id</code>	Read-only attribute that represents the largest possible domain ID. Domain IDs can range from 0 to this number, which depends on the mainframe model.
<code>ap_control_domain_mask</code>	Read-only attribute that represents the installed control domain facilities as a 32-byte field in hexadecimal notation. A maximum number of 256 domains can be addressed. Each bit position represents a dedicated control domain.
<code>ap_usage_domain_mask</code>	Read-only attribute that represents the installed usage domain facilities as a 32-byte field in hexadecimal notation. A maximum number of 256 domains can be addressed. Each bit position represents a usage domain.
<code>ap_interrupts</code>	Read-only attribute that indicates whether interrupt handling for the AP bus is enabled.
<code>apmask</code>	Read-write attribute that represents up to 256 cryptographic adapters. The attribute is a 64-digit hexadecimal representation of the 256-digit binary mask. In combination with the <code>aqmask</code> attribute, it marks a set of AP queues that are reserved for device drivers other than <code>zcrypt</code> . See “ Freeing AP queues for KVM guests ” on page 462.

Table 62. AP bus attributes (continued)

Attribute	Explanation
aqmask	Read-write attribute that represents 256 cryptographic domains. The attribute is a 64-digit hexadecimal representation of the 256-digit binary mask. In combination with the apmask attribute, it marks a set of AP queues that are reserved for device drivers other than zcrypt. See “Freeing AP queues for KVM guests” on page 462.
config_time	Read-write attribute that represents a time interval in seconds used to detect new crypto devices.
poll_thread	Read-write attribute that indicates whether polling for the AP bus is enabled.
poll_timeout	Read-write attribute that represents the time interval of the poll thread in nanoseconds.

Example

```
# lszcrypt -b
ap_domain=0x6
ap_max_domain_id=0x54
ap_interrupts are enabled
config_time=30 (seconds)
poll_thread is disabled
poll_timeout=250000 (nanoseconds)
```

Working with cryptographic devices

Typically, cryptographic devices are not directly accessed by users but through user programs. Some tasks can be performed through the sysfs interface.

- [“Displaying information about cryptographic devices”](#) on page 455
- [“Setting devices online or offline”](#) on page 459
- [“Setting the polling thread”](#) on page 459
- [“Using AP adapter interrupts”](#) on page 460
- [“Setting the polling interval”](#) on page 461
- [“Dynamically adding and removing cryptographic adapters”](#) on page 461
- [“Freeing AP queues for KVM guests”](#) on page 462
- [“Displaying information about the AP bus”](#) on page 454

Displaying information about cryptographic devices

Use the **lszcrypt** command to display status information about your cryptographic devices; alternatively, you can use sysfs.

About this task

For information about **lszcrypt**, see [“lszcrypt - Display zcrypt devices”](#) on page 619.

Each cryptographic adapter is represented in sysfs as a directory of the form

```
/sys/bus/ap/devices/card<XX>
```

where <XX> is the device index for each device. For example, device 0x1a can be found under `/sys/bus/ap/devices/card1a`. The sysfs directory contains a number of attributes with information about the cryptographic adapter.

Table 63. Cryptographic adapter attributes

Attribute	Explanation
ap_functions	Read-only attribute that represents the function facilities that are installed on this device.
depth	Read-only attribute that represents the input queue length for this device.
hwtype	<p>Read-only attribute that represents the numeric hardware type for this device. The following values are defined:</p> <p>8 CEX3A adapters.</p> <p>9 CEX3C adapters.</p> <p>10 CEX4A, CEX4C, or CEX4P adapters.</p> <p>11 CEX5A, CEX5C, or CEX5P adapters.</p> <p>12 CEX6A, CEX6C, or CEX6P adapters.</p> <p>13 CEX7A, CEX7C, or CEX7P adapters.</p> <p>The hwtype attribute shows the hardware type as interpreted by the device driver. See also the raw_hwtype attribute.</p>
raw_hwtype	Read-only attribute that represents the original hardware type of the cryptographic adapter.
modalias	Read-only attribute that represents an internally used device bus-ID.
online	Read-write attribute that shows whether the device is online (1) or offline (0).
pendingq_count	Read-only attribute that represents the number of requests in the hardware queue.
request_count	Read-only attribute that represents the number of requests that are already processed by this device.
requestq_count	Read-only attribute that represents the number of outstanding requests (not including the requests in the hardware queue).
serialnr	For CCA and EP11 coprocessors only: Read-only attribute that shows the adapter serial number. The serial number is a unique ASCII string of 8 characters for CCA coprocessors and 16-characters for EP11 coprocessors.
type	<p>Read-only attribute with a name for the device type. The following types are defined:</p> <ul style="list-style-type: none"> • CEX3A, CEX3C, CEX4A • CEX4C, CEX4P • CEX5A, CEX5C, CEX5P • CEX6A, CEX6C, CEX6P • CEX7A, CEX7C, CEX7P

Each AP queue is independently configurable and represented in a subdirectory of the cryptographic device it belongs to:


```
/sys/bus/ap/devices/card<XX>/<XX>.<YYYY>
```

where <XX> is the adapter ID of the cryptographic device and <YYYY> is the domain. For example, a cryptographic device with adapter ID 1a might have domains 5 (0005), 31 (001f), and 77 (004d) configured. The cryptographic device together with its AP queues would be represented in sysfs as:

```
/sys/devices/ap/card1a  
/sys/devices/ap/card1a/1a.0005  
/sys/devices/ap/card1a/1a.001f  
/sys/devices/ap/card1a/1a.004d
```

Actions that you take on the cryptographic device also apply to its associated AP queues. Attributes like `type` and `hwtype` are inherited by the AP queues. The `sysfs` directory contains a number of attributes with information about the AP queues.

Table 64. Attributes of the AP queues

Attribute	Explanation
<code>online</code>	Read-write attribute that shows whether the AP queue is online (1) or offline (0).
<code>interrupt</code>	Read-only attribute that represents the interrupt state (enabled or disabled) of the AP queue, and hence the request queue.

Table 64. Attributes of the AP queues (continued)

Attribute	Explanation
mkvps	<p>CCA or EP11 coprocessors with AES master keys only: Read-only attribute with multiple lines of information about the master key states and verification patterns.</p> <p>CCA coprocessors</p> <p>The information has this format:</p> <pre>AES NEW: <new_aes_mk_state> <new_aes_mkvp> AES CUR: <cur_aes_mk_state> <cur_aes_mkvp> AES OLD: <old_aes_mk_state> <old_aes_mkvp></pre> <p>Where:</p> <p><new_aes_mk_state> is the key state of the new master key, which can be one of the following values: empty, partial, or full.</p> <p><cur_aes_mk_state> and <old_aes_mk_state> are the key states of the current and old master key, which can be one of the following values: valid or invalid.</p> <p><new_aes_mkvp>, <cur_aes_mkvp>, and <old_aes_mkvp> are 8-byte hexadecimal master key verification patterns, with a leading 0x.</p> <p>Useful verification patterns are present only for key states full and valid. For other states, 0x0000000000000000 is shown instead.</p> <p>If no valid state information is available, dashes (-) are shown instead of both the state and the verification pattern.</p> <p>EP11 coprocessors</p> <p>The information has this format:</p> <pre>MK CUR: <cur_mk_state> <cur_mkvp> MK NEW: <new_mk_state> <new_mkvp></pre> <p>Where:</p> <p><new_mk_state> is the key state of the new master key, which can be one of the following values: empty, uncommitted, or committed.</p> <p><cur_mk_state> are the key states of the current and old master key, which can be one of the following values: valid or invalid.</p> <p><new_mkvp> and <cur_mkvp> are 32-byte hexadecimal master key verification patterns with a 0x prefix.</p> <p>Useful verification patterns are present only for key states committed and valid. For other states, 0x followed by 64 zeroes is shown instead.</p> <p>If no valid state information is available, dashes (-) are shown instead of both the state and the verification pattern.</p>
reset	Read-only attribute that indicate the state of pending resets of the AP queues, and hence the request queue.
pendingq_count	Read-only attribute that represents the number of requests in the hardware queue.

Table 64. Attributes of the AP queues (continued)

Attribute	Explanation
request_count	Read-only attribute that represents the number of requests that are already processed by this AP queue.
requestq_count	Read-only attribute that represents the number of outstanding requests (not including the requests in the hardware queue).

To display status information about your cryptographic devices, you can also use the **lszcrypt** command (see [“lszcrypt - Display zcrypt devices”](#) on page 619).

Setting devices online or offline

Use the **chzcrypt** command to set cryptographic devices online or offline.

Procedure

- Preferably, use the **chzcrypt** command with the **-e** option to set cryptographic devices online, or use the **-d** option to set devices offline.

Examples:

- To set cryptographic devices (in decimal notation) 0, 1, 4, 5, and 12 online issue:

```
# chzcrypt -e 0 1 4 5 12
```

- To set all available cryptographic devices offline issue:

```
# chzcrypt -d -a
```

For more information about **chzcrypt**, see [“chzcrypt - Modify the zcrypt configuration”](#) on page 529.

- Alternatively, write 1 to the online sysfs attribute of a cryptographic device to set the device online, or write 0 to set the device offline.

Examples:

- To set a cryptographic device with device ID 0x3e online issue:

```
# echo 1 > /sys/bus/ap/devices/card3e/online
```

- To set a cryptographic device with device ID 0x3e offline issue:

```
# echo 0 > /sys/bus/ap/devices/card3e/online
```

- To check the online status of the cryptographic device with device ID 0x3e issue:

```
# cat /sys/bus/ap/devices/card3e/online
```

The value is 1 if the device is online or 0 otherwise.

Setting the polling thread

For Linux on z/VM, enabling the polling thread can improve cryptographic performance.

About this task

Linux in LPAR mode supports AP interrupts that indicate the completion of cryptographic requests. See [“Using AP adapter interrupts”](#) on page 460. If AP interrupts are available, it is not possible to activate the polling thread.

The cryptographic device driver can run with or without the polling thread. When it runs with the polling thread, one processor constantly polls the cryptographic cards for finished cryptographic requests while requests are being processed. The polling thread sleeps when no cryptographic requests are being processed. This mode uses the cryptographic cards as much as possible, at the cost of blocking one processor during cryptographic operations.

Without the polling thread, the cryptographic cards are polled at a much lower rate. The lower rate results in higher latency and reduced throughput for cryptographic requests, but without a noticeable processor load.

Procedure

- Use the **chzcrypt** command to set the polling thread.

Examples:

- To activate the polling thread issue:

```
# chzcrypt -p
```

- To deactivate the polling thread issue:

```
# chzcrypt -n
```

For more information about **chzcrypt**, see [“chzcrypt - Modify the zcrypt configuration”](#) on page 529.

- Alternatively, you can set the polling thread through the `poll_thread` sysfs attribute. This read-write attribute can be found at the AP bus level.

Examples:

- To activate the polling thread issue:

```
# echo 1 > /sys/bus/ap/poll_thread
```

- To deactivate the polling thread issue:

```
# echo 0 > /sys/bus/ap/poll_thread
```

Using AP adapter interrupts

To improve cryptographic performance for Linux instances that run in LPAR mode, use AP interrupts.

About this task

Using AP interrupts instead of the polling thread frees one processor while cryptographic requests are processed.

During module initialization, the cryptographic device driver checks whether AP adapter interrupts are supported by the hardware. If so, polling is disabled and the interrupt mechanism is automatically used.

To query whether AP adapter interrupts are used, read the sysfs attribute `interrupt` of the device. Another interrupt attribute at the AP bus level, `/sys/bus/ap/ap_interrupts`, indicates that the AP bus is able to handle interrupts.

Example

To read the interrupt attribute for a device `0x3e`, issue:

```
# cat /sys/bus/ap/devices/card3e/interrupt
```

If interrupts are used, the attribute shows "Interrupts enabled", otherwise "Interrupts disabled".

Setting the polling interval

Request polling is supported at nanosecond intervals.

Procedure

- Use the **lszcrypt** and **chzcrypt** commands to read and set the polling time.

Examples:

- To find out the current polling time, issue:

```
# lszcrypt -b
...
poll_timeout=250000 (nanoseconds)
```

- To set the polling time to 1 microsecond, issue:

```
# chzcrypt -t 1000
```

For more information about **lszcrypt** and **chzcrypt**, see [“lszcrypt - Display zcrypt devices”](#) on page 619 and [“chzcrypt - Modify the zcrypt configuration”](#) on page 529.

- Alternatively, you can set the polling time through the `poll_timeout` sysfs attribute. This read-write attribute can be found at the AP bus level.

Examples:

- To read the `poll_timeout` attribute for the ap bus issue:

```
# cat /sys/bus/ap/poll_timeout
```

- To set the `poll_timeout` attribute for the ap bus to poll, for example, every microsecond, issue:

```
# echo 1000 > /sys/bus/ap/poll_timeout
```

Dynamically adding and removing cryptographic adapters

You can add or remove cryptographic adapters from a running Linux instance.

Before you begin

For z/VM or KVM guests, your hypervisor version must support dynamic adding and removing of cryptographic adapters.

About this task

Linux attempts to detect new cryptographic adapters and set them online every time a configuration timer expires. Read or modify the expiration time with the **lszcrypt** and **chzcrypt** commands.

For more information about **lszcrypt** and **chzcrypt**, see [“lszcrypt - Display zcrypt devices”](#) on page 619 and [“chzcrypt - Modify the zcrypt configuration”](#) on page 529.

Adding or removing of cryptographic adapters to or from an LPAR is transparent to applications that use clear key functions. If a cryptographic adapter is removed while cryptographic requests are being processed, zcrypt automatically resubmits lost requests to the remaining adapters. Special handling is required for secure key.

Secure key requests are submitted to a dedicated cryptographic coprocessor. If this coprocessor is removed or lost, new requests cannot be submitted to a different coprocessor. Therefore, dynamically adding and removing adapters with a secure key application requires support within the application. For more information about secure key cryptography, see *Secure Key Solution with the Common Cryptographic*

Architecture Application Programmer's Guide, SC33-8294. You can obtain this publication at ibm.com/docs/en/linux-on-systems?topic=overview-secure-key-solution-cca-application-programmers-guide.

Alternatively, you can read or set the configuration timer through the `config_time` sysfs attribute. This read-write attribute can be found at the AP bus level. Valid values for the `config_time` sysfs attribute are in the range 5 - 120 seconds.

For the secure key cryptographic functions on EP11 coprocessors, see *Exploiting Enterprise PKCS #11 using openCryptoki, SC34-2713*. You can obtain this publication at ibm.com/docs/en/linux-on-systems?topic=security-cryptographic-hardware-support

Procedure

You can work with cryptographic adapters in the following ways:

- Add or remove cryptographic adapters by using the SE or HMC.
After the configuration timer expires, the cryptographic adapter is added to or removed from Linux, and the corresponding sysfs entries are created or deleted.
- Enable or disable a cryptographic adapter by using the **chzcrypt** command.
The cryptographic adapter is only set online or offline in sysfs. The sysfs entries for the cryptographic adapter are retained. Use the **lszcrypt** command to check the results of the **chzcrypt** command.

Examples

- To use the **lszcrypt** and **chzcrypt** commands to find out the current configuration timer setting, issue:

```
# lszcrypt -b
...
config_time=30 (seconds)
...
```

In the example, the timer is set to 30 seconds.

- To set the configuration timer to 60 seconds, issue:

```
# chzcrypt -c 60
```

To use sysfs to find out the current configuration timer setting, issue:

- To read the configuration timer setting, issue:

```
# cat /sys/bus/ap/config_time
```

- To set the configuration timer to 60 seconds, issue:

```
# echo 60 > /sys/bus/ap/config_time
```

Freeing AP queues for KVM guests

By default, the `zcrypt` device driver controls all AP queues on a Linux instance. Free AP queues from `zcrypt` to make them available to alternative device drivers, such as `vfio_ap`. The `vfio_ap` device driver controls AP queues on behalf of KVM guests. While `vfio_ap` is the only eligible alternative device driver, freeing an AP queue from `zcrypt` makes it available to `vfio_ap`.

Before you begin

Free AP queues only if your Linux instance is a KVM host that needs to provide these AP queues to its KVM guests (see Chapter 47, “Setting up a KVM host for VFIO pass-through,” on page 435).

**Attention:**

Do not change the settings for adapters or domains that are in use or reserved for another exploiter. In particular, do not bring already freed adapters or queues back under control of the zcrypt device driver while they are assigned to a KVM guest.

About this task

Two masks rule which AP queues are controlled by the zcrypt device driver and which are available to alternative device drivers, such as vfiio_ap.

Adapter mask

The adapter mask is a 256-bit value, each bit representing a cryptographic adapter. The leftmost bit represents the adapter with ID 0x00. In sysfs, the mask is available as the value of attribute `/sys/bus/ap/apmask`. If an adapter bit is set to 0, all AP queues on this adapter are available to alternative device drivers, across all domains.

Domain mask

The domain mask is a 256-bit value, each bit representing a cryptographic domain. The leftmost bit represents the domain with ID 0x0000. In sysfs, the mask is available as the value of attribute `/sys/bus/ap/aqmask`. If a domain bit is set to 0, all AP queues with this domain are available to alternative device drivers, across all adapters.

The sysfs representation of both masks is a big-endian, 64-bit, hexadecimal value. For example

- For an adapter mask 0x8000 . . . , the bit for adapter 0x00 is 1 and all others are 0.
- For a adapter mask 0xFF00 . . . , bits for adapters 0x00 to 0x07 are 1 and all others are 0.

zcrypt controls all AP queues for which both the adapter bit and the domain bit are set to 1. The default for both masks is 1 for all bits. Hence, the default value for both masks in sysfs is 0xff and zcrypt is the default device driver for all AP queues. To free an AP queue for alternative device drivers, the corresponding adapter bit, or the corresponding domain bit, or both must be set to 0.

You can use kernel parameters (see “Kernel parameters” on page 449) to set the mask. On a running Linux instance, you can write to the respective sysfs attribute to change the masks.

Procedure

Use the following methods to change a mask on a running Linux instance.

- Write a new mask value to the sysfs attribute.

You can write a 1 - 64-digit hexadecimal number to the respective sysfs attribute to replace the mask. If fewer than 64 digits are specified, the number is padded with 0s on the right.

Examples:

- To set the bit for the adapters with ID 0x00 and 0x01 to 0 and all other bits to 1, issue the following command:

```
# echo 0x3ffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffff > /sys/bus/ap/apmask
```

- To set the bit for the domains with ID 0x0000 and 0x0001 to 1 and all other bits to 0, issue the following command:

```
# echo 0xc > /sys/bus/ap/aqmask
```

- Set an individual bit value.

You can set an individual bit by specifying the bit-number, counting from the left, with one of the following prefixes:

- The minus sign (-) sets the bit to 0.

+

The plus sign (+) sets the bit to 1.

Bit numbers can be in decimal or hexadecimal notation. Hexadecimal numbers must be prefixed with 0x.

Examples:

- To set the bit for the adapter with ID 0x01 to 0, issue the following command:

```
# echo -1 > /sys/bus/ap/apmask
```

- To set the bit for the domain with ID 0x000a to 1, issue the following command:

```
# echo +10 > /sys/bus/ap/aqmask
```

The following equivalent command uses hexadecimal notation:

```
# echo +0xa > /sys/bus/ap/aqmask
```

Note: Do not omit the leading plus (+) or minus (-) sign. Plain numbers that can be interpreted as hexadecimal values replace the entire mask, even if they are specified without the 0x prefix.

- Set a range of bit values.

Using the same prefixes as for individual bits, you can specify a range of bit-numbers to set all bits in the range to the same value. Specify a range by specifying the bit numbers of the first and last bit in the range, separated by a hyphen (-).

Examples:

- To set the bit for the adapters with IDs 0x00, 0x01, 0x02, and 0x03 to 0, issue the following command:

```
# echo -0-3 > /sys/bus/ap/apmask
```

- To set the bit for the domains with ID 0x0008, 0x0009, 0x000a, 0x000b, and 0x000c to 1, issue the following command:

```
# echo +8-12 > /sys/bus/ap/aqmask
```

The following equivalent command uses hexadecimal notation:

```
# echo +0x8-0xc > /sys/bus/ap/aqmask
```

- To set all domains to 0 issue:

```
# echo -0-255 > /sys/bus/ap/aqmask
```

This command is equivalent to the following hexadecimal notation:

```
# echo -0x0-0xff > /sys/bus/ap/aqmask
```

The same results can be achieved by replacing the entire mask with 0s with the following command:

```
# echo 0x0 > /sys/bus/ap/aqmask
```

- Set multiple bits and bit ranges with a single command.

You can set multiple bits and bit ranges with the same command, by using a comma-separated list of specifications for individual bits and ranges. The expressions are processed individually from left to right.

Examples:


```
# dpkg -L libopencryptoki-dev
```

- The EP11 library `/usr/include/ep11-host-devel/ep11.h` and `/usr/include/ep11-host-devel/ep11adm.h`. These files are available after installing the `libep11-dev` package:

```
# dpkg -L libep11-dev
```

- The CCA library `/opt/IBM/<prod>/include/csulincl.h`, where `<prod>` is specific to the particular hardware product.

Clear key cryptographic functions

The `libica` library provides a C API to clear-key cryptographic functions that are supported by IBM Z hardware. You can configure both `openCryptoki` (by using the `icatoken`) and `openssl` (by using the `ibmca` engine) to use IBM Z clear-key cryptographic hardware support through `libica`. See *libica Programmer's Reference*, SC34-2602 for details about the `libica` functions.

If you must circumvent `libica` and access the `zcrypt` device driver directly, your user space program must open the `z90crypt` device node, and submit the cryptographic request with an IOCTL. The IOCTL subfunction `ICARSAMODEXPO` performs RSA modular exponent encryption and decryption. The IOCTL `ICARSACRT` performs RSA CRT decryption. See the cryptographic device driver header file in the Linux source tree:

```
/usr/include/s390x-linux-gnu/asm/zcrypt.h
```

Secure key cryptographic functions

To use secure key cryptographic functions in your user space program by accessing an EP11 coprocessor adapter, see *Exploiting Enterprise PKCS #11 using openCryptoki*, SC34-2713. You can obtain it at ibm.com/docs/en/linux-on-systems?topic=security-cryptographic-hardware-support

Reading true random numbers

To read true random numbers, a user space program must open the `hwrng` device and read as many bytes as needed from the device.

Tip: Using the output of the `hwrng` device to periodically reseed a pseudo-random number generator might be an efficient use of the random numbers.

Chapter 49. Pseudorandom number generator device driver

The pseudorandom number generator (PRNG) device driver provides user-space applications with pseudorandom numbers that are generated by the IBM Z CP Assist for Cryptographic Function (CPACF).

The PRNG device driver supports the Deterministic Random Bit Generator (DRBG) requirements that are defined in NIST Special Publication 800-90/90A. The device driver uses the SHA-512 based DRBG mechanism.

If prerequisites for the SHA-512 based DRBG are not fulfilled, the device driver uses the Triple Data Encryption Standard (TDES) algorithm instead. In TDES mode, the PRNG device driver uses a DRBG in compliance with ANSI X9.17 based on the TDES cipher algorithm. You can force the fallback to TDES mode by using the `mode=1` module parameter.

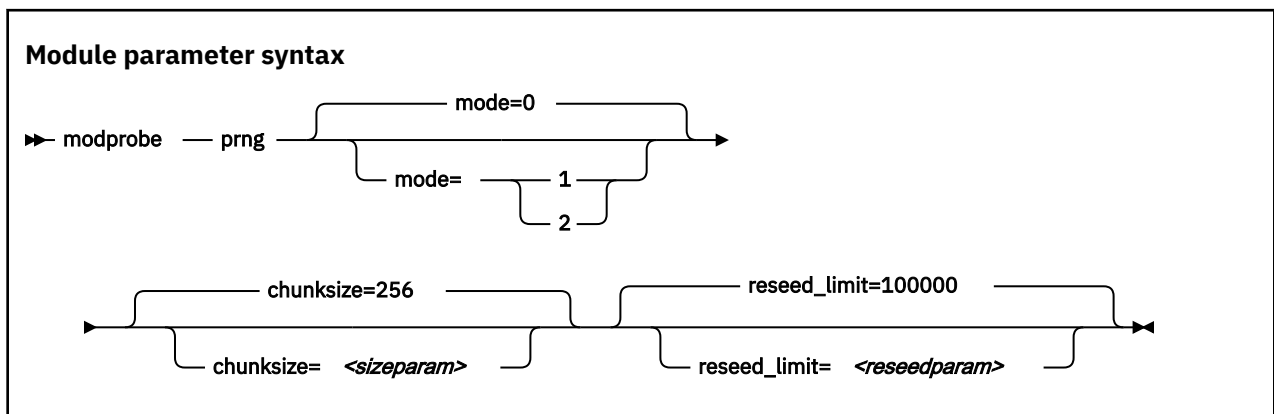
Terminology hint: Various abbreviations are commonly used for Triple Data Encryption Standard, for example: TDES, triple DES, 3DES, and TDEA.

User-space programs access the PRNG device through a device node, `/dev/prandom`. Ubuntu Server 20.04.1 provides `udev` to create it for you.

By default, the random data for seeding and reseeding the PRNG is supplied by the TRNG (see [Chapter 50, “True random-number generator device driver,”](#) on page 471). If the TRNG is unavailable, the PRNG uses an approved algorithm to derive random data from the jitter of the high-precision, built-in real-time clock of the Z hardware.

Loading and configuring the PRNG device driver

In Ubuntu Server 20.04.1 the device driver is compiled as a module and is normally loaded automatically. If needed, you can load it manually with `modprobe`.



where:

mode=

specifies the mode in which the device driver runs:

0

Default. In this mode, the device driver automatically detects the MSA extension level and feature enablement. The device driver runs in SHA512 mode if the requirements are fulfilled, otherwise it falls back to TDES mode.

1

forces the device driver to run in TDES mode. The device driver starts only if the requirements for TDES mode are fulfilled.

2

forces the device driver to run in SHA512 mode. The device driver starts only if the requirements for SHA512 mode are fulfilled. The device driver does not fall back to TDES mode.

<sizeparam>

adjusts the random-buffer block size that the device driver uses to generate new random bytes. In TDES mode, this value can be in the range 8 - 65536, for SHA512 mode, the range is 64 - 65536. The default is 256 bytes.

<reseedparam>

adjusts the reseed limit in SHA512 mode. Multiply this value with the chunksize to obtain the reseed boundary in bytes. The value can be in the range 10000 - 100000. The default is 100000. In TDES mode, the reseed limit is a constant value of 4096 bytes.

The defaults were chosen for good results with most workloads. Changing these settings might degrade cryptographic performance.

Working with the PRNG device driver

Read random numbers and control the settings of the PRNG device driver.

Tasks include:

- “[Reading pseudorandom numbers](#)” on page 468
- “[Displaying PRNG information](#)” on page 468
- “[Reseeding the PRNG](#)” on page 470
- “[Setting the reseed limit](#)” on page 469

Reading pseudorandom numbers

The pseudo-random number device is read-only. Use the read function, cat program, or dd program to obtain random numbers.

Example

In this example `bs` specifies the block size in bytes for transfer, and `count` specifies the number of records with block size. The bytes are written to the output file.

```
dd if=/dev/prandom of=<output file name> bs=<xxxx> count=<nnnn>
```

Displaying PRNG information

Read the attributes of the `prandom` device in `sysfs`.

About this task

The `sysfs` representation of a PRNG device is a directory: `/sys/devices/virtual/misc/prandom`. This `sysfs` directory contains a number of attributes with information about the device.

Table 65. Attributes with PRNG information

Attribute	Explanation
<code>chunksize</code>	The size, in bytes, of the random-data bytes buffer that is used to generate new random numbers. The value can be in the range 64 bytes - 64 KB. The default is 256 bytes. It is rounded up to the next 64-byte boundary and can be adjusted as a module parameter when you start the module.
<code>byte_counter</code>	The number of random bytes generated since the PRNG device driver was started. You can reset this value only by removing and reloading the kernel module, or rebooting Linux (if PRNG was compiled into the kernel). This attribute is read-only.

Table 65. Attributes with PRNG information (continued)

Attribute	Explanation
errorflag	SHA512 mode only: 0 if the PRNG device driver is instantiated and running well. Any other value indicates a problem. If there is an error indication other than 0: <ul style="list-style-type: none">• The DRBG does not provide random data bytes to user space• The read() function fails• The error code errno is set to EPIPE (broken pipe) This attribute is read-only.
mode	SHA512 if the PRNG device driver runs in SHA512 mode, TDES if the PRNG device driver runs in TDES mode. This attribute is read-only.
reseed	SHA512 mode only: An integer, writable only by root. Write any integer to this attribute to trigger an immediate reseed of the PRNG. See “Reseeding the PRNG” on page 470.
reseed_limit	SHA512 mode only: An integer, writable only by root to query or set the reseed counter limit. Valid values are in the range 10000 - 100000. The default is 100000. See “Setting the reseed limit” on page 469.
strength	SHA512 mode only: A read-only integer that shows the security strength according to NIST SP800-57. Returns the integer value of 256 in SHA512 mode.

Procedure

Issue a command of this form to read an attribute:

```
# cat /sys/devices/virtual/misc/prandom/<attribute>
```

where *<attribute>* is one of the attributes of [Table 65 on page 468](#).

Example

This example shows a prandom device that is running in SHA512 mode, set to reseed after 2.56 MB:

```
# cat /sys/devices/virtual/misc/prandom/chunksize
256
# cat /sys/devices/virtual/misc/prandom/mode
2
# cat /sys/devices/virtual/misc/prandom/reseed_limit
10000
```

Setting the reseed limit

The PRNG reseeds after $\text{chunksize} \times \text{reseed_limit}$ bytes are read. By default, $100000 \times 256 \approx 25.6$ MB can be read before an automatic reseed occurs.

Procedure

To set the number of times a chunksize amount of random data can be read from the PRNG before reseeding, write the number to the reseed_limit attribute.

For example:

```
# echo 10000 > /sys/devices/virtual/misc/prandom/reseed_limit
```

The reseed_limit value must be in the range 10000 - 100000.

Reseeding the PRNG

You can force a reseed by writing to the `reseed` attribute.

Procedure

To reseed the PRNG, write an integer to its `reseed` attribute:

```
# echo 1 > /sys/devices/virtual/misc/prandom/reseed
```

Writing any integer value to this attribute triggers an immediate reseed of the PRNG instance.

Chapter 50. True random-number generator device driver

The true random number generator (TRNG) device driver provides user-space applications with random data generated from the IBM Z hardware CPACF true random source.

The TRNG device is designed to provide high-quality random data for sensitive operations. This random data can be the base for cryptographic key generation or for seeding a pseudorandom number generator. The device is not intended to provide mass random data, for example, for overwriting disks.

Setting up the TRNG device driver

The true random-number generator is compiled as a separate module. To use it, load the module.

The true random-number generator requires Message-Security-Assist Extension 7 (MSA 7), which is available as of the IBM z14. During initialization of the TRNG kernel module the device driver checks for the prerequisite. If the prerequisite is not fulfilled, the device driver silently exits.

The TRNG device driver module registers itself to the CPU feature MSA. The device driver is then loaded automatically. However, you can activate the TRNG device driver manually with the command:

```
modprobe s390_trng
```

There are no module parameters for the TRNG device driver.

Device nodes for random data

The true random-number generator device driver provides two interfaces to user space applications: the device node `/dev/trng` for direct access, and the generic device node `/dev/hwrng`.

The `/dev/hwrng` node appears when the TRNG or another source of random data registers with the `hwrng` device driver. If both the TRNG and a CCA coprocessor are registered, the TRNG takes precedence.

As of the z14, the kernel random device driver also uses the CPACF TRNG true random source through the `arch_get_random_seed_*` functions. The kernel random device driver provides two device nodes, `/dev/random` and `/dev/urandom`. The `arch_get_random_seed_*` functions require the CPACF TRNG.

Working with the TRNG device driver

Read random numbers and retrieve the counters of the TRNG device driver.

Tasks include:

- [“Reading random numbers” on page 471](#)
- [“Displaying TRNG information” on page 472](#)

Reading random numbers

The TRNG device is read-only. Use the read function, cat program, or dd program to obtain random numbers.

Example

In this example `bs` specifies the block size in bytes for transfer, and `count` specifies the number of records with block size. The bytes are written to the output file.

```
dd if=/dev/trng of=<output file name> bs=<xxxx> count=<nnnn>
```

Displaying TRNG information

Read the `byte_counter` attribute of the TRNG device in `sysfs`.

About this task

The `sysfs` representation of a TRNG device is a directory: `/sys/devices/virtual/misc/trng`. This `sysfs` directory contains an attribute, `byte_counter`, with statistical data.

Procedure

Issue this command to read the `byte_counter` attribute:

```
# cat /sys/devices/virtual/misc/trng/byte_counter
```

Example

To see statistics of a TRNG device, issue:

```
# cat /sys/devices/virtual/misc/trng/byte_counter
trng: 6187
hwrng: 528
arch: 1319696
total: 1326411
```

Where:

trng

shows the number of bytes delivered through the `/dev/trng` device node.

hwrng

shows the bytes retrieved from the generic `hw_rng` device driver and contributed to `/dev/hwrng`.

arch

shows the amount of data that is supplied by the `arch` random implementation and delivered to the random device driver device nodes `/dev/random` and `/dev/urandom`.

total

shows the sum of all bytes.

Chapter 51. Protected key device driver

The protected key device driver provides functions for generating and verifying protected keys.

Protected keys are encrypted with wrapping keys that, for Linux in LPAR mode, are specific to the LPAR. For guests of z/VM or KVM, the wrapping key is specific to the guest. Both the wrapping keys and the clear key values of protected keys are invisible to the operating system. Protected keys are designed for accelerated encryption and decryption with CPACF. For more information, see the chapter about protected keys in *z/Architecture Principles of Operation*, SA22-7832.

Pervasive encryption uses protected keys for data-at-rest, see *Pervasive Encryption for Data Volumes*, SC34-2782.

Functions

The device driver provides the following functions to cryptographic applications. The following secure key functions require a Crypto Express adapter:

- Generate a random secure key, then generate a protected key from the secure key.

The secure key must be available to create a new version of the protected key whenever the current protected key is invalidated.

- Generate a secure key from a clear key, then generate a protected key from the secure key.

The clear key must be in memory when the protected key is generated. Thereafter, the clear key can be deleted.

The secure key must be available to create a new version of the protected key whenever the current protected key is invalidated.

The following functions do not require a Crypto Express adapter:

- Generate a protected key from a clear key. The clear key must be in memory when the protected key is generated.

The clear key must also be available to create a new protected key if the existing protected key is invalidated.

- Generate a protected AES key from random data.

The effective clear key is never exposed in memory.

Important: The key is volatile and cannot be recreated if lost, for example during a reboot. Use a protected key generated from random data only to protect transient data.

The device driver also provides an in-kernel interface to generate protected keys. This interface is used, for example, by the `paes_s390` module.

Prerequisites

The protected key device driver requires the message-security-assist-extension 3 facility (MSA level 3), which was introduced with z196.

The protected key device driver requires permission for the AES key import functions. To grant this permission, go to the security settings within the profile of the applicable LPAR on the HMC. In the **CPACF Key Management Operations** section, select the **Permit AES Key import functions** option. For z/VM and KVM guests, the LPAR in which the hypervisor runs requires this option.

Secure keys are encoded with a master key that is held in Crypto Express adapters. Functions that involve secure keys require an IBM Crypto Express adapter in CCA coprocessor mode with a valid master key. For Linux on z/VM, the adapter must be dedicated to the z/VM guest virtual machine.

Crypto Express adapters can provide the following types of secure keys:

CCA AES data secure key

Requires an IBM CEX4S or later adapter in CCA coprocessor mode.

CCA AES cipher secure key

Requires an IBM CEX6S or later adapter in CCA coprocessor mode.

EP11 AES secure key

Requires an IBM CEX7S adapter in EP11 coprocessor mode.

Loading the device driver module

The protected key device driver is compiled as a separate module. Ubuntu Server loads the module automatically during the boot process.

The pkey module has no module parameters. You can check that the module loaded properly with:

```
# lsmod | grep pkey
pkey                20480  0
zcrypt              69632  3 pkey,zcrypt_cex4
```

If needed, you can load the pkey module with the **modprobe** command:

```
# modprobe pkey
```

Generating volatile protected keys by using the pkey device driver

You can generate protected keys from random data by reading the binary sysfs pkey attributes.

About this task

You do not need a Crypto Express adapter to generate a protected key from random data.

The `/sys/devices/virtual/misc/pkey/protkey` directory contains an attribute for each available key type. Read an attribute to obtain a protected key token.

Procedure

Go to the `protkey` subdirectory. The following attributes are available:

- `protkey_aes_128`
- `protkey_aes_192`
- `protkey_aes_256`
- `protkey_aes_128_xts`
- `protkey_aes_256_xts`

When reading from an attribute, you receive exactly one protected-key token. That is, for non-XTS keys, you get 80 bytes. For attributes related to the XTS cipher mode, you get two concatenated protected-key tokens, that is, you get 160 bytes.

Important: Do not use protected keys that are generated from random data to encrypt persistent data.

Alternatively to sysfs, you can use the ioctl calls, see [“External programming interfaces”](#) on page 476.

For secure key tokens, see [“Generating secure keys using the pkey device driver”](#) on page 474

Generating secure keys using the pkey device driver

The pkey device driver uses random data from an AP queue to generate secure keys.

Such keys can be used for example, for swap disks where you might want a new key to be generated at every boot. Secure keys for this and other purposes can be read from secure key sysfs attributes.

Alternatively to sysfs, you can use the ioctl calls, see [“External programming interfaces ” on page 476.](#)

Procedure

Read the sysfs attribute according to the required the type, length, and cipher mode of the key.

- For a CCA AES data secure key, read from one of the attributes in `/sys/devices/virtual/misc/pkey/ccadata`. The following attributes are available:
 - `ccadata_aes_128`
 - `ccadata_aes_192`
 - `ccadata_aes_256`
 - `ccadata_aes_128_xts`
 - `ccadata_aes_256_xts`
- For a CCA AES cipher secure key read from one of the attributes in `/sys/devices/virtual/misc/pkey/ccacipher`. The following attributes are available:
 - `ccacipher_aes_128`
 - `ccacipher_aes_192`
 - `ccacipher_aes_256`
 - `ccacipher_aes_128_xts`
 - `ccacipher_aes_256_xts`
- For an EP11 AES secure key read from one of the attributes `/sys/devices/virtual/misc/pkey/ep11`. The following attributes are available:
 - `ep11_aes_128`
 - `ep11_aes_192`
 - `ep11_aes_256`
 - `ep11_aes_128_xts`
 - `ep11_aes_256_xts`

Results

Attributes for non-XTS keys yield exactly one secure-key token. Attributes for XTS cipher mode yield two concatenated secure-key tokens. The length of a token also varies by key type and length as summarized in [Table 66 on page 475.](#)

Key type	Attribute length non-XTS (single key token)	Attribute length XTS (two key tokens)
CCA AES data secure key	64 bytes	128 bytes
CCA AES cipher secure key	136 bytes	272 bytes
EP11 AES secure key	320 bytes	640 bytes

Setting up an encrypted swap disk

You can use a volatile protected key generated by the pkey device driver to encrypt a swap disk.

About this task

Because swap disks are discarded on reboot, volatile encryption keys are an option. You can generate volatile protected keys or secure keys from random data.

Important: Use a protected key based on random data for cases where the key is not needed after a reboot. In particular, do not use such a key in a guest that might be subject to:

- KVM guest migration
- z/VM live guest relocation in a single system image (SSI)

Also, do not use such a key in any Linux instance that might be subject to:

- Suspend and resume

Procedure

1. Add an entry to `/etc/crypttab`. To encrypt the swap device using a protected key, the entry must point to one of the sysfs attributes within the `protkey` directory. Use the attribute for the required key type (see “Generating volatile protected keys by using the pkey device driver” on page 474). For example:

```
# <name> <device> <password> <options>
swap /dev/dasdx /sys/devices/virtual/misc/pkey/protkey/protkey_aes_256_xts swap, \
cipher=paes-xts-plain64,size=1280
```

The swap option causes an **mkswap** to be performed after the dm-crypt device is set up.

Tip: Consider adding the `sector-size=4096` option to increase the performance of dm-crypt encrypted disks with large block sizes.

2. Add an entry to `/etc/fstab` to use the device-mapper device swap as swap device: For example:

```
<filesystem> <dir> <type> <options> <dump> <pass>
/dev/mapper/swap none swap defaults 0 0
```

Results

During system startup, `/etc/crypttab` is evaluated, the pkey kernel module is loaded, and a dm-crypt device is set up in plain mode as a swap device, using protected key AES in XTS cipher mode. The random protected AES key is read from `/sys/devices/virtual/misc/pkey/protkey/protkey_aes_256_xts`. Its size is 2x80 bytes, which is 1280 bits.

Linux now runs with a swap device that is encrypted with a protected key.

External programming interfaces

Applications can use the protected key device driver through ioctls or corresponding kernel APIs.

Programmers: This information is intended for programmers of cryptographic applications who want to use protected keys for accelerated cryptographic operations with CPACF.

Issue ioctls on the misc character device `/dev/pkey` to generate and handle protected keys. The ioctl interface, including the required defines and structure definitions, is described in `/usr/include/s390x-linux-gnu/asm/pkey.h`. Each ioctl has a matching kernel API that is also described in this file.

Name	Structure passed	Description
PKEY_GENSECK	struct pkey_genseck	Obtain a random CCA AES data secure key from an AP queue. The secure key is encrypted with the master key of the AP queue.

Table 67. *ioctl*s of the protected key device driver (continued)

Name	Structure passed	Description
PKEY_GENSECK2	struct pkey_genseck2	Obtain a random secure key from an AP queue. The secure key is encrypted with the master key of the AP queue. Available key types are: CCA AES data secure key, CCA AES cipher secure key, and EP11 AES secure key.
PKEY_CLR2SECK	struct pkey_clr2seck	Obtain a CCA AES data secure key from an AP queue. The secure key is generated from a specified clear key and encrypted with the master key of the AP queue.
PKEY_CLR2SECK2	struct pkey_clr2seck2	Obtain a secure key from an AP queue. The secure key is generated from a specified clear key and encrypted with the master key of the AP queue. Available key types are: CCA AES data secure key, CCA AES cipher secure key, and EP11 AES secure key.
PKEY_SEC2PROTK	struct pkey_sec2protk	Obtain a protected CCA AES data key from an AP queue. The protected key is generated from a specified secure key.
PKEY_CLR2PROTK	struct pkey_clr2protk	Obtain a protected key. The protected key is generated from a specified clear key.
PKEY_FINDCARD	struct pkey_findcard	Find an AP queue that holds the applicable master key for a specified CCA AES data secure key.
PKEY_SKEY2PKEY	struct pkey_skey2pkey	Find an AP queue that holds the applicable master key for a specified CCA AES data secure key. Then use that AP queue to obtain a protected key that is generated from the secure key. This <i>ioctl</i> call combines PKEY_FINDCARD and PKEY_SEC2PROTK.
PKEY_GENPROTK	struct pkey_genprotk	Generates a volatile protected key using pkey.
PKEY_VERIFYPROTK	struct pkey_verifyprotk	Verifies an AES protected key.
PKEY_VERIFYKEY2	struct pkey_verifykey2	Verifies a key blob and returns information about the key. The key can be verified against one specific AP queue. If no AP queue is specified, all available queues are checked and the ID of a queue is returned for which the key is valid. The call ends with an error if the key is not valid for the specified queue or if no queue is available for which the key is valid.
PKEY_KBLOB2PKEY	struct pkey_kblob2pkey	Transforms a key blob of a protected key or of a CCA AES data secure key into a protected key.
PKEY_KBLOB2PKEY2	struct pkey_kblob2pkey2	Transforms a key blob into a protected key. The key blob can be for a protected key, a CCA AES data secure key, a CCA AES cipher secure key, or an EP11 AES secure key.
PKEY_APQNS4K	struct pkey_apqns4key	Finds all available AP queues for which a specified key blob is valid.

Table 67. *ioctl*s of the protected key device driver (continued)

Name	Structure passed	Description
PKEY_APQNS4KT	struct pkey_apqns4keytype	Finds all available AP queues for which a specified key type is valid for a particular master key.

Chapter 52. Hardware-accelerated in-kernel cryptography

The Linux kernel implements cryptographic operations for kernel subsystems like dm-crypt and IPsec. Applications can use these operations through the kernel cryptographic API.

In-kernel cryptographic and checksum operations can be performed by platform-specific implementations instead of the generic implementations within the Linux kernel. On IBM Z, hardware-accelerated processing is available for some of these operations.

Hardware dependencies and restrictions

The cryptographic operations that can be accelerated by hardware implementations depend on your IBM Z hardware and mode of operating Ubuntu Server.

The following functions require a z14 or later:

- AES for GCM for 128-bit, 192-bit, and 256-bit keys
- SHA3-256 and SHA3-512

IBM z15 provides CPACF MSA9, including Edwards-curve DSA (Ed25519, Ed448), and Elliptic Curve DSA (P-256, P-384, P-521).

CPACF dependencies

Hardware-acceleration for DES, TDES, AES, GHASH, PAES, and SHA requires the Central Processor Assist for Cryptographic Function (CPACF). For information about enabling CPACF, see the documentation for your IBM Z hardware.

Vector Extension Facility dependencies

Hardware-acceleration for CRC32 algorithms requires the Vector Extension Facility. Read the `features` line from `/proc/cpuinfo` to find out whether this facility is available on your hardware.

Example:

```
# grep features /proc/cpuinfo
features          : esan3 zarch stfle msa ldisp eimm dfp edat etf3eh highgprs te vx sie
```

In the output line, `vx` indicates that the Vector Extension Facility is available.

FIPS restrictions of the hardware capabilities

If the kernel runs in Federal Information Processing Standard (FIPS) mode, only FIPS 140-2 approved algorithms are available. DES, for example, is not approved by FIPS 140-2.

Read `/proc/sys/crypto/fips_enabled` to find out whether your kernel runs in FIPS mode.

Example:

```
# cat /proc/sys/crypto/fips_enabled
0
```

The kernel of the example does not run in FIPS mode. Also, if the `/proc/sys/crypto/fips_enabled` file does not exist, the kernel does not run in FIPS mode. For kernels that run in FIPS mode, the file exists and the output of the command is `1`.

You control the FIPS mode with the `fips` kernel parameter, see “[fips - Run Linux in FIPS mode](#)” on page 703.

For more information about FIPS, see csrc.nist.gov/publications/detail/fips/140/2/final.

For more information about FIPS and Ubuntu, see the Ubuntu Security Certifications at:

<https://docs.ubuntu.com/security-certs/en>

Support modules

Ubuntu Server 20.04.1 LTS automatically loads the modules that support the available hardware-acceleration.

sha1_s390

enables hardware-acceleration for SHA-1 operations. `sha1_s390` requires the `sha_common` module.

sha256_s390

enables hardware-acceleration for SHA-224 and SHA-256 operations. `sha256_s390` requires the `sha_common` module.

sha512_s390

enables hardware-acceleration for SHA-384 and SHA-512 operations. `sha512_s390` requires the `sha_common` module.

sha3_256_s390

enables hardware-acceleration for SHA3-224 and SHA3-256 operations. `sha3_256_s390` requires the `sha_common` module.

sha3_512_s390

enables hardware-acceleration for SHA3-384 and SHA3-512 operations. `sha3_512_s390` requires the `sha_common` module.

ghash_s390

enables hardware-acceleration for Galois hashes.

aes_s390

enables hardware-acceleration for AES encryption and decryption for the following modes of operation:

- ECB, CBC, and CTR for key lengths 128, 192, and 256 bits
- XTS for key lengths 128 and 256 bits
- GCM for key lengths 128, 192, and 256 bits

des_s390

enables hardware-acceleration for DES and TDES for the following modes of operation: ECB, CBC, and CTR.

crc32-vx_s390

enables hardware-acceleration for CRC-32 (IEEE 802.3 Ethernet) and CRC-32C (Castagnoli).

paes_s390

enables protected key AES encryption and decryption for the following modes of operation:

- ECB, CBC, and CTR for key lengths 128, 192, and 256 bits
- XTS for key lengths 128 and 256 bits

The `paes_s390` kernel module includes a self test for each cipher that it provides. These self tests run by default. As a prerequisite for a successful self test, at least one of the following conditions must be met:

- The PCKMO instruction is enabled in the profile of the LPAR on which the Linux instance or its hosting hypervisor runs. To enable the PCKMO instruction, select the **Permit AES Key import functions** option in the **CPACF Key Management Operations** section.
- The Linux instance can access a cryptographic adapter in CCA coprocessor mode.

- The Linux instance can access a cryptographic adapter in EP11 coprocessor mode.

The `paes_s390` module requires the `pkey` device driver, see [Chapter 51, “Protected key device driver,”](#) on page 473.

The module also requires a cryptographic adapter for creating and handling secure and protected keys:

- To use CCA AES data or CCA AES cipher secure keys, the module requires a cryptographic adapter in CCA coprocessor mode.
- To use EP11 secure keys, the module requires a cryptographic adapter in EP11 coprocessor mode.

The `paes_390` module accepts key tokens of different types as key material, as produced by the `pkey` driver:

- Secure key tokens. For secure key tokens, the module needs a CCA cryptographic adapter. For more information about secure key tokens, see [“Generating secure keys using the pkey device driver”](#) on page 474
- Protected key tokens from random data. No cryptographic adapter is needed. For more information about protected key tokens from random data, see [“Generating volatile protected keys by using the pkey device driver”](#) on page 474.

The ciphers in the `paes_s390` module can work with CCA secure data keys and CCA secure cipher keys, for example, keys that are generated by the `pkey` device driver. XTS requires two secure keys.

Before the `paes_s390` module uses secure keys in a cipher, it transforms them into protected keys. If a protected key becomes invalid, the `paes_s390` module re-generates the protected key from the secure key.

Mainframe hardware prior to z14: To use CPACF for AES-GCM operations, you must load both the `aes_s390` and `ghash_s390` module.

Confirming hardware support for cryptographic operations

Read `/proc/crypto` to confirm that cryptographic operations are performed with hardware support.

Procedure

Read the `driver` lines from the content of `/proc/crypto`.

Example:

```
# cat /proc/crypto | grep driver
driver      : sha512-s390
driver      : sha224-s390
driver      : sha256-s390
driver      : sha3-512-s390
driver      : sha3-256-s390
driver      : sha1-s390
driver      : ghash-s390
...
driver      : crc32c-vx
driver      : crc32be-vx
driver      : crc32-vx
```

Each line that ends in `-s390` indicates hardware-acceleration for a corresponding algorithm or mode. Lines that end in `-vx` indicate hardware-acceleration for CRC32 checksums.

Chapter 53. Instruction execution protection

The instruction execution protection feature on IBM mainframes protects against data execution, similar to the NX feature on other architectures.

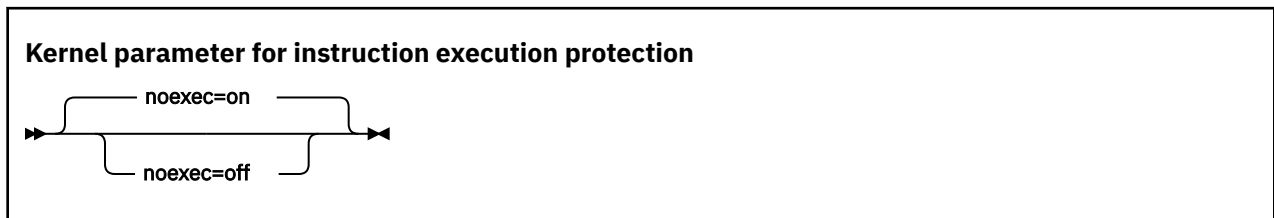
Instruction execution protection prevents stack-overflow exploits and generally makes a system insensitive to buffer-overflow attacks.

Data instruction protection is available on IBM mainframe hardware with the IEP feature. For Linux as a guest of a hypervisor, the hypervisor must support and use the instruction execution protection feature.

Instruction execution protection is available to your Linux instance if the features line in `/proc/cpuinfo` includes `iep`.

Setting up instruction execution protection

By default, Linux on Z uses the instruction execution protection feature if it is available. You can use the `noexec` kernel parameter to disable the feature in Linux.



If set to `on`, `noexec` enables instruction execution protection, this is the default. If set to `off`, `noexec` disables instruction execution protection.

Controlling stack execution protection

To prevent stack-overflow exploits, the stack of a binary or shared library must be marked as not executable.

About this task

Use the `execstack` command to set, clear, or query the executable stack flag of ELF binaries and shared libraries (`GNU_STACK`). For details about `execstack`, see the man page.

Example

- Set and query the executable stack flag.

```
# execstack -s /usr/bin/find
# execstack -q /usr/bin/find
X /usr/bin/find
```

The leading `X` at the beginning of the query output line indicates that the stack is executable.

Hint: You can also use the `readelf` command to confirm that the stack can be executed.

```
# readelf -a /usr/bin/find | grep GNU_STACK -A 1
GNU_STACK 0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 RWE 8
```

The `RWE` towards the end of the output line means read/write/execute. You can obtain the `readelf` command as part of the `binutils` package. For command details, see the man page.

- Clear and query the executable stack flag.

```
# execstack -c /usr/bin/find
# execstack -q /usr/bin/find
- /usr/bin/find
```

The leading - at the beginning of the query output line indicates that the stack is not executable.

Hint: You can also use the **readelf** command to confirm that the stack cannot be executed.

```
# readelf -a /usr/bin/find | grep GNU_STACK -A 1
GNU_STACK 0x0000000000000000 0x0000000000000000 0x0000000000000000
0x0000000000000000 0x0000000000000000 RW 8
```

The RW towards the end of the output line means read/write, but not execute.

Part 9. Performance measurement using hardware facilities

The Z hardware provides performance data that can be accessed by Linux on Z.

Gathering performance data constitutes an additional load on the Linux instance on which the application to be analyzed runs. Hardware support for data gathering can reduce the extra load and can yield more accurate data.

For the performance measurement facilities of z/VM, see [“Performance monitoring for z/VM guest virtual machines”](#) on page 367.

Other performance relevant information is provided in the context of the respective device driver or feature. For example, see [“Working with DASD statistics in debugfs”](#) on page 132 for DASD performance and [“Displaying and resetting QETH performance statistics”](#) on page 241 for qeth group devices.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 54. Channel measurement facility

LPAR and z/VM: The channel measurement facility is supported for Linux in LPAR mode and for Linux on z/VM.

The IBM Z architecture provides a channel measurement facility to collect statistical data about I/O on the channel subsystem.

Data collection can be enabled for all CCW devices. User space applications can access this data through the sysfs.

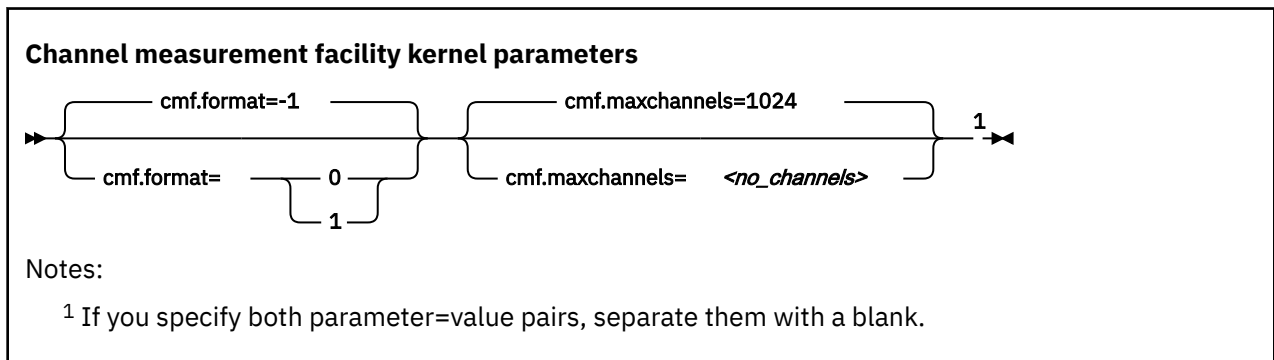
The channel measurement facility provides the following features:

- Basic channel measurement format for concurrently collecting data on up to 4096 devices. (Specifying 4096 or more channels causes high memory consumption, and enabling data collection might not succeed.)
- Extended channel measurement format for concurrently collecting data on an unlimited number of devices.
- Data collection for all channel-attached devices, except those using QDIO (that is, except qeth and SCSI-over-Fibre channel attached devices)

Setting up the channel measurement facility

Configure the channel measurement facility by adding parameters to the kernel parameter file.

You can configure the channel measurement facility by adding parameters to the kernel parameter file.



where:

cmf.format

defines the format, 0 for basic and 1 for extended, of the channel measurement blocks. The default, -1, uses the extended format for z990 and later mainframes and the basic format for earlier mainframes.

cmf.maxchannels=<no_channels>

limits the number of devices for which data measurement can be enabled concurrently with the basic format. The maximum for <no_channels> is 4096. A warning will be printed if more than 4096 channels are specified. The channel measurement facility might still work; however, specifying more than 4096 channels causes a high memory consumption.

For the extended format there is no limit and any value you specify is ignored.

Working with the channel measurement facility

Typical tasks that you need to perform when you work with the channel measurement facility is controlling data collection and reading data.

Enabling, resetting, and switching off data collection

Control data collection through the `cmb_enable` sysfs attribute of the device.

Procedure

- To enable data collection, write 1 to the `cmb_enable` attribute. If data collection was already enabled, writing 1 to the attribute resets all collected data to zero.

Issue a command of this form:

```
# echo 1 > /sys/bus/ccw/devices/<device_bus_id>/cmb_enable
```

where `/sys/bus/ccw/devices/<device_bus_id>` represents the device in sysfs.

When data collection is enabled for a device, a subdirectory `/sys/bus/ccw/devices/<device_bus_id>/cmf` is created that contains several attributes. These attributes contain the collected data (see “Reading data” on page 488).

- To switch off data collection issue a command of this form:

```
# echo 0 > /sys/bus/ccw/devices/<device_bus_id>/cmb_enable
```

When data collection for a device is switched off, the subdirectory `/sys/bus/ccw/devices/<device_bus_id>/cmf` and its content are deleted.

Example

In this example, data collection for a device `/sys/bus/ccw/devices/0.0.b100` is already active and reset:

```
# cat /sys/bus/ccw/devices/0.0.b100/cmb_enable
1
# echo 1 > /sys/bus/ccw/devices/0.0.b100/cmb_enable
```

Reading data

Read the sysfs attributes with collected I/O data, for example with the `cat` command.

Procedure

To read one of the attributes issue a command of this form:

```
# cat /sys/bus/ccw/devices/<device_bus_id>/cmf/<attribute>
```

where `/sys/bus/ccw/devices/<device_bus_id>` is the directory that represents the device, and `<attribute>` the attribute to be read. [Table 68 on page 488](#) summarizes the available attributes.

Table 68. Attributes with collected I/O data

Attribute	Value
<code>ssch_rsch_count</code>	An integer that represents the <code>ssch_rsch</code> count value.
<code>sample_count</code>	An integer that represents the sample count value.
<code>avg_device_connect_time</code>	An integer that represents the average device connect time, in nanoseconds, per sample.
<code>avg_function_pending_time</code>	An integer that represents the average function pending time, in nanoseconds, per sample.

Table 68. Attributes with collected I/O data (continued)

Attribute	Value
avg_device_disconnect_time	An integer that represents the average device disconnect time, in nanoseconds, per sample.
avg_control_unit_queuing_time	An integer that represents the average control unit queuing time, in nanoseconds, per sample.
avg_initial_command_response_time	An integer that represents the average initial command response time, in nanoseconds, per sample.
avg_device_active_only_time	An integer that represents the average device active only time, in nanoseconds, per sample.
avg_device_busy_time	An integer that represents the average value device busy time, in nanoseconds, per sample.
avg_utilization	A percent value that represents the fraction of time that has been spent in device connect time plus function pending time plus device disconnect time during the measurement period.
avg_sample_interval	An integer that represents the average time, in nanoseconds, between two samples during the measurement period. Can be "-1" if no measurement data has been collected.
avg_initial_command_response_time	An integer that represents the average time in nanoseconds between the first command of a channel program being sent to the device and the command being accepted. Available in extended format only.
avg_device_busy_time	An integer that represents the average time in nanoseconds of the subchannel being in the "device busy" state when initiating a start or resume function. Available in extended format only.

Example

To read the avg_device_busy_time attribute for a device /sys/bus/ccw/devices/0.0.b100:

```
# cat /sys/bus/ccw/devices/0.0.b100/cmF/avg_device_busy_time
21
```

Chapter 55. Using the CPU-measurement facilities

LPAR only: The CPU-measurement facilities apply to Linux in LPAR mode only.

Use the CPU-measurement counter facility and sampling facility to obtain performance data for Linux in LPAR mode.

Counter facility

The hardware counters are grouped into the following counter sets:

- Basic counter set
- Problem-state counter set
- Crypto-activity counter set
- Extended counter set
- MT-diagnostic counter set

A further common counter set, the Coprocessor group counter set, cannot be accessed from Linux on Z.

Sampling facility

The sampling facility includes the following sampling modes:

- Basic-sampling mode
- Diagnostic-sampling mode

The diagnostic-sampling mode is intended for use by IBM Support only.

The number and type of individual counters and the details of the sampling facility depend on your Z hardware model. Use the **lscpumf** command to find out what is available for your hardware (see [“lscpumf - Display information about the CPU-measurement facilities”](#) on page 597). For details, see *IBM The CPU-Measurement Facility Extended Counters Definition for z10, z196/z114, zEC12/zBC12, z13/z13s, z14, and z15, SA23-2261*.

You can use the perf tool on Linux to access the hardware counters and sample data of the CPU-measurement facilities.

To use the perf tool, you need to install the linux-tools-common package provided by Debian.

If you want to write your own application for analyzing counter or sample data, you can use the libpfm4 library. This library is available from Debian at perfmon2.sourceforge.net.

Working with the CPU-measurement facilities

You can use the perf tool to work with the CPU-measurement facilities for authorized LPARs.

- [“Authorizing an LPAR”](#) on page 491
- [“Reading CPU-measurement counters”](#) on page 492
- [“Collecting CPU-measurement sample data”](#) on page 494
- [“Setting limits for the sampling facility buffer”](#) on page 494
- [“Obtaining details about the CPU-measurement facilities”](#) on page 495

Authorizing an LPAR

The LPAR within which the Linux instance runs must be authorized to use the CPU-measurement counter sets or sampling modes. Use the HMC or SE to authorize the LPAR.

About this task

The details of the steps in this task can differ, depending on your hardware. For more information, see the *Support Element Operations Guide* for your mainframe system.

Procedure

Perform these steps on the HMC or SE to grant authorizations:

1. Navigate to the LPAR for which you want to grant authorizations.
2. Within the LPAR profile, select the **Security** page.
3. Within the counter facility options, select each counter set you want to use. The coprocessor group counter set is not supported by Linux on Z.
4. If you want to use the sampling facility, select the basic sampling mode within the sampling facility options.

Note: You cannot enable the diagnostic mode unless it has been enabled for you by IBM Support.

5. Click **Save**.

What to do next

Deactivate, activate, and IPL the LPAR to make the authorization take effect. For more information, see the *Support Element Operations Guide* for your mainframe system.

When your Linux instance is available again, you can use the **lscpumf** command to confirm that the authorizations are in place (see [“lscpumf - Display information about the CPU-measurement facilities”](#) on page 597).

Reading CPU-measurement counters

Use the perf tool to read CPU-measurement counters.

Before you begin

You must know the symbolic name for the counter or the decimal value of the counter number. Issue `lscpumf -c` to obtain a list of counters, their symbolic names, and their numbers (see [“lscpumf - Display information about the CPU-measurement facilities”](#) on page 597).

You can also find the decimal values in *z/Architecture The Load-Program-Parameter and the CPU-Measurement Facilities*, SA23-2260 and in *IBM The CPU-Measurement Facility Extended Counters Definition for z10, z196/z114, zEC12/zBC12, z13/z13s, z14, and z15*, SA23-2261.

Procedure

Issue a **perf** command to read a counter.

- Using symbolic names:

```
# perf stat -e cpum_cf/event=<symbolic_name>/ -- <path_to_app>
```

- Using raw events:

```
# perf stat -e <type>:<counter_number> -- <path_to_app>
```

- Using raw events without specifying the type:

```
# perf stat -e cpum_cf/event=<counter_number>/ -- <path_to_app>
```

Where:

-e cpum_cf/event=<symbolic_name>/

specifies a counter through a symbolic name. Symbolic names are lengthy but meaningful and the same for all mainframes models that support the counter.

-e <type>:<counter_number>

specifies a counter as a raw event. In the specification, <counter_number> is a decimal number.

<type> is a decimal number that the kernel assigns to the CPU-measurement facilities device driver. To find that value on a running Linux instance, read the value of /sys/devices/cpum_cf/type.

Interface change: As of kernel 5.5 the notation <type>:<counter_number> replaces the former *r<hex_counter_number>*, where <hex_counter_number> was the counter number in hexadecimal notation.

This specification is short but abstract, the numbers can differ between hardware models, and the value for <type> can change across boot cycles.

-e cpum_cf/event=<counter_number>/

specifies a counter as a raw event. In the specification, <counter_number> is the same decimal number as in the previous format. This format avoids the type specification.

<path_to_app>

specifies the path to the application to be evaluated. The counters are incremented for all threads that belong to the specified application. If you specify -a instead of the double hyphen and path, system-wide counter data is read.

Tip: You can read multiple counters by specifying a comma-separated list of counters. For example, with 5 as the value for <type>: -e 5:32,5:33.

For more information about the **perf** command, see the **perf** or **perf-stat** man page.

Examples

Issue one of the following commands to read the problem-state cycle count counter (symbolic name `PROBLEM_STATE_CPU_CYCLES`; decimal value 32) and the problem-state instruction count counter (symbolic name `PROBLEM_STATE_INSTRUCTIONS`; decimal value 33) for an application `/bin/df`.

- Using symbolic names:

```
# perf stat -e cpum_cf/event=PROBLEM_STATE_CPU_CYCLES/, \
cpum_cf/event=PROBLEM_STATE_INSTRUCTIONS/ -- /bin/df
Filesystem            1K-blocks      Used Available Use% Mounted on
/dev/dasda1            6967656      3360888   3229780   51% /
none                   942956         88    942868    1% /dev/shm
/dev/dasdb1            6967656      4135792   2471260   63% /root

Performance counter stats for '/bin/df':

      1,258,624      PROBLEM_STATE_CPU_CYCLES
       341,792      PROBLEM_STATE_INSTRUCTIONS

0.002676094 seconds time elapsed
```

- Using raw events:

```
# cat /sys/devices/cpum_cf/type
5
# perf stat -e 5:32,5:33 -- /bin/df
Filesystem            1K-blocks      Used Available Use% Mounted on
/dev/dasda1            6967656      3360884   3229784   51% /
none                   942956         88    942868    1% /dev/shm
/dev/dasdb1            6967656      4135792   2471260   63% /root

Performance counter stats for '/bin/df':

      1,233,295      5:32
       341,792      5:33

0.002526281 seconds time elapsed
```

Collecting CPU-measurement sample data

Use the `perf` tool to read CPU-measurement sample data.

Procedure

Issue a command of this form to read sample data:

```
# perf record -e cpum_sf/event=SF_CYCLES_BASIC/ -- <path_to_app>
```

Where `<path_to_app>` is the path to the application for which you want to collect sample data. If you specify `-a` instead of the double hyphen and path, system-wide sample data is collected.

Instead of the symbolic name, you can also specify the raw event name `1B0000`.

Example

```
# perf record -e cpum_sf/event=SF_CYCLES_BASIC/ -- /bin/df
Filesystem      1k-blocks      Used Available Use% Mounted on
/dev/dasda1      6967656      3360508   3230160   51% /
none            942956         88     942868    1% /dev/shm
/dev/dasdb1      6967656      4132924   2474128   63% /root
[ perf record: Woken up 1 times to write data ]
[ perf record: Captured and wrote 0.001 MB perf.data (~29 samples) ]
```

What to do next

You can now display the sample data by issuing the following command:

```
# perf report
```

For more information about collecting and displaying sample data with the `perf` command, see the `perf-record` and the `perf-report` man pages.

Hint: You can use the `perf record -F` option to collect sample data at a high frequency or the `perf record -c` option to collect sample data for corresponding short sampling intervals. Specified values must be supported by both the CPU-measurement sampling facility and `perf`. Issue `lscpumf -i` to find out the maximum and minimum values for the CPU-measurement sampling facility. If `perf` fails at a high sampling frequency, you might have to adjust the `kernel.perf_event_max_sample_rate` system control to override default `perf` limitations.

Setting limits for the sampling facility buffer

Use the `chcpumf` command to set the minimum and maximum buffer size for the CPU-measurement sampling facility. See [“chcpumf - Set limits for the CPU measurement sampling facility buffer”](#) on page 522.

Before you begin

For each CPU, the CPU-measurement sampling facility has a buffer for writing sample data. The required buffer size depends on the sampling function and the sampling interval that is used by the `perf` tool. The sampling facility starts with an initial buffer size that depends on the expected requirements, your IBM Z hardware, and the available hardware resources. During the sampling process, the sampling facility increases the buffer size if required.

The sampling facility is designed for autonomous buffer management, and you do not usually need to intervene. You might want to change the minimum or maximum buffer size, for example, for one of the following reasons:

- There are considerable resource constraints on your system that cause `perf` sampling to malfunction and sample data to be lost.

- As an expert user of perf and the sampling facility, you want to explore results with particular buffer settings.

Procedure

Use the **chcpumf** command to set the minimum and maximum buffer sizes.

1. Optional: Specify the **lscpumf** command with the **-i** parameter to display the current limits for the buffer size (see “[lscpumf - Display information about the CPU-measurement facilities](#)” on page 597).
2. Optional: Specify the **chcpumf** command with the **-m** parameter to set the minimum buffer size.

Example:

```
# chcpumf -m 500
```

The value that you specify with **-m** is the minimum buffer size in multiples of sample-data-blocks. A sample-data-block occupies approximately 4 KB. The specified minimum value is compared with the initial buffer size that is calculated by the sampling facility. The greater value is then used as the initial size when the sampling facility is started.

3. Optional: Specify the **chcpumf** command with the **-x** parameter to set the maximum buffer size.

Example:

```
# chcpumf -x 1000
```

The value that you specify with **-x** is the maximum buffer size in multiples of sample-data-blocks. A sample-data-block occupies approximately 4 KB. The specified maximum is the upper limit to which the sampling facility can adjust the buffer.

Example

Tips:

- You can specify both, the minimum and the maximum buffer size with a single command.
- Use the **-V** parameter to display the minimum and maximum buffer settings that apply as a result of the command.

Example: To change the minimum buffer size to 500 times the size of a sample-data-block and the maximum buffer size to 1000 times the size of a sample-data-block, issue:

```
# chcpumf -V -m 500 -x 1000
Sampling buffer sizes:
  Minimum:    500 sample-data-blocks
  Maximum:   1000 sample-data-blocks
```

Obtaining details about the CPU-measurement facilities

You can obtain version information for the CPU-measurement counter and sampling facility and check which counter sets are authorized on your LPAR.

Procedure

1. Issue the **lscpumf** command with the **-i** parameter to display detailed information and debug data about the CPU-measurement facilities.

Example:

```

# lscpumf -i
CPU-measurement counter facility
-----
Version: 1.2

Authorized counter sets:
  Basic counter set
  Problem-State counter set

Linux perf event support: Yes (PMU: cpum_cf)

CPU-measurement sampling facility
-----
Sampling Interval:
  Minimum:      18228 cycles (approx.   285714 Hz)
  Maximum:     170650536 cycles (approx.   30 Hz)

Authorized sampling modes:
  basic        (sample size: 32 bytes)

Linux perf event support: Yes (PMU: cpum_sf)

Current sampling buffer settings for cpum_sf:
  Basic-sampling mode
  Minimum:      15 sample-data-blocks ( 64KB)
  Maximum:     8176 sample-data-blocks ( 32MB)

```

2. Optional: For more detailed information, including debug information, use the magic sysrequest function with character p. This function triggers kernel messages.

For example, trigger the messages from procfs:

```
# echo p > /proc/sysrq-trigger
```

Note: If you call magic sysrequest functions with a method other than through the procfs, you might need to activate them first. For more information about the magic sysrequest functions, see [“Using the magic sysrequest feature”](#) on page 49.

Find the messages by issuing the **dmesg** command and looking for output lines that include CPUM_CF or CPUM_SF.

More information: For details about the information in the messages, see *z/Architecture The Load-Program-Parameter and the CPU-Measurement Facilities*, SA23-2260, and the perf section in *Kernel Messages*, SC34-2599.

Part 10. Diagnostics and troubleshooting

These resources are useful when diagnosing and solving problems for Ubuntu Server 20.04.1.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

When reporting a problem to IBM Support, you might be asked to supply a kernel dump. See *Using the Dump Tools*, SC33-8412 for information about how to create dumps.

Chapter 56. Logging I/O subchannel status information

When investigating I/O subchannels, support specialists might request operation status information for the subchannel.

About this task

The channel subsystem offers a logging facility that creates a set of log entries with such information. You can trigger this logging facility through sysfs.

The log entries are available through the SE Console Actions Work Area with the View Console Logs function. The entries differ dependent on the device and model that is connected to the subchannel. On the SE, the entries are listed with a prefix that identifies the model. The content of the entries is intended for support specialists.

Procedure

To create a log entry, issue a command of this form:

```
# echo 1 > /sys/devices/css0/<subchannel-bus-id>/logging
```

where *<subchannel-bus-id>* is the bus ID of the I/O subchannel that corresponds to the I/O device for which you want to create a log entry.

To find out how your I/O devices map to subchannels you can use, for example, the **lscss** command.

Example

In this example, first the subchannel for an I/O device with bus ID 0.0.3d07 is identified, then logging is initiated.

```
# lscss -d 0.0.3d07
Device  Subchan.  DevType CU Type Use  PIM PAM POM  CHPIDs
-----
0.0.3d07 0.0.000c  1732/01 1731/01    80 80 ff  05000000 00000000
# echo 1 > /sys/devices/css0/0.0.000c/logging
```

Chapter 57. Control program identification

For Linux in LPAR mode, you can provide data about the Linux instance to the control program identification (CPI) feature.

The data is used, for example, to represent the Linux instance on the HMC or SE.

You provide data to the CPI feature in two steps:

1. Write values for one or more of the following items to specific sysfs attributes. Use the sysfs attributes in `/sys/firmware/cpi` for testing purposes. Use the sysfs attributes in `/etc/sysconfig/cpi` to make the changes persistent across reboots:

- The system name
- The sysplex name (if applicable)
- The operating system type
- The operating system level

Ubuntu Server 20.04.1 sets the following default values:

- "Ubuntu" as the system name
- The version, for example "18.04.1" as the sysplex name
- "Linux" as the operating system type.
- The kernel level, for example "4.15.0" as the operating system level.

2. Transfer the data to the SE, see [“Sending system data to the SE” on page 503](#).

Specifying a system name

Use the `system_name` attribute in the `/etc/sysconfig/cpi` directory in sysfs to specify a system name for your Linux instance.

About this task

The system name is a string that consists of up to eight characters of the following set: A-Z, 0-9, \$, @, #, and blank.

Example

```
# echo LPAR12 > /etc/sysconfig/cpi/system_name
```

To make a change to the currently running system, use:

```
# echo LPAR12 > /sys/firmware/cpi/system_name
```

What to do next

To make the setting take effect, transfer the data from `/sys/firmware/cpi/system_name` to the SE (see [“Sending system data to the SE” on page 503](#)).

Specifying a sysplex name

Use the `sysplex_name` attribute in the `/etc/sysconfig/cpi` directory in sysfs to specify a sysplex name.

About this task

The sysplex name is a string that consists of up to eight characters of the following set: A-Z, 0-9, \$, @, #, and blank.

Example

```
# echo SYSPLEX1 > /etc/sysconfig/cpi/sysplex_name
```

To make a change to the currently running system, use:

```
# echo LPAR12 > /sys/firmware/cpi/sysplex_name
```

What to do next

To make the setting take effect, transfer the data from `/sys/firmware/cpi/system_name` to the SE (see [“Sending system data to the SE”](#) on page 503).

Specifying a system type

Linux uses the `/sys/firmware/cpi/system_type` sysfs attribute to identify itself as a Linux instance.

About this task

Unless Ubuntu Server 20.04.1 sets this value for you, write LINUX to the attribute.

Example

```
# cat /sys/firmware/cpi/system_type
""
# echo LINUX > /sys/firmware/cpi/system_type
```

What to do next

To make the setting take effect, transfer the data to the SE (see [“Sending system data to the SE”](#) on page 503).

Specifying the system level

Linux uses the `/etc/sysconfig/cpi/system_level` sysfs attribute for the kernel version.

About this task

Write the kernel version to the attribute unless Ubuntu Server 20.04.1 sets the correct value for you. The value must conform to this format:

```
0x<hh>00000000<aa><bb><cc>
```

where:

<hh>

are two hexadecimal digits. A value of 80 indicates that the Linux instance acts as a hypervisor. The SE ignores this value.

<aa>

are two digits for the major version of the kernel.

<bb>

are two digits for the minor version of the kernel.

<cc>

are two digits for the stable version of the kernel.

Example

Linux kernel 4.15 displays as

```
# cat /etc/sysconfig/cpi/system_level  
0x00000000000040100
```

What to do next

To make a change to the currently running system, use:

```
# echo 0x00000000000041005 > /sys/firmware/cpi/system_level
```

To make the setting take effect, transfer the data to the SE (see [“Sending system data to the SE”](#) on page 503).

Sending system data to the SE

Use the set attribute in the `/sys/firmware/cpi` directory in sysfs to send data to the Support Element (SE).

About this task

To send the data in attributes `sysplex_name`, `system_level`, `system_name`, and `system_type` to the SE, write an arbitrary string to the set attribute.

Example

```
# echo 1 > /sys/firmware/cpi/set
```


Chapter 58. Displaying system information

You can display information about the resources, and capabilities of your Linux instance and about the hardware and hypervisor on which your Linux instance runs.

Displaying hardware and hypervisor information

You can display information about the physical and virtual hardware on which your Linux instance runs.

Procedure

Issue the following command:

```
# cat /proc/sysinfo
```

The output of the command is divided into several blocks.

- The first two blocks provide information about the mainframe hardware.
- The third block provides information about the LPAR on which the Linux instance runs, either in LPAR mode or as a guest of a hypervisor.
- Further blocks are present only if the Linux instance runs as a guest of a hypervisor. The field names in these sections have a prefix, VM<nn>, where <nn> is the hypervisor level.

If the hypervisor runs in LPAR mode, there is only one such block, with prefix VM00. If the hypervisor runs as a guest of another hypervisor, there are multiple such blocks with prefixes VM00, VM01, and so on. The highest prefix number describes the hypervisor that is closest to the Linux instance.

You can use the information from `/proc/sysinfo`, for example, to verify that a guest relocation has taken place.

The following example shows the command output for an instance of Linux as a KVM guest.

Example:

```
# cat /proc/sysinfo
Manufacturer:      IBM
...
LPAR Number:      9
...
LPAR Name:         LP4KVM09
...
LPAR Extended Name: Partition 9 KVM Host
LPAR UUID:         93724168-fda3-429b-8b28-a5d245dcb3ff
...
VM00 Name:         Linux in
VM00 Control Program: KVM/Linux
VM00 Adjustment:   1000
VM00 CPUs Total:   4
VM00 CPUs Configured: 4
VM00 CPUs Standby: 0
VM00 CPUs Reserved: 0
VM00 Extended Name: Linux instance 42
VM00 UUID:         82038f2a-1344-aaf7-1a85-2a7250be2076
```

The fields with prefix LPAR include information that identifies and labels the partition:

Number

shows a number that identifies the partition within the mainframe.

Name

shows a partition name of up to 8 characters, as assigned on the HMC.

Extended Name

depending on your hardware, this field can contain an extended partition name, it can be empty, or it might be omitted.

UUID

shows the universally unique identifier (UUID) of the partition.

This field is present only if a UUID is assigned to the partition. On hardware that does not support UUIDs for partitions, this field is always omitted.

The fields with prefix VM<nn> show the following information:

Name

Depends on your hypervisor, z/VM or KVM:

z/VM

shows the name of the z/VM guest virtual machine according to the z/VM directory.

KVM

shows the name of the virtual server according to the domain XML on the KVM host. Long names are truncated to 8 characters. The full name is always shown in the **Extended Name** field (see [“Extended Name \(KVM only\)”](#) on page 506).

Control Program

shows hypervisor information.

Adjustment

does not show useful information for Linux on Z.

CPUs Total

shows the number of virtual CPUs that the hypervisor provides to Linux.

CPUs Configured

shows the number of virtual CPUs that are online to Linux.

CPUs Standby

for Linux on z/VM, shows the number of virtual CPUs that are available to Linux but offline.

CPUs Reserved

for Linux on z/VM, shows the number of extra virtual CPUs that z/VM could make available to Linux. This is the difference between the maximum number of CPUs in the z/VM directory entry for the guest virtual machine and the number of CPUs that are currently available to Linux.

For Linux on KVM, this number is always 0.

Extended Name (KVM only)

shows the name of the virtual server as specified in the domain XML on the KVM host. See also [“Name”](#) on page 506.

UUID (KVM only)

shows the universally unique identifier (UUID) according to the domain XML on the KVM host. If you do not specify an identifier, libvirt generates a UUID when creating a virtual server definition.

Retrieving STHYI data

Store Hypervisor Information (STHYI) includes information about the IBM Z hardware, LPAR and, if applicable, the hypervisor host system on which your Linux instance runs.

STHYI includes, but is not limited to, the following information:

- The CPU count, by type (CP or IFL)
- Limitations for shared CPUs
- CEC and LPAR identifiers

The methods that you can use to retrieve this information differ between Linux in LPAR mode and Linux as a guest operating system of z/VM or of KVM.

Table 69. Available methods by environment

Method	Linux in LPAR mode	Linux as a z/VM or KVM guest
STHYI instruction with the GCC inline assembly For an example, see arch/s390/kernel/sthyi.c in the Linux source tree.	No	Yes
qclib See the readme file of the qclib package for details.	Yes	Yes
s390_sthyi() system call See the man page for details.	Yes	No

The return data for both the STHYI instruction and the s390_sthyi() system call matches the content of the STHYI response buffer as described in *z/VM: CP Programming Services*, SC24-6272. The qclib library provides an API for querying the information. See the readme file of the qclib package about obtaining the API description.

You can find the qclib package and more information about qclib on developerWorks at www.ibm.com/developerworks/linux/linux390/qclib.html.

Check whether the Linux instance can be a hypervisor

An instance of Linux on Z must have the SIE (Start Interpretive Execution) capability to be able to act as a hypervisor, such as a KVM host.

Procedure

1. Issue the following command to find out whether you can operate your Linux instance as a hypervisor.

```
# cat /proc/cpuinfo
vendor_id : IBM/S390
# processors : 1
bogomips per cpu: 14367.00
features : esan3 zarch stfle msa ldisp eimm dfp edat etf3eh
highprsr sie
cache0 : level=1 type=Data scope=Private size=128K
...
```

2. Examine the features line in the command output. If the list of features includes sie, the Linux instance can be a hypervisor.

The Linux instance of the example can be a hypervisor.

Chapter 59. Avoiding common pitfalls

Common problems and how to avoid them.

Ensuring correct channel path status

Ensure that you varied the path offline before you perform a planned task on it.

Before you begin

Do not vary channel paths offline that provide access to vital resources, such as the root file system.

KVM: A KVM guest might have only one channel path through which all CCW devices are accessed.

Tasks that require the channel path to be offline include:

- Pulling out or plugging in a cable on a path.
- Configuring a path off or on at the SE.

To vary the path offline, issue a command of the form:

```
# chchp -v 0 <chpid>
```

where <chpid> is the channel path ID.

After the operation completed and the path is available again, vary the path online by using a command of the form:

```
# chchp -v 1 <chpid>
```

Alternatively, you can write `on` or `off` to the channel path status attribute in `sysfs` to vary the path online or offline.

```
# echo on|off > /sys/devices/css0/chp0.<chpid>/status
```

An unplanned change in path availability can occur due to, for example, unplanned cable pulls or a temporary path malfunction. Then, the PIM/PAM/POM values (as obtained through **lscss**) might not be as expected. To update the PIM/PAM/POM values, vary one of the paths that lead to the affected devices.

Example:

```
# chchp -v 0 0.12  
# chchp -v 1 0.12
```

Rationale: Linux does not always receive a notification (machine check) when the status of a path changes (especially for a path that comes online again). To make sure Linux has up-to-date information about the usable paths, path verification is triggered through the Linux vary operation.

Determining channel path usage on LPAR

To determine the usage of a specific channel path on LPAR, for example, to check whether traffic is distributed evenly over all channel paths, use the channel path measurement facility.

See “Channel path measurement” on page 14 for details.

Ignore unnecessary I/O devices

An instance of Linux on Z should ignore all I/O devices that it does not currently use.

A mainframe environment often includes numerous I/O devices. Especially for Linux in LPAR mode, more of these I/O devices might be available to a particular instance of Linux on Z than needed. Limit the I/O devices by:

- Adding only the needed devices to the applicable LPAR in the IOCDs.

z/VM and KVM: Making only needed devices available to guests.

- Using the `cio_ignore=` kernel parameter to ignore all devices that are not currently in use by this instance of Linux on Z.

If more devices are needed later, they can be dynamically removed from the list of devices to be ignored. Use the `cio_ignore` kernel parameter or the `/proc/cio_ignore` dynamic control to remove devices, see [“cio_ignore - List devices to be ignored”](#) on page 698 and [“Changing the exclusion list”](#) on page 699.

Rationale: Numerous unused devices can cause:

- Unnecessary high memory usage due to allocation of device structures.
- Unnecessary high load on status changes because hot-plug handling must be done for every device found.
- Prolonged boot and shutdown time.

Using `cio_ignore`

With `cio_ignore`, essential devices might be hidden.

For example, Linux might not boot because the device with the root file system is ignored.

If Linux does not boot under z/VM and does not show any message except:

```
HCPGIR450W CP entered; disabled wait PSW 00020001 80000000 00000000 00144D7A
```

Check if `cio_ignore` is used and verify that the console device, which is typically device number 0.0.0009, is not ignored.

Excessive guest swapping

Avoid excessive guest swapping by using the timed page pool size and the static page pool size attributes.

An instance of Linux on z/VM might be swapping and stalling. Setting the timed page pool size and the static page pool size to zero might solve the problem:

```
# echo 0 > /proc/sys/vm/cmm_timed_pages
# echo 0 > /proc/sys/vm/cmm_pages
```

If you see a temporary relief, the guest does not have enough memory. Try increasing the guest memory.

If the problem persists, z/VM might be out of memory.

If you are using cooperative memory management (CMM), unload the cooperative memory management module:

```
# modprobe -r cmm
```

See [Chapter 42, “Cooperative memory management,”](#) on page 413 for more details about CMM.

Including service levels of the hardware and the hypervisor

The service levels of the different hardware cards, the LPAR level, and the z/VM service level are valuable information for problem analysis.

If possible, include this information with any problem you report to IBM Support for Linux in LPAR mode or Linux on z/VM.

A `/proc` interface that provides a list of service levels is available. To see the service levels issue:

```
# cat /proc/service_levels
```

Example for a z/VM system with a qeth device and a zfcpc device:

```
# cat /proc/service_levels
VM: z/VM Version 7 Release 1.0, service level 2001 (64-bit)
qeth: 0.0.f900 firmware level 0180
zfcpc: 0.0.2461 microcode level 20600106
```

Example for an LPAR with two zfcpc devices, a qeth device, and a CPU counter:

```
# cat /proc/service_levels
CPU-MF: Counter facility: version=1.4 authorization=0020
zfcpc: 0.0.e100 microcode level 716
zfcpc: 0.0.e000 microcode level 716
qeth: 0.0.c000 firmware level 0771
```

The service level information is automatically included in the `DBGINFO` file that IBM Support might ask you to generate when analyzing a problem for you.

Booting stops with disabled wait state

An automatic processor type check might stop the boot process with a disabled wait PSW.

On some distributions, a processor type check is automatically run at every kernel startup. If the check determines that the distribution used is not compatible with the hardware, it stops the boot process with a disabled wait PSW.

If this problem occurs, ensure that you are using a distribution that is supported on your hardware.

If you are using an SCLP console, you might get a message that indicates the problem.

Preparing for dump-on-panic

You might want to consider setting up your system to automatically create a memory dump after a kernel panic.

Before you begin: If you set up `kdump`, a kernel panic or PSW restart automatically triggers a dump. For a KVM guest, `kdump` is the only option for an automatic dump-on-panic.

Configuring and using dump-on-panic is a good idea for several reasons:

- You have a memory dump disk that is prepared ahead of time.
- You do not have to reproduce the problem since a memory dump will be triggered automatically immediately after the failure.

See [Chapter 8, “Shutdown actions,”](#) on page 99 for details.

Function unavailable or degraded in Linux on z/VM

For some functions, Linux on z/VM issues diagnose instructions to the z/VM hypervisor.

Which diagnose codes are available to your Linux instance depends on the z/VM version and configuration. The z/VM administrator can enable, disable, or customize diagnose instructions. For details, see *z/VM: CP Commands and Utilities Reference*, SC24-6268.

Linux on z/VM can fail, or one or more functions might be unavailable or degraded if required diagnose instructions are modified or unavailable.

Read and compare `/sys/kernel/debug/diag_stat` to obtain a list of calls and a counter for each call (see also Chapter 63, “Linux diagnose code use,” on page 719). The counts include failed calls. Thus, comparing the counts with and without running the affected workload provides an indication of the calls that the workload uses or tries to use. Assure that these calls are not restricted by the z/VM configuration.

Chapter 60. Creating a kernel dump

When reporting a problem to IBM Support, you might be asked to supply a kernel dump. The dump tools you can use depend on your hypervisor environment.

Creating a kernel dump of Linux in LPAR mode or of a z/VM guest

The dump tools for Linux in LPAR mode and Linux as a z/VM guest include stand-alone dump tools, `kdump`, and `zgetdump`.

With `kdump` in place, a dump is triggered automatically by a kernel panic. Use the `zgetdump` command for a live-system dump.

For Linux as a z/VM guest you can also use `VMDUMP`.

For details about the dump tools, see *Using the Dump Tools*, SC33-8412.

Creating a kernel dump of a KVM guest

A dump of a KVM guest can be driven by the host or by the guest.

Guest-driven dumps

You can set up `kdump` to create a kernel dump for an instance of Linux as a KVM guest on Z. With `kdump` in place, a dump is triggered automatically by a kernel panic.

Alternatively, you can use the `zgetdump` command to create a live-system dump.

See the `kdump` information in *Using the Dump Tools*, SC33-8412.

Host-driven dumps

The KVM virtual server administrator can initiate dumps of KVM guests. See the section about dumping KVM guests in *KVM Virtual Server Management*, SC34-2752.

Part 11. Reference

Use these commands, kernel parameters, and kernel options to configure Linux on Z. Be aware of the z/VM DIAG calls required by Ubuntu Server 20.04.1.

Newest version

You can find the newest version of this publication at ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server

Restrictions

For prerequisites and restrictions see the IBM LinuxONE and IBM Z architecture-specific information in the Ubuntu Server 20.04.1 release notes at wiki.ubuntu.com/FocalFossa/ReleaseNotes

Chapter 61. Commands for Linux on Z

You can use z/Architecture specific commands to configure and work with the Ubuntu Server 20.04.1 device drivers and features.

Most of the commands described in this section are included in the s390-tools package.

Some commands come with an init script or a configuration file or both. It is assumed that init scripts are installed in `/etc/init.d/`. You can extract any missing files from the `etc` subdirectory in the s390-tools package.

Commands described elsewhere

- For the **zipl** command, see [Chapter 6, “Initial program loader for IBM Z - zipl,”](#) on page 55.
- For commands and tools related to creating and analyzing system dumps, see *Using the Dump Tools*, SC33-8412.
- For commands related to terminal access over IUCV connections, see *How to Set up a Terminal Server Environment on z/VM*, SC34-2596.
- The **icainfo** and **icastats** commands are provided with the libica package and described in *libica Programmer's Reference*, SC34-2602.
- The **zkey** and **zkey-cryptsetup** commands are described in *Pervasive Encryption for Data Volumes*, SC34-2782.
- The **genprotimg** command is described in *Introducing IBM Secure Execution for Linux*, SC34-7721.

Generic command options

There are common command options that, for simplicity, have been omitted from some of the syntax diagrams.

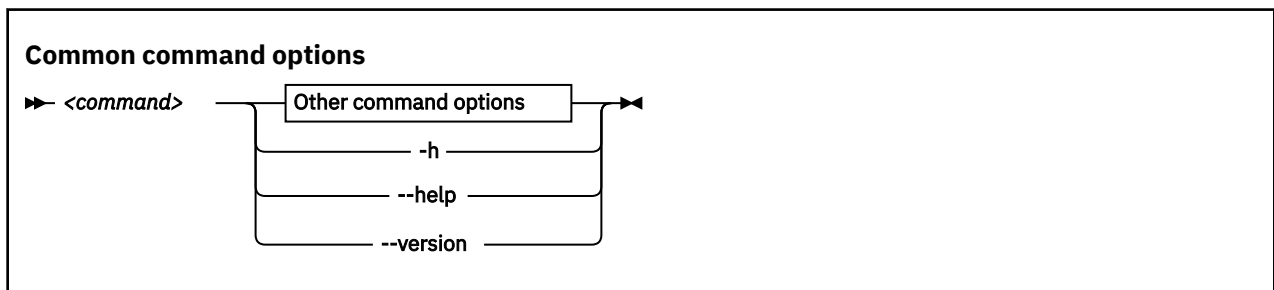
-h or --help

to display help information for the command.

--version

to display version information for the command.

The syntax for these options is:



where `command` can be any of the commands described in this section.

See [Appendix B, “Understanding syntax diagrams,”](#) on page 723 for general information about reading syntax diagrams.

Examples

- To set a CCW device 0.0.b100 online issue:

```
# chccwdev -e 0.0.b100
```

- Alternatively, use **-a** to set a CCW device 0.0.b100 online. Issue:

```
# chccwdev -a online=1 0.0.b100
```

- To set all CCW devices in the range 0.0.b200 through 0.0.b2ff online, issue:

```
# chccwdev -e 0.0.b200-0.0.b2ff
```

- To set a CCW device 0.0.b100 and all CCW devices in the range 0.0.b200 through 0.0.b2ff offline, issue:

```
# chccwdev -d 0.0.b100,0.0.b200-0.0.b2ff
```

- To set several CCW devices in different ranges and different subchannel sets offline, issue:

```
# chccwdev -d 0.0.1000-0.0.1100,0.1.7000-0.1.7010,0.0.1234,0.1.4321
```

- To set devices with bus ID 0.0.0192, and 0.0.0195 through 0.0.0198 offline after completing all outstanding I/O requests:

```
# chccwdev -s 0.0.0192,0.0.0195-0.0.0198
```

If an outstanding I/O request is blocked, the command might wait forever. Reasons for blocked I/O requests include reserved devices that can be released or disconnected devices that can be reconnected.

1. Try to resolve the problem that blocks the I/O request and wait for the command to complete.
 2. If you cannot resolve the problem, issue **chccwdev -d** to cancel the outstanding I/O requests. The data is lost.
- To set an ECKD DASD 0.0.b100 online and to enable extended error reporting and logging issue:

```
# chccwdev -e -a eer_enabled=1 -a explog=1 0.0.b100
```

chchp - Change channel path status

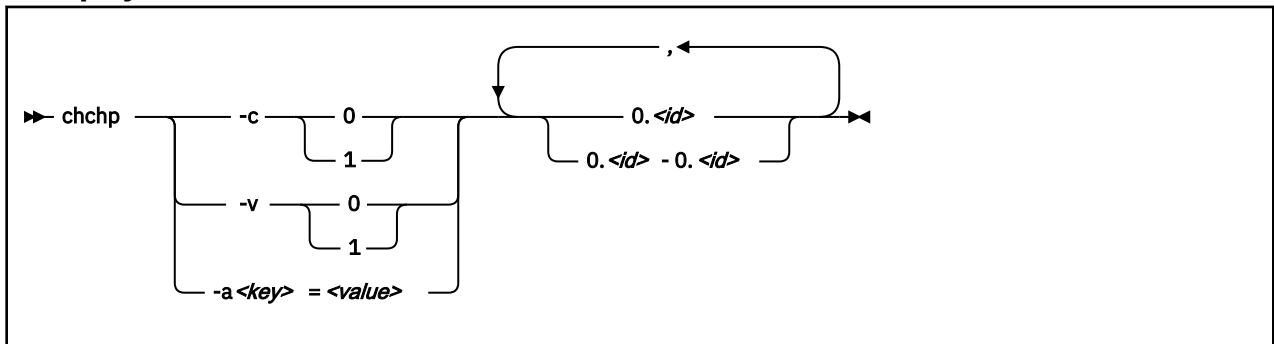
Use the **chchp** command to set channel paths online or offline.

The actions are equivalent to performing a Configure Channel Path Off or Configure Channel Path On operation on the Hardware Management Console.

The channel path status that results from a configure operation is persistent across IPLs.

Note: Changing the configuration state of an I/O channel path might affect the availability of I/O devices. It can also trigger associated functions (such as channel-path verification or device scanning), which in turn can result in a temporary increase in processor, memory, and I/O load.

chchp syntax



Where:

-c or --configure <value>

sets the device to configured (1) or standby (0).

Note: Setting the configured state to standby can stop running I/O operations.

-v or --vary <value>

changes the logical channel-path state to online (1) or offline (0).

Note: Setting the logical state to offline can stop running I/O operations.

-a or --attribute <key>=<value>

changes the channel-path sysfs attribute *<key>* to *<value>*. The *<key>* can be the name of any available channel-path sysfs attribute (that is, *configure* or *status*). *<value>* can take any valid value that can be written to the attribute (for example, 0 or *offline*). Using *-a* is a generic way of writing to the corresponding sysfs attribute. It is intended for cases where sysfs attributes or attribute values are available in the kernel but not in **chchp**.

0.<id> and 0.<id> - 0.<id>

where *<id>* is a hexadecimal, two-digit, lowercase identifier for the channel path. An operation can be performed on more than one channel path by specifying multiple identifiers as a comma-separated list, or a range, or a combination of both.

--version

displays the version number of **chchp** and exits.

-h or --help

displays a short help text. To view the man page, enter **man chchp**.

Examples

- To set channel path 0.19 into standby state issue:

```
# chchp -a configure=0 0.19
```


- To set the channel path with the channel path ID 0.40 to the standby state, write 0 to the configure file with the **chchp** command:

```
# chchp --configure 0 0.40  
Configure standby 0.40... done.
```

- To set a channel-path to the configured state, write 1 to the configure file with the **chchp** command:

```
# chchp --configure 1 0.40  
Configure online 0.40... done.
```

- To set channel-paths 0.65 to 0.6f to the configured state issue:

```
# chchp -c 1 0.65-0.6f
```

- To set channel-paths 0.12, 0.7f and 0.17 to 0.20 to the logical offline state issue:

```
# chchp -v 0 0.12,0.7f,0.17-0.20
```

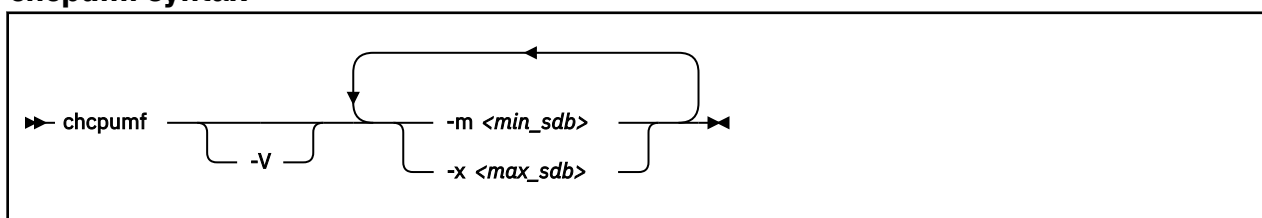
chcpumf - Set limits for the CPU measurement sampling facility buffer

Use the **chcpumf** command to set limits for the CPU measurement sampling facility buffer.

The sampling facility is designed for autonomous buffer management, and you do not usually need to intervene. However, you might want to change the minimum or maximum size, for example, for one of the following reasons:

- There are considerable resource constraints on your system, and the sampling facility stops because it tries to allocate more buffer space than is available.
- As an expert user of perf and the sampling facility, you want to explore results with particular buffer settings.

chcpumf syntax



where:

-m <min_sdb> or --min <min_sdb>

specifies the minimum sampling facility buffer size in sample-data-blocks. A sample-data-block occupies approximately 4 KB. The sampling facility starts with this buffer size if it exceeds the initial buffer size that is calculated by the sampling facility.

-x <max_sdb> or --max <max_sdb>

specifies the maximum sampling facility buffer size in sample-data-blocks. A sample-data-block occupies approximately 4 KB. While it is running, the sampling facility dynamically adjusts the buffer size to a suitable value, but cannot exceed this limit.

-V or --verbose

displays the buffer size settings after the changes.

-v or --version

displays the version number of **chcpumf** and exits.

-h or --help

displays out a short help text, then exits. To view the man page, enter **man chcpumf**.

Example

To change the minimum buffer size to 500 times the size of a sample-data-block and the maximum buffer size to 1000 times the size of a sample-data-block, issue:

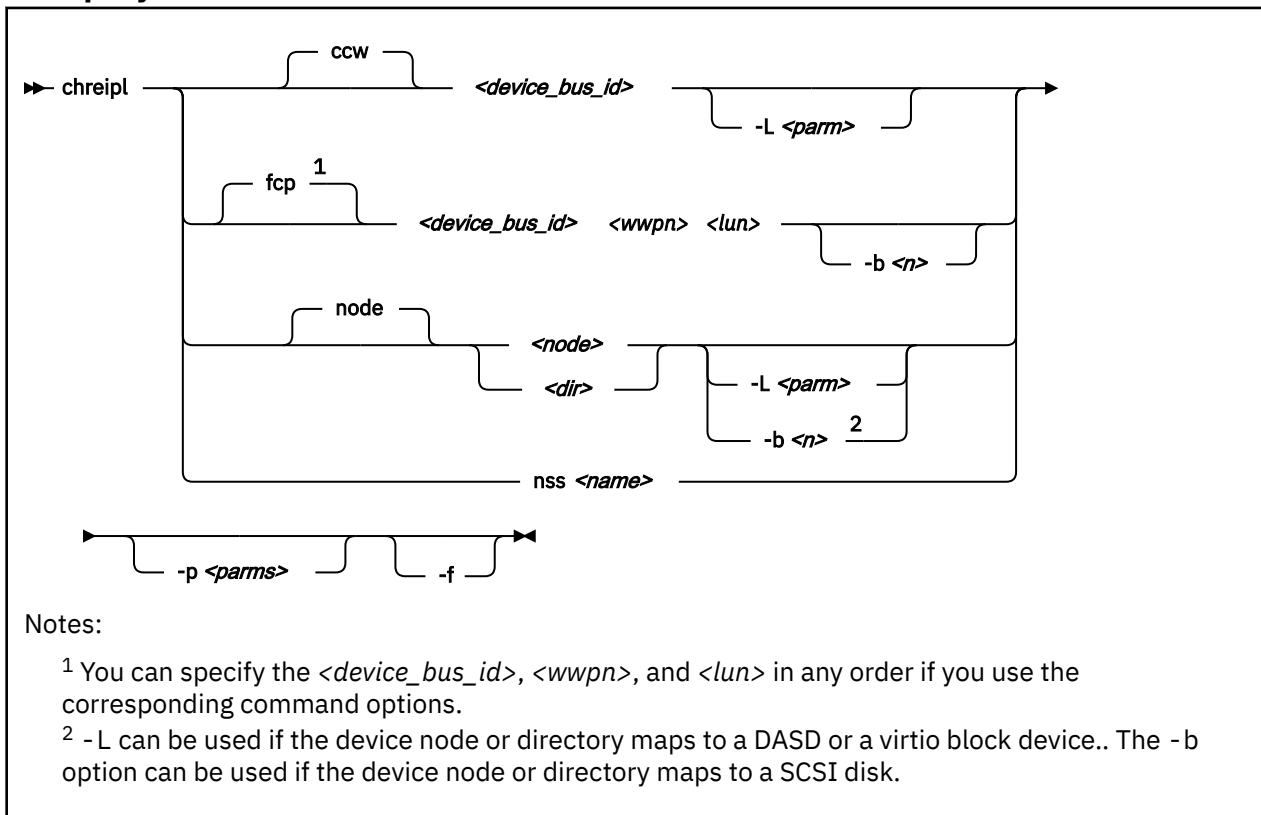
```
# chcpumf -V -m 500 -x 1000
Sampling buffer sizes:
  Minimum:   500 sample-data-blocks
  Maximum:  1000 sample-data-blocks
```

chreipl - Modify the re-IPL configuration

Use the **chreipl** tool to modify the re-IPL configuration for Linux on Z.

You can configure a particular device as the reboot device. For **zipl** boot menu configurations, you can set the boot menu entry to be used for the next reboot. You can also specify additional kernel parameters for the next reboot.

chreipl syntax



Where:

<device_bus_id> or -d <device_bus_id> or --device <device_bus_id>

specifies the device bus-ID of a CCW re-IPL device or of the FCP device through with a SCSI re-IPL device is attached.

<wwpn> or -w <wwpn> or --wwpn <wwpn>

specifies the worldwide port name (WWPN) of a SCSI re-IPL device.

<lun> or -l <lun> or --lun <lun>

specifies the logical unit number (LUN) of a SCSI re-IPL device.

<node>

specifies a device node of a DASD, SCSI, or logical device mapper re-IPL device. For more information about logical boot devices, see [“Preparing a logical device as a boot device”](#) on page 61.

<dir>

specifies a directory in the Linux file system on the re-IPL device.

nss

declares that the following parameters refer to a z/VM named saved system (NSS).

Note: You cannot load Ubuntu Server 20.04.1 or later from an NSS. The NSS could contain a Linux distribution with NSS support or another mainframe operating system, for example, CMS.

<name> or -n <name> or --name <name>

specifies the name of an NSS as defined on the z/VM system.

Note: You cannot load Ubuntu Server 20.04.1 or later from an NSS. The NSS could contain a Linux distribution with NSS support or another mainframe operating system, for example, CMS.

-L or --loadparm <parameter>

specifies the entry in the boot menu to be used for the next reboot. This parameter applies to DASD or virtio block re-IPL devices with a **zipl** boot menu configuration.

Omitting this parameter eliminates an existing selection in the boot configuration. Depending on your boot menu configuration, a **zipl** interactive boot menu might be displayed during the re-IPL process or the default configuration is used. See “[Example for a DASD menu configuration on z/VM](#)” on page 91, “[Example for a DASD menu configuration \(LPAR\)](#)” on page 84, and “[Menu configurations](#)” on page 74 for details.

A SCSI re-IPL device might hold a distribution that supports this parameter for SCSI devices. See the distribution-specific documentation for this distribution about valid specifications.

-b or --bootprog <n>

specifies the entry in the boot menu to be used for the next reboot. This parameter applies only if the re-IPL device is a SCSI disk with a **zipl** boot menu configuration.

Omitting this parameter eliminates an existing selection in the boot configuration and the default boot configuration is used.

-p or --bootparms

specifies boot parameters for the next reboot. The boot parameters, which typically are kernel parameters, are appended to the kernel parameter line in the boot configuration. The number of characters you can specify depends on your environment and re-IPL device as shown in [Table 70](#) on page 524.

Table 70. Maximum characters for additional kernel parameters

Virtual hardware where Linux runs	DASD re-IPL device	SCSI re-IPL device	NSS re-IPL device
LPAR	none	3452	n/a
z/VM guest virtual machine	64	3452	56
KVM	none	n/a	n/a

If you omit this parameter, the existing boot parameters in the next boot configuration are used without any changes.

-f or --force

With this option, you can force the re-IPL from a target device even if the target cannot be verified by the system. This is the case, for example, if the device is on the `cio_ignore` exclusion list (blacklist).

Note: Use this option with great care. Specifying a non-existing device causes the re-IPL to fail.

-h or --help

displays help information for the command. To view the man page, enter `man chreipl`.

-v or --version

displays version information.

For disk-type re-IPL devices, the command accepts but does not require an initial statement:

ccw

declares that the following parameters refer to a DASD or a virtio block re-IPL device.

fcp

declares that the following parameters refer to a SCSI re-IPL device.

node

declares that the following parameters refer to a disk re-IPL device that is identified by a device node or by a directory in the Linux file system on that device. The disk device can be a DASD or a SCSI disk.

Examples

These examples illustrate common uses for **chreipl**.

- The following commands all configure the same DASD as the re-IPL device, assuming that the device bus-ID of the DASD is 0.0.7e78, that the standard device node is /dev/dasdc, that udev creates an alternative device node /dev/disk/by-path/ccw-0.0.7e78, that /mnt/boot is located on the Linux file system in a partition of the DASD.

- Using the bus ID:

```
# chreipl 0.0.7e78
```

- Using the bus ID and the optional ccw statement:

```
# chreipl ccw 0.0.7e78
```

- Using the bus ID, the optional statement and the optional **--device** keyword:

```
# chreipl ccw --device 0.0.7e78
```

- Using the standard device node:

```
# chreipl /dev/dasdc
```

- Using the udev-created device node:

```
# chreipl /dev/disk/by-path/ccw-0.0.7e78
```

- Using a directory within the file system on the DASD:

```
# chreipl /mnt/boot
```

- The following commands all configure the same SCSI disk as the re-IPL device, assuming that the device bus-ID of the FCP device through which the device is attached is 0.0.1700, the WWPN of the storage server is 0x500507630300c562, and the LUN is 0x401040b300000000. Further it is assumed that the standard device node is /dev/sdb, that udev creates an alternative device node /dev/disk/by-id/scsi-36005076303ffc562000000000000010b4, and that /mnt/fcpboot is located on the Linux file system in a partition of the SCSI disk.

- Using bus ID, WWPN, and LUN:

```
# chreipl 0.0.1700 0x500507630300c562 0x401040b300000000
```

- Using bus ID, WWPN, and LUN with the optional fcp statement:

```
# chreipl fcp 0.0.1700 0x500507630300c562 0x401040b300000000
```

- Using bus ID, WWPN, LUN, the optional statement, and keywords for the parameters. When you use the keywords, the parameters can be specified in any order:

```
# chreipl fcp --wwpn 0x500507630300c562 -d 0.0.1700 --lun 0x401040b300000000
```

- Using the standard device node:

```
# chreipl /dev/sdb
```

- Using the udev-created device node:

```
# chreipl /dev/disk/by-id/scsi-36005076303ffc56200000000000010b4
```

- Using a directory within the file system on the SCSI disk:

```
# chreipl /mnt/fcpboot
```

- To configure a DASD with bus ID 0.0.7e78 as the re-IPL device, using the first entry of the **zip1** boot menu:

```
# chreipl 0.0.7e78 -L 1
Re-IPL type: ccw
Device:      0.0.7e78
Loadparm:   "1"
Bootparms:  ""
```

- The following examples configures a DASD with bus ID 0.0.7e78 as the re-IPL device. To also display all kernel messages on the console, add `ignore_loglevel` to the existing kernel parameters in the boot configuration:

```
# chreipl 0.0.7e78 -p "ignore_loglevel"
Re-IPL type: ccw
Device:      0.0.7e78
Loadparm:   ""
Bootparms:  "ignore_loglevel"
```

chshut - Control the system shutdown actions

Use the **chshut** command to change the shutdown actions for specific shutdown triggers.

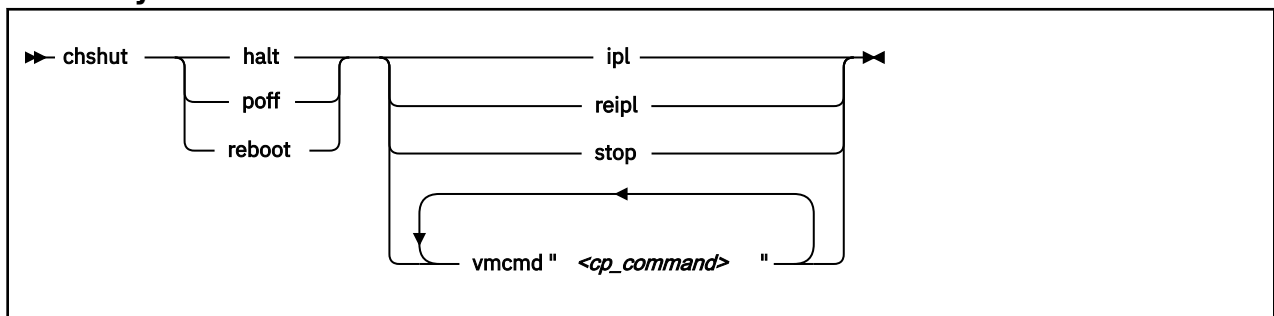
The shutdown triggers are:

- halt
- poff
- reboot

The shutdown triggers `restart` and `panic` are handled by the `dumpconf` service script, see *Using the Dump Tools*, SC33-8412 for details.

Linux on Z performs shutdown actions according to sysfs attribute settings within the `/sys/firmware` directory structure. The **chshut** command sets a shutdown action for a shutdown trigger by changing the corresponding sysfs attribute setting. For more information about the sysfs attributes and the shutdown actions, see Chapter 8, “Shutdown actions,” on page 99.

chshut syntax



Where:

halt

sets an action for the `halt` shutdown trigger.

poff

sets an action for the `poff` shutdown trigger.

reboot

sets an action for the `reboot` shutdown trigger.

ipl

sets IPL as the action to be taken.

reipl

sets re-IPL as the action to be taken.

stop

sets "stop" as the action to be taken.

vmcmd "<cp_command>"

sets the action to be taken to issuing a z/VM CP command. The command must be specified in uppercase characters and enclosed in quotation marks. To issue multiple commands, repeat the `vmcmd` attribute with each command.

-h or --help

displays help information for the command. To view the man page, enter `man chshut`.

-v or --version

displays version information.

Examples

These examples illustrate common uses for **chshut**.

chshut

- To make the system start again after a power off:

```
# chshut poff ip1
```

- To log off the z/VM guest virtual machine if the Linux **poweroff** command was run successfully:

```
# chshut poff vmcmd LOGOFF
```

- To send a message to z/VM user ID OPERATOR and automatically log off the z/VM guest virtual machine if the Linux **poweroff** command is run:

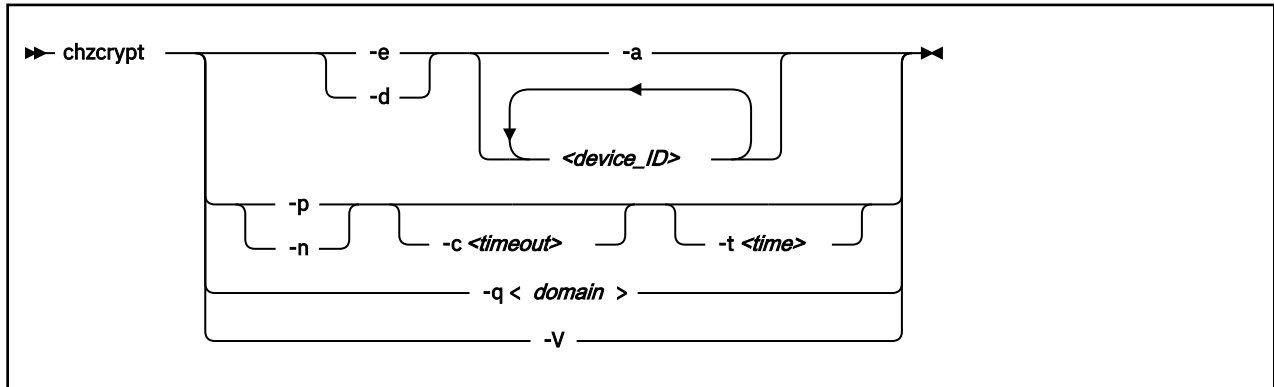
```
# chshut poff vmcmd "MSG OPERATOR Going down" vmcmd "LOGOFF"
```


chzcrypt - Modify the zcrypt configuration

Use the **chzcrypt** command to configure cryptographic adapters that are managed by zcrypt and modify zcrypt's AP bus attributes.

To display the attributes, use [“lszcrypt - Display zcrypt devices”](#) on page 619.

chzcrypt syntax



Where:

-e or --enable

sets the given cryptographic devices and AP queues online.

-d or --disable

sets the given cryptographic devices and AP queues offline.

-a or --all

sets all available cryptographic adapters online or offline.

<device ID>

specifies a cryptographic adapter that is to be set online or offline. A cryptographic adapter can be specified either in decimal notation or hexadecimal notation with a '0x' prefix.

-p or --poll-thread-enable

enables zcrypt's poll thread.

-n or --poll-thread-disable

disables zcrypt's poll thread.

-c <timeout> or --config-time <timeout>

sets configuration timer for rescanning the AP bus to <timeout> seconds.

-t <time> or --poll-timeout=<time>

sets the high-resolution polling timer to <time> nanoseconds. To display the value, use **lszcrypt -b**.

-q <domain> or --default-domain <domain>

changes the default domain. Specify the domain as either a hexadecimal or decimal value.

Important: Be sure to enter an existing domain. The Trusted Key Entry (TKE) workstation does not find the cryptographic adapters if a non-existing domain is entered here. All CCA applications use the default domain, and do not work correctly if the specified domain does not exist.

-V or --verbose

displays verbose messages.

-h or --help

displays help information for the command. To view the man page, enter **man chzcrypt**.

-v or --version

displays version information.

Examples

These examples illustrate common uses for **chzcrypt**.

- To set the cryptographic devices with the adapter IDs 0, 1, 4, 5, and 12 and their associated AP queues online (in decimal notation):

```
chzcrypt -e 0 1 4 5 12
```

Or, in hexadecimal notation:

```
chzcrypt -e 0x00 0x01 0x04 0x05 0x0C
```

- To set all available cryptographic adapters, including all AP queues, offline:

```
chzcrypt -d -a
```

- To set the AP queue defined by adapter ID 00 and domain 77 (0x4d) offline:

```
chzcrypt -d 00.004d
```

- To set the configuration timer for rescanning the AP bus to 60 seconds and disable zcrypt's poll thread:

```
chzcrypt -c 60  
chzcrypt -n
```

- To change the default domain to 77 (0x4d):

```
chzcrypt -q 0x4d
```

or

```
chzcrypt -q 77
```

chzdev - Configure IBM Z devices

Use the **chzdev** command to configure devices and device drivers on IBM Z. Supported devices include storage devices (DASD and zFCP) and networking devices (QETH and LCS). For more examples of how to use the command, see [Chapter 24, “Persistent device configuration,”](#) on page 313.

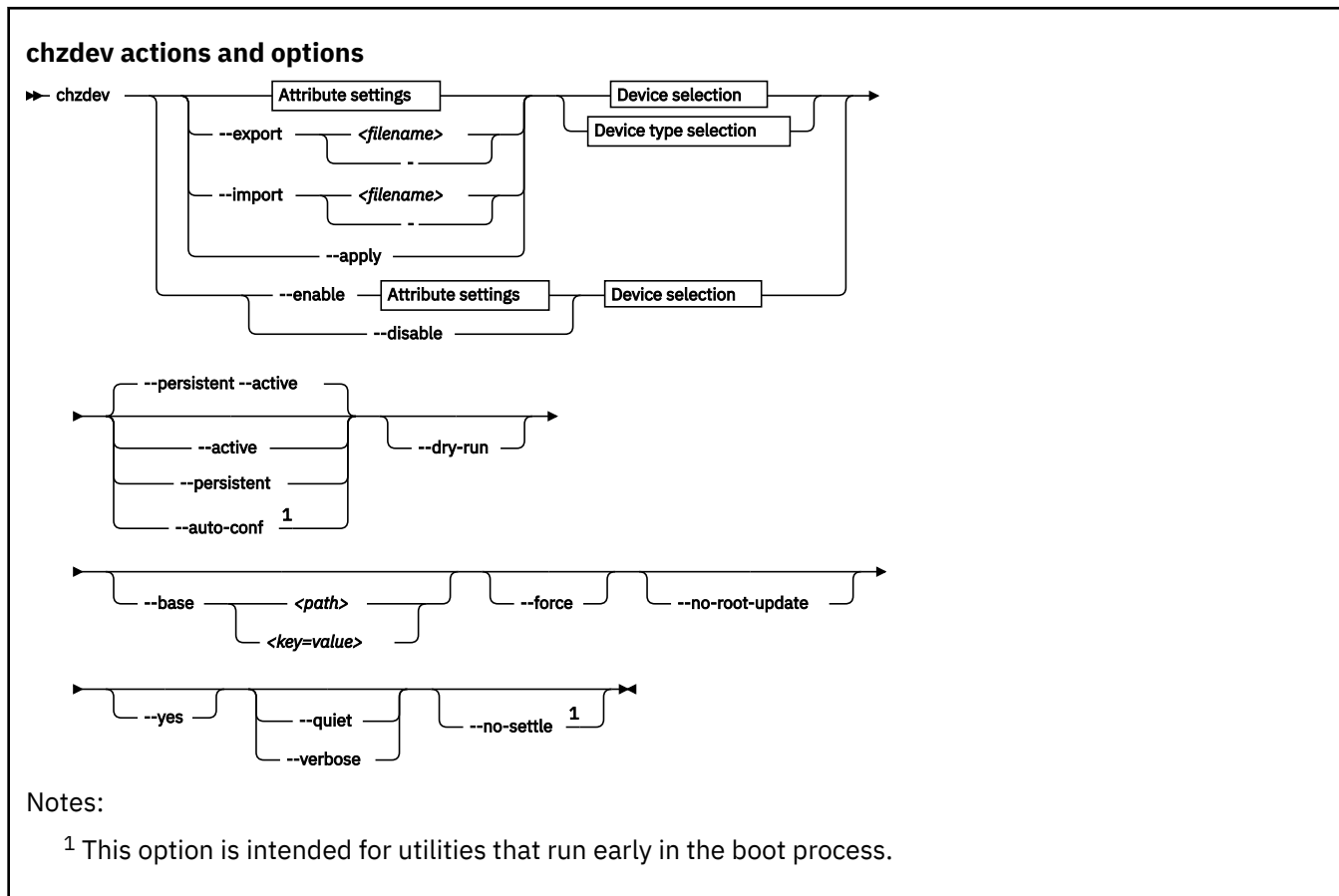
You can apply configuration changes to the active configuration of the currently running system, or to the persistent configuration stored in configuration files:

- Changes to the active configuration are effective immediately. They are lost on reboot, when a device driver is unloaded, or when a device becomes unavailable.
- Changes to the persistent configuration are applied when the system boots, when a device driver is loaded, or when a device becomes available.

By default, **chzdev** applies changes to both the active and the persistent configuration.

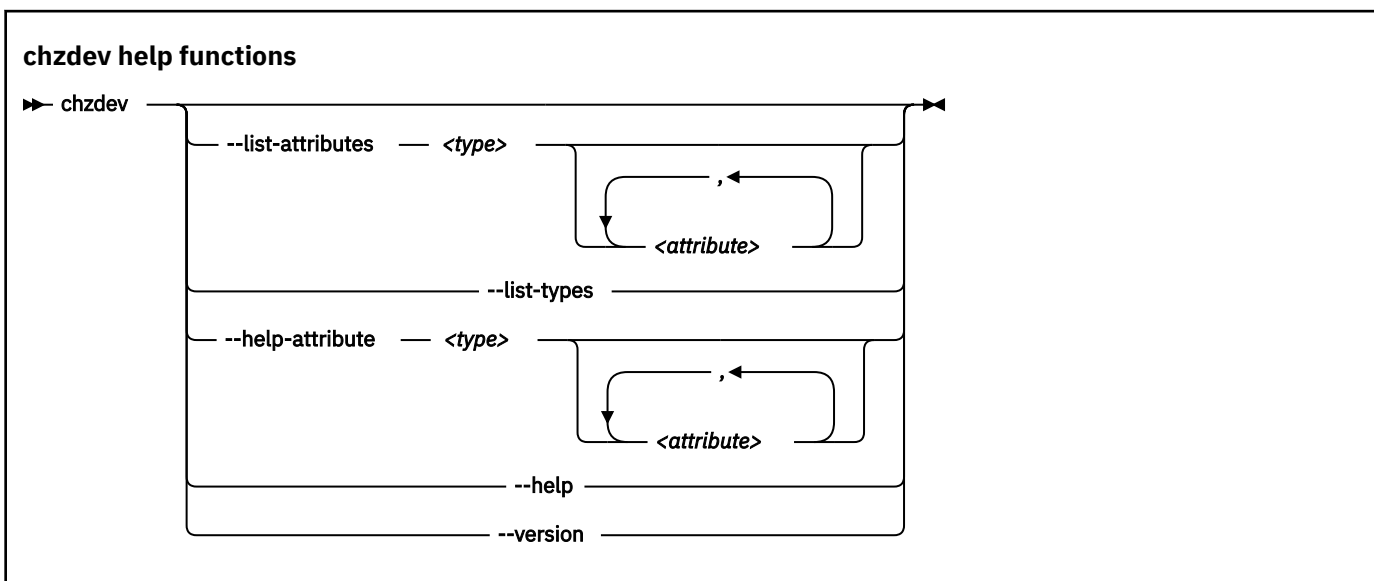
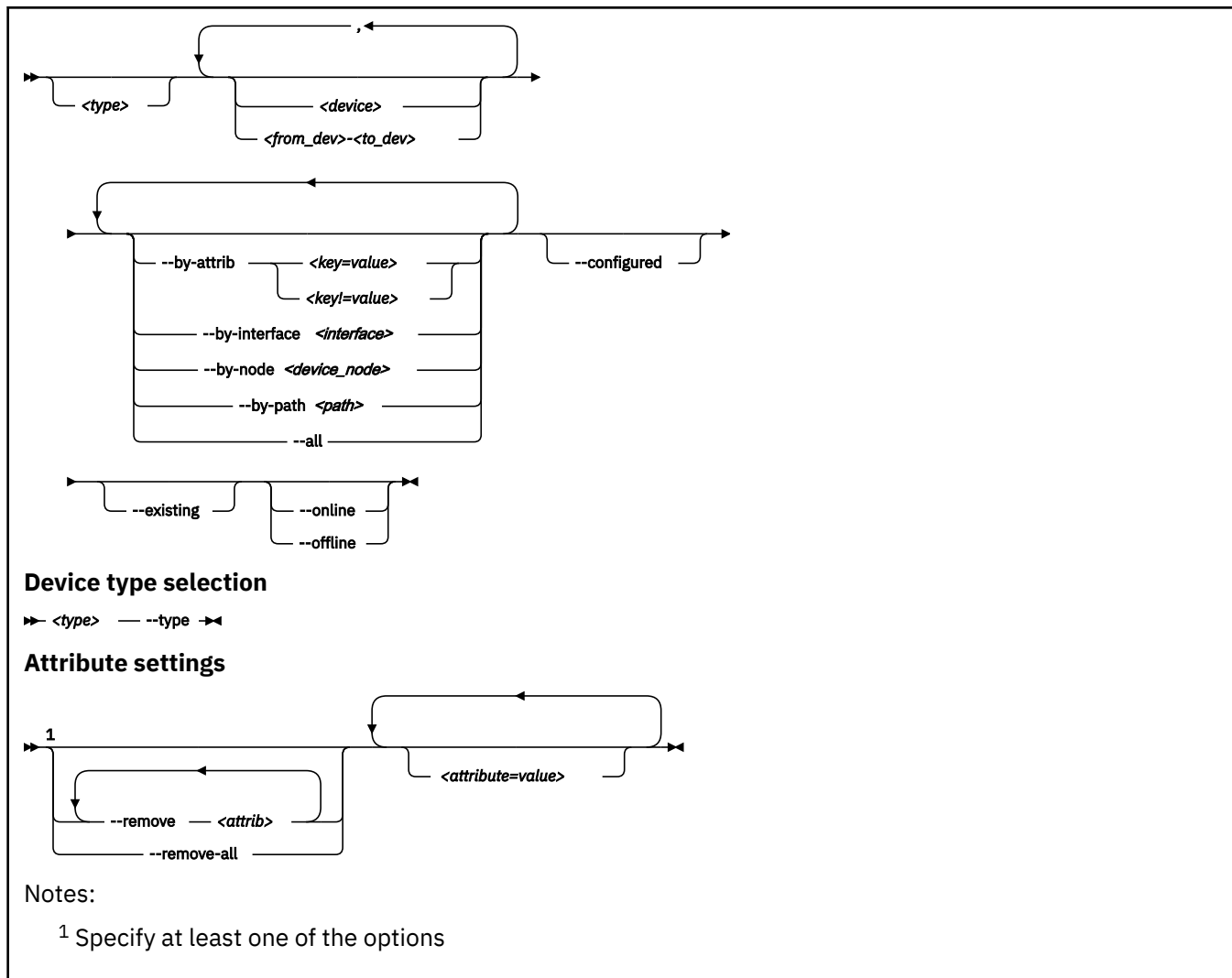
You can also temporarily remove existing auto-configuration data, see [“Managing auto-configuration data”](#) on page 20.

chzdev supports enabling and disabling devices, exporting and importing configuration data to and from a file, and displaying a list of available device types and attributes.



Device selection

chzdev



where:

<type>

restricts the scope of an action to the specified device type:

- Specify a device type and optionally a device ID to work on devices with matching type and ID only.

- Specify a device type together with the `--type` option to manage the configuration of the device type itself.

Note:

As a precaution, use the most specific device type when you configure a device by ID. Otherwise, the same device ID might accidentally match other devices of a different subtype. To get a list of supported device types, use the `--list-types` option.

<device>

selects a single device or a range of devices by device ID. Separate multiple IDs or ranges with a comma (,). To select a range of devices, specify the ID of the first and the last device in the range separated by a hyphen (-).

-t <device_type> or --type <device_type>

selects a device type as target for a configuration or query action. For example: `dasd-eckd`, `zfc`, or `qeth`.

<attribute=value>

specifies a device attribute and its value. To specify multiple attributes, separate attribute-value pairs with a blank.

You can use the `--list-attributes` option to display a list of available attributes and the `--help-attribute` to get more detailed information about a specific attribute.

Tip: To specify an attribute that is not known to **chzdev**, use the `--force` option.

-r <attrib> or --remove <attrib>

removes the setting for attribute *<attrib>*.

Active configuration

For attributes that maintain a list of values, clears all values for that list.

Persistent configuration

Removes any setting for the specified attribute. When the device or device driver is configured again, the attribute is set to its default value.

Some attributes cannot be removed.

-R or --remove-all

removes the settings for all attributes of the selected device or device driver.

Active configuration

For attributes that maintain a list of values, clears all values for that list.

Persistent configuration

Removes all attribute settings that can be removed. When the device or device driver is configured again, the attribute is set to its default value.

Some attributes cannot be removed.

--by-attr <attrib=value> | <attrib!=value>

selects devices with a specific attribute, *<attrib>* that has a value of *<value>*. When specified as *<attrib>!=<value>*, selects all devices that do not provide an attribute named *<attrib>* with a value of *<value>*.

Tip: You can use the `--list-attributes` option to display a list of available attributes and the `--help-attribute` to get more detailed information about a specific attribute.

--by-interface <interface>

selects devices by network interface, for example, `encl500`. *<interface>* must be the name of an existing networking interface.

--by-node <device_node>

selects devices by device node, for example, `/dev/sda`. *<device_node>* must be the path to the device node for a block device or character device.

Note: If *<device_node>* is the device node for a logical device (such as a device mapper device), **lszdev** tries to resolve the corresponding physical device nodes. The **lsblk** tool must be available for this resolution to work.

--by-path <path>

selects devices by file-system path, for example, */usr*. The *<path>* parameter can be the mount point of a mounted file system, or a path on that file system.

Note: If the file system that provides *<path>* is stored on multiple physical devices (such as supported by btrfs), **lszdev** tries to resolve the corresponding physical device nodes. The **lsblk** tool must be available and the file system must provide a valid UUID for this resolution to work.

--all

selects all existing and configured devices.

--configured

narrows the selection to those devices for which a persistent configuration exists.

--existing

narrows the selection to all devices that are present in the active configuration.

--configured --existing

specifying both **--configured** and **--existing** narrows the selection to devices that are present in both configurations, persistent and active.

--online

narrows the selection to devices that are enabled in the active configuration.

--offline

narrows the selection to devices that are disabled in the active configuration.

-a or --active

applies changes to the active configuration only. The persistent configuration is not changed unless you also specify **--persistent**.

Note: Changes to the active configuration are effective immediately. They are lost on reboot, when a device driver is unloaded, or when a device becomes unavailable.

-p or --persistent

applies changes to the persistent configuration only. The persistent configuration takes effect when the system boots, when a device driver is loaded, or when a device becomes available.

--auto-config

applies changes to the auto-configuration. Changes to the auto-configuration take effect when a device becomes available, but do not persist across reboots. This option is primarily intended for use by the boot process. For details about auto-configuration data, see [Chapter 3, “Device auto-configuration for Linux in LPAR mode,” on page 19](#).

--export <filename>|-

writes configuration data to a text file called *<filename>*. If a single hyphen (-) is specified instead of a file name, data is written to the standard output stream. The output format of this option can be used with the **--import** option. To reduce the scope of exported configuration data, you can select specific devices, a device type, or define whether to export only data for the active or persistent configuration.

--import <filename>|-

reads configuration data from *<filename>* and applies it. If a single hyphen (-) is specified instead of a file name, data is read from the standard input stream. The input format must be the same as the format produced by the **--export** option.

By default, all configuration data that is read is also applied. To reduce the scope of imported configuration data, you can select specific devices, a device type, or define whether to import only data for the active or persistent configuration.

-a or --apply

applies the persistent configuration of all selected devices and device types to the active configuration.

-e or --enable

enables the selected devices. Any steps necessary for the devices to function are taken, for example: create a CCW group device, remove a device from the CIO exclusion list, or set a CCW device online.

Active configuration

Performs all setup steps required for a device to become operational, for example, as a block device or as a network interface.

Persistent configuration

Creates configuration files and settings associated with the selected devices.

-d or --disable

disables the selected devices.

Active configuration

Disables the selected devices by reverting the configuration steps necessary to enable them.

Persistent configuration

Removes configuration files and settings associated with the selected devices.

--dry-run

processes the actions and displays command output without changing the configuration of any devices or device types. Combine with `--verbose` to display details about skipped configuration steps.

--base <path> | <key=value>

changes file system paths that are used to access files. If *<path>* is specified without an equal sign (=), it is used as base path for accessing files in the active and persistent configuration. If the specified parameter is in *<key=value>* format, only those paths that begin with *<key>* are modified. For these paths, the initial *<key>* portion is replaced with *<value>*.

Example: `lszdev --persistent --base /etc=/mnt/etc`

-f or --force

overrides safety checks and confirmation questions, including:

- More than 256 devices selected
- Configuring unknown attributes
- Combining apparently inconsistent settings

--no-root-update

skips any additional steps that are required to change the root device configuration persistently. Typically such steps include rebuilding the initial RAM disk, or modifying the kernel command line.

-y or --yes

answers all confirmation questions with "yes".

-q or --quiet

prints only minimal run-time information.

-l or --list-attributes

lists all supported device or device type attributes, including a short description. Use the `--help-attribute` option to get more detailed information about an attribute.

-L or --list-types

lists the name and a short description for all device types supported by chzdev.

--no-settle

continue without waiting for udev processing to complete. This option is intended for utilities that run during the early initial RAM disc stage of the boot process, when udev is not fully functional.

-V or --verbose

prints additional run-time information.

-v or --version

displays the version number of **chzdev**, then exits.

-h or --help

displays help information for the command.

-H or --help-attribute

displays help information for the command.

Examples

- To enable an FCP device with device number 0.0.198d, WWPN 0x50050763070bc5e3, and LUN 0x4006404600000000, and create a persistent configuration, issue:

```
# chzdev --enable zfcplun 0.0.198d:0x50050763070bc5e3:0x4006404600000000
```

- To enable the same FCP device without creating a persistent configuration, issue:

```
# chzdev --enable --active zfcplun 0.0.198d:0x50050763070bc5e3:0x4006404600000000
```

- To export configuration data for all FCP devices to a file called `config.txt`, issue:

```
# chzdev zfcplun --all --export config.txt
```

- To enable a QETH device and create a persistent configuration, issue:

```
# chzdev --enable qeth 0.0.a000:0.0.a001:0.0.a002
```

- To enable a QETH device without creating a persistent configuration, issue:

```
# chzdev --enable --active qeth 0.0.a000:0.0.a001:0.0.a002
```

- To enable a device that provides networking interface `encf500`, issue:

```
# chzdev --by-interface encf500 --active
```

- To get help for the QETH-device attribute `layer2`, issue:

```
# chzdev qeth --help-attribute layer2
```

- To enable DASD 0.0.8000 and create a persistent configuration, issue:

```
# chzdev -e dasd 8000
```

- To enable DASDs 0.0.1000 and 0.0.2000 through 0.0.2010, issue:

```
# chzdev dasd 1000,200-2010 -e
```

- To change the `dasd` device type parameter `eer_pages` to 14, issue:

```
# chzdev dasd --type eer_pages=14
```

- To remove the persistent `use_diag` setting of DASD 0.0.8000, issue:

```
# chzdev dasd 8000 --remove use_diag --persistent
```

- To persistently configure the root device, issue:

```
# chzdev --by-path / --persistent
```

See the man page for information about the command exit codes.

Activating a device early during the boot process

Use the `zdev:early` device attribute to activate a device early during the boot process and to override any existing auto-configuration with a persistent device configuration.

zdev:early=1

The device is activated during the initial RAM disc phase according to the persistent configuration.

zdev:early=0

The device is activated as usual during the boot process. This is the default. If auto-configuration data is present, the device is activated during the initial RAM disc phase according to the auto-configuration.

Example: To assure that the qeth device with bus-ID 0.0.f5f0 is enabled early in the boot process in layer 2 mode, issue:

```
# chzdev -e qeth 0.0.f5f0:0.0.f5f1:0.0.f5f2 layer2=1 zdev:early=1
```

See also [Chapter 3, “Device auto-configuration for Linux in LPAR mode,”](#) on page 19.

Files used

The **chzdev** command uses these files:

/etc/udev/rules.d/

chzdev creates udev rules to store the persistent configuration of devices. File names start with 41-.

/etc/modprobe.d/

chzdev creates modprobe configuration files to store the persistent configuration of certain device types. File names start with s390x-.

/run

holds udev rules that represent auto-configuration data. **chzdev** can remove entries so the auto-configuration settings do not apply as devices appear on the running Linux instance.

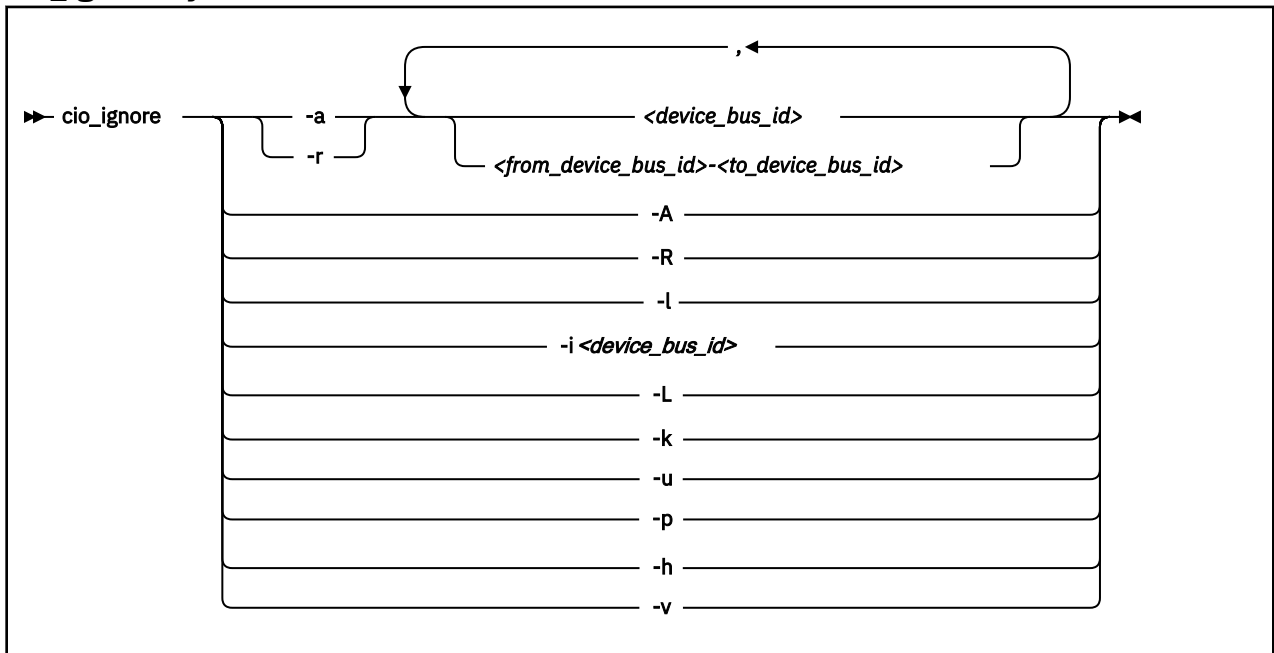
cio_ignore - Manage the I/O exclusion list

Use the **cio_ignore** command to specify I/O devices that are to be ignored by Linux.

When an instance of Linux on Z boots, it senses and analyzes all available I/O devices. You can use the `cio_ignore` kernel parameter (see “`cio_ignore` - List devices to be ignored” on page 698) to specify devices that are to be ignored. This exclusion list can cover all possible devices, even devices that do not actually exist.

The **cio_ignore** command manages this exclusion list on a running Linux instance. You can change the exclusion list and display it in different formats.

cio_ignore syntax



Where:

-a or --add

adds one or more device specifications to the exclusion list.

When you add specifications for a device that is already sensed and analyzed, there is no immediate effect of adding it to the exclusion list. For example, the device still appears in the output of the **lscss** command and can be set online. However, if the device subsequently becomes unavailable, it is ignored when it reappears. For example, if the device is detached in z/VM, it is ignored when it is attached again.

See the [-p option](#) about making devices that are already sensed and analyzed unavailable to Linux.

-r or --remove

removes one or more device specifications from the exclusion list.

When you remove device specifications from the exclusion list, the corresponding devices are sensed and analyzed if they exist. Where possible, the corresponding device driver is informed, and the devices become available to Linux.

<device_bus_id>

identifies a single device.

Device bus-IDs are of the form `0.<n>.<devno>`, where `<n>` is a subchannel set ID and `<devno>` is a device number. If the subchannel set ID is 0, you can abbreviate the specification to the device number, with or without a leading 0x.

Example: The specifications 0.0.0190, 190, 0190, and 0x190 are all equivalent. There is no short form of 0.1.0190.

<from_device_bus_id>-<to_device_bus_id>

identifies a range of devices. *<from_device_bus_id>* and *<to_device_bus_id>* have the same format as *<device_bus_id>*.

-A or --add-all

adds the entire range of possible devices to the exclusion list.

When you add specifications for a device that is already sensed and analyzed, there is no immediate effect of adding it to the exclusion list. For example, the device still appears in the output of the **lscss** command and can be set online. However, if the device subsequently becomes unavailable, it is ignored when it reappears. For example, if the device is detached in z/VM, it is ignored when it is attached again.

See the [-p option](#) about making devices that are already sensed and analyzed unavailable to Linux.

-R or --remove-all

removes all devices from the exclusion list.

When you remove device specifications from the exclusion list, the corresponding devices are sensed and analyzed if they exist. Where possible, the corresponding device driver is informed, and the devices become available to Linux.

-l or --list

displays the current exclusion list.

-i or --is-ignored

checks if the specified device is on the exclusion list. The command prints an information message and completes with exit code 0 if the device is on the exclusion list. The command completes with exit code 2 if the device is not on the exclusion list.

-L or --list-not-blacklisted

displays specifications for all devices that are not in the current exclusion list.

-k or --kernel-param

returns the current exclusion list in kernel parameter format.

You can make the current exclusion list persistent across rebooting Linux by using the output of the **cio_ignore** command with the **-k** option as part of the Linux kernel parameter. See [Chapter 4, “Kernel and module parameters,”](#) on page 23.

-u or --unused

discards the current exclusion list and replaces it with a specification for all devices that are not online. This includes specification for possible devices that do not actually exist.

-p or --purge

makes all devices that are in the exclusion list and that are currently offline unavailable to Linux. This option does not make devices unavailable if they are online.

-h or --help

displays help information for the command. To view the man page, enter **man cio_ignore**.

-v or --version

displays version information.

Examples

These examples illustrate common uses for **cio_ignore**.

- The following command shows the current exclusion list:

cio_ignore

```
# cio_ignore -l
Ignored devices:
=====
0.0.0000-0.0.7e8e
0.0.7e94-0.0.f4ff
0.0.f503-0.0.ffff
0.1.0000-0.1.ffff
0.2.0000-0.2.ffff
0.3.0000-0.3.ffff
```

- The following command shows specifications for the devices that are not on the exclusion list:

```
# cio_ignore -L
Accessible devices:
=====
0.0.7e8f-0.0.7e93
0.0.f500-0.0.f502
```

The following command checks if `0.0.7e8f` is on the exclusion list:

```
# cio_ignore -i 0.0.7e8f
Device 0.0.7e8f is not ignored.
```

- The following command adds, `0.0.7e8f`, to the exclusion list:

```
# cio_ignore -a 0.0.7e8f
```

The previous example then becomes:

```
# cio_ignore -L
Accessible devices:
=====
0.0.7e90-0.0.7e93
0.0.f500-0.0.f502
```

And for `0.0.7e8f` in particular:

```
# cio_ignore -i 0.0.7e8f
Device 0.0.7e8f is ignored.
```

- The following command shows the current exclusion list in kernel parameter format:

```
# cio_ignore -k
cio_ignore=all,!7e90-7e93,!f500-f502
```

cmsfs-fuse - Mount a z/VM CMS file system

Use the **cmsfs-fuse** command to mount the enhanced disk format (EDF) file system on a z/VM minidisk.

In Linux, the minidisk is represented as a DASD and the file system is mounted as a cmsfs-fuse file system. The cmsfs-fuse file system converts the record-based file system on the minidisk into Linux semantics.

Through the cmsfs-fuse file system, the files on the minidisk become available to applications on Linux. Applications can read from and write to files on minidisks. Optionally, the cmsfs-fuse file system converts text files between EBCDIC on the minidisk and ASCII within Linux.



Attention: You can inadvertently damage files and lose data when directly writing to files within the cmsfs-fuse file system. To avoid problems when you write, multiple restrictions must be observed, especially regarding linefeeds (see [restrictions for write](#)).

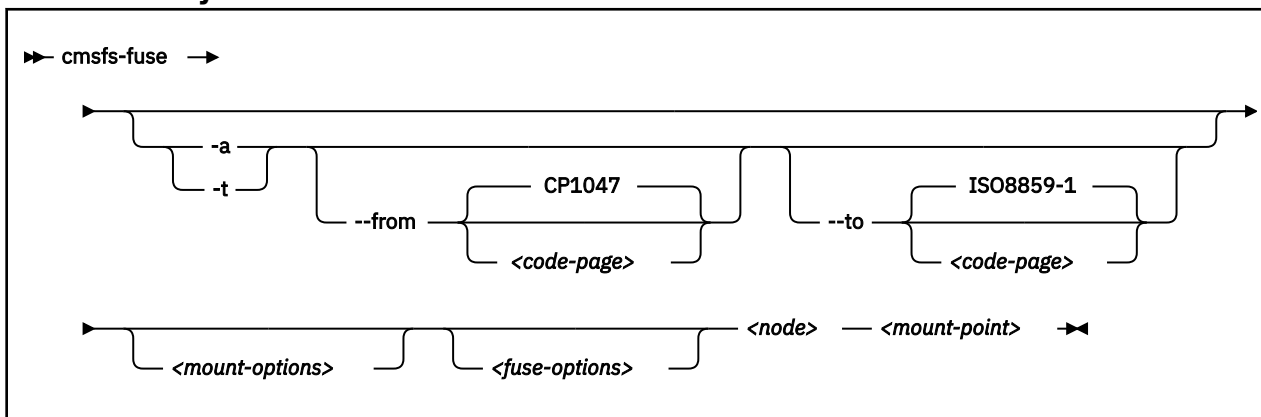
Tip: If you are unsure about how to safely write to a file on the cmsfs-fuse file system, copy the file to a location outside the cmsfs-fuse file system, edit the file, and then copy it back to its original location.

Use **fusemount** to unmount file systems that you mounted with **cmsfs-fuse**. See the **fusemount** man page for details.

Before you begin:

- **cmsfs-fuse** requires the FUSE library. You can obtain it from sourceforge at sourceforge.net/projects/fuse/.
- The DASD must be online.
- Depending whether you intend to read, write, or both, you must have the appropriate permissions for the device node.

cmsfs-fuse syntax



where:

-a or --ascii

treats all files on the minidisk as text files and converts them from EBCDIC to ASCII.

-t or --filetype

treats files with extensions as listed in the **cmsfs-fuse** configuration file as text files and converts them from EBCDIC to ASCII.

By default, the cmsfs-fuse command uses `/etc/cmsfs-fuse/filetypes.conf` as the configuration file. You can replace the list in this default file by creating a file `.cmsfs-fuse/filetypes.conf` in your home directory.

The `filetypes.conf` file lists one file type per line. Lines that start with a number sign (#) followed by a space are treated as comments and are ignored.

--from <code-page>

specifies the encoding of the files on the z/VM minidisk. If this option is not specified, code page CP1047 is used. Enter **iconv --list** to display a list of all available code pages.

--to <code-page>

specifies the encoding to which the files on the z/VM minidisk are converted in Linux. If this option is not specified, code page ISO-8859-1 is used. Enter **iconv --list** to display a list of all available code pages.

<mount-options>

options as available for the **mount** command. See the **mount** man page for details.

<fuse-options>

options for FUSE. The following options are supported by the **cmsfs-fuse** command. To use an option, it must also be supported by the version of FUSE that you have.

-d or -o debug

enables debug output (implies **-f**).

-f

runs the command as a foreground operation.

-o allow_other

allows access to other users.

-o allow_root

allows access to root.

-o nonempty

allows mounts over files and non-empty directories.

-o default_permissions

enables permission checking by the kernel.

-o max_read=<n>

sets maximum size of read requests.

-o kernel_cache

caches files in the kernel.

-o [no]auto_cache

enables or disables caching based on modification times.

-o umask=<mask>

sets file permissions (octal).

-o uid=<n>

sets the file owner.

-o gid=<n>

sets the file group.

-o max_write=<n>

sets the maximum size of write requests.

-o max_readahead=<n>

sets the maximum readahead value.

-o async_read

performs reads asynchronously (default).

-o sync_read

performs reads synchronously.

-o big_writes

enables write operations with more than 4 KB.

<node>

the device node for the DASD that represents the minidisk in Linux.

<mount-point>

the mount point in the Linux file system where you want to mount the CMS file system.

-h or --help

displays help information for the command. To view the man page, enter **man cmsfs-fuse**.

-v or --version

displays version information for the command.

Extended attributes

You can use the following extended attributes to handle the CMS characteristics of a file:

user.record_format

specifies the format of the file. The format is F for fixed record length files and V for variable record length files. This attribute can be set only for empty files. The default file format for new files is V.

user.record_lrecl

specifies the record length of the file. This attribute can be set only for an empty fixed record length file. A valid record length is an integer in the range 1-65535.

user.file_mode

specifies the CMS file mode of the file. The file mode consists of a mode letter from A-Z and mode number from 0 - 6. The default file mode for new files is A1.

You can use the following system calls to work with extended attributes:

listxattr

to list the current values of all extended attributes.

getxattr

to read the current value of a particular extended attribute.

setxattr

to set a particular extended attribute.

You can use these system calls through the **getfattr** and **setfattr** commands. For more information, see the man pages of these commands and of the listxattr, getxattr, and setxattr system calls.

Restrictions

When you work with files in the cmsfs-fuse file system, restrictions apply for the following system calls:

write

Be aware of the following restrictions when you write to a file on the cmsfs-fuse file system:

Write location

Writing is supported only at the end of a file.

Padding

For fixed-length record files, the last record is padded to make up a full record length. The padding character is zero in binary mode and the space character in ASCII mode.

Sparse files

Sparse files are not supported. To prevent the **cp** tool from writing in sparse mode, specify **-sparse=never**.

Records and linefeeds with ASCII conversion (-a and -t)

In the ASCII representation of an EBCDIC file, a linefeed character determines the end of a record. Follow these rules about linefeed characters requirements when you write to EBCDIC files in ASCII mode:

For fixed record length files

Use linefeed characters to separate character strings of the fixed record length.

For variable record length files

Use linefeed characters to separate character strings. The character strings must not exceed the maximum record length.

The CMS file system does not support empty records. cmsfs-fuse adds a space to records that consist of a linefeed character only.

rename and creat

Uppercase file names are enforced.

truncate

Only shrinking of a file is supported. For fixed-length record files, the new file size must be a multiple of the record length.

Examples

- To mount the CMS file system on the minidisk represented by the file node `/dev/dasde` at `/mnt`:

```
# cmsfs-fuse /dev/dasde /mnt
```

- To mount the CMS file system on the minidisk represented by the file node `/dev/dasde` at `/mnt` and enable EBCDIC to ASCII conversion for text files with extensions as specified in `~/ .cmsfs-fuse/filetypes.conf` or `/etc/cmsfs-fuse/filetypes.conf` if the former does not exist:

```
# cmsfs-fuse -t /dev/dasde /mnt
```

- To mount the CMS file system on the minidisk represented by the file node `/dev/dasde` at `/mnt` and allow root to access the mounted file system:

```
# cmsfs-fuse -o allow_root /dev/dasde /mnt
```

- To unmount the CMS file system that was mounted at `/mnt`:

```
# fusermount -u /mnt
```

- To show the record format of a file, `PROFILE.EXEC`, on a z/VM minidisk that is mounted on `/mnt`:

```
# getfattr -n user.record_format /mnt/PROFILE.EXEC
F
```

- To set record length 80 for an empty fixed record format file, `PROFILE.EXEC`, on a z/VM minidisk that is mounted on `/mnt`:

```
# setfattr -n user.record_lrecl -v 80 /mnt/PROFILE.EXEC
```


cpacfstats - Monitor CPACF cryptographic activity

Use the **cpacfstats** command to display the number of cryptographic operations that are performed by the Central Processor Assist for Cryptographic Function (CPACF). You can display and enable, disable, or reset specific hardware counters for AES, DES, TDES, SHA, and pseudo random functions.

CPACF performance counters are available on LPARs only.

All counters are initially disabled and must be enabled in the LPAR activation profile on the SE or HMC to measure CPACF activities. There is a slight performance penalty with CPACF counters enabled.

Prerequisites

- The performance monitoring event library libpfm version 4 or later is required. You can obtain the libpfm4 package from Debian.
- On the HMC or SE, authorize the LPAR for each counter set you want to use. Customize the LPAR activation profile and modify the Counter Facility Security Options. You need to activate the "Crypto activity counter set authorization control" checkbox.
- The cpacfstatsd daemon must be running. Check the syslog for the message: cpacfstatsd: Running. To start the daemon, issue:

```
# cpacfstatd
```

The daemon requires root privileges to open and work with the perf kernel API functions. Issue **man cpacfstatd** for more information about the daemon.

Note: The counter value is increased once per API call and also for every additional 4096 bytes of data.

Setting up the cpacfstats group

Only root and members of the group cpacfstats are allowed to communicate with the daemon process. You must create the group and add users to it.

1. Create the group cpacfstats:

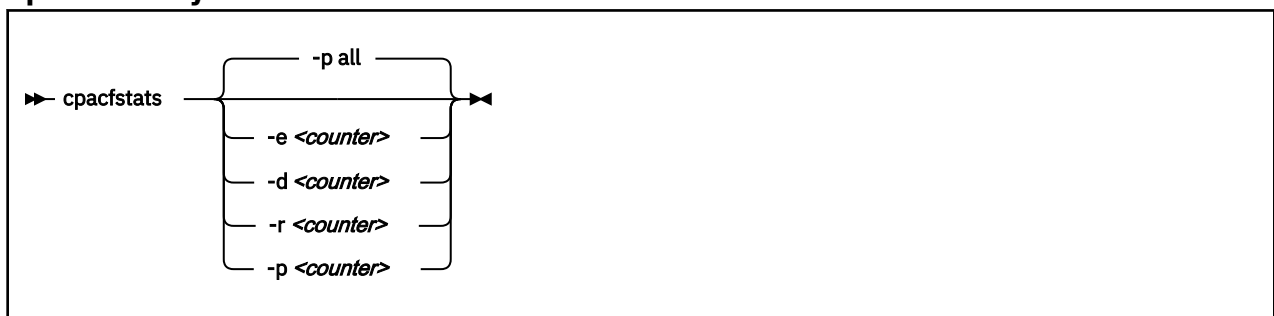
```
# groupadd cpacfstats
```

2. Add all users who are allowed to run the cpacfstats client application to the group:

```
usermod -a -G cpacfstats <user>
```

All users in the cpacfstats group are also able to modify the CPACF counter states (enable, disable, reset).

cpacfstats syntax



Where:

-e <counter> or --enable <counter>

enables one or all CPACF performance counters. The optional counter argument can be one of:

des

counts all DES- and 3DES-related cipher message CPACF instructions.

aes

counts all AES-related cipher message CPACF instructions.

sha

counts all message digest (that is, SHA-1 through SHA-512) related CPACF instructions.

rng

counts all pseudo-random related CPACF instructions.

all

counts all CPACF instructions.

If you omit the counter, all performance counters are enabled. Enabling a counter does not reset it. New events are added to the current counter value.

-d <counter> or --disable <counter>

disables one or all CPACF performance counters. If you omit the counter, all performance counters are disabled. Disabling a counter does not reset it. The counter value is preserved when a counter is disabled, and counting resumes with the preserved value when the counter is re-enabled.

-r <counter> or --reset <counter>

resets one or all CPACF performance counters. If you omit the counter, all performance counters are reset to 0.

-p <counter> or --print <counter>

displays the value of one or all CPACF performance counters. If you omit the counter, all performance counters are displayed.

-h or --help

displays help information for the command. To view the command man page, enter **man cpacfstats**.

-v or --version

displays version information for **cpacfstats**.

The default command is **--print all**.

Examples

- To print status and values of all CPACF performance counters:

```
# cpacfstats
des counter: disabled
aes counter: disabled
sha counter: disabled
rng counter: disabled
```

- To enable the AES CPACF performance counter:

```
# cpacfstats --enable aes
aes counter: 0
```

- To enable all CPACF performance counters:

```
# cpacfstats -e
des counter: 0
aes counter: 192
sha counter: 0
rng counter: 0
```

For the already enabled aes counter, the value is not reset.

cpuplugd - Control CPUs and memory

Use the **cpuplugd** command and a set of rules in a configuration file to dynamically enable or disable CPUs. For Linux on z/VM, you can also dynamically add or remove memory.

Ubuntu Server 20.04.1 provides the **cpuplugd** utility as a package, `s390-tools-cpuplugd`.

When Linux is running in an LPAR, setting a CPU offline can result in the LPAR status "Exceptions" in the HMC or SE. With one or more CPUs offline, this status does not necessarily indicate a problem.

Rules that are tailored to a particular system environment and the associated workload can increase performance. The rules can include various system load variables.

Ubuntu Server 20.04.1 automatically starts **cpuplugd** for you after you install the package.

Note: Do not run multiple instances of `cpuplugd` simultaneously.

You can start `cpuplugd` from the command line in two ways:

- With the service utility
- Through a command-line interface

cpuplugd service utility syntax

If you run the **cpuplugd** daemon through the service utility, you configure the daemon through specifications in the `/etc/cpuplugd.conf` configuration file.



Where:

start

starts the `cpuplugd` daemon with the configuration in `/etc/cpuplugd.conf`. Do not run multiple instances of `cpuplugd` simultaneously. Check the `cpuplugd` status before starting a new instance.

stop

stops the `cpuplugd` daemon.

status

shows current status of `cpuplugd`.

restart

stops and restarts the `cpuplugd` daemon. Useful to re-read the configuration file when it was changed.

Examples

- To stop a running instance of `cpuplugd`:

```
# service cpuplugd stop
```

- To display the status:

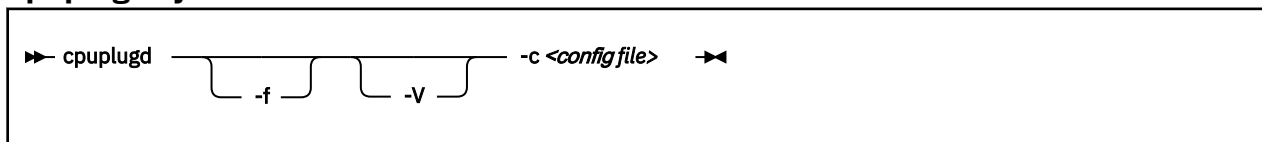
```
# service cpuplugd status
...
Active: active (running) ...
```

cpuplugd command-line syntax

You can start cpuplugd through a command interface.

Before you begin: Do not run multiple instances of cpuplugd simultaneously. Check the cpuplugd status through the service utility before you issue the **cpuplugd** command (see [“cpuplugd service utility syntax”](#) on page 547).

cpuplugd syntax



Where:

-c <config file> or --config <config file>

specifies the path to the configuration file with the rule (see [“Configuration file structure”](#) on page 548). You can find a sample configuration file at `/etc/cpuplugd.conf`.

-f or --foreground

runs cpuplugd in the foreground and not as a daemon. If this option is omitted, cpuplugd runs as a daemon in the background.

-V or --verbose

displays verbose messages to stdout when cpuplugd is running in the foreground or to syslog when cpuplugd is running as a daemon in the background. This option can be useful for debugging.

-h or --help

displays help information for the command. To view the command man page, enter **man cpuplugd**. To view the man page for the configuration file, enter **man cpuplugd.conf**.

-v or --version

displays version information for cpuplugd.

Examples

- To start cpuplugd in daemon mode with a configuration file `/etc/cpuplugd.conf`:

```
# cpuplugd -c /etc/cpuplugd.conf
```

- To run cpuplugd in the foreground with verbose messages and with a configuration file `/etc/cpuplugd.conf`:

```
# cpuplugd -V -f -c /etc/cpuplugd.conf
```

Configuration file structure

The cpuplugd configuration file can specify rules for controlling the number of active CPUs and for Linux on z/VM, for controlling the amount of memory.

The configuration file contains:

- `<variable>=<value>` pairs

These pairs must be specified within one line. The maximum valid line length is 2048 characters. The values can be decimal numbers or algebraic or Boolean expressions.

- Comments

Any part of a line that follows a number sign (`#`) is treated as a comment. There can be full comment lines with the number sign at the beginning of the line or comments can begin in mid-line.

- Empty lines



Attention: These configuration file samples illustrate the syntax of the configuration file. Do not use the sample rules on production systems. Useful rules differ considerably, depending on the workload, resources, and requirements of the system for which they are designed.

Basic configuration file for CPU control

A configuration file for dynamically enabling or disabling CPUs has several required specifications.

The configuration file sample of [Figure 84 on page 549](#) has been reduced to the specifications that are required for dynamically enabling or disabling CPUs.

```
UPDATE="10"
CPU_MIN="2"
CPU_MAX="10"

HOTPLUG = "idle < 10.0"
HOTUNPLUG = "idle > 100"
```

Figure 84. Simplified configuration file with CPU hotplug rules

In the configuration file:

UPDATE

specifies the time interval, in seconds, at which cpuplugd evaluates the rules and, if a rule is met, enables or disables CPUs. This variable is also required for controlling memory (see [“Basic configuration file for memory control” on page 550](#)).

In the example, the rules are evaluated every 10 seconds.

CPU_MIN

specifies the minimum number of CPUs. Even if the rule for disabling CPUs is met, cpuplugd does not reduce the number of CPUs to less than this number.

In the example, the number of CPUs cannot become less than 2.

CPU_MAX

specifies the maximum number of CPUs. Even if the rule for enabling CPUs is met, cpuplugd does not increase the number of CPUs to more than this number. If 0 is specified, the maximum number of CPUs is the number of CPUs available on the system.

In the example, the number of CPUs cannot become more than 10.

HOTPLUG

specifies the rule for dynamically enabling CPUs. The rule resolves to a boolean true or false. Each time this rule is true, cpuplugd enables one CPU, unless the number of CPUs has already reached the maximum specified with CPU_MAX.

Setting HOTPLUG to 0 disables dynamically adding CPUs.

In the example, a CPU is enabled when the idle times of all active CPUs sum up to less than 10.0%. See [“Keywords for CPU hotplug rules” on page 551](#) for information about available keywords.

HOTUNPLUG

specifies the rule for dynamically disabling CPUs. The rule resolves to a boolean true or false. Each time this rule is true, cpuplugd disables one CPU, unless the number of CPUs has already reached the minimum specified with CPU_MIN.

Setting HOTUNPLUG to 0 disables dynamically removing CPUs.

In the example, a CPU is disabled when the idle times of all active CPUs sum up to more than 100%. See [“Keywords for CPU hotplug rules” on page 551](#) for information about available keywords.

If one of these variables is set more than once, only the last occurrence is used. These variables are not case sensitive.

If both the HOTPLUG and HOTUNPLUG rule are met simultaneously, HOTUNPLUG is ignored.

Basic configuration file for memory control

For Linux on z/VM, you can also use cpuplugd to dynamically add or take away memory. There are several required specifications for memory control.

The configuration file sample of [Figure 85 on page 550](#) was reduced to the specifications that are required for dynamic memory control.

```
UPDATE="10"
CMM_MIN="0"
CMM_MAX="131072"    # 512 MB
CMM_INC="10240"    # 40 MB

MEMPLUG = "swaprte > 250"
MEMUNPLUG = "swaprte < 10"
```

Figure 85. Simplified configuration file with memory hotplug rules

In the configuration file:

UPDATE

specifies the time interval, in seconds, at which cpuplugd evaluates the rules and, if a rule is met, adds or removes memory. This variable is also required for controlling CPUs (see [“Basic configuration file for CPU control” on page 549](#)).

In the example, the rules are evaluated every 10 seconds.

CMM_MIN

specifies the minimum amount of memory, in 4 KB pages, that Linux surrenders to the CMM static page pool (see [“Cooperative memory management background” on page 368](#)). Even if the MEMPLUG rule for taking memory from the CMM static page pool and adding it to Linux is met, cpuplugd does not decrease this amount.

In the example, the amount of memory that is surrendered to the static page pool can be reduced to 0.

CMM_MAX

specifies the maximum amount of memory, in 4 KB pages, that Linux surrenders to the CMM static page pool (see [“Cooperative memory management background” on page 368](#)). Even if the MEMUNPLUG rule for removing memory from Linux and adding it to the CMM static page pool is met, cpuplugd does not increase this amount.

In the example, the amount of memory that is surrendered to the static page pool cannot become more than 131072 pages of 4 KB (512 MB).

CMM_INC

specifies the amount of memory, in 4 KB pages, that is removed from Linux when the MEMUNPLUG rule is met. Removing memory from Linux increases the amount that is surrendered to the CMM static page pool.

In the example, the amount of memory that is removed from Linux is 10240 pages of 4 KB (40 MB) at a time.

CMM_DEC

Optional: specifies the amount of memory, in 4 KB pages, that is added to Linux when the MEMPLUG rule is met. Adding memory to Linux decreases the amount that is surrendered to the CMM static page pool.

If this variable is omitted, the amount of memory that is specified for CMM_INC is used.

In the example, CMM_DEC is omitted and the amount of memory added to Linux is 10240 pages of 4 KB (40 MB) at a time, as specified with CMM_INC.

MEMPLUG

specifies the rule for dynamically adding memory to Linux. The rule resolves to a Boolean true or false. Each time this rule is true, cpuplugd adds the number of pages that are specified by CMM_DEC, unless the CMM static page pool already reached the minimum that is specified with CMM_MIN.

Setting MEMPLUG to 0 disables dynamically adding memory to Linux.

In the example, memory is added to Linux if there are more than 250 swap operations per second. See [“Keywords for memory hotplug rules” on page 552](#) for information about available keywords.

MEMUNPLUG

specifies the rule for dynamically removing memory from Linux. The rule resolves to a Boolean true or false. Each time this rule is true, cpuplugd removes the number of pages specified by CMM_INC, unless the CMM static page pool already reached the maximum that is specified with CMM_MAX.

Setting MEMUNPLUG to 0 disables dynamically removing memory from Linux.

In the example, memory is removed from Linux when there are less than 10 swap operations per second. See [“Keywords for memory hotplug rules” on page 552](#) for information about available keywords.

If any of these variables are set more than once, only the last occurrence is used. These variables are not case-sensitive.

If both the MEMPLUG and MEMUNPLUG rule are met simultaneously, MEMUNPLUG is ignored.

CMM_DEC and CMM_INC can be set to a decimal number or to a mathematical expression that uses the same algebraic operators and variables as the MEMPLUG and MEMUNPLUG hotplug rules (see [“Keywords for memory hotplug rules” on page 552](#) and [“Writing more complex rules” on page 553](#)).

Predefined keywords

There is a set of predefined keywords that you can use for CPU hotplug rules and a set of keywords that you can use for memory hotplug rules.

All predefined keywords are case sensitive.

Keywords for CPU hotplug rules

Use the predefined keywords in the CPU hotplug rules, HOTPLUG and HOTUNPLUG.

The following keywords are available:

loadavg

is the current load average.

onumcpus

is the current number of online CPUs.

runnable_proc

is the current number of runnable processes.

user

is the current CPU user percentage.

nice

is the current CPU nice percentage.

system

is the current CPU system percentage.

idle

is the current CPU idle percentage.

iowait

is the current CPU iowait percentage.

irq

is the current CPU irq percentage.

softirq

is the current CPU softirq percentage.

steal

is the current CPU steal percentage.

guest

is the current CPU guest percentage for a z/VM or KVM guest.

guest_nice

is the current CPU guest_nice percentage for a z/VM or KVM guest.

cpustat.<name>

is data from `/proc/stat` and `/proc/loadavg`. In the keyword, `<name>` can be any of the previously listed keywords, for example, `cpustat.idle`. See the `proc` man page for more details about the data that is represented by these keywords.

With this notation, the keywords resolve to raw timer ticks since system start, not to current percentages. For example, `idle` resolves to the current idle percentage and `cpustat.idle` resolves to the total timer ticks spent idle. See [“Using historical data” on page 552](#) about how to obtain average and percentage values.

`loadavg`, `onumcpus`, and `runnable_proc` are not percentages and resolve to the same values as `cpustat.loadavg`, `cpustat.onumcpus`, and `cpustat.runnable_proc`.

cpustat.total_ticks

is the total number of timer ticks since system start.

time

is the UNIX epoch time in the format "seconds.microseconds".

Percentage values are accumulated for all online CPUs. Hence, the values for the percentages range from 0 to $100 \times$ (number of online CPUs). To get the average percentage per CPU device, divide the accumulated value by the number of CPUs. For example, `idle / onumcpus` yields the average idle percentage per CPU.

Keywords for memory hotplug rules

Use the predefined keywords in the memory hotplug rules, MEMPLUG and MEMUNPLUG.

The following keywords are available:

apcr

is the number of page cache operations, `pgpin + pgpout`, from `/proc/vmstat` in 512-byte blocks per second.

freemem

is the amount of free memory in MB.

swaprte

is the number of swap operations, `pswpin + pswpout`, from `/proc/vmstat` in 4 KB pages per second.

meminfo.<name>

is the value for the symbol `<name>` as shown in the output of `cat /proc/meminfo`. The values are plain numbers but refer to the same units as those used in `/proc/meminfo`.

vmstat.<name>

is the value for the symbol `<name>` as shown in the output of `cat /proc/vmstat`.

Using historical data

Historical data is available for the keyword `time` and the sets of keywords `cpustat.<name>`, `meminfo.<name>`, and `vmstat.<name>`.

See [“Keywords for CPU hotplug rules” on page 551](#) and [“Keywords for memory hotplug rules” on page 552](#) for details about these keywords.

Use the suffixes [`<n>`] to retrieve the data of `<n>` intervals in the past, where `<n>` can be in the range 0 - 100.

Examples

cpustat.idle

yields the current value for the counted idle ticks.

cpustat.idle[1]

yields the idle ticks as counted one interval ago.

cpustat.idle[5]

yields the idle ticks as counted five intervals ago.

cpustat.idle - cpustat.idle[5]

yields the idle ticks during the past five intervals.

time - time[1]

yields the length of an update interval in seconds.

cpustat.total_ticks - cpustat.total_ticks[5]

yields the total number of ticks during the past five intervals.

(cpustat.idle - cpustat.idle[5]) / (cpustat.total_ticks - cpustat.total_ticks[5])

yields the average ratio of idle ticks to total ticks during the past five intervals.

Multiplying this ratio with 100 yields the percentage of idle ticks during the last five intervals.

Multiplying this ratio with $100 * \text{onumcpus}$ yields the accumulated percentage of idle ticks for all processors during the last five intervals.

Writing more complex rules

In addition to numbers and keywords, you can use mathematical and Boolean operators, and you can use user-defined variables to specify rules.

- The keywords of [“Predefined keywords” on page 551](#)
- Decimal numbers
- The mathematical operators
 - +
addition
 - subtraction
 - *
multiplication
 - /
division
 - <
less than
 - >
greater than
- Parentheses (and) to group mathematical expressions
- The Boolean operators
 - &
and
 - |
or
 - !
not
- User-defined variables

You can specify complex calculations as user-defined variables, which can then be used in expressions. User-defined variables are case-sensitive and must not match a pre-defined variable or keyword. In the configuration file, definitions for user-defined variables must precede their use in expressions.

Variable names consist of alphanumeric characters and the underscore (`_`) character. An individual variable name must not exceed 128 characters. All user-defined variable names and values, in total, must not exceed 4096 characters.

Examples

- `HOTPLUG = "loadavg > onumcpus + 0.75"`
- `HOTPLUG = "(loadavg > onumcpus + 0.75) & (idle < 10.0)"`
- ```
my_idle_rate = "(cpustat.idle - cpustat.idle[5]) / (cpustat.total_ticks -
cpustat.total_ticks[5])"
my_idle_percent_total = "my_idle_rate * 100 * onumcpus"
...
HOTPLUG = "(loadavg > onumcpus + 0.75) & (my_idle_percent_total < 10.0)"
```

### Sample configuration file

A typical configuration file includes multiple user-defined variables and values from procs, for example, to calculate the page scan rate or the cache size.

```

Required static variables

CPU_MIN="1"
CPU_MAX="0"
UPDATE="1"
CMM_MIN="0"
CMM_MAX="131072" # 512 MB

User-defined variables

pgscan_d="vmstat.pgscan_direct_dma[0] + vmstat.pgscan_direct_normal[0] +
vmstat.pgscan_direct_movable[0]"
pgscan_d1="vmstat.pgscan_direct_dma[1] + vmstat.pgscan_direct_normal[1] +
vmstat.pgscan_direct_movable[1]"
page scan rate in pages / timer tick
pgscanrate="(pgscan_d - pgscan_d1) / (cpustat.total_ticks[0] - cpustat.total_ticks[1])"
cache usage in kilobytes
avail_cache="meminfo.Cached - meminfo.Shmem"

user_0="(cpustat.user[0] - cpustat.user[1])"
nice_0="(cpustat.nice[0] - cpustat.nice[1])"
system_0="(cpustat.system[0] - cpustat.system[1])"
user_2="(cpustat.user[2] - cpustat.user[3])"
nice_2="(cpustat.nice[2] - cpustat.nice[3])"
system_2="(cpustat.system[2] - cpustat.system[3])"
CP_Active0="(user_0 + nice_0 + system_0) / (cpustat.total_ticks[0] - cpustat.total_ticks[1])"
CP_Active2="(user_2 + nice_2 + system_2) / (cpustat.total_ticks[2] - cpustat.total_ticks[3])"
CP_ActiveAVG="(CP_Active0+CP_Active2) / 2"

idle_0="(cpustat.idle[0] - cpustat.idle[1])"
iowait_0="(cpustat.iowait[0] - cpustat.iowait[1])"
idle_2="(cpustat.idle[2] - cpustat.idle[3])"
iowait_2="(cpustat.iowait[2] - cpustat.iowait[3])"
CP_idle0="(idle_0 + iowait_0) / (cpustat.total_ticks[0] - cpustat.total_ticks[1])"
CP_idle2="(idle_2 + iowait_2) / (cpustat.total_ticks[2] - cpustat.total_ticks[3])"
CP_idleAVG="(CP_idle0 + CP_idle2) / 2"

More required variables

cmm_inc: 10% of free memory, in 4K pages
CMM_INC="meminfo.MemFree / 40"
cmm_dec: 10% of total memory, in 4K pages
CMM_DEC="meminfo.MemTotal / 40"

Hotplug rules
HOTPLUG="((1 - CP_ActiveAVG) * onumcpus) < 0.08"
HOTUNPLUG="(CP_idleAVG * onumcpus) > 1.15"
MEMPLUG="pgscanrate > 20"
MEMUNPLUG="(meminfo.MemFree + avail_cache) > (meminfo.MemTotal / 10)"

```

**Figure 86.** Sample configuration file for Linux on z/VM with CPU and memory hotplug



**Attention:** These configuration file samples illustrate the syntax of the configuration file. Useful rules might differ considerably, depending on the workload, resources, and requirements of the system for which they are designed.

After you install cpuplugd, a commented sample configuration file is available at `/etc/cpuplugd.conf`.

## dasdfmt - Format a DASD

Use the **dasdfmt** command to low-level format ECKD-type direct access storage devices (DASD).

**dasdfmt** uses an ioctl call to the DASD driver to format tracks. A block size (hard sector size) can be specified. The formatting process can take quite a long time (hours for large DASD).

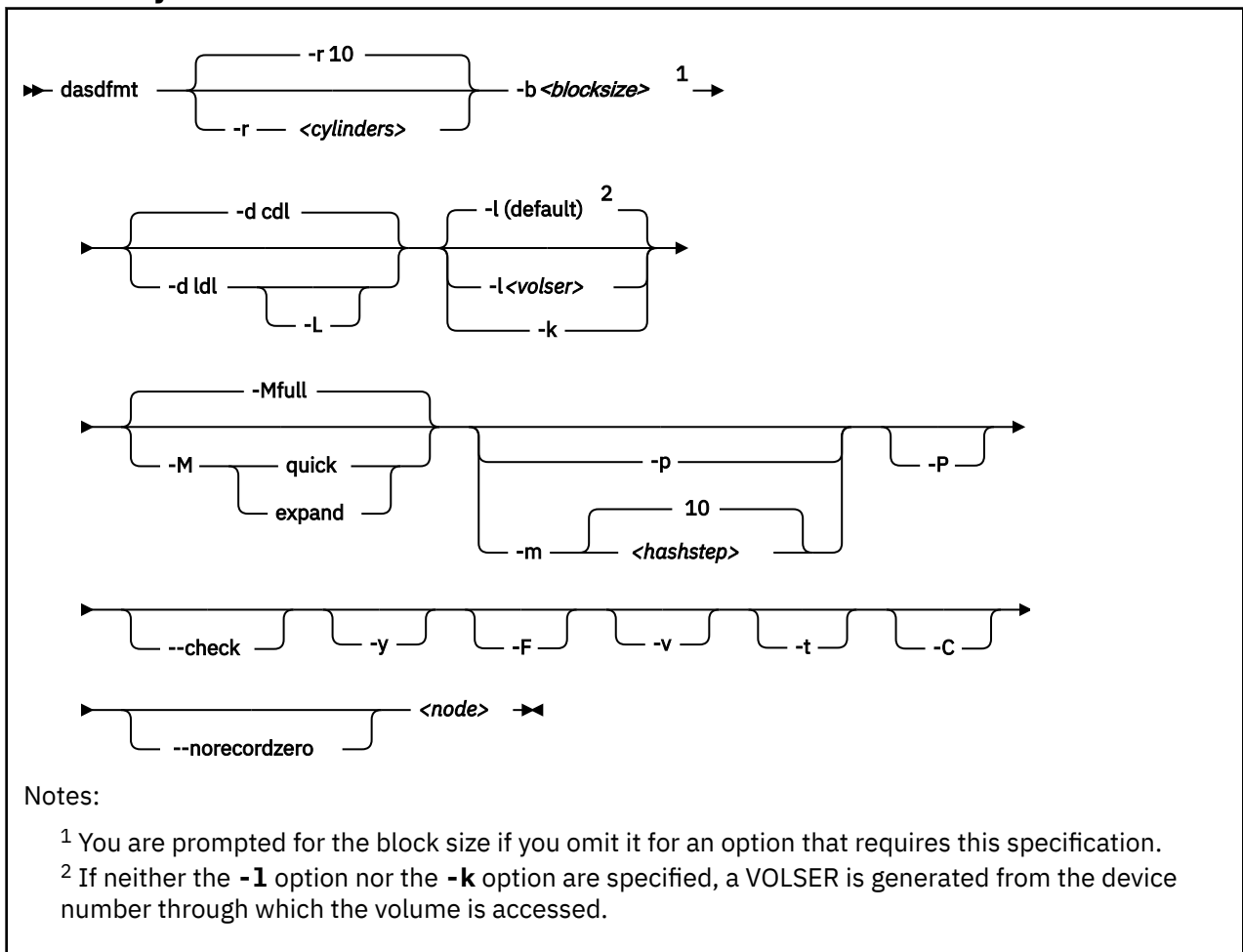
### Tips:

- For DASDs that have previously been formatted with **dasdfmt**, use the **dasdfmt** quick format mode.
- Use the **-p** option to monitor the progress.



**CAUTION:** As on any platform, formatting irreversibly destroys data on the target disk. Be sure not to format a disk with vital data unintentionally.

### dasdfmt syntax



Where:

#### **-r <cylinders> or --requestsize=<cylinders>**

specifies the number of cylinders to be processed in one formatting step. The value must be an integer in the range 1 - 255. The default is 10 cylinders. Use this parameter to use any available PAV devices. Ideally, the number of cylinders matches the number of associated devices, counting the base device and all alias devices.

#### **-b <block\_size> or --blocksize=<block\_size>**

specifies one of the following block sizes in bytes: 512, 1024, 2048, or 4096.

For the **quick** and **expand** modes and for the **--check** option, you can omit the block size. Otherwise, you are prompted if you do not specify a value for the block size. You can then press Enter to accept 4096 or specify a different value.

**Tip:** Set *<block\_size>* as large as possible (ideally 4096); the net capacity of an ECKD DASD decreases for smaller block sizes. For example, a DASD formatted with a block size of 512 byte has only half of the net capacity of the same DASD formatted with a block size of 4096 byte.

**<node>**

specifies the device node of the device to be formatted, for example, /dev/dasdzzz. See “[DASD naming scheme](#)” on page 116 for more details about device nodes.

**-d <disklayout> or --disk\_layout=<disklayout>**

formats the device with the compatible disk layout (cd1) or the Linux disk layout (ld1). If the parameter is not specified, the default (cd1) is used.

**-L or --no\_label**

valid for -d ld1 only, where it suppresses the default LNX1 label.

**-l <volser> or --label=<volser>**

specifies the volume serial number (see [VOLSER](#)) to be written to the disk. If the VOLSER contains special characters, it must be enclosed in single quotation marks. In addition, any '\$' character in the VOLSER must be preceded by a backslash ('\').

**-k or --keep\_volser**

keeps the volume serial number when writing the volume label (see [VOLSER](#)). Keeping the volume serial number is useful, for example, if the volume serial number was written with a z/VM tool and should not be overwritten.

**-M <mode> or --mode=<mode>**

specifies the mode to be used for formatting the device. Valid modes are:

**full**

Format the entire disk with the specified block size. This is the default mode.

**quick**

formats the first two tracks and writes label and partition information. Only use this option if you are sure that the target DASD already contains a regular format with the specified block size.

**expand**

format all unformatted tracks at the end of the target DASD. This mode assumes that tracks at the beginning of the DASD volume have already been correctly formatted, while a consecutive set of tracks at the end are unformatted. You can use this mode to make added space available for Linux use after dynamically increasing the size of a DASD volume.

For the **quick** and **expand** modes, omit the block size specification (**-b** option) to use the existing block size. If you specify a block size, **dasdfmt** checks that the specification matches the existing block size before formatting.

**-p or --progressbar**

displays a progress bar. Do not use this option if you are using a line-mode terminal console driver. For example, if you are using a 3215 terminal device driver or a line-mode hardware console device driver.

**-P or --percentage**

displays one line for each formatted cylinder. The line shows the number of the cylinder and percentage of formatting process. Intended for use by higher level interfaces.

**-m <hashstep> or --hashmarks=<hashstep>**

displays a number sign (#) after every *<hashstep>* cylinders are formatted. *<hashstep>* must be in the range 1 - 1000. The default is 10.

The **-m** option is useful where the console device driver is not suitable for the progress bar (**-p** option).

**--check**

performs a complete format check on a DASD volume.

Omit the block size specification (**-b** option) to check for a consistent format for any valid block size. Specify a block size to confirm that the DASD has been formatted consistently with that particular block size.

- y**  
starts formatting immediately without prompting for confirmation.
- F or --force**  
formats the device without checking whether it is mounted.
- v**  
displays extra information messages (verbose).
- t or --test**  
runs the command in test mode. Analyzes parameters and prints what would happen, but does not modify the disk.
- C or --check\_host\_count**  
checks the host-access open count to ensure that the device is not online to another operating system instance. Use this option to ensure that the operation is safe, and cancel it if other operating system instances are accessing the volume.
- norecordzero**  
prevents a format write of record zero. This option is intended for experts: Subsystems in DASD drivers are by default granted permission to modify or add a standard record zero to each track when needed. Before you revoke the permission with this option, you must ensure that the device contains standard record zeros on all tracks.
- V or --version**  
displays the version number of **dasdfmt** and exits.
- h or --help**  
displays an overview of the syntax. Any other parameters are ignored. To view the man page, enter **man dasdfmt**.

## Examples

- To format a 100 cylinder z/VM minidisk with the standard Linux disk layout and a 4 KB blocksize with device node `/dev/dasdc`:

```
dasdfmt -b 4096 -d ldl -p /dev/dasdc
Drive Geometry: 100 Cylinders * 15 Heads = 1500 Tracks

I am going to format the device /dev/dasdc in the following way:
Device number of device : 0x192
 Labelling device : yes
 Disk label : LNX1
 Disk identifier : 0X0192
 Extent start (trk no) : 0
 Extent end (trk no) : 1499
 Compatible Disk Layout : no
 Blocksize : 4096
 Mode : Full

--->> ATTENTION! <<---
All data of that device will be lost.
Type yes to continue, no will leave the disk untouched: yes
Formatting the device. This may take a while (get yourself a coffee).

cyl 100 of 100 |#####|100% [1s]

Finished formatting the device.
Rereading the partition table... ok
#
```

- To format the same disk with the compatible disk layout (accepting the default value of the **-d** option).

```
dasdfmt -b 4096 -p /dev/dasdc
Drive Geometry: 100 Cylinders * 15 Heads = 1500 Tracks

I am going to format the device /dev/dasdc in the following way:
 Device number of device : 0x192
 Labelling device : yes
 Disk label : VOL1
 Disk identifier : 0X0192
 Extent start (trk no) : 0
 Extent end (trk no) : 1499
 Compatible Disk Layout : yes
 Blocksize : 4096
 Mode : Full

--->> ATTENTION! <<---
All data of that device will be lost.
Type yes to continue, no will leave the disk untouched: yes
Formatting the device. This may take a while (get yourself a coffee).

cyl 100 of 100 |#####|100% [1s]

Finished formatting the device.
Rereading the partition table... ok
#
```

- To format with the **-P** option:

```
dasdfmt -P /dev/dasde

cyl 1 of 500 | 0%
cyl 2 of 500 | 0%
cyl 3 of 500 | 0%
cyl 4 of 500 | 0%
cyl 5 of 500 | 1%

...
cyl 496 of 500 | 99%
cyl 497 of 500 | 99%
cyl 498 of 500 | 99%
cyl 499 of 500 | 99%
cyl 500 of 500 | 100%
```

- To make best use of PAV when formatting a DASD that has one base device and four alias devices, specify five cylinders:

```
dasdfmt /dev/dasdd -y -b 4096 -d cdl -r 5
Finished formatting the device.
Rereading the partition table... ok
```

- To format a previously formatted DASD in quick format mode.

```
dasdfmt -b 4096 -p --mode=quick /dev/dasdf
```

- To format tracks that have been added at the end of an already formatted DASD.

```
dasdfmt -b 4096 -p --mode=expand /dev/dasdg
```

- To check whether a DASD has been correctly formatted with a block size of 4096 bytes.

```
dasdfmt -b 4096 -p --check /dev/dasdg
Checking format of the entire disk...
cyl 1113 of 1113 |#####|100% [19s]
Done. Disk is fine.
```

- To ensure that the DASD is not online to an operating system instance in a different LPAR when you start formatting the DASD:

```
dasdfmt -b 4096 -p -C /dev/dasdh
```

## **dasdfmt**

**dasdfmt** always checks the host-access open count. If the count indicates access by another operating system instance, the response depends on the **-C** option. With this option, the command is canceled. Otherwise, a warning is displayed before you are prompted to confirm that you want to proceed.

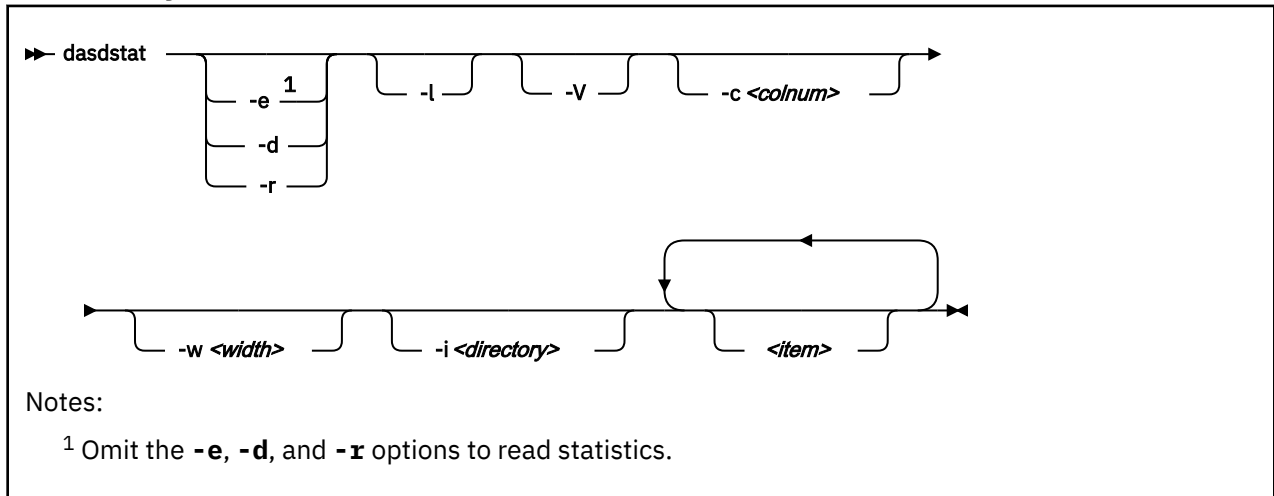


## dasdstat - Display DASD performance statistics

Use the **dasdstat** command to display DASD performance statistics, including statistics about Parallel Access Volume (PAV) and High Performance Ficon.

This command includes and extends the performance statistics that is also available through the **tunedasd** command.

### dasdstat syntax



Where:

**-e or --enable**

starts statistics data collection.

**-d or --disable**

stops statistics data collection.

**-r or --reset**

sets the statistics counters to zero.

**-l or --long**

displays more detailed statistics information, for example, differentiates between read and write requests.

**-V or --verbose**

displays more verbose command information.

**-c <colnum> or --columns <colnum>**

formats the command output in a table with the specified number of columns. The default is 16. Each row gets wrapped after the specified number of lines.

**-w <width> or --column-width <width>**

sets the minimum width, in characters, of a column in the output table.

**-i <directory> or --directory <directory>**

specifies the directory that contains the statistics. The default is *<mountpoint>/dasd*, where *<mountpoint>* is the mount point of debugfs. You need to specify this parameter if the **dasdstat** command cannot determine this mount point or if the statistics are copied to another location.

**<item>**

limits the command to the specified items. For *<item>* you can specify:

- **global** for summary statistics for all available DASDs.
- The block device name by which a DASD is known to the DASD device driver.
- The bus ID by which a DASD is known as a CCW device. DASDs that are set up for PAV or HyperPAV have a CCW base device and, at any one time, can have one or more CCW alias devices for the same

## dasdstat

block device. Alias devices are not permanently associated with the same block device. Statistics that are based on bus ID, therefore, show additional detail for PAV and HyperPAV setups.

If you do not specify any individual item, the command applies to all DASD block devices, CCW devices, and to the summary.

### **-v or --version**

displays the version number of **dasdstat**, then exits.

### **-h or --help**

displays help information for the command.

## Examples

- This command starts data collection for dasda, 0.0.b301, and for a summary of all available DASDs.

```
dasdstat -e dasda 0.0.b301 0.0.b302 global
```

- This command resets the statistics counters for dasda.

```
dasdstat -r dasda
```

- This command reads the summary statistics:

```
statistics data for statistic: global
start time of data collection: Wed Aug 17 09:52:47 CEST 2011

3508 dasd I/O requests
with 67616 sectors(512B each)
0 requests used a PAV alias device
3458 requests used HPF
 <4 8 16 32 64 128 256 512 1k 2k 4k 8k 16k 32k 64k 128k
 256 512 1M 2M 4M 8M 16M 32M 64M 128M 256M 512M 1G 2G 4G >4G
Histogram of sizes (512B secs)
 0 0 2456 603 304 107 18 9 3 8 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O times (microseconds)
 0 0 0 0 0 0 100 1738 813 725 30 39 47 15 1 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time till ssch
 0 0 901 558 765 25 28 288 748 161 17 16 1 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time between ssch and irq
 0 0 0 0 0 0 316 2798 283 13 19 22 41 15 1 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time between irq and end
 0 3023 460 8 4 9 4 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
of req in chanq at enqueueing (0..31)
 --0 --1 --2 --3 --4 --5 --6 --7 --8 --9 --10 --11 --12 --13 --14 --15
 --16 --17 --18 --19 --20 --21 --22 --23 --24 --25 --26 --27 --28 --29 --30 --31
 0 2295 319 247 647 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

For details about the data items, see [“Interpreting the data rows” on page 134](#).

## dasdview - Display DASD structure

Use the **dasdview** command to display DASD information.

**dasdview** displays:

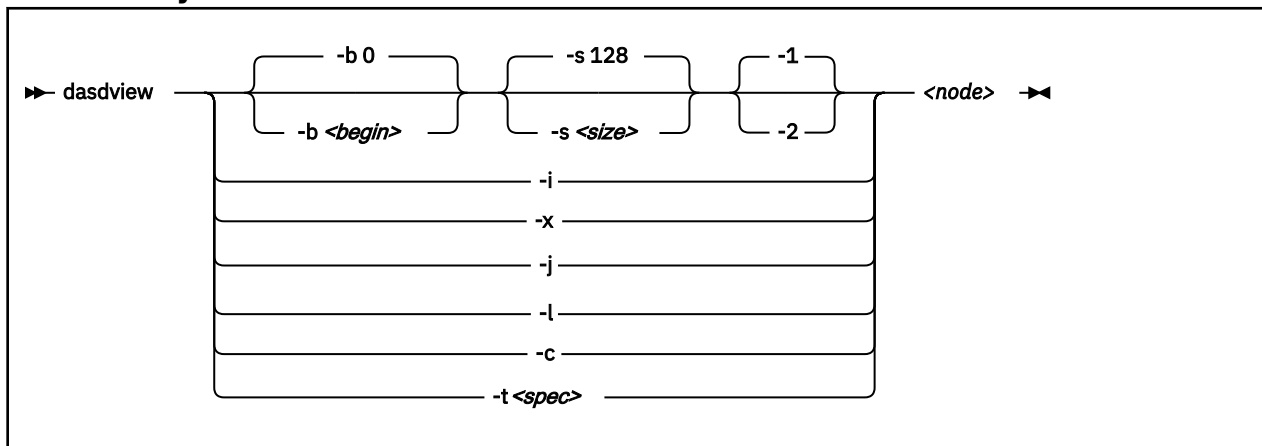
- The volume label.
- VTOC details (general information, and the DSCBs of format 1, format 3, format 4, format 5, format 7, format 8, and format 9).
- The content of the DASD, by specifying:
  - Starting point
  - Size

You can display these values in hexadecimal, EBCDIC, and ASCII format.

- Device characteristics, such as:
  - Whether the data on the DASD is encrypted.
  - Whether the disk is a solid-state device.

If you specify a start point and size, you can also display the contents of a disk dump. For more information about partitioning, see [“The IBM label partitioning scheme”](#) on page 112.

### dasdview syntax



Where:

#### **-b <begin> or --begin=<begin>**

displays disk content on the console, starting from *<begin>*. The contents of the disk are displayed as hexadecimal numbers, ASCII text, and EBCDIC text. If *<size>* is not specified, **dasdview** takes the default size (128 bytes). You can specify the variable *<begin>* as:

```
<begin>[k|m|b|t|c]
```

If the disk is in raw-track access mode, you can specify only track (t) or cylinder (c) entities.

The default for *<begin>* is 0.

**dasdview** displays a disk dump on the console by using the DASD driver. The DASD driver might suppress parts of the disk, or add information that is not relevant. Such discrepancies might occur, for example, when **dasdview** displays the first two tracks of a disk that was formatted with the compatible disk layout option (-d cd1. In this situation, the DASD driver pads shorter blocks with zeros to maintain a constant blocksize. All Linux applications (including **dasdview**) process according to this rule.

Here are some examples of how this option can be used:

```
-b 32 (start printing at Byte 32)
-b 32k (start printing at kByte 32)
-b 32m (start printing at MByte 32)
-b 32b (start printing at block 32)
-b 32t (start printing at track 32)
-b 32c (start printing at cylinder 32)
```

**-s <size> or --size=<size>**

displays a disk dump on the console, starting at *<begin>*, and continuing for *size=<size>*. The contents of the dump are displayed as hexadecimal numbers, ASCII text, and EBCDIC text. If a start value, *<begin>*, is not specified, **dasdview** takes the default. You can specify the variable *<size>* as:

```
size[k|m|b|t|c]
```

If the disk is in raw-track access mode, you can specify only track (t) or cylinder (c) entities.

The default for *<size>* is 128 bytes. Here are some examples of how this option can be used:

```
-s 16 (use a 16 Byte size)
-s 16k (use a 16 kByte size)
-s 16m (use a 16 MByte size)
-s 16b (use a 16 block size)
-s 16t (use a 16 track size)
-s 16c (use a 16 cylinder size)
```

**-1**

displays the disk dump with format 1 (as 16 Bytes per line in hexadecimal, ASCII and EBCDIC). A line number is not displayed. You can use option **-1** only together with **-b** or **-s**.

Option **-1** is the default.

**-2**

displays the disk dump with format 2 (as 8 Bytes per line in hexadecimal, ASCII and EBCDIC). A decimal and hexadecimal byte count are also displayed. You can use option **-2** only together with **-b** or **-s**.

**-i or --info**

displays basic information such as device node, device bus-ID, device type, or geometry data.

**-x or --extended**

displays the information that is obtained by using **-i** option, but also open count, subchannel identifier, and so on.

**-j or --volser**

displays volume serial number (volume identifier).

**-l or --label**

displays the volume label.

The **-l** option displays all known label fields. The fields that are shown depend on the label, which is identified by the 'volume label identifier'. The most important differences are:

**volume label key**

is only valid for 'VOL1' labels (used for ECKD compatible disk layout format)

**VTOC pointer**

is only valid for 'VOL1' labels

**ldl\_version**

is only valid for 'LNX1' labels (used for ECKD Linux disk layout format)

**formatted\_blocks**

is only valid for 'LNX1' labels and when the (EBCDIC) `ldl_version` field is 2 or higher

**-c or --characteristics**

displays model-dependent device characteristics, for example disk encryption status or whether the disk is a solid-state device.

**-t <spec> or --vtoc=<spec>**

displays the VTOC's table-of-contents, or a single VTOC entry, on the console. The variable <spec> can take these values:

**info**

displays overview information about the VTOC, such as a list of the data set names and their sizes.

**f1**

displays the contents of all *format 1* data set control blocks (DSCBs).

**f3**

displays the contents of all (z/OS-specific) *format 3* DSCBs.

**f4**

displays the contents of all *format 4* DSCBs.

**f5**

displays the contents of all *format 5* DSCBs.

**f7**

displays the contents of all *format 7* DSCBs.

**f8**

displays the contents of all *format 8* DSCBs.

**f9**

displays the contents of all *format 9* DSCBs.

**all**

displays the contents of *all* DSCBs.

**<node>**

specifies the device node of the device for which you want to display information, for example, /dev/dasdzzz. See [“DASD naming scheme”](#) on page 116 for more details about device nodes).

**-h or --help**

displays short usage text on console. To view the man page, enter **man dasdview**.

**-v or --version**

displays version number on console, and exit.

**Examples**

- To display basic information about a DASD:

```
dasdview -i /dev/dasdzzz
```

This example displays:

```
--- general DASD information -----
device node : /dev/dasdzzz
busid : 0.0.0193
type : ECKD
device type : hex 3390 dec 13200

--- DASD geometry -----
number of cylinders : hex 64 dec 100
tracks per cylinder : hex f dec 15
blocks per track : hex c dec 12
blocksize : hex 1000 dec 4096
#
```

- To display device characteristics:

```
dasdview -c /dev/dasda
```

This example displays:

```
encrypted disk : no
solid state device : no
```

- To include extended information:

```
dasdview -x /dev/dasdzzz
```

This example displays:

```
--- general DASD information -----
device node : /dev/dasdzzz
busid : 0.0.0193
type : ECKD
device type : hex 3390 dec 13200

--- DASD geometry -----
number of cylinders : hex 64 dec 100
tracks per cylinder : hex f dec 15
blocks per track : hex c dec 12
blocksize : hex 1000 dec 4096

--- extended DASD information -----
real device number : hex 452bc08 dec 72530952
subchannel identifier : hex e dec 14
CU type (SenseID) : hex 3990 dec 14736
CU model (SenseID) : hex e9 dec 233
device type (SenseID) : hex 3390 dec 13200
device model (SenseID) : hex a dec 10
open count : hex 1 dec 1
req_queue_len : hex 0 dec 0
chanq_len : hex 0 dec 0
status : hex 5 dec 5
label_block : hex 2 dec 2
FBA_layout : hex 0 dec 0
characteristics_size : hex 40 dec 64
confdata_size : hex 100 dec 256

characteristics : 3990e933 900a5f80 dff72024 0064000f
 e000e5a2 05940222 13090674 00000000
 00000000 00000000 24241502 dfee0001
 0677080f 007f4a00 1b350000 00000000

configuration_data : dc010100 4040f2f1 f0f54040 40c9c2d4
 f1f3f0f0 f0f0f0f0 f0c6c3f1 f1f30509
 dc000000 4040f2f1 f0f54040 40c9c2d4
 f1f3f0f0 f0f0f0f0 f0c6c3f1 f1f30500
 d4020000 4040f2f1 f0f5c5f2 f0c9c2d4
 f1f3f0f0 f0f0f0f0 f0c6c3f1 f1f3050a
 f0000001 4040f2f1 f0f54040 40c9c2d4
 f1f3f0f0 f0f0f0f0 f0c6c3f1 f1f30500
 00000000 00000000 00000000 00000000
 00000000 00000000 00000000 00000000
 00000000 00000000 00000000 00000000
 00000000 00000000 00000000 00000000
 00000000 00000000 00000000 00000000
 00000000 00000000 00000000 00000000
 800000a1 00001e00 51400009 0909a188
 0140c009 7cb7efb7 00000000 00000800

#
```

- To display volume label information for a disk formatted with the compatible disk layout:

```
dasdview -l /dev/dasdzzz
```

This example displays:

```

--- volume label -----
volume label key : ascii 'ã00ñ'
 : ebcdic 'VOL1'
 : hex e5d6d3f1

volume label identifier : ascii 'ã00ñ'
 : ebcdic 'VOL1'
 : hex e5d6d3f1

volume identifier : ascii 'ðçðñùó'
 : ebcdic '0X0193'
 : hex f0e7f0f1f9f3

security byte : hex 40

VTOC pointer : hex 0000000101
 (cyl 0, trk 1, blk 1)

reserved : ascii '@@@@'
 : ebcdic ' '
 : hex 4040404040

CI size for FBA : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

blocks per CI (FBA) : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

labels per CI (FBA) : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

reserved : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

owner code for VTOC : ascii '@@@@@@@@@@@@@'
 : ebcdic ' '
 : hex 40404040 40404040 40404040 4040

reserved : ascii '@@@@@@@@@@@@@@@@@@@@@@@@@@@@@'
 : ebcdic ' '
 : hex 40404040 40404040 40404040 40404040
 40404040 40404040 40404040

ldl_version : ascii '@'
 : ebcdic ' '
 : hex 40

formatted_blocks : dec 16565899579919558117
 : hex e5e5e5e5e5e5e5e5#

```

- To display volume label information for a disk formatted with theLinux disk layout:

```

--- volume label -----
volume label key : ascii ' '
 : ebcdic ' '
 : hex 00000000

volume label identifier : ascii 'ÓÛçñ'
 : ebcdic 'LNX1'
 : hex d3d5e7f1

volume identifier : ascii 'ðçðñùó'
 : ebcdic '0X0193'
 : hex f0e7f0f1f9f3

security byte : hex 40

VTOC pointer
reserved : hex 4040404040
 : ascii '@@@@'
 : ebcdic ' '
 : hex 4040404040

CI size for FBA : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

blocks per CI (FBA) : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

labels per CI (FBA) : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

reserved : ascii '@@@@'
 : ebcdic ' '
 : hex 40404040

owner code for VTOC : ascii '@@@@@@@@@@@@@@'
 : ebcdic ' '
 : hex 40404040 40404040 40404040 4040

reserved : ascii '@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@'
 : ebcdic ' '
 : hex 40404040 40404040 40404040 40404040
 : hex 40404040 40404040 40404040

ldl_version : ascii 'ò'
 : ebcdic '2'
 : hex f2

formatted_blocks : dec 18000
 : hex 0000000000004650

```

- To display partition information:

```
dasdview -t info /dev/dasdzzz
```

This example displays:





```
dasdview -b 2b -s 128 /dev/dasdzzz
```

This example displays:

| HEXADECIMAL |          |          |          | EBCDIC            | ASCII             |
|-------------|----------|----------|----------|-------------------|-------------------|
| 01...04     | 05...08  | 09...12  | 13...16  | 1.....16          | 1.....16          |
| E5D6D3F1    | E5D6D3F1 | F0E7F0F1 | F9F34000 | VOL1VOL10X0193?.  | ?????????????@.   |
| 00000101    | 40404040 | 40404040 | 40404040 | .....             | .....             |
| 40404040    | 40404040 | 40404040 | 40404040 | ????????????????? | @@@@@@@@@@@@@@@@@ |
| 40404040    | 40404040 | 40404040 | 40404040 | ????????????????? | @@@@@@@@@@@@@@@@@ |
| 40404040    | 40404040 | 40404040 | 40404040 | ????????????????? | @@@@@@@@@@@@@@@@@ |
| 40404040    | 88001000 | 10000000 | 00808000 | ?????h.....       | @@@@?.....        |
| 00000000    | 00000000 | 00010000 | 00000200 | .....             | .....             |
| 21000500    | 00000000 | 00000000 | 00000000 | ?.....            | !.....            |

- To display the contents of a disk on the console starting at block 14 (first FMT1 DSCB) with format 2:

```
dasdview -b 14b -s 128 -2 /dev/dasdzzz
```

This example displays:

| BYTE<br>DECIMAL | BYTE<br>HEXADECIMAL | HEXADECIMAL |          |           |           | EBCDIC | ASCII |   |   |          |          |
|-----------------|---------------------|-------------|----------|-----------|-----------|--------|-------|---|---|----------|----------|
|                 |                     | 1           | 2        | 3         | 4         | 5      | 6     | 7 | 8 | 12345678 | 12345678 |
| 57344           | E000                | D3C9D5E4    | E74BE5F0 | LINUX.V0  | ?????K??  |        |       |   |   |          |          |
| 57352           | E008                | E7F0F1F9    | F34BD7C1 | X0193.PA  | ?????K??  |        |       |   |   |          |          |
| 57360           | E010                | D9E3F0F0    | F0F14BD5 | RT0001.N  | ?????K?   |        |       |   |   |          |          |
| 57368           | E018                | C1E3C9E5    | C5404040 | ATIVE???  | ?????@@@  |        |       |   |   |          |          |
| 57376           | E020                | 40404040    | 40404040 | ????????? | @@@@@@@@@ |        |       |   |   |          |          |
| 57384           | E028                | 40404040    | F1F0E7F0 | ????10X0  | @@@@????? |        |       |   |   |          |          |
| 57392           | E030                | F1F9F300    | 0165013D | 193.????  | ???.?e?=  |        |       |   |   |          |          |
| 57400           | E038                | 63016D01    | 0000C9C2 | ??.?.IB   | c?m?...?? |        |       |   |   |          |          |
| 57408           | E040                | D440D3C9    | D5E4E740 | M?LINUX?  | ?@?????@  |        |       |   |   |          |          |
| 57416           | E048                | 40404065    | 013D0000 | ??????.   | @@@e?=-.  |        |       |   |   |          |          |
| 57424           | E050                | 00000000    | 88001000 | ...h.?    | ...?.?.   |        |       |   |   |          |          |
| 57432           | E058                | 10000000    | 00808000 | ?...??.   | ?...??.   |        |       |   |   |          |          |
| 57440           | E060                | 00000000    | 00000000 | .....     | .....     |        |       |   |   |          |          |
| 57448           | E068                | 00010000    | 00000200 | .?....?.  | ?.....?   |        |       |   |   |          |          |
| 57456           | E070                | 21000500    | 00000000 | ?..?....  | !..?....  |        |       |   |   |          |          |
| 57464           | E078                | 00000000    | 00000000 | .....     | .....     |        |       |   |   |          |          |

- To see what is at block 1234 (in this example there is nothing there):

```
dasdview -b 1234b -s 128 /dev/dasdzzz
```

This example displays:

| HEXADECIMAL |          |          |          | EBCDIC   | ASCII    |
|-------------|----------|----------|----------|----------|----------|
| 01...04     | 05...08  | 09...12  | 13...16  | 1.....16 | 1.....16 |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |
| 00000000    | 00000000 | 00000000 | 00000000 | .....    | .....    |

- To try byte 0 instead:

```
dasdview -b 0 -s 64 /dev/dasdzzz
```

This example displays:

```
-----+-----+-----+
| HEXADECIMAL | EBCDIC | ASCII |
| 01....04 05....08 09....12 13....16 | 1.....16 | 1.....16 |
|-----+-----+-----+
C9D7D3F1 000A0000 0000000F 03000000	IPL1.....	????.
00000001 00000000 00000000 40404040	??????????????	?????????????
40404040 40404040 40404040 40404040	??????????????	@@@@@@@@@@@@@@
40404040 40404040 40404040 40404040	??????????????	@@@@@@@@@@@@@@
-----+-----+-----+		
#
```

- To display the contents of a disk on the console starting at cylinder 2 and printing one track of data:

```
dasdview -b 2c -s 1t /dev/dasdk
```

This example displays:

```
-----+-----+-----+
| HEXADECIMAL | EBCDIC | ASCII |
| 01....04 05....08 09....12 13....16 | 1.....16 | 1.....16 |
|-----+-----+-----+
| 52B7DBEE D6B9530B 0179F420 CB6EA95E | ???0????4??>z; | R????S??y???n?^ |
| EF49C03C 513542E7 D8F17D9D 06DC44F7 | ??{????XQ1'????? | ?I?<Q5B??}????D? |
|
| 92963D5B 0200B0FA 53745C12 C3B45125 | ko?$. | ??=[?..... |
| 0D6040C2 F933381E 7A4C4797 F40FEDAB | ?-?B9????:<?p4??? | ??@??38?zLG????? |
|
| ...
|-----+-----+-----+
#
```

- To display the full record information of the same disk when it in raw-track access mode:

```
dasdview -b 2c -s 1t /dev/dasdk
```

This example displays:

```

cylinder 2, head 0, record 0
+-----+
| count area:
| hex: 0002000000000008
| cylinder: 2
| head: 0
| record: 0
| key length: 0
| data length: 8
+-----+
| key area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
+-----+
| data area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
| 00000000 00000000 | |
+-----+

cylinder 2, head 0, record 1
+-----+
| count area:
| hex: 0002000001000200
| cylinder: 2
| head: 0
| record: 1
| key length: 0
| data length: 512
+-----+
| key area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
+-----+
| data area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
| 52B7DBEE D6B9530B 0179F420 CB6EA95E | ???0????4??>z; | R????S?y???n?^
| EF49C03C 513542E7 D8F17D9D 06DC44F7 | ??{????XQ1'????? | ?I?<Q5B?????D?
| ...
+-----+

cylinder 2, head 0, record 2
+-----+
| count area:
| hex: 0002000002000200
| cylinder: 2
| head: 0
| record: 2
| key length: 0
| data length: 512
+-----+
| key area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
+-----+
| data area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
| 92963D5B 0200B0FA 53745C12 C3B45125 | ko?$?.^???*?C??? | ??=[?.??St\???Q%
| 0D6040C2 F933381E 7A4C4797 F40FEDAB | ?-?B9????:<?p4??? | ??@??38?zLG?????
| ...
+-----+

```

- To display the contents of a disk, which is in raw-access mode, printing one track of data from the start of the disk:

```
dasdview -s 1t /dev/dasdk
```

This example displays:

```

cylinder 0, head 0, record 0
+-----+
| count area:
| hex: 0000000000000008
| cylinder: 0
| head: 0
| record: 0
| key length: 0
| data length: 8
+-----+
| key area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
+-----+
| data area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
| 00000000 00000000 | | |
+-----+

cylinder 0, head 0, record 1
+-----+
| count area:
| hex: 0000000001040018
| cylinder: 0
| head: 0
| record: 1
| key length: 4
| data length: 24
+-----+
| key area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
| C9D7D3F1 | IPL1..... | ????. |
+-----+
| data area:
| HEXADECIMAL
| 01....04 05....08 09....12 13....16 | EBCDIC
| 1.....16 | ASCII
| 1.....16 |
| 000A0000 0000000F 03000000 00000001 | .?.?.?.?.?.? | .?.?.?.?.?.? |
| 00000000 00000000 | | |
+-----+
...

```

## fdasd - Partition a DASD

Use the **fdasd** command to manage partitions on ECKD-type DASD that were formatted with the compatible disk layout.

See “[dasdfmt - Format a DASD](#)” on page 556 for information about formatting a DASD. With **fdasd** you can create, change, and delete partitions, and also change the volume serial number.

**fdasd** checks that the volume has a valid volume label and VTOC. If either is missing or incorrect, **fdasd** re-creates it. See “[IBM Z compatible disk layout](#)” on page 113 for details about the volume label and VTOC.

Calling **fdasd** with a node, but without options, enters interactive mode. In interactive mode, you are given a menu through which you can display DASD information, add or remove partitions, or change the volume identifier. Your changes are not written to disk until you type the `write` option on the menu. You can quit without altering the disk at any time before this.

For more information about partitions, see “[The IBM label partitioning scheme](#)” on page 112.

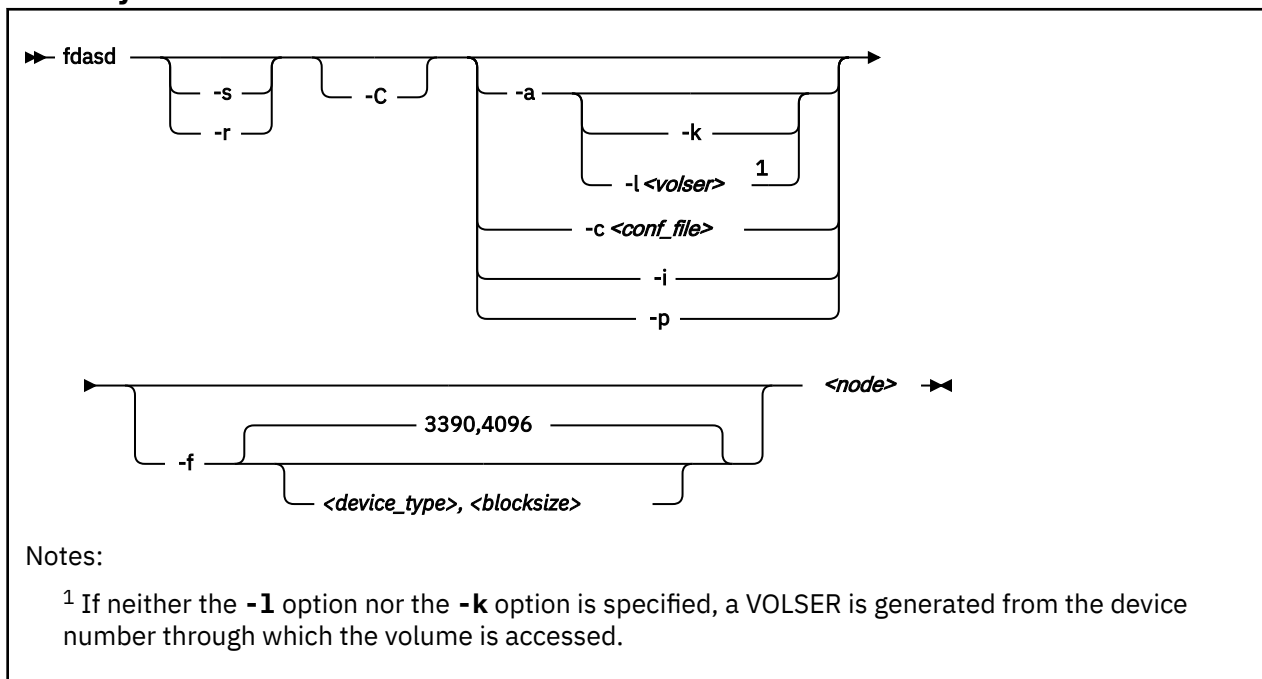
### Before you begin:

- To partition a SCSI disk, use **fdisk** rather than **fdasd**.
- The disk must be formatted with **dasdfmt**, using the compatible disk layout.



**Attention:** Careless use of **fdasd** can result in loss of data.

### fdasd syntax



Where:

#### **-s or --silent**

suppresses messages.

#### **-r or --verbose**

displays additional messages that are normally suppressed.

#### **-a or --auto**

auto-creates one partition using the whole disk in non-interactive mode.

**-k or --keep\_volser**

keeps the volume serial number when writing the volume label (see [VOLSER](#)). Keeping the serial number is useful, for example, if the volume serial number was written with a z/VM tool and should not be overwritten.

**-l <volser> or --label <volser>**

specifies the volume serial number (see [VOLSER](#)).

A volume serial consists of one through six alphanumeric characters or the following special characters:

\$ # @ %

All other characters are ignored. Avoid using special characters in the volume serial. Special characters can cause problems when accessing a disk by VOLSER. If you must use special characters, enclose the VOLSER in single quotation marks. In addition, any '\$' character in the VOLSER must be preceded by a backslash ('\').

For example, specify:

```
-l 'a@b\${c#'
```

to get:

```
A@B$C#
```

VOLSER is interpreted as an ASCII string and is automatically converted to uppercase, padded with blanks and finally converted to EBCDIC before it is written to disk.

Do not use the following reserved volume serials:

- SCRTCH
- PRIVAT
- MIGRAT
- Lnnnnn (L followed by a five-digit number)

These volume serials are used as keywords by other IBM Z operating systems, such as z/OS.

Omitting this parameter causes **fdasd** to prompt for it, if it is needed.

**-c <conf\_file> or --config <conf\_file>**

creates partitions, in non-interactive mode, according to specifications in the configuration file *<conf\_file>*.

For each partition you want to create, add one line of the following format to *<conf\_file>*:

```
[<first_track>,<last_track>,<type>]
```

*<first\_track>* and *<last\_track>* are required and specify the first and last track of the partition. You can use the keyword `first` for the first possible track on the disk and the keyword `last` for the last possible track on the disk.

*<type>* describes the partition type and is one of:

**native**

for partitions to be used for Linux file systems.

**gpfs**

for partitions to be used as part of an Elastic Storage file system setup.

**swap**

for partitions to be used as swap devices.

**raid**

for partitions to be used as part of a RAID setup.

**lvm**

for partitions to be used as part of a logical volume group.

The type specification is optional. If the type is omitted, `native` is used.

The type describes the intended use of a partition to tools or other operating systems. For example, swap partitions could be skipped by backup programs. How Linux actually uses the partition depends on how the partition is formatted and set up. For example, a partition of type `native` can still be used in an LVM logical volume or in a RAID configuration.

**Example:** With the following sample configuration file, you can create three partitions:

```
[first,1000,raid]
[1001,2000,swap]
[2001,last]
```

**-i or --volser**

displays the volume serial number and exits.

**-p or --table**

displays the partition table and exits.

**-f or --force**

specifies values for the disk geometry instead of detecting them.

**Note:** Specifying incorrect values can render the disk unusable. Do not use this option if **fdasd** can automatically detect the disk geometry. For example, do not use the force option for native DASD or any disk with the disk geometry of a type 3390 DASD.

**<device\_type>, <blocksize>**

specifies the disk device type. Valid device types are: 3390, 3380, and 9345. Valid block sizes are: 4096, 2048, 1024, and 512. The default specification is the combination of disk type 3390 with block size 4096.

For disks with the default geometry, you can omit the specifications for the device type and block size, and the following specifications are all valid:

- **-f**
- **-f3390,4096**
- **--force**
- **--force=3390,4096**

For all other disks, you must specify both values with the command. The following specifications are all valid for a disk of type 3390 and block size 512:

- **-f3390,512**
- **--force=3390,512**

Use the verbose option for information about the disk geometry as computed from the specified or default device type and block size.

**<node>**

specifies the device node of the DASD you want to partition, for example, `/dev/dasdzzz`. See [“DASD naming scheme” on page 116](#) for more details about device nodes.

**-C or --check\_host\_count**

checks the host-access open count to ensure that the device is not online to another operating system instance. The operation is canceled if another operating system instance is accessing the device.

**-h or --help**

displays help on command-line arguments. To view the man page, enter **man fdasd**.

**-v or --version**

displays the version of **fdasd**.



## fdasd menu

If you call **fdasd** in the interactive mode (that is, with just a node), a menu is displayed.

```
Command action
m print this menu
p print the partition table
n add a new partition
d delete a partition
v change volume serial
t change partition type
r re-create VTOC and delete all partitions
u re-create VTOC re-using existing partition sizes
s show mapping (partition number - data set name)
q quit without saving changes
w write table to disk and exit
```

Command (m for help):

## fdasd menu commands

Use the **fdasd** menu commands to modify or view information about DASDs

### m

re-displays the **fdasd** command menu.

### p

displays information about the DASD and the partitions.

#### DASD information:

- Number of cylinders
- Number of tracks per cylinder
- Number of blocks per track
- Block size
- Volume label
- Volume identifier
- Number of partitions defined

#### Partition information:

- Linux node
- Start track
- End track
- Number of tracks
- Partition ID
- Partition type

There is also information about the free disk space that is not used for a partition.

### n

adds a partition to the DASD. You are asked to give the start track and the length or end track of the new partition.

### d

deletes a partition from the DASD. You are asked which partition to delete.

### v

changes the volume identifier. You are asked to enter a new volume identifier. See [VOLSER](#) for the format.

## fdasd

**t**

changes the partition type. You are prompted for the partition to be changed and for the new partition type.

Changing the type changes the disk description but does not change the disk itself. How Linux uses the partition depends on how the partition is formatted and set up. For example, as an LVM logical volume or in a RAID configuration.

The partition type describes the partition to other operating systems so that; for example, swap partitions can be skipped by backup programs.

**r**

re-creates the VTOC and deletes all partitions.

**u**

re-creates all VTOC labels without removing all partitions. Existing partition sizes are reused. This option is useful to repair damaged labels or migrate partitions that are created with older versions of **fdasd**.

**s**

displays the mapping of partition numbers to data set names. For example:

```
Command (m for help): s
device: /dev/dasdzzz
volume label ...: VOL1
volume serial ..: 0X0193

WARNING: This mapping may be NOT up-to-date,
 if you have NOT saved your last changes!

/dev/dasdzzz1 - LINUX.V0X0193.PART0001.NATIVE
/dev/dasdzzz2 - LINUX.V0X0193.PART0002.NATIVE
/dev/dasdzzz3 - LINUX.V0X0193.PART0003.NATIVE
```

**q**

quits **fdasd** without updating the disk. Any changes that you have made (in this session) are discarded.

**w**

writes your changes to disk and exits. After the data is written, Linux rereads the partition table.

## Example using the menu

This example shows how to use **fdasd** to create two partitions on a z/VM minidisk, change the type of one of the partitions, save the changes, and check the results.

### About this task

This example shows you how to format a z/VM minidisk with the compatible disk layout. The minidisk has device number 193.

### Procedure

1. Call **fdasd**, specifying the minidisk:

```
fdasd /dev/dasdzzz
```

**fdasd** reads the existing data and displays the menu:

```

reading volume label: VOL1
reading vtoc : ok

Command action
 m print this menu
 p print the partition table
 n add a new partition
 d delete a partition
 v change volume serial
 t change partition type
 r re-create VTOC and delete all partitions
 u re-create VTOC re-using existing partition sizes
 s show mapping (partition number - data set name)
 q quit without saving changes
 w write table to disk and exit
Command (m for help):

```

2. Use the p option to verify that no partitions are created yet on this DASD:

```

Command (m for help): p

Disk /dev/dasdzzz:
 cylinders: 100
 tracks per cylinder ..: 15
 blocks per track: 12
 bytes per block: 4096
 volume label: VOL1
 volume serial: 0X0193
 max partitions: 3

----- tracks -----
 Device start end length Id System
 2 1499 1498 unused

```

3. Define two partitions, one by specifying an end track and the other by specifying a length.
 

(In both cases the default start tracks are used):

```

Command (m for help): n
First track (1 track = 48 KByte) ([2]-1499):
Using default value 2
Last track or +size[c|k|M] (2-[1499]): 700
You have selected track 700

```

```

Command (m for help): n
First track (1 track = 48 KByte) ([701]-1499):
Using default value 701
Last track or +size[c|k|M] (701-[1499]): +400
You have selected track 1100

```

4. Check the results by using the p option:

```

Command (m for help): p

Disk /dev/dasdzzz:
 cylinders: 100
 tracks per cylinder ..: 15
 blocks per track: 12
 bytes per block: 4096
 volume label: VOL1
 volume serial: 0X0193
 max partitions: 3

----- tracks -----
 Device start end length Id System
 /dev/dasdzzz1 2 700 699 1 Linux native
 /dev/dasdzzz2 701 1100 400 2 Linux native
 1101 1499 399 unused

```

5. Change the type of a partition:

```

Command (m for help): t

Disk /dev/dasdzzz:
 cylinders: 100
 tracks per cylinder ..: 15
 blocks per track: 12
 bytes per block: 4096
 volume label: VOL1
 volume serial: 0X0193
 max partitions: 3

----- tracks -----
 Device start end length Id System
 /dev/dasdzzz1 2 700 699 1 Linux native
 /dev/dasdzzz2 701 1100 400 2 Linux native
 1101 1499 399 unused

change partition type
partition id (use 0 to exit):

```

Enter the ID of the partition you want to change; in this example partition 2:

```
partition id (use 0 to exit): 2
```

6. Enter the new partition type; in this example type 2 for swap:

```

current partition type is: Linux native

 1 Linux native
 2 Linux swap
 3 Linux raid
 4 Linux lvm

new partition type: 2

```

7. Check the result:

```

Command (m for help): p

Disk /dev/dasdzzz:
 cylinders: 100
 tracks per cylinder ..: 15
 blocks per track: 12
 bytes per block: 4096
 volume label: VOL1
 volume serial: 0X0193
 max partitions: 3

----- tracks -----
 Device start end length Id System
 /dev/dasdzzz1 2 700 699 1 Linux native
 /dev/dasdzzz2 701 1100 400 2 Linux swap
 1101 1499 399 unused

```

8. Write the results to disk with the w option:

```

Command (m for help): w
writing VTOC...
rereading partition table...
#

```

## Example using options

You can partition a DASD by using the **-a** or **-c** option without entering the menu mode.

This method is useful for partitioning with scripts, for example, if you need to partition several hundred DASDs.

With the **-a** parameter you can create one large partition on a DASD:

```
fdasd -a /dev/dasdzzz
auto-creating one partition for the whole disk...
writing volume label...
writing VTOC...
rereading partition table...
#
```

This command creates a partition as follows:

| Device        | start | end  | length | Id | System       |
|---------------|-------|------|--------|----|--------------|
| /dev/dasdzzz1 | 2     | 1499 | 1498   | 1  | Linux native |

Using a configuration file, you can create several partitions. For example, the following configuration file, `config`, creates three partitions:

```
[first,500]
[501,1100,swap]
[1101,last]
```

Submitting the command with the `-c` option creates the partitions:

```
fdasd -c config /dev/dasdzzz
parsing config file 'config'...
writing volume label...
writing VTOC...
rereading partition table...
#
```

This command creates partitions as follows:

| Device        | start | end  | length | Id | System       |
|---------------|-------|------|--------|----|--------------|
| /dev/dasdzzz1 | 2     | 500  | 499    | 1  | Linux native |
| /dev/dasdzzz2 | 501   | 1100 | 600    | 2  | Linux swap   |
| /dev/dasdzzz3 | 1101  | 1499 | 399    | 3  | Linux native |

## hmcdrvfs - Mount a FUSE file system for remote access to media in the HMC media drive

Use the **hmcdrvfs** command for read-only access to contents in a DVD, CD, or USB-attached storage in the media drive of an HMC.

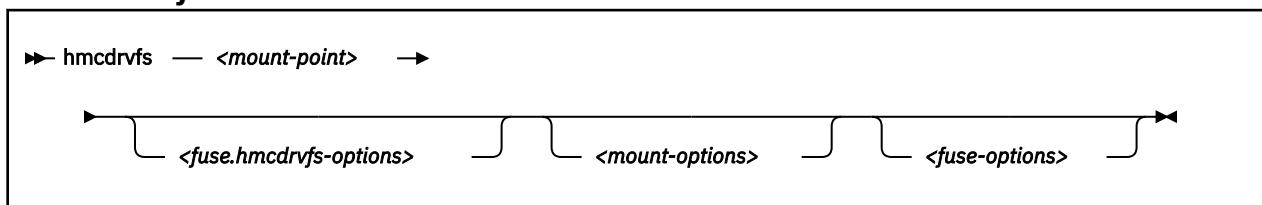
### Before you begin:

- The fuse.hmcdrvfs file system needs access to device node `/dev/hmcdrv`. This node is created automatically when the hmcdrv kernel module is loaded, see [Chapter 29, “HMC media device driver,”](#) on page 341.
- On the HMC, the media must be assigned to the associated system image (use menu Access Removable Media).
- In a z/VM environment, the z/VM guest virtual machine must have at least privilege class B. The media must be assigned to the LPAR where the z/VM hypervisor runs.
- For Linux in LPAR mode, the LPAR activation profile must allow issuing SCLP requests.

With the media assigned to your Linux instance, this command creates a `fuse.hmcdrvfs` file system with the media content at the specified mount point.

To unmount file systems that you mounted with **hmcdrvfs**, you can use **umount**.

### hmcdrvfs syntax



Where:

#### **-o or --opt**

FUSE or mount command options; for the FUSE options see the following lists, for mount options see the **mount** man page.

#### **<fuse.hmcdrvfs-options>**

options specific to the `fuse.hmcdrvfs` file system:

##### **-o hmclang=<language>**

specifies the language setting on the HMC; for valid values, see the **locale** man page.

##### **-o hmctz=<time zone>**

specifies the time zone setting on the HMC; for valid values, see the **tzset** man page.

#### **<mount-options>**

options as available for the **mount** command. See the **mount** man page for details.

#### **<fuse-options>**

options for FUSE. The following options are supported by the **cmsfs-fuse** command. To use an option, it must also be supported by the version of FUSE that you have.

##### **-d or -o debug**

enables debug output (implies **-f**).

##### **-f**

runs the command as a foreground operation.

##### **-s**

disables multi-threaded operation.

- o allow\_other**  
allows access to the file system by other users.
- o allow\_root**  
allows access to the file system by root.
- o nonempty**  
allows mounts over files and non-empty directories.
- o default\_permissions**  
enables permission checking by the kernel.
- o fsname=<name>**  
sets the file system name.
- o subtype=<type>**  
sets the file system type.
- o max\_read=<n>**  
sets maximum size of read requests.
- o direct\_io**  
uses direct I/O.
- o kernel\_cache**  
caches files in the kernel.
- o [no]auto\_cache**  
enables or disables caching based on modification times.
- o umask=<mask>**  
sets file permissions (octal).
- o uid=<n>**  
sets the file owner.
- o gid=<n>**  
sets the file group.
- o entry\_timeout=<secs>**  
sets the cache timeout for names. The default is 1.0 second.
- o attr\_timeout=<secs>**  
sets the cache timeout for attributes. The default is 1.0 second.
- o ac\_attr\_timeout=<secs>**  
sets the auto cache timeout for attributes. The default is the attr\_timeout value.
- o max\_readahead=<n>**  
sets the maximum read ahead value.
- o async\_read**  
performs reads asynchronously (default).
- o sync\_read**  
performs reads synchronously.
- o no\_remote\_lock**  
disables remote file locking.
- o intr**  
allows requests to be interrupted
- o intr\_signal=<num>**  
specifies the signal to send on interrupt.
- v or --version**  
displays version information for the command.
- h or --help**  
displays a short help text, then exits. To view the man page, enter **man hmcdrvfs**.

The following options for mount policy can be set in the file `/etc/fuse.conf` file:

**mount\_max=<number>**

sets the maximum number of FUSE mounts allowed for non-root users. The default is 1000.

**user\_allow\_other**

allows non-root users to specify the `allow_other` or `allow_root` mount options.

**Examples**

- To mount the contents of the HMC media drive at `/mnt/hmc` without any special options, use:

```
hmcdrvfs /mnt/hmc
```

- If the `hmcdrv` kernel module is not loaded, load it before you issue the **hmcdrvfs** command:

```
modprobe hmcdrv
hmcdrvfs /mnt/hmc
```

- To translate the UID and GID of files on the HMC media drive to your system users and groups along with overriding the permissions, issue, for example:

```
hmcdrvfs /mnt/hmc -o uid=500 -o gid=1000 -o umask=0337
```

- To speed up transfer rates to frequently accessed directories, use the `cache_timeout` option:

```
hmcdrvfs /mnt/hmc -o entry_timeout=60
```

- If the HMC is in a different timezone and is configured for a different language use, for example:

```
hmcdrvfs /mnt/hmc -o hmclang=de_DE -o hmctz=Europe/Berlin
```

- To also disregard any Daylight Saving Time, specifying hours west of the Prime Meridian (Coordinated Universal Time):

```
hmcdrvfs /mnt/hmc -o hmclang=de_DE -o hmctz="GMT-1"
```

- To unmount the HMC media drive contents mounted on `/mnt/hmc`, issue:

```
umount -u /mnt/hmc
```



## hyptop - Display hypervisor performance data

---

Use the **hyptop** command to obtain a dynamic real-time view of a hypervisor environment on IBM Z.

It works with both the z/VM hypervisor and the LPAR hypervisor, Processor Resource/Systems Manager (PR/SM). Depending on the available data, it shows, for example, CPU and memory information about LPARs or z/VM guest virtual machines.

System names provided by hyptop are either LPAR names as shown on the SE or HMC, or z/VM guest IDs that identify z/VM guest virtual machines.

The **hyptop** command provides two main windows:

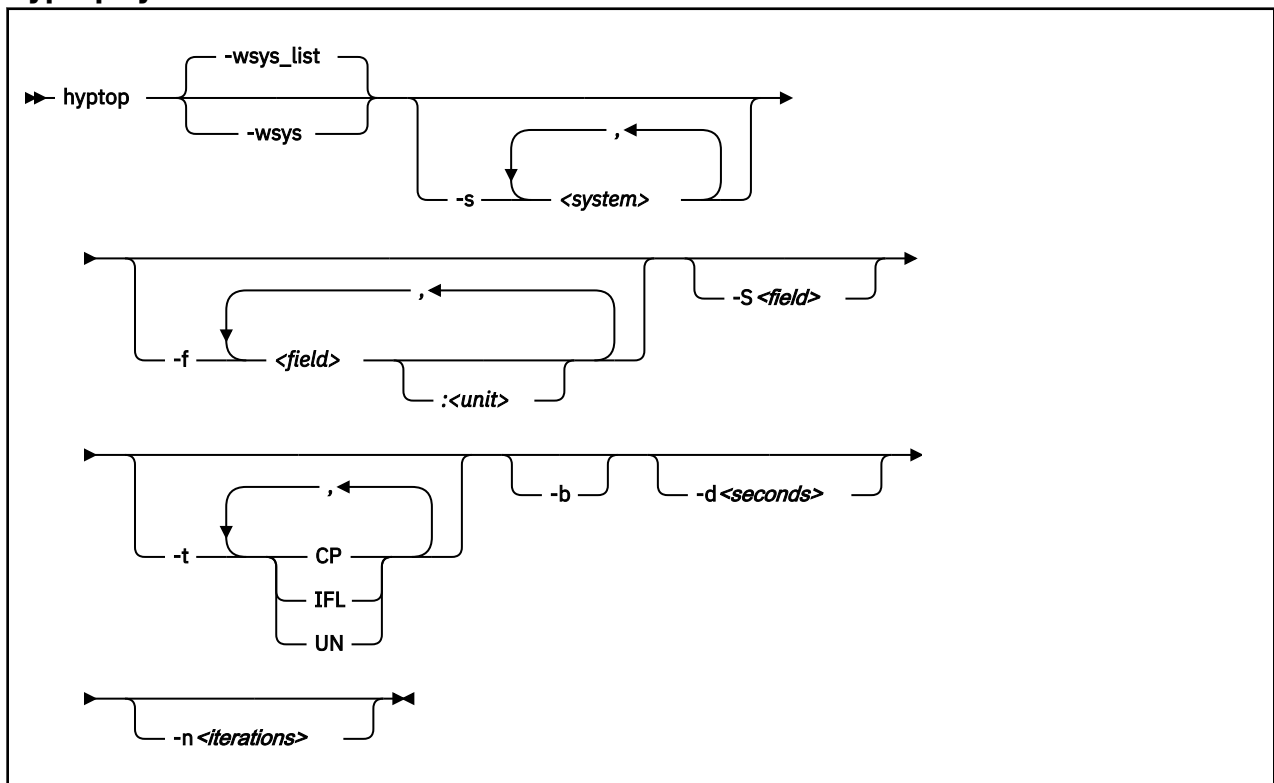
- A list of systems that the hypervisor is currently running (sys\_list).
- One system in more detail (sys).

You can run **hyptop** in interactive mode (default) or in batch mode with the **-b** option.

**Before you begin:** The following things are required to run **hyptop**:

- The debugfs file system must be mounted.
- The Linux kernel must have the required support to provide the performance data. Check that `<debugfs mount point>/s390_hypfs` is available after you mount debugfs.
- The hyptop user must have read permission for the required debugfs files:
  - z/VM: `<debugfs mount point>/s390_hypfs/diag_2fc`
  - z/VM: `<debugfs mount point>/s390_hypfs/diag_0c`  
(Required only for management time data, identifiers m and M. See [“z/VM fields” on page 589](#) )
  - LPAR: `<debugfs mount point>/s390_hypfs/diag_204`
- You can always monitor the guest operating system where **hyptop** is running. To monitor any other operating system instances running on the same hypervisor as **hyptop**, you will need additional permissions:
  - For z/VM: The guest virtual machine must be assigned privilege class B.
  - For LPAR: On the HMC or SE security menu of the LPAR activation profile, select the **Global performance data control** check box.

## hyptop syntax



Where:

**-w <window name> or --window=<window name>**

selects the window to display, either sys or sys\_list. Use the options **--sys**, **--fields**, and **--sort** to modify the current window. The last window that is specified with the **--window** option is used as the start window. The default window is sys\_list.

**-s <system> or --sys=<system>**

selects systems for the current window. If you specify this option, only the selected systems are shown in the window. For the sys window, you can specify only one system. <system> can be an LPAR name as shown on the SE or HMC, or it can be a z/VM guest ID that identifies a z/VM guest virtual machine. Enter **hyptop** without any options to display the names of all available systems.

**-f <field>[:<unit>] or --fields=<field>[:<unit>]**

selects fields and units in the current window. The <field> variable is a one letter unique identifier for a field (for example "c" for CPU time). The <unit> variable specifies the unit that is used for the field (for example "us" for microseconds). See [“Available fields and units”](#) on page 588 for definitions. If the **--fields** option is specified, only the selected fields are shown.

**Note:** If your field specification includes the number sign (#), enclose the specification in double quotation marks. Otherwise, the command shell might interpret the number sign and all characters that follow as a comment.

**-S <field> or --sort=<field>**

selects the field that is used to sort the data in the current window. To reverse the sort order, specify the option twice. See [“Available fields and units”](#) on page 588 for definitions.

**-t <type> or --cpu\_types=<type>**

selects CPU types that are used for dispatch time calculations. See [“CPU types”](#) on page 590 for definitions.

**-b or --batch\_mode**

uses batch mode. Batch mode can be useful for sending output from **hyptop** to another program, a file, or a line mode terminal. In this mode no user input is accepted.

**-d <seconds> or --delay=<seconds>**

specifies the delay between screen updates.

**-n <iterations> or --iterations=<iterations>**

specifies the maximum number of screen updates before the program ends.

**-h or --help**

prints usage information, then exits. To view the man page, enter **man hyptop**.

**-v or --version**

displays the version of **hyptop**, then exits.

## Navigating between windows

Use letter or arrow keys to navigate between the windows.

When you start the **hyptop** command, the `sys_list` window opens in normal mode. Data is updated at regular intervals, and sorted by dispatch time. You can navigate between the windows as shown in [Figure 87](#) on page 587.

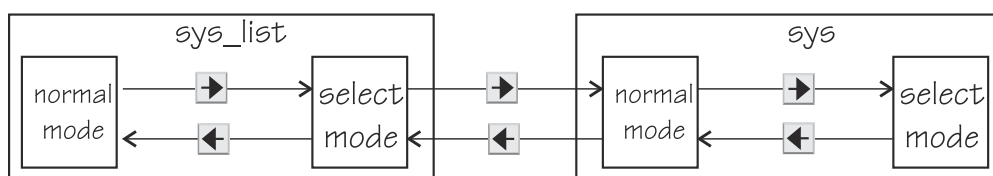


Figure 87. *hyptop* window navigation overview

To navigate between the windows, use the `←` and `→` arrow keys. The windows have two modes, normal mode and select mode.

You can get online help for every window by pressing the `?` key. Press `Q` in the `sys_list` window to exit `hyptop`.

Instead of using the arrow keys, you can use letter keys (equivalent to the vi editor navigation) in all windows as listed in [Table 71](#) on page 587.

| Arrow key      | Letter key equivalent |
|----------------|-----------------------|
| <code>←</code> | <code>H</code>        |
| <code>↓</code> | <code>J</code>        |
| <code>↑</code> | <code>K</code>        |
| <code>→</code> | <code>L</code>        |

## Selecting data

You can scroll windows and select data rows.

To enter select mode, press the `→` key. The display is frozen so that you can select rows. Select rows by pressing the `↑` and `↓` keys and mark the rows with the Spacebar. Marked rows are displayed in bold font. Leave the select mode by pressing the `←` key.

To see the details of one system, enter select mode in the `sys_list` window, then navigate to the row for the system you want to look at, and press the `→` key. The `sys` window for the system opens. The `←` key always returns you to the previous window.

To scroll any window, press the **↑** and **↓** keys or the Page Up and Page Down keys. Jump to the end of a window by pressing the **Shift + G** keys and to the beginning by pressing the **G** key.

## Sorting data

You can sort data according to column.

The sys window or sys\_list window table is sorted according to the values in the selected column. Select a column by pressing the hot key of the column. This key is underlined in the heading. If you press the hot key again, the sort order is reversed. Alternatively, you can select columns with the **<** and **>** keys.

## Filtering data

You can filter the displayed data by CPU types and by data fields.

From the sys or sys\_list window you can access the fields selection window and the CPU-type selection window as shown in [Figure 88 on page 588](#).

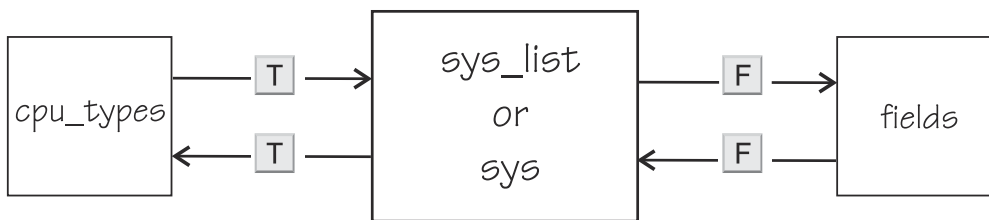


Figure 88. Accessing the fields and CPU-type selection windows

Use the **T** key to toggle between the CPU-type selection window and the main window. Use the **F** key to toggle between the fields selection window and the main window. You can also use the **←** key to return to the main window from the CPU types and fields windows.

In the fields and CPU-type selection windows, press the field or CPU type identifier key (see [“LPAR fields” on page 588](#), [“z/VM fields” on page 589](#), and [“CPU types” on page 590](#)) to select or de-select.

Selected rows are bold and de-selected rows are grey. When you return to the main window, the data is filtered according to your field and CPU type selections.

## Available fields and units

Different fields are supported depending whether your hypervisor is LPAR PR/SM or z/VM.

The fields might also be different depending on machine type, z/VM version, and kernel version. Each field has a unique one letter identifier that can be used in interactive mode to enable the field in the field selection window. Also, use it to select the sort field in the sys or sys\_list window. You can also select fields and sort data using the **--fields** and **--sort** command line options.

### LPAR fields

Some fields for Linux in LPAR mode are available in both the sys\_list and sys windows others are available only in the sys\_list window or only in the sys window.

| Identifier | Column label | Explanation                   |
|------------|--------------|-------------------------------|
| c          | core         | Core dispatch time per second |
| e          | the          | Thread time per second        |
| m          | mgm          | Management time per second    |
| C          | Core+        | Total core dispatch time      |
| E          | thE+         | Total thread time             |

| Identifier | Column label | Explanation           |
|------------|--------------|-----------------------|
| M          | Mgm+         | Total management time |
| o          | online       | Online time           |

If multithreading is not available or not enabled, the values for core and for thread are identical.

In the sys\_list window only:

| Identifier | Column label | Explanation                                     |
|------------|--------------|-------------------------------------------------|
| y          | system       | Name of the LPAR                                |
| #          | #core        | Number of cores (sum of initial and reserved)   |
| T          | #The         | Number of threads (sum of initial and reserved) |

In the sys window only:

| Identifier | Column label | Explanation                                           |
|------------|--------------|-------------------------------------------------------|
| i          | coreid       | Core identifier (always shown)                        |
| p          | type         | CPU type. See <a href="#">“CPU types” on page 590</a> |
| v          | visual       | Visualization of core dispatch time per second        |

## z/VM fields

Some fields for Linux on z/VM are available in both the sys\_list and sys windows. Others are available only in the sys\_list window or only in the sys window.

In the sys\_list and sys windows:

| Identifier | Column label | Explanation                |
|------------|--------------|----------------------------|
| c          | cpu          | CPU time per second        |
| m          | mgm          | Management time per second |
| C          | Cpu+         | Total CPU time             |
| M          | Mgm+         | Total management time      |
| o          | online       | Online time                |

**Note:** Data for the management time, identifiers m and M, is available only for the z/VM guest virtual machine on which **hyptop** runs.

In the sys\_list window only:

| Identifier | Column label | Explanation                                           |
|------------|--------------|-------------------------------------------------------|
| y          | system       | Name of the z/VM guest virtual machine (always shown) |
| #          | #cpu         | Number of CPUs                                        |
| O          | #cpuop       | Number of operating CPUs                              |
| u          | memuse       | Used memory                                           |
| a          | memmax       | Maximum memory                                        |
| r          | wcur         | Current weight                                        |
| x          | wmax         | Maximum weight                                        |

In the sys window only:

| Identifier | Column label | Explanation                          |
|------------|--------------|--------------------------------------|
| i          | cpuid        | CPU identifier (always shown)        |
| v          | visual       | Visualization of CPU time per second |

## Units

Depending on the field type, the values can be displayed in different units.

In the sys\_list and sys windows, the units are displayed under the column headings in parenthesis. Each unit can be specified through the **--fields** command line option. Units can also be selected interactively. To change a unit, enter select mode in the fields window. Then, select the field where you want to change the unit, and press the "+" or "-" keys to go through the available units. The following units are supported:

Units of time:

| Unit | Explanation                                          |
|------|------------------------------------------------------|
| us   | Microseconds ( $10^{-6}$ seconds)                    |
| ms   | Milliseconds ( $10^{-3}$ seconds)                    |
| %    | Hundreds of a second ( $10^{-2}$ seconds) or percent |
| s    | Seconds                                              |
| m    | Minutes                                              |
| hm   | Hours and minutes                                    |
| dhm  | Days, hours, and minutes                             |

Units of memory:

| Unit | Explanation                     |
|------|---------------------------------|
| KiB  | Kibibytes (1 024 bytes)         |
| MiB  | Mebibytes (1 048 576 bytes)     |
| GiB  | Gibibytes (1 073 741 824 bytes) |

Other units:

| Unit | Explanation     |
|------|-----------------|
| str  | String          |
| #    | Count or number |
| vis  | Visualization   |

## CPU types

Enable or disable CPU types in interactive mode in the cpu\_types window.

The CPU types can also be specified with the **--cpu\_types** command line option.

The calculation of the CPU data uses CPUs of the specified types only. For example, if you want to see how much CPU time is consumed by your Linux systems, enable CPU type IFL.

On z/VM the processor type is always UN and you cannot select the type.

In an LPAR the following CPU types can be selected either interactively or with the `--cpu_types` command line option:

| Identifier | Column label | Explanation                                                                  |
|------------|--------------|------------------------------------------------------------------------------|
| i          | IFL          | Integrated Facility for Linux. On older machines IFLs might be shown as CPs. |
| p          | CP           | CP processor type.                                                           |
| u          | UN           | Unspecified processor type (other than CP or IFL).                           |

## Examples

These examples show typical uses of **hyptop**.

- To start **hyptop** with the `sys_list` window in interactive mode, enter:

```
hyptop
```

- If your Linux instance is running in an LPAR that has permission to see the other LPARs, the output looks like the following example:

```
12:30:48 | cpu-t: IFL(18) CP(3) UN(3) ?=help
system #core core mgm Core+ Mgm+ online
(str) (#) (%) (%) (hm) (hm) (dhm)
S05LP30 10 461.14 10.18 1547:41 8:15 11:05:59
S05LP33 4 133.73 7.57 220:53 6:12 11:05:54
S05LP50 4 99.26 0.01 146:24 0:12 10:04:24
S05LP02 1 99.09 0.00 269:57 0:00 11:05:58
TRX2CFA 1 2.14 0.03 3:24 0:04 11:06:01
S05LP13 6 1.36 0.34 4:23 0:54 11:05:56
TRX1 19 1.22 0.14 13:57 0:22 11:06:01
TRX2 20 1.16 0.11 26:05 0:25 11:06:00
S05LP55 2 0.00 0.00 0:22 0:00 11:05:52
S05LP56 3 0.00 0.00 0:00 0:00 11:05:52
 413 823.39 23.86 3159:57 38:08 11:06:01
```

- If your Linux instance runs in a z/VM guest virtual machine that has permission to see the other z/VM guest virtual machines, the output looks like the following example:

```
12:32:21 | cpu-t: UN(16) ?=help
system #cpu cpu Cpu+ online memuse memmax wcur
(str) (#) (%) (hm) (dhm) (GiB) (GiB) (#)
T6360004 6 100.31 959:47 53:05:20 1.56 2.00 100
DTCVSW1 1 0.00 0:00 53:16:42 0.01 0.03 100
T6360002 6 0.00 166:26 40:19:18 1.87 2.00 100
OPERATOR 1 0.00 0:00 53:16:42 0.00 0.03 100
T6360008 2 0.00 0:37 30:22:55 0.32 0.75 100
T6360003 6 0.00 3700:57 53:03:09 4.00 4.00 100
NSLCF1 1 0.00 0:02 53:16:41 0.03 0.25 500
PERFSVM 1 0.00 0:53 2:21:12 0.04 0.06 0
TCP/IP 1 0.00 0:01 53:16:42 0.01 0.12 3000
DIRMAINT 1 0.00 0:04 53:16:42 0.01 0.03 100
DTCVSW2 1 0.00 0:00 53:16:42 0.01 0.03 100
RACFVM 1 0.00 0:00 53:16:42 0.01 0.02 100
 75 101.57 5239:47 53:16:42 15.46 22.50 3000
```

At the top, the `sys` and `sys_list` windows show a list of the CPU types that are used for the current CPU and core dispatch time calculation.

- To start **hyptop** with the `sys` window showing performance data for LPAR MYLPAR, enter:

```
hyptop -w sys -s mylpar
```

The result looks like the following example:

```
11:18:50 MYLPAR cpu-t: IFL(0) CP(24) UN(2) ?=help
coreid type core mgm visual
(#)(str) (%) (%) (vis)
0 CP 50.78 0.28 |#####|
1 CP 62.76 0.17 |#####|
2 CP 71.11 0.48 |#####|
3 CP 32.38 0.24 |#####|
4 CP 64.35 0.32 |#####|
5 CP 67.61 0.40 |#####|
6 CP 70.95 0.35 |#####|
7 CP 62.16 0.41 |#####|
8 CP 70.48 0.25 |#####|
9 CP 56.43 0.20 |#####|
10 CP 0.00 0.00 |
11 CP 0.00 0.00 |
12 CP 0.00 0.00 |
13 CP 0.00 0.00 |
=:V:N 609.02 3.10
```

- To start **hyptop** with the sys\_list window in batch mode, enter:

```
hyptop -b
```

- To start **hyptop** with the sys\_list window in interactive mode, with the fields dispatch time (in milliseconds), and online time (unit default), and sort the output according to online time, enter:

```
hyptop -f c:ms,o -S o
```

- To start **hyptop** with the sys\_list window in batch mode with update delay 5 seconds and 10 iterations, enter:

```
hyptop -b -d 5 -n 10
```

- To start **hyptop** with the sys\_list window and use only CPU types IFL and CP for dispatch time calculation, enter:

```
hyptop -t ifl,cp
```

- To start **hyptop** on Linux in LPAR mode with the sys\_list window and display all LPAR fields, including the thread information, enter:

```
hyptop -f "#,T,c,e,m,C,E,M,o"
```

The result looks like the following example:

```
13:47:42 cpu-t: IFL(0) CP(38) UN(0) ?=help
system #core #The core the mgm Core+ thE+ Mgm+ online
(str) (#) (#) (%) (%) (%) (hm) (hm) (hm) (dhm)
S35LP41 12 24 101.28 170.28 0.28 1056:10 1756:11 8:45 158:04:04
S35LP42 16 32 35.07 40.07 0.44 5194:52 6193:52 12:45 158:04:04
S35LP64 3 3 1.20 1.20 0.00 0:31 0:31 0:00 12:03:54
...
```

In the example, the Linux instances in LPARs S35LP41 and S35LP43 run with 2 threads per core. The thread time, as the sum of the two threads, exceeds the core dispatch time.

The Linux instance in LPAR S35LP64 does not use simultaneous multithreading.

- To start **hyptop** on Linux on z/VM with the sys\_list window and display a selection of z/VM fields, including the management time, enter:

```
hyptop -f "#,c,m,C,M,o"
```

The result looks like the following example:



```

17:52:56 cpu-t: IFL(0) UN(2) ?=help
system #cpu cpu mgm Cpu+ Mgm+ online
(str) (#) (%) (%) (hm) (hm) (dhm)
G3545010 3 0.55 0.05 0:05 0:02 0:03:14
G3545021 3 0.04 - 0:00 - 0:02:43
G3545025 2 0.01 - 0:00 - 0:04:08
...
G3545099 1 0.00 - 0:00 - 0:09:06
 52 0.61 0.05 0:27 0:02 0:09:06

```

In the example, hyptop runs on a Linux instance in z/VM guest virtual machine G3545010. In the sys\_list window, this is the only guest virtual machine for which management data is displayed.

## Scenario

Perform the steps described in this scenario to start **hyptop** with the sys window with system MYLPAR with the fields dispatch time (unit milliseconds) and total dispatch time (unit default), sort the output according to the total dispatch time, and then reverse the sort order.

## Procedure

1. Start hyptop.

```
hyptop
```

2. Go to select mode by pressing the **▶** key. The display will freeze.
3. Navigate to the row for the system you want to look (in the example MYLPAR) at using the **↑** and **↓** keys.

```

12:15:00 | cpu-t: IFL(18) CP(3) UN(3) ?=help
system #core core mgm Core+ Mgm+ online
(str) (#) (%) (%) (hm) (hm) (dhm)
MYLPAR 4 199.69 0.04 547:41 8:15 11:05:59
S05LP33 4 133.73 7.57 220:53 6:12 11:05:54
S05LP50 4 99.26 0.01 146:24 0:12 10:04:24
S05LP02 1 99.09 0.00 269:57 0:00 11:05:58
...
S05LP56 3 0.00 0.00 0:00 0:00 11:05:52
 413 823.39 23.86 3159:57 38:08 11:06:01

```

4. Open the sys window for MYLPAR by pressing the **▶** key.

```

12:15:51 MYLPAR cpu-t: IFL(18) CP(3) UN(2) ?=help
coreid type core mgm visual
(#) (str) (%) (%) (vis)
0 IFL 99.84 0.02 |#####
1 IFL 99.85 0.02 |#####
2 IFL 0.00 0.00 |
3 IFL 0.00 0.00 |
=:V:N 199.69 0.04

```

5. Press the **F** key to go to the fields selection window:

```

Select Fields and Units ?=help
K S ID UNIT AGG DESCRIPTION
p * type str none CPU type
c * core % sum Core dispatch time per second
e the % sum Thread time per second
m * mgm % sum Management time per second
C core+ hm sum Total core dispatch time
E thE+ % sum Total thread time
M mgm+ hm sum Total management time
o online dhm max Online time
v * visual vis none Visualization of CPU time per second

```

Ensure that dispatch time per second and total dispatch time are selected and for dispatch time microseconds are used as unit:

- a. Press the **P** key, the **M** key, and the **V** key to disable CPU type, Management time per second, and Visualization.
- b. Press the **C** key to enable Total core dispatch time.
- c. Then select the Core dispatch time per second row by pressing the **→** and **↓** keys.
- d. Press the minus key (-) to switch from the percentage (%) unit to the microseconds (ms) unit.

```
Select Fields and Units ?=help
K S ID UNIT AGG DESCRIPTION
p type str none CPU type
c * core ms sum Core dispatch time per second
e the % sum Thread time per second
m mgm % sum Management time per second
C * core+ hm sum Total core dispatch time
E thE+ % sum Total thread time
M mgm+ hm sum Total management time
o online dhm max Online time
v visual vis none Visualization of CPU time per second
```

Press the **←** key twice to return to the sys window.

6. To sort by Total core dispatch time press the **Shift + C** keys:

```
13:44:41 MYLPAR cpu-t: IFL(18) CP(3) UN(2) ?=help
coreid core Core+
(#) (ms) (hm)
0 23.84 548:52
1 37.48 492:55
3 0.00 0:00
2 0.00 0:00
=:^:N 61.33 1041:47
```

To reverse the sort order, press the **Shift + C** keys again:

```
13:44:41 MYLPAR cpu-t: IFL(18) CP(3) UN(2) ?=help
coreid core Core+
(#) (ms) (hm)
2 0.00 0:00
3 0.00 0:00
1 37.48 492:55
0 23.84 548:52
=:^:N 61.33 1041:47
```

## Results

You can do all of these steps in one by entering the command:

```
hyptop -w sys -s mylpar -f c:ms,C -S C -S C
```

## lschp - List channel paths

Use the **lschp** command to display information about channel paths.

### lschp syntax



where:

#### **-v or --version**

displays the version number of **lschp** and exits.

#### **-h or --help**

displays out a short help text, then exits. To view the man page, enter **man lschp**.

Output column description:

#### **CHPID**

Channel-path identifier.

#### **Vary**

Logical channel-path state:

- 0 = channel-path is not used for I/O.
- 1 = channel-path is used for I/O.

#### **Cfg.**

Channel-path configure state:

- 0 = stand-by
- 1 = configured
- 2 = reserved
- 3 = not recognized

#### **Type**

Channel-path type identifier.

#### **Cmg**

Channel measurement group identifier.

#### **Shared**

Indicates whether a channel path is shared between LPARs:

- 0 = channel path is not shared
- 1 = channel path is shared

#### **PCHID**

Physical channel path identifier, or, if enclosed in brackets, internal channel identifier. The mapping might not be available to Linux when it is running as a z/VM guest. If so, use the CP command:

```
QUERY CHPID <num> PCHID
```

A column value of '-' indicates that a facility associated with the corresponding channel-path attribute is not available.

## Examples

- To query the configuration status of channel path ID 0.40 issue:

```
lschp
CHPID Vary Cfg. Type Cmg Shared PCHID
=====
...
...
0.40 1 1 1b 2 1 0580
...
...
```

The value under **Cfg.** shows that the channel path is configured (1).

## lscpumf - Display information about the CPU-measurement facilities

Use the **lscpumf** command to display information about the CPU-measurement facilities.

### lscpumf syntax



where:

#### **-i or --info**

displays detailed information about available and supported CPU measurement facilities.

#### **-c or --list-counters**

lists counters that are provided by the CPU-measurement facility, omitting counters for which the LPAR is not authorized. For counter measurements with the perf program, the raw event identifier and symbolic counter name are displayed.

#### **-C or --list-all-counters**

lists all counters that are provided by the CPU-measurement counter facility, regardless of LPAR authorization. To list only those counters for which the LPAR is authorized, use the **-c** option. For counter measurements with the perf program, the raw event identifier and symbolic counter name are displayed.

#### **-s or --list-sampling-events**

lists perf raw events that activate the sampling facility.

#### **-v or --version**

displays the version number of **lscpumf** and exits.

#### **-h or --help**

displays out a short help text, then exits. To view the man page, enter **man lscpumf**.

### Examples

- To display the supported facilities, issue:

```
lscpumf
CPU-measurement Counter Facility
CPU-measurement Sampling Facility
```

- To display details about the facilities, issue:

```

lscpumf -i
CPU-measurement Counter Facility

Version: 3.6

Authorized counter sets:
 Basic counter Set
 Crypto-Activity counter Set
 Extended counter Set
 MT-diagnostic counter Set
 Problem-State counter Set

Linux perf event support: Yes (PMU: cpum_cf)

CPU-measurement Sampling Facility

Sampling Interval:
 Minimum: 18200 cycles (approx. 285714 Hz)
 Maximum: 170388400 cycles (approx. 30 Hz)

Authorized sampling modes:
 basic: (sample size: 32 bytes)
 diagnostic: (sample size: 165 bytes)

Linux perf event support: Yes (PMU: cpum_sf)

Current sampling buffer settings for cpum_sf:
 Basic-sampling mode
 Minimum: 15 sample-data-blocks (64KB)
 Maximum: 8176 sample-data-blocks (32MB)

 Diagnostic-sampling mode (including basic-sampling)
 Minimum: 90 sample-data-blocks (364KB)
 Maximum: 49056 sample-data-blocks (192MB)
 Size factor: 6

```

- To display perf event information for authorized sampling functions, issue:

```

lscpumf -s
Perf events for activating the sampling facility
=====

Raw
event Name Description

rb0000 SF_CYCLES_BASIC

 Sample CPU Cycles Using Basic-sampling Mode.
 This event is not associated with a counter set.

rbd000 SF_CYCLES_BASIC_DIAG

 Sample CPU Cycle Using Diagnostic-sampling Mode
 (not for ordinary use).
 This event is not associated with a counter set.

```

- To list all counters that are provided by your IBM Z hardware, issue:

```

lscpumf -C
perf event counter list for IBM z15
=====
Raw
event Name Description

9:0 CPU_CYCLES
 Cycle Count
 Counter 0 / Basic Counter Set.
9:1 INSTRUCTIONS
 Instruction Count
 Counter 1 / Basic Counter Set.
9:2 L1I_DIR_WRITES
 Level-1 I-Cache Directory Write Count
 Counter 2 / Basic Counter Set.
9:3 L1I_PENALTY_CYCLES
 Level-1 I-Cache Penalty Cycle Count
 Counter 3 / Basic Counter Set.
9:4 L1D_DIR_WRITES
 Level-1 D-Cache Directory Write Count
 Counter 4 / Basic Counter Set.
9:5 L1D_PENALTY_CYCLES
 Level-1 D-Cache Penalty Cycle Count
 Counter 5 / Basic Counter Set.
9:32 PROBLEM_STATE_CPU_CYCLES
 Problem-State Cycle Count
 Counter 32 / Problem-State Counter Set.
9:33 PROBLEM_STATE_INSTRUCTIONS
 Problem-State Instruction Count
 Counter 33 / Problem-State Counter Set.
9:64 PRNG_FUNCTIONS
.....

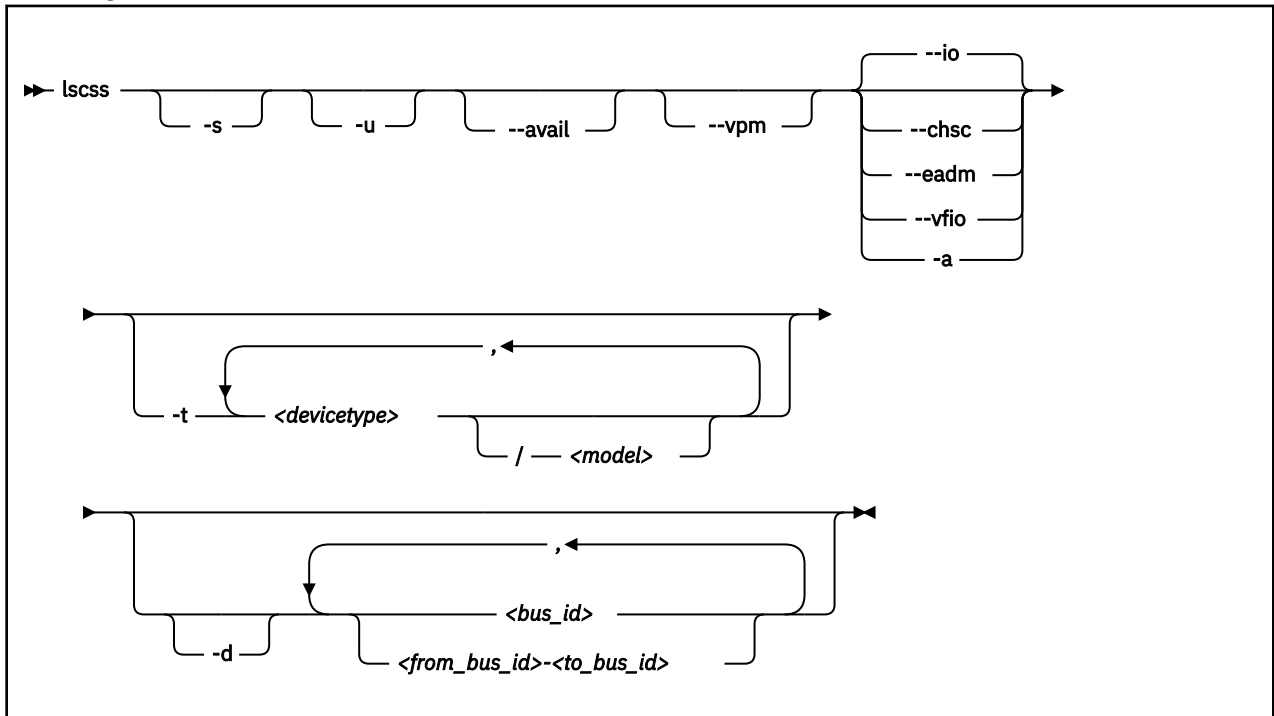
```

The leading 9 for raw event identifiers in the output example is a value that the kernel assigns to the CPU-measurement facilities. This number can vary across boot cycles.

## lscss - List subchannels

Use the **lscss** command to gather subchannel information from sysfs and display it in a summary format.

### lscss syntax



Where:

#### **-s or --short**

strips the 0.0. from the device bus-IDs in the command output.

**Note:** This option limits the output to bus IDs that begin with 0.0.

#### **-u or --uppercase**

displays the output with uppercase letters. The default is lowercase.

**Changed default:** Earlier versions of **lscss** printed the command output in uppercase. Specify this option to obtain the former output style.

#### **--avail**

includes the availability attribute of I/O devices.

#### **--vpm**

shows verified paths in a mask. Channel paths that are listed in this mask are available to Linux device drivers for I/O. Reasons for a channel path to be unavailable include:

- The corresponding bit is not set in at least one of the PIM, PAM, or POM masks.
- The channel path is varied offline.
- Linux received no interrupt to I/O when using this channel path.

#### **--io**

limits the output to I/O subchannels and corresponding devices. This option is the default.

#### **--chsc**

limits the output to CHSC subchannels.

#### **--eadm**

limits the output to EADM subchannels.



**--vfio**

For KVM hosts: shows information for subchannels that are used for VFIO CCW mediated devices, see [“Assigning DASDs to vfio\\_ccw”](#) on page 438.

**-a or --all**

does not limit the output.

**-t or --devtype**

limits the output to subchannels that correspond to devices of the specified device types and, if provided, the specified model.

**<devicetype>**

specifies a device type.

**<model>**

is a specific model of the specified device type.

**-d or --devrange**

interprets bus IDs as specifications of devices. By default, bus IDs are interpreted as specifications of subchannels.

**<bus\_id>**

specifies an individual subchannel; if used with `-d` specifies an individual device. If you omit the leading `0.<subchannel set ID>.`, `0.0.` is assumed.

If you specify subchannels or devices, the command output is limited to these subchannels or devices.

**<from\_bus\_id>-<to\_bus\_id>**

specifies a range of subchannels; if used with `-d` specifies a range of devices. If you omit the leading `0.<subchannel set ID>.`, `0.0.` is assumed.

If you specify subchannels or devices, the command output is limited to these subchannels or devices.

**-h or --help**

displays help information for the command. To view the man page, enter **man lscss**.

**-v or --version**

displays version information for the command.

**Examples**

- This command lists all subchannels, including subchannels that do not correspond to I/O devices:

```
lscss -a
IO Subchannels and Devices:
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs

0.0.f500 0.0.05cf 1732/01 1731/01 yes 80 80 ff 76000000 00000000
0.0.f501 0.0.05d0 1732/01 1731/01 yes 80 80 ff 76000000 00000000
0.0.f502 0.0.05d1 1732/01 1731/01 yes 80 80 ff 76000000 00000000
0.0.6194 0.0.36e0 3390/0c 3990/e9 yes fc fc ff 32333435 40410000
0.0.6195 0.0.36e1 3390/0c 3990/e9 yes fc fc ff 32333435 40410000
0.0.6196 0.0.36e2 3390/0c 3990/e9 yes fc fc ff 32333435 40410000

CHSC Subchannels:
Device Subchan.

n/a 0.0.ff40

EADM Subchannels:
Device Subchan.

n/a 0.0.ff00
n/a 0.0.ff01
n/a 0.0.ff02
n/a 0.0.ff03
n/a 0.0.ff04
n/a 0.0.ff05
n/a 0.0.ff06
n/a 0.0.ff07
```

- This command limits the output to subchannels with attached DASD model 3390 type 0a:

```
lscss -t 3390/0a
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs

0.0.2f08 0.0.0a78 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000
0.0.2fe5 0.0.0b55 3390/0a 3990/e9 c0 c0 bf 34400000 00000000
0.0.2fe6 0.0.0b56 3390/0a 3990/e9 c0 c0 bf 34400000 00000000
0.0.2fe7 0.0.0b57 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000
```

- This command limits the output to the subchannel range 0.0.0b00-0.0.0bff:

```
lscss 0.0.0b00-0.0.0bff
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs

0.0.2fe5 0.0.0b55 3390/0a 3990/e9 c0 c0 bf 34400000 00000000
0.0.2fe6 0.0.0b56 3390/0a 3990/e9 c0 c0 bf 34400000 00000000
0.0.2fe7 0.0.0b57 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000
```

- This command limits the output to subchannels 0.0.0a78 and 0.0.0b57 and shows the availability:

```
lscss --avail 0a78,0b57
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs Avail.

0.0.2f08 0.0.0a78 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000 good
0.0.2fe7 0.0.0b57 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000 good
```

- This command limits the output to subchannel 0.0.0a78 and prints uppercase output:

```
lscss -u 0a78
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs

0.0.2F08 0.0.0A78 3390/0A 3990/E9 YES C0 C0 FF 34400000 00000000
```

- This command limits the output to subchannels that correspond to I/O device 0.0.7e10 and the device range 0.0.2f00-0.0.2fff:

```
lscss -d 2f00-2fff,0.0.7e10
Device Subchan. DevType CU Type Use PIM PAM POM CHPIDs

0.0.2f08 0.0.0a78 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000
0.0.2fe5 0.0.0b55 3390/0a 3990/e9 c0 c0 bf 34400000 00000000
0.0.2fe6 0.0.0b56 3390/0a 3990/e9 c0 c0 bf 34400000 00000000
0.0.2fe7 0.0.0b57 3390/0a 3990/e9 yes c0 c0 ff 34400000 00000000
0.0.7e10 0.0.1828 3390/0c 3990/e9 yes f0 f0 ef 34403541 00000000
```

- This example shows a CHPID with PIM, PAM, and POM masks that are OK. However, the entry in the **vpm** column indicates that one of the paths, 0x41, is not usable for I/O.

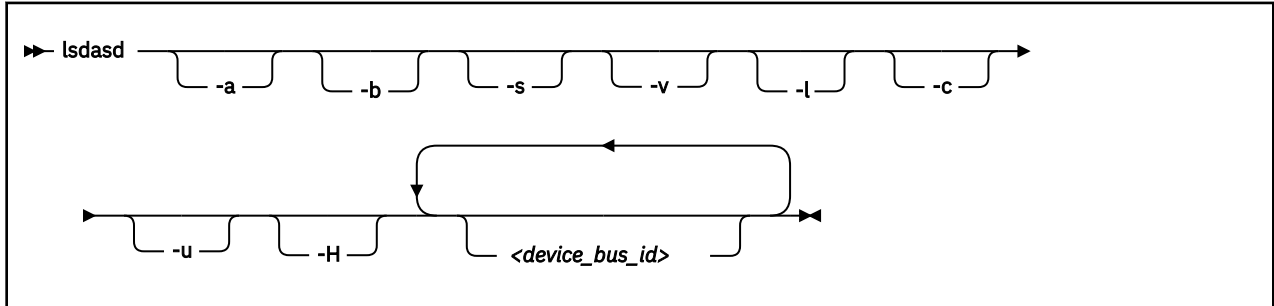
```
lscss --vpm
Device Subchan. DevType CU Type Use PIM PAM POM VPM CHPIDs

0.0.f500 0.0.05cf 1732/01 1731/01 yes 80 80 ff 80 76000000 00000000
0.0.f501 0.0.05d0 1732/01 1731/01 yes 80 80 ff 80 76000000 00000000
0.0.f502 0.0.05d1 1732/01 1731/01 yes 80 80 ff 80 76000000 00000000
0.0.6194 0.0.3700 3390/0c 3990/e9 yes fc fc ff f8 32333435 40410000
0.0.6195 0.0.3701 3390/0c 3990/e9 yes fc fc ff f8 32333435 40410000
0.0.6196 0.0.3702 3390/0c 3990/e9 yes fc fc ff f8 32333435 40410000
0.0.6197 0.0.3703 3390/0c 3990/e9 fc fc ff 00 32333435 40410000
0.2.5600 0.2.0040 1732/03 1731/03 80 80 ff 00 5d000000 00000000
```

## lsdasd - List DASD devices

Use the **lsdasd** command to gather information about DASD devices from sysfs and display it in a summary format.

### lsdasd syntax



Where:

- a or --offline**  
includes devices that are currently offline.
- b or --base**  
omits PAV alias devices. Lists only base devices.
- s or --short**  
strips the bus ID in the command output down to the four-digit device number.
- v or --verbose**  
Obsolete. This option has no effect on the output.
- l or --long**  
extends the output to include attributes, the UID, and path information.
- c or --compat**  
creates output of this command as with versions earlier than 1.7.0.
- u or --uid**  
includes and sorts output by UID.
- H or --host\_access\_list**  
shows information about all operating system instances that use this device.
- <device\_bus\_id>**  
limits the output to information about the specified devices only.
- version**  
displays the version of the command.
- h or --help**  
displays out a short help text, then exits. To view the man page, enter **man lsdasd**.

### Examples

- The following command lists all DASD (including offline DASDS):

```
lsdasd -a
Bus-ID Status Name Device Type BlkSz Size Blocks
=====
0.0.0190 offline
0.0.0191 offline
0.0.019d offline
0.0.019e offline
0.0.0592 offline
0.0.4711 offline
0.0.4712 offline
0.0.4f2c offline
0.0.4d80 active dasda 94:0 ECKD 4096 4695MB 1202040
0.0.4f19 active dasdb 94:4 ECKD 4096 23034MB 5896800
0.0.4d81 active dasdc 94:8 ECKD 4096 4695MB 1202040
0.0.4d82 active dasdd 94:12 ECKD 4096 4695MB 1202040
0.0.4d83 active dasde 94:16 ECKD 4096 4695MB 1202040
```

- The following command shows information only for the DASD with device number 0x4d80 and strips the bus ID in the command output down to the device number:

```
lsdasd -s 0.0.4d80
Bus-ID Status Name Device Type BlkSz Size Blocks
=====
4d80 active dasda 94:0 ECKD 4096 4695MB 1202040
```

- The following command shows only online DASDs in the format of **lsdasd** versions earlier than 1.7.0:

```
lsdasd -c
0.0.4d80(ECKD) at (94: 0) is dasda : active at blocksize 4096, 1202040 blocks, 4695 MB
0.0.4f19(ECKD) at (94: 4) is dasdb : active at blocksize 4096, 5896800 blocks, 23034 MB
0.0.4d81(ECKD) at (94: 8) is dasdc : active at blocksize 4096, 1202040 blocks, 4695 MB
0.0.4d82(ECKD) at (94: 12) is dasdd : active at blocksize 4096, 1202040 blocks, 4695 MB
0.0.4d83(ECKD) at (94: 16) is dasde : active at blocksize 4096, 1202040 blocks, 4695 MB
```

- The following command shows the device geometry, UID, path information, and some of the settings for the DASD with device bus-ID 0.0.4d82:

```
lsdasd -l 0.0.4d82
0.0.4d82/dasdd/94:12
status: active
type: ECKD
blkksz: 4096
size: 4695MB
blocks: 1202040
use_diag: 0
readonly: 0
eer_enabled: 0
explog: 0
hpf: 1
uid: IBM.75000000010671.4d82.16
paths_installed: 30 31 32 33 3c 3d
paths_in_use: 31 32 33
paths_non_preferred:
paths_invalid_cabling: 3c
paths_cuir_quiesced: 30
paths_invalid_hpf_characteristics: 3d
paths_error_threshold_exceeded:
```

In the example, three of the installed paths are unused for different reasons:

- The path with CHPID 3c is not used because of a cabling error to the storage system. This channel path does not connect to the same physical disk space as the other channel path for this device.
  - The path with CHPID 30 is not used because of a control-unit initiated reconfiguration (CUIR).
  - The path with CHPID 3d is not used because its High Performance FICON characteristics do not match with the paths currently in use.
- The following command shows whether other operating system instances access device 0.0.bf45:

```
lsdasd -H bf45
Host information for 0.0.bf45
Path-Group-ID LPAR CPU FL Status Sysplex Max_Cyls Time

88000d29e72964ce8570b8 0d 29e7 50 ON TRX1LNX1 268434453 0
88000e29e72964ce8570c3 0e 29e7 50 ON TRX1LNX1 268434453 0
88000f29e72964ce8570d1 0f 29e7 50 ON TRX1LNX1 268434453 0
88011d29e72964ce8570d4 1d 29e7 50 ON TRX1LNX1 268434453 0
88011e29e72964ce8570d9 1e 29e7 50 ON TRX1LNX1 268434453 0
88011f29e72964ce8570e3 1f 29e7 50 ON TRX1LNX1 268434453 0
88022d29e72964ce8570e6 2d 29e7 50 ON TRX1LNX1 268434453 0
88022e29e72964ce8570ea 2e 29e7 50 ON TRX1LNX1 268434453 0
88022f29e72964ce8570f1 2f 29e7 50 ON TRX1LNX1 268434453 0
88033d29e72964ce8570f7 3d 29e7 50 ON TRX1LNX1 268434453 0
88033e29e72964ce8570fe 3e 29e7 50 ON TRX1LNX1 268434453 0
88033f29e72964ce85710e 3f 29e7 50 ON TRX1LNX1 268434453 0
80004229e72964ce7dce74 42 29e7 00 OFF TRX1LNX1 65520 0
80004a29e72964ce7db60d 4a 29e7 00 OFF TRX1LNX1 65520 0
80003c29e72964ce8481a6 3c 29e7 00 OFF TRX1LNX1 65520 0
80004629e72964ce7f1c13 46 29e7 70 ON-RSV TRX1LNX1 65520 1424174863
```

Status values are:

**ON**

The device is online.

**OFF**

The device is offline.

**ON-RSV**

The device is online and reserved.

**OFF-RSV**

The device is offline and reserved by an operating system instance in another LPAR.

The meaning of the columns is as follows:

**Path-group-ID**

A 22-digit hexadecimal number assigned by the operating system when setting the DASD online. This ID uniquely identifies the operating system to the storage server.

**LPAR**

A 2 digit LPAR ID.

**CPU**

A 4 digit CPU ID, as it is defined in the HMC or can be read from `/proc/cpuinfo`.

**FL**

A 2 digit hexadecimal flag. 0x20 means reserved, 0x50 means online.

**Sysplex**

The 8-character EBCDIC name of the SYSPLEX.

**MAX\_CYLS**

The maximum number of cylinders per volume that are supported by the host.

**TIME**

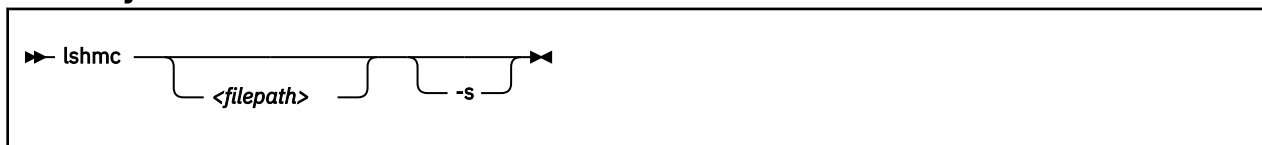
Time the device has been reserved in seconds since July 1, 1970.

## lshmc - List media contents in the HMC media drive

Use the **lshmc** command to display the contents of the media in the HMC media drive.

**Before you begin:** To be able to use this command, you need the **hmcdrv** module (see [Chapter 29, “HMC media device driver,”](#) on page 341).

### lshmc syntax



Where:

#### <filepath>

specifies a directory or path to a file to be listed. Path specifications are relative to the root of the file system on the media. You can use the asterisk (\*) and question mark (?) as wildcards. If this specification is omitted, the contents of the root directory are listed.

#### -s or --short

limits the output to regular files in a short listing format. Omits directories, symbolic links, and device nodes and other special files.

#### -v or --version

displays version information for the command.

#### -h or --help

displays a short help text, then exits. To view the man page, enter **man lshmc**.

### Examples

- To list the files in the root directory of the media in the HMC's media drive, issue:

```
lshmc
```

- If the hmcdrv kernel module is not loaded, load it before you issue the **lshmc** command:

```
modprobe hmcdrv
lshmc
```

- To list all HTML files in subdirectory www, issue:

```
lshmc /www/*.html
```

## lsluns - Discover LUNs, or show encryption state of attached LUNs

Use the **lsluns** command to list logical unit numbers (LUNs) discovered in the Fibre Channel storage area networks (SAN), or to show the encryption state of zfc-attached LUNs.

**lsluns** is designed for environments where all SCSI devices are attached through the zfc device driver.

**lsluns** lists all LUNs discovered in the Fibre Channel SAN. [“Discover LUNs in the Fibre Channel storage area network \(SAN\)” on page 607](#)

**lsluns -a** shows the encryption state of the attached LUNs. [“Show the encryption state of zfc-attached LUNs” on page 608](#)

For all other uses, such as listing attached LUNs or properties other than encryption, use other tools such as

- **lszfc -D** See [“lszfc - List zfc devices” on page 627](#)
- **lszdev zfc-lun -ii** See [“lszdev - Display IBM Z device configurations” on page 623](#)
- **lsscsi -tv** See the man page for more details.

### Discover LUNs in the Fibre Channel storage area network (SAN)

Discovering LUNs only makes sense for NPIV-enabled FCP devices without zfc automatic LUN scan. zfc automatic LUN scan is available as of kernel version 2.6.37, if not disabled with `zfc.allow_lun_scan=0`. See [“Setting up the zfc device driver” on page 151](#).

**Note:** Discovering LUNs causes extra SAN traffic for each target port WWPN.

#### Temporary LUN Attachment

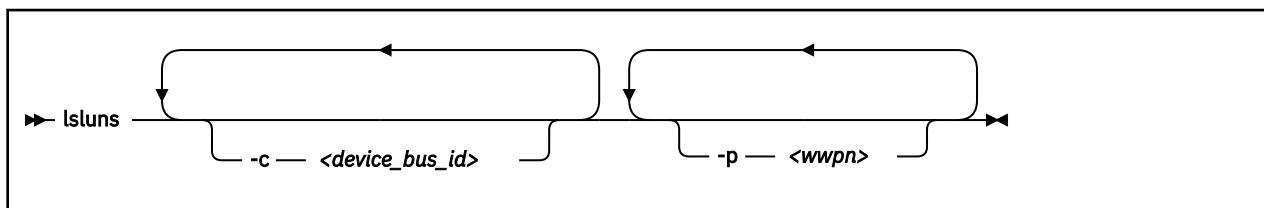
If not attached already, **lsluns** temporarily attaches LUN 0 (or if this fails, the WLUN 0xc101000000000000) during runtime. Do not terminate **lsluns** with a signal. Signals interfere with the removal of temporarily attached LUNs.

#### Storage Products

Some storage products return a peripheral device type of 31==0x1f with peripheral qualifier 0 in a SCSI standard INQUIRY command for an unmapped FCP LUN 0. Examples are: IBM Storwize products, including IBM V7000, IBM V840, IBM V9000, and IBM SAN Volume Controller. For **lsluns** to work with such storage products, you must have a host mapping on the storage side, which maps some volume to exported FCP LUN 0x0000000000000000 (Storwize host map property "SCSI ID" 0) for each used FCP-device initiator WWPN. The volume can be a minimum-sized thin-provisioned shared stand-in volume.

### lsluns syntax

Filter the listing by specifying one or more FCP device bus-IDs, target WWPNs, or both.



Where:

**-c <device\_bus\_id> or --ccw <device\_bus\_id>**

filters LUNs by one or more adapters with the specified FCP device-bus IDs. When used in conjunction with `-p`, only those LUNs are listed that also satisfy at least one of the `-p` constraints.

## lsluns

### **-p <wwpn> or --port <wwpn>**

filters LUNs by one or more target ports with the specified WWPNs. When used in conjunction with `-c`, only those LUNs are listed that also satisfy at least one of the `-c` constraints.

### **-v or --version**

displays version information and exits.

### **-h or --help**

displays an overview of the syntax. To view the man page, enter `man lsluns`.

## Examples

- This example lists all LUNs discovered in the FC SAN on adapter 0.0.3922:

```
lsluns -c 0.0.3922
```

- This example shows all LUNs discovered in the FC SAN on target port 0x500507630300c562:

```
lsluns -p 0x500507630300c562
Scanning for LUNs on adapter 0.0.5922
 at port 0x500507630300c562:
 0x4010400000000000
 0x4010400100000000
 0x4010400200000000
 0x4010400300000000
 0x4010400400000000
 0x4010400500000000
```

- This example shows all LUNs discovered in the FC SAN on:

- Adapter 0.0.3922 and port 0x5005123456789000
- Adapter 0.0.3922 and port 0x5005abcdefabc000
- Adapter 0.0.fc00 and port 0x5005123456789000
- Adapter 0.0.fc00 and port 0x5005abcdefabc000

```
lsluns -c 0.0.3922 -c 0.0.fc00 -p 0x5005123456789000 -p 0x5005abcdefabc000
```

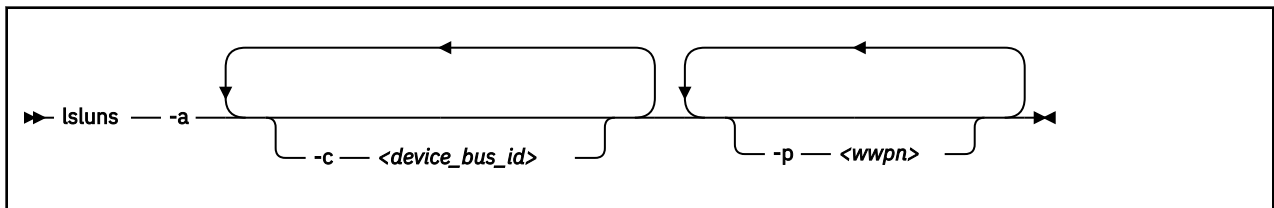
## Show the encryption state of zfcP-attached LUNs

`lsluns -a` shows the encryption state of the attached LUNs.

**Note:** Running `lsluns -a` causes extra SAN traffic for each attached LUN.

### lsluns syntax

Filter the listing by specifying one or more FCP device bus-IDs, target port WWPNs, or both.



Where:

### **-a or --active**

shows the encryption state of the attached LUNs. Encrypted devices are indicated with a bracketed X immediately after the LUN number.



**-c <device\_bus\_id> or --ccw=<device\_bus\_id>**

filters LUNs by one or more adapters with the specified FCP device-bus IDs. When used in conjunction with `-p`, only those LUNs are listed that also satisfy at least one of the `-p` constraints.

**-p <wwpn> or --port=<wwpn>**

filters LUNs by one or more target ports with the specified WWPNs. When used in conjunction with `-c`, only those LUNs are listed that also satisfy at least one of the `-c` constraints.

**-v or --version**

displays version information and exits.

**-h or --help**

displays an overview of the syntax. To view the man page, enter **man lsluns**.

**Examples**

- This example shows the encryption status of attached LUNs:

```
lsluns -a
adapter = 0.0.3c02
 port = 0x500507630300c562
 lun = 0x401040a200000000(X) /dev/sg0 Disk IBM:2107900
 lun = 0x401040a300000000 /dev/sg1 Disk IBM:2107900
 ...
 port = 0x500507630303c562
 ...
adapter = 0.0.593a
 ...
```

The (X) after the LUN number indicates that the device is encrypted.

## lsqeth - List qeth-based network devices

Use the **lsqeth** command to display a summary of information about qeth-based network devices.

**Before you begin:** To be able to use this command, you must also install **qethconf** (see “qethconf - Configure qeth devices” on page 644). You install both **qethconf** and **lsqeth** with the s390-tools package.

### lsqeth syntax



Where:

#### **-p or --proc**

displays the interface information in the former `/proc/qeth` format. This option can generate input to tools that expect this particular format.

#### **<interface>**

limits the output to information about the specified interface only.

#### **-v or --version**

displays version information for the command.

#### **-h or --help**

displays a short help text, then exits. To view the man page, enter **man lsqeth**.

### Examples

- The following command lists information about interface `encf500` in the default format:

```

lsqeth encf500
Device name : encf500

card_type : OSD_10GIG
cdev0 : 0.0.f5a2
cdev1 : 0.0.f5a3
cdev2 : 0.0.f5a4
chpid : B5
online : 1
portname : no portname required
portno : 0
route4 : no
route6 : no
state : UP (LAN ONLINE)
priority_queueing : always queue 2
fake_broadcast : 0
buffer_count : 64
layer2 : 0
isolation : none
sniffer : 0
switch_attrs : [802.1] rr

```

- The following command lists information about all qeth-based interfaces in the former `/proc/qeth` format:

```

lsqeth -p
devices CHPID interface cardtype port chksum prio-q'ing rtr4 rtr6 lay'2 cnt

0.0.833f/0.0.8340/0.0.8341 xFE enc8000 HiperSockets 0 sw always_q_2 no no 0 128
0.0.f5a2/0.0.f5a3/0.0.f5a4 xB5 encf500 OSD_1000 0 sw always_q_2 no no 1 64
0.0.fba2/0.0.fba3/0.0.fba4 xB0 ence400 OSD_1000 0 sw always_q_2 no no 0 64

```

## lsreipl - List IPL and re-IPL settings

Use the **lsreipl** command to find out which boot device and which options are used if you issue the reboot command.

You can also display information about the current boot device.

### lsreipl syntax



where:

**-i or --ipl**

displays the IPL setting.

**-v or --version**

displays the version number of **lsreipl** and exits.

**-h or --help**

displays an overview of the syntax. Any other parameters are ignored. To view the man page, enter **man lsreipl**.

By default the re-IPL device is set to the current IPL device. Use the **chreipl** command to change the re-IPL settings.

This example shows the current re-IPL settings:

```

lsreipl
Re-IPL type: fcp
WWPN: 0x500507630300c562
LUN: 0x401040b300000000
Device: 0.0.1700
bootprog: 0
br_lba: 0
Loadparm: ""
Bootparms: ""

```

## lsscm - List storage-class memory increments

Use the **lsscm** command to list status and other information about available storage-class memory increments.

### lsscm syntax



Where:

#### **-h or --help**

displays help information for the command. To view the man page, enter **man lsscm**.

#### **-v or --version**

displays version information for the command.

In the output table, the columns have the following meaning:

#### **SCM Increment**

Starting address of the storage-class memory increment.

#### **Size**

Size of the block device that represents the storage-class memory increment.

#### **Name**

Name of the block device that represents the storage-class memory increment.

#### **Rank**

A quality ranking in the form of a number in the range 1 - 15 where a lower number means better ranking.

#### **D\_state**

Data state of the storage-class memory increment. A number that indicates whether there is data on the increment. The data state can be:

##### **1**

The increment contains zeros only.

##### **2**

Data was written to the increment.

##### **3**

No data was written to the increment since the increment was attached.

#### **O\_state**

Operation state of the storage-class memory increment.

#### **Pers**

Persistence attribute.

#### **ResID**

Resource identifier.

### Examples

- This command lists all increments:

```
lsscm
SCM Increment Size Name Rank D_state O_state Pers ResID

0000000000000000 16384MB scma 1 2 1 2 1
0000000040000000 16384MB scmb 1 2 1 2 1
```

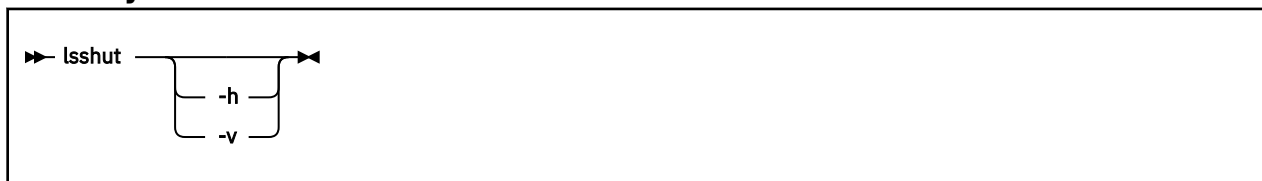
## lsshut - List the current system shutdown actions

Use the **lsshut** command to see how the Linux instance is configured for the halt, poff, reboot, restart, and panic system shutdown triggers.

For more information about the shutdown triggers and possible shutdown actions, see [Chapter 8, “Shutdown actions,”](#) on page 99.

If the action is kdump, a second action might be listed. This second action is the backup action that is taken if kdump fails. See *Using the Dump Tools*, SC33-8412 for details about using kdump.

### lsshut syntax



where:

#### **-h or --help**

displays a short help text, then exits. To view the man page, enter **man lsshut**.

#### **-v or --version**

displays the version number of **lsshut** and exits.

### Examples

- To query the configuration issue:

```

lsshut
Trigger Action
=====
Halt stop
Power off vmcmd (LOGOFF)
Reboot reipl
Restart kdump,dump_reipl
Panic kdump,dump_reipl

```

## lstape - List tape devices

Use the **lstape** command to gather information about tape devices and display it in a summary format.

It gathers information about the following types of tape devices:

- CCW-attached tape devices
- Tape drive and medium changer devices that are available through the sysfs SCSI bus (see [“Displaying tape information”](#) on page 200)

CCW-attached tape devices and tape devices that are attached to the SCSI bus from sysfs.

For information about SCSI tape devices, the command uses the following sources for the information displayed:

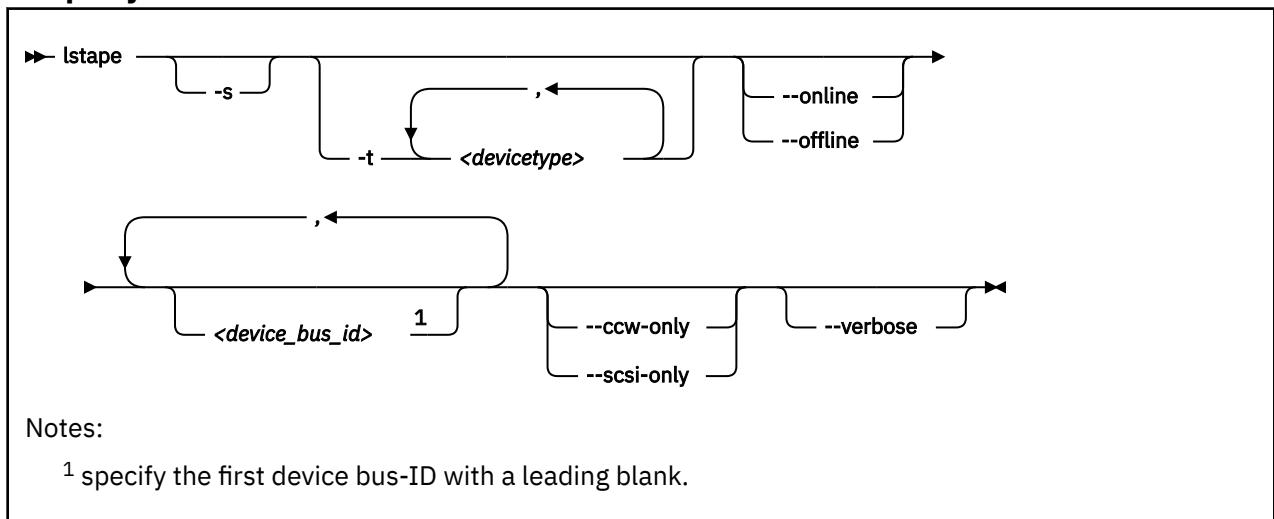
- The IBMtape or the open source lin\_tape driver.
- The sg\_inq command from the scsi/sg3\_utils package.

**Note:** Issuing **lstape** without option `--ccw-only` causes extra SAN traffic for each SCSI tape or changer device.

- The st (SCSI tape) device driver in the Linux kernel.
- The ch SCSI medium changer device driver in the Linux kernel.

If you use the IBMtape or lin\_tape driver, the sg\_inq utility is required. If sg\_inq is missing, certain information about the IBMtape or lin\_tape driver cannot be displayed.

### lstape syntax



Where:

**-s or --shortid**

strips the "0.<n>" from the device bus-IDs in the command output. For CCW-attached devices only.

**-t or --type**

limits the output to information about the specified type or types of CCW-attached devices only.

**--ccw-only**

limits the output to information about CCW-attached devices only.

**--scsi-only**

limits the output to information about tape devices that are attached to the SCSI bus.

**--online | --offline**

limits the output to information about online or offline CCW-attached tape devices only.

**<device\_bus\_id>**

limits the output to information about the specified CCW-attached tape device or devices.

**-V or --verbose**

For tape devices attached to the SCSI bus only. Displays the serial of the tape and information about the FCP or virtio-scsi-ccw connection as an additional text line that follows each SCSI tape in the list.

**-h or --help**

displays a short help text. To view the man page, enter **man lstape**.

**-v or --version**

displays the version of the command.

**Examples**

- This command displays information about all tapes found, here one CCW-attached tape and one tape and changer device that is configured for zFCP:

```
lstape
FICON/ESCON tapes (found 1):
TapeNo BusID CuType/Model DevType/Model BlkSize State Op MedState
0 0.0.0480 3480/01 3480/04 auto UNUSED --- UNLOADED

SCSI tape devices (found 2):
Generic Device Target Vendor Model Type State
sg4 IBMchanger0 0:0:0:0 IBM 03590H11 changer running
sg5 IBMtape0 0:0:0:1 IBM 03590H11 tapedrv running
```

If only the st tape device driver and the ch changer device driver are loaded, the output lists those names in the device section:

```
lstape
FICON/ESCON tapes (found 1):
TapeNo BusID CuType/Model DevType/Model BlkSize State Op MedState
0 0.0.0480 3480/01 3480/04 auto UNUSED --- UNLOADED

SCSI tape devices (found 2):
Generic Device Target Vendor Model Type State
sg0 sch0 0:0:0:0 IBM 03590H11 changer running
sg1 st0 0:0:0:1 IBM 03590H11 tapedrv running
```

- This command displays information about all available CCW-attached tapes.

```
lstape --ccw-only
TapeNo BusID CuType/Model DevType/DevMod BlkSize State Op MedState
0 0.0.0132 3590/50 3590/11 auto IN_USE --- LOADED
1 0.0.0110 3490/10 3490/40 auto UNUSED --- UNLOADED
2 0.0.0133 3590/50 3590/11 auto IN_USE --- LOADED
3 0.0.012a 3480/01 3480/04 auto UNUSED --- UNLOADED
N/A 0.0.01f8 3480/01 3480/04 N/A OFFLINE --- N/A
```

- This command limits the output to tapes of type 3480 and 3490.

```
lstape -t 3480,3490
TapeNo BusID CuType/Model DevType/DevMod BlkSize State Op MedState
1 0.0.0110 3490/10 3490/40 auto UNUSED --- UNLOADED
3 0.0.012a 3480/01 3480/04 auto UNUSED --- UNLOADED
N/A 0.0.01f8 3480/01 3480/04 N/A OFFLINE --- N/A
```

- This command limits the output to those tapes of type 3480 and 3490 that are currently online.

```
lstape -t 3480,3490 --online
TapeNo BusID CuType/Model DevType/DevMod BlkSize State Op MedState
1 0.0.0110 3490/10 3490/40 auto UNUSED --- UNLOADED
3 0.0.012a 3480/01 3480/04 auto UNUSED --- UNLOADED
```

- This command limits the output to the tape with device bus-ID 0.0.012a and strips the "0.<n>." from the device bus-ID in the output.



```
lstape -s 0.0.012a
TapeNo BusID CuType/Model DevType/DevMod BlkSize State Op MedState
3 012a 3480/01 3480/04 auto UNUSED --- UNLOADED
```

- This command limits the output to SCSI devices but gives more details. The serial numbers are only displayed if the **sg\_inq** command is found on the system.

```
lstape --scsi-only --verbose
Generic Device Target Vendor Model Type State
HBA WWPN Serial
sg0 st0 0:0:0:1 IBM 03590H11 tapedrv running
0.0.1708 0x500507630040727b NO/INQ
sg1 sch0 0:0:0:2 IBM 03590H11 changer running
0.0.1708 0x500507630040727b NO/INQ
```

- Example details about a zfcplib-attached SCSI tape library with multiple paths operated by the IBM lin\_tape device driver instead of Linux st or ch.

```
lstape --scsi-only --verbose
SCSI tape devices (found 8):
Generic Device Target Vendor Model Type State
HBA WWPN Serial
sg0 IBMtape0 0:0:0:0 IBM ULT3580-TD6 tapedrv running
0.0.5080 0x2002000e1115c62f 10WT037733
sg1 IBMchanger0 0:0:0:1 IBM 3573-TL changer running
0.0.5080 0x2002000e1115c62f 00L4U78W6497_LL0
sg4 IBMtape2 0:0:1:0 IBM ULT3580-TD6 tapedrv running
0.0.5080 0x2008000e1115c62f 10WT037701
sg5 IBMchanger2 0:0:1:1 IBM 3573-TL changer running
0.0.5080 0x2008000e1115c62f 00L4U78W6497_LL0
sg6 IBMtape3 1:0:0:0 IBM ULT3580-TD6 tapedrv running
0.0.50c0 0x2002000e1115c62f 10WT037733
sg7 IBMchanger3 1:0:0:1 IBM 3573-TL changer running
0.0.50c0 0x2002000e1115c62f 00L4U78W6497_LL0
sg2 IBMtape1 1:0:1:0 IBM ULT3580-TD6 tapedrv running
0.0.50c0 0x2008000e1115c62f 10WT037701
sg3 IBMchanger1 1:0:1:1 IBM 3573-TL changer running
0.0.50c0 0x2008000e1115c62f 00L4U78W6497_LL0
```

## Data fields for SCSI tape devices

There are specific data fields for SCSI tape devices.

| Table 72. Istape data fields for SCSI tape devices |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Attribute                                          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Generic                                            | SCSI generic device file for the tape drive (for example /dev/sg0). This attribute is "N/A" if the SCSI generic device driver, sg, is not available.                                                                                                                                                                                                                                                                                                                                                                             |
| Device                                             | Main device file for accessing the tape drive, for example: <ul style="list-style-type: none"> <li>• /dev/st0 for a tape drive that is attached through the Linux st device driver</li> <li>• /dev/sch0 for a medium changer device that is attached through the Linux changer device driver</li> <li>• /dev/IBMchanger0 for a medium changer that is attached through the IBMtape or lin_tape device driver</li> <li>• /dev/IBMtape0 for a tape drive that is attached through the IBMtape or lin_tape device driver</li> </ul> |
| Target                                             | The ID in Linux used to identify the SCSI device.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Vendor                                             | The vendor field from the tape drive.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Model                                              | The model field from the tape drive.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Type                                               | "Tapedrv" for a tape driver or "changer" for a medium changer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

| <i>Table 72. lstape data fields for SCSI tape devices (continued)</i> |                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Attribute</b>                                                      | <b>Description</b>                                                                                                                                                                                                       |
| State                                                                 | The state of the SCSI device in Linux. This state is an internal state of the Linux kernel, any state other than "running" can indicate problems.                                                                        |
| HBA                                                                   | The bus-ID of the FCP device or of the virtio-scsi-ccw virtual HBA to which the tape drive is attached. "N/A" if the device does not have a sysfs ancestor with subsystem ccw.                                           |
| WWPN                                                                  | The WWPN (worldwide port name) of the tape drive in the SAN. "N/A" if the device is not attached through zfc.                                                                                                            |
| Serial                                                                | The serial number field from the tape drive. "NO/SG" if the SCSI generic device driver, sg, is not available. "NO/INQ" if sg is available, but the <b>sg_inq</b> command from the scsi/sg3_utils package is unavailable. |

## lszcrypt - Display zcrypt devices

Use the **lszcrypt** command to display information about cryptographic adapters that are managed by zcrypt and its AP bus attributes.

To set the attributes, use “[chzcrypt - Modify the zcrypt configuration](#)” on page 529. The following information can be displayed for each cryptographic adapter:

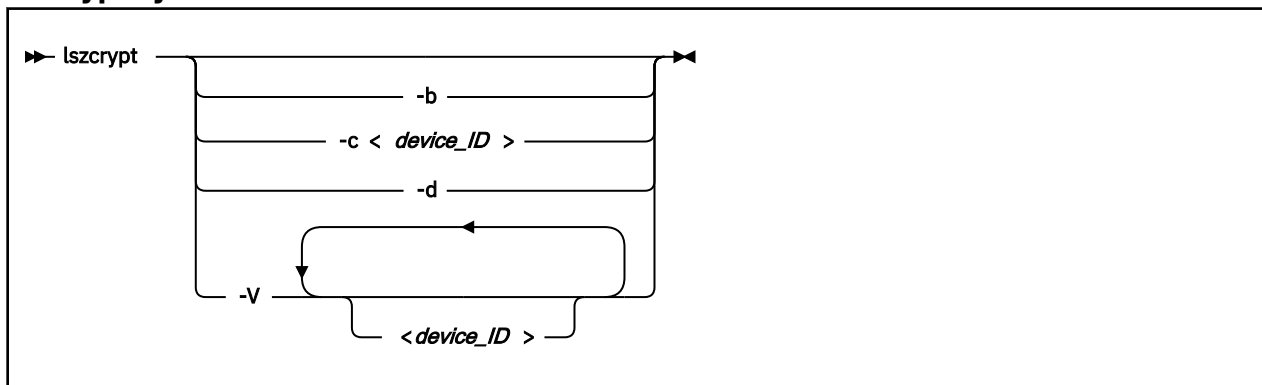
- The card type
- The online status
- The hardware card type
- The card capability
- The hardware queue depth
- The request count
- The zcrypt submodule or alternative device driver that handles the device

For information about alternative device drivers, see “[Freeing AP queues for KVM guests](#)” on page 462.

The following AP bus attributes can be displayed:

- The default AP domain
- The configuration timer
- The poll thread status
- The poll timeout
- The AP interrupt status

### lszcrypt syntax



Where:

#### <device ID>

specifies a cryptographic adapter to display. A cryptographic device can be either an adapter ID or an AP queue device. If no devices are specified, information about all available devices is displayed. Both the adapter ID representation and the AP queue device representation are hexadecimal.

#### -b or --bus

displays the AP bus attributes.

#### -c <device ID> or --capability <device ID>

shows the capabilities of a cryptographic adapter. The capabilities of a cryptographic adapter depend on the card type and the installed function facilities. A cryptographic adapter can provide one or more of the following capabilities:

- RSA 2 K Clear Key
- RSA 4 K Clear Key

- CCA Secure Key (full function set)
- CCA Secure Key (restricted function set)
- EP11 Secure Key
- Long RNG

The restricted function set for CCA Secure Key applies to shared adapters for z/VM guests (see [“Cryptographic devices on z/VM” on page 448](#)).

### **-d or --domains**

shows the usage and control domains of the cryptographic device. The displayed domains of the cryptographic device depend on the initial cryptographic configuration.

- "C" indicates a control domain.
- "U" indicates a usage domain.
- "B" indicates both (control and usage domain).

### **-V or --verbose**

enables the verbose level for cryptographic device information. It displays card type, online status, hardware card type, hardware queue depth, request count, pending request queue count, outstanding request queue count, and installed function facilities.

The installed functions are shown, as a sequence of letters, in the FUNCTION column of the verbose output mode, with the following meaning:

#### **S**

APSC facility available

#### **M and C**

RSA 4096 bit support

#### **D**

CCA Coprocessor function available

#### **A**

Accelerator function available

#### **X**

EP11 Coprocessor function available

#### **N**

APXA facility available

#### **F**

Full function set available

#### **R**

Restricted function set (only stateless)

Depending on the hypervisor configuration, the hypervisor might filter cryptographic requests to allow only a subset of functions within the virtual runtime environment. For example, a shared CCA Coprocessor can be restricted by the hypervisor to allow only clear-key operations within the guests.

### **-h or --help**

displays help information for the command. To view the man page, enter **man lszcrypt**.

### **-v or --version**

displays version information.

### **Examples**

These examples illustrate common uses for **lszcrypt**.

- To display information about all available cryptographic devices and AP queues:

```
lszcrypt
```

This command lists all devices grouped by cryptographic device, similar to the following example. Card and domain IDs are hexadecimal values.

```

CARD.DOMAIN TYPE MODE STATUS REQUESTS

0a CEX7P EP11-Coproc online 2506
0a.0011 CEX7P EP11-Coproc online 1615
0a.0036 CEX7P EP11-Coproc online 891
0c CEX7A Accelerator online 3506
0c.0011 CEX7A Accelerator online 1753
0c.0036 CEX7A Accelerator online 1753
0e CEX7C CCA-Coproc online 1507
0e.0011 CEX7C CCA-Coproc online 753
0e.0036 CEX7C CCA-Coproc online 754

```

- To display AP bus information:

```
lszcrypt -b
```

This command displays output similar to the following example:

```

ap_domain=0x11
ap_max_domain_id=0x54
ap_interrupts are enabled
config_time=30 (seconds)
poll_thread is disabled
poll_timeout=250000 (nanoseconds)

```

- To display the capabilities for the cryptographic device with adapter ID 0x0e:

```
lszcrypt -c 0x0e
```

This command displays output similar to the following example:

```

card0e provides capability for:
RSA 4K Clear Key
CCA Secure Key (full function set)
Long RNG

```

- To list the usage and control domains of the cryptographic devices:

```
lszcrypt -d
```

This command displays a table that lists all domains (in hex notation) similar to the following example:

```

DOMAIN 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f

00 B
10
20
30
40
50 . B
60
70
80
90
a0
b0
c0
d0
e0
f0

C: Control domain
U: Usage domain
B: Both (Control + Usage domain)

```

- To display detailed information of all available cryptographic devices:

```
lszcrypt -V
```

This example shows a CEX6S cryptographic device in accelerator mode (ID 0x03). It also shows three CEX7S devices, two of them in CCA coprocessor mode (IDs 0x08 and 0x0e) and one in EP11 coprocessor mode (ID 0x0a). The configured domains are 17 (0x0011) and 54 (0x0036). Adapter IDs and domain IDs are hexadecimal values.

```
lszcrypt -V
CARD.DOMAIN TYPE MODE STATUS REQUESTS PENDING HWTYPE QDEPTH FUNCTIONS DRIVER

03 CEX6A Accelerator online 2095 0 12 08 -MC-A-NF- cex4card
03.0011 CEX6A Accelerator online 1047 0 12 08 -MC-A-NF- cex4queue
03.0036 CEX6A Accelerator online 1048 0 12 08 -MC-A-NF- cex4queue
08 CEX7C CCA-Coproc online 0 0 13 08 S--D--NF- cex4card
08.0011 CEX7C CCA-Coproc - 0 0 13 08 S--D--NF- -no-driver-
08.0036 CEX7C CCA-Coproc - 0 0 13 08 S--D--NF- -no-driver-
0a CEX7P EP11-Coproc online 2506 0 13 08 ----XNF- cex4card
0a.0011 CEX7P EP11-Coproc online 1615 0 13 08 ----XNF- cex4queue
0a.0036 CEX7P EP11-Coproc online 891 0 13 08 ----XNF- cex4queue
0e CEX7C CCA-Coproc online 1507 0 13 08 S--D--NF- cex4card
0e.0011 CEX7C CCA-Coproc online 753 0 13 08 S--D--NF- cex4queue
0e.0036 CEX7C CCA-Coproc online 754 0 13 08 S--D--NF- cex4queue
```

"-no-driver-" in the DRIVER column means that the AP queue has been freed for use by alternative device drivers (see [“Freeing AP queues for KVM guests”](#) on page 462), but no such device driver is available. In the example, the `vfi0_ap` device driver is not loaded. Otherwise, `"vfi0_ap"` would be displayed instead of `"-no-driver-"`.

In the example, all domains for adapter 0x08 have been freed from control by `zcrypt`. AP queues that are not handled by the `zcrypt` device driver are omitted from the non-verbose listing.

```
lszcrypt
CARD.DOMAIN TYPE MODE STATUS REQUESTS

03 CEX6A Accelerator online 2095
03.0011 CEX6A Accelerator online 1047
03.0036 CEX6A Accelerator online 1048
08 CEX7C CCA-Coproc online 0
0a CEX7P EP11-Coproc online 2506
0a.0011 CEX7P EP11-Coproc online 1615
0a.0036 CEX7P EP11-Coproc online 891
0e CEX7C CCA-Coproc online 1507
0e.0011 CEX7C CCA-Coproc online 753
0e.0036 CEX7C CCA-Coproc online 754
```

- To limit the scope of the `lszcrypt -V` command, specify one or more device IDs as arguments to the command.

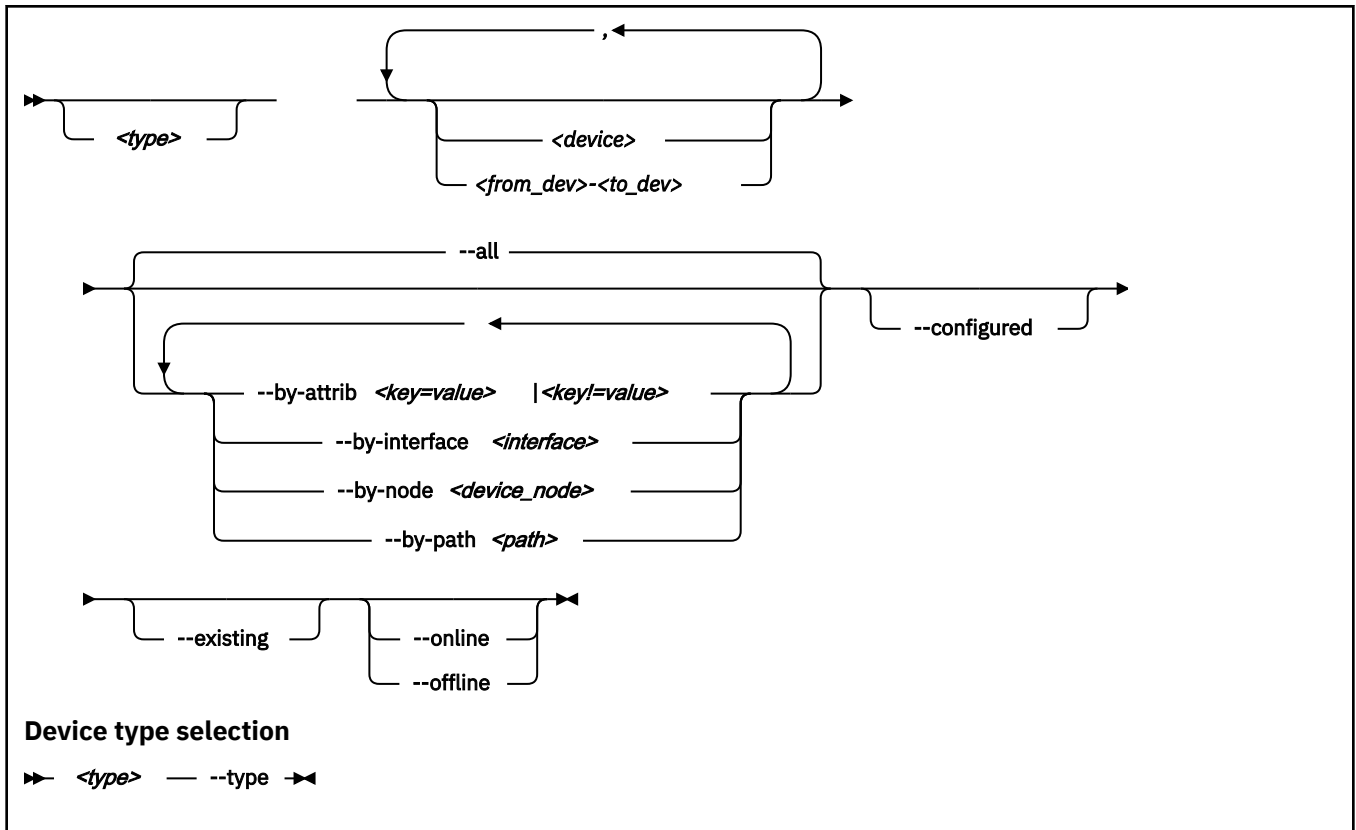
```
lszcrypt -V 0x0a
CARD.DOMAIN TYPE MODE STATUS REQUESTS PENDING HWTYPE QDEPTH FUNCTIONS DRIVER

0a CEX7P EP11-Coproc online 2506 0 13 08 ----XNF- cex4card
0a.0011 CEX7P EP11-Coproc online 1615 0 13 08 ----XNF- cex4queue
0a.0036 CEX7P EP11-Coproc online 891 0 13 08 ----XNF- cex4queue
```

**Tip:** In the device specification, you can also use one-digit hexadecimal or decimal notation. The following specifications are all equivalent:

- 0x0 0x2 0xb
- 0x00 0x02 0x0b
- 0 2 11





### lszdev help functions



Where:

#### <type>

restricts the output to the specified device type. A device type typically corresponds to a device driver. Multiple device types are sometimes provided for the same driver, for example, both "dasd-eckd" and "dasd-fba" are related to the DASD device driver. You can work with types in the following ways:

- To display data for devices with matching type and ID only, specify a device type and a device ID, for example:

```
lszdev dasd 0.0.8000
```

- To display the configuration of the device type itself, specify a device type together with the --type option, for example:

```
lszdev dasd --type
```

To get a list of supported device types, use the --list-types option.

#### <device>

limits the output to information about a single device or a range of devices by device ID. To select a range of devices, specify the ID of the first and the last device in the range separated by a hyphen (-). Specify multiple IDs or ID ranges by separating IDs with a comma (,).



**--all**

lists all existing and configured devices. This option is the default.

**--by-attrib <key=value> | <key!=value>**

selects devices with a specified attribute, <key> that has a value of <value>. When specified as <key!=value>, lists all devices that do not provide an attribute named <key> with a value of <value>.

**Tip:** You can use the `--list-attributes` option to display a list of available attributes and the `--help-attribute` to get more detailed information about a specific attribute.

**--by-interface <interface>**

selects devices by network interface, for example, `encl500`. The <interface> parameter must be the name of an existing networking interface.

**--by-node <node>**

selects devices by device node, for example, `/dev/sda`. The <node> must be the path to a block device or character device special file.

**Note:** If <node> is the device node for a logical device (such as a device mapper device), **lszdev** tries to resolve the corresponding physical device nodes. The **lsblk** tool must be available for this resolution to work.

**--by-path <path>**

selects devices by file-system path, for example, `/usr`. The <path> parameter can be the mount point of a mounted file system, or a path on that file system.

**Note:** If the file system that provides <path> is stored on multiple physical devices (such as supported by `btrfs`), **lszdev** tries to resolve the corresponding physical device nodes. The **lsblk** tool must be available and the file system must provide a valid UUID for this resolution to work.

**--configured**

narrows the selection to those devices for which a persistent configuration exists.

**--existing**

narrows the selection to devices that are present in the active configuration.

**--online**

narrows the selection to devices that are enabled in the active configuration.

**--offline**

narrows the selection to devices that are disabled in the active configuration.

**-a or --active**

lists information obtained from the active configuration, that is, information from the running system.

**-p or --persistent**

lists information from the persistent configuration.

**--auto-conf**

lists information from the auto-configuration, see [Chapter 3, “Device auto-configuration for Linux in LPAR mode,” on page 19](#).

**-i or --info**

displays detailed information about the configuration of the selected device or device type.

**-c <columns> or --columns <columns>**

specifies a comma-separated list of columns to display.

Example:

```
lszdev --columns TYPE,ID
```

**Tip:** To get a list of supported column names, use the `--list-columns` option.

**-n or --no-headings**

suppresses column headings for list output.

**--pairs**

produces output in `<key="value">` format. Use this option to generate output in a format more suitable for processing by other programs. In this format, column values are prefixed with the name of the corresponding column. Values are enclosed in double quotation marks. The **lszdev** command automatically escapes quotation marks and slashes that are part of the value string.

**--base <path> | <key=value>**

changes file system paths that are used to access files. If `<path>` is specified without an equal sign (=), it is used as base path for accessing files in the active and persistent configuration. If the specified parameter is in `<key=value>` format, only those paths that begin with `<key>` are modified. For these paths, the initial `<key>` portion is replaced with `<value>`.

Example:

```
lszdev --persistent --base /etc/mnt/etc
```

**-t <device\_type> or --type <device\_type>**

lists information about a device type. Use this option to display configuration information of a device type instead of a device.

**-q or --quiet**

prints only minimal run-time information.

**-V or --verbose**

prints additional run-time information.

**-L or --list-types**

lists all available device types that you can use with the `--type` option.

**-l or --list-columns**

lists all available columns that you can use with the `--columns` option.

**-h or --help**

displays help information for the command.

**-v or --version**

displays the version number of **lszdev**, then exits.

**Input files**

The **lszdev** command uses these input files:

**/etc/udev/rules.d/**

**lszdev** reads udev rules that represent the persistent configuration of devices from this directory. The udev rules are named `41-<device subtype>-<id>.rules`.

**/etc/modprobe.d/**

**lszdev** reads modprobe configuration files that represent the persistent configuration of certain device types from this directory. File names start with `s390x-`.

**/usr**

**lszdev** reads udev rules that represent the auto-configuration of devices from this directory.

**Examples**

- To display a list of all devices:

```
lszdev
```

- To return type and ID of root device in machine-readable format:

```
lszdev --columns TYPE,ID --by-path /
```

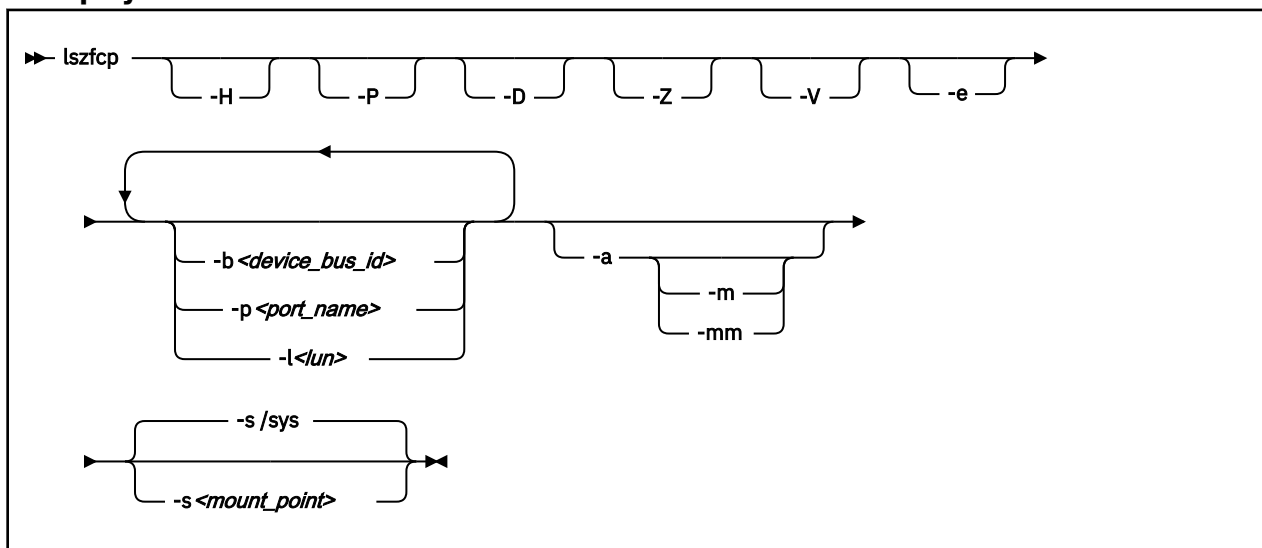
- To display DASD driver settings:

```
lszdev --type dasd
```

## lszfc - List zfc devices

Use the **lszfc** command to gather information about zfc devices, ports, units, and their associated class devices from sysfs and to display it in a summary format.

### lszfc syntax



Where:

**-H or --hosts**

shows information about hosts.

**-P or --ports**

shows information about ports.

**-D or --devices**

shows information about SCSI devices.

**-Z or --modparms**

lists zfc module parameters with a scope of the device driver.

**-V or --verbose**

shows sysfs paths of associated class and bus devices.

**-e or --extended**

generates extended output.

**-b or --busid <device\_bus\_id>**

limits the output to information about the specified device.

**-p or --wwpn <port\_name>**

limits the output to information about the specified port name.

**-l or --lun <lun>**

limits the output to information about the specified LUN.

**-a or --attributes**

shows the main attributes of the specified objects.

**-m or --moreattrs**

shows more attributes of the specified objects.

Specify twice (-mm) to show even more attributes for SCSI devices.

**-s or --sysfs <mount\_point>**

specifies the mount point for sysfs.

## lszfc

### **-v or --version**

displays version information.

### **-h or --help**

displays a short help text. To view the man page, enter **man lszfc**.

### **Examples**

- This command displays information about all available hosts, ports, and SCSI devices.

```
lszfc -H -D -P
0.0.3d0c host0
0.0.500c host1
...
0.0.3c0c host5
0.0.3d0c/0x500507630300c562 rport-0:0-0
0.0.3d0c/0x50050763030bc562 rport-0:0-1
0.0.3d0c/0x500507630303c562 rport-0:0-2
0.0.500c/0x50050763030bc562 rport-1:0-0
...
0.0.3c0c/0x500507630303c562 rport-5:0-2
0.0.3d0c/0x500507630300c562/0x4010403200000000 0:0:0:1077035024
0.0.3d0c/0x500507630300c562/0x4010403300000000 0:0:0:1077100560
0.0.3d0c/0x50050763030bc562/0x4010403200000000 0:0:1:1077035024
0.0.3d0c/0x500507630303c562/0x4010403200000000 0:0:2:1077035024
0.0.500c/0x50050763030bc562/0x4010403200000000 1:0:0:1077035024
...
0.0.3c0c/0x500507630303c562/0x4010403200000000 5:0:2:1077035024
```

- This command shows SCSI devices and limits the output to the devices that are attached through the FCP device with bus ID 0.0.3d0c:

```
lszfc -D -b 0.0.3d0c
0.0.3d0c/0x500507630300c562/0x4010403200000000 0:0:0:1077035024
0.0.3d0c/0x500507630300c562/0x4010403300000000 0:0:0:1077100560
0.0.3d0c/0x50050763030bc562/0x4010403200000000 0:0:1:1077035024
0.0.3d0c/0x500507630303c562/0x4010403200000000 0:0:2:1077035024
```

## mon\_fsstatd – Monitor z/VM guest file system size

The **mon\_fsstatd** command is a user space daemon that collects physical file system size data from Linux on z/VM.

The daemon periodically writes the data as defined records to the z/VM monitor stream using the monwriter character device driver.

You can start the daemon with the systemd service unit `mon_fsstatd`. When the daemon is started as a service unit, it reads the configuration file `/etc/sysconfig/mon_fsstatd`.

### Before you begin:

- Install the `s390-tools-statd` package, for example with **apt-get**:

```
apt-get install s390-tools-statd
```

- Install the monwriter device driver and set up z/VM to start the collection of monitor sample data. See [Chapter 35, “Writing z/VM monitor records,”](#) on page 377 for information about the setup for and usage of the monwriter device driver.
- Customize the configuration file `/etc/sysconfig/mon_fsstatd` if you plan to call it as a systemd service.
- The Linux instance on which the `mon_fsstatd` daemon runs requires a z/VM guest virtual machine with the `OPTION APPLMON` statement in the CP directory entry.

The following publications provide general information about DCSSs, `DIAG x'DC'`, CP commands, and `APPLDATA`:

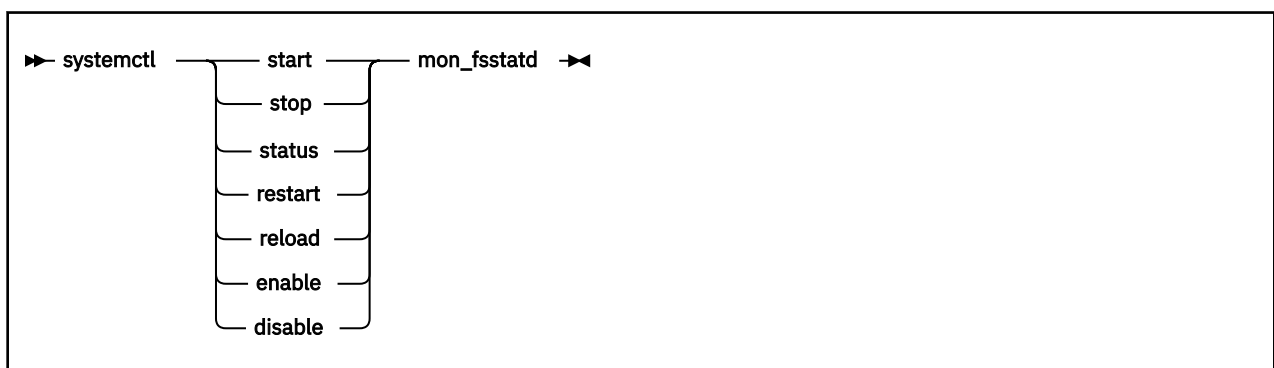
- See *z/VM: Saved Segments Planning and Administration*, SC24-6322 for general information about DCSSs.
- See *z/VM: CP Programming Services*, SC24-6272 for information about the `DIAG x'DC'` instruction.
- See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about the CP commands.
- See *z/VM: Performance*, SC24-6301 for information about monitor `APPLDATA`.

You can run the **mon\_fsstatd** command in two ways.

- Calling `mon_fsstatd` as a systemd service. This method reads the configuration file `/etc/sysconfig/mon_fsstatd`. This method uses the default configuration with an interval of 60 seconds. If you want to use a different interval, consider starting `mon_fsstatd` manually.
- Calling `mon_fsstatd` manually from a command line.

### mon\_fsstatd service utility syntax

If you run the **mon\_fsstatd** daemon as a systemd service unit, you configure the daemon through specifications in a configuration file.



Where:

**start**

starts monitoring of guest file system size, using the configuration in `/etc/sysconfig/mon_fsstatd`.

**stop**

stops monitoring of guest file system size.

**status**

shows current status of guest file system size monitoring.

**restart**

stops and restarts monitoring.

**reload**

reloads the configuration. Use **reload** to re-read the configuration file when it was changed.

**enable**

starts the service automatically at boot time.

**disable**

disables automatic start of the service at boot time.

## Configuration file keywords

**FSSTAT\_INTERVAL="*n*"**

specifies the wanted sampling interval in seconds.

## Examples of systemd service unit use

This example configuration file for `mon_fsstatd` (`/etc/sysconfig/mon_fsstatd`) sets the sampling interval to 30 seconds:

```
FSSTAT_INTERVAL="30"
```

Examples of `mon_fsstatd` use:

- To start guest file system size monitoring:

```
systemctl start mon_fsstatd
```

- To display the status:

```
systemctl status mon_fsstatd
| mon_fsstatd.service - Monitor z/VM guest file system size
...
Active: active (running) since Wed 2018-02-21 14:52:11 CET; 4s ago
```

- To stop guest file system size monitoring:

```
systemctl stop mon_fsstatd
```

- To display the status again and check that monitoring is now stopped:

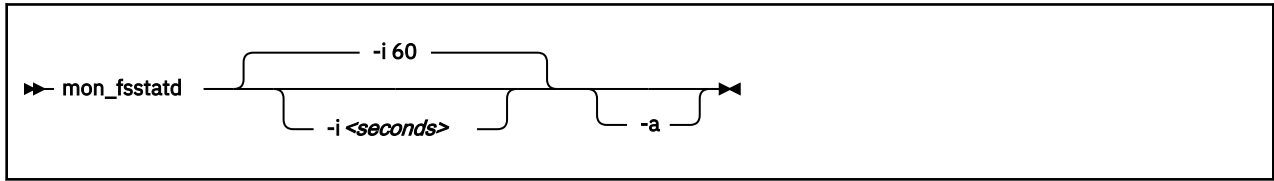
```
systemctl status mon_fsstatd
| mon_fsstatd.service - Monitor z/VM guest file system size
...
Active: inactive (dead)
...
```

- To restart the daemon and re-read the configuration file:

```
systemctl restart mon_fsstatd
```

## mon\_fsstatd command-line syntax

If you call the **mon\_fsstatd** daemon from the command line, you configure the daemon through command parameters.



Where:

- i or --interval <seconds>**  
specifies the wanted sampling interval in seconds.
- a or --attach**  
runs the daemon in the foreground.
- h or --help**  
displays help information for the command. To view the man page, enter **man mon\_fsstatd**.
- v or --version**  
displays version information for the command.

### Examples of command-line use

- To start **mon\_fsstatd** with default setting:

```
> mon_fsstatd
```

- To start **mon\_fsstatd** with a sampling interval of 30 seconds:

```
> mon_fsstatd -i 30
```

- To start **mon\_fsstatd** and have it run in the foreground:

```
> mon_fsstatd -a
```

- To start **mon\_fsstatd** with a sampling interval of 45 seconds and have it run in the foreground:

```
> mon_fsstatd -a -i 45
```

## Processing monitor data

The **mon\_fsstatd** daemon writes physical file system size data for Linux on z/VM to the z/VM monitor stream.

The following is the format of the file system size data that is passed to the z/VM monitor stream. One sample monitor record is written for each physical file system that is mounted at the time of the sample interval. The monitor data in each record contains a header that consists of a time stamp, the length of the data, and an offset. The header is followed by the file system data (as obtained from `statvfs`). The file system data fields begin with "fs\_".

| Type  | Name       | Description                                     |
|-------|------------|-------------------------------------------------|
| __u64 | time_stamp | Time at which the file system data was sampled. |
| __u16 | data_len   | Length of data that follows the header.         |

| <i>Table 73. File system size data format (continued)</i> |             |                                                                                                                                                                                                   |
|-----------------------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Type                                                      | Name        | Description                                                                                                                                                                                       |
| __u16                                                     | data_offset | Offset from start of the header to the start of the file system data (that is, to the fields that begin with fs_).                                                                                |
| __u16                                                     | fs_name_len | Length of the file system name. The file system name can be too long to fit in the monitor record. If so, this length is the portion of the name that is contained in the monitor record.         |
| char [fs_name_len]                                        | fs_name     | The file system name. If the name is too long to fit in the monitor record, the name is truncated to the length in the fs_name_len field.                                                         |
| __u16                                                     | fs_dir_len  | Length of the mount directory name. The mount directory name can be too long to fit in the monitor record. If so, this length is the portion of the name that is contained in the monitor record. |
| char[fs_dir_len]                                          | fs_dir      | The mount directory name. If the name is too long to fit in the monitor record, the name is truncated to the length in the fs_dir_len field.                                                      |
| __u16                                                     | fs_type_len | Length of the mount type. The mount type can be too long to fit in the monitor record. If so, this length is the portion that is contained in the monitor record.                                 |
| char[fs_type_len]                                         | fs_type     | The mount type (as returned by getmntent). If the type is too long to fit in the monitor record, the type is truncated to the length in the fs_type_len field.                                    |
| __u64                                                     | fs_bsize    | File system block size.                                                                                                                                                                           |
| __u64                                                     | fs_fsize    | Fragment size.                                                                                                                                                                                    |
| __u64                                                     | fs_blocks   | Total data blocks in file system.                                                                                                                                                                 |
| __u64                                                     | fs_bfree    | Free blocks in fs.                                                                                                                                                                                |
| __u64                                                     | fs_bavail   | Free blocks avail to non-superuser.                                                                                                                                                               |
| __u64                                                     | fs_files    | Total file nodes in file system.                                                                                                                                                                  |
| __u64                                                     | fs_ffree    | Free file nodes in fs.                                                                                                                                                                            |
| __u64                                                     | fs_favail   | Free file nodes available to non-superuser.                                                                                                                                                       |
| __u64                                                     | fs_flag     | Mount flags.                                                                                                                                                                                      |

Use the time\_stamp to correlate all file systems that were sampled in a given interval.

## Reading the monitor data

All records that are written to the z/VM monitor stream begin with a product identifier.

The product ID is a 16-byte structure of the form pppppppffnvrmm, where for records that are written by mon\_fsstatd, these values are:

### **ppppppp**

is a fixed ASCII string LNXAPPL.

### **ff**

is the application number for mon\_fsstatd = x'0001'.



**n**

is the record number = x'00'.

**vv**

is the version number = x'0000'.

**rr**

is reserved for future use and should be ignored.

**mm**

is reserved for mon\_fsstatd and should be ignored.

**Note:** Though the mod\_level field (mm) of the product ID varies, there is no relationship between any particular mod\_level and file system. The mod\_level field should be ignored by the reader of this monitor data.

There are many tools available to read z/VM monitor data. One such tool is the Linux monreader character device driver. For more information about monreader, see [Chapter 36, “Reading z/VM monitor records,” on page 381](#).

## mon\_procd – Monitor Linux on z/VM

The **mon\_procd** command is a user space daemon that gathers system summary information and information about up to 100 concurrent processes on Linux on z/VM.

The daemon writes this data to the z/VM monitor stream by using the monwriter character device driver. You can start the daemon as a systemd service `mon_procd` or call it manually. When it is called as a systemd service unit, it reads the configuration file `/etc/sysconfig/mon_procd`.

### Before you begin:

- Install the `s390-tools-statd` package, for example with **apt-get**:

```
apt-get install s390-tools-statd
```

- Install the monwriter device driver and set up z/VM to start the collection of monitor sample data. See [Chapter 35, “Writing z/VM monitor records,”](#) on page 377 for information about the setup for and usage of the monwriter device driver.
- Customize the configuration file `/etc/sysconfig/mon_procd` if you plan to call it as a systemd service unit.
- The Linux instance on which the `mon_procd` daemon runs requires a z/VM guest virtual machine with the `OPTION APPLMON` statement in the CP directory entry.

The following publications provide general information about DCSSs, CP commands, and APPLDATA:

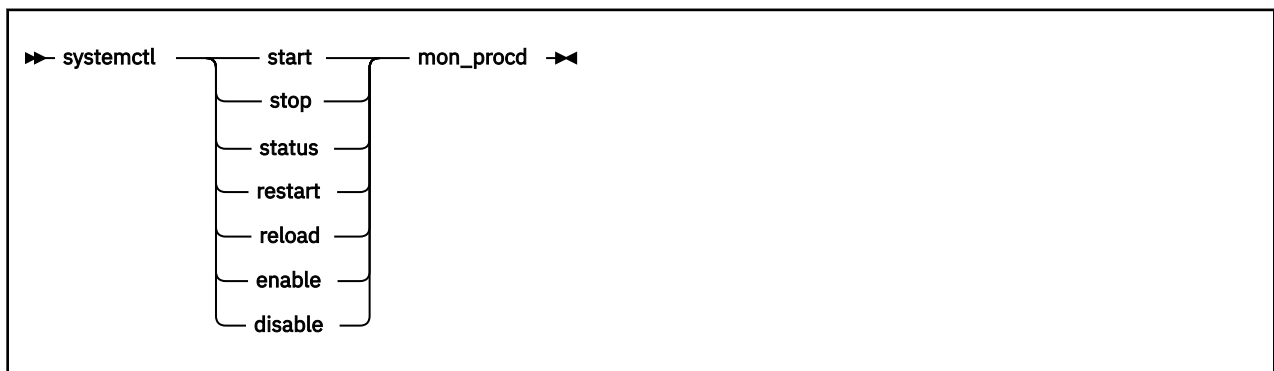
- See *z/VM: Saved Segments Planning and Administration*, SC24-6322 for general information about DCSSs.
- See *z/VM: CP Commands and Utilities Reference*, SC24-6268 for information about the CP commands.
- See *z/VM: Performance*, SC24-6301 for information about monitor APPLDATA.

You can run the **mon\_procd** command in two ways:

- Calling **mon\_procd** as a systemd service. This method reads the configuration file `/etc/sysconfig/mon_procd`. This method uses the default configuration with an interval of 60 seconds. If you want to use a different interval, consider starting `mon_procd` manually.
- Calling **mon\_procd** manually from a command line.

### mon\_procd service utility syntax

If you run the **mon\_procd** daemon as a systemd service unit, you configure the daemon through specifications in a configuration file.



Where:

#### start

starts monitoring of guest process data, using the configuration in `/etc/sysconfig/mon_procd`.

**stop**

stops monitoring of guest process data.

**status**

shows current status of guest process data monitoring.

**restart**

stops and restarts guest process data monitoring.

**reload**

reloads the configuration. Use **reload** to re-read the configuration file when it was changed.

**enable**

starts the service automatically at boot time.

**disable**

disables automatic start of the service at boot time.

**Configuration file keywords****PROC\_INTERVAL="*<n>*"**

specifies the desired sampling interval in seconds.

**PROC="yes | no"**

specifies whether to enable the mon\_procd daemon. Set to "yes" to enable the daemon. Anything other than "yes" will be interpreted as "no".

**Examples of systemd service unit use**

This example configuration file for mon\_procd (/etc/sysconfig/mon\_procd) sets the process monitoring interval to 60 seconds:

```
PROC_INTERVAL=60
```

Examples of mon\_procd use:

- To start guest process data monitoring:

```
systemctl start mon_procd
```

- To display the status:

```
systemctl status mon_procd
| mon_procd.service - Monitor Linux on z/VM
...
Active: active (running) since Mon 2018-02-26 12:16:00 CET; 4s ago
```

- To stop guest process data monitoring:

```
systemctl stop mon_procd
```

- To display the status again and check that monitoring is now stopped:

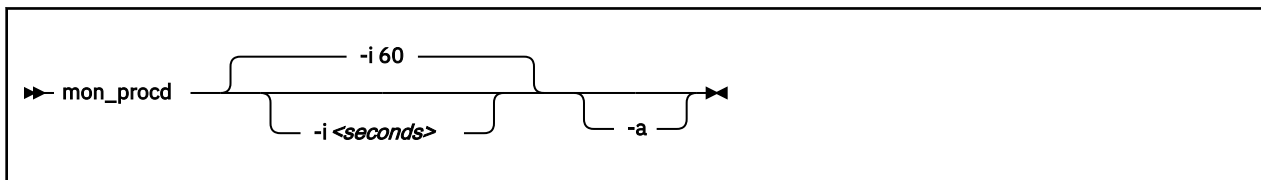
```
systemctl status mon_procd
| mon_procd.service - Monitor Linux on z/VM
...
Active: inactive (dead)
...
```

- To restart the daemon and re-read the configuration file:

```
systemctl restart mon_procd
```

## mon\_procd command-line syntax

If you call the **mon\_procd** daemon from the command line, you configure the daemon through command parameters.



Where:

- i or --interval <seconds>**  
specifies the wanted sampling interval in seconds.
- a or --attach**  
runs the daemon in the foreground.
- h or --help**  
displays help information for the command. To view the man page, enter **man mon\_procd**.
- v or --version**  
displays version information for the command.

### Examples of command-line use

- To start **mon\_procd** with default setting:

```
> mon_procd
```

- To start **mon\_procd** with a sampling interval of 30 seconds:

```
> mon_procd -i 30
```

- To start **mon\_procd** and have it run in the foreground:

```
> mon_procd -a
```

- To start **mon\_procd** with a sampling interval of 45 seconds and have it run in the foreground:

```
> mon_procd -a -i 45
```

## Processing monitor data

The **mon\_procd** daemon writes process data to the z/VM monitor stream.

The data includes system summary information and information of each process for up to 100 processes currently being managed by an instance of Linux on z/VM to the z/VM monitor stream.

At the time of the sample interval, one sample monitor record is written for system summary data. Then, one sample monitor record is written for each process for up to 100 processes currently being managed by the Linux instance. If more than 100 processes exist in a Linux instance at a given time, processes are sorted by the sum of CPU and memory usage percentage values. Only the top 100 processes' data is written to the z/VM monitor stream.

The monitor data in each record begins with a header (a time stamp, the length of the data, and the offset). The data after the header depends on the field "record number" of the 16-bit product ID and can be summary data or process data. See [“Reading the monitor data”](#) on page 639 for details.

Table 74. System summary data format

| Type    | Name          | Description                                                                                                     |
|---------|---------------|-----------------------------------------------------------------------------------------------------------------|
| __u64   | time_stamp    | Time at which the process data was sampled.                                                                     |
| __u16   | data_len      | Length of data that follows the header.                                                                         |
| __u16   | data_offset   | Offset from start of the header to the start of the process data.                                               |
| __u64   | uptime        | Uptime of the Linux instance.                                                                                   |
| __u32   | users         | Number of users on the Linux instance.                                                                          |
| char[6] | loadavg_1     | Load average over the last 1 minute.                                                                            |
| char[6] | loadavg_5     | Load average over the last 5 minutes.                                                                           |
| char[6] | loadavg_15    | Load average over the last 15 minutes.                                                                          |
| __u32   | task_total    | total number of tasks on the Linux instance.                                                                    |
| __u32   | task_running  | Number of running tasks.                                                                                        |
| __u32   | task_sleeping | Number of sleeping tasks.                                                                                       |
| __u32   | task_stopped  | Number of stopped tasks.                                                                                        |
| __u32   | task_zombie   | Number of zombie tasks.                                                                                         |
| __u32   | num_cpus      | Number of CPUs.                                                                                                 |
| __u16   | puser         | A number that represents (100 * percentage of total CPU time used for normal processes executing in user mode). |
| __u16   | pnice         | A number that represents (100 * percentage of total CPU time used for niced processes executing in user mode).  |
| __u16   | psystem       | A number that represents (100 * percentage of total CPU time used for processes executing in kernel mode).      |
| __u16   | pidle         | A number that represents (100 * percentage of total CPU idle time).                                             |
| __u16   | piowait       | A number that represents (100 * percentage of total CPU time used for I/O wait).                                |
| __u16   | pirq          | A number that represents (100 * percentage of total CPU time used for interrupts).                              |
| __u16   | psoftirq      | A number that represents (100 * percentage of total CPU time used for softirqs).                                |
| __u16   | psteal        | A number that represents (100 * percentage of total CPU time spent in stealing).                                |
| __u64   | mem_total     | Total memory in KB.                                                                                             |
| __u64   | mem_used      | Used memory in KB.                                                                                              |
| __u64   | mem_free      | Free memory in KB.                                                                                              |
| __u64   | mem_buffers   | Memory in buffer cache in KB.                                                                                   |
| __u64   | mem_pgpgin    | Data read from disk in KB.                                                                                      |
| __u64   | mem_pgpgout   | Data written to disk in KB                                                                                      |

*Table 74. System summary data format (continued)*

| Type  | Name         | Description                 |
|-------|--------------|-----------------------------|
| __u64 | swap_total   | Total swap memory in KB.    |
| __u64 | swap_used    | Used swap memory in KB.     |
| __u64 | swap_free    | Free swap memory in KB.     |
| __u64 | swap_cached  | Cached swap memory in KB.   |
| __u64 | swap_pswpin  | Pages that are swapped in.  |
| __u64 | swap_pswpout | Pages that are swapped out. |

The following is the format of a process information data that is passed to the z/VM monitor stream.

*Table 75. Process data format*

| Type  | Name        | Description                                                                                                          |
|-------|-------------|----------------------------------------------------------------------------------------------------------------------|
| __u64 | time_stamp  | Time at which the process data was sampled.                                                                          |
| __u16 | data_len    | Length of data that follows the header.                                                                              |
| __u16 | data_offset | Offset from start of the header to the start of the process data.                                                    |
| __u32 | pid         | ID of the process.                                                                                                   |
| __u32 | ppid        | ID of the process parent.                                                                                            |
| __u32 | eid         | Effective user ID of the process owner.                                                                              |
| __u16 | tty         | Device number of the controlling terminal or 0.                                                                      |
| __s16 | priority    | Priority of the process                                                                                              |
| __s16 | nice        | Nice value of the process.                                                                                           |
| __u32 | processor   | Last used processor.                                                                                                 |
| __u16 | pcpu        | A number that represents (100 * percentage of the elapsed cpu time that is used by the process since last sampling). |
| __u16 | pmem        | A number that represents (100 * percentage of physical memory that is used by the process).                          |
| __u64 | total_time  | Total cpu time the process used.                                                                                     |
| __u64 | ctotal_time | Total cpu time the process and its dead child processes used.                                                        |
| __u64 | size        | Total virtual memory that is used by the task in KB.                                                                 |
| __u64 | swap        | Swapped out portion of the virtual memory in KB.                                                                     |
| __u64 | resident    | Non-swapped physical memory that is used by the task in KB.                                                          |
| __u64 | trs         | Physical memory that is devoted to executable code in KB.                                                            |
| __u64 | drs         | Physical memory that is devoted to other than executable code in KB.                                                 |
| __u64 | share       | Shared memory that is used by the task in KB.                                                                        |
| __u64 | dt          | Dirty page count.                                                                                                    |
| __u64 | majflt      | Number of major page faults occurred for the process.                                                                |
| char  | state       | Status of the process.                                                                                               |

| Type                | Name         | Description                                                                                                                       |
|---------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------|
| __u32               | flags        | The process current scheduling flags.                                                                                             |
| __u16               | ruser_len    | Length of real user name of the process owner and should not be larger than 64.                                                   |
| char[ruser_len]     | ruser        | Real user name of the process owner. If the name is longer than 64, the name is truncated to the length 64.                       |
| __u16               | euser_len    | Length of effective user name of the process owner and should not be larger than 64.                                              |
| char[euser_len]     | euser        | Effective user name of the process owner. If the name is longer than 64, the name is truncated to the length 64.                  |
| __u16               | egroup_len   | Length of effective group name of the process owner and should not be larger than 64.                                             |
| char [egroup_len]   | egroup       | Effective group name of the process owner. If the name is longer than 64, the name is truncated to the length 64.                 |
| __u16               | wchan_len    | Length of sleeping in function's name and should not be larger than 64.                                                           |
| char[wchan_len]     | wchan_name   | Name of sleeping in function or '-'. If the name is longer than 64, the name is truncated to the length 64.                       |
| __u16               | cmd_len      | Length of command name or program name that is used to start the process and should not be larger than 64.                        |
| char[cmd_len]       | cmd          | Command or program name that is used to start the process. If the name is longer than 64, the name is truncated to the length 64. |
| __u16               | cmd_line_len | Length of command line that is used to start the process and should not be larger than 1024.                                      |
| char [cmd_line_len] | cmd_line     | Command line that is used to start the process. If the name is longer than 1024, the name is truncated to the length 1024.        |

Use the time\_stamp to correlate all process information that were sampled in a given interval.

## Reading the monitor data

All records that are written to the z/VM monitor stream begin with a product identifier.

The product ID is a 16-byte structure of the form pppppppffnvvrrmm, where for records that are written by mon\_procd, these values are:

### ppppppp

is a fixed ASCII string LNXAPPL.

### ff

is the application number for mon\_procd = x'0002'.

### n

is the record number as follows:

- x'00' indicates summary data.
- x'01' indicates process data.

### vv

is the version number = x'0000'.

## mon\_procd

### rr

is the release number, which can be used to mark different versions of process APPLDATA records.

### mm

is reserved for mon\_procd and should be ignored.

**Note:** Though the mod\_level field (mm) of the product ID varies, there is no relationship between any particular mod\_level and process. The mod\_level field should be ignored by the reader of this monitor data.

This item uses at most 101 monitor buffer records from the monwriter device driver. A maximum number of buffers is set when a monwriter module is loaded. Because of this, the maximum number of buffers must not be less than the sum of buffer records that are used by all monwriter applications.

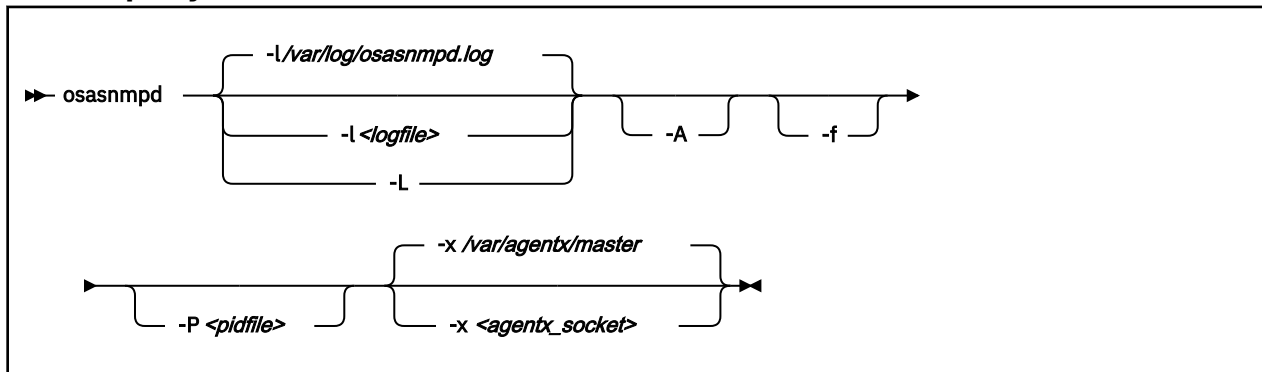
There are many tools available to read z/VM monitor data. One such tool is the Linux monreader character device driver. For more information about monreader, see [Chapter 36, “Reading z/VM monitor records,” on page 381](#).



## osasnmppd – Start OSA-Express SNMP subagent

Use the **osasnmppd** command to start the OSA-Express Simple Network Management Protocol (SNMP) subagent (osasnmppd).

### osasnmppd syntax



#### **-l or --logfile <logfile>**

specifies a file for logging all subagent messages and warnings, including stdout and stderr. If no path is specified, the log file is created in the current directory. The default log file is `/var/log/osasnmppd.log`.

#### **-L or --stderrlog**

prints messages and warnings to stdout or stderr.

#### **-A or --append**

appends to an existing log file rather than replacing it.

#### **-f or --nofork**

prevents forking from the calling shell.

#### **-P or --pidfile <pidfile>**

saves the process ID of the subagent in a file `<pidfile>`. If a path is not specified, the current directory is used.

#### **-x or --sockaddr <agentx\_socket>**

specifies the socket to be used for the AgentX connection. The default socket is `/var/agentx/master`.

The socket can either be a UNIX domain socket path, or the address of a network interface. If a network address of the form `inet-addr:port` is specified, the subagent uses the specified port. If a net address of the form `inet-addr` is specified, the subagent uses the default AgentX port, 705. The AgentX sockets of the snmpd daemon and osasnmppd must match.

#### **-h or --help**

displays help information for the command.

#### **-v or --version**

displays version information for the command.

### Examples

To start the osasnmppd subagent with all default settings:

```
osasnmppd
```

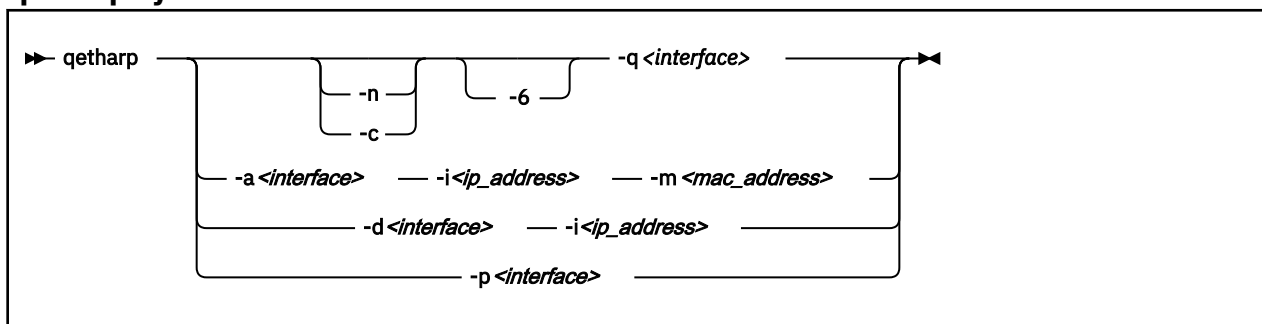
## qetharp - Query and modify ARP data

Use the **qetharp** command to query and purge address data such as MAC and IP addresses from the ARP cache of the OSA and HiperSockets hardware.

### Before you begin:

- The **qetharp** command applies only to devices in layer 3 mode (see “Layer 2 and layer 3” on page 212).
- The **qetharp** command supports IPv6 only for real HiperSockets and z/VM guest LAN HiperSockets.
- For HiperSockets, z/VM guest LAN and VSWITCH interfaces, the **qetharp** command supports only the **--query** option.

### qetharp syntax



Where:

#### **-q or --query**

shows the address resolution protocol (ARP) information about the specified network interface. Depending on the device that the interface was assigned to, this information is obtained from an OSA feature's ARP cache or a HiperSockets ARP cache.

The default command output shows symbolic host names and includes only numerical addresses for host names that cannot be resolved. Use the **-n** option to show numerical addresses instead of host names.

By default, qetharp omits IPv6 related information. Use the **-6** option to include IPv6 information for HiperSockets.

#### **-n or --numeric**

shows numerical addresses instead of trying to resolve the addresses to the symbolic host names. This option can be used only with the **-q** option.

#### **-c or --compact**

limits the output to numerical addresses only. This option can be used only with the **-q** option.

#### **-6 or --ipv6**

includes IPv6 information for HiperSockets. For real HiperSockets, shows the IPv6 addresses. For guest LAN HiperSockets, shows the IPv6 to MAC address mappings. This option can be used only with the **-q** option.

#### **<interface>**

specifies the qeth interface to which the command applies.

#### **-a or --add**

adds a static ARP entry to the OSA adapter. Static entries can be deleted with **-d**.

#### **-d or --delete**

deletes a static ARP entry from the OSA adapter. Static entries are created with **-a**.

**-p or --purge**

flushes the ARP cache of the OSA. The cache contains dynamic ARP entries, which the OSA adapter creates through ARP queries. After flushing the cache, the OSA adapter creates new dynamic entries. This option works only with OSA devices. qetharp returns immediately.

**-i <ip\_address> or --ip <ip\_address>**

specifies the IP address to be added to or removed from the OSA adapter.

**-m <mac\_address> or --mac <mac\_address>**

specifies the MAC address to be added to the OSA adapter.

**-v or --version**

displays version information and exits.

**-h or --help**

displays usage information and exits. To view the man page, enter **man qetharp**.

**Examples**

- Show all ARP entries of the OSA defined as encf500:

```
qetharp -q encf500
```

- Show all ARP entries of the HiperSockets interface that is defined as enc8000 including IPv6 entries:

```
qetharp -6q enc8000
```

- Show all ARP entries of the OSA defined as encf500 without resolving host names:

```
qetharp -nq encf500
```

- Show all ARP entries, including IPv6 entries, of the HiperSockets interface that is defined as enc8000 without resolving host names:

```
qetharp -n6q enc8000
```

- Flush the OSA ARP cache for encf500:

```
qetharp -p encf500
```

- Add a static entry for encf500 and IP address 1.2.3.4 to the OSA ARP cache, with MAC address aa:bb:cc:dd:ee:ff:

```
qetharp -a encf500 -i 1.2.3.4 -m aa:bb:cc:dd:ee:ff
```

- Delete the static entry for encf500 and IP address 1.2.3.4 from the OSA ARP cache.

```
qetharp -d encf500 -i 1.2.3.4
```

## qethconf - Configure qeth devices

Use the **qethconf** command to configure IP address takeover, virtual IP address (VIPA), and proxy ARP for layer3 qeth devices.

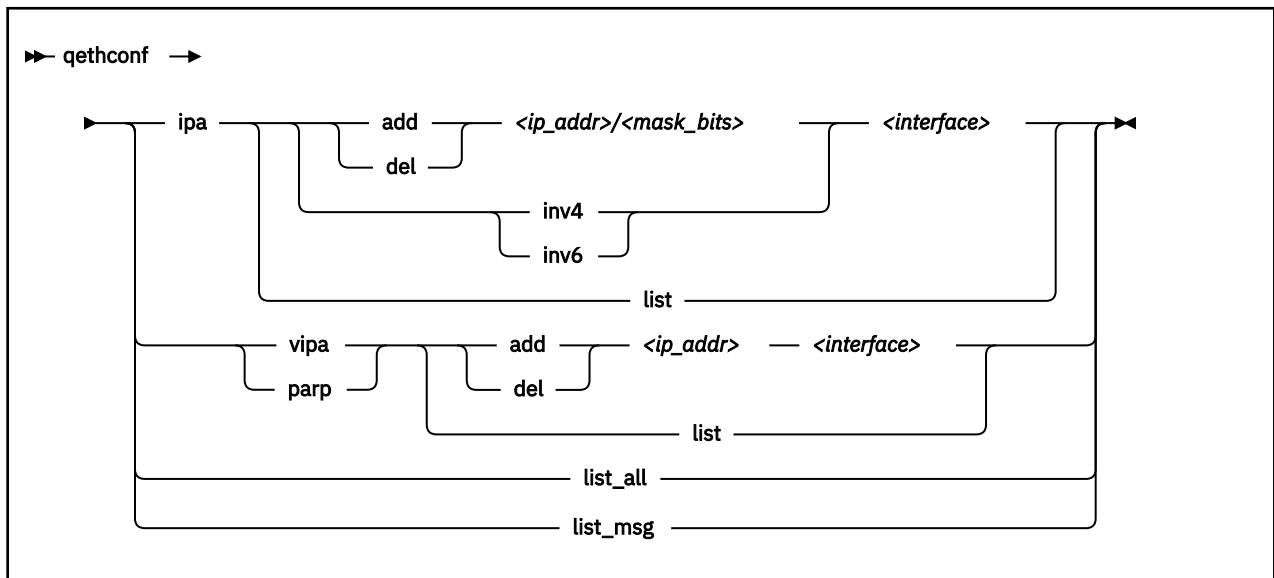
See Chapter 15, “qeth device driver for OSA-Express (QDIO) and HiperSockets,” on page 207 for details about the following concepts:

- IP address takeover
- VIPA (virtual IP address)
- Proxy ARP

You cannot use this command with the layer2 option.

From the arguments that are specified, **qethconf** assembles the function command and redirects it to the corresponding sysfs attributes. You can also use **qethconf** to list the already defined entries.

### qethconf syntax



The **qethconf** command has these function keywords:

#### ipa

configures qeth for IP address takeover (IPA).

#### vipa

configures qeth for virtual IP address (VIPA).

#### parp or rxip

configures qeth for proxy ARP.

The **qethconf** command has these action keywords:

#### add

adds an IP address or address range.

#### del

deletes an IP address or address range.

#### inv4

inverts the selection of address ranges for IPv4 address takeover. This inversion makes the list of IP addresses that was specified with `qethconf add` and `qethconf del` an exclusion list.

**inv6**

inverts the selection of address ranges for IPv6 address takeover. This inversion makes the list of IP addresses that was specified with `qethconf add` and `qethconf del` an exclusion list.

**list**

lists existing definitions for specified qeth function.

**list\_all**

lists existing definitions for IPA, VIPA, and proxy ARP.

**<ip\_addr>**

specifies the IP address. Can be specified in one of these formats:

- IP version 4 format, for example, `192.168.10.38`
- IP version 6 format, for example, `FE80::1:800:23e7:f5db`
- 8- or 32-character hexadecimals prefixed with `-x`, for example, `-xc0a80a26`

**<mask\_bits>**

specifies the number of bits that are set in the network mask. Enables you to specify an address range.

**Example:** A `<mask_bits>` of 24 corresponds to a network mask of `255.255.255.0`.

**<interface>**

specifies the name of the interface that is associated with the specified address or address range.

**list\_msg**

lists qethconf messages and explanations.

**-h or --help**

displays help information. To view the man page, enter `man qethconf`.

**-v or --version**

displays version information.

**Examples**

- List existing proxy ARP definitions:

```
qethconf parp list
parp add 1.2.3.4 encf500
```

- Assume responsibility for packages that are destined for 1.2.3.5:

```
qethconf parp add 1.2.3.5 encf500
qethconf: Added 1.2.3.5 to /sys/class/net/encf500/device/rxip/add4.
qethconf: Use "qethconf parp list" to check for the result
```

Confirm the new proxy ARP definitions:

```
qethconf parp list
parp add 1.2.3.4 encf500
parp add 1.2.3.5 encf500
```

- Configure encf500 for IP address takeover for all addresses that start with 192.168.10:

```
qethconf ipa add 192.168.10.0/24 encf500
qethconf: Added 192.168.10.0/24 to /sys/class/net/encf500/device/ipa_takeover/add4.
qethconf: Use "qethconf ipa list" to check for the result
```

Display the new IP address takeover definitions:

```
qethconf ipa list
ipa add 192.168.10.0/24 encf500
```

- Configure VIPA for ence400:

## qethconf

```
qethconf vipa add 10.99.3.3 ence400
qethconf: Added 10.99.3.3 to /sys/class/net/ence400/device/vipa/add4.
qethconf: Use "qethconf vipa list" to check for the result
```

Display the new VIPA definitions:

```
qethconf vipa list
vipa add 10.99.3.3 ence400
```

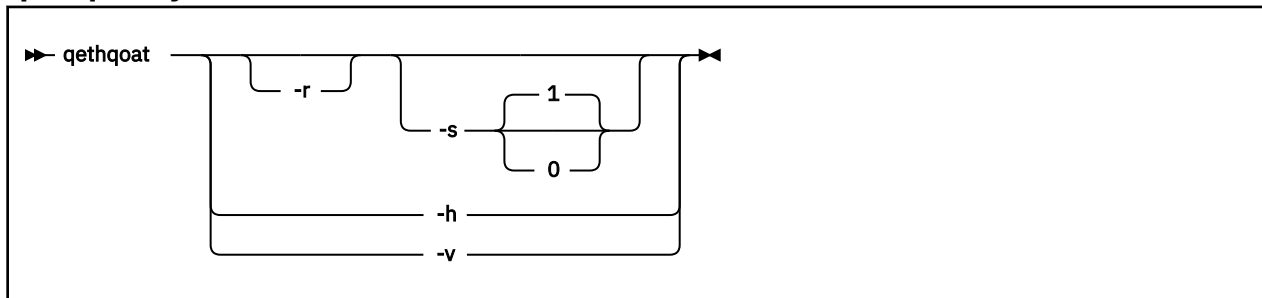
- List all existing IPA, VIPA, and proxy ARP definitions.

```
qethconf list_all
parp add 1.2.3.4 encf500
parp add 1.2.3.5 encf500
ipa add 192.168.10.0/24 encf500
vipa add 10.99.3.3 ence400
```

## qethqoat - Query OSA address table

Use the **qethqoat** command to query the OSA address table and display physical and logical device information.

### qethqoat syntax



where:

**-r or --raw**

writes raw data to stdout.

**-s or --scope**

defines the scope of the query. The following values are valid:

**0**

queries the level of the OSA address table.

**1**

interface (this option is the default).

**-h or --help**

displays help information. To view the man page, enter **man qethqoat**.

**-v or --version**

displays version information.

### Examples

To display physical and logical device information for interface encf500, issue:

## qethqoat

```
qethqoat encf500
PCHID: 0x0310
CHPID: 0xa9
Manufacturer MAC address: 6c:ae:8b:48:0b:68
Configured MAC address: 00:00:00:00:00:00
Data device sub-channel address: 0xf402
CULA: 0x00
Unit address: 0x02
Physical port number: 0
Number of output queues: 1
Number of input queues: 1
Number of active input queues: 0
CHPID Type: OSD
Interface flags: 0x0a000000
OSA Generation: OSA-Express7S
Port speed/mode: 25 Gb/s / full duplex

Port media type: multi mode (SR/SX)
Jumbo frames: yes
Firmware: 0x00000c9a

IPv4 router: no
IPv6 router: no
IPv4 vmac router: no
IPv6 vmac router: no
Connection isolation: not active
Connection isolation VEPA: no
IPv4 assists enabled: 0x00111c77
IPv6 assists enabled: 0x00f15c60
IPv4 outbound checksum enabled: 0x0000003a
IPv6 outbound checksum enabled: 0x00000000
IPv4 inbound checksum enabled: 0x0000003a
IPv6 inbound checksum enabled: 0x00000000

IPv4 Multicast Address: MAC Address:

224.0.0.1 01:00:5e:00:00:01

IPv6 Address: IPA Flags:

fe80::6cae:8b00:748:b68 0x00000000

IPv6 Multicast Address: MAC Address:

ff01::1 33:33:00:00:00:01
ff02::1 33:33:00:00:00:01
ff02::1:ff48:b68 33:33:ff:48:0b:68
ff02::1:3 33:33:00:01:00:03
```

This example uses scope 0 to query the supported OAT level and descriptor header types.

```
qethqoat -s 0 encf500
Supported Scope mask: 0x00000001
Supported Descriptor hdr types: 0x0001070f
```

This example shows how the binary output from **qethqoat** can be processed in another tool. Here it is displayed in a hexdump viewer:



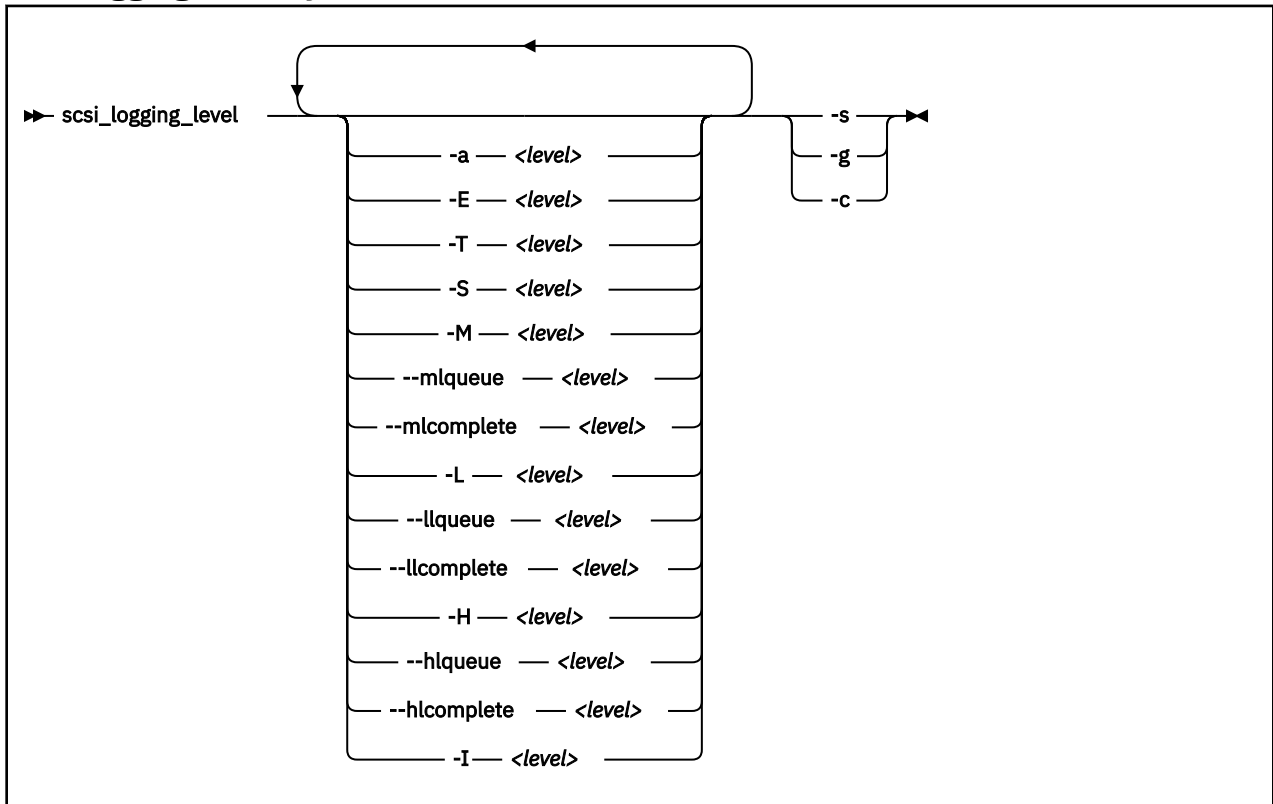
```
qethqoat -r encf500 | hexdump
00000000 0158 0000 0008 0000 0000 0101 0000 0000
00000010 0000 0001 0000 0000 0000 0000 0000 0000
00000020 0004 0050 0001 0000 0000 0000 d7c8 4040
00000030 0120 0094 001a 643b 8a22 0000 0000 0000
00000040 e102 0002 0000 0004 0001 0000 0800 0000
00000050 0100 0480 0000 0766 0000 0000 0000 0000
00000060 0000 0000 0000 0000 0000 0000 0000 0000
00000070 0008 0060 0001 0000 0000 0000 d3c8 4040
00000080 0000 0000 0000 0000 0000 0000 0000 0000
00000090 0000 0000 0000 0000 0000 0000 0011 1c77
000000a0 0021 5c60 0000 001a 0000 0000 0000 001a
000000b0 0000 0000 0000 0000 0000 0000 0000 0000
000000c0 0002 0000 0000 0000 0000 0000 0000 0000
000000d0 0010 0030 0001 0000 0000 0000 c4c8 f4d4
000000e0 0000 0002 0000 0000 0000 0001 0000 0010
000000f0 0001 0001 0000 0000 0000 0000 0000 0000
00001000 e000 0001 0100 5e00 0001 0000 0000 0000
00001100 0010 0030 0001 0000 0000 0000 c4c8 f6d4
00001200 0000 0008 0000 0000 0000 0001 0000 0018
00001300 0001 0001 0000 0000 0000 0000 0000 0000
00001400 ff02 0000 0000 0000 0000 0000 0000 0001
00001500 3333 0000 0001 0000
0000158
```

## scsi\_logging\_level - Set and get the SCSI logging level

Use the **scsi\_logging\_level** command to create, set, or get the SCSI logging level.

The SCSI logging feature is controlled by a 32-bit value – the SCSI logging level. This value is divided into 3-bit fields that describe the log level of a specific log area. Due to the 3-bit subdivision, setting levels or interpreting the meaning of current levels of the SCSI logging feature is not trivial. The `scsi_logging_level` script helps with both tasks.

### scsi\_logging\_level syntax



Where:

- a <level> or --all <level>**  
specifies value for all SCSI\_LOG fields.
- E <level> or --error <level>**  
specifies SCSI\_LOG\_ERROR.
- T <level> or --timeout <level>**  
specifies SCSI\_LOG\_TIMEOUT.
- S <level> or --scan <level>**  
specifies SCSI\_LOG\_SCAN.
- M <level> or --midlevel <level>**  
specifies SCSI\_LOG\_MLQUEUE and SCSI\_LOG\_MLCOMPLETE.
- mlqueue <level>**  
specifies SCSI\_LOG\_MLQUEUE.
- mlcomplete <level>**  
specifies SCSI\_LOG\_MLCOMPLETE.
- L <level> or --lowlevel <level>**  
specifies SCSI\_LOG\_LLQUEUE and SCSI\_LOG\_LLCOMPLETE.

- llqueue <level>**  
specifies SCSI\_LOG\_LLQUEUE.
- llcomplete <level>**  
specifies SCSI\_LOG\_LLCOMPLETE.
- H <level> or --highlevel <level>**  
specifies SCSI\_LOG\_HLQUEUE and SCSI\_LOG\_HLCOMPLETE.
- hlqueue <level>**  
specifies SCSI\_LOG\_HLQUEUE.
- hlcomplete <level>**  
specifies SCSI\_LOG\_HLCOMPLETE.
- I <level> or --ioctl <level>**  
specifies SCSI\_LOG\_IOCTL.
- s or --set**  
creates and sets the logging level as specified on the command line.
- g or --get**  
gets the current logging level.
- c or --create**  
creates the logging level as specified on the command line.
- v or --version**  
displays version information.
- h or --help**  
displays help text.

You can specify several SCSI\_LOG fields by using several options. When multiple options specify the same SCSI\_LOG field, the most specific option has precedence.

### Examples

- This command displays the logging word of the SCSI logging feature and each logging level.

```
scsi_logging_level -g
Current scsi logging level:
dev.scsi.logging_level = 0
SCSI_LOG_ERROR=0
SCSI_LOG_TIMEOUT=0
SCSI_LOG_SCAN=0
SCSI_LOG_MLQUEUE=0
SCSI_LOG_MLCOMPLETE=0
SCSI_LOG_LLQUEUE=0
SCSI_LOG_LLCOMPLETE=0
SCSI_LOG_HLQUEUE=0
SCSI_LOG_HLCOMPLETE=0
SCSI_LOG_IOCTL=0
```

- This command sets all logging levels to 3:

```
scsi_logging_level -s -a 3
New scsi logging level:
dev.scsi.logging_level = 460175067
SCSI_LOG_ERROR=3
SCSI_LOG_TIMEOUT=3
SCSI_LOG_SCAN=3
SCSI_LOG_MLQUEUE=3
SCSI_LOG_MLCOMPLETE=3
SCSI_LOG_LLQUEUE=3
SCSI_LOG_LLCOMPLETE=3
SCSI_LOG_HLQUEUE=3
SCSI_LOG_HLCOMPLETE=3
SCSI_LOG_IOCTL=3
```

- This command sets SCSI\_LOG\_HLQUEUE=3, SCSI\_LOG\_HLCOMPLETE=2 and assigns all other SCSI\_LOG fields the value 1.

## scsi\_logging\_level

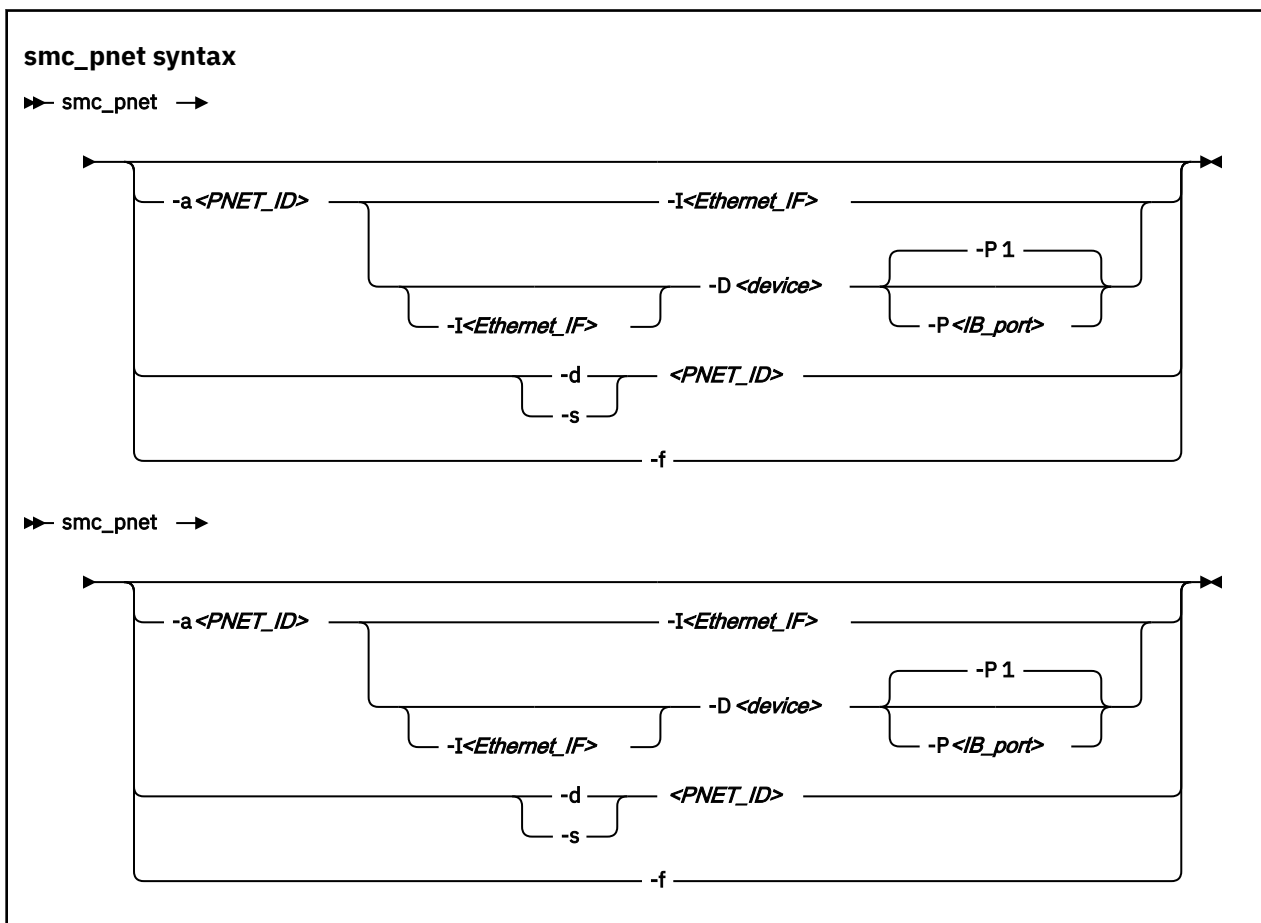
```
scsi_logging_level --hlqueue 3 --highlevel 2 --all 1 -s
New scsi logging level:
dev.scsi.logging_level = 174363209
SCSI_LOG_ERROR=1
SCSI_LOG_TIMEOUT=1
SCSI_LOG_SCAN=1
SCSI_LOG_MLQUEUE=1
SCSI_LOG_MLCOMPLETE=1
SCSI_LOG_LLQUEUE=1
SCSI_LOG_LLCOMPLETE=1
SCSI_LOG_HLQUEUE=3
SCSI_LOG_HLCOMPLETE=2
SCSI_LOG_IOCTL=1
```

## smc\_pnet - Create network mapping table

Use the **smc\_pnet** command to map a RoCE adapter port to a standard Ethernet interface.

The SMC protocol requires grouping of standard Ethernet and RoCE networks or ISM devices. Such groups are called physical networks (PNETs). The mapping is configured within a table called PNET table. Within the same Converged Ethernet fabric, any available Ethernet interface can be combined with an available RDMA-capable network interface card (RNIC) or a DMA-capable ISM device.

**Note:** The mapping of a RoCE adapter port or ISM device to a standard Ethernet interface can be defined in the IOCDS or it can be defined as an entry in a PNET table. Only use the **smc\_pnet** command if the IOCDS does not contain the required PNET IDs. IOCDS specifications override PNET table entries that are created with **smc\_pnet**.



Enter **smc\_pnet** without parameters to display all entries in the PNET table.

**-a <PNET\_ID> or --add <PNET\_ID>**

creates a new entry in the PNET table and allocates the specified ID, if it does not already exist. Only one entry can be defined for a specific Ethernet interface and a specific Infiniband device port or ISM device. A PNET ID consists of up to 16 alphanumeric uppercase characters without blanks.

**-I <Ethernet\_IF> or --interface <Ethernet\_IF>**

specifies the name of the Ethernet interface for a new PNET.

**-D <IB\_device> or --ibdevice <IB\_device>**

specifies the name of the Infiniband device or ISM device for a new PNET.

**-P <IB\_port> or --ibport <IB\_port>**

Optional: specifies the port number of the Infiniband device port. Valid values are 1 or 2. The default value is 1.

- s <PNET\_ID> or --show <PNET\_ID>**  
displays the PNET table entry with the specified ID.
- d <PNET\_ID> or --delete <PNET\_ID>**  
deletes the PNET table entry with the specified ID.
- f or --flush**  
removes all entries from the PNET table.
- h or --help**  
displays help information for the command.
- v or --version**  
displays the version number of **smc\_pnet**.

### Examples

- To create a PNET with ID ABC for the Ethernet interface names eth0 and bond0, and add Infiniband device with ID 0001:00:00.0 on port number 2 and ISM device with ID 0004:00:00.0 on port 1:

```
smc_pnet -a ABC -I eth0
smc_pnet -a ABC -I bond0
smc_pnet -a ABC -D 0001:00:00.0 -P 2
smc_pnet -a ABC -D 0004:00:00.0
```

- To show all PNET entries:

```
smc_pnet
ABC eth0 n/a 255
ABC bond0 n/a 255
ABC n/a 0001:00:00.0 2
ABC n/a 0004:00:00.0 1
```

- To define PNET ID XYZ for the Ethernet interface name vlan0201 and the InfiniBand device ID 0001:00:00.0 on port 1:

```
smc_pnet -a XYZ -I vlan0201 -D 0001:00:00.0 -P 1
```

- To show all entries for PNET ID XYZ:

```
smc_pnet -s XYZ
XYZ vlan0201 n/a 255
XYZ n/a 0001:00:00.0 1
```

- To delete a PNET table entry with PNET ID ABC:

```
smc_pnet -d ABC
```

- To delete all entries in the PNET table:

```
smc_pnet -f
```

For command return codes, see the man page.

## smc\_run - Run a TCP socket program with the SMC protocol using a preloaded library

Use the **smc\_run** command to start a TCP socket program that uses SMC as the networking protocol.

### smc\_run syntax

```

▶▶ smc_run -d <program> — <program parameters> ▶▶

```

Where:

### **smc\_run <program> <program\_parameters>**

Starts the specified TCP socket program with the specified parameters, using the SMC protocol.

### **-d**

Optional: Display diagnostic messages while the program is running.

### Examples

- To start a program called iperf3 with parameters "-s -p 12345":

```

smc_run iperf3 -s -p 12345

Server listening on 12345

...

```

- To start a program called iperf3 with parameters "-s -p 12345" and diagnostic messages:

```

smc_run -d iperf3 -s -p 12345

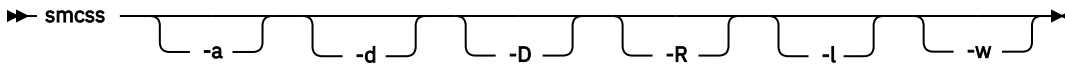
```

For command return codes, see the man page.

## smcss - Display information about the AF\_SMC sockets and link groups

Use the **smcss** command to display information about the AF\_SMC sockets and link groups.

### smcss syntax



Entering **smcss** without any parameters displays a list of connecting, closing, or connected SMC sockets.

#### **-a or --all**

lists all SMC sockets: listening, opening, closing, and connected.

#### **-d or --debug**

displays debug information, such as the shutdown state.

#### **-D or --smcd**

lists SMC-D sockets only. Displays additional SMC-D specific information.

#### **-R or --smcr**

lists SMC-R sockets only. Displays additional SMC-R specific information.

#### **-l or --listening**

lists listening sockets only. These are omitted in the default listing.

#### **-w or --wide**

prevents truncation of IP addresses.

#### **-h or --help**

displays help information for the command.

#### **-v or --version**

displays the version number of **smcss**.

### Meaning of the output fields

| Entry | Values and meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| State | <p><b>INIT</b><br/>The SMC socket is being initialized. It is not connected nor listening yet.</p> <p><b>CLOSED</b><br/>The SMC socket is closed. It is not connected nor listening anymore.</p> <p><b>LISTEN</b><br/>The SMC socket is a listening socket, waiting for incoming connection requests.</p> <p><b>ACTIVE</b><br/>The SMC socket has an established connection. In this state, the TCP connection is fully established, rendezvous processing has been completed, and SMC peers can exchange data via RDMA.</p> <p><b>PEERCLW1</b><br/>No further data will be sent to the peer.</p> <p><b>PEERCLW2</b><br/>No further data will be sent to or received from the peer.</p> <p><b>APPLCLW1</b><br/>No further data will be received from the peer.</p> |



| Entry         | Values and meaning                                                                                                                                                                                                                                                                                                                                                              |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <p><b>APPLCLW2</b><br/>No further data will be received from or sent to the peer.</p> <p><b>APPLFINCLW</b><br/>The peer has closed the socket.</p> <p><b>PEERFINCLW</b><br/>The socket is closed locally.</p> <p><b>PEERABORTW</b><br/>The socket was abnormally closed locally.</p> <p><b>PROCESSABORT</b><br/>The peer has closed the socket abnormally.</p>                  |
| Inode         | denotes the inode of the SMC socket.                                                                                                                                                                                                                                                                                                                                            |
| UID           | denotes the unique ID of the SMC socket.                                                                                                                                                                                                                                                                                                                                        |
| Local Address | denotes address and port number of the local end of the SMC socket. Trailing dots indicate a truncated address. Use the -w option to display full addresses.                                                                                                                                                                                                                    |
| Peer Address  | denotes address and port number of the remote end of the socket.                                                                                                                                                                                                                                                                                                                |
| Intf          | denotes that if the socket is explicitly bound with <b>setsockopt</b> option SO_BINDTODEVICE, Intf shows the interface number of the Ethernet device to which the socket is bound.                                                                                                                                                                                              |
| Mode          | <p>can have the following values:</p> <p><b>SMCD</b><br/>The SMC socket uses SMC-D for data exchange.</p> <p><b>SMCR</b><br/>The SMC socket uses SMC-R for data exchange.</p> <p><b>TCP</b><br/>An SMC connection could not be established. The SMC socket uses the TCP protocol for data exchange.</p>                                                                         |
| ShutD         | <p>(shutdown) can take the following values:</p> <p><b>&lt;-&gt;</b><br/>The SMC socket has not been shut down.</p> <p><b>R-&gt;</b><br/>The SMC socket is shut down one-way and cannot receive data.</p> <p><b>&lt;-W</b><br/>The SMC socket is shut down one-way and cannot send data.</p> <p><b>R-W</b><br/>The SMC socket is shut down and cannot receive or send data.</p> |
| Token         | is a unique ID of the SMC socket connection.                                                                                                                                                                                                                                                                                                                                    |
| Sndbuf        | denotes the size of the to-be-sent window of the SMC socket connection.                                                                                                                                                                                                                                                                                                         |
| Rcvbuf        | denotes the size of the receiving window of the SMC socket connection (filled by peer).                                                                                                                                                                                                                                                                                         |
| Peerbuf       | denotes the size of the peer receiving window of the SMC socket connection (to fill during RDMA-transfer).                                                                                                                                                                                                                                                                      |
| rxprod-Cursor | Describes the current cursor location of the "Rcvbuf" for data to be received from the peer.                                                                                                                                                                                                                                                                                    |

| Entry         | Values and meaning                                                                                                                                                                                          |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| rxcons-Cursor | Describes the current cursor location of the "Peerbuf" for data sent to peer and confirmed by the peer.                                                                                                     |
| rxFlags       | SMC socket connection flags set by and received from the peer.                                                                                                                                              |
| txprod-Cursor | Describes the current cursor location of the "Peerbuf" for data sent to peer.                                                                                                                               |
| txcons-Cursor | Describes the current cursor location of the "Rcvbuf" for data received from the peer and confirmed to the peer.                                                                                            |
| txFlags       | SMC socket connection flags set locally and sent to the peer.                                                                                                                                               |
| txprep-Cursor | Describes the current cursor location of the "Sndbuf" for data to be sent. The data is to be moved to the "Peerbuf" by using RDMA-write.                                                                    |
| txsent-Cursor | Describes the current cursor location of the "Sndbuf" for data sent. The data was moved to the "Peerbuf" by using RDMA-write.                                                                               |
| txfin-Cursor  | Describes the current cursor location of the "Sndbuf" for data sent and send completion confirmed. The data was moved to the "Peerbuf" by using RDMA-write and completion was confirmed.                    |
| Role          | "Role" can take the following values:<br><b>CLNT</b><br>The link group of the SMC socket is used for client connections.<br><b>SERV</b><br>The link group of the SMC socket is used for server connections. |
| IB-Device     | Name of the RoCE device used by the link group to which the SMC socket belongs.                                                                                                                             |
| Port          | Port of the RoCE device used by the link group to which the SMC socket belongs.                                                                                                                             |
| Linkid        | unique link ID of the link within the link group to which the SMC socket belongs.                                                                                                                           |
| GID           | Group identifier of the RoCE port used by the link group to which the SMC socket belongs.                                                                                                                   |
| Peer-GID      | GID of the foreign RoCE port used by the link group to which the SMC socket belongs.                                                                                                                        |

## Examples

- To display information about all SMC sockets on the server:

```
[root@myserver]# smcss -a
State UID Inode Local Address Peer Address Intf Mode
INIT 00000 0000000
ACTIVE 00000 0060177 ::ffff:10.100.80...:6668 ::ffff:10.100.8...:40812 0000 SMCD
ACTIVE 00000 0060173 ::ffff:10.100.80...:6668 ::ffff:10.100.8...:40804 0000 SMCD
LISTEN 00000 0059058 :::6668
```

- To list listening sockets on the server:

```
[root@myserver]# smcss -l
State UID Inode Local Address Peer Address Intf Mode
LISTEN 00000 0059058 :::6668
```

- To display debug information about all SMC sockets on the server:

```
[root@myserver]# smcss -d
State UID Inode Local Address Peer Address Intf Mode Shutd Token
ACTIVE 00000 0060177 ::ffff:10.100.80.:6668 ::ffff:10.100.8.:40812 0000 SMCD <-> 00...
ACTIVE 00000 0060173 ::ffff:10.100.80.:6668 ::ffff:10.100.8.:40804 0000 SMCD <-> 00...
...
```

For command return codes, see the man page.



**-k or --key**

sets tape encryption keys. You can specify the `-k` option only if the tape medium is loaded and rewound. While processing the `-k` option, the tape medium is initialized and all previous data contained on the tape medium is lost.

You can specify the `-k` option twice because the tape medium can store two EEDKs. If you specify the `-k` option once, two identical EEDKs are stored.

**<value>**

specifies the key encrypting key (KEK), which can be up to 64 characters long. The keywords `label` or `hash` specify how the KEK in `<value>` is to be stored on the tape medium. The default store type is `label`.

**-d or --delimiter**

specifies the character that separates the KEK in `<value>` from the store type (`label` or `hash`). The default delimiter is `:` (colon).

**<char>**

is a character that separates the KEK in `<value>` from the store type (`label` or `hash`).

**-f or --force**

specifies that no prompt message is to be issued before writing the KEK information and initializing the tape medium.

**<node>**

specifies the device node of the tape device.

**-h or --help**

displays help text. To view the man page, enter `man tape390_crypt`.

**-v or --version**

displays information about the version.

**Examples**

The following scenarios illustrate the most common use of tape encryption. In all examples `/dev/ntibm0` is used as the tape device.

**Querying a tape device before and after encryption is turned on**

This example shows a query of tape device `/dev/ntibm0`. Initially, encryption for this device is off. Encryption is then turned on, and the status is queried again.

```
tape390_crypt -q /dev/ntibm0
ENCRYPTION: OFF
MEDIUM: NOT ENCRYPTED

tape390_crypt -e on /dev/ntibm0

tape390_crypt -q /dev/ntibm0
ENCRYPTION: ON
MEDIUM: NOT ENCRYPTED
```

Then, two keys are set, one in label format and one in hash format. The status is queried and there is now additional output for the keys.

```
tape390_crypt -k my_first_key:label -k my_second_key:hash /dev/ntibm0
--->> ATTENTION! <<---
All data on tape /dev/ntibm0 will be lost.
Type "yes" to continue: yes
SUCCESS: key information set.

tape390_crypt -q /dev/ntibm0
ENCRYPTION: ON
MEDIUM: ENCRYPTED
KEY1:
 value: my_first_key
 type: label
 ontape: label
KEY2:
 value: my_second_key
 type: label
 ontape: hash
```

### Using default keys for encryption

1. Load the cartridge. If the cartridge is already loaded:

- Switch off encryption:

```
tape390_crypt -e off /dev/ntibm0
```

- Rewind:

```
mt -f /dev/ntibm0 rewind
```

2. Switch encryption on:

```
tape390_crypt -e on /dev/ntibm0
```

3. Write data.

### Using specific keys for encryption

1. Load the cartridge. If the cartridge is already loaded, rewind:

```
mt -f /dev/ntibm0 rewind
```

2. Switch encryption on:

```
tape390_crypt -e on /dev/ntibm0
```

3. Set new keys:

```
tape390_crypt -k key1 -k key2 /dev/ntibm0
```

4. Write data.

### Writing unencrypted data

1. Load the cartridge. If the cartridge is already loaded, rewind:

```
mt -f /dev/ntibm0 rewind
```

2. If encryption is on, switch off encryption:

```
tape390_crypt -e off /dev/ntibm0
```

3. Write data.

### Appending new files to an encrypted cartridge

1. Load the cartridge

2. Switch encryption on:

```
tape390_crypt -e on /dev/ntibm0
```

3. Position the tape.
4. Write data.

## Reading an encrypted tape

1. Load the cartridge
2. Switch encryption on:

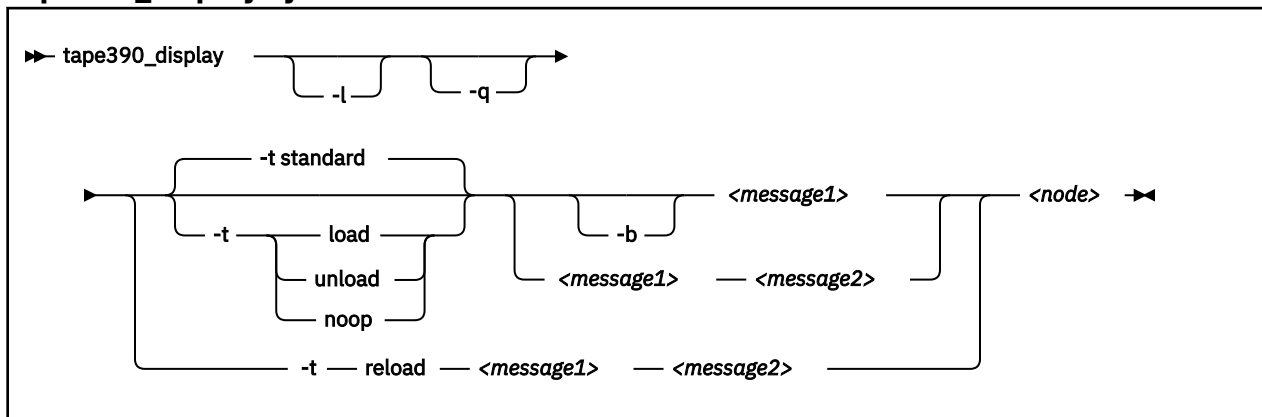
```
tape390_crypt -e on /dev/ntibm0
```

3. Read data.

## tape390\_display - Display messages on tape devices and load tapes

Use the **tape390\_display** command to show messages on the display unit of a physical tape device, optionally in conjunction with loading a tape.

### tape390\_display syntax



where:

#### **-l or --load**

instructs the tape unit to load the next indexed tape from the automatic tape loader (if installed). Ignored if no loader is installed or if the loader is not in "system" mode. The loader "system" mode allows the operating system to handle tape loads.

#### **-t or --type**

The possible values have the following meanings:

##### **standard**

displays the message or messages until the physical tape device processes the next tape movement command.

##### **load**

displays the message or messages until a tape is loaded; if a tape is already loaded, the message is ignored.

##### **unload**

displays the message or messages while a tape is loaded; if no tape is loaded, the message is ignored.

##### **reload**

displays the first message while a tape is loaded and the second message when the tape is removed. If no tape is loaded, the first message is ignored and the second message is displayed immediately. The second message is displayed until the next tape is loaded.

##### **noop**

is intended for test purposes only. It accesses the tape device but does not display the message or messages.

#### **-b or --blink**

causes *<message1>* to be displayed repeatedly for 2 seconds with a half-second pause in between.

#### **<message1>**

is the first or only message to be displayed. The message can be up to 8 byte.

#### **<message2>**

is a second message to be displayed alternately with the first, at 2-second intervals. The message can be up to 8 byte.



**<node>**

is a device node of the target tape device

**-q or --quiet**

suppresses all error messages.

**-h or --help**

displays help text. To view the man page, enter **man tape390\_display**.

**-v or --version**

displays information about the version.

**Note:**

1. Symbols that can be displayed include:

**Alphabetic characters:**

A through Z (uppercase only) and spaces. Lowercase letters are converted to uppercase.

**Numeric characters:**

0 1 2 3 4 5 6 7 8 9

**Special characters:**

@ \$ # , . / ' ( ) \* & + - = % : \_ < > ? ;

The following are included in the 3490 hardware reference but might not display on all devices: | ¢

2. If only one message is defined, it remains displayed until the tape device driver next starts to move or the message is updated.
3. If the messages contain spaces or shell-sensitive characters, they must be enclosed in quotation marks.

**Examples**

The following examples assume that you are using standard devices nodes and not device nodes that are created by udev:

- Alternately display "BACKUP" and "COMPLETE" at 2-second intervals until device /dev/ntibm0 processes the next tape movement command:

```
tape390_display BACKUP COMPLETE /dev/ntibm0
```

- Display the message "REM TAPE" while a tape is in the physical tape device followed by the message "NEW TAPE" until a new tape is loaded:

```
tape390_display --type reload "REM TAPE" "NEW TAPE" /dev/ntibm0
```

- Attempts to unload the tape and load a new tape automatically, the messages are the same as in the previous example:

```
tape390_display -l -t reload "REM TAPE" "NEW TAPE" /dev/ntibm0
```

## tunedasd - Adjust low-level DASD settings

Use the **tunedasd** command to adjust performance relevant settings and other low-level DASD device settings.

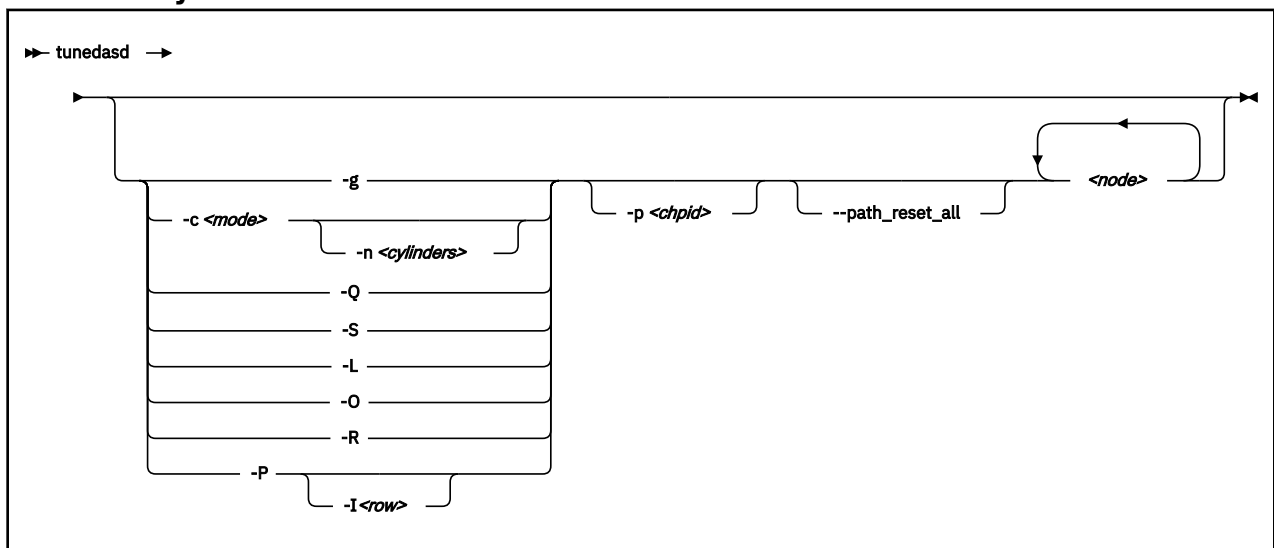
In particular, you can perform these tasks:

- Query and set a DASD's cache mode
- Display and reset DASD performance statistics

**Tip:** Use the **dasdstat** command to display performance statistics. This command includes and extends the statistics that are available through the **tunedasd** command.

- Reserve and release DASD
- Break the lock of an online DASD (to learn how to access a boxed DASD that is not yet online, see [“Accessing DASD by force”](#) on page 125)

### tunedasd syntax



Where:

#### <node>

specifies a device node for the DASD to which the command is to be applied.

#### -g or --get\_cache

gets the current caching mode of the storage controller. This option applies to ECKD only.

#### -c <mode> or --cache <mode>

Sets the caching mode on the storage controller to <mode>. This option applies to ECKD only.

Today's ECKD devices support the following behaviors:

#### normal

for normal cache replacement.

#### bypass

to bypass cache.

#### inhibit

to inhibit cache.

#### sequential

for sequential access.

#### prestige

for sequential prestige.

**record**

for record access.

**-n <cylinders> or --no\_cyl <cylinders>**

specifies the number of cylinders to be cached. This option applies to ECKD only.

**-Q or --query\_reserve**

queries the reserve status of the device. The status can be:

**none**

the device is not reserved.

**implicit**

the device is not reserved, but there is a contingent or implicit allegiance to this Linux instance.

**other**

the device is reserved to another operating system instance.

**reserved**

the device is reserved to this Linux instance.

For details, see the "Storage Control Reference" of the attached storage server.

This option applies to ECKD only.

**-S or --reserve**

reserves the device. This option applies to ECKD only.

**-L or --release**

releases the device. This option applies to ECKD only.

**-O or --slock**

unconditionally reserves the device. This option applies to ECKD only.

**Note:** This option is to be used with care as it breaks any existing reserve by another operating system.

**-R or --reset\_prof**

resets the profile information of the device.

**-P or --profile**

displays a usage profile of the device.

**-I <row> or --prof\_item <row>**

displays the usage profile item that is specified by <row>. <row> can be one of:

**reqs**

number of DASD I/O requests.

**sects**

number of 512-byte sectors.

**sizes**

histogram of sizes.

**total**

histogram of I/O times.

**totsect**

histogram of I/O times per sector.

**start**

histogram of I/O time until ssch.

**irq**

histogram of I/O time between ssch and irq.

**irqsect**

histogram of I/O time between ssch and irq per sector.

**end**

histogram of I/O time between irq and end.

**queue**

number of requests in the DASD internal request queue at enqueueing.

**-p or --path\_reset <chpid>**

resets a channel path <chpid> of a selected device. A channel path might be suspended due to high IFCC error rates or a High Performance FICON failure. Use this option to resume considering the channel path for I/O.

**--path\_reset\_all**

resets all channel paths of a selected device. The channel paths might be suspended due to high IFCC error rates or a High Performance FICON failure. Use this option to resume considering all defined channel paths for I/O.

**-v or --version**

displays version information.

**-h or --help**

displays help information. To view the man page, enter **man tunedasd**.

**Examples**

- The following sequence of commands first checks the reservation status of a DASD and then reserves it:

```
tunedasd -Q /dev/dasdzzz
none
tunedasd -S /dev/dasdzzz
Reserving device </dev/dasdzzz>...
Done.
tunedasd -Q /dev/dasdzzz
reserved
```

- This example first queries the current setting for the cache mode of a DASD with device node /dev/dasdzzz and then sets it to one cylinder "prestige".

```
tunedasd -g /dev/dasdzzz
normal (0 cyl)
tunedasd -c prestige -n 2 /dev/dasdzzz
Setting cache mode for device </dev/dasdzzz>...
Done.
tunedasd -g /dev/dasdzzz
prestige (2 cyl)
```

- In this example two device nodes are specified. The output is printed for each node in the order in which the nodes were specified.

```
tunedasd -g /dev/dasdzzz /dev/dasdzy
prestige (2 cyl)
normal (0 cyl)
```

- The following command displays the usage profile of a DASD.

```
tunedasd -P /dev/dasdzzz

19617 dasd I/O requests
with 4841336 sectors(512B each)

 <4 <8 <16 <32 <64 <128 <256 <512 <1k <2k <4k <8k <16k <32k <64k <128k
 256 512 1M 2M 4M 8M 16M 32M 64M 128M 256M 512M 1G 2G 4G >4G
Histogram of sizes (512B secs)
0 0 441 77 78 87 188 18746 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O times (microseconds)
0 0 0 0 0 0 0 0 235 150 297 18683 241 3 4 4
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O times per sector
0 0 0 18736 333 278 94 78 97 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time till ssch
19234 40 32 2 0 0 3 40 53 128 85 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time between ssch and irq
0 0 0 0 0 0 0 0 387 208 250 18538 223 3 4 4
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time between ssch and irq per sector
0 0 0 18803 326 398 70 19 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Histogram of I/O time between irq and end
18520 735 246 68 43 4 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
of req in chanq at enqueueing (1..32)
0 19308 123 30 25 130 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

- The following command displays a row of the usage profile of a DASD. The output is on a single line as indicated by the (cont...) (... cont) in the illustration:

```
tunedasd -P -I irq /dev/dasdzzz
0| 0| 0| 0| 0| 503| 271|(cont...)
(... cont) 267| 18544| 224| 3| 4| 4| 0| 0| 0|(cont...)
(... cont) 0| 0| 0| 0| 0| 0| 0|(cont...)
(... cont) 0| 0| 0| 0| 0| 0| 0|
```

- The following command resets a failed channel path with CHPID 45:

```
tunedasd -p 45 /dev/dasdc
```



```
ALL ALL=NOPASSWD:/sbin/vmcp indicate
```

every user on the system can run the indicate command by using:

```
sudo vmcp indicate
```

- If you need a larger response buffer, use the **--buffer** option:

```
vmcp --buffer=128k q 1-ffff
```

## vmur - Work with z/VM spool file queues

---

Use the **vmur** command to work with z/VM spool file queues.

The **vmur** command provides these main functions:

### Receive

Read data from the z/VM reader file queue. The command performs the following steps:

- Places the reader queue file to be received at the beginning of the queue.
- Changes the reader queue file attribute to NOHOLD.
- Closes the z/VM reader after the file is received.

The **vmur** command detects z/VM reader queue files in:

- VMDUMP format as created by CP VMDUMP.
- NETDATA format as created by CMS SENDFILE or TSO XMIT.

### Punch or print

Write data to the z/VM punch or printer file queue and transfer it to another user's virtual reader, optionally on a remote z/VM node. The data is sliced up into 80-byte or 132-byte chunks (called *records*) and written to the punch or printer device. If the data length is not an integer multiple of 80 or 132, the last record is padded.

### List

Display detailed information about one or all files on the specified spool file queue.

### Purge

Remove one or all files on a spool file queue.

### Order

Position a file at the beginning of a spool file queue.

**Before you begin:** To use the receive, punch, and print functions, the vmur device driver must be loaded and the corresponding unit record devices must be set online.

## Serialization

The **vmur** command provides strict serialization of all its functions other than list, which does not affect a file queue's contents or sequence. Thus concurrent access to spool file queues is blocked to prevent unpredictable results or destructive conflicts.

For example, this serialization prevents a process from issuing **vmur purge -f** while another process is running **vmur receive 1234**. However, **vmur** is not serialized against concurrent CP commands that are issued through **vmcp**: If one process is running **vmur receive 1234** and another process issues **vmcp purge rdr 1234**, then the received file might be incomplete. To avoid such unwanted effects, always use **vmur** to work with z/VM spool file queues.

## Spooling options

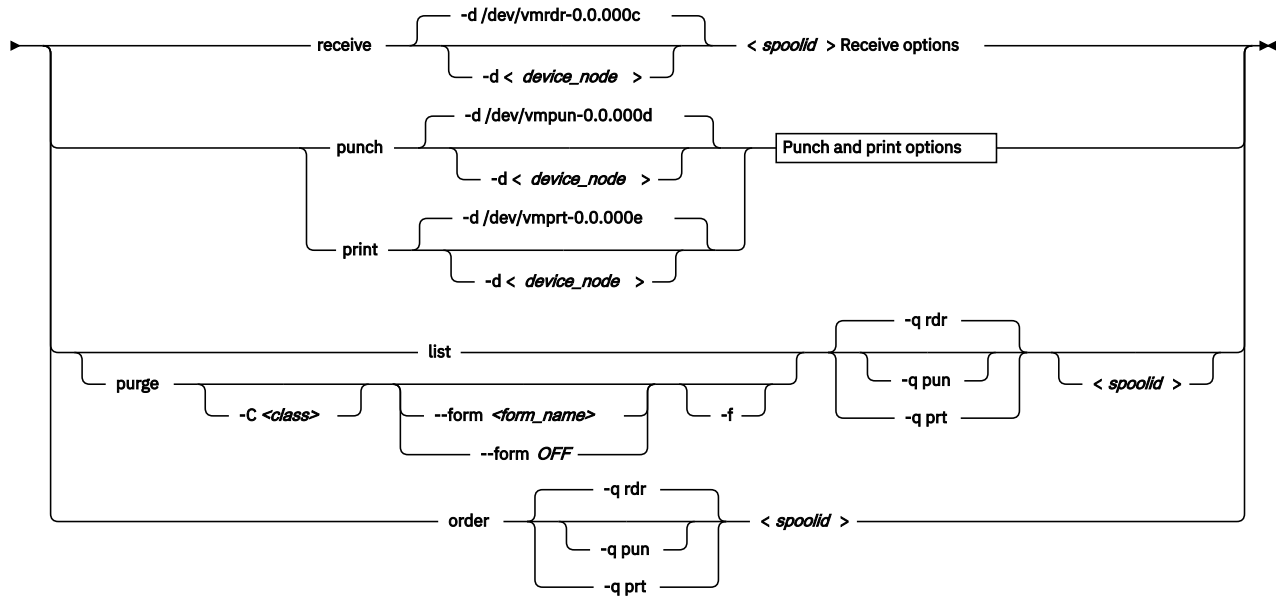
With the **vmur** command, you can temporarily override the z/VM settings for the CLASS, DEST, FORM, and DIST spooling options for virtual unit record devices. The **vmur** command restores the original settings before it returns control.

For more information about the spooling options, see the z/VM product information. In particular, see the sections about the z/VM CP SPOOL, QUERY VIRTUAL RDR, QUERY VIRTUAL PUN, and QUERY VIRTUAL PRT commands in *z/VM: CP Commands and Utilities Reference*, SC24-6268.

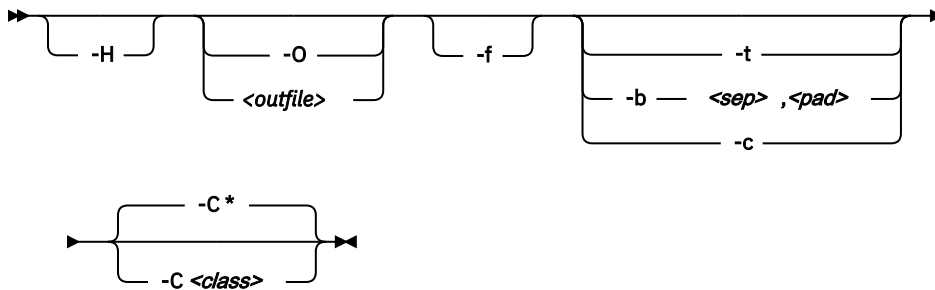


# vmur syntax

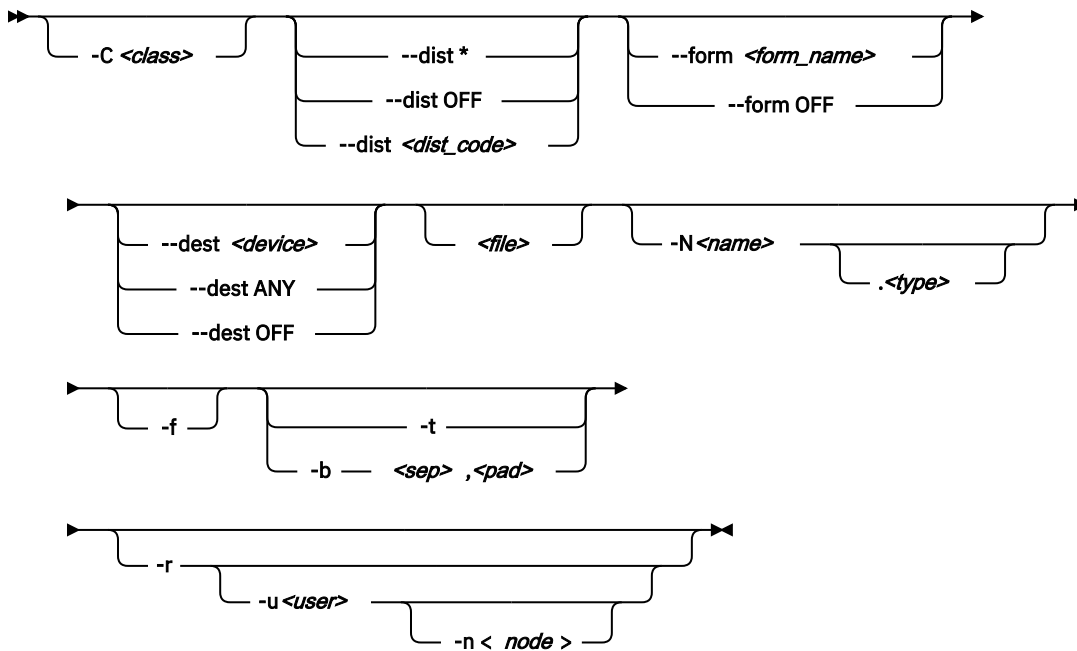
vmur →



## Receive options



## Punch and print options



Where these options are the main commands:

**re or receive**

receives a file from the z/VM reader queue.

**pun or punch**

writes to the z/VM punch queue.

**pr or print**

writes to the z/VM printer queue.

**li or list**

lists information about one or all files on a z/VM spool file queue.

**pur or purge**

purges one or all files from a z/VM spool file queue.

**or or order**

places a file on a z/VM spool file queue at the beginning of the queue.

**Note:** The short forms that are given for receive, punch, print, list, purge, and order are the shortest possible abbreviations. In keeping with z/VM style, you can abbreviate commands by dropping any number of letters from the end of the full keywords until you reach the short form. For example, **vmur re**, **vmur rec**, or **vmur rece** are all equivalent.

The remaining specifications are listed alphabetically by switch. Variable specifications that do not require a switch are listed first.

**<file>**

specifies a file, in the Linux file system, with data to be punched or printed. If this specification is omitted, the data is read from standard input.

**<outfile>**

specifies a file, in the Linux file system, to receive data from the reader spool file. If neither a file name nor **--stdout** are specified, the name and type of the spool file to be received are used to build an output file name of the form *<name>.<type>*. The name and type are the same as the NAME and TYPE columns in **vmur list** output. If the spool file to be received is an unnamed file, an error message is issued.

Use the **--force** option to overwrite existing files without a confirmation prompt.

**<spoolid>**

specifies the spool ID of a file on the z/VM reader, punch, or printer queue. Spool IDs are decimal numbers in the range 0-9999.

For the list or purge function: omitting the spool ID lists or purges all files in the queue.

**-b <sep>, <pad> or --blocked <sep>, <pad>**

receives or writes a file in blocked mode, where *<sep>* specifies the separator and *<pad>* specifies the padding character in hexadecimal notation. Example: *<sep>*

```
--blocked 0xSS,0xPP
```

Use this option to use character sets other than IBM037 and ISO-8859-1 for conversion.

- For the receive function: All trailing padding characters are removed from the end of each record that is read from the virtual reader and the separator character is inserted afterward. The receive function's output can be piped to **iconv** by using the appropriate character sets. Example:

```
vmur rec 7 -b 0x25,0x40 -0 | iconv -f EBCDIC-US -t ISO-8859-1 > myfile
```

- For the punch or print function: The separator is used to identify the line end character of the file to punch or print. If a line has fewer characters than the record length of the used unit record device, the residual of the record is filled up with the specified padding byte. If a line exceeds the record size, an error is printed. Example:

```
iconv test.txt -f ISO-8859-1 -t EBCDIC-US | vmur pun -b 0x25,0x40 -N test
```

**-c or --convert**

converts a VMDUMP spool file into a format appropriate for further analysis with crash.

**-C <class> or --class <class>**

specifies a spool class.

- For the receive function: The file is received only if it matches the specified class.
- For the purge function: Only files with the specified class are purged.
- For the punch or printer function: Sets the spool class for the virtual reader or virtual punch device. Output files inherit the spool class of the device.

The class is designated by a single alphanumeric character. For receive, it can also be an asterisk (\*) to match all classes. Lowercase alphabetic characters are converted to uppercase.

See also [“Spooling options” on page 672](#).

**--dest <device>**

sets the destination device for spool files that are created on the virtual punch or printer device. The value can be ANY, OFF, or it must be a valid device as defined on z/VM.

See also [“Spooling options” on page 672](#).

**-d or --device**

specifies the device node of the virtual unit record device.

- If omitted in the receive function, /dev/vmrdx-0.0.000c is assumed.
- If omitted in the punch function, /dev/vmpun-0.0.000d is assumed.
- If omitted in the print function, /dev/vmprt-0.0.000e is assumed.

**--dist <distcode>**

sets the distribution code for spool files that are created on the virtual punch or printer device. The value can be an asterisk (\*), OFF, or it must be a valid distribution code as defined on z/VM.

OFF and \* are equivalent. Both specifications reset the distribution code to the value that is set in the user directory.

See also [“Spooling options” on page 672](#).

**-f or --force**

suppresses confirmation messages.

- For the receive function: overwrites an existing output file without prompting for a confirmation.
- For the punch or print option: automatically converts the Linux input file name to a valid spool file name without any error message.
- For the purge function: purges the specified spool files without prompting for a confirmation.

**--form <form\_name>**

sets the form name for spool files that are created on the virtual punch or printer device. The value can be OFF, to use the system default, or it must be a valid z/VM form name.

See also [“Spooling options” on page 672](#).

**-h or --help**

displays help information for the command. To view the man page, enter **man vmur**.

**-H or --hold**

keeps the spool file to be received in the reader queue. If omitted, the spool file is purged after it is received.

**-n <node> or --node <node>**

specifies the node name of the z/VM system to which the data is to be transferred. Remote Spooling Communications Subsystem (RSCS) must be installed on the z/VM systems and the specified node must be defined in the RSCS machine's configuration file.

The default node is the local z/VM system. The node option is valid only with the `-u` option.

**-N <name>.<type> or --name <name>.<type>**

specifies a name and, optionally, a type for the z/VM spool file to be created by the punch or print option. To specify a type after the file name, enter a period followed by the type. For example:

```
vmur pun -r /boot/parmfile -N myname.mytype
```

Both the name and the type must comply with z/VM file name rules, for example, they must be 1 - 8 characters long.

If omitted, a spool file name is generated from the Linux input file name, if applicable.

Use the **--force** option to suppress warning messages about automatically generated file names or about specified file names that do not adhere to the z/VM file naming rules.

**-O or --stdout**

writes the reader file content to standard output.

**-q or --queue**

specifies the z/VM spool file queue to be listed, purged, or ordered. If omitted, the reader file queue is assumed.

**-r or --rdr**

transfers a punch or print file to a reader.

**-t or --text**

converts the encoding between EBCDIC and ASCII according to character sets IBM037 and ISO-8859-1.

- For the receive function: receives the reader file as text file. That is, it converts EBCDIC to ASCII and inserts an ASCII line feed character (0x0a) for each input record that is read from the z/VM reader. Trailing EBCDIC blanks (0x40) in the input records are stripped.
- For the punch or print function: punches or prints the input file as text file. That is, converts ASCII to EBCDIC and pads each input line with trailing blanks to fill up the record. The record length is 80 for a punch and 132 for a printer. If an input line length exceeds 80 for punch or 132 for print, an error message is issued.

The **--text** and the **--blocked** attributes are mutually exclusive.

**-u <user> or --user <user>**

specifies the z/VM user ID to whose reader the data is to be transferred. If omitted, the data is transferred to your own machine's reader. The user option is valid only with the **-r** option.

**-v or --version**

displays version information.

## Examples

These examples illustrate common scenarios for unit record devices.

In all examples the following device nodes are used:

- `/dev/vmrdx-0.0.000c` as virtual reader.
- `/dev/vmpun-0.0.000d` as virtual punch.

Besides the vmur device driver and the **vmur** command, these scenarios require that:

- The **vmcp** module is loaded.
- The **vmcp** and **vmconvert** commands from the s390-tools package are available.

## Creating and reading a guest memory dump

You can use the **vmur** command to read a guest memory dump that was created, for example, with the **vmcp** command.

## Procedure

1. Produce a memory dump of the z/VM guest virtual machine memory:

```
vmcp vmdump
```

Depending on the memory size this command might take some time to complete.

2. List the spool files for the reader to find the spool ID of the dump file, VMDUMP.

In the example, the spool ID of VMDUMP is 463.

```
vmur li
```

```
ORIGINID FILE CLASS RECORDS CPY HOLD DATE TIME NAME TYPE DIST
T6360025 0463 V DMP 00020222 001 NONE 06/11 15:07:42 VMDUMP FILE T6360025
```

3. Read and convert the VMDUMP spool file to a file in the current working directory of the Linux file system:

```
vmur rec 463 -c linux_dump
```

### *Using FTP to receive and convert a dump file*

Use the `--convert` option with the `--stdout` option to receive a VMDUMP spool file straight from the z/VM reader queue, convert it, and send it to another host with FTP.

## Procedure

1. Establish an FTP session with the target host and log in.
2. Enter the FTP command **binary**.
3. Enter the FTP command:

```
put |"vmur re <spoolid> -c -0" <filename_on_target_host>
```

## Logging and reading the z/VM guest virtual machine console

You can use the **vmur** command to read a console transcript that was spooled, for example, with the **vmcp** command.

## Procedure

1. Begin console spooling:

```
vmcp sp cons start
```

2. Produce output to the z/VM console.  
Use, for example, CP TRACE.
3. Stop console spooling, close the file with the console output, and transfer the file to the reader queue.  
In the resulting CP message, the spool ID follows the FILE keyword. In the example, the spool ID is 398:

```
vmcp sp cons stop close * rdr
```

```
RDR FILE 0398 SENT FROM T6360025 CON WAS 0398 RECS 1872 CPY 001 T NOHOLD NOKEEP
```

4. Read the file with the console output into a file in the current working directory on the Linux file system:

```
vmur re -t 398 linux_cons
```

## Preparing the z/VM reader as an IPL device for Linux

You can use the **vmur** command to transfer all files for booting Linux to the z/VM reader. You can also arrange the files such that the reader can be used as an IPL device.

### Procedure

1. Send the kernel parameter file, `parmfile`, to the z/VM punch device and transfer the file to the reader queue.

The resulting message shows the spool ID of the parameter file.

```
vmur pun -r /boot/parmfile
Reader file with spoolid 0465 created.
```

2. Send the kernel image file to the z/VM punch device and transfer the file to the reader queue.

The resulting message shows the spool ID of the kernel image file.

```
vmur pun -r /boot/vmlinuz -N image
Reader file with spoolid 0466 created.
```

3. Optional: Check the spool IDs of `image` and `parmfile` in the reader queue. In this example, the spool ID of `parmfile` is 465 and the spool ID of `image` is 466.

```
vmur li
ORIGINID FILE CLASS RECORDS CPY HOLD DATE TIME NAME TYPE DIST
T6360025 0463 V DMP 00020222 001 NONE 06/11 15:07:42 VMDUMP FILE T6360025
T6360025 0465 A PUN 00000002 001 NONE 06/11 15:30:31 parmfile T6360025
T6360025 0466 A PUN 00065200 001 NONE 06/11 15:30:52 image T6360025
```

4. Move `image` to the first and `parmfile` to the second position in the reader queue:

```
vmur or 465
vmur or 466
```

5. Configure the z/VM reader as the re-IPL device:

```
chreipl ccw 0.0.000c
```

For details about the **chreipl** command, see [“chreipl - Modify the re-IPL configuration”](#) on page 523. To pass additional options, use the `-p` option.

6. Boot Linux from the z/VM reader:

```
reboot
```

## Sending a file to different z/VM guest virtual machines

You can use the **vmur** command to send files to other z/VM guest virtual machines.

### About this task

This scenario describes how to send a file called `lnxprofile.exec` from the file system of an instance of Linux on z/VM to other z/VM guest virtual machines.

For example, `lnxprofile.exec` could contain the content of a PROFILE EXEC file with CP and CMS commands to customize z/VM guest virtual machines for running Linux.

## Procedure

1. Send `lnxprofile.exec` to two z/VM guest virtual machines: z/VM user ID `t2930020` at node `boet2930` and z/VM user ID `t6360025` at node `boet6360`.

```
vmur pun lnxprofile.exec -t -r -u t2930020 -n boet2930 -N PROFILE
vmur pun lnxprofile.exec -t -r -u t6360025 -n boet6360 -N PROFILE
```

2. Log on to `t2930020` at `boet2930`, IPL CMS, and issue the CP command:

```
QUERY RDR ALL
```

The command output shows the spool ID of PROFILE in the FILE column.

3. Issue the CMS command:

```
RECEIVE <spoolid> PROFILE EXEC A (REPL
```

In the command, `<spoolid>` is the spool ID of PROFILE found in step “2” on [page 679](#).

4. Repeat steps “2” on [page 679](#) and “3” on [page 679](#) for `t6360025` at `boet6360`.

## Sending a file to a z/VSE instance

You can use the **vmur** command to send files to a z/VSE instance.

### Procedure

To send `lserv.job` to user ID `vseuser` at node `vse01sys`, issue:

```
vmur pun lserv.job -t -r -u vseuser -n vse01sys -N LSERV
```

## zdsfs - Mount a z/OS DASD

Use the **zdsfs** command to mount z/OS DASDs as a Linux file system.

The zdsfs file system translates the z/OS data sets, which are stored on the DASDs in records of arbitrary or even variable size, into Linux semantics.

Through the zdsfs file system, applications on Linux can read z/OS physical sequential data sets (PS) and partitioned data sets (PDS) on the DASD. In the Linux file system, physical sequential data sets are represented as files. Partitioned data sets are represented as directories that contain the PDS members as files. Other z/OS data set formats, such as extended format data sets or VSAM data sets, are not supported. zdsfs is optimized for sequential read access.



### Attention:

- To avoid data inconsistencies, set the DASDs offline in z/OS before you mount them in Linux.
- Through the zdsfs file system, the whole DASDs are accessible to Linux, but the access is not controlled by z/OS auditing mechanisms.

To avoid security problems, you might want to dedicate the z/OS DASDs only for providing data for Linux.

Per default, only the Linux user who mounts the zdsfs file system has access to it.

**Tip:** If you want to grant a user group access to the zdsfs file system, mount it with the fuse options `default_permissions`, `allow_other`, and `gid`.

To unmount file systems that you mounted with **zdsfs**, you can use **umount**.

See *z/OS DFSMS Using Data Sets*, SC26-7410 for more information about z/OS data sets.

### Before you begin:

- The FUSE library must be installed on your system. Ubuntu Server installs this library for you by default. You can also obtain it from sourceforge at [sourceforge.net/projects/fuse](https://sourceforge.net/projects/fuse).
- The raw-track access mode of the DASD must be enabled.

Make sure that the DASD is set offline when you enable the raw-track access mode.

See “[Accessing full ECKD tracks](#)” on page 136 for details.

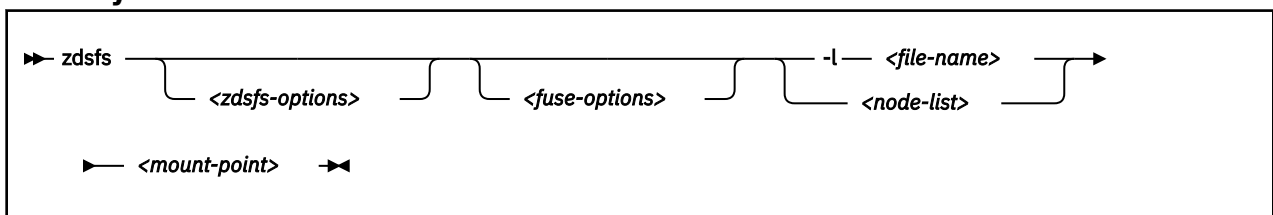
- The DASD must be online.

**Tip:** You can use the **chccwdev** command to enable the raw-track access mode and set the device online afterward in one step.

Set the DASD offline in z/OS before you set it online in Linux.

- You must have the appropriate read permissions for the device node.

### zdsfs syntax



where:

#### <zdsfs-options>

zdsfs-specific options.



**-o ignore\_incomplete**

represents all complete data sets in the file system, even if there are incomplete data sets. Incomplete data sets are not represented.

In z/OS, data sets might be distributed over different DASDs. For each incomplete data set, a warning message is issued to the standard error stream. If there are incomplete data sets and this option is not specified, the **zdsfs** command returns with an error.

**-o rdw**

keeps record descriptor words (RDWs) of data sets that are stored by using the z/OS concept of variable record lengths.

**-o tracks=<n>**

specifies the track buffer size in tracks. The default is 128 tracks.

zdsfs allocates a track buffer of <n>\*120 KB for each open file to store and extract the user data. Increasing the track buffer size might improve your system performance.

**-o seekbuffer=<s>**

sets the maximum seek history buffer size in bytes. The default is 1,048,576 B.

zdsfs saves offset information about a data set in the seek history buffer to speed up the performance of a seek operation.

**-o check\_host\_count**

checks the host-access open count to ensure that the device is not online to another operating system instance. The operation is canceled if another operating system instance is accessing the volume.

**<fuse-options>**

options for FUSE. The following options are supported by the **zdsfs** command. To use an option, it must also be supported by the version of FUSE that is installed.

**-d or -o debug**

enables debug output (implies **-f**).

**-f**

runs the command as a foreground operation.

**-o allow\_other**

allows access to other users.

**-o allow\_root**

allows access to root.

**-o nonempty**

allows mounts over files and non-empty directories.

**-o default\_permissions**

enables permission checking by the kernel.

**-o max\_read=<n>**

sets maximum size of read requests.

**-o kernel\_cache**

caches files in the kernel.

**-o [no]auto\_cache**

enables or disables caching based on modification times.

**-o umask=<mask>**

sets file permissions (octal).

**-o uid=<n>**

sets the file owner.

**-o gid=<n>**

sets the file group.

- o max\_write=<n>**  
sets the maximum size of write requests.
- o max\_readahead=<n>**  
sets the maximum readahead value.
- o async\_read**  
performs reads asynchronously (default).
- o sync\_read**  
performs reads synchronously.

**<node-list>**

one or more device nodes for the DASDs, separated by blanks.

**<file-name>**

a file that contains a node list.

**<mount-point>**

the mount point in the Linux file system where you want to mount the z/OS data sets.

**-h or --help**

displays help information for the command. To view the man page, enter **man zdsfs**.

**-v or --version**

displays version information for the command.

## File characteristics

There are two ways to handle the z/OS characteristics of a file:

- The file metadata.txt:

The metadata.txt file is in the root directory of the mount point. It contains one row for each file or directory, where:

**dsn**

specifies

- the name of the file in the form *<file-name>* for z/OS physical sequential data sets.
- the name of the directory in the form *<directory-name>*, and the name of a file in that directory in the form *<directory-name>(<file-name>)* for z/OS partitioned data sets.

**dsorg**

specifies the organization of the file. The organization is PO for a directory, and PS for a file.

**lrecl**

specifies the record length of the file.

**recfm**

specifies the z/OS record format of the file. Supported record formats are: V, F, U, B, S, A, and M.

### Example:

```
dsn=F00BAR.TESTF.TXT,recfm=FB,lrecl=80,dsorg=PS
dsn=F00BAR.TESTVB.TXT,recfm=VB,lrecl=100,dsorg=PS
dsn=F00BAR.PDSF.DAT,recfm=F,lrecl=80,dsorg=PO
dsn=F00BAR.PDSF.DAT(TEST1),recfm=F,lrecl=80,dsorg=PS
dsn=F00BAR.PDSF.DAT(TEST2),recfm=F,lrecl=80,dsorg=PS
dsn=F00BAR.PDSF.DAT(TEXT3),recfm=F,lrecl=80,dsorg=PS
```

- Extended attributes:

**user.dsorg**

specifies the organization of the file.

**user.lrecl**

specifies the record length of the file.

**user.recfm**

specifies the z/OS record format of the file.

You can use the following system calls to work with extended attributes:

### listxattr

to list the current values of all extended attributes.

### getxattr

to read the current value of a particular extended attribute.

You can use these system calls through the **getfattr** command. For more information, see the man pages of these commands and of the listxattr and getxattr system calls.

## Examples

- Enable the raw-track access mode of DASD device 0.0.7000 and set the device online afterward:

```
chccwdev -a raw_track_access=1 -e 0.0.7000
```

- Mount the partitioned data set on the DASDs represented by the file nodes /dev/dasde and /dev/dasdf at /mnt:

```
zdsfs /dev/dasde /dev/dasdf /mnt
```

- As user "myuser", mount the partitioned data set on the DASD represented by the file node /dev/dasde at /home/myuser/mntzos:

– Access the mounted file system exclusively:

```
zdsfs /dev/dasde /home/myuser/mntzos
```

– Allow the root user to access the mounted file system:

```
zdsfs -o allow_root /dev/dasde /home/myuser/mntzos
```

The **ls** command does not reflect these permissions. In both cases, it shows:

```
ls -al /home/myuser/mntzos
total 121284
dr-xr-x--- 2 root root 0 Dec 3 15:54 .
drwx----- 3 myuser myuser 4096 Dec 3 15:51 ..
-r--r----- 1 root root 2833200 Jun 27 2012 EXPORT.BIN1.DAT
-r--r----- 1 root root 2833200 Jun 27 2012 EXPORT.BIN2.DAT
-r--r----- 1 root root 2833200 Jun 27 2012 EXPORT.BIN3.DAT
-r--r----- 1 root root 2833200 Feb 14 2013 EXPORT.BIN4.DAT
dr-xr-x--- 2 root root 13599360 Aug 9 2012 EXPORT.PDS1.DAT
dr-xr-x--- 2 root root 13599360 Aug 9 2012 EXPORT.PDS2.DAT
dr-xr-x--- 2 root root 13599360 Aug 9 2012 EXPORT.PDS3.DAT
dr-xr-x--- 2 root root 55247400 Aug 9 2012 EXPORT.PDS4.DAT
-r--r----- 1 root root 981 Dec 3 15:54 metadata.txt

$ ls -al /dev/dasde
brw-rw---- 1 root disk 94, 16 Dec 3 13:58 /dev/dasde
```

- As root user, mount the partitioned data set on the DASD represented by the file node /dev/dasde at /mnt on behalf of the user ID "myuser" (UID=1002), and permit the members of the group ID "zosimport" (GID=1002) file access:

```
zdsfs /dev/dasde /mnt -o uid=1002,gid=1002,allow_other,default_permissions
```

The **ls** command indicates the owner "myuser" and the access right for group "zosimport":

```
$ ls -al /mnt
total 121284
dr-xr-x--- 2 myuser zosimport 0 Dec 3 14:22 .
drwxr-xr-x 23 root root 4096 Dec 3 13:59 ..
-r--r----- 1 myuser zosimport 981 Dec 3 14:22 metadata.txt
-r--r----- 1 myuser zosimport 2833200 Jun 27 2012 EXPORT.BIN1.DAT
-r--r----- 1 myuser zosimport 2833200 Jun 27 2012 EXPORT.BIN2.DAT
-r--r----- 1 myuser zosimport 2833200 Feb 14 2013 EXPORT.BIN3.DAT
-r--r----- 1 myuser zosimport 2833200 Jun 27 2012 EXPORT.BIN4.DAT
dr-xr-x--- 2 myuser zosimport 13599360 Aug 9 2012 EXPORT.PDS1.DAT
dr-xr-x--- 2 myuser zosimport 13599360 Aug 9 2012 EXPORT.PDS2.DAT
dr-xr-x--- 2 myuser zosimport 55247400 Aug 9 2012 EXPORT.PDS3.DAT
dr-xr-x--- 2 myuser zosimport 13599360 Aug 9 2012 EXPORT.PDS4.DAT
```

- Unmount the partitioned data set that is mounted at /mnt:

```
fusemount -u /mnt
```

- Show the extended attributes of a file, FB.XMP.TXT, on a z/OS DASD that is mounted on /mnt:

```
getfattr -d /mnt/FB.XMP.TXT
```

- Show the extended attributes of all files on a z/OS DASD that is mounted on /mnt:

```
cat /mnt/metadata.txt
```

## znetconf - List and configure network devices

Use the **znetconf** command to list, configure, add, and remove network devices.

The **znetconf** command:

- Lists potential network devices.
- Lists configured network devices.
- Automatically configures and adds network devices.
- Removes network devices.

For automatic configuration, **znetconf** first builds a channel command word (CCW) group device from sensed CCW devices. It then configures any specified option through the sensed network device driver and sets the new network device online.

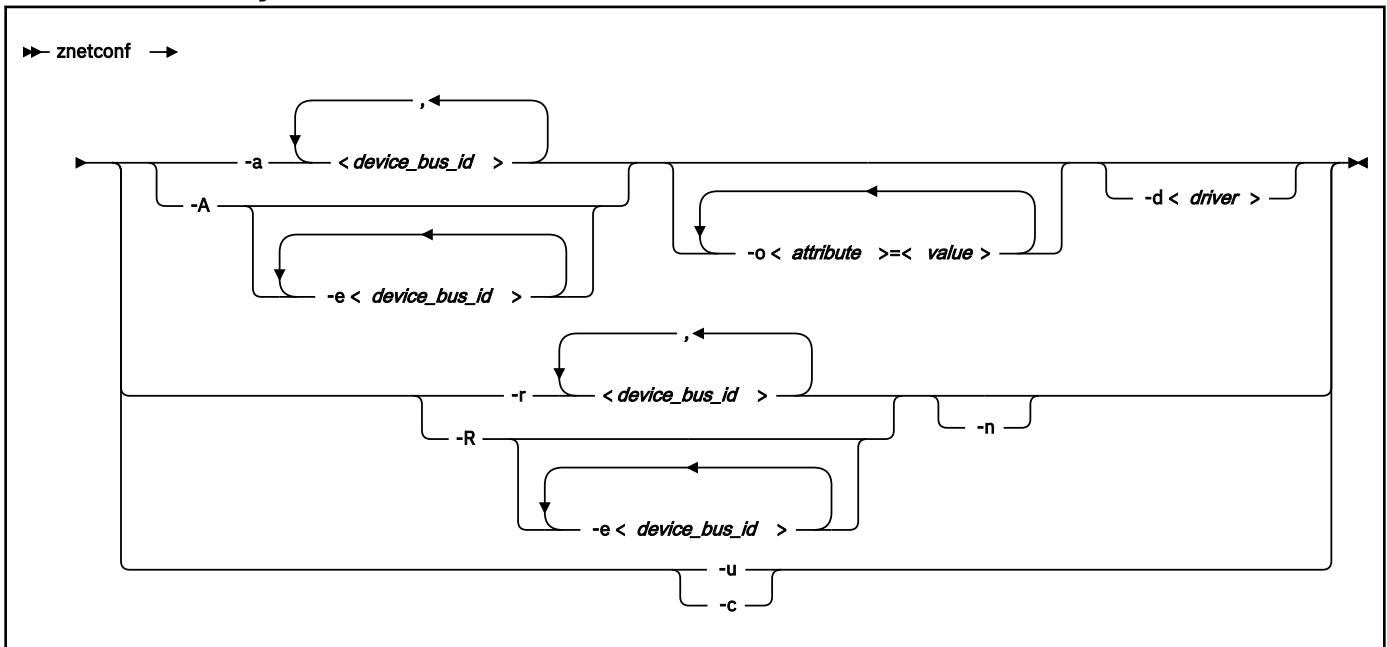
During automatic removal, **znetconf** sets the device offline and removes it.



**Attention:** Removing all network devices might lead to complete loss of network connectivity. Unless you can access your Linux instance from a terminal server on z/VM (see *How to Set up a Terminal Server Environment on z/VM*, SC34-2596), you might require the HMC or a 3270 terminal session to restore the connectivity.

**Before you begin:** The qeth or lcs device drivers must be loaded. If needed, the **znetconf** command attempts to load the particular device driver.

### znetconf syntax



Where:

#### **-a or --add**

configures the network device with the specified device bus-ID. If you specify only one bus ID, the command automatically identifies the remaining bus IDs of the group device. You can enter a list of device bus-IDs that are separated by commas. The **znetconf** command does not check the validity of the combination of device bus-IDs.

#### **<device\_bus\_id>**

specifies the device bus-ID of the CCW devices that constitute the network device. If a device bus-ID begins with "0.0.", you can abbreviate it to the final hexadecimal digits. For example, you can abbreviate 0.0.f503 to f503.

**-A or --add-all**

configures all potential network devices. After you run **znetconf -A**, enter **znetconf -c** to see which devices were configured. You can also enter **znetconf -u** to display devices that were not configured.

**-e or --except**

omits the specified devices when configuring all potential network devices or removing all configured network devices.

**-o or --option <attribute>=<value>**

configures devices with the specified sysfs option.

**-d or --driver <driver name>**

configures devices with the specified device driver. Valid values are qeth or lcs.

**-n or --non-interactive**

answers all confirmation questions with "Yes".

**-r or --remove**

removes the network device with the specified device bus-ID. You can enter a list of device bus-IDs that are separated by a comma. You can remove only configured devices as listed by **znetconf -c**.

**-R or --remove-all**

removes all configured network devices. After successfully running this command, all devices that are listed by **znetconf -c** become potential devices that are listed by **znetconf -u**.

**-u or --unconfigured**

lists all network devices that are not yet configured.

**-c or --configured**

lists all configured network devices.

**-h or --help**

displays help information for the command. To view the man page, enter **man znetconf**.

**-v or --version**

displays version information.

If the command completes successfully, **znetconf** returns 0. Otherwise, 1 is returned.

**Examples**

- To list all potential network devices:

```
znetconf -u
Device IDs Type Card Type CHPID Drv.

0.0.f500,0.0.f501,0.0.f502 1731/01 OSA (QDIO) 00 qeth
0.0.f503,0.0.f504,0.0.f505 1731/01 OSA (QDIO) 01 qeth
```

- To configure device 0.0.f503:

```
znetconf -a 0.0.f503
```

or

```
znetconf -a f503
```

- To configure the potential network device 0.0.f500 with the `layer2` option with the value 0 and the `portno` option with the value 1:

```
znetconf -a f500 -o layer2=0 -o portno=1
```

- To list configured network devices:

```
znetconf -c
Device IDs Type Card Type CHPID Drv. Name State

0.0.f500,0.0.f501,0.0.f502 1731/01 Virt.NIC QDIO 00 qeth encf500 online
0.0.f503,0.0.f504,0.0.f505 1731/01 Virt.NIC QDIO 01 qeth encf503 online
0.0.f5f0,0.0.f5f1,0.0.f5f2 1731/01 OSD_1000 76 qeth encf5f0 online
```

- To remove network device 0.0.f503:

```
znetconf -r 0.0.f503
```

or

```
znetconf -r f503
```

- To remove all configured network devices except the devices with bus IDs 0.0.f500 and 0.0.f5f0:

```
znetconf -R -e 0.0.f500 -e 0.0.f5f0
```

- To configure all potential network devices except the device with bus ID 0.0.f503:

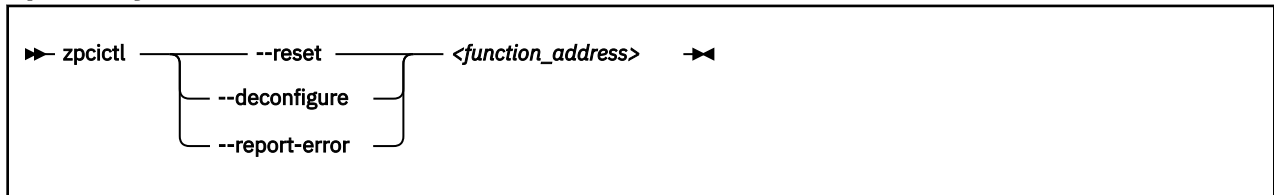
```
znetconf -A -e 0.0.f503
```

## zpcictl - Manage defective PCIe devices

Use the **zpcictl** to manage PCI devices on Linux in LPAR mode and Linux on z/VM. In particular, use this command to report defective PCI devices to the Support Element (SE).

**Note:** With the `smartmontools` package installed, diagnostic data might be collected and sent with the recovery action. Whether diagnostic data is collected and which data is available depends on the PCI device type.

### zpcictl syntax



Where:

**--reset**

resets the device.

**--deconfigure**

deconfigures the device to prepare for any repair action.

**--report-error**

reports the device error to the SE.

**<function\_address>**

the PCI function address of the device, for example, `0000:00:00.0`.

**-h or --help**

displays help information for the command. To view the man page, enter `man zpcictl`.

**-v or --version**

displays version information.

### Example

In this example, an error is reported for a PCI device with slot ID `0000:00:00.0`.

```
zpcictl --report-error 0000:00:00.0
```

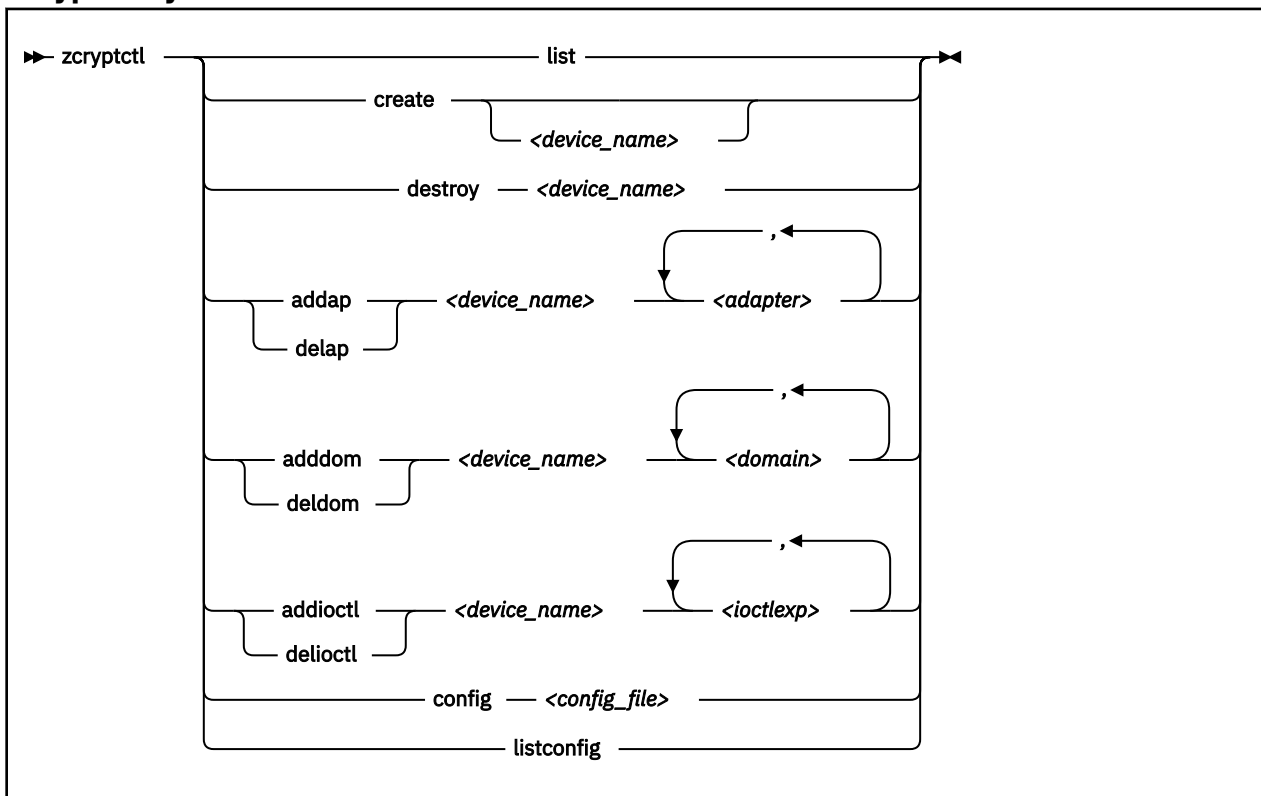


## zcryptctl - Control access to AP queues and functions

Use the **zcryptctl** command to control access to AP queues and functions.

For more information about cryptographic device nodes, see [“Creating customized device nodes”](#) on page 452.

### zcryptctl syntax



Where:

#### list

lists all zcrypt device nodes.

#### create <node\_name>

creates a new zcrypt device node. The *<device\_name>* is optional and must be unique. If no node name is provided, the zcrypt device driver creates one with a name of the form: `zcrypt_<n>`, where *<n>* is the next free number. By default no adapter, domain, or IOCTL is allowed on the new device.

By default the device node file is created with permissions 0600 and might need adjustments to be usable by non-root users.

#### destroy <device\_name>

destroys a zcrypt device. Marks the given zcrypt device as disposable. The device is removed when the use counter is zero.

#### addap <device\_name> <adapter>

adds a cryptographic adapter to be accessible through this device. The adapter argument is a number in the range 0 - 255. Specify ALL to enable all adapters.

#### delap <device\_name> <adapter>

deletes the adapter from the specified device. The adapter argument is a number in the range 0 - 255. Specify ALL to remove all adapters.

**adddom <device\_name> <domain\_nr>**

adds a domain to be accessible through the specified device. The domain argument is a number in the range 0 - 255. Specify ALL to enable all domains.

**deldom <device\_name> <domain\_nr>**

deletes a domain from the specified device. Specify ALL to delete all domains.

**addioctl<device\_name> <ioclt\_exp>**

adds an IOCTL to the functions supported by the specified device. Specify the IOCTL by its name or the corresponding numeric value in the range 0 - 255. Specify ALL to include all IOCTLs. The IOCTL macros, to be used as name, and their numbers are listed in arch/s390/include/uapi/asm/zcrypt.h.

Set IOCTLs according to the functions you want to support. The following table lists the IOCTLs that are required by the CCA, EP11, and libica library.

| Library | Functions                                                | Required IOCTLs                        |
|---------|----------------------------------------------------------|----------------------------------------|
| CCA     | Secure key cryptographic functions on CCA coprocessors.  | ZSESEND CPRB                           |
| EP11    | Secure key cryptographic functions on EP11 coprocessors. | ZSENDEP11 CPRB                         |
| libica  | Clear key cryptographic functions.                       | ICARSAMODEXPO, ICARSACRT, ZSESEND CPRB |

**delioctl <device\_name> <ioclt\_exp>**

deletes the specified IOCTL from the functions supported by the specified device. Specify the IOCTL by its name or the corresponding numeric value in the range 0 - 255. Specify ALL to delete all IOCTLs.

**config <config\_file>**

processes a configuration file.

**listconfig**

lists the current configuration in a format suitable for the config command.

**Tip:** Use **listconfig** to generate a configuration file that can be used as input to the **config** command.

**Examples**

These examples illustrate common uses for **zcryptctl**.

- To set up a zcrypt device with access to secure key operations on domain 81 of two CCA adapters, 7 and 10.

```
zcryptctl new zcrypt_0
zcryptctl addap zcrypt_0 7
zcryptctl addap zcrypt_0 10
zcryptctl adddom zcrypt_0 81
zcryptctl addioctl zcrypt_0 ZSESEND CPRB
```

You might have to change the access rights to the device before a container can use it.

- To list the currently defined devices and their attributes:

```
zcryptctl list
zcdn node name: zcrypt_2
device node: /dev/zcrypt_2
major:minor: 250:2
ioctls: ICARSAMODEXPO,ICARSACRT,ZSESEND CPRB
adapter: 4,8,9
domains: 6,11,81
zcdn node name: zcrypt_0
device node: /dev/zcrypt_0
major:minor: 250:0
ioctls: ZSESEND CPRB
adapter: 7,10
domains: 81
zcdn node name: zcrypt_1
device node: /dev/zcrypt_1
major:minor: 250:1
ioctls: ZSESEND CPRB
adapter: 6,11
domains: 11
```

- To remove an obsolete device.

```
zcryptctl destroy zcrypt_0
```

## Creating a configuration file

The given configuration file is read line by line and the actions are executed. The syntax is as follows:

- A `node=<node_name>` line creates a new device node with the given name. The subsequent actions act on this node until another `node=` line encountered. For example, to create a device node called `zcdn_node_1`:

```
node = zcdn_node_1
```

- The `aps=<list_of_ap_numbers>` action adds allowed adapters to the node configuration. The adapters must be separated by space, tab, or commas. For example, to add adapters 1,2,5, and 7:

```
aps = 1, 2, 5, 7
```

- The `doms=<list_of_domain_numbers>` action adds allowed domains to the node configuration. The domains must be separated by space, tab, or commas. For example, to allow domain 6:

```
doms = 6
```

- The `ioctls=<list_of_ioctl_as_number_or_symbolic_name>` adds allowed IOCTLs to the node configuration. The IOCTLs must be separated by space, tab, or commas. For example, to allow ZSESEND CPRB:

```
ioctls = ZSESEND CPRB
```

The IOCTL macros, to be used as name, and their numbers are listed in `arch/s390/include/uapi/asm/zcrypt.h`.

The symbol ALL is also recognized for the `aps`, `doms` and `ioctls` actions.

Empty lines are ignored and the number sign (#) marks the rest of the line as a comment. Each action must fit on one line, multiple lines is not supported. You can use more than one `aps`, `doms`, or `ioctls` line to customize the same node.

## Example configuration file

```

Sample zcrypt device node configuration

node 1 for CCA requests on domain 6
node = zcdn_node_1
aps = 1, 2, 5, 7
doms = 6
ioctls = ZSESEND CPRB

node 2 for CCA requests on domain 11
node = zcdn_node_2
aps = 1, 2, 5, 7
doms = 11
ioctls = ZSESEND CPRB

node 3 for EP11 on domain 6 and 11
node = zcdn_node_3
aps = 3, 6, 11
doms = 6, 11
ioctls = ZSEND EP11 CPRB

node 4 for clear key on everything
node = zcdn_node_4
aps = ALL
doms = ALL
ioctls = ICARSAMODEXPO, ICARSACRT, ZSESEND CPRB

node 5 special EP11 on adapter 10, any domain
node = zcdn_node_5
aps = 0x0a
doms = ALL
ioctls = ZSEND EP11 CPRB

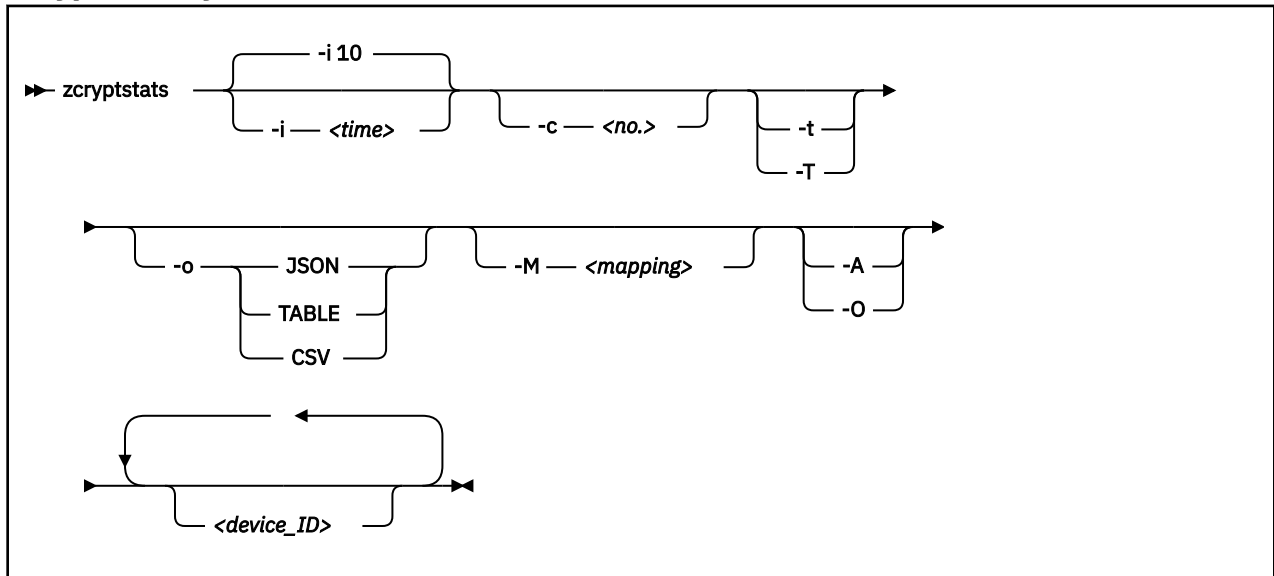
node 6 special CCA only on adapter 7, domain 81
node = zcdn_node_6
aps = 7
doms = 0x51
ioctls = ZSESEND CPRB
```

## zcryptstats - Display crypto statistics

Use the **zcryptstats** command to report cryptographic performance measurement data for cryptographic devices at specified intervals.

Device node `/dev/chsc` must exist. Ubuntu Server loads the `chsh_sch` kernel module during the boot process and makes the device node `/dev/chsc` available to you.

### zcryptstats syntax



Where:

**-i or --interval <time>**

specifies the time interval between reports in seconds. The default is 10 seconds.

**-c or --count <no.>**

specifies the number of reports to be generated. By default the **zcryptstats** command keeps generating reports until it is stopped with Ctrl+C.

**-o or --output JSON|TABLE|CSV**

displays the statistics in the specified format. By default, a comprehensive report is displayed in a human readable format. Supported output formats are: JSON, TABLE, or CSV.

With TABLE and CSV, only the totals are displayed, that is, TABLE and CSV formats imply the `--only-totals` option.

With JSON or the default display, you can optionally specify one of the `--only-totals` or `--no-totals` options.

**-t or --no-totals**

omits the totals of all counters of a cryptographic adapter (CARD) or queue device (APQN). This option cannot be specified together with the `--only-totals` option or the `--output TABLE | CSV` option.

**-T or --only-totals**

omits the individual counters of a cryptographic adapter or a queue device. This option is implied with the `--output TABLE | CSV` option.

**-a or --no-apqn**

displays only the counters of the cryptographic adapter, but omits the counters of the queue device. This option is implied for mainframes before the October 2018 upgrade of IBM z14®.

**-M or --map-type <mapping>**

maps unknown cryptographic device types and modes to known types and modes. Use this option only when new, unknown cryptographic devices are found. You can map unknown devices to known devices and modes, if the new device reports the same counters as the known device. Specify the mapping as a comma-separated list of FROM-TYPE:FROM-MODE=TO-TYPE:TO-MODE specifications. The type and mode values must be specified in decimal notation.

**-A or --all**

displays all adapter devices and queue devices, not only those devices that are available to the LPAR in which Linux runs. Using this option, additional cryptographic devices that are available in the CEC are also monitored. This option cannot be specified together with the `--only-online` option.

**-O or --only-online**

displays only online cryptographic adapters and queue devices. This option cannot be specified together with the `--all` option.

**-V or --verbose**

displays additional information messages during processing.

**-h or --help**

displays help information for the command. To view the man page, enter `man zcryptstats`.

**-v or --version**

displays version information for the command.

**<device\_ID>**

List of cryptographic device IDs, separated by blanks, for which statistics are displayed. Device IDs can either be cryptographic adapter IDs or queue device IDs (<adapter\_ID>.<domain\_ID>). To filter all devices according to a dedicated domain, provide "<domain\_ID>". If no IDs are given, all available devices are displayed.

**Examples**

- To display statistics for the cryptographic adapter with ID 0x02.

```
zcryptstats 02
```

- Display statistics for domain 0x0005 on adapter 0x02 (APQN 02.0005).

```
zcryptstats 02.0005
```

- Example of output in default display format:

```
zcryptstats 06
Linux <version> <system> 16/01/20 s390x

TIME: 16/01/20 10:48:34 INTERVAL: 1
```

```
DEVICE TYPE TIMESTAMP

06 CARD CEX7A (Accelerator) 16/01/20 10:48:34
COUNTER OPS RATE UTILIZATION AVG.DURATION

RSA 1024 ME 0 0.00 0.00 % 0.000 usec
RSA 2048 ME 4149 4148.81 17.46 % 42.074 usec
RSA 1024 CRT 0 0.00 0.00 % 0.000 usec
RSA 2048 CRT 4564 4563.79 82.12 % 179.943 usec
RSA 4096 ME 0 0.00 0.00 % 0.000 usec
RSA 4096 CTR 0 0.00 0.00 % 0.000 usec

Total 8713 8712.60 99.58 % 114.292 usec
```

```
DEVICE TYPE TIMESTAMP

06.0011 APQN CEX7A (Accelerator) 16/01/20 10:48:34
COUNTER OPS RATE UTILIZATION AVG.DURATION

RSA 1024 ME 0 0.00 0.00 % 0.000 usec
RSA 2048 ME 2166 2165.90 10.06 % 46.428 usec
RSA 1024 CRT 0 0.00 0.00 % 0.000 usec
RSA 2048 CRT 1302 1301.94 23.31 % 179.071 usec
RSA 4096 ME 0 0.00 0.00 % 0.000 usec
RSA 4096 CTR 0 0.00 0.00 % 0.000 usec

Total 3468 3467.84 33.37 % 96.226 usec
```

```
DEVICE TYPE TIMESTAMP

06.0023 APQN CEX7A (Accelerator) 16/01/20 10:48:34
...
```

- Example of the same output in TABLE format:

```
Linux <version> <system> 16/01/20 s390x
TIMESTAMP DEVICE OPS RATE UTILIZATION AVG.DURATION

16/01/20 10:48:34 06 8713 8712.60 99.58 % 114.292 usec
16/01/20 10:48:34 06.0011 3468 3467.84 33.37 % 96.226 usec
16/01/20 10:48:34 06.0023 3267 3266.85 30.15 % 92.278 usec
16/01/20 10:48:34 06.0024 1978 1977.91 36.06 % 182.325 usec
....
```

- Example of the same output in CSV format:

```
TIMESTAMP,DEVICE,OPS,RATE,UTILIZATION,AVG.DURATION
16/01/20 10:48:34,06,8713,8712.60,99.58 %,0.000114292
16/01/20 10:48:34,06.0011,3468,3467.84,33.37 %,0.000096226
16/01/20 10:48:34,06.0023,3267,3266.85,30.15 %,0.000092278
16/01/20 10:48:34,06.0024,1978,1977.91,36.06 %,0.000182325
....
```

- Example of the same output in JSON format:

```

{"zcryptstats": {
 "host": {
 "nodename": "lpar01",
 "sysname": "Linux",
 "release": "5.4",
 "machine": "s390x",
 "date": "16/01/20",
 "statistics": [
 {
 "interval": 1, "timestamp": "16/01/20 10:48:34", "devices": [
 {"device": "06", "type": "CEX7A (Accelerator)",
 "counters": [
 {"counter": "RSA 1024 ME", "ops": 0, "rate": 0.00,
 "utilization": 0.00, "duration": 0.000000000},
 {"counter": "RSA 2048 ME", "ops": 4149, "rate": 4148.81,
 "utilization": 17.46, "duration": 0.000042074},
 {"counter": "RSA 1024 CRT", "ops": 0, "rate": 0.00,
 "utilization": 0.00, "duration": 0.000000000},
 {"counter": "RSA 2048 CRT", "ops": 4564, "rate": 4563.79,
 "utilization": 82.12, "duration": 0.000179943},
 {"counter": "RSA 4096 ME", "ops": 0, "rate": 0.00,
 "utilization": 0.00, "duration": 0.000000000},
 {"counter": "RSA 4096 CTR", "ops": 0, "rate": 0.00,
 "utilization": 0.00, "duration": 0.000000000},
 {"counter": "Total", "ops": 8713, "rate": 8712.60,
 "utilization": 99.58, "duration": 0.000114292}
]},
 {"device": "06.0011", "type": "CEX7A (Accelerator)",
 "counters": [

```

....



---

## Chapter 62. Selected kernel parameters

You can use kernel parameters that are beyond the scope of an individual device driver or feature to configure Linux in general.

Kernel parameters that are specific to a particular device driver or feature are described in the setup section of the respective device driver or feature.

See [Chapter 4, “Kernel and module parameters,” on page 23](#) for information about specifying kernel parameters.

## cio\_ignore - List devices to be ignored

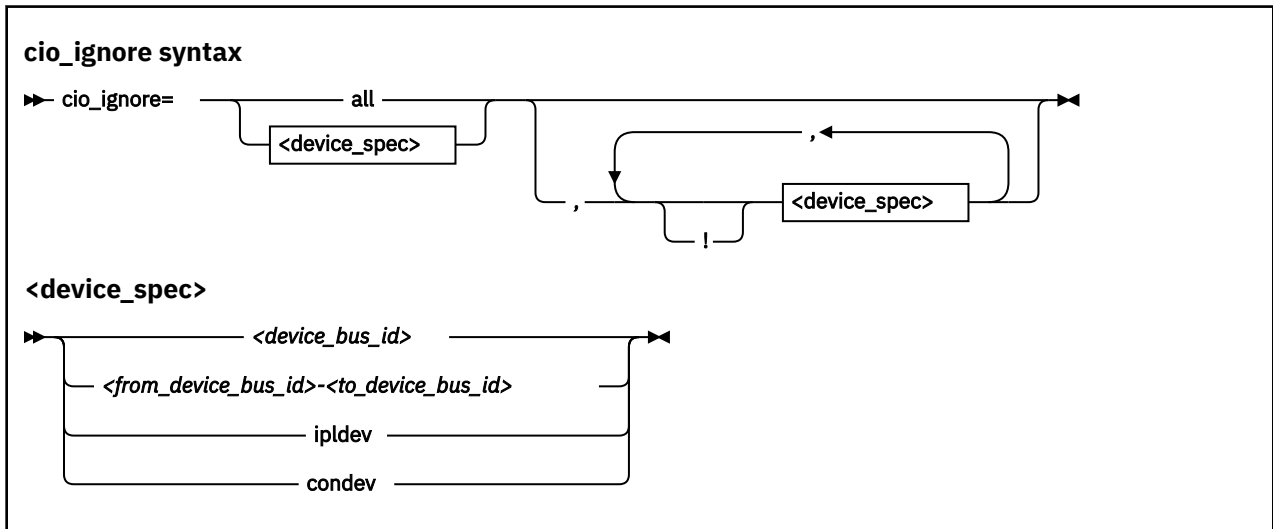
Use the `cio_ignore=` kernel parameter to list specifications for I/O devices that are to be ignored.

When an instance of Linux on Z boots, it senses and analyzes all available I/O devices. You can use the `cio_ignore=` kernel parameter to list specifications for devices that are to be ignored. This exclusion list can cover all possible devices, even devices that do not actually exist. The following applies to ignored devices:

- Ignored devices are not sensed and analyzed. The device cannot be used until it is analyzed.
- Ignored devices are not represented in `sysfs`.
- Ignored devices do not occupy storage in the kernel.
- The subchannel to which an ignored device is attached is treated as if no device were attached.
- For Linux on z/VM, `cio_ignore` might hide essential devices such as the console. The console is typically device number 0.0.0009.

See also [“Changing the exclusion list”](#) on page 699.

### Format



Where:

#### all

states that all devices are to be ignored.

#### <device\_bus\_id>

specifies a device. Device bus-IDs are of the form `0.<n>.<devno>`, where `<n>` is a subchannel set ID and `<devno>` is a device number.

#### <from\_device\_bus\_id>-<to\_device\_bus\_id>

are two device bus-IDs that specify the first and the last device in a range of devices.

#### ipldev

specifies the IPL device. Use this keyword with the `!` operator to avoid ignoring the IPL device.

#### condev

specifies the CCW console. Use this keyword with the `!` operator to avoid ignoring the console device.

**!**

makes the following term an exclusion statement. This operator is used to exclude individual devices or ranges of devices from a preceding more general specification of devices.

## Examples

- This example specifies that all devices in the range 0.0.b100 through 0.0.b1ff, and the device 0.0.a100 are to be ignored.

```
cio_ignore=0.0.b100-0.0.b1ff,0.0.a100
```

- This example specifies that all devices except the console are to be ignored.

```
cio_ignore=all,!condev
```

- This example specifies that all devices but the range 0.0.b100 through 0.0.b1ff, and the device 0.0.a100 are to be ignored.

```
cio_ignore=all,!0.0.b100-0.0.b1ff,!0.0.a100
```

- This example specifies that all devices in the range 0.0.1000 through 0.0.1500 are to be ignored, except for devices in the range 0.0.1100 through 0.0.1120.

```
cio_ignore=0.0.1000-0.0.1500,!0.0.1100-0.0.1120
```

This is equivalent to the following specification:

```
cio_ignore=0.0.1000-0.0.10ff,0.0.1121-0.0.1500
```

- This example specifies that all devices in range 0.0.1000 through 0.0.1100 and all devices in range 0.1.7000 through 0.1.7010, plus device 0.0.1234 and device 0.1.4321 are to be ignored.

```
cio_ignore=0.0.1000-0.0.1100, 0.1.7000-0.1.7010, 0.0.1234, 0.1.4321
```

## Changing the exclusion list

Use the **cio\_ignore** command or the `procfs` interface to view or change the list of I/O device specifications that are ignored.

When an instance of Linux on Z boots, it senses and analyzes all available I/O devices. You can use the `cio_ignore` kernel parameter to list specifications for devices that are to be ignored.

On a running Linux instance, you can view and change the exclusion list through a `procfs` interface or with the **cio\_ignore** command (see [“cio\\_ignore - Manage the I/O exclusion list” on page 538](#)). This information describes the `procfs` interface.

After booting Linux you can display the exclusion list by issuing:

```
cat /proc/cio_ignore
```

To add device specifications to the exclusion list issue a command of this form:

```
echo add <device_list> > /proc/cio_ignore
```

When you add specifications for a device that is already sensed and analyzed, there is no immediate effect of adding it to the exclusion list. For example, the device still appears in the output of the **lscss** command and can be set online. However, if the device later becomes unavailable, it is ignored when it reappears. For example, if the device is detached in z/VM it is ignored when it is attached again.

To make all devices that are in the exclusion list and that are currently offline unavailable to Linux issue a command of this form:

```
echo purge > /proc/cio_ignore
```

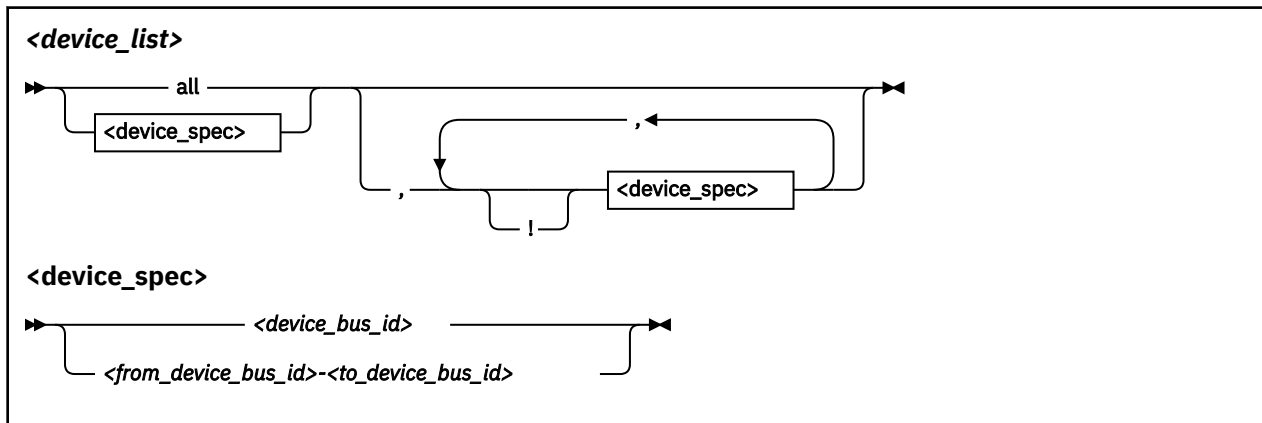
This command does not make devices unavailable if they are online.

To remove device specifications from the exclusion list issue a command of this form:

```
echo free <device_list> > /proc/cio_ignore
```

When you remove device specifications from the exclusion list, the corresponding devices are sensed and analyzed if they exist. Where possible, the respective device driver is informed, and the devices become available to Linux.

In these commands, <device\_list> follows this syntax:



Where the keywords and variables have the same meaning as in “Format” on page 698.

### Ensure device availability

After the echo command completes successfully, some time might elapse until the freed device becomes available to Linux. Issue the following command to ensure that the device is ready to be used:

```
echo 1 > /proc/cio_settle
```

This command returns after all required sysfs structures for the newly available device are completed. The `cio_ignore` command (see “[cio\\_ignore - Manage the I/O exclusion list](#)” on page 538) also returns after any new sysfs structures are completed. You do not need a separate `echo` command when using `cio_ignore` to remove devices from the exclusion list.

### Results

The dynamically changed exclusion list is taken into account only when a device in this list is newly made available to the system, for example after it is defined to the system. It does not have any effect on setting devices online or offline within Linux.

### Examples

- This command removes all devices from the exclusion list.

```
echo free all > /proc/cio_ignore
```

- This command adds all devices in the range 0.0.b100 through 0.0.b1ff and device 0.0.a100 to the exclusion list.

```
echo add 0.0.b100-0.0.b1ff,0.0.a100 > /proc/cio_ignore
```

- This command lists the ranges of devices that are ignored by common I/O.

```
cat /proc/cio_ignore
0.0.0000-0.0.a0ff
0.0.a101-0.0.b0ff
0.0.b200-0.0.ffff
```

- This command removes all devices in the range 0.0.b100 through 0.0.b1ff and device 0.0.a100 from the exclusion list.

```
echo free 0.0.b100-0.0.b1ff,0.0.a100 > /proc/cio_ignore
```

- This command removes the device with bus ID 0.0.c104 from the exclusion list.

```
echo free 0.0.c104 > /proc/cio_ignore
```

- This command adds the device with bus ID 0.0.c104 to the exclusion list.

```
echo add 0.0.c104 > /proc/cio_ignore
```

- This command makes all devices that are in the exclusion list and that are currently offline unavailable to Linux.

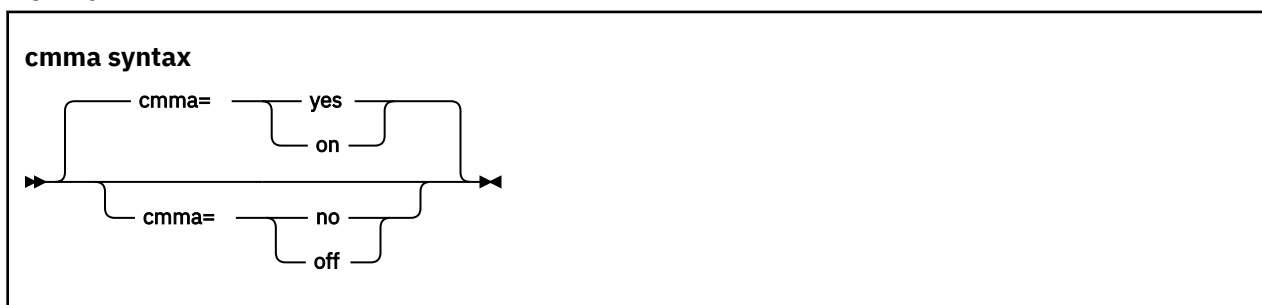
```
echo purge > /proc/cio_ignore
```

## cmma - Reduce hypervisor paging I/O overhead

Use the `cmma=` kernel parameter to reduce hypervisor paging I/O overhead.

With Collaborative Memory Management Assist (CMMA, or "cmm2") support, the z/VM control program and guest virtual machines can communicate attributes for specific 4K-byte blocks of guest memory. This exchange of information helps both the z/VM host and the guest virtual machines to optimize their use and management of memory.

### Format



### Examples

This specification disables the CMMA support:

```
cmma=off
```

Alternatively, you can use the following specification to disable the CMMA support:

```
cmma=no
```

## fips - Run Linux in FIPS mode

In Federal Information Processing Standard (FIPS) mode, the kernel enforces FIPS 140-2 security standards. For example, in FIPS mode only FIPS 140-2 approved encryption algorithms can be used (see “FIPS restrictions of the hardware capabilities” on page 479).

**Note:** Enabling FIPS mode is not sufficient to make your kernel certified according to FIPS 140-2.

FIPS 140-2 certification is specific to a particular hardware platform and kernel build. Typically, running in FIPS mode is required, but not sufficient to be FIPS 140-2 certified.

Check with Ubuntu to find out whether your kernel is certified according to FIPS 140-2. See the Ubuntu Security Certifications at:

<https://docs.ubuntu.com/security-certs/en>

For more information about FIPS 140-2, go to [csrc.nist.gov/publications/detail/fips/140/2/final](https://csrc.nist.gov/publications/detail/fips/140/2/final).

### Format



1 enables the FIPS mode. 0, the default, disables the FIPS mode.

### Example

```
fips=1
```

## maxcpus - Limit the number of CPUs Linux can use at IPL

---

Use the `maxcpus=` kernel parameter to limit the number of CPUs that Linux can use at IPL and that are online after IPL.

If the real or virtual hardware provides more than the specified number of CPUs, these surplus CPUs are initially offline. For example, if five CPUs are available, `maxcpus=2` results in two online CPUs and three offline CPUs after IPL.

Offline CPUs can be set online dynamically unless the `possible_cpus=` parameter is set and specifies a maximum number of online CPUs that is already reached. The `possible_cpus=` parameter sets an absolute limit for the number of CPUs that can be online at any one time (see `possible_cpus`). If both `maxcpus=` and `possible_cpus=` are set, a lower value for `possible_cpus=` overrides `maxcpus=` and makes it ineffective.

### Format

#### maxcpus syntax

```
▶▶ maxcpus= <number> ◀◀
```

### Examples

```
maxcpus=2
```



## nokaslr - Disable kernel randomization

---

By default, Linux uses KASLR. Specify the `nokaslr` kernel parameter to disable kernel randomization, that is, cause the kernel to be loaded at its standard location.

For more information about kernel randomization, see [Chapter 10, “KASLR support,” on page 107](#).

### Format

**nokaslr kernel parameter syntax**

▶▶ nokaslr ▶▶

## nosmt - Disable simultaneous multithreading

---

By default, Linux in LPAR mode uses simultaneous multithreading if it is supported by the hardware. Specify the `nosmt` kernel parameter to disable simultaneous multithreading. See also [“smt - Reduce the number of threads per core” on page 712](#).

For more information about simultaneous multithreading, see [“Simultaneous multithreading” on page 301](#).

### Format

#### **nosmt syntax**

▶▶ nosmt ▶◀

## novx - Disable the Vector Extension Facility

---

By default, Linux uses the Vector Extension Facility if it is supported by the hardware. Specify the `novx` kernel parameter to disable the Vector Extension Facility.

Do not disable the Vector Extension Facility for regular operations. This parameter is intended for test and diagnostics.

### Format

**novx syntax**

▶▶ novx ▶◀

## possible\_cpus - Limit the number of CPUs Linux can use

---

Use the `possible_cpus=` parameter to set an absolute limit for the number of CPUs that can be online at any one time. If the real or virtual hardware provides more than the specified maximum, the surplus number of CPUs must be offline. Alternatively, you can use the common code kernel parameter `nr_cpus`.

Use the `maxcpus=` parameter to limit the number of CPUs that are online initially after IPL (see [maxcpus](#)).

### Format

#### possible\_cpus syntax

▶▶ possible\_cpus= <number> ◀◀

### Examples

```
possible_cpus=8
```

## ramdisk\_size - Specify the ramdisk size

---

Use the `ramdisk_size=` kernel parameter to specify the size of the ramdisk in kilobytes.

### Format

**ramdisk\_size syntax**

▶▶ ramdisk\_size= <size> -▶▶

### Examples

```
ramdisk_size=32000
```

## ro - Mount the root file system read-only

---

Use the `ro` kernel parameter to mount the root file system read-only.

### Format

**ro syntax**

▶▶ ro ▶◀

## root - Specify the root device

---

Use the `root=` kernel parameter to tell Linux what to use as the root when mounting the root file system.

### Format

#### root syntax

```
➤ root= <rootdevice> ➤
```

### Examples

This example makes Linux use `/dev/dasda1` when mounting the root file system:

```
root=/dev/dasda1
```

## smt - Reduce the number of threads per core

---

By default, Linux in LPAR mode uses the maximum number of threads per core that is supported by the hardware. Use the `smt=` kernel parameter to use fewer threads. The value can be any integer in the range 1 to the maximum number of threads that is supported by the hardware.

Specifying `smt=1` effectively disables simultaneous multithreading. See also [“nosmt - Disable simultaneous multithreading”](#) on page 706.

For more information about simultaneous multithreading, see [“Simultaneous multithreading”](#) on page 301.

### Format



where `<hwmax>` is the maximum number of threads per core that is supported by the hardware, and `<number>` is an integer in the range 1 - `<hwmax>`.

### Examples

```
smt=1
```



## vdso - Optimize system call performance

Use the `vdso=` kernel parameter to control the vdso support for the `gettimeofday`, `clock_gettime`, and `clock_gettime` system calls.

The virtual dynamic shared object (vdso) support is a shared library that the kernel maps to all dynamically linked programs. The glibc detects the presence of the vdso and uses the functions that are provided in the library.

Because the vdso library is mapped to all user-space processes, this change is visible in user space. In the unlikely event that a user-space program does not work with the vdso support, you can disable the support.

The default, which is to use vdso support, works well for most installations. Do not override this default, unless you observe problems.

The vdso support is included in the Linux kernel.

### Format



### Examples

This example disables the vdso support:

```
vdso=0
```

## vmhalt - Specify CP command to run after a system halt

---

Use the `vmhalt=` kernel parameter to specify a command to be issued to CP after a system halt. This command applies only to Linux on z/VM.

### Format

#### vmhalt syntax

```
▶▶ vmhalt= <COMMAND> -▶▶
```

### Examples

This example specifies that an initial program load of CMS is to follow the Linux **halt** command:

```
vmhalt="CPU 00 CMD I CMS"
```

**Note:** The command must be entered in uppercase.

## vmpanic - Specify CP command to run after a kernel panic

---

Use the `vmpanic=` kernel parameter to specify a command to be issued to CP after a kernel panic.

This command applies only to Linux on z/VM.

**Note:** Ensure that the `dumpconf` service is disabled when you use this kernel parameter. Otherwise, `dumpconf` will override the setting.

### Format

#### vmpanic syntax

```
▶▶ vmpanic= <COMMAND> -▶▶
```

### Examples

This example specifies that a VMDUMP is to follow a kernel panic:

```
vmpanic="VMDUMP"
```

**Note:** The command must be entered in uppercase.

## vmpoff - Specify CP command to run after a power off

---

Use the `vmpoff=` kernel parameter to specify a command to be issued to CP after a system power off. This command applies only to Linux on z/VM.

### Format

#### vmpoff syntax

```
▶ vmpoff= <COMMAND> -▶
```

### Examples

This example specifies that CP is to clear the guest virtual machine after the Linux **power off** or **halt -p** command:

```
vmpoff="SYSTEM CLEAR"
```

**Note:** The command must be entered in uppercase.

## vmreboot - Specify CP command to run on reboot

---

Use the `vmreboot=` kernel parameter to specify a command to be issued to CP on reboot.

This command applies only to Linux on z/VM.

### Format

#### vmreboot syntax

```
▶▶ vmreboot= <COMMAND> -◀◀
```

### Examples

This example specifies a message to be sent to the z/VM guest virtual machine OPERATOR if a reboot occurs:

```
vmreboot="MSG OPERATOR Reboot system"
```

**Note:** The command must be entered in uppercase.



## Chapter 63. Linux diagnose code use

Linux on Z issues several diagnose instructions to the hypervisor (LPAR or z/VM).

Read `/sys/kernel/debug/diag_stat` to find out which diagnose instructions are called how frequently on your Linux instance.

```
cat /sys/kernel/debug/diag_stat
 CPU0 CPU1
diag 008: 7 7 Console Function
diag 00c: 0 0 Pseudo Timer
diag 010: 0 0 Release Pages
diag 014: 0 0 Spool File Services
diag 044: 616 962 Voluntary Timeslice End
diag 064: 0 0 NSS Manipulation
diag 09c: 7772 6606 Relinquish Timeslice
diag 0dc: 0 0 Appldata Control
diag 204: 2 0 Logical-CPU Utilization
diag 210: 3 6 Device Information
diag 224: 0 0 EBCDIC-Name Table
diag 250: 0 0 Block I/O
diag 258: 1 1 Page-Reference Services
diag 26c: 2 0 Certain System Information
diag 288: 0 0 Time Bomb
diag 2c4: 0 0 FTP Services
diag 2fc: 2 0 Guest Performance Data
diag 304: 0 0 Partition-Resource Service
diag 308: 1 1 List-Directed IPL
diag 500: 0 0 Virtio Service
```

The z/VM configuration can modify and restrict the diagnose calls that are available to its guests (see [“Function unavailable or degraded in Linux on z/VM” on page 511](#)).





---

## Appendix A. Accessibility

Accessibility features help users who have a disability, such as restricted mobility or limited vision, to use information technology products successfully.

### **Documentation accessibility**

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## Appendix B. Understanding syntax diagrams

This section describes how to read the syntax diagrams in this manual.

To read a syntax diagram follow the path of the line. Read from left to right and top to bottom.

- The ►— symbol indicates the beginning of a syntax diagram.
- The —► symbol, at the end of a line, indicates that the syntax diagram continues on the next line.
- The ►— symbol, at the beginning of a line, indicates that a syntax diagram continues from the previous line.
- The —►◀ symbol indicates the end of a syntax diagram.

Syntax items (for example, a keyword or variable) may be:

- Directly on the line (required)
- Above the line (default)
- Below the line (optional)

If defaults are determined by your system status or settings, they are not shown in the diagram. Instead the rule is described together with the option, keyword, or variable in the list following the diagram.

### Case sensitivity

Unless otherwise noted, entries are case sensitive.

### Symbols

You **must** code these symbols exactly as they appear in the syntax diagram

- \* Asterisk
- :
- Colon
- ,
- Comma
- =
- Equals sign
- 
- Hyphen
- //
- Double slash
- ( )
- Parentheses
- .
- Period
- +
- Add
- \$
- Dollar sign

For example:

```
dasd=0.0.7000-0.0.7fff
```

### Variables

An *<italicized>* lowercase word enclosed in angled brackets indicates a variable that you must substitute with specific information. For example:

▶▶ -p — <interface> ▶▶

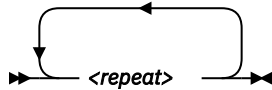
Here you must code **-p** as shown and supply a value for <interface>.

An italicized uppercase word in angled brackets indicates a variable that must appear in uppercase:

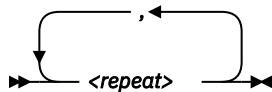
▶▶ vmhalt — = — <COMMAND> ▶▶

### Repetition

An arrow returning to the left means that the item can be repeated.

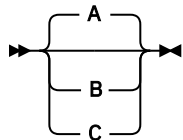


A character within the arrow means you must separate repeated items with that character.



### Defaults

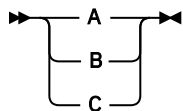
Defaults are above the line. The system uses the default unless you override it. You can override the default by coding an option from the stack below the line. For example:



In this example, A is the default. You can override A by choosing B or C.

### Required Choices

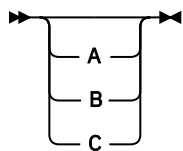
When two or more items are in a stack and one of them is on the line, you **must** specify one item. For example:



Here you must enter either A or B or C.

### Optional Choice

When an item is below the line, the item is optional. Only one item **may** be chosen. For example:



Here you may enter either A or B or C, or you may omit the field.

## Notices

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# Glossary

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This glossary includes IBM product terminology as well as selected other terms and definitions.

Additional information can be obtained in:

- The American National Standard Dictionary for Information Systems, ANSI X3.172-1990, copyright 1990 by the American National Standards Institute (ANSI). Copies may be purchased from the American National Standards Institute, 11 West 42nd Street, New York, New York 10036.
- The ANSI/EIA Standard–440-A, Fiber Optic Terminology. Copies may be purchased from the Electronic Industries Association, 2001 Pennsylvania Avenue, N.W., Washington, DC 20006.
- The Information Technology Vocabulary developed by Subcommittee 1, Joint Technical Committee 1, of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC1/SC1).
- The IBM Dictionary of Computing, New York: McGraw-Hill, 1994.
- Internet Request for Comments: 1208, Glossary of Networking Terms
- Internet Request for Comments: 1392, Internet Users' Glossary
- The Object-Oriented Interface Design: IBM Common User Access Guidelines, Carmel, Indiana: Que, 1992.

## Numerics

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### 10 Gigabit Ethernet

An Ethernet network with a bandwidth of 10000-Mbps.

### 3215

IBM console printer-keyboard.

### 3270

IBM information display system.

### 3370, 3380 or 3390

IBM direct access storage device (disk).

### 3480, 3490, 3590

IBM magnetic tape subsystem.

### 3DES

See Triple Data Encryption Standard.

### 9336 or 9345

IBM direct access storage device (disk).

## A

---

### address space

The range of addresses available to a computer program or process. Address space can refer to physical storage, virtual storage, or both.

### asynchronous transfer mode (ATM)

A transfer mode in which the information is organized into cells; it is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic. ATM is specified in international standards such as ATM Forum UNI 3.1.

### auto-detection

Listing the addresses of devices attached to a card by issuing a query command to the card.

## C

---

### CEC

(Central Electronics Complex). A synonym for *CPC*.

### channel subsystem

The programmable input/output processors of the IBM Z, which operate in parallel with the CPU.

### checksum

An error detection method using a check byte appended to message data

### CHPID

channel path identifier. In a channel subsystem, a value assigned to each installed channel path of the system that uniquely identifies that path to the system.

### compatible disk layout

A disk structure for Linux on Z which allows access from other IBM Z operating systems. This replaces the older Linux disk layout.

### Console

In Linux, an output device for kernel messages.

### CPC

(Central Processor Complex). A physical collection of hardware that includes main storage, one or more central processors, timers, and channels. Also referred to as a *CEC*.

### CRC

cyclic redundancy check. A system of error checking performed at both the sending and receiving station after a block-check character has been accumulated.

### CSMA/CD

carrier sense multiple access with collision detection



## CUU

control unit and unit address. A form of addressing for IBM Z devices using device numbers.

## D

---

### DASD

direct access storage device. A mass storage medium on which a computer stores data.

### device driver

- A file that contains the code needed to use an attached device.
- A program that enables a computer to communicate with a specific peripheral device; for example, a printer, a videodisc player, or a CD-ROM drive.
- A collection of subroutines that control the interface between I/O device adapters and the processor.

### DIAGNOSE

In z/VM, a set of instructions that programs running on z/VM guest virtual machines can call to request CP services.

### disconnected device

In Linux on z Systems®, a device that is online, but to which Linux can no longer find a connection. Reasons include:

- The device was physically removed
- The device was logically removed, for example, with a CP DETACH command in z/VM
- The device was varied offline

## E

---

### ECKD

extended count-key-data device. A disk storage device that has a data transfer rate faster than some processors can utilize and that is connected to the processor through use of a speed matching buffer. A specialized channel program is needed to communicate with such a device.

### ESCON

enterprise systems connection. A set of IBM products and services that provide a dynamically connected environment within an enterprise.

### Ethernet

A 10-Mbps baseband local area network that allows multiple stations to access the transmission medium at will without prior coordination, avoids contention by using carrier sense and deference, and resolves contention by using collision detection and delayed retransmission. Ethernet uses CSMA/CD.

## F

---

### Fast Ethernet (FENET)

Ethernet network with a bandwidth of 100 Mbps

## **FBA**

fixed block architecture. An architecture for a virtual device that specifies the format of and access mechanisms for the virtual data units on the device. The virtual data unit is a block. All blocks on the device are the same size (fixed size). The system can access them independently.

## **FDDI**

fiber distributed data interface. An American National Standards Institute (ANSI) standard for a 100-Mbps LAN using optical fiber cables.

## **fibre channel**

A technology for transmitting data between computer devices. It is especially suited for attaching computer servers to shared storage devices and for interconnecting storage controllers and drives.

## **FTP**

file transfer protocol. In the Internet suite of protocols, an application layer protocol that uses TCP and Telnet services to transfer bulk-data files between machines or hosts.

## **G**

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### **Gigabit Ethernet (GbE)**

An Ethernet network with a bandwidth of 1000-Mbps

## **H**

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### **hardware console**

A service-call logical processor that is the communication feature between the main processor and the service processor.

### **Host Bus Adapter (HBA)**

An I/O controller that connects an external bus, such as a Fibre Channel, to the internal bus (channel subsystem).

In a Linux environment HBAs are normally virtual and are shown as an FCP device.

## **HMC**

hardware management console. A console used to monitor and control hardware such as the IBM Z microprocessors.

## **HFS**

hierarchical file system. A system of arranging files into a tree structure of directories.

## **I**

---

### **intraensemble data network (IEDN)**

A private 10 Gigabit Ethernet network for application data communications within an ensemble. Data communications for workloads can flow over the IEDN within and between nodes of an ensemble. All of the physical and logical resources of the IEDN are configured, provisioned, and managed by the Unified Resource Manager.

## **intranode management network (INMN)**

A private 1000BASE-T Ethernet network operating at 1 Gbps that is required for the Unified Resource Manager to manage the resources within a single zEnterprise node. The INMN connects the Support Element (SE) to the zEnterprise CPC and to any attached zEnterprise BladeCenter Extension (zBX).

## **ioctl system call**

Performs low-level input- and output-control operations and retrieves device status information. Typical operations include buffer manipulation and query of device mode or status.

## **IOCS**

input / output channel subsystem. See channel subsystem.

## **IP**

internet protocol. In the Internet suite of protocols, a connectionless protocol that routes data through a network or interconnected networks and acts as an intermediary between the higher protocol layers and the physical network.

## **IP address**

The unique 32-bit address that specifies the location of each device or workstation on the Internet. For example, 9.67.97.103 is an IP address.

## **IPIP**

IPv4 in IPv4 tunnel, used to transport IPv4 packets in other IPv4 packets.

## **IPL**

initial program load (or boot).

- The initialization procedure that causes an operating system to commence operation.
- The process by which a configuration image is loaded into storage at the beginning of a work day or after a system malfunction.
- The process of loading system programs and preparing a system to run jobs.

## **IPv6**

IP version 6. The next generation of the Internet Protocol.

## **IUCV**

inter-user communication vehicle. A z/VM facility for passing data between virtual machines and z/VM components.

## **K**

---

## **kernel**

The part of an operating system that performs basic functions such as allocating hardware resources.

## **kernel module**

A dynamically loadable part of the kernel, such as a device driver or a file system.

## kernel image

The kernel when loaded into memory.

## L

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### LCS

LAN channel station. A protocol used by OSA.

### LDP

Linux Documentation Project. An attempt to provide a centralized location containing the source material for all open source Linux documentation. Includes user and reference guides, HOW TOs, and FAQs. The homepage of the Linux Documentation Project is

[www.linuxdocs.org](http://www.linuxdocs.org)

### Linux

a variant of UNIX which runs on a wide range of machines from wristwatches through personal and small business machines to enterprise systems.

### Linux disk layout

A basic disk structure for Linux on Z. Now replaced by compatible disk layout.

### Linux on Z

the port of Linux to the IBM Z architecture.

### LPAR

logical partition of an IBM Z.

### LVS (Linux virtual server)

Network sprayer software used to dispatch, for example, http requests to a set of web servers to balance system load.

## M

---

### MAC

medium access control. In a LAN this is the sub-layer of the data link control layer that supports medium-dependent functions and uses the services of the physical layer to provide services to the logical link control (LLC) sub-layer. The MAC sub-layer includes the method of determining when a device has access to the transmission medium.

### Mbps

million bits per second.

### MIB (Management Information Base)

- A collection of objects that can be accessed by means of a network management protocol.
- A definition for management information that specifies the information available from a host or gateway and the operations allowed.

## **MTU**

maximum transmission unit. The largest block which may be transmitted as a single unit.

## **Multicast**

A protocol for the simultaneous distribution of data to a number of recipients, for example live video transmissions.

## **N**

---

## **NIC**

network interface card. The physical interface between the IBM mainframe and the network.

## **O**

---

## **OSA-Express**

Abbreviation for Open Systems Adapter-Express networking features. These include 10 Gigabit Ethernet, Gigabit Ethernet, Fast Ethernet, and ATM.

## **OSPF**

open shortest path first. A function used in route optimization in networks.

## **P**

---

## **POR**

power-on reset

## **POSIX**

Portable Operating System Interface for Computer Environments. An IEEE operating system standard closely related to the UNIX system.

## **R**

---

## **router**

A device or process which allows messages to pass between different networks.

## **S**

---

## **SE**

Support Element.

A hardware unit that provides communications, monitoring, and diagnostic functions to a central processor complex (CPC).

## **SNA**

systems network architecture. The IBM architecture that defines the logical structure, formats, protocols, and operational sequences for transmitting information units through, and controlling the configuration

and operation of, networks. The layered structure of SNA allows the ultimate origins and destinations of information (the users) to be independent of and unaffected by the specific SNA network services and facilities that are used for information exchange.

## **SNMP (Simple Network Management Protocol)**

In the Internet suite of protocols, a network management protocol that is used to monitor routers and attached networks. SNMP is an application layer protocol. Information about devices managed is defined and stored in the application's Management Information Base (MIB).

## **Sysctl**

system control programming manual control (frame). A means of dynamically changing certain Linux kernel parameters during operation.

## **T**

---

### **TDEA**

See Triple Data Encryption Standard.

### **TDES**

See Triple Data Encryption Standard.

### **Telnet**

A member of the Internet suite of protocols which provides a remote terminal connection service. It allows users of one host to log on to a remote host and interact as if they were using a terminal directly attached to that host.

### **Terminal**

A physical or emulated device, associated with a keyboard and display device, capable of sending and receiving information.

### **Triple Data Encryption Standard**

A block cipher algorithm that can be used to encrypt data transmitted between managed systems and the management server. Triple DES is a security enhancement of DES that employs three successive DES block operations.

## **U**

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### **Unified Resource Manager**

IBM zEnterprise Unified Resource Manager. Licensed internal code (LIC), also known as firmware, that is part of the Hardware Management Console. The Unified Resource Manager provides energy monitoring and management, goal-oriented policy management, increased security, virtual networking, and data management for the physical and logical resources of a given ensemble.

### **UNIX**

An operating system developed by Bell Laboratories that features multiprogramming in a multiuser environment. The UNIX operating system was originally developed for use on minicomputers but has been adapted for mainframes and microcomputers.

## V

---

### **VEPA**

Virtual Ethernet Port Aggregator

### **V=R**

In VM, a guest whose real memory (virtual from a VM perspective) corresponds to the real memory of VM.

### **V=V**

In VM, a guest whose real memory (virtual from a VM perspective) corresponds to virtual memory of VM.

### **Virtual Ethernet Port Aggregator**

The capability of a physical server to collaborate with an adjacent bridge to provide frame relay services between multiple virtual machines, which are located on a server and also on the external network.

### **Virtual LAN (VLAN)**

A group of devices on one or more LANs that are configured (using management software) so that they can communicate as if they were attached to the same wire, when in fact they are located on a number of different LAN segments. Because VLANs are based on logical rather than physical connections, they are extremely flexible.

### **volume**

A data carrier that is usually mounted and demounted as a unit, for example a tape cartridge or a disk pack. If a storage unit has no demountable packs the volume is the portion available to a single read/write mechanism.

## Z

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### **z13**

IBM z13.

### **z13s**

IBM z13s.

A member of the IBM Z<sup>®</sup> family. The IBM<sup>®</sup> z13<sup>®</sup> mainframe offers high capacity and processing power, real-time insight to personalize customer experiences, and security to minimize client exposure and protect against cyber threats.

### **z14**

IBM z14.

A member of the IBM Z<sup>®</sup> family. z14 is the enterprise platform for pervasive encryption, integrating data, transactions, and insights into the data. IBM z14 servers are designed with improved scalability, performance, security, resiliency, availability, and virtualization. The superscalar design allows z14 servers to deliver a record level of capacity over the prior IBM Z platforms. In its maximum configuration, z14 is powered by up to 170 client characterizable microprocessors (cores) running at 5.2 GHz. This configuration can run more than 146,000 million instructions per second (MIPS) and up to 32 TB of client memory.

## **z15**

A member of the IBM Z<sup>®</sup> family. IBM z15 enables cloud native services while extending the value of your most valuable data and application investments to address today's business challenges and lead tomorrow's transformation.

## **zBX**

IBM zEnterprise BladeCenter Extension.



## Bibliography

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The publications listed in this chapter are considered useful for a more detailed study of the topics contained in this publication.

### Linux on Z and LinuxONE publications

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The Linux on Z and LinuxONE publications can be found on the developerWorks website.

You can find the latest versions of these publications on IBM Knowledge Center at [ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server](http://ibm.com/docs/en/linux-on-systems?topic=distributions-ubuntu-server) or on developerWorks at [www.ibm.com/developerworks/linux/linux390/documentation\\_ubuntu.html](http://www.ibm.com/developerworks/linux/linux390/documentation_ubuntu.html)

For each of the following publications, you can find the version that most closely reflects Ubuntu Server 20.04.1:

- *Using the Dump Tools*, SC33-8412
- *How to use FC-attached SCSI devices with Linux on z Systems*, SC33-8413
- *libica Programmer's Reference*, SC34-2602
- *Exploiting Enterprise PKCS #11 using openCryptoki*, SC34-2713
- *Secure Key Solution with the Common Cryptographic Architecture Application Programmer's Guide*, SC33-8294
- *Getting started with pervasive disk encryption*, SC34-2783
- *Troubleshooting*, SC34-2612
- *How to Improve Performance with PAV*, SC33-8414
- *How to Set up a Terminal Server Environment on z/VM*, SC34-2596

### z/VM publications

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The publication numbers listed are for z/VM version 7.

For the complete library including other versions, see

[www.ibm.com/vm/library](http://www.ibm.com/vm/library)

- *z/VM: Connectivity*, SC24-6267
- *z/VM: CP Commands and Utilities Reference*, SC24-6268
- *z/VM: CP Planning and Administration*, SC24-6271
- *z/VM: CP Programming Services*, SC24-6272
- *z/VM: Getting Started with Linux on System z*, SC24-6287
- *z/VM: Performance*, SC24-6301
- *z/VM: Saved Segments Planning and Administration*, SC24-6322
- *z/VM: Systems Management Application Programming*, SC24-6327
- *z/VM: TCP/IP Planning and Customization*, SC24-6331
- *z/VM: Virtual Machine Operation*, SC24-6334
- *z/VM: REXX/VM Reference*, SC24-6314
- *z/VM: REXX/VM User's Guide*, SC24-6315

## IBM Redbooks publications

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You can search for, view, or download Redbooks publications, Redpapers, Hints and Tips, draft publications and additional materials on the Redbooks website.

See

[www.ibm.com/redbooks](http://www.ibm.com/redbooks)

- *Building Linux Systems under IBM VM*, REDP-0120
- *Networking Overview for Linux on zSeries*, REDP-3901
- *IBM Communication Controller Migration Guide*, SG24-6298
- *Linux on IBM eServer zSeries and S/390: TCP/IP Broadcast on z/VM Guest LAN*, REDP-3596
- *z/VM: Secure Configuration Guide*, SG24-6323
- *Linux on IBM eServer zSeries and S/390: VSWITCH and VLAN Features of z/VM 4.4*, REDP-3719
- *Fibre Channel Protocol for Linux and z/VM on IBM System z*, SG24-7266
- *IBM Fibre Channel Endpoint Security for IBM DS8900F and IBM Z*, SG24-8455
- *Reduce Storage Occupancy and Increase Operations Efficiency with IBM zEnterprise Data Compression*, SG24-8259

## Other IBM Z publications

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General IBM Z publications that might be of interest in the context of Linux on Z.

- *System z Application Programming Interfaces*, SB10-7030
- *IBM TotalStorage™ Enterprise Storage Server® System/390® Command Reference 2105 Models E10, E20, F10, and F20*, SC26-7295
- *Processor Resource/Systems Manager Planning Guide*, SB10-7041
- *z/Architecture Principles of Operation*, SA22-7832
- *z/Architecture The Load-Program-Parameter and the CPU-Measurement Facilities*, SA23-2260
- *IBM The CPU-Measurement Facility Extended Counters Definition for z10, z196/z114, zEC12/zBC12, z13/z13s, z14, and z15*, SA23-2261

### Networking publications

- *HiperSockets Implementation Guide*, SG24-6816
- *Open Systems Adapter-Express Customer's Guide and Reference*, SA22-7935
- *OSA-Express Implementation Guide*, SG24-5948

### Security related publications

- *zSeries Crypto Guide Update*, SG24-6870
- *Secure Key Solution with the Common Cryptographic Architecture Application Programmer's Guide*, SC33-8294

## ibm.com resources

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On the [ibm.com](http://ibm.com)® website you can find information about many aspects of Linux on Z and LinuxONE including z/VM, I/O connectivity, and cryptography.

- For CMS and CP Data Areas, Control Block information, and the layout of the z/VM monitor records see

[www.ibm.com/vm/pubs/ctlblk.html](http://www.ibm.com/vm/pubs/ctlblk.html)

- For I/O connectivity on IBM Z information, see

[www.ibm.com/systems/support/storage/ssic/interoperability.wss](http://www.ibm.com/systems/support/storage/ssic/interoperability.wss)

- For I/O networks to servers and storage devices to deliver high-performing, secure networking and connectivity, see

[www.ibm.com/it-infrastructure/z/capabilities/networking](http://www.ibm.com/it-infrastructure/z/capabilities/networking)

- For Communications server for Linux information, see

[www.ibm.com/software/network/commserver/linux](http://www.ibm.com/software/network/commserver/linux)

- For information about performance monitoring on z/VM, see

[www.ibm.com/vm/perf](http://www.ibm.com/vm/perf)

- For cryptographic coprocessor information, see

[www.ibm.com/security/cryptocards](http://www.ibm.com/security/cryptocards)

- (Requires registration.) For information for planning, installing, and maintaining IBM systems, see

[www.ibm.com/servers/resourceLink](http://www.ibm.com/servers/resourceLink)

- For information about STP, see

[www.ibm.com/systems/z/advantages/pso/stp.html](http://www.ibm.com/systems/z/advantages/pso/stp.html)



# Index

## Special Characters

- \*ACCOUNT, z/VM record [387](#)
- \*LOGREC, z/VM record [387](#)
- \*MONITOR record reader [381](#)
- \*SYMPTOM, z/VM record [387](#)
- /debug, mount point [xi](#)
- /proc, mount point [xi](#)
- /proc, sysinfo [505](#)
- /sys, mount point [xi](#)
- /sys/kernel/debug, mount point [xi](#)

## Numerics

- 10 Gigabit Ethernet
  - SNMP [271](#)
- 1000Base-T Ethernet
  - LAN channel station [281](#)
  - SNMP [271](#)
- 1750, control unit [111](#)
- 2105, control unit [111](#)
- 2107, control unit [111](#)
- 3088, control unit [281](#)
- 3270 emulation [46](#)
- 3270 terminal device driver
  - switching the views of [48](#)
- 3370, DASD [111](#)
- 3380, DASD [111](#)
- 3390, DASD [111](#)
- 3480 tape drive [195](#)
- 3490 tape drive [195](#)
- 3590 tape drive [195](#)
- 3592 tape drive [195](#)
- 3880, control unit [111](#)
- 3990, control unit [111](#)
- 3DES [467](#)
- 6310, control unit [111](#)
- 64-bit ix
- 9336, DASD [111](#)
- 9343, control unit [111](#)
- 9345, DASD [111](#)

## A

- acceleration
  - applications, user space [345](#)
  - kernel [345](#)
- acceleration, in-kernel cryptography [479](#)
- access control
  - osasmpd [273](#)
- access\_denied
  - zfcplib attribute (FCP LUN) [178](#)
  - zfcplib attribute (port) [167](#)
  - zfcplib attribute (SCSI device) [178](#)
- access\_shared
  - zfcplib attribute [178](#)
- accessibility [721](#)

- ACCOUNT, z/VM record [387](#)
- actions, shutdown [99](#)
- ACTIVE\_CONSOLES [44](#)
- adapter outage [257](#)
- adapter virtualization [447](#)
- add, DCSS attribute [400](#)
- adding and removing cryptographic adapters [461](#)
- Address Resolution Protocol, *See* ARP
- AES [479](#)
- aes\_s390, kernel module [480](#)
- AF\_IUCV
  - addressing sockets in applications [289](#)
  - set up devices for addressing [288](#)
- AF\_IUCV address family
  - features [287](#)
  - set up support for [287](#)
- af\_iucv, kernel module [288](#)
- AgentX protocol [271](#)
- alias
  - DASD attribute [143](#)
- allow\_lun\_scan=, module parameters [151](#)
- AP
  - devices [7](#)
- AP bus
  - attributes [454](#)
- ap module
  - parameters [29](#)
- AP queue [449](#)
- ap\_functions
  - cryptographic adapter attribute [455](#)
- ap\_interrupts
  - cryptographic adapter attribute [460](#)
- ap.apmask=
  - kernel parameter [449](#)
- ap.aqmask=
  - kernel parameter [449](#)
- ap.domain=
  - kernel parameter [449](#)
- ap.poll\_thread=
  - kernel parameter [449](#)

## API

- cryptographic [465](#)
- FC-HBA [150](#)
- GenWQE zlib [358](#)
- zfcplib HBA [188](#)

- apmask, cryptographic device driver attribute [462](#)
- APPLDATA monitor records
  - monitoring Linux instances [367](#)
- APPLDATA, monitor stream [371](#)
- applet
  - emulation of the HMC Operating System Messages [51](#)
- applications
  - addressing AF\_IUCV sockets in [289](#)
- aqmask, cryptographic device driver attribute [462](#)
- arch
  - trng counter [472](#)

## ARP

- ARP (*continued*)
  - proxy ARP [249](#)
  - query/purge OSA-Express ARP cache [642](#)
- attributes
  - device [9](#)
  - for CCW devices [9](#)
  - for subchannels [13](#)
  - qeth [221–223](#)
  - setting [10](#)
- authorization
  - CPU-measurement counter facility [491](#)
- auto-configuration
  - managing [20](#)
- auto-detection
  - DASD [120](#)
- autoconfiguration, IPv6 [214](#)
- autopurge, z/VM recording attribute [390](#)
- autorecording, z/VM recording attribute [389](#)
- availability
  - common CCW attribute [9](#)
  - DASD attribute [125](#)
- avg\_\*, cmf attributes [488](#), [489](#)
- avg\_control\_unit\_queuing\_time, cmf attribute [489](#)
- avg\_device\_active\_only\_time, cmf attribute [489](#)
- avg\_device\_busy\_time [489](#)
- avg\_device\_busy\_time, cmf attribute [489](#)
- avg\_device\_connect\_time, cmf attribute [488](#)
- avg\_device\_disconnect\_time, cmf attribute [489](#)
- avg\_function\_pending\_time, cmf attribute [488](#)
- avg\_initial\_command\_response\_time, cmf attribute [489](#)
- avg\_sample\_interval, cmf attribute [489](#)
- avg\_utilization, cmf attribute [489](#)

## B

- b2b\_credit, zfcf attribute [162](#)
- balloon device [422](#)
- base device
  - helper script [64](#)
- base name, ethernet [428](#)
- ber\_stop=, module parameters [151](#)
- block devices
  - major and minor numbers [426](#)
  - naming [426](#)
- block\_size\_bytes
  - memory sysfs attribute [309](#)
- blocksize, tape attribute [200](#)
- BLS [77](#)
- book\_siblings
  - CPU sysfs attribute [304](#)
- boot configuration
  - module parameters [28](#)
- boot devices
  - logical [61](#)
  - preparing [55](#)
- boot loader code [81](#)
- Boot Loader Specification [77](#)
- boot menu
  - DASD, LPAR example [84](#)
  - DASD, z/VM example [91](#)
  - zipl [67](#)
- boot\_image
  - kernel parameter [27](#)
- booting Linux

- booting Linux (*continued*)
  - troubleshooting [511](#)
- bridge\_hostnotify, qeth attribute [218](#)
- bridge\_invisible, qeth attribute [254](#)
- bridge\_role, qeth attribute [218](#), [252](#)
- bridge\_state, qeth attribute [218](#)
- broadcast forwarding [254](#)
- btrfs [349](#)
- buffer\_count, qeth attribute [229](#)
- buffer-overflow protection [483](#)
- buffer, CPU-measurement sampling facility [494](#)
- bus ID [9](#)
- byte\_counter
  - prandom attribute [468](#)
  - trng attribute [472](#)

## C

- cachesize=, module parameters [341](#)
- capability
  - CPU sysfs attribute [302](#)
- capped
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- card\_type, qeth attribute [231](#)
- card\_version, zfcf attribute [156](#)
- case conversion [52](#)
- Castagnoli [479](#)
- CBC [479](#)
- CCA coprocessor [445](#)
- CCW
  - channel measurement facility [487](#)
  - common attributes [9](#)
  - devices [7](#)
  - group devices [7](#)
  - hotplug events [18](#)
  - setting attributes [518](#)
  - setting devices online/offline [518](#)
- CCW terminal device
  - switching on- or offline [48](#)
- CD-ROM, loading Linux [87](#)
- CD/DVD drive [431](#)
- Central Processor Assist for Cryptographic Function, See CPACF
- CEX3A (Crypto Express3) [445](#)
- CEX3C (Crypto Express3) [445](#)
- CEX4A (Crypto Express4S) [445](#)
- CEX4C (Crypto Express4S) [445](#)
- CEX4P (Crypto Express4S) [445](#)
- CEX5A (Crypto Express5S) [445](#)
- CEX5C (Crypto Express5S) [445](#)
- CEX5P (Crypto Express5S) [445](#)
- CEX6A (Crypto Express6S) [445](#)
- CEX6C (Crypto Express6S) [445](#)
- CEX6P (Crypto Express6S) [445](#)
- CEX7A (Crypto Express7S) [445](#)
- CEX7C (Crypto Express7S) [445](#)
- CEX7P (Crypto Express7S) [445](#)
- change, CPU capability [302](#)
- channel measurement facility
  - cmb\_enable attribute [488](#)
  - features [487](#)
  - kernel parameters [487](#)
  - read-only attributes [488](#)
- channel path

- channel path (*continued*)
  - changing status [520](#)
  - determining usage [509](#)
  - ensuring correct status [509](#)
  - list [595](#)
- channel path availability
  - planned changes [509](#)
  - unplanned changes [509](#)
- channel path ID [14](#)
- channel path measurement [14](#)
- channel subsystem view [12](#)
- channel-attached tape [195](#)
- chccwdev [10](#)
- chccwdev, Linux command [518](#)
- chchp, Linux command [520](#)
- chcpu, Linux command [301](#)
- chcpumf, Linux command [522](#)
- checksum
  - inbound [237](#)
  - outbound [237](#)
  - receive [237](#)
  - transmit [237](#)
- CHID
  - mapping physical to virtual [16](#)
- Chinese-Remainder Theorem [445](#)
- chiucvallow, Linux command [43](#)
- CHPID
  - in sysfs [14](#)
  - map to PCHID [16](#)
  - online attribute [15](#)
- chpids, subchannel attribute [14](#)
- chreipl, Linux command [523](#)
- chshut, Linux command [527](#)
- chunksizes
  - prandom attribute [468](#)
- chunksizes=, module parameters [467](#)
- chzencrypt, Linux command [529](#)
- chzdev [10](#)
- chzdev command [313](#)
- chzdev, Linux command [531](#)
- cio\_ignore
  - disabled wait [510](#)
  - procfs interface [699](#)
- cio\_ignore, Linux command [538](#)
- cio\_ignore=, kernel parameter [698](#)
- clock synchronization
  - enabling and disabling [337](#)
  - switching on and off [337](#)
- cm\_enable
  - channel subsystem sysfs attribute [14](#)
- cmb\_enable
  - cmf attribute [488](#)
  - common CCW attribute [9](#)
  - tape attribute [200](#)
- cmd=, diag288 watchdog [104](#)
- cmf.format=, kernel parameter [487](#)
- cmf.maxchannels=, kernel parameter [487](#)
- cmm
  - avoid swapping with [369](#)
  - background information [368](#)
- CMM
  - unload module [510](#)
- cmm.sender=, kernel parameters [413](#)
- CMMA [702](#)
- cmma=, kernel parameter [702](#)
- CMS disk layout [115](#)
- CMS1 labeled disk [115](#)
- cmsfs-fuse, Linux command [541](#)
- code page
  - for x3270 [46](#)
- Collaborative Memory Management Assist [702](#)
- collecting QETH performance statistics [241](#)
- commands, Linux
  - chccwdev [518](#)
  - chchp [520](#)
  - chcpu [301](#)
  - chcpumf [522](#)
  - chiucvallow [43](#)
  - chreipl [523](#)
  - chshut [527](#)
  - chzencrypt [529](#)
  - cio\_ignore [538](#)
  - cmsfs-fuse [541](#)
  - cpacstats [545](#)
  - cpuplugd [547](#), [548](#)
  - dasdfmt [556](#)
  - dasdstat [561](#)
  - dasdview [563](#)
  - dmesg [4](#), [428](#)
  - dumpconf [100](#)
  - execstack [483](#)
  - fdasd [574](#)
  - genwqe\_echo [353](#)
  - genwqe\_gunzip [353](#)
  - genwqe\_gzip [353](#)
  - gunzip [355](#)
  - gzip [355](#)
  - hmcdrvfs [582](#)
  - hyptop [585](#)
  - icainfo [517](#)
  - icastats [517](#)
  - ip [3](#)
  - iucvconn [44](#)
  - iucvtty [44](#)
  - lschp [595](#)
  - lscpu [301](#)
  - lscpumf [597](#)
  - lscss [600](#)
  - lsdasd [603](#)
  - lshmc [606](#)
  - lsluns [607](#)
  - lsqeth [610](#)
  - lsreipl [611](#)
  - lsscm [612](#)
  - lsshut [614](#)
  - lstape [615](#)
  - lszencrypt [619](#)
  - lszfcps [627](#)
  - mon\_fsstatd [629](#)
  - mon\_procd [634](#)
  - osasnmpd [641](#)
  - qetharp [642](#)
  - qethconf [644](#)
  - qethqoat [647](#)
  - readelf [483](#)
  - readlink [4](#), [428](#)
  - scsi\_logging\_level [650](#)
  - sg\_inq [615](#)

- commands, Linux (*continued*)
  - tape390\_crypt [660](#)
  - tape390\_display [664](#)
  - tar [355](#)
  - time [355](#)
  - tunedasd [666](#)
  - vmconvert [676](#)
  - vmcp [670](#)
  - vmur [672](#)
  - zcryptctl [689](#)
  - zcryptstats [693](#)
  - zdsfs [680](#)
  - zfcg\_ping [190](#)
  - zfcg\_show [190](#)
  - zipl [55](#)
  - znetconf [685](#)
  - zpcictl [688](#)
- commands, z/VM
  - sending from Linux [670](#)
- communication facility
  - Inter-User Communication Vehicle [287](#)
- compatible disk layout [113](#)
- compress=, btrfs mount option [349](#)
- compression
  - GenWQE [351](#)
  - tape [202](#)
- conceal=, diag288 watchdog [104](#)
- configuration file
  - CPU control [549](#)
  - cpuplugd [554](#)
  - memory control [550](#)
  - zipl [72](#)
- configure LPAR I/O devices [509](#)
- configuring standby CPU [302](#)
- conmode=, kernel parameter [41](#)
- connector\_type, zfcg attribute [162](#)
- ConnectX-3 EN [295](#)
- ConnectX-4 [295](#)
- console
  - definition [35](#)
  - device names [35](#)
  - device nodes [36](#)
  - mainframe versus Linux [35](#)
- console device driver
  - kernel parameter [42](#)
  - overriding default driver [41](#)
  - restricting access to HVC terminal devices [43](#)
  - SCLP line-mode buffer page reuse [43](#)
  - SCLP line-mode buffer pages [43](#)
  - specifying preferred console [42](#)
  - specifying the number of HVC terminal devices [43](#)
- console device drivers
  - device and console names [35](#)
  - features [33](#)
  - terminal modes [36](#)
- console=, kernel parameter [42](#)
- control characters [49](#)
- control program identification [501](#)
- control unit
  - 1750 [111](#)
  - 2105 [111](#)
  - 2107 [111](#)
  - 3880 [111](#)
  - 3990 [111](#)
- control unit (*continued*)
  - 6310 [111](#)
  - 9343 [111](#)
- controlling automatic port scans [165](#)
- cooperative memory management
  - set up [413](#)
- coprocessor, cryptographic [445](#)
- core [301](#)
- core\_siblings
  - CPU sysfs attribute [304](#)
- count
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- CP Assist for Cryptographic Function [467](#)
- CP commands
  - send to z/VM hypervisor [670](#)
  - VINPUT [53](#)
- CP Error Logging System Service [387](#)
- CP VINPUT [53](#)
- CP1047 [541](#)
- CPACF
  - in-kernel cryptography [479](#)
  - protected key [473](#)
  - support modules, in-kernel cryptography [480](#)
- cpacfstats, Linux command [545](#)
- cpc\_name attribute [339](#)
- CPI
  - set attribute [503](#)
  - sysplex\_name attribute [501](#)
  - system\_level attribute [502](#)
  - system\_name attribute [501](#)
  - system\_type attribute [502](#)
- CPI (control program identification) [501](#)
- CPU
  - managing [301](#)
- CPU capability change [302](#)
- CPU configuration [545](#), [547](#)
- CPU control
  - complex rules [553](#)
  - configuration file [549](#)
- CPU hotplug
  - sample configuration file [554](#)
- CPU hotplug rules [551](#)
- CPU sysfs attribute
  - book\_siblings [304](#)
  - capability [302](#)
  - core\_siblings [304](#)
  - dispatching [305](#)
  - online [303](#)
  - polarization [305](#)
  - thread\_siblings [304](#)
- CPU sysfs attributes
  - location of [301](#)
- cpu\_delay
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- cpu\_using
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- CPU-measurement counter facility [495](#)
- CPU-measurement facilities
  - chcpumf command [522](#)
  - lscpumf command [597](#)
- CPU-measurement sampling facility
  - buffer limits [494](#)
- CPU, configuring standby [302](#)
- CPU, state [302](#)



- cpuplugd
  - complex rules [553](#)
  - configuration file [554](#)
  - service utility syntax [547](#)
- cpuplugd, Linux command [547](#), [548](#)
- cpustat
  - cpuplugd keywords
  - use with historical data [552](#)
- cputime
  - S/390 hypervisor file system attribute, LPAR [332](#)
- cputime\_us
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- CRC32 [479](#)
- CRT [445](#)
- crypto
  - display statistics [693](#)
- Crypto Express3 [445](#)
- Crypto Express4 [445](#)
- Crypto Express5 [445](#)
- Crypto Express6S [445](#)
- Crypto Express7S [445](#)
- cryptographic
  - request processing [447](#)
- cryptographic adapter
  - attributes [455](#)
  - display information [619](#)
- cryptographic adapters
  - adding and removing dynamically [461](#)
  - detection [447](#)
- cryptographic coprocessor [445](#)
- cryptographic device
  - Linux [449](#)
  - LPAR [448](#)
  - z/VM [448](#)
- cryptographic device driver
  - API [465](#)
  - features [445](#)
  - hardware and software prerequisites [446](#)
  - See also* zcrypt
- cryptographic device nodes [447](#)
- cryptographic domain
  - control [448](#)
  - usage [448](#)
- csulincl.h [466](#)
- CTR [479](#)
- cutype
  - common CCW attribute [9](#)
  - tape attribute [200](#)

## D

- DASD
  - access by udev-created device nodes [119](#)
  - access by VOLSER [118](#)
  - alias attribute [143](#)
  - availability attribute [125](#)
  - boot menu, LPAR example [84](#)
  - boot menu, z/VM example [91](#)
  - booting from [82](#), [90](#)
  - boxed [125](#)
  - CMS disk layout [115](#)
  - compatible disk layout [113](#)
  - control unit attached devices [111](#)
  - device driver [111](#)

- DASD (*continued*)
  - device names [116](#)
  - discipline attribute [143](#)
  - disk layout summary [116](#)
  - displaying information [563](#)
  - displaying overview [603](#)
  - eer\_enabled attribute [127](#)
  - erplog attribute [130](#)
  - expires attribute [131](#)
  - extended error reporting [111](#)
  - failfast attribute [130](#)
  - features [111](#)
  - forcing online [125](#)
  - formatting ECKD [556](#)
  - High Performance FICON [136](#)
  - host\_access\_count attribute [140](#)
  - hpf attribute [142](#)
  - last\_known\_reservation\_state attribute [139](#)
  - Linux disk layout [115](#)
  - module parameter [120](#)
  - online attribute [128](#), [129](#)
  - partitioning [574](#)
  - partitions on [112](#)
  - path\_interval attribute [141](#)
  - path\_threshold attribute [141](#)
  - PAV [136](#)
  - performance statistics [561](#)
  - performance tuning [666](#)
  - raw\_track\_access attribute [136](#)
  - readonly attribute [144](#)
  - reservation\_policy attribute [138](#)
  - safe\_offline attribute [128](#)
  - statistics [132](#)
  - status attribute [145](#)
  - timeout attribute [131](#), [145](#)
  - uid attribute [145](#)
  - use\_diag attribute [126](#), [145](#)
  - vendor attribute [145](#)
  - virtual [111](#)
  - volume label [113](#)
- dasd\_diag\_mod [121](#)
- dasd\_eckd\_mod [121](#)
- dasd\_fba\_mod [121](#)
- dasd\_mod [120](#)
- DASD, SCSI, and tape [65](#)
- dasd=
  - module parameter [120](#)
- dasdfmt, Linux command [556](#)
- dasdstat, Linux command [561](#)
- dasdview, Linux command [563](#)
- data
  - compression [351](#)
  - consistency checking, SCSI [184](#)
  - integrity extension [184](#)
  - integrity field [184](#)
- datarouter=, module parameters [151](#)
- dbfsiz=, module parameters [151](#)
- DCSS
  - access mode [402](#)
  - add attribute [400](#)
  - adding [400](#)
  - device driver [397](#)
  - device names [397](#)
  - device nodes [397](#)

DCSS (*continued*)

- exclusive-writable mode [397](#)
- minor number [401](#)
- performance monitoring using [368](#)
- remove attribute [404](#)
- save attribute [403](#)
- saving with properties [403](#)
- seglst attribute [401](#)
- shared attribute [402](#)
- with options [398](#)

dcssblk [398](#)

deactivating a qeth interface [235](#)

debug feature [370](#)

debugfs

- DASD statistics [132](#)

debugging

- mlx4 [296](#)
- mlx5 [296](#)

decompression, GenWQE [351](#)

decryption [445](#)

dedicated

- S/390 hypervisor file system attribute, z/VM guest [333](#)

delete, zfcf attribute [183](#)

depth

- cryptographic adapter attribute [455](#)

des\_s390, kernel module [480](#)

determine channel path usage [509](#)

device

- interoperability matrix [147](#)

device bus-ID

- of a qeth interface [234](#)

device driver

- crypto [445](#)
- DASD [111](#)
- DCSS [397](#)
- Generic Work Queue Engine [351](#)
- HiperSockets [207](#)
- HMC media [341](#)
- internal shared memory [297](#)
- LCS [281](#)
- mlx4\_en [295](#)
- mlx5\_core [295](#)
- monitor stream application [377](#)
- OSA-Express (QDIO) [207](#)
- overview [7](#)
- PCIe [359](#)
- protected key [473](#)
- pseudorandom number [467](#)
- qeth [207](#)
- SCSI-over-Fibre Channel, *See* zfcf
- smsgiucv\_app [409](#)
- storage-class memory [191](#)
- tape [195](#)
- true random number [471](#)
- virtio CCW transport [425](#)
- vmcp [407](#)
- vmur [395](#)
- watchdog [103](#)
- z/VM \*MONITOR record reader [381](#)
- z/VM recording [387](#)
- zcrypt [445](#)

device drivers

- support of the FCP environment [147](#)

device names (*continued*)

- block devices [426](#)
- console [35](#)
- DASD [116](#)
- DCSS [397](#)
- SCSI-attached tape [429](#)
- storage-class memory [191](#)
- tape [196](#)
- vmcp [407](#)
- vmur [395](#)
- z/VM \*MONITOR record [381](#)
- z/VM recording [387](#)

device nodes

- block devices [426](#)
- CD/DVD drive [431](#)
- console [36](#)
- DASD [117](#)
- DCSS [397](#)
- GenWQE [353](#)
- SCSI [148](#)
- storage-class memory [191](#)
- tape [197](#)
- vmcp [407](#)
- vmur [395](#)
- z/VM \*MONITOR record [381](#)
- z/VM recording [387](#)
- zcrypt [451](#)
- zfcf [148](#)

device numbers [3](#)

device special file, *See* device nodes

device view

- by category [11](#)
- by device drivers [11](#)

device\_blocked

- zfcf attribute (SCSI device) [178](#)

devices

- alias [143](#)
- attributes [9](#)
- balloon [422](#)
- base [143](#)
- CCW, types of [422](#)
- corresponding interfaces [4](#), [428](#)
- ignoring [698](#)
- in sysfs [9](#)
- initialization errors [10](#)
- types of CCW [422](#)
- working with newly available [10](#)

devtype

- common CCW attribute [9](#)
- tape attribute [200](#)

DFLTCC [347](#)

DFLTCC\_LEVEL\_MASK [347](#)

dfltcc=, kernel parameter [349](#)

dhcp [266](#)

DHCP

- required options [266](#)

DIAG

- access method [126](#)

DIAG access method

- for ECKD [116](#)
- for FBA [116](#)

DIAG call [511](#), [719](#)

diag\_max\_age, zfcf attribute [156](#)

diagnose call [511](#), [719](#)

- diagnostics and troubleshooting [497](#)
- diagnostics, FCP channel [161](#)
- DIF [184](#)
- dif=, module parameters [151](#)
- Direct Access Storage Device, *See* DASD
- Direct SNMP [271](#)
- disabled wait
  - booting stops with [511](#)
  - cio\_ignore [510](#)
- discipline
  - DASD attribute [143](#)
  - qeth [220](#)
- discontiguous saved segments, *See* DCSS
- disk layout
  - CMS [115](#)
  - compatible [113](#)
  - LDL [115](#)
  - summary [116](#)
- dispatching
  - CPU sysfs attribute [305](#)
- displaying information
  - FCP channel and device [155](#)
- displaying IPL parameters [94](#)
- DIX [184](#)
- dix=, kernel parameters [151](#)
- dmesg [4](#), [428](#)
- domain, cryptographic [447](#)
- DPM [19](#)
- drive, CD/DVD [431](#)
- drivers, *See* device driver
- dsn
  - metadata file attribute [680](#)
- dsorg
  - metadata file attribute [680](#)
- dump
  - creating automatically after kernel panic [511](#)
- dump device
  - ECKD DASD [66](#)
- dump file
  - receive and convert [677](#)
- dump, virtual server [513](#)
- dumpconf, Linux command [100](#)
- dumped\_frames, zfcf attribute [157](#)
- DVD drive [431](#)
- DVD drive, HMC [341](#)
- DVD, loading Linux [87](#)
- Dynamic Host Configuration Protocol, *See* DHCP
- Dynamic Partitioning Manager [19](#)

## E

- EADM subchannels
  - list [192](#)
  - working with [192](#)
- EBCDIC
  - conversion through cmsfs-fuse [541](#)
  - kernel parameters [81](#)
- ECB [479](#)
- ECDSA
  - P-256 [479](#)
  - P-384 [479](#)
  - P-521 [479](#)
- ECKD
  - devices [111](#)

- ECKD (*continued*)
  - disk layout summary [116](#)
  - raw\_track\_access attribute [136](#)
- ECKD type DASD
  - preparing for use [123](#)
- EdDSA
  - Ed25519 [479](#)
  - Ed448 [479](#)
- edit characters, z/VM console [53](#)
- Edwards-Curve Digital Signature Algorithm [479](#)
- EEDK [660](#)
- eer\_enabled
  - DASD attribute [127](#)
- EKM [660](#)
- Elliptic Curve Digital Signature Algorithm [479](#)
- emulation of the HMC Operating System Messages applet [51](#)
- enable, qeth IP takeover attribute [246](#)
- encoding [541](#)
- encryption [445](#)
- encryption key manager [660](#)
- end-of-line character [52](#)
- end-to-end data consistency, SCSI [184](#)
- Endpoint Security, Fibre Channel [185](#)
- Enterprise PKCS#11 [445](#)
- Enterprise Storage Server [111](#)
- environment variable
  - DFLTCC [347](#)
  - DFLTCC\_LEVEL\_MASK [347](#)
- environment variable [410](#)
- environment variables
  - for CP special messages [410](#)
  - TERM [44](#)
  - ZIPLCONF [72](#)
  - ZLIB\_CARD [354](#)
  - ZLIB\_DEFLATE\_IMPL [354](#)
  - ZLIB\_INFLATE\_IMPL [354](#)
  - ZLIB\_TRACE [354](#)
- EP11
  - display adapter information [619](#)
  - supported functions [445](#)
- EP11 coprocessor [445](#)
- ep11.h [466](#)
- erplog, DASD attribute [130](#)
- Error Logging System Service [387](#)
- error\_frames, zfcf attribute [157](#)
- errorflag
  - prandom attribute [468](#)
- escape character
  - for terminals [52](#)
- ESS [111](#)
- ethernet
  - CCW devices [428](#)
  - interface names [428](#)
- Ethernet
  - interface name [214](#)
  - LAN channel station [281](#)
- exclusive-writable mode
  - DCSS access [397](#)
- execstack, Linux command [483](#)
- expires, DASD attribute [131](#)
- extended error reporting
  - DASD [127](#)
- extended error reporting, DASD [111](#)
- extended remote copy [337](#)

external encrypted data key [660](#)

## F

fabric\_name  
zfc attribute [156](#)

failed  
zfc attribute (channel) [160](#)  
zfc attribute (port) [169](#)

failfast, DASD attribute [130](#)

fake\_broadcast, qeth attribute [245](#)

Fast Ethernet  
LAN channel station [281](#)

FBA  
disk layout summary [116](#)

FBA devices [111](#)

FBA type DASD  
preparing for use [124](#)

FC Endpoint Security [185](#)

fc\_security  
zfc attribute (port) [167](#)

fc\_security, zfc attribute [156](#)

FC-HBA [150](#)

FC-HBA API functions [188](#)

FCP  
channel [147](#)  
debugging [151](#)  
device [147](#)  
traces [151](#)

FCP channel  
diagnostic data [161](#)  
displaying information [155](#)

FCP device  
displaying information [155](#)

FCP devices  
listing [187](#)  
status information [164](#)  
sysfs structure [148](#)

FCP environment [147](#)

fc\_control\_requests zfc attribute [158](#)

fc\_input\_megabytes zfc attribute [158](#)

fc\_input\_requests zfc attribute [158](#)

fc\_output\_megabytes zfc attribute [158](#)

fc\_output\_requests zfc attribute [158](#)

fdasd  
menu commands [577](#)  
menu example [578](#)  
options, example [580](#)

fdasd menu [577](#)

fdasd, Linux command [574](#)

fdisk command [150](#)

fec\_active, zfc attribute [162](#)

Federal Information Processing Standard [479](#), [703](#)

Fibre Channel [147](#)

Fibre Channel Endpoint Security [185](#)

Field Programmable Gate Array [351](#)

file  
configuration, zipl [72](#)

file system  
hugetlbf [327](#)

file systems  
cmsfs-fuse for z/VM minidisk [541](#)  
sysfs [7](#)  
XFS [184](#)

file systems (*continued*)  
zdsfs for z/OS DASD [680](#)

FIPS [479](#)

FIPS restrictions [479](#)

fips=, kernel parameter [703](#)

firmware\_version  
zfc attribute [156](#)

Flash Express memory [191](#)

flooding, qeth attribute [254](#)

for performance measuring [485](#)

formatting [123](#)

FPGA [351](#)

FTP server, loading Linux [87](#)

full ECKD tracks [136](#)

full-screen mode terminal [44](#)

function\_handle  
PCIe attribute [362](#)

function\_id  
PCIe attribute [362](#)

functions  
qeth device driver [210](#)

## G

GB [xi](#)

Generic Work Queue Engine, *See* GenWQE

GenWQE  
environment variables [354](#)  
Java acceleration [351](#)  
load distribution [353](#)

genwqe\_echo, command [353](#)

genwqe\_gunzip, command [353](#)

genwqe\_gzip, command [353](#)

genwqe, package [353](#)

getxattr [541](#), [680](#)

GHASH [479](#)

ghash\_s390, kernel module [480](#)

giga [xi](#)

Gigabit Ethernet  
SNMP [271](#)

GNU\_STACK [483](#)

gpfs, partition type [574](#)

group  
LCS attribute [282](#)  
qeth attribute [224](#)

group devices  
LCS [281](#)  
qeth [213](#)

guest console transcript  
vmur command [677](#)

guest LAN sniffer [268](#)

guest live migration [419](#)

guest memory dump  
vmur command [676](#)

guest swapping [510](#)

gzip, command [355](#)

gzip [345](#)

gzip, command [355](#)

## H

hardware  
configuration [19](#)

- hardware (*continued*)
  - random number [471](#)
  - service level [510](#)
- hardware adapters, SAN access [147](#)
- hardware counter
  - reading with perf tool [492](#)
- hardware facilities [485](#)
- hardware information [505](#), [506](#)
- Hardware Management Console, *See* HMC
- hardware status, z90crypt
  - hardware status, zcrypt [459](#)
  - online
    - zcrypt sysfs attribute [459](#)
  - zcrypt
    - hardware status [459](#)
  - zcrypt sysfs attribute
    - online [459](#)
- hardware\_version
  - zfcf attribute [157](#)
- hardware\_version, zfcf attribute [156](#)
- hardware-acceleration, in-kernel cryptography [479](#)
- HBA API
  - developing applications that use [188](#)
  - functions [188](#)
  - running applications that use [189](#)
- HBA API support
  - zfcf [188](#)
- High Performance FICON [136](#)
- High Performance FICON, suppressing [121](#)
- high resolution polling timer [529](#)
- HiperSockets
  - bridge port [218](#)
  - device driver [207](#)
  - interface name [214](#)
  - network traffic analyzer [266](#)
- HiperSockets Network Concentrator [261](#)
- historical data
  - cpuplugd keywords [552](#)
- HMC
  - as terminal [46](#)
  - definition [35](#)
  - for booting Linux [80](#)
  - Integrated ASCII console applet [37](#), [38](#)
  - Operating System Messages applet
    - on HMC [37](#)
  - using in LPAR [37](#)
  - using on z/VM [38](#)
- HMC DVD drive [342](#), [343](#)
- HMC media
  - list media contents [606](#)
  - mount media [582](#)
- HMC media, device driver [341](#)
- HMC Operating System Messages applet
  - emulation of the [51](#)
- HMC removable media
  - assign to LPAR [342](#)
- hmc\_network attribute [339](#)
- hmcdrvfs, kernel module [341](#)
- hmcdrvfs, Linux command [582](#)
- host
  - KVM, setup [433](#)
- host\_access\_count
  - DASD attribute [140](#)
- hotplug

- hotplug (*continued*)
  - adding memory [310](#)
  - CCW devices [18](#)
  - memory [307](#)
- hotplug memory
  - defining to LPAR [308](#)
  - defining to z/VM [308](#)
  - huge pages [328](#)
- hotplug rules
  - CPU [551](#)
  - memory [552](#)
- hpage=, module parameter [433](#)
- hpf
  - DASD attribute [142](#)
- hsuid, qeth attribute [251](#)
- huge page support
  - change number of [328](#)
  - display information about [328](#)
  - read current number of [328](#)
- huge page support attribute
  - nr\_hugepages [329](#)
- huge pages
  - hotplug memory [328](#)
- hugepages=, kernel parameters [327](#)
- hugetlbfs
  - virtual file system [327](#)
- HVC device driver [40](#)
- hvc\_iucv\_allow=, kernel parameter [73](#)
- hvc\_iucv=, kernel parameter [43](#)
- hw\_trap
  - qeth attribute [241](#)
- hwrng
  - trng counter [472](#)
- hwtype
  - cryptographic adapter attribute [455](#)
- Hyper-Threading [301](#)
- HyperPAV [136](#)
- hypervisor
  - service level [510](#)
- hypervisor capability [507](#)
- hypervisor information [506](#)
- hypfs [331](#)
- hyptop
  - select data [587](#)
  - sort data [588](#)
  - units [590](#)
- hyptop command
  - z/VM fields [589](#)
- hyptop, Linux command [585](#)

**I**

- IBM compatible disk layout [113](#)
- IBM Endpoint Security, Fibre Channel [185](#)
- IBM Java [356](#)
- IBM label partitioning scheme [112](#)
- IBM TotalStorage Enterprise Storage Server [111](#)
- ica\_api.h [465](#)
- icainfo, Linux command [517](#)
- icastats, Linux command [517](#)
- idle
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- IDRC compression [202](#)
- ids=, module parameter [439](#)

- IEEE 802.3 Ethernet [479](#)
- IEP [483](#)
- if names [4](#)
- if\_name
  - qeth attribute [233](#)
- IFCC [141](#)
- immediate failure of I/O requests [130](#)
- Improved Data Recording Capability compression [202](#)
- in\_recovery
  - zfcplib attribute (channel) [160](#)
  - zfcplib attribute (port) [167](#), [169](#)
  - zfcplib attribute (SCSI device) [178](#)
- in\_recovery, zfcplib attribute [156](#)
- in-kernel cryptography [479](#)
- inbound checksum
  - offload operation [236](#)
- inbound checksum, qeth [237](#)
- inbuf\_size, qeth attribute [230](#)
- Initial Program Load, *See* IPL
- initial RAM disk [81](#)
- initrd
  - module parameters [28](#)
- input/output configuration data set [19](#)
- instruction execution protection [483](#)
- Integrated Accelerator for zEDC [345](#)
- Integrated ASCII console applet
  - on HMC [37](#)
- interface
  - MTIO [197](#)
  - network [3](#)
- interface control check [141](#)
- interface names
  - ethernet [428](#)
  - qeth [214](#), [233](#)
  - storage-class memory [191](#)
  - versus devices [4](#), [428](#)
  - vmcp [407](#)
  - vmur [395](#)
- interfaces
  - FC-HBA [150](#)
- internal shared memory
  - device driver [297](#)
- invalid\_crc\_count zfcplib attribute [158](#)
- invalid\_tx\_word\_count zfcplib attribute [158](#)
- IOCDs [19](#)
- iocounterbits
  - zfcplib attribute [178](#)
- ioctl
  - protected key device driver [476](#)
- iodone\_cnt
  - zfcplib attribute (SCSI device) [178](#)
- ioerr\_cnt
  - zfcplib attribute (SCSI device) [178](#)
- IOMMU [435](#)
- iorequest\_cnt
  - zfcplib attribute (SCSI device) [178](#)
- ip [3](#)
- IP address
  - confirming [235](#)
  - duplicate [235](#)
  - takeover [246](#)
  - virtual [250](#)
- IP address takeover, activating and deactivating [247](#)
- ip-link (*continued*)
  - command [260](#)
- ipa\_takeover, qeth attributes [246](#)
- IPL
  - displaying current settings [611](#)
  - SCSI device
    - secure boot [56](#)
- IPL configurations [74](#)
- IPL device
  - FCP
    - device, IPL parameter [94](#)
    - lun, IPL parameter [94](#)
    - wwpn, IPL parameter [94](#)
- IPL devices
  - for booting [80](#)
  - preparing [55](#)
- IPLipl\_type
  - device [94](#)
  - loadparm [94](#)
  - parameters, displaying [94](#)
  - secure [94](#)
- IPv6
  - qeth support for [214](#)
  - stateless autoconfiguration [214](#)
- ISM
  - device driver [297](#)
  - listing devices [297](#)
- ism module [297](#)
- ISO-8859-1 [541](#)
- isolation, qeth attribute [238](#)
- IUCV
  - accessing terminal devices over [47](#)
  - authorizations [288](#)
  - enablement [288](#)
  - maximum number of connections [288](#)
  - OPTION MAXCONN [288](#)
- iucvconn
  - set up a z/VM guest virtual machine for [44](#)
  - using on z/VM [40](#)
- iucvtty [44](#)
- iucvtty, Linux command [44](#)

## J

- Java
  - huge page support [328](#)
- Java, GenWQE [351](#)
- Java, GenWQE acceleration [356](#)
- journaling file systems
  - write barrier [124](#)

## K

- KASLR [107](#)
- KB [xi](#)
- kdump [513](#)
- KEK [660](#)
- kernel address space
  - layout randomization [107](#)
- kernel configuration menu options
  - channel measurement facility [487](#)
- kernel cryptographic API [479](#)
- kernel module

kernel module (*continued*)

- [aes\\_s390 480](#)
- [af\\_iucv 288](#)
- [apldata\\_mem 371](#)
- [apldata\\_net\\_sum 371](#)
- [apldata\\_os 371](#)
- [dasd\\_diag\\_mod 121](#)
- [dasd\\_eckd\\_mod 121](#)
- [dasd\\_fba\\_mod 121](#)
- [dasd\\_mod 120](#)
- [dcssblk 398](#)
- [des\\_s390 480](#)
- [eadm\\_sch 191](#)
- [ghash\\_s390 480](#)
- [hmcdrvfs 341](#)
- [lcs 281](#)
- [monwriter 377](#)
- [paes\\_s390 480](#)
- [pkey 474](#)
- [qdio 207](#)
- [qeth 220](#)
- [qeth\\_l2 220](#)
- [qeth\\_l3 220](#)
- [scm\\_block 191](#)
- [sha1\\_s390 480](#)
- [sha256\\_s390 480](#)
- [sha3\\_256\\_s390 480](#)
- [sha3\\_512\\_s390 480](#)
- [sha512\\_s390 480](#)
- [smsgiucv\\_app 409](#)
- [tape\\_34xx 198](#)
- [tape\\_3590 198](#)
- [vfiopci 439](#)
- [vfiopci\\_ccw 438](#)
- [vfiopci\\_mdev 438, 439](#)
- [vfiopci\\_pci 439](#)
- [virtio\\_blk 422](#)
- [virtio\\_gpu 422](#)
- [virtio\\_input 422](#)
- [virtio\\_net 422](#)
- [virtio\\_rng 422](#)
- [virtio\\_scsi 422](#)
- [vmlogrdr 388](#)
- [vmur 395](#)

kernel panic

- creating dump automatically after [511](#)

kernel parameter

- [pci= 359](#)

kernel parameter file

- for z/VM reader [25](#)

kernel parameter line

- length limit for booting [26](#)
- module parameters [28](#)

kernel parameters

- and [zipl 61](#)
- [ap.apmask= 449](#)
- [ap.aqmask= 449](#)
- [ap.domain= 449](#)
- [ap.poll\\_thread= 449](#)
- channel measurement facility [487](#)
- [cio\\_ignore= 698](#)
- [cmf.format= 487](#)
- [cmf.maxchannels= 487](#)
- [cmm.sender= 413](#)

kernel parameters (*continued*)

- [cmma= 702](#)
- [conmode= 41](#)
- [console= 42](#)
- [dfltcc= 349](#)
- [dix= 151](#)
- [encoding 23](#)
- [fips= 703](#)
- [general 697](#)
- [hugepages= 327](#)
- [hvc\\_iucv\\_allow= 43](#)
- [hvc\\_iucv= 43](#)
- [maxcpus= 704](#)
- [noexec= 483](#)
- [nokaslr 705](#)
- [nosmt 706](#)
- [novx 707](#)
- [possible\\_cpus= 708](#)
- [ramdisk\\_size= 709](#)
- [reboot 27](#)
- [ro 710](#)
- [root= 711](#)
- [sclp\\_con\\_drop= 43](#)
- [sclp\\_con\\_pages= 43](#)
- [smt= 712](#)
- [specifying 23](#)
- [topology= 305](#)
- [vdso= 713](#)
- [vmhalt= 714](#)
- [vmpanic= 715](#)
- [vmpoff= 716](#)
- [vmreboot= 717](#)
- [zipl 23](#)

kernel parameters, example [27](#)

kernel source tree [ix](#)

kernel zlib [345](#)

key

- [pkey-generated protected 474](#)

key encrypting key [660](#)

kilo [xi](#)

KVM

- [host setup 433](#)
- [nested hosts 433](#)
- [VFIO 435](#)

KVM guest

- [console access, virsh 38](#)

## L

LAN

- [sniffer 266](#)
- [z/VM guest LAN sniffer 268](#)

LAN channel station, *See* [LCS](#)

[lancmd\\_timeout](#), [LCS attribute 283](#)

large page support [327](#)

[last\\_known\\_reservation\\_state](#), [DASD attribute 139](#)

layer 2

- [qeth discipline 212](#)

layer 3

- [qeth discipline 212](#)

layer2

- [qeth attribute 226](#)

layer2, [qeth attribute 215](#)

lcs



- lcs (*continued*)
  - recover attribute [285](#)
- LCS
  - activating an interface [284](#)
  - device driver [281](#)
  - group attribute [282](#)
  - lancmd\_timeout attribute [283](#)
  - online attribute [283](#)
  - subchannels [281](#)
  - ungroup attribute [283](#)
- LCS device driver
  - setup [281](#)
- LDL disk layout [115](#)
- learning\_timeout, qeth attribute [254](#)
- learning, qeth attribute [254](#)
- LGR [370](#)
- libcard, GenWQE [351](#)
- libfuse
  - package [541](#), [680](#)
- libhbaapi-dev [188](#)
- libica [446](#)
- libvirt [433](#)
- libzadc4, package [353](#)
- libzfcphbaapi0 [189](#)
- libzfcphbaapi0, package [189](#)
- libzHW [351](#)
- lic\_version, zfcf attribute [156](#)
- line edit characters, z/VM console [53](#)
- line-mode terminal
  - control characters [49](#)
  - special characters [49](#)
- link\_failure\_count, zfcf attribute [157](#)
- Linux
  - as LAN sniffer [266](#)
- Linux commands
  - generic options [517](#)
- Linux device special file, *See* device nodes
- Linux guest relocation [370](#)
- Linux in LPAR mode, booting [82](#)
- Linux on KVM, booting [94](#)
- Linux on z/VM
  - booting [89](#)
  - reducing memory of [369](#)
- Linux source tree [xi](#)
- lip\_count, zfcf attribute [157](#)
- list media contents [342](#)
- listxattr [541](#), [680](#)
- live migration, virtual server [419](#)
- LNX1 labeled disk [115](#)
- LOADDEV [91](#)
- LOADNSHR operand
  - DCSS [397](#)
- log file, osasnmpd [277](#)
- log information
  - FCP devices [164](#)
- logging
  - I/O subchannel status [499](#)
- logical boot device
  - base parameters [63](#)
  - helper script [64](#)
- login at terminals [44](#)
- LOGREC, z/VM record [387](#)
- loss\_of\_signal\_count, zfcf attribute [158](#)
- loss\_of\_sync\_count, zfcf attribute [158](#)
- lost DASD reservation [138](#)
- LPAR
  - configuration
    - device pre-configuration [19](#)
    - storage-class memory [191](#)
  - DPM mode [19](#)
  - hardware counters [491](#)
  - I/O devices, configuring [509](#)
- LPAR configuration [191](#)
- LPAR Linux, booting [82](#)
- lrecl
  - metadata file attribute [680](#)
- lschp, Linux command [595](#)
- lscpu, Linux command [301](#)
- lscpumf, Linux command [597](#)
- lscss, Linux command [192](#), [600](#)
- lsdasd, Linux command [603](#)
- lshmc, Linux command [606](#)
- lsluns, Linux command [607](#)
- lsqeth
  - command [233](#)
- lsqeth, Linux command [610](#)
- lsreipl, Linux command [611](#)
- lsscm, Linux command [193](#), [612](#)
- lsshut, Linux command [614](#)
- lstape, Linux command [615](#)
- lszcrypt, Linux command [619](#)
- lszdev command [313](#)
- lszdev, Linux command [623](#)
- lszfcf, Linux command [627](#)
- LUNs
  - finding available [187](#)
- LVM [193](#)
- lvm, partition type [574](#)

## M

- MAC
  - address learning [254](#)
- MAC addresses [215](#)
- MAC header
  - layer2 for qeth [215](#)
- magic sysrequest functions
  - hvc0 [49](#)
  - line-mode terminal [49](#)
  - VT220 terminal [49](#)
- major and minor
  - block devices [426](#)
- major number
  - console devices [35](#)
  - DASD devices [116](#)
  - tape devices [196](#)
  - vmcp [407](#)
  - z/VM recording [387](#)
  - zcrypt with udev [451](#)
- management information base [271](#)
- manufacturer
  - zfcf attribute [157](#)
- max\_KiB
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- maxcpus=, kernel parameter [704](#)
- maxframe\_size
  - zfcf attribute [157](#)
- maximum frame size



- maximum frame size (*continued*)
  - qeth [230](#)
- MB [xi](#)
- mcast\_flooding, qeth attribute [254](#)
- measurement
  - channel path [14](#)
- measurements
  - PCIe attribute [362](#)
- Media Access Control (MAC) addresses [215](#)
- mediated device
  - VFIO AP [439](#)
  - VFIO CCW [438](#)
- mediated device, VFIO [435](#)
- Medium Access Control (MAC) header [216](#)
- medium\_state, tape attribute [201](#)
- mega [xi](#)
- Mellanox
  - ConnectX-3 EN [295](#)
  - ConnectX-4 [295](#)
- mem\_dela
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- memory
  - adding hotplug [310](#)
  - block\_size\_bytes attribute [309](#)
  - Flash Express [191](#)
  - guest, reducing [369](#)
  - hotplug [307](#)
  - state attribute [309](#)
  - storage-class [191](#)
- memory control
  - complex rules [553](#)
  - configuration file [550](#)
- memory hotplug
  - sample configuration file [554](#)
- memory hotplug rules [552](#)
- memory sysfs attribute
  - block\_size\_bytes [309](#)
- menu configuration
  - z/VM example [91](#)
- metadata file for z/OS DASD [680](#)
- MFS [230](#)
- mgmtime
  - S/390 hypervisor file system attribute [332](#)
  - S/390 hypervisor file system attribute, LPAR [332](#)
- MIB (management information base) [271](#)
- migration, virtual server [419](#)
- min\_KiB
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- minor and major
  - block devices [426](#)
- minor number
  - console devices [35](#)
  - DASD devices [116](#)
  - DCSS devices [401](#)
  - tape devices [196](#)
  - vmcp [407](#)
  - z/VM recording [387](#)
  - z90crypt with udev [451](#)
- mkvps
  - cryptographic adapter attribute [458](#)
- mlx4\_en
  - device driver [295](#)
- mlx4, debug [296](#)
- mlx5\_core
  - device driver [295](#)
- mlx5\_core (*continued*)
  - device driver [295](#)
- mlx5, debug [296](#)
- modalias
  - common CCW attribute [9](#)
  - cryptographic adapter attribute [455](#)
- mode
  - prandom attribute [468](#)
- mode terminal
  - full-screen [44](#)
- model
  - zfcf attribute [157](#)
  - zfcf attribute (SCSI device) [178](#)
- modprobe [28](#)
- module
  - ism [297](#)
- module parameter
  - hpage= [433](#)
  - ids= [439](#)
  - nested= [433](#)
- module parameters
  - allow\_lun\_scan= [151](#)
  - ber\_stop= [151](#)
  - boot configuration [28](#)
  - cache\_size= [341](#)
  - chunksize= [467](#)
  - dasd= [120](#)
  - datarouter= [151](#)
  - dbfsize= [151](#)
  - dif= [151](#)
  - kernel parameter line [28](#)
  - mode=
    - module parameters [467](#)
  - mondcss= [377](#), [383](#)
  - queue\_depth= [151](#)
  - reseed\_limit= [467](#)
  - scm\_block= [191](#)
  - sender= [409](#)
- modules
  - qeth, removing [221](#)
- modulus-exponent [445](#)
- mon\_fsstatd
  - command-line syntax [631](#)
  - monitor data, processing [631](#)
  - monitor data, reading [632](#)
  - systemd service unit syntax [629](#)
- mon\_fsstatd, command [629](#)
- mon\_procd
  - command-line syntax [636](#)
  - monitor data, reading [639](#)
- mon\_procd, command [634](#)
- mon\_statd
  - monitor data, processing [636](#)
  - systemd service unit syntax [634](#)
- mondcss=, module parameters [377](#), [383](#)
- monitor data
  - read [368](#)
- monitor DCSS [383](#)
- monitor stream
  - module activation [372](#)
  - on/off [371](#)
  - sampling interval [372](#)
- monitor stream application
  - device driver [377](#)

- monitoring
  - z/VM performance [367](#)
- monitoring Linux instances [367](#)
- mount media contents [343](#)
- mount point
  - debugfs [xi](#)
  - procfs [xi](#)
  - sysfs [xi](#)
- mt-st, package [202](#)
- MTIO interface [197](#)
- MTU
  - qeth [234](#)
- multicast forwarding [254](#)
- multicast\_router, value for qeth router attribute [243](#)
- multithreading [301](#)

## N

- name
  - devices, *See* device names
  - ethernet interfaces [428](#)
- names
  - DASD [116](#)
- native, partition type [574](#)
- nested hosts, KVM [433](#)
- nested=, module parameter [433](#)
- net-snmp [271](#)
- network concentrator
  - examples [263](#)
- Network Concentrator [261](#)
- network interfaces [3](#)
- network names [4](#)
- network traffic analyzer
  - HiperSockets [266](#)
- no\_prio\_queueing [227](#)
- no\_router, value for qeth router attribute [243](#)
- node\_name
  - zfcplib attribute (port) [167](#)
- node, device, *See* device nodes
- noexec=
  - kernel parameter [483](#)
- nokaslr, kernel parameter [705](#)
- non-operational terminals
  - preventing re-spawns for [45](#)
- non-priority commands [51](#)
- non-rewinding tape device [195](#)
- nos\_count, zfcplib attribute [157](#)
- nosmt, kernel parameter [706](#)
- novx, kernel parameter [707](#)
- nowayout=, diag288 watchdog [104](#)
- NPIV
  - example [163](#)
  - FCP channel mode [163](#)
  - for FCP channels [151](#)
  - removing SCSI devices [183](#)
- nr\_hugepages
  - huge page support attribute [329](#)

## O

- object ID [271](#)
- offline
  - CHPID [15](#)

- offline (*continued*)
  - devices [9](#)
- offload operations
  - inbound checksum [236](#)
  - outbound checksum [236](#)
  - TCP segmentation offload (TSO) [236](#)
- OID (object ID) [271](#)
- on-chip data compression [345](#)
- online
  - CHPID [15](#)
  - common CCW attribute [9](#)
  - CPU attribute [303](#)
  - cryptographic adapter attribute [459](#)
  - DASD attribute [128](#), [129](#)
  - LCS attribute [283](#)
  - qeth attribute [232](#)
  - tape attribute [199](#), [200](#)
  - TTY attribute [49](#)
  - zfcplib attribute [154](#)
- onlinetime
  - S/390 hypervisor file system attribute, LPAR [332](#)
- Open Source Development Network, Inc. [271](#)
- openCryptoki, library [465](#)
- Operating System Messages applet
  - emulation of the HMC [51](#)
- operation, tape attribute [201](#)
- optical\_port, zfcplib attribute [162](#)
- OPTION MAXCONN [288](#)
- optional properties
  - DCSS [398](#)
- OSA-Express
  - device driver [207](#)
  - LAN channel station [281](#)
  - SNMP subagent support [271](#)
- OSA-Express MIB file [273](#)
- osasnmpd
  - access control [273](#)
  - checking the log file [277](#)
  - master agent [271](#)
  - setup [272](#)
  - starting the subagent [276](#)
  - stopping [278](#)
  - subagent [271](#)
- osasnmpd, command [641](#)
- osasnmpd, OSA-Express SNMP subagent [271](#)
- OSDN (Open Source Development Network, Inc.) [271](#)
- other
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- outbound checksum
  - offload operation [236](#)
- outbound checksum, qeth [237](#)
- overlap with guest storage [382](#)

## P

- package
  - genwqe [353](#)
  - libfuse [680](#)
  - libhbaapi-dev [188](#)
  - libhugetlbfs [327](#)
  - libica [446](#)
  - libzadc4 [353](#)
  - mt-st [202](#)
  - openCryptoki [465](#)

- package (*continued*)
  - s390-tools [517](#)
  - util-linux [301](#)
- paes\_s390, kernel module [480](#)
- page pool
  - static [369](#)
  - timed [369](#)
- parallel access volume (PAV) [143](#)
- parameter
  - kernel and module [23](#)
- parameters
  - displaying IPL [94](#)
- partition
  - on DASD [112](#)
  - schemes for DASD [112](#)
  - table [114](#)
- partitioning
  - SCSI devices [150](#)
- pass-through, VFIO [435](#)
- path\_interval
  - DASD attribute [141](#)
- path\_threshold
  - DASD attribute [141](#)
- PAV (parallel access volume) [143](#)
- PAV enablement, suppression [121](#)
- pchid
  - PCIe attribute [362](#)
- PCHID
  - map to CHPID [16](#)
- pci=, kernel parameter [359](#)
- PCIe
  - defective [361](#)
  - device driver [359](#)
  - function\_handle attribute [362](#)
  - function\_id attribute [362](#)
  - pchid attribute [362](#)
  - pfgid attribute [362](#)
  - pfip attribute [362](#)
  - power attribute [360](#)
  - recover attribute [361](#)
  - set up [359](#)
  - statistics attribute [362](#)
  - uid attribute [362](#)
  - vfn attribute [362](#)
- peer\_d\_id, zfcf attribute [156](#)
- peer\_wwnn, zfcf attribute [156](#)
- peer\_wwpn, zfcf attribute [156](#)
- pendingq\_count
  - cryptographic adapter attribute [456](#), [458](#)
- perf tool
  - reading a hardware counter [492](#)
  - reading sample data [494](#)
- performance
  - CPU-measurement facilities [491](#)
  - DASD [132](#), [561](#)
- performance measuring
  - with hardware facilities [485](#)
- performance monitoring
  - z/VM [367](#)
- performance statistics, QETH [241](#)
- Peripheral Component Interconnect [359](#)
- permanent\_port\_name, zfcf attribute [157](#), [163](#)
- permissions
  - S/390 hypervisor file system [334](#)
- persistent device configuration [313](#)
- pfgid
  - PCIe attribute [362](#)
- pfip
  - PCIe attribute [362](#)
- physical channel ID
  - for CHPID [16](#)
- physical\_s\_id, zfcf attribute [163](#)
- pimpampom, subchannel attribute [14](#)
- pkey
  - protected AES key [475](#)
  - secure key [474](#)
- pkey-generated protected key [474](#)
- pkey, kernel module [474](#)
- pksc11.h [465](#)
- PNET ID [297](#)
- polarization
  - CPU sysfs attribute [305](#)
  - values [305](#)
- poll thread
  - enable using chcrypt [529](#)
- poll\_thread
  - AP bus [454](#)
  - cryptographic adapter attribute [459](#)
- poll\_timeout
  - cryptographic adapter attribute [461](#)
  - set using chcrypt [529](#)
- port scan
  - controlling [165](#)
- port\_id
  - zfcf attribute (port) [167](#)
- port\_id, zfcf attribute [157](#)
- port\_name
  - zfcf attribute (port) [167](#)
- port\_name, zfcf attribute [157](#)
- port\_remove, zfcf attribute [169](#)
- port\_rescan, zfcf attribute [164](#)
- port\_scan\_backoff [165](#)
- port\_scan\_ratelimit [165](#)
- port\_state
  - zfcf attribute (port) [167](#)
- port\_tx\_type, zfcf attribute [162](#)
- port\_type, NPIV [171](#)
- port\_type, zfcf attribute [157](#)
- portno, qeth attribute [230](#)
- ports
  - listing [187](#)
- possible\_cpus=, kernel parameter [708](#)
- power attribute
  - PCIe [360](#)
- prandom
  - byte\_counter attribute [468](#)
  - chunksize attribute [468](#)
  - errorflag attribute [468](#)
  - mode attribute [468](#)
- preferred console [42](#)
- preparing as dump device [65](#)
- preparing ECKD [123](#)
- preparing FBA [124](#)
- prerequisites [111](#)
- prim\_seq\_protocol\_err\_count, zfcf attribute [158](#)
- primary\_connector, value for qeth router attribute [243](#)
- primary\_router, value for qeth router attribute [243](#)
- prio\_queueing\_prec [227](#)

- prio\_queueing\_skb [227](#)
- prio\_queueing\_vlan [227](#)
- prio\_queueing, value for qeth priority\_queueing attribute [228](#)
- priority command [51](#)
- priority\_queueing, qeth attribute [227](#)
- prng
  - reseed [470](#)
  - reseed\_limit [469](#)
- processors
  - cryptographic [7](#)
- prodfs
  - apldata [371](#)
  - cio\_ignore [699](#)
  - magic sysrequest function [50](#)
  - VLAN [260](#)
- programming interfaces
  - protected key device driver [476](#)
- promiscuous mode [218](#)
- prot\_capabilities
  - zfcf attribute [184](#)
- protected key
  - pkey generated [474](#)
- protected key device driver
  - programming interfaces [476](#)
- protected keyswap disk [475](#)
- proxy ARP [249](#)
- proxy ARP attributes [223](#)
- pseudorandom number
  - device driver [467](#)
- PSW
  - disabled wait [511](#)
- purge, z/VM recording attribute [390](#)
- PVMSG [51](#)

## Q

- qclib [506](#)
- QDIO [213](#)
- QEMU [433](#)
- qeth
  - activating an interface [234](#)
  - activating and deactivating IP addresses for takeover [247](#)
  - auto-detection [214](#)
  - bridge\_hostnotify attribute [218](#)
  - bridge\_invisible attribute [254](#)
  - bridge\_role attribute [218](#), [252](#)
  - bridge\_state attribute [218](#)
  - buffer\_count attribute [229](#)
  - card\_type attribute [231](#)
  - configuration tool [644](#)
  - deactivating an interface [235](#)
  - device driver [207](#)
  - discipline, switching [220](#)
  - displaying device overview [610](#)
  - enable attribute for IP takeover [246](#)
  - fake\_broadcast attribute [245](#)
  - flooding attribute [254](#)
  - function summary [210](#)
  - group attribute [224](#)
  - group devices, names of [212](#)
  - hsuid attribute [251](#)
  - hw\_trap attribute [241](#)
  - if\_name attribute [233](#)

- qeth (*continued*)
  - inbuf\_size attribute [230](#)
  - ipa\_takeover attributes [246](#)
  - isolation attribute [238](#)
  - layer 2 [212](#)
  - layer 3 [212](#)
  - layer2 attribute [215](#), [226](#)
  - learning attribute [254](#)
  - learning\_timeout attribute [254](#)
  - mcast\_flooding attribute [254](#)
  - MTU [234](#)
  - online attribute [232](#)
  - portno attribute [230](#)
  - priority\_queueing attribute [227](#)
  - problem determination attribute [222](#)
  - proxy ARP attributes [223](#)
  - recover attribute [236](#)
  - removing modules [221](#)
  - route4 attribute [242](#)
  - route6 attribute [242](#)
  - rx\_bcast attribute [254](#)
  - sniffer attributes [223](#)
  - subchannels [213](#)
  - summary of attributes [221](#)–[223](#)
  - takeover\_learning attribute [254](#)
  - takeover\_setvmac attribute [254](#)
  - TCP segmentation offload [238](#)
  - VIPA attributes [223](#)
  - vnicc attributes [254](#)
- qeth device driver
  - IPv6 [214](#)
- qeth interfaces, mapping [4](#), [428](#)
- QETH performance statistics [241](#)
- qetharp, Linux command [642](#)
- qethconf, Linux command [644](#)
- qethcoat, Linux command [647](#)
- query host access
  - DASD [140](#)
- query HPF
  - DASD [142](#)
- queue\_depth, zfcf attribute [179](#)
- queue\_depth=, module parameters [151](#)
- queue\_ramp\_up\_period, zfcf attribute [179](#)
- queueing, priority [227](#)

## R

- raid, partition type [574](#)
- RAM disk, initial [81](#)
- ramdisk\_size=, kernel parameter [709](#)
- random number
  - device driver [467](#), [471](#)
- random numbers
  - reading [468](#), [471](#)
- randomization
  - kernel address space layout [107](#)
- raw\_track\_access, DASD attribute [136](#)
- raw-track access mode [136](#), [563](#), [680](#)
- RDMA [359](#)
- read monitor data [368](#)
- readelf, Linux command [483](#)
- readlink, Linux command [4](#), [428](#)
- readonly
  - DASD attribute [144](#)

- reboot
  - kernel parameters [27](#)
- receive checksum, qeth [237](#)
- recfm
  - metadata file attribute [680](#)
- record layout
  - z/VM [387](#)
- recording, z/VM recording attribute [389](#)
- recover
  - PCIe attribute [361](#)
- recover, lcs attribute [285](#)
- recover, qeth attribute [236](#)
- reflective relay mode [238](#)
- relative port number
  - qeth [230](#)
- Remote Direct Memory Access (RDMA) [359](#)
- Remote Spooling Communications Subsystem [672](#)
- Removable media, loading Linux [87](#)
- remove channel path
  - DASD [141](#)
- remove, DCSS attribute [404](#)
- request processing
  - cryptographic [447](#)
- request\_count
  - cryptographic adapter attribute [455](#)
- requestq\_count
  - cryptographic adapter attribute [456](#), [459](#)
- rescan
  - zfcf attribute (SCSI device) [181](#)
- reseed
  - prandom attribute [468](#)
  - prng [470](#)
- reseed\_limit
  - prandom attribute [468](#)
  - prng [469](#)
- reseed\_limit=, module parameters [467](#)
- reservation state
  - DASD [139](#)
- reservation\_policy, DASD attribute [138](#)
- reset\_statistics
  - zfcf attribute [157](#)
- respawn prevention [45](#)
- restrictions [111](#)
- retrieving hardware information [506](#)
- rev
  - zfcf attribute (SCSI device) [178](#)
- rewinding tape device [195](#)
- RFC
  - 1950 (zlib) [351](#)
  - 1951 (deflate) [351](#)
  - 1952 (gzip) [351](#)
  - 2131 (DHCP) [265](#)
  - 2132 (DHCP options and BOOTP Vendor Extensions) [265](#)
- Rivest-Shamir-Adleman [445](#)
- ro, kernel parameter [710](#)
- RoCE [359](#)
- roles
  - zfcf attribute (port) [167](#)
- root=, kernel parameter [711](#)
- route4, qeth attribute [242](#)
- route6, qeth attribute [242](#)
- router
  - IPv4 router settings [242](#)

- router (*continued*)
  - IPv6 router settings [242](#)
- RSA [445](#)
- RSA exponentiation [445](#)
- RSCS [672](#)
- rx\_bcast, qeth attribute [254](#)
- rx\_frames, zfcf attribute [157](#)
- rx\_power, zfcf attribute [162](#)
- rx\_words, zfcf attribute [157](#)

**S**

- s\_id, zfcf attribute [163](#)
- S/390 hypervisor file system
  - defining access rights [334](#)
  - directory structure [331](#)
  - LPAR directory structure [331](#)
  - updating hypfs information [335](#)
  - z/VM directory structure [332](#)
- s390\_sthyi() [506](#)
- s390-tools, package [517](#)
- s390dbf [370](#)
- safe\_offline
  - DASD attribute [128](#)
- sample\_count, cmf attribute [488](#)
- sampling facility
  - reading data [494](#)
- SAN access, adapters [147](#)
- save, DCSS attribute [403](#)
- sclp\_con\_drop=, kernel parameter [43](#)
- sclp\_con\_pages=, kernel parameter [43](#)
- SCM [193](#)
- scm\_block=, module parameters [191](#)
- script
  - base device [64](#)
- SCSI
  - data consistency checking [184](#)
  - multipath devices [150](#)
  - tape [429](#)
  - virtual CD/DVD drive [431](#)
  - virtual HBA [422](#)
- SCSI device
  - automatically attached, configuring [171](#)
  - configuring manually [171](#)
- SCSI devices
  - information in sysfs [177](#)
  - partitioning [150](#)
  - removing [183](#)
  - sysfs structure [148](#)
- SCSI tape
  - lstape data [617](#)
- scsi\_host\_no, zfcf attribute [173](#)
- scsi\_id, zfcf attribute [173](#)
- scsi\_level
  - zfcf attribute (SCSI device) [178](#)
- scsi\_logging\_level, Linux command [650](#)
- scsi\_lun, zfcf attribute [173](#)
- scsi\_target\_id
  - zfcf attribute (port) [167](#)
- SCSI-over-Fibre Channel [147](#)
- SCSI-over-Fibre Channel device driver [147](#)
- SCSI, booting from [82](#), [91](#)
- SE (Support Element) [80](#)
- secondary\_connector, value for qeth router attribute [243](#)

- secondary\_router, value for qeth router attribute [243](#)
- seconds\_since\_last\_reset
  - zfcplib attribute [157](#)
- secure boot
  - zipl syntax [56](#)
- secure key
  - pkey [474](#)
- seglist, DCSS attribute [401](#)
- segmentation offload, TCP [238](#)
- send files
  - vmur command [678](#)
- send files to z/VSE
  - vmur command [679](#)
- sender=, module parameter [409](#)
- serial\_number, zfcplib attribute [157](#)
- service levels
  - reporting to IBM Support [510](#)
- service utility
  - cpuplugd [547](#)
- set, CPI attribute [503](#)
- setup
  - KVM host [433](#)
  - LCS device driver [281](#)
  - standard VIPA [257](#)
- setxattr [541](#)
- sfp\_invalid, zfcplib attribute [161](#)
- sg\_inq, Linux command [615](#)
- sg3\_utils, package [615](#)
- SHA-1 [479](#)
- SHA-256 [479](#)
- SHA-512
  - in-kernel cryptography [479](#)
- sha1\_s390, kernel module [480](#)
- sha256\_s390, kernel module [480](#)
- sha3\_256\_s390, kernel module [480](#)
- sha3\_512\_s390, kernel module [480](#)
- SHA3-256 [479](#)
- SHA3-512 [479](#)
- sha512\_s390, kernel module [480](#)
- share\_KiB
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- shared, DCSS attribute [402](#)
- shutdown actions [99](#)
- SIE capability [507](#)
- Simple Network Management Protocol [271](#)
- simultaneous multithreading [301](#)
- smc\_pnet, Linux command [653](#)
- smc\_run, Linux command [655](#)
- smcss, Linux command [656](#)
- SMSG\_ID [410](#)
- SMSG\_SENDER [410](#)
- smsgiucv\_app
  - device driver [409](#)
- SMT [301](#)
- smt=, kernel parameter [712](#)
- sniffer
  - attributes [223](#)
- sniffer, guest LAN [268](#)
- snippet, BLS [77](#)
- SNMP [271](#)
- SNMP queries [277](#)
- snmpcmd command [277](#)
- source tree, Linux [xi](#)
- special characters
  - special characters (*continued*)
    - line-mode terminals [49](#)
    - z/VM console [53](#)
- special file
  - DASD [117](#)
  - See also* device nodes
- speed, zfcplib attribute [157](#)
- ssch\_rsch\_count, cmf attribute [488](#)
- standard VIPA
  - adapter outage [257](#)
  - setup [257](#)
- standby CPU, configuring [302](#)
- state
  - sysfs attribute [309](#)
  - zfcplib attribute (SCSI device) [182](#)
- state, tape attribute [201](#)
- stateless autoconfiguration, IPv6 [214](#)
- static page pool
  - reading the size of the [413](#)
- static page pool size
  - setting to avoid guest swapping [510](#)
- statistics
  - crypto [693](#)
  - DASD [132](#), [561](#)
  - PCIe attribute [362](#)
  - QETH [241](#)
- status
  - DASD attribute [145](#)
- status information
  - FCP devices [164](#)
- status, CHPID attribute [15](#)
- STHYI instruction [506](#)
- storage
  - memory hotplug [307](#)
- storage-class memory
  - device driver [191](#)
  - device names [191](#)
  - device nodes [191](#)
  - displaying overview [612](#)
  - working with increments [192](#)
- Store Hypervisor Information instruction [506](#)
- STP
  - sysfs interface [337](#)
- strength
  - prandom attribute [468](#)
- subchannel
  - status logging [499](#)
- subchannels
  - attributes in sysfs [13](#)
  - CCW and CCW group devices [7](#)
  - displaying overview [600](#)
  - EADM [191](#)
  - in sysfs [12](#)
  - LCS [281](#)
  - qeth [213](#)
- support
  - AF\_IUCV address family [287](#)
- Support Element [80](#)
- supported\_classes
  - zfcplib attribute (port) [167](#)
- supported\_classes, zfcplib attribute [157](#)
- supported\_speeds, zfcplib attribute [157](#)
- swap disk
  - pkey-generated protected key [475](#)

- swap, partition type [574](#)
- swapping
  - avoiding [369](#)
- symbolic\_name, zfcplib attribute [157](#)
- SYMPTOM, z/VM record [387](#)
- syntax diagrams [723](#)
- syntax overview
  - zipl [56](#)
- sysfs
  - channel subsystem view [12](#)
  - device view [12](#)
  - device view by category [11](#)
  - device view by drivers [11](#)
  - FCP devices [148](#)
  - information about SCSI devices [177](#)
  - SCSI devices [148](#)
- sysfs attribute
  - block\_size\_bytes [309](#)
  - cm\_enable [14](#)
  - state [309](#)
- sysinfo [505](#)
- sysplex\_name, CPI attribute [501](#)
- system states
  - displaying current settings [614](#)
- system time [337](#)
- system time protocol [337](#)
- system\_level, CPI attribute [502](#)
- system\_name, CPI attribute [501](#)
- system\_type, CPI attribute [502](#)
- systemd [45](#)

## T

- T10 DIF [185](#)
- takeover\_learning, qeth attribute [254](#)
- takeover\_setvmac, qeth attribute [254](#)
- tape
  - blocksize attribute [200](#)
  - booting from [82](#), [86](#), [89](#)
  - cmb\_enable attribute [200](#)
  - cutype attribute [200](#)
  - device names [196](#)
  - device nodes [197](#)
  - devtype attribute [200](#)
  - display support [664](#)
  - displaying overview [615](#)
  - encryption support [660](#)
  - IDRC compression [202](#)
  - loading and unloading [202](#)
  - medium\_state attribute [201](#)
  - MTIO interface [197](#)
  - online attribute [199](#), [200](#)
  - operation attribute [201](#)
  - state attribute [201](#)
  - uid attribute [362](#)
- tape device driver [195](#)
- tape devices
  - typical tasks [198](#)
- tape390\_crypt, Linux command [660](#)
- tape390\_display, Linux command [664](#)
- tar command, acceleration [355](#)
- TCP segmentation offload [238](#)
- TCP segmentation offload (TSO)
  - offload operation [236](#)

- TCP/IP
  - ARP [217](#)
  - DHCP [266](#)
  - service machine [295](#), [297](#)
- TDEA [467](#)
- TDES
  - in-kernel cryptography [479](#)
- temperature, zfcplib attribute [161](#)
- TERM, environment variable [44](#)
- terminal
  - 3270, switching the views of [48](#)
  - accessing over IUCV [47](#)
  - CCW, switching device on- or offline [48](#)
  - enabling user logins with /etc/sysconfig/init [44](#)
  - line-mode [44](#)
  - mainframe versus Linux [35](#)
  - non-operational, preventing re-spawns for [45](#)
  - provided by the 3270 terminal device driver [44](#)
- terminals
  - escape character [52](#)
- tgid\_bind\_type, zfcplib attribute [157](#)
- thread\_siblings
  - CPU sysfs attribute [304](#)
- time
  - command [355](#)
  - cpuplugd keyword
    - use with historical data [552](#)
- time-of-day clock [337](#)
- time, command [355](#)
- timed page pool
  - reading the size of the [414](#)
- timed page pool size
  - setting to avoid guest swapping [510](#)
- timeout
  - DASD attribute [145](#)
  - DASD I/O requests [131](#)
  - zfcplib attribute (SCSI device) [182](#)
- timeout for LCS LAN commands [283](#)
- timeout, DASD attribute [131](#)
- TOD clock [337](#)
- topology=, kernel parameter [305](#)
- total
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- transmit checksum
  - offload operation [236](#)
- transmit checksum, qeth [237](#)
- Triple Data Encryption Standard [467](#)
- triple DES [467](#)
- trng
  - byte\_counter attribute [472](#)
- TRNG device driver
  - setup [471](#)
- troubleshooting [497](#), [509](#)
- true random numbers
  - reading [471](#)
- true random-number device driver
  - setup [471](#)
- TTY
  - console devices [35](#)
  - online attribute [49](#)
  - routines [36](#)
- ttyrun
  - systemd [45](#)
- tunedasd, Linux command [666](#)



- tuning automatic port scans [165](#)
- tx\_bias, zfcpx attribute [162](#)
- tx\_frames, zfcpx attribute [157](#)
- tx\_power, zfcpx attribute [162](#)
- tx\_words, zfcpx attribute [157](#)
- type
  - cryptographic adapter attribute [455](#)
  - S/390 hypervisor file system attribute [332](#)
  - S/390 hypervisor file system attribute, LPAR [332](#)
  - zfcpx attribute (SCSI device) [178](#)

## U

- udev
  - DASD device nodes [117](#)
  - handling CP special messages [410](#)
- uevent [410](#)
- uid
  - DASD attribute [145](#)
  - PCIe attribute [362](#)
- ungroup
  - LCS attribute [283](#)
- unit\_add, zfcpx attribute [171](#)
- unit\_remove, zfcpx attribute [183](#)
- update
  - S/390 hypervisor file system attribute [331](#)
  - S/390 hypervisor file system attribute, z/VM [332](#)
- updating information
  - S/390 hypervisor file system [335](#)
- USB storage, HMC [341](#)
- USB-attached storage, loading Linux [87](#)
- use\_diag
  - DASD attribute [145](#)
- use\_diag, DASD attribute [126](#)
- used\_KiB
  - S/390 hypervisor file system attribute, z/VM guest [333](#)
- user terminal login [45](#)
- user.dsorg
  - extended attribute for z/OS data set [680](#)
- user.lrecl
  - extended attribute for z/OS data set [680](#)
- user.recfm
  - extended attribute for z/OS data set [680](#)
- using SCM devices with [193](#)

## V

- VACM (View-Based Access Control Mechanism) [273](#)
- vcc, zfcpx attribute [161](#)
- vdso=, kernel parameter [713](#)
- vendor
  - DASD attribute [145](#)
  - zfcpx attribute (SCSI device) [178](#)
- VEPA mode [238](#)
- versus guest storage [399](#)
- VFIO [435](#)
- vfiop\_ap, kernel module [439](#)
- vfiop\_ccw, kernel module [438](#)
- vfiop\_mdev, kernel module [438](#), [439](#)
- vfiop\_pci, kernel module [439](#)
- vfn
  - PCIe attribute [362](#)
- view

- view (*continued*)
  - channel subsystem [12](#)
  - device [12](#)
  - device by category [11](#)
  - device by drivers [11](#)
- View-Based Access Control Mechanism (VACM) [273](#)
- VINPUT
  - CP command [53](#)
- VIPA (virtual IP address)
  - attributes [223](#)
  - description [250](#), [257](#)
  - example [257](#)
- VIPA, standard
  - adapter outage [257](#)
  - setup [257](#)
- virtio-blk [417](#), [426](#)
- virtio-net [417](#)
- virtio, kernel modules [422](#)
- virtual
  - DASD [111](#)
  - IP address [250](#)
- virtual dynamic shared object [713](#)
- Virtual Ethernet Port Aggregator mode [238](#)
- Virtual Flash Memory [191](#)
- Virtual Function I/O [435](#)
- virtual server
  - dump [513](#)
  - live migration [419](#)
- VLAN
  - configure [260](#)
  - introduction to [259](#)
- VLAN example [261](#)
- vmconvert, Linux command [676](#)
- vmcpx
  - device driver [407](#)
  - device names [407](#)
  - device nodes [407](#)
- vmcpx, Linux command [670](#)
- vmhalt=, kernel parameter [714](#)
- vmpanic=, kernel parameter [715](#)
- vmppoff=, kernel parameter [716](#)
- vmreboot=, kernel parameter [717](#)
- VMRM [370](#)
- VMSG [51](#)
- vmur
  - device driver [395](#)
  - device names [395](#)
  - device nodes [395](#)
- vmur command
  - FTP [677](#)
  - guest memory dump [676](#)
  - log console transcript [677](#)
  - read console transcript [677](#)
  - send files [678](#)
  - send files to z/VSE [679](#)
  - z/VM reader as IPL device [678](#)
- vmur, Linux command [672](#)
- VNIC characteristics [254](#)
- vnicc, qeth attributes [254](#)
- VOL1 labeled disk [113](#)
- VOLSER [113](#)
- VOLSER, DASD device access by [118](#)
- volume label [113](#)
- Volume Table Of Contents [114](#)



VTOC [113](#), [114](#)

## W

watchdog  
  device driver [103](#)  
  when adding DCSS [400](#)  
weight\_cur  
  S/390 hypervisor file system attribute, z/VM guest [333](#)  
weight\_max  
  S/390 hypervisor file system attribute, z/VM guest [333](#)  
write barrier [124](#)  
wwpn, zfcip attribute [163](#)

## X

x3270 code page [46](#)  
XFS [184](#)  
XRC, extended remote copy [337](#)  
XTS [479](#)

## Z

z/VM  
  guest LAN sniffer [268](#)  
  monitor stream [371](#)  
  performance monitoring [367](#)  
z/VM \*MONITOR record  
  device name [381](#)  
  device node [381](#)  
z/VM \*MONITOR record reader  
  device driver [381](#)  
z/VM console, line edit characters [53](#)  
z/VM discontinuous saved segments, See DCSS  
z/VM reader  
  booting from [93](#)  
z/VM reader as IPL device  
  vmur command [678](#)  
z/VM record layout [387](#)  
z/VM recording  
  device names [387](#)  
  device nodes [387](#)  
z/VM recording device driver  
  autopurge attribute [390](#)  
  autorecording attribute [389](#)  
  purge attribute [390](#)  
  recording attribute [389](#)  
z/VM spool file queues [672](#)  
z90crypt  
  hardware status [459](#)  
z90crypt sysfs attribute  
  poll\_thread [459](#)  
zcrypt  
  device driver [445](#)  
  device nodes [451](#)  
  kernel parameter [449](#)  
zcrypt configuration [529](#), [619](#), [689](#)  
zcrypt sysfs attribute  
  ap\_interrupts [460](#)  
  depth [455](#)  
  hwtype [455](#)  
  modalias [455](#)  
  poll\_thread [459](#)

zcrypt sysfs attribute (*continued*)  
  request\_count [455](#)  
  type [455](#)  
zcryptctl, Linux command [689](#)  
zcryptstats, Linux command [693](#)  
zdev:early [19](#)  
zdsfs, Linux command [680](#)  
zEDC  
  applications in user space [345](#)  
  compression levels [346](#)  
  features [345](#)  
  kernel [345](#)  
zEDC Express [351](#)  
zEnterprise Data Compression [345](#)  
zfcip  
  access\_denied attribute (FCP LUN) [178](#)  
  access\_denied attribute (port) [167](#)  
  access\_denied attribute (SCSI device) [178](#)  
  access\_shared attribute [178](#)  
  b2b\_credit attribute [162](#)  
  card\_version attribute [156](#)  
  connector\_type attribute [162](#)  
  delete attribute [183](#)  
  device driver [147](#)  
  device nodes [148](#)  
  device\_blocked attribute (SCSI device) [178](#)  
  diag\_max\_age attribute [156](#)  
  dumped\_frames attribute [157](#)  
  error\_frames attribute [157](#)  
  fabric\_name attribute [156](#)  
  failed attribute (channel) [160](#)  
  failed attribute (port) [169](#)  
  fc\_security attribute [156](#)  
  fc\_security attribute (port) [167](#)  
  fcp\_control\_requests attribute [158](#)  
  fcp\_input\_megabytes attribute [158](#)  
  fcp\_input\_requests attribute [158](#)  
  fcp\_output\_megabytes attribute [158](#)  
  fcp\_output\_requests attribute [158](#)  
  fec\_active attribute [162](#)  
  firmware\_version attribute [156](#)  
  hardware\_version attribute [156](#), [157](#)  
  HBA API support [188](#)  
  in\_recovery attribute [156](#)  
  in\_recovery attribute (channel) [160](#)  
  in\_recovery attribute (port) [167](#), [169](#)  
  in\_recovery attribute (SCSI device) [178](#)  
  invalid\_crc\_count attribute [158](#)  
  invalid\_tx\_word\_count attribute [158](#)  
  iocounterbits attribute [178](#)  
  iodone\_cnt attribute (SCSI device) [178](#)  
  ioerr\_cnt attribute (SCSI device) [178](#)  
  iorequest\_cnt attribute (SCSI device) [178](#)  
  lic\_version attribute [156](#)  
  link\_failure\_count attribute [157](#)  
  lip\_count attribute [157](#)  
  loss\_of\_signal\_count attribute [158](#)  
  loss\_of\_sync\_count attribute [158](#)  
  manufacturer attribute [157](#)  
  maxframe\_size attribute [157](#)  
  model attribute [157](#)  
  model attribute (SCSI device) [178](#)  
  node\_name attribute (port) [167](#)  
  nos\_count attribute [157](#)

zfcplib (continued)

- online attribute [154](#)
- optical\_port attribute [162](#)
- peer\_d\_id attribute [156](#)
- peer\_wwnn attribute [156](#)
- peer\_wwpn attribute [156](#)
- permanent\_port\_name attribute [157](#), [163](#)
- physical\_s\_id attribute [163](#)
- port\_id attribute [157](#)
- port\_id attribute (port) [167](#)
- port\_name attribute [157](#)
- port\_name attribute (port) [167](#)
- port\_remove attribute [169](#)
- port\_rescan attribute [164](#)
- port\_state attribute (port) [167](#)
- port\_tx\_type attribute [162](#)
- port\_type attribute [157](#)
- prim\_seq\_protocol\_err\_count attribute [158](#)
- prot\_capabilities attribute [184](#)
- queue\_depth attribute [179](#)
- queue\_ramp\_up\_period attribute [179](#)
- rescan attribute (SCSI device) [181](#)
- reset\_statistics attribute [157](#)
- rev attribute (SCSI device) [178](#)
- roles attribute (port) [167](#)
- rx\_frames attribute [157](#)
- rx\_power attribute [162](#)
- rx\_words attribute [157](#)
- s\_id attribute [163](#)
- scsi\_host\_no attribute [173](#)
- scsi\_id attribute [173](#)
- scsi\_level attribute (SCSI device) [178](#)
- scsi\_lun attribute [173](#)
- scsi\_target\_id attribute (port) [167](#)
- seconds\_since\_last\_reset attribute [157](#)
- serial\_number attribute [157](#)
- sfp\_invalid attribute [161](#)
- speed attribute [157](#)
- state attribute (SCSI device) [182](#)
- supported\_classes attribute [157](#)
- supported\_classes attribute (port) [167](#)
- supported\_speeds attribute [157](#)
- symbolic\_name attribute [157](#)
- temperature attribute [161](#)
- tgid\_bind\_type attribute [157](#)
- timeout attribute (SCSI device) [182](#)
- tx\_bias attribute [162](#)
- tx\_frames attribute [157](#)
- tx\_power attribute [162](#)
- tx\_words attribute [157](#)
- type attribute (SCSI device) [178](#)
- unit\_add attribute [171](#)
- unit\_remove attribute [183](#)
- vcc attribute [161](#)
- vendor attribute (SCSI device) [178](#)
- wwpn attribute [163](#)
- zfcplib\_access\_denied attribute (SCSI device) [178](#)
- zfcplib\_failed attribute (SCSI device) [180](#)
- zfcplib\_in\_recovery attribute (SCSI device) [178](#), [180](#)

zfcplib HBA API [150](#)

zfcplib HBA API library [189](#)

zfcplib traces [151](#)

zfcplib\_access\_denied

- zfcplib attribute (SCSI device) [178](#)

zfcplib\_failed

- zfcplib attribute (SCSI device) [180](#)

zfcplib\_in\_recovery

- zfcplib attribute (SCSI device) [178](#), [180](#)

zfcplib\_ping [190](#)

zfcplib\_show [190](#)

zipl

- and kernel parameters [61](#)
- base functions [55](#)
- base parameters [63](#)
- configuration file [72](#)
- configuration file structure [72](#)
- Linux command [55](#)
- menu configurations [74](#)
- modes [56](#)
- parameters [68](#)
- syntax overview [56](#)

zipl boot menu [35](#)

zipl syntax

- secure boot [56](#)

ZIPLCONF, environment variable [72](#)

zlib [345](#)

ZLIB\_CARD, environment variable [354](#)

ZLIB\_DEFLATE\_IMPL, environment variable [354](#)

ZLIB\_INFLATE\_IMPL, environment variable [354](#)

ZLIB\_TRACE, environment variable [354](#)

zlib, GenWQE [351](#)

zlib, RFC 1950 [351](#)

znetconf, Linux command [685](#)

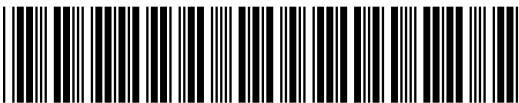
zpcictl, Linux command [688](#)





Part Number:

SC34-2765-03



(1P) P/N: