Linux on z Systems

How to use FC-attached SCSI devices with Linux on z Systems

Development stream (Kernel 4.0)

SC33-8413-08

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Note
Before using this document, be sure to read the information in "Notices" on page 79.

This edition applies to the Linux on z Systems Development stream for kernel 4.0 with the zfcp HBA API library 2.0, and to all subsequent releases and modifications until otherwise indicated in new editions.

Contents

Summary of changes

This revision reflects changes to the Development stream for kernel 4.0.

Updates for kernel 4.0

This revision (SC33-8413-08) contains changes for kernel 4.0.

New Information

- None

Changed Information

- System z was re-branded to z Systems™ throughout.

Deleted Information

- None.

This revision also 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.

Updates for kernel 2.6.38

This revision (SC33-8413-07) contains changes for kernel 2.6.38.

New Information

- None

Changed Information

- The lin_tape device driver download location has changed, see Chapter 7, "Using SCSI tape and the lin_tape driver," on page 35.

Deleted Information

- The section about debugging using zfcp traces
- Appendix. Traces

This revision also 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.

Updates for kernel 2.6.37

This revision (SC33-8413-06) contains changes for kernel 2.6.37.

New Information

- LUN scanning is now automatic for FCP setups running in NPIV mode. See
  - "Step 5: Configuring the zfcp device driver" on page 7
  - "Example of a multipath I/O configuration for IBM TotalStorage DS8000" on page 17

Changed Information

- None

Deleted Information

- None

This revision also 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.

About this document

This document describes the SCSI-over-Fibre Channel device driver (zfcp device driver) and related system tools available for Linux kernel 4.0 with the zfcp HBA API library 2.0 on IBM® z Systems.

As of January 2015, IBM System z® is re-branded to IBM z Systems. In this document, *Linux on z Systems* and *Linux on System z* are used synonymously to refer to Linux running on an IBM mainframe, including zSeries in 64- and 31-bit mode.

The information provided in this document extends the information already available in *Device Drivers, Features, and Commands, SC33-8411*, for the Development stream.

Information provided in this document applies to Linux in general and does not cover distribution specific topics. For information specific to the zfcp driver and system tools available in your Linux distribution refer to the documentation provided by your Linux distributor.

You can find the latest version of this and other publications in the Linux on z Systems library on the developerWorks® website at www.ibm.com/developerworks/linux/linux390/documentation_dev.html

Who should read this document

This document is intended for Linux administrators and system programmers in charge of a virtual Linux server farm that runs under z/VM® or natively on z Systems.

Any zfcp messages logged, for example messages found in `/var/log/messages`, are alerts which usually require subsequent intervention by administrators. The sysfs statistics, I/O data, and FCP performance data described here provide additional information.

Such data can be used to advantage by:

- Service personnel who investigate problems
- System administrators with an intermediate or advanced level of FCP experience who want to understand what is going on underneath the surface of zfcp
- SCSI device driver developers
- Hardware developers and testers

Note: This document is intended for expert users. Be sure you understand the implications of running traces and debug tools before you attempt to perform the tasks described in this document.

How this document is organized

The scope of this document is on how to configure, operate and troubleshoot Linux on z Systems attached to a SAN environment.

The following topics are discussed in this document:

Chapter 1, “Introduction,” on page 1 presents a general description of FCP and SAN. It gives you a general description of the zfcp device driver and how to configure the device driver.

Chapter 2, “Using N_Port ID virtualization,” on page 3 introduces N_Port virtualization as it is available on System z9®, and how to use it for improved access control and simplified system administration.

Chapter 3, “Configuring FCP devices,” on page 5 discusses the concepts of IODF, zoning, LUN masking, and how to configure the zfcp driver.

Chapter 4, “Naming SCSI devices persistently using udev,” on page 11 explains how udev can help you with persistent naming of SCSI devices.

Chapter 5, “Improving system availability by using multipathing,” on page 15 describes options and recommendations to improve system availability by using multipath disk setups.

Chapter 6, “Booting the system by using SCSI IPL,” on page 23 introduces the ability to IPL a zSeries operating system from an FCP-attached SCSI device.

Chapter 7, “Using SCSI tape and the lin_tape driver,” on page 35 describes the device driver for IBM tape drives (ibmtape).

Chapter 8, “Logging using the SCSI logging feature,” on page 37 contains a detailed description about the available log areas and recommended log level settings for certain debugging tasks.

Chapter 9, “Statistics available through sysfs,” on page 43 describes additional statistics that the zfcp driver provides through sysfs.

Chapter 10, “I/O tracing using blktrace,” on page 47 describes how to use **blktrace** to gather some of the zfcp performance statistics.

Chapter 11, “Collecting FCP performance data with ziomon,” on page 53 describes the performance monitor ziomon.

Chapter 12, “Creating FCP performance reports,” on page 57 describes how you can use the output from the performance monitor to create reports.

Chapter 13, “Investigating the SAN fabric,” on page 71 describes tools that can help you to investigate your SAN configuration and solve configuration problems.

Chapter 14, “Hints and tips,” on page 75 offers help with common pitfalls, as well as troubleshooting using different system facilities and tools.

Conventions used in this book

This section informs you on the styles, highlighting, and assumptions used throughout the book.

Hexadecimal numbers

Mainframe books and Linux books tend to use different styles for writing hexadecimal numbers.

Thirty-one, for example, would typically read X'1F' in a mainframe book and 0x1f in a Linux book.

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

Highlighting

The following highlighting styles are used.

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

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

or, for clarity, including the current working directory:
[statistics]#
```

Other publications for Linux on z Systems

You can find publications for Linux on z Systems on IBM Knowledge Center and on developerWorks.

These publications are available on IBM Knowledge Center at

ibm.com/support/knowledgecenter/linuxonibm/liaaf/lnz_r_lib.html

- *Device Drivers, Features, and Commands* (distribution-specific editions)
- *Using the Dump Tools* (distribution-specific editions)
- *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
- *Linux on z Systems Troubleshooting*, SC34-2612
- *Linux Health Checker User's Guide*, SC34-2609
- *Kernel Messages*, SC34-2599
- *How to Set up a Terminal Server Environment on z/VM*, SC34-2596

These publications are available on developerWorks at

www.ibm.com/developerworks/linux/linux390/documentation_dev.html

- *Device Drivers, Features, and Commands*, SC33-8411
- *Using the Dump Tools*, SC33-8412
- *How to Improve Performance with PAV*, SC33-8414
- *How to use FC-attached SCSI devices with Linux on z Systems*, SC33-8413
- *How to use Execute-in-Place Technology with Linux on z/VM*, SC34-2594
- *How to Set up a Terminal Server Environment on z/VM*, SC34-2596
- *Kernel Messages*, SC34-2599
- *libica Programmer's Reference*, SC34-2602

- *Secure Key Solution with the Common Cryptographic Architecture Application Programmer's Guide*, SC33-8294
- *Exploiting Enterprise PKCS #11 using openCryptoki*, SC34-2713
- *Linux on z Systems Troubleshooting*, SC34-2612
- *Linux Health Checker User's Guide*, SC34-2609

Where to find more information

Use these resources to find more information.

Books and papers:

- *Running Linux on IBM System z9 and zSeries under z/VM, 0738496405, SG24-6311* available from

  `www.ibm.com/redbooks/`
- *Introducing N_Port Identifier Virtualization for IBM System z9, REDP-4125*, available at:

  `www.ibm.com/redbooks/abstracts/redp4125.html`

Web resources:

- IBM mainframe connectivity:

  `www.ibm.com/systems/z/connectivity/`

Note: For prerequisites and restrictions for the tools and device drivers described here refer to the Development stream pages on developerWorks at:

`www.ibm.com/developerworks/linux/linux390/development_restrictions.html`

Finding IBM books

The PDF version of this book contains URL links to much of the referenced literature.

For some of the referenced IBM books, links have been omitted to avoid pointing to a particular edition of a book. You can locate the latest versions of the referenced IBM books through the IBM Publications Center at:

`www.ibm.com/shop/publications/order`

Supported hardware

Use these resources to find out if your hardware is supported.

Supported Fibre Channel features for IBM z Systems servers are listed in the *Device Drivers, Features, and Commands*, SC33-8411. You can find the latest version of this document on developerWorks at

`www.ibm.com/developerworks/linux/linux390/documentation_dev.html`

A list of z Systems qualified storage and Storage Area Network (SAN) devices is available at:

`http://www.ibm.com/systems/z/hardware/connectivity/products/index.html`

Also see IBM z Systems support of Fibre Channel Protocol for SCSI and FCP channels at:

`www.ibm.com/systems/z/connectivity`

To find out whether a combination of device, Linux distribution, and IBM mainframe is supported, see the individual interoperability matrix for each storage device. The interoperability matrices are available at:

`www.ibm.com/systems/support/storage/config/ssic/index.jsp`

Chapter 1. Introduction

You can attach Linux on z Systems to a SAN environment by using the Fibre Channel Protocol (FCP).

SAN and FCP

Storage area networks (SANs) are specialized networks dedicated to the transport of mass storage data.

SANs are typically used to connect large servers in enterprise environments with storage systems and tape libraries. These specialized networks provide reliable and fast data paths between the servers and their storage devices. Major advantages of a SAN include:

- Consolidating storage devices
- Physically separating storage devices from the servers
- Sharing storage devices among different servers

A typical SAN consists of the following components:

- Servers
- Storage devices
- Switches

Today the most common SAN technology used is the Fibre Channel Protocol (FCP). Within this technology the traditional SCSI protocol is used to address and transfer raw data blocks between the servers and the storage devices. This is in contrast to other storage communication protocols like the Common Internet File System (CIFS) or the Network File System (NFS) which operate on file level.

Figure 1 shows how the zfcp device driver allows you to connect Linux on z Systems to a SAN using FCP. For more details on the zfcp device driver, see "The zfcp device driver" on page 2.

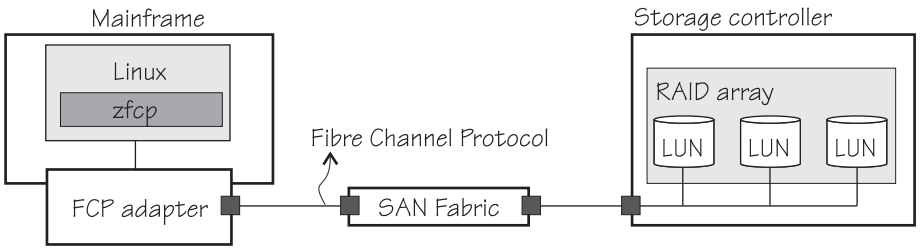


Figure 1. SAN connected to mainframe through FCP

The mainframe in Figure 1 is equipped with a hardware feature that has at least one channel configured as an FCP channel. This FCP channel provides the physical connection to the SAN. In a typical mainframe environment, multiple FCP channels are configured to increase the I/O bandwidth and improve data availability. For supported hardware features, see "Supported hardware" on page x. Multiple operating system instances can share one FCP channel.

Storage devices used in SANs are disk storage systems and tape libraries. A disk storage system comprises multiple hard drives combined into one or more RAID

arrays and a storage controller communicating through one or more HBAs with the SAN. The usage of RAID arrays and multiple HBAs increases the I/O bandwidth and improves data availability. The RAID arrays are used to store the user data and the controller is responsible for providing functions such as I/O processing, data caching, and system management. The storage available on the RAID arrays is usually divided into smaller units that are then accessible as a single, logical storage device, called a logical unit number (LUN), from the SAN.

Fibre Channel switches connect multiple servers with their storage devices to form a fiber channel fabric. A fiber channel fabric is a network of Fibre Channel devices that allows communication and provides functions such a device lookup or access control. To address a physical Fibre Channel port within a Fibre Channel fabric each port is assigned a unique identifier called worldwide port name (WWPN).

The zfcp device driver

The zfcp device driver supports SCSI-over-Fibre Channel host bus adapters (HBAs) for Linux on mainframes.

The device driver is the backend for a driver and software stack that includes other parts of the Linux SCSI stack as well as block request and multipathing functions, file systems, and SCSI applications. Figure 2. shows how the zfcp device driver fits into Linux and the SCSI stack.

HBAs are normally virtual in a Linux environment and are shown as an *FCP device*. FCP devices are represented by CCW devices that are listed under `/sys/bus/ccw/drivers/zfcp`. Do not confuse FCP devices with SCSI devices. A SCSI device is a disk device that is identified by a LUN.

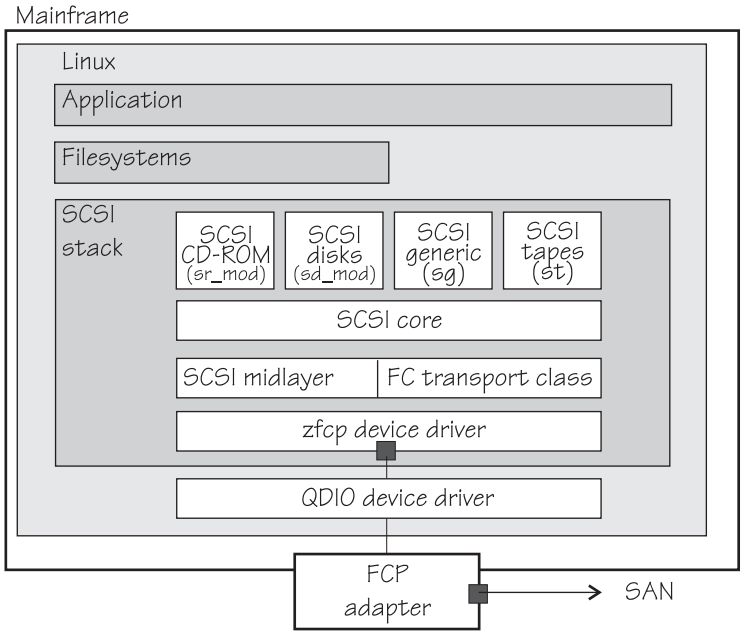


Figure 2. The zfcp device driver is a low level SCSI device driver

The zfcp device driver is discussed in detail in *Device Drivers, Features, and Commands, SC33-8411*.

Chapter 2. Using N_Port ID virtualization

Devices attach to the SAN fabric by logging in to it. The device ports are called target ports or also N_ports.

Figure 3 shows an example of a mainframe with two Linux instances and three devices logged in to the SAN fabric.

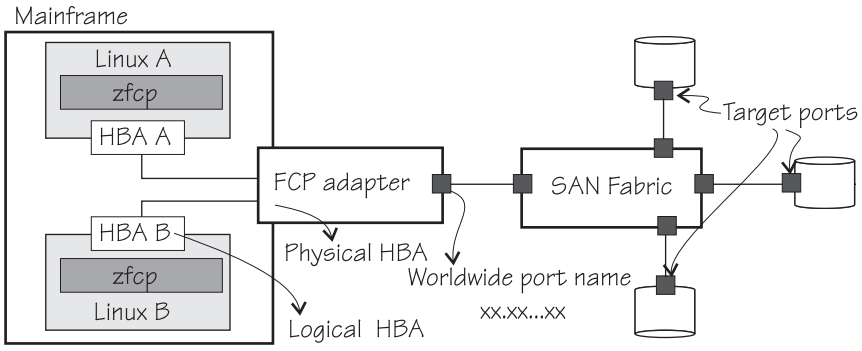


Figure 3. Target ports in a SAN fabric

In the example, a mainframe is attached to the Fibre Channel fabric through one FCP channel that is shared by the two Linux instances. Consequently, both Linux instances are known to the SAN by the same shared WWPN. Thus, from the point of view of the SAN, the Linux instances become indistinguishable from each other. This is shown in Figure 4

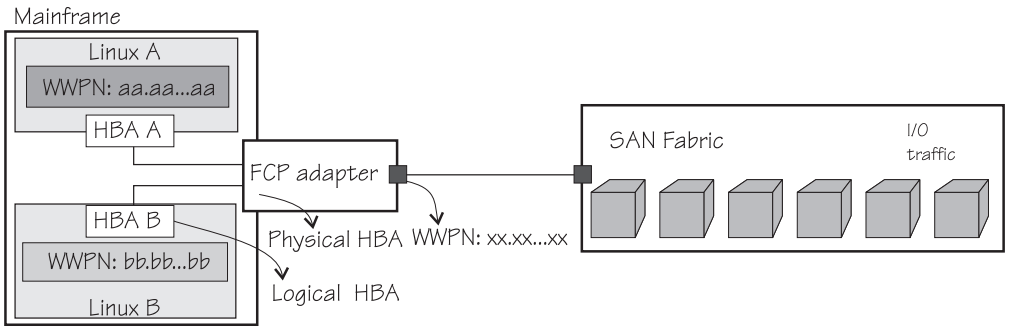


Figure 4. I/O traffic from two Linux instances are indistinguishable

N_Port ID Virtualization (NPIV) utilizes a recent extension to the International Committee for Information Technology Standardization (INCITS) Fibre Channel standard. This extension allows an FCP channel to log in multiple times to a Fibre Channel fabric using a single physical port (N_Port). (The previous implementation of the standard required a separate FCP channel for each login.)

Each login uses a different unique port name, and the switch fabric assigns a unique Fibre Channel N_Port identifier (N_Port ID) for each login. These virtualized Fibre Channel N_Port IDs allow a physical Fibre Channel port to appear as multiple, distinct ports, providing separate port identification and security zoning within the fabric for each operating system image. The I/O transactions of each operating system image are separately identified, managed,

and transmitted, and are processed as if each operating system image had its own unique physical N_Port (see Figure 5).

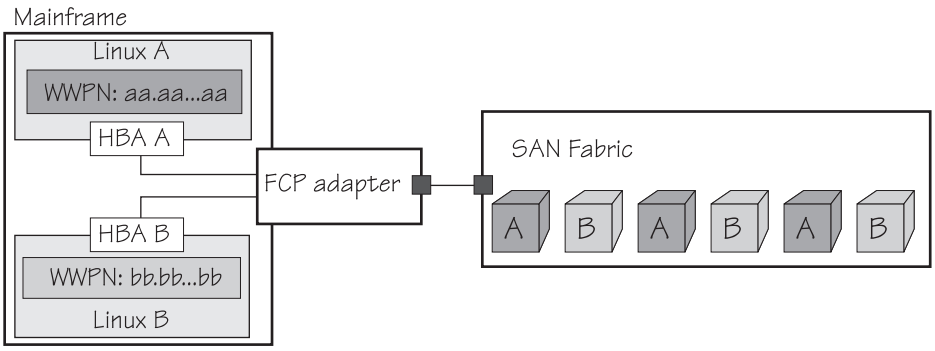


Figure 5. NPIV allows initiators of I/O and their traffic to be distinguished in the SAN

NPIV allows you to implement access control using security zoning. Returning to our example in Figure 4 on page 3, without NPIV all storage devices are visible to the Linux instances that share one FCP channel. With NPIV, you can define what storage devices the different Linux instances should be able to access.

NPIV support can be configured on the SE per CHPID and LPAR for an FCP channel. The zfcp device driver supports NPIV error messages and FCP channel attributes. For tips on troubleshooting NPIV, see Chapter 14, "Hints and tips," on page 75.

NPIV is available as of IBM System z9 and is applicable to most FICON® features supported on System z9 channel type FCP, except FICON Express. For more details on configuring NPIV, see *Introducing N_Port Identifier Virtualization for IBM System z9, REDP-4125*, available at:

`www.redbooks.ibm.com/abstracts/redp4125.html`

Chapter 3. Configuring FCP devices

To configure FCP devices you must configure the IODF, define zones in the switch or fabric, control access to the LUN with LUN masking, and configure the zfcp device driver. Under z/VM, you might also need to attach the FCP device.

Before you begin

- A FICON or FICON Express feature is available. See "Supported hardware" on page x. You must configure the hardware as an FCP channel within your IODF.
- The FCP channel is connected to a Fibre Channel SAN through a switched fabric connection (unless a point-to-point connection is used)
- The target device is connected to the same Fibre Channel SAN (or through a point-to-point connection to the FCP channel).

Procedure

To access a Fibre Channel-attached SCSI device follow these configuration steps:

1. Configure an FCP channel in the IODF of the mainframe.
2. Configure zoning for the FCP channel to gain access to desired target ports within a SAN. If the FCP channel is directly attached to a target device (point-to-point connection), this step is not needed.
3. Configure LUN masking for the FCP channel at the target device to gain access to desired LUNs.
4. In Linux, configure target ports and LUNs of the SCSI device at the target port for use of zfcp.

What to do next

The configuration steps are explained in more detail in the following sections.

Step 1: Configuring the IODF

This example shows how to configure two ports of a FICON or FICON Express feature for FCP.

Procedure

1. Define two FCP CHPIDs. Both are given the number 50, one for channel subsystem 0 and one for channel subsystem 1:

```
CHPID PATH=(CSS(0),50),SHARED,                                  *
      PARTITION=((LP01,LP02,LP03,LP04,LP05,LP06,LP07,LP08,LP09*
      ,LP10,LP11,LP12,LP13,LP14,LP15),(=)),PCHID=160,TYPE=FCP
CHPID PATH=(CSS(1),50),SHARED,                                  *
      PARTITION=((LP16,LP17,LP18,LP19,LP20,LP21,LP22,LP23,LP24*
      ,LP25,LP26,LP27,LP28,LP29,LP30),(=)),PCHID=161,TYPE=FCP
```

2. Assign FCP control unit 5402 to the new CHPIDs:

```
CNTLUNIT CUNUMBR=5402,PATH=((CSS(0),50),(CSS(1),50)),UNIT=FCP
```

3. Define several FCP devices starting with device number 5400:

```
IODEVICE ADDRESS=(5400,002),CUNUMBR=(5402),                    *
      PARTITION=((CSS(0),LP01),(CSS(1),LP16)),UNIT=FCP
IODEVICE ADDRESS=(5402,002),CUNUMBR=(5402),                    *
      PARTITION=((CSS(0),LP02),(CSS(1),LP17)),UNIT=FCP

...

IODEVICE ADDRESS=(5460,144),CUNUMBR=(5402),                    *
      PARTITION=((CSS(0),LP15),(CSS(1),LP30)),UNIT=FCP
```

Step 2: Defining zones

There are different kinds of zones in a switch or fabric.

About this task

In *port zoning* a zone is a set of Fibre Channel ports where each Fibre Channel port is specified by the port number at the switch or fabric to which it is connected. Port zoning allows devices attached to particular ports on the switch to communicate only with devices attached to other ports in the same zone. The switch keeps a table of ports that are allowed to communicate with each other.

In *WWN zoning* a zone is a set of Fibre Channel ports where each Fibre Channel port is specified by its worldwide name (WWN). WWN zoning allows a device to communicate only with other devices whose WWNs are included in the same zone, see Figure 6.

In both cases you need to ensure that the FCP channel and the target port you want to access are members of the same zone. Otherwise it is impossible to gain access to the target port.

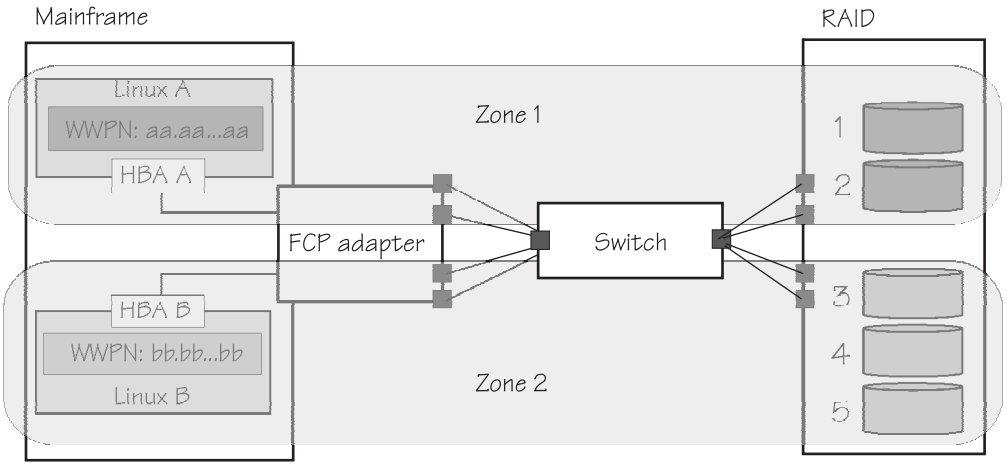


Figure 6. Zoning partitions storage resources.

For further information on how to configure zoning for your setup, refer to the documentation of your switch.

Step 3: LUN masking

The purpose of LUN masking is to control Linux instance access to the LUNs.

About this task

Within a storage device (for example, IBM DS8000®) it is usually possible to configure which Fibre Channel port can access a LUN, see Figure 7. You must ensure that the WWPN of the FCP channel (for NPIV setups, the WWPN of the FCP device) is allowed to access the desired LUN. Otherwise you might not be able to access the SCSI device. See also "Troubleshooting NPIV" on page 75.

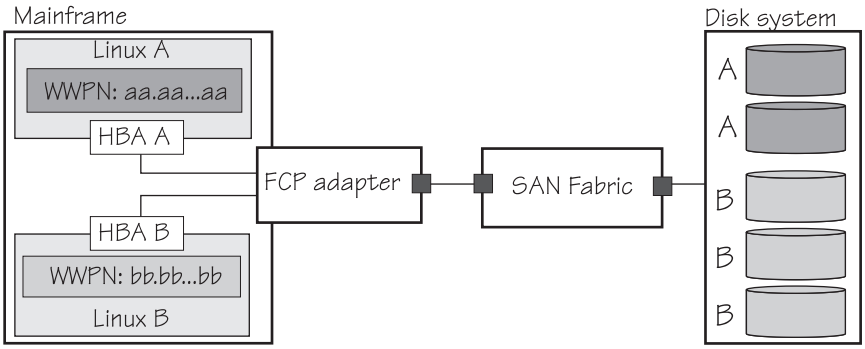


Figure 7. LUN masking where Linux A has access to two disks and Linux B has access to three disks in a disk system

For further information on how to configure LUN masking for your setup, refer to the documentation of your storage device.

Step 4: Attaching an FCP device under z/VM

These instructions apply to z/VM only. The FCP device number must be available in your z/VM guest virtual machine.

Procedure

If the device number is not available in your z/VM guest already, do either:

- Update the z/VM user directory. To do this, add a DEDICATE statement to the guest directory:

  ```
  DEDICATE 5400 5400
  ```

- Use the CP ATTACH command to dynamically add the path. To do this, issue a command of the form:

  ```
  CP ATTACH 5400 to <userid>
  ```

  Note that the user directory still needs to be updated in order for the device to survive a log off.

Step 5: Configuring the zfcp device driver

FCP setups running in NPIV mode detect the LUNs automatically and after setting the device online. No further configuration is necessary.

Procedure

- **NPIV example**

  1. To set FCP device 0.0.5400 online, issue the following command:

```
# chccwdev --online 0.0.5400
Setting device 0.0.5400 online
Done
```

The **chccwdev** command is part of s390-tools. For a description of the command see *Device Drivers, Features, and Commands, SC33-8411*

After setting the FCP device online, all LUNs with valid host-connections for the WWPN of the NPIV FCP device are automatically visible as SCSI devices:

```
# lsscsi
[0:0:0:1073758410]disk IBM 2107900 0.33 /dev/sda
[0:0:0:1073823946]disk IBM 2107900 0.33 /dev/sdb
```

2. To find out if the FCP setup is running in NPIV mode, check the port_type attribute of the FCP device, for example:

```
# cat /sys/bus/ccw/drivers/zfcp/0.0.5400/host0/fc_host/host0/port_type
NPIV VPORT
```

- **Non-NPIV example**
  1. To set the non-NPIV FCP device 0.0.54ea online, issue the following command:

```
# chccwdev --online 0.0.54ea
Setting device 0.0.54ea online
Done
```

  2. To configure a LUN 0x4010403200000000, issue the following command:

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.54ea
# echo 0x4010403200000000 > 0x500507630303c562/unit_add
```

  If the port and the LUN specify a disk in a storage subsystem you should now see a new SCSI disk:

```
# lsscsi
[0:0:0:0] disk IBM 2107900 .309 /dev/sda
# lszfcp -D
0.0.5400/0x500507630303c562/0x4010403200000000 0:0:0:0
```

The **lszfcp** command is part of s390-tools. For a description of the command see *Device Drivers, Features, and Commands, SC33-8411*

Results

Now the device, for example `/dev/sda`, can be used. In our example the disk can be formatted and mounted.

Examples

- To format a SCSI disk, issue:

```
# fdisk /dev/sda
...
```

- To generate a file system, issue:

```
# mke2fs -j /dev/sda1
```

- To mount partition 1 of the SCSI disk, issue:

```
# mount -t ext3 /dev/sda1 /mnt
```

Port scanning

The zfcp device driver automatically adds port information to sysfs when the FCP device is set online and when target ports are added.

About this task

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 adapter configuration or if you are unsure whether all ports are added to sysfs. Issue, for example:

```
# echo 1 > /sys/bus/ccw/drivers/zfcp/0.0.5400/port_rescan
```

Triggering a LUN scan for NPIV FCP devices using sysfs

For FCP setups using NPIV, the zfcp device driver automatically scans for and attaches available SCSI devices, that is, LUNs with valid host connections for the WWPN of the NPIV FCP device.

About this task

You can optionally trigger a scan for LUNs using sysfs, for example, if you have accidentally deleted a port. To trigger the scan for all available remote ports issue, for example:

```
# echo '- - -' >\
/sys/bus/ccw/drivers/zfcp/0.0.1901/host0/scsi_host/host0/scan
```

where the three dashes ("- - -") are SCSI channel ID, SCSI target ID, and LUN (in the Linux packed LUN format, that is, the last part in the ID 0:0:5:1079066641). The minus-sign (-) is the wildcard character. The SCSI channel ID is always 0, so writing 0 is equivalent to using the wildcard for the SCSI channel ID.

To trigger the scan for a specific port, first look up the target ID of the remote port to scan. The SCSI target ID is the last part of the remote port ID:

```
# lszfcp -P -p 0x5005076303100104 -b 0.0.1901
0.0.1901/0x5005076303100104 rport-0:0-9
```

Then issue the scan for the single SCSI target ID:

```
# echo '0 9 -' >\
/sys/bus/ccw/drivers/zfcp/0.0.1901/host0/scsi_host/host0/scan
```

Chapter 4. Naming SCSI devices persistently using udev

With udev you can create persistent SCSI device names.

About this task

As of kernel 2.6 Linux distributions use udev as the mechanism to handle devices that appear or disappear at run time. udev provides a `/dev` directory that contains a minimal set of device nodes for devices that are actually used. The udev utility uses the `/sys` file system and the hotplug mechanism. Whenever a new device is detected, the kernel creates the entries in the `/sys` file system and creates hotplug events. Finally, the hotplug mechanism triggers udev, which uses a set of rules to create the device node for the detected device.

An additional benefit of udev is the possibility to create persistent device names. In contrast to the usual Linux device names, persistent names are independent of the order in which the devices appear in the system. Based on a given unique property a device can be recognized and is always accessible under the same name in `/dev`.

Using udev and zfcp

An example system with two FCP disks illustrates how to use udev and zfcp.

About this task

Assuming an example system with two FCP disks and udev, use the following commands to make the disks accessible:

```
# chccwdev --online 0.0.54ae
Setting device 0.0.54ae online
Done
```

Alternatively, you can write "1" to the online attribute of the FCP device to set it online:

```
cd /sys/bus/ccw/drivers/zfcp/0.0.54ae/
echo 1 > online
```

If you are using NPIV for your setup, LUNs are detected automatically and no further configuration is necessary.

If you are not using NPIV for your setup, write the LUNs to the unit_add attribute of the target port:

```
cd /sys/bus/ccw/drivers/zfcp/0.0.54ae/0x5005076300cb93cb
echo 0x512e000000000000 > unit_add
echo 0x512f000000000000 > unit_add
```

No further steps are necessary to create the device files if udev is installed and set up correctly. The new device nodes `/dev/sda` and `/dev/sdb` are created automatically and even the entries for the partitions on the disks, that is, `/dev/sda1` will appear. If the last two commands are issued in reversed order the naming of

the disks will also be reversed. The sd devices /dev/sda, /dev/sdb, and so on, are not persistent. If one device disappears and another appears on the system, the new device might take the free name.

You should not directly access a SCSI device in a FC SAN environment: The storage server might decide to failover to its backup controller, forcing the host systems to access the storage over another path. If there is no multipath setup in place, access to the storage is then lost. Using multipathing, the names /dev/sda, /dev/sdb, and so on, do not matter, as multipathing automatically adds the SCSI devices to the correct multipath device. See Chapter 5, "Improving system availability by using multipathing," on page 15 for details.

Persistent SCSI device naming

With udev, you can define naming schemes that provide persistent SCSI device naming.

About this task

In persistent naming each device is always assigned the same unique name, independent of the sequence in which the devices are discovered. If a distribution has no predefined naming scheme for specific devices, or if a customized naming scheme is required, you can extend the set of rules for udev. Examples are given in the following paragraphs.

Procedure

1. To display all information about a disk that is available to udev, use the **udevinfo** command:

   ```
   udevinfo -a -p /sys/class/scsi_generic/sg0
   ```

   The **udevinfo** command starts with the device the node belongs to and then walks up the device chain. For every device found, it prints all possibly useful attributes in the udev key format. Only attributes within one device section can be used together in one rule to match the device for which the node is created.

```
device '/sys/class/scsi_generic/sg0' has major:minor 21:0
looking at class device '/sys/class/scsi_generic/sg0':
SUBSYSTEM=="scsi_generic"
SYSFS{dev}=="21:0"
follow the "device"-link to the physical device:
looking at the device chain at
'/sys/devices/css0/0.0.000e/0.0.54ae/host0/rport-0:0-0/target0:0:0/0:0:0:0':

BUS=="scsi"
ID=="0:0:0:0"
DRIVER=="sd"
SYSFS{device_blocked}=="0"
SYSFS{fcp_lun}=="0x512e000000000000"
SYSFS{hba_id}=="0.0.54ae"
SYSFS{iocounterbits}=="32"
SYSFS{iodone_cnt}=="0x3a0"
SYSFS{ioerr_cnt}=="0x1"
SYSFS{iorequest_cnt}=="0x3a0"
SYSFS{model}=="2105F20 "
SYSFS{queue_depth}=="32"
SYSFS{queue_type}=="simple"
SYSFS{rev}==".693"
SYSFS{scsi_level}=="4"
SYSFS{state}=="running"
SYSFS{timeout}=="30"
SYSFS{type}=="0"
SYSFS{vendor}=="IBM "
SYSFS{wwpn}=="0x5005076300cb93cb"
...
```

2. The combination of wwpn and fcp_lun provide a unique identifier for the device. Based on this information an additional rule can be written.

   Note: To avoid rules being overwritten in case of a udev update, keep additional rules in an extra file (for example, `/etc/udev/rules.d/10-local.rules`).

   For example, an additional rule to create a link for the LUN 0x401040c300000000 behind the WWPN 0x500507630310c562 with the persistent name `/dev/my_zfcp_disk` is:

   ```
   KERNEL=="sd*", SYSFS{wwpn}=="0x500507630310c562", \
    SYSFS{fcp_lun}=="0x401040c300000000", NAME="%k", SYMLINK+="my_zfcp_disk%n"
   ```

   Where:

   %k refers to the kernel name for the device

   %n is substituted by the number that is given by the kernel

   A detailed description of the udev rules can be found on the udev man page.

Results

The new rule leaves the original device names provided by the kernel intact and add symbolic links with the new device names:

```
# ll /dev/my_zfcp_disk*
lrwxrwxrwx 1 root root 3 Mar 14 16:14 /dev/my_zfcp_disk -> sda
lrwxrwxrwx 1 root root 4 Mar 14 16:14 /dev/my_zfcp_disk1 -> sda1
```

A more general rule that applies to all FCP disks and provides a generic persistent name based on fcp_lun and WWPN can be written as:

```
KERNEL=="sd*[a-z]", SYMLINK+="scsi/%s{hba_id}-%s{wwpn}-%s{fcp_lun}/disk"
KERNEL=="sd*[0-9]", SYMLINK+="scsi/%s{hba_id}-%s{wwpn}-%s{fcp_lun}/part%n"
```

Where:

%s points to the information as it was given by the **udevinfo** command

With these rules, udev creates links similar to the following examples:

```
# ll /dev/scsi/*/*
lrwxrwxrwx  1 root root  9 May 22 15:19
          /dev/scsi/0.0.54ae-0x5005076300cb93cb-0x512e000000000000/disk -> ../../sda
lrwxrwxrwx  1 root root 10 May 22 15:19
          /dev/scsi/0.0.54ae-0x5005076300cb93cb-0x512e000000000000/part1 -> ../../sda1
lrwxrwxrwx  1 root root  9 May 22 15:19
          /dev/scsi/0.0.54ae-0x5005076300cb93cb-0x512f000000000000/disk -> ../../sdb
lrwxrwxrwx  1 root root 10 May 22 15:19
          /dev/scsi/0.0.54ae-0x5005076300cb93cb-0x512f000000000000/part1 -> ../../sdb1
```

Chapter 5. Improving system availability by using multipathing

Multipath I/O provides failover and might improve performance. You can configure multiple physical I/O paths between server nodes and storage arrays into a single multipath device.

Multipathing thus aggregates the physical I/O paths, creating a new device that consists of the aggregated paths.

Linux multipathing provides I/O failover and path load sharing for multipathed block devices. In Linux, multipathing is implemented with multi-path tools that provide a user-space daemon for monitoring and an interface to the device mapper. The device-mapper, which provides a container for configurations, maps block devices to each other.

A single SCSI device (or a single zfcp unit) constitutes one physical path to the storage. The multipath user-space configuration tool scans sysfs for SCSI devices and then groups the paths into multipath devices. This mechanism that automatically puts each detected SCSI device underneath the correct multipath device is called *coalescing*.

Use a multipath setup to access SCSI storage in an FC SAN. The multipath device automatically switches to an alternate path in case of an interruption on the storage system controllers or due to maintenance on one path.

The multipath daemon has default configuration entries for most storage systems, and thus you only need do basic configuration for these systems. This chapter describes how to access, configure, and use FCP multipathing with Linux kernel 2.6 with minimal setup. This minimal setup uses the default configuration entries. The following topics are included:

- Using multipath-tools to implement multipathing
- Using the device-mapper and multipath-tools to configure multipathing

Implementing multipathing with the multipath-tools

The multipath-tools project is an open source project that implements I/O multipathing at the operating system level.

The project delivers an architecture and vendor-independent multipathing solution that is based on kernel components and the following user-space tools:

- The kernel device-mapper module (dm_multipath)
- The hotplug kernel subsystem
- The device-naming tool udev
- The user-space configuration tool multipath
- The user-space daemon multipathd
- The user-space configuration tool kpartx to create device maps from partition tables

Redundant paths that are defined in Linux appear as separate SCSI devices, one for each logical path (see Figure 8 on page 16). The device-mapper provides a

single block device for each logical unit (LU) and reroutes I/O over the available paths. You can partition the device-mapper multipath I/O (MPIO) devices or use them as physical volumes for LVM or software RAID.

You can use user-space components to set up the MPIO devices and automated path retesting as follows:

- Use the **multipath** command to detect multiple paths to devices. It configures, lists, and removes MPIO devices.
- Use the multipathd daemon to monitor paths. The daemon tests MPIO devices for path failures and reactivates paths if they become available again.

Figure 8 shows an example multipath setup with two FCP channels for the mainframe and two HBAs for the storage subsystem.

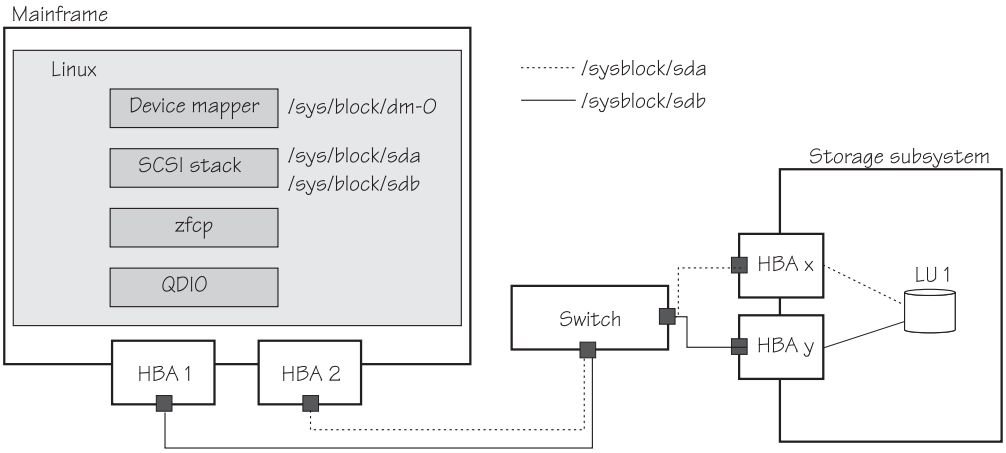


Figure 8. Multipathing with multipath-tools and device mapper

Configuring multipathing with the device-mapper and multipath-tools

The multipath-tools package includes settings for known storage subsystems in a default hardware table, and no additional configuration is required for these devices.

You can specify additional device definitions in `/etc/multipath.conf`. If the file is present, its content overrides the defaults. You must include the parameters for the storage subsystem that is used either in the default hardware table or in the configuration file. There is no man page available for this file.

Within the multipath-tools package there is a template configuration, see `/usr/share/doc/packages/multipathtools/multipath.conf.annotated`. This file contains a list of all options with short descriptions.

You can find more information about the MPIO at the following URL in the Documentation section for the multipath-tools package:

`http://christophe.varoqui.free.fr/`

You can find more information about the kernel device-mapper components at:

`http://sources.redhat.com/dm/`

Example of a multipath I/O configuration for IBM TotalStorage DS8000

This example shows the special configuration for storage devices like IBM Total Storage DS8000 with multibus as the path grouping policy.

Procedure

1. Set the FCP devices online:

```
# chccwdev -e 5222
Setting device 0.0.5222 online
Done
# chccwdev -e 1722
Setting device 0.0.1722 online
Done
```

2. The zfcp device driver automatically attaches remote storage ports to the FCP device configuration when the device is set online as well as when remote storage ports are added. If you are unsure whether all ports are attached, you can use the port_rescan attribute. Issue, for example:

```
# echo 1 > /sys/bus/ccw/drivers/zfcp/0.0.1722/port_rescan
```

   If you are using NPIV for your setup, LUNs are detected automatically and no further configuration is necessary.

   If you are not using NPIV for your setup, write the LUNs to the unit_add attribute of the target port:

```
# echo 0x401040d000000000 > /sys/bus/ccw/devices/zfcp/0.0.1722/0x500507630313c562/unit_add
# echo 0x401040d100000000 > /sys/bus/ccw/devices/zfcp/0.0.1722/0x500507630313c562/unit_add
# echo 0x401040d200000000 > /sys/bus/ccw/devices/zfcp/0.0.1722/0x500507630313c562/unit_add
# echo 0x401040d300000000 > /sys/bus/ccw/devices/zfcp/0.0.1722/0x500507630313c562/unit_add
# echo 0x401040d000000000 > /sys/bus/ccw/devices/zfcp/0.0.5222/0x500507630310c562/unit_add
# echo 0x401040d100000000 > /sys/bus/ccw/devices/zfcp/0.0.5222/0x500507630310c562/unit_add
# echo 0x401040d200000000 > /sys/bus/ccw/devices/zfcp/0.0.5222/0x500507630310c562/unit_add
# echo 0x401040d300000000 > /sys/bus/ccw/devices/zfcp/0.0.5222/0x500507630310c562/unit_add
```

3. Load the dm_multipath module:

```
# modprobe dm_multipath
```

4. Use the **multipath** command to detect multiple paths to devices for failover or performance reasons and coalesce them:

```
# multipath
create: 36005076303ffc56200000000000010d0 undef IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
`-+- policy='round-robin 0' prio=2 status=undef
  |- 0:0:24:1087389712 sda   8:0   undef ready running
  `- 1:0:20:1087389712 sde   8:64  undef ready running
create: 36005076303ffc56200000000000010d1 undef IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
`-+- policy='round-robin 0' prio=2 status=undef
  |- 0:0:24:1087455248 sdb   8:16  undef ready running
  `- 1:0:20:1087455248 sdf   8:80  undef ready running
create: 36005076303ffc56200000000000010d2 undef IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
`-+- policy='round-robin 0' prio=2 status=undef
  |- 0:0:24:1087520784 sdc   8:32  undef ready running
  `- 1:0:20:1087520784 sdg   8:96  undef ready running
create: 36005076303ffc56200000000000010d3 undef IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
`-+- policy='round-robin 0' prio=2 status=undef
  |- 0:0:24:1087586320 sdd   8:48  undef ready running
  `- 1:0:20:1087586320 sdh   8:112 undef ready running
```

Note: The priority displays only after you call multipath for the first time.

5. Start the multipathd daemon to run a proper working multipath environment:

```
# /etc/init.d/multipathd start
```

6. Use the **multipath** command to display the resulting multipath configuration:

```
# multipath -ll
36005076303ffc56200000000000010d2 dm-2 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=2 status=enabled
  |- 0:0:24:1087520784 sdc   8:32  active ready running
  `- 1:0:20:1087520784 sdg   8:96  active ready running
36005076303ffc562000000000000010d1 dm-1 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=2 status=enabled
  |- 0:0:24:1087455248 sdb   8:16  active ready running
  `- 1:0:20:1087455248 sdf   8:80  active ready running
36005076303ffc56200000000000010d0 dm-0 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=2 status=enabled
  |- 0:0:24:1087389712 sda   8:0   active ready running
  `- 1:0:20:1087389712 sde   8:64  active ready running
36005076303ffc56200000000000010d3 dm-3 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=2 status=enabled
  |- 0:0:24:1087586320 sdd   8:48  active ready running
  `- 1:0:20:1087586320 sdh   8:112 active ready running
```

Example of a multipath I/O configuration for IBM TotalStorage DS6000

The following example describes the configuration of one IBM TotalStorage DS6000™ SCSI device that is attached through four different FCP channels.

About this task

The example shows the special configuration for storage devices with group_by_prio as the path grouping policy. The Asymmetric Logical Unit Access (ALUA) tool is used to get the priority for each device. The ALUA tool is part of the multipath-tools.

Procedure

1. Set the FCP devices online:

```
# chccwdev -e c20f
Setting device 0.0.c20f online
Done
# chccwdev -e c01f
Setting device 0.0.c01f online
Done
```

   If you are using NPIV for your setup, LUNs are detected automatically and no further configuration is necessary.

   If you are not using NPIV for your setup, write the LUNs to the unit_add attribute of the target port:

```
# echo 0x4011404500000000 > /sys/bus/ccw/drivers/zfcp/0.0.c20f/0x500507630e8601f9/unit_add
# echo 0x4011404600000000 > /sys/bus/ccw/drivers/zfcp/0.0.c20f/0x500507630e8601f9/unit_add
# echo 0x4011404700000000 > /sys/bus/ccw/drivers/zfcp/0.0.c20f/0x500507630e8601f9/unit_add
# echo 0x4011404800000000 > /sys/bus/ccw/drivers/zfcp/0.0.c20f/0x500507630e8601f9/unit_add
# echo 0x4011404500000000 > /sys/bus/ccw/drivers/zfcp/0.0.c01f/0x500507630e0001f9/unit_add
# echo 0x4011404600000000 > /sys/bus/ccw/drivers/zfcp/0.0.c01f/0x500507630e0001f9/unit_add
# echo 0x4011404700000000 > /sys/bus/ccw/drivers/zfcp/0.0.c01f/0x500507630e0001f9/unit_add
# echo 0x4011404800000000 > /sys/bus/ccw/drivers/zfcp/0.0.c01f/0x500507630e0001f9/unit_add
```

2. Load the dm_multipath module:

```
# modprobe dm_multipath
```

3. Use the **multipath** command to detect multiple paths to devices for failover or performance reasons and coalesce them:

```
# multipath
create: 3600507630efe01f90000000000001145 undef IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
|-+- policy='round-robin 0' prio=50 status=undef
| `- 0:0:0:1078280209 sda   8:0   undef ready  running
`-+- policy='round-robin 0' prio=10 status=undef
  `- 1:0:0:1078280209 sde   8:64  undef ready  running
create: 3600507630efe01f90000000000001146 undef IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
|-+- policy='round-robin 0' prio=50 status=undef
| `- 0:0:0:1078345745 sdb   8:16  undef ready  running
`-+- policy='round-robin 0' prio=10 status=undef
  `- 1:0:0:1078345745 sdf   8:80  undef ready  running
create: 3600507630efe01f90000000000001147 undef IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
|-+- policy='round-robin 0' prio=50 status=undef
| `- 0:0:0:1078411281 sdc   8:32  undef ready  running
`-+- policy='round-robin 0' prio=10 status=undef
  `- 1:0:0:1078411281 sdg   8:96  undef ready  running
create: 3600507630efe01f90000000000001148 undef IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=undef
|-+- policy='round-robin 0' prio=50 status=undef
| `- 0:0:0:1078476817 sdd   8:48  undef ready  running
`-+- policy='round-robin 0' prio=10 status=undef
  `- 1:0:0:1078476817 sdh   8:112 undef ready  running
```

Note: The priority displays only after you call multipath for the first time.

4. Start the multipathd daemon to run a working multipath environment:

```
# /etc/init.d/multipathd start
```

5. Use the **multipath** command to display the resulting multipath configuration:

```
# multipath -ll
3600507630efe01f90000000000001148 dm-3 IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=50 status=enabled
| `- 0:0:0:1078476817 sdd   8:48  active ready  running
`-+- policy='round-robin 0' prio=10 status=enabled
  `- 1:0:0:1078476817 sdh   8:112 active ready  running
3600507630efe01f90000000000001147 dm-2 IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=50 status=enabled
| `- 0:0:0:1078411281 sdc   8:32  active ready  running
`-+- policy='round-robin 0' prio=10 status=enabled
  `- 1:0:0:1078411281 sdg   8:96  active ready  running
3600507630efe01f90000000000001146 dm-1 IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=50 status=enabled
| `- 0:0:0:1078345745 sdb   8:16  active ready  running
`-+- policy='round-robin 0' prio=10 status=enabled
  `- 1:0:0:1078345745 sdf   8:80  active ready  running
3600507630efe01f90000000000001145 dm-0 IBM,1750500
size=1.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=50 status=enabled
| `- 0:0:0:1078280209 sda   8:0   active ready  running
`-+- policy='round-robin 0' prio=10 status=enabled
  `- 1:0:0:1078280209 sde   8:64  active ready  running
```

Example of multipath I/O devices as physical volumes for LVM2

By default, LVM2 does not consider device-mapper block devices.

Procedure

To enable the multipath I/O devices for LVM2, change the device section of `/etc/lvm/lvm.conf` as follows:

1. Add the directory with the DM device nodes to the array that contains directories that are scanned by LVM2. LVM2 accepts device nodes within these directories only:

   ```
   scan = [ "/dev", "/dev/mapper" ]
   ```

2. Add device-mapper volumes as an acceptable block devices type:

   ```
   types = [ "device-mapper". 16]
   ```

3. Modify the filter patterns, which LVM2 applies to devices found by a scan. The following line instructs LVM2 to accept the multipath I/O and reject all other devices.

   Note: If you are also using LVM2 on non-multipath I/O devices, you need to modify this line according to your requirements.

   ```
   filter = [ "a|/dev/disk/by-name/.*|", "r|.*|" ]
   ```

Results

With the preceding settings, you should be able to use the multipath I/O devices for LVM2. The next steps are similar for all types of block devices.

Example

The following example shows the steps to create a volume group that is composed of four multipath I/O devices. It assumes that the multipath I/O devices are already configured.

1. List available multipath I/O devices:

```
# multipath -l
36005076303ffc56200000000000010d2 dm-2 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=-2 status=enabled
  |- 0:0:24:1087520784 sdc   8:32  active undef running
  `- 1:0:20:1087520784 sdg   8:96  active undef running
36005076303ffc56200000000000010d1 dm-1 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=-2 status=enabled
  |- 0:0:24:1087455248 sdb   8:16  active undef running
  `- 1:0:20:1087455248 sdf   8:80  active undef running
36005076303ffc56200000000000010d0 dm-0 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=-2 status=enabled
  |- 0:0:24:1087389712 sda   8:0   active undef running
  `- 1:0:20:1087389712 sde   8:64  active undef running
36005076303ffc56200000000000010d3 dm-3 IBM,2107900
size=5.0G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='round-robin 0' prio=-2 status=enabled
  |- 0:0:24:1087586320 sdd   8:48  active undef running
  `- 1:0:20:1087586320 sdh   8:112 active undef running
```

2. Initialize the volume by using **pvcreate** (you must initialize before a volume can be used for LVM2):

```
# pvcreate /dev/mapper/36005076303ffc56200000000000010d0
 Physical volume "/dev/mapper/36005076303ffc56200000000000010d0" successfully created
```

   Repeat this step for all multipath I/O devices that you intend to use for LVM2.

3. Create the volume group:

```
# vgcreate sample_vg /dev/mapper/36005076303ffc56200000000000010d[0123]
   Volume group "sample_vg" successfully created
# vgdisplay sample_vg
   --- Volume group ---
   VG Name               sample_vg
   System ID
   Format                lvm2
   Metadata Areas        4
   Metadata Sequence No  1
   VG Access             read/write
   VG Status             resizable
   MAX LV                0
   Cur LV                0
   Open LV               0
   Max PV                0
   Cur PV                4
   Act PV                4
   VG Size               19.98 GB
   PE Size               4.00 MB
   Total PE              5116
   Alloc PE / Size       0 / 0
   Free  PE / Size       5116 / 19.98 GB
   VG UUID               Lmlgx9-2A2p-oZEP-CEH3-ZKqc-yTpY-IVOG6v
```

   Now you can proceed normally: Create logical volumes, build file systems, and mount the logical volumes.

When configured, the multipath I/O devices and LVM2 volume groups can be made available at start time. To do this, continue with the following additional steps.

1. Include the zfcp unit configuration in the distribution configuration, see the documentation of your distribution about how to do this.
2. Update the IPL record:

```
# zipl
Using config file '/etc/zipl.conf'
Building bootmap in '/boot/zipl'
Adding IPL section 'ipl' (default)
Preparing boot device: dasda (2c1a).
Done.
```

3. Ensure that multipathing and LVM are enabled in the init scripts for your distribution. Consult the distribution documentation for details.

After re-boot you should see messages that report multipath I/O devices and LVM2 groups, for example:

```
SCSI subsystem initialized
...
scsi0 : zfcp
qdio: 0.0.181d ZFCP on SC 10 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
scsi1 : zfcp
qdio: 0.0.191d ZFCP on SC 11 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
...
device-mapper: uevent: version 1.0.3
device-mapper: ioctl: 4.16.0-ioctl (2009-11-05) initialised: dm-devel@redhat.com
device-mapper: multipath: version 1.1.1 loaded
device-mapper: multipath round-robin: version 1.0.0 loaded
device-mapper: multipath queue-length: version 0.1.0 loaded
device-mapper: multipath service-time: version 0.2.0 loaded
...
```

For each SCSI device, you see output messages, for example:

```
scsi 1:0:20:1087127568: Direct-Access     IBM      2107900          .280 PQ: 0 ANSI: 5
scsi 1:0:20:1087127568: alua: supports implicit TPGS
scsi 1:0:20:1087127568: alua: port group 00 rel port 233
scsi 1:0:20:1087127568: alua: rtpg failed with 8000002
scsi 1:0:20:1087127568: alua: port group 00 state A supports tousNA
sd 1:0:20:1087127568: Attached scsi generic sg0 type 0
sd 1:0:20:1087127568: [sda] 10485760 512-byte logical blocks: (5.36 GB/5.00 GiB)
sd 1:0:20:1087127568: [sda] Write Protect is off
sd 1:0:20:1087127568: [sda] Mode Sense: ed 00 00 08
sd 1:0:20:1087127568: [sda] Write cache: enabled, read cache: enabled, doesn't support DPO or FUA
 sda: unknown partition table
sd 1:0:20:1087127568: [sda] Attached SCSI disk
```

Chapter 6. Booting the system by using SCSI IPL

SCSI IPL (initial program load) is the ability to load a mainframe operating system from an FCP-attached SCSI device.

The SCSI device can be a SCSI disk, SCSI CD, or SCSI DVD device. SCSI IPL is a mechanism that expands the set of I/O devices that you can use during IPL.

Before you begin, see "Hardware requirements."

What you should know about SCSI IPL

SCSI IPL opens the way to a new set of IPL I/O devices with a somewhat different processing compared to CCW-based devices.

At first glance, a traditional IPL (also called CCW IPL) and a SCSI IPL are similar:

1. A mainframe administrator initiates an IPL at the SE, HMC, or at a z/VM console.
2. The machine checks the IPL parameters and tries to access the corresponding IPL devices.
3. Some code will be loaded from the IPL device into main storage and executed. Usually this initial code will load some more code into storage until the entire operating system is in memory.

The difference between SCSI IPL and CCW IPL is the connection to the IPL device. In the CCW case the IPL device is connected more or less directly to the host. In contrast, in the SCSI IPL case there could be an entire Fibre Channel SAN between the host and the IPL device.

In traditional CCW IPL, a channel command word (CCW) contains a command to perform a read, write, or control operation. A chain of CCWs is called a channel program, and this will be executed in a channel by channel engines that run independently of the usual CPUs.

All I/O is controlled by channel programs. I/O devices are identified by a two-byte device number. The I/O devices are configured within the I/O definition file (IODF). A CCW IPL is also called 24-bytes-IPL because only one PSW and two CCWs are read from the disk initially. These 24 bytes are the first stage boot loader and are enough to allow the reading of more IPL code from the IPL device.

SCSI IPL is more complex than CCW IPL and can:

- Log in to an Fibre Channel fabric.
- Maintain a connection through the Fibre Channel SAN.
- Send SCSI commands and associated data.

To accomplish this, an enhanced set of IPL parameters is required (see "SCSI IPL parameters" on page 24).

Hardware requirements

You require hardware that supports the SCSI IPL feature.

To be able to IPL a Linux system from a SCSI disk, the following hardware is required:

- The SCSI IPL hardware feature.
  - As of z10™ machines, SCSI IPL is a base function.
  - On z9 machines, you require the no-charge feature FC 9904.
  - On z990 and older machines, you need to order and install SCSI IPL separately using Feature Code FC 9904. Models z800 and z900 require an initial, one-time power-on-reset (POR) of the machine to activate the feature. Activating the SCSI IPL feature is concurrent on z890, z990, or newer, machines.
- An FCP channel. See "Supported hardware" on page x. You must configure the hardware as an FCP channel within your IODF.
- One or more FCP-attached SCSI disks from which to IPL.

Also see your Linux distribution for further prerequisites.

SAN addressing

Every device in a SAN is specified by addressing parameters.

To access a device within a Fibre Channel SAN the following addressing parameters are required (see Figure 9):

- The device number of the FCP device (the device-bus ID without the leading "0.0"). This is a two-byte hexadecimal number specifying the FCP device, and, indirectly, the port at the local FCP channel. This is the only addressing parameter configured within the IODF. The device-bus ID is the way out of the mainframe.
- The worldwide port name (WWPN) of your target port. There can be several hundred storage devices with several ports each within your storage area network. You must specify the storage device and the entry port into this storage device. For this reason, each port has a unique number, called the worldwide port name. This WWPN is eight bytes in length and is, as the name says, unique worldwide.
- The logical unit (LUN). This parameter specifies the device within the storage controller. There could be several hundred disks in your storage controller.

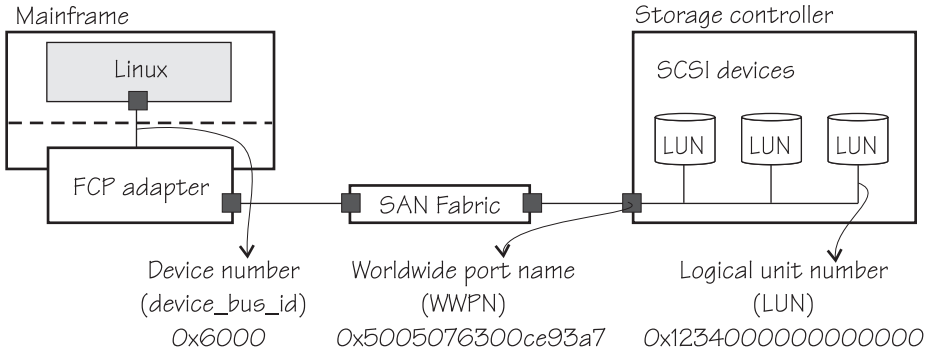


Figure 9. SAN addressing parameters

SCSI IPL parameters

Use these IPL parameters to configure SCSI IPL.

Load type

Without SCSI IPL there are the two load types, normal and clear. Both are used to IPL an operating system. The only difference is that the memory will be cleared before IPL in the second case. SCSI IPL introduces two new load types called SCSI and SCSI dump. The load type SCSI loads an operating system from a SCSI device and clears the memory every time. SCSI dump loads a dump program from a SCSI device. In this case the memory will not be cleared.

Load address

(Required.) The load address is a two-byte hexadecimal number. It is the device number of the FCP device and it is NOT associated with an I/O device, but with the FCP channel! This is one of the most important differences compared to CCW IPL. This is the only SCSI IPL parameter defined in the IODF.

Worldwide port name

(Required.) The worldwide port name (WWPN) is an eight-byte hexadecimal number and uniquely identifies the target port of the SCSI target device.

Logical unit number

(Required.) The logical unit number (LUN) is an eight-byte hexadecimal number that identifies the logical unit representing the IPL device.

Boot program selector

(Optional.) Selects a boot configuration, which can be a Linux kernel, a kernel parameter file, or optionally a ram disk. There could be up to 31 (decimal 0 – 30) different configurations on a single SCSI disk, independent of on which partition they are stored. The different configurations must be prepared with the Linux zipl tool. The default value is 0.

There are several possible uses for this parameter. For example, if you have one production and one development kernel, it allows you to always IPL the system even if the development kernel does not work. Another use would be a rescue system, or the same kernel with several different kernel parameters or ram disks. This parameter adds flexibility to SCSI IPL.

Boot record logical block address

(Optional.) The boot record logical block address specifies the entry or anchor point to find the operating system on a SCSI disk. A block number can be specified here. Usually, in Linux, this block is the master boot record and the first block on the IPL device. With this parameter it is possible to use a different block as entry point. For example, z/VM does not have a master boot record. The default value is 0.

Operating system specific load parameters

(Optional.) Operating system specific load parameters are parameters for the loaded operating system. It is intended to hand over parameters to the operating system or dump program. This field is only passed through. The main difference to all other SCSI IPL parameters is that this field is not used to access the IPL device or the operating system on the IPL device. This field is currently restricted to 256 Bytes (SE) and 4096 Bytes (z/VM).

For booting Linux, use this field to specify kernel parameters. During the boot process, these parameters are concatenated to the end of the existing kernel parameters that are used by your boot configuration. The specifications must contain ASCII characters only. If characters other than ASCII are present, the content of the field is ignored during IPL.

If you specify the kernel parameters with a leading equal sign (=), the existing kernel parameters are ignored and replaced with the kernel parameters in this field. If you replace the existing kernel parameters, be sure not to omit any kernel parameters required by your boot configuration.

For dump tools, use this field to specify additional dump tool parameters. Other than with kernel parameters, you cannot replace the existing dump tool parameters.

Load parameter
This parameter is SCSI IPL independent and can be used as usual. The loaded operating system receives these IPL parameters at a later point in time. This parameter is not used to access the IPL device.

The following parameters are not needed for SCSI IPL, but are mentioned for completeness:

Store status and time-out value
These two parameters are not needed for SCSI IPL. For SCSI IPL, no store status is required and for SCSI dump a store status command is always performed.

SCSI disk installation and preparation

Usually the disk preparation is done by a distribution-specific installation tool. If there is no such tool available or the distribution does not support an installation on a SCSI disk, it is also possible to perform these steps manually to make a disk bootable.

The standard Linux disk preparation tool on z Systems is **zipl**. The **zipl** command writes the boot loader for IBM z Systems machines. This preparation might be done on the command line or by using the config file `/etc/zipl.conf`. The **zipl** command prepares SCSI disks as well as ECKD™ DASDs and it is possible to write several boot configurations (kernel, parameter file, ram disk) to one disk. This possibility is called *boot menu option* or multi-boot option.

It is also possible to prepare a SCSI dump disk with the zipl command and it is possible to have IPL and dump programs on the same disk. For more information, see the zipl and zipl.conf man pages.

The following zipl.conf example defines two boot configurations, scsi-ipl-1 and scsi-ipl-2, which are selectable with boot program selector 1 and 2. The default boot program selector 0 will IPL scsi-ipl-2 (the default).

```
/etc/zipl.conf

[defaultboot]
default = scsi-ipl-1
[scsi-ipl-1]
target     = "/boot"
image      = "/boot/kernel-image-1"
parmfile   = "/boot/parmfile-1"
[scsi-ipl-2]
target     = "/boot"
image      = "/boot/kernel-image-2"
parmfile   = "/boot/parmfile-2"
ramdisk    = "/boot/initrd-2"

:menu1
target     = "/boot"
1=scsi-ipl-1
2=scsi-ipl-2
default=2
```

The parameter file `parmfile-1` must define the SCSI IPL device by giving the device bus-ID, the WWPN and the LUN. Example:

```
zfcp.device=0.0.3c04,0x500507630310c562,0x4010405f00000000    #Defines the SCSI IPL device
root=/dev/sda1                                                #Defines the root file system
ro                                                      #Mounts the root file system read-only
noinitrd                                                      #Suppresses an initial RAM disk
selinux=0
audit=0
audit_enable=0
zfcp.allow_lun_scan=0                             #Disables the LUN scan for NPIV setups
```

The kernel parameter `zfcp.allow_lun_scan=0` is required for setups using NPIV. The parameter disables the automatic LUN scan. This ensures that the specified LUN is attached in the SCSI mid-layer as sda.

Alternatively, you can specify the parameters directly in the zipl.conf:

```
[scsi-ipl-1]
target     = "/boot"
image      = "/boot/kernel-image-1"
parameters = "zfcp.device=0.0.3c04,0x500507630310c562,0x4010405f00000000 root=/dev/sda1
              ro noinitrd selinux=0 audit=0 audit_enable=0 zfcp.allow_lun_scan=0"
```

Note:

1. Using `root=/dev/sda1` places the root file system on a single path SCSI device. For reliable production systems, you should use a multipath setup. See your distribution documentation about how to configure multipath paths in the initrd, and how to place the root file system on a multipath device.
2. When using the multipath setup in the initrd the exact names of the SCSI devices (sda, sdb, ...) are no longer important for accessing the disk volumes. This means that you should not set the kernel parameter `zfcp.allow_lun_scan=0` for distributions.

This zipl.conf configuration is activated with the following **zipl** command:

```
[root@host /]# zipl -m menu1
Using config file '/etc/zipl.conf'
Building bootmap '/boot/bootmap'
Building menu 'menu1'
Adding #1: IPL section 'scsi-ipl-1'
Adding #2: IPL section 'scsi-ipl-2'
(default)
Preparing boot device: 08:00
Done.
[root@host /]#
```

The disk is now bootable and contains two boot configurations, selectable through the boot program selector parameter bootprog (see also Figure 10 on page 30). Note that the interactive boot menu is not shown when booting from SCSI.

SCSI dump

SCSI dump is a stand-alone dump to a SCSI disk. It is the IPL of an operating system-dependent dump program.

An initiated SCSI dump always performs a store status automatically. A reset normal instead of reset clear will be performed, which does not clear the memory.

Machine loader and system dump program run in the same LPAR memory that must be dumped. For this reason the lower-address area of the LPAR memory are copied into a reserved area (HSA) of the machine. The system dump program then reads the first part of the dump from the HSA and the second part from memory.

This is why SCSI dumps are serialized on a machine. There is only one save area for all LPARs. Normally this does not cause problems because you seldom need a dump and the HSA is locked less than a second. Should you happen on this short timeframe, you will get a pop-up window on the SE that tells you what LPAR currently uses the HSA.

The system dumper under Linux on z Systems is the **zfcpdump** command. It is part of the s390-tools package and must be prepared with the zipl tool.

The dump program determines where to put the dump. Currently, the dump program places the dump on the SCSI disk where the program resides.

The dump disk contains the dump program and a file system. The dump disk is mountable and all dumps are files. It is possible to have several dumps on one dump disk.

For more information about the dump utilities see *Using the Dump Tools, SC33-8412*.

Example: IODF definition

An example of how the IODF could look.

Only the FCP channel must be configured within the mainframe. All other parameters must be configured outside the mainframe, that is, within switches or at the target storage system.

In this example two channels of a FICON or FICON Express hardware feature are configured as FCP. First two FCP CHPIDs are defined, both get the number 50, one for channel subsystem 0 and one for channel subsystem 1. An FCP control unit 5402 is then assigned to these new CHPIDs. The last step is to define several FCP devices starting with device number 5400.

```
CHPID PATH=(CSS(0),50),SHARED,                                  *
      PARTITION=((LP01,LP02,LP03,LP04,LP05,LP06,LP07,LP08,LP09*
      ,LP10,LP11,LP12,LP13,LP14,LP15),(=)),PCHID=160,TYPE=FCP
CHPID PATH=(CSS(1),50),SHARED,                                  *
      PARTITION=((LP16,LP17,LP18,LP19,LP20,LP21,LP22,LP23,LP24*
      ,LP25,LP26,LP27,LP28,LP29,LP30),(=)),PCHID=161,TYPE=FCP

...

CNTLUNIT CUNUMBR=5402,PATH=((CSS(0),50),(CSS(1),50)),UNIT=FCP

...

IODEVICE ADDRESS=(5400,002),CUNUMBR=(5402),                     *
      PARTITION=((CSS(0),LP01),(CSS(1),LP16)),UNIT=FCP
IODEVICE ADDRESS=(5402,002),CUNUMBR=(5402),                     *
      PARTITION=((CSS(0),LP02),(CSS(1),LP17)),UNIT=FCP

...

IODEVICE ADDRESS=(5460,144),CUNUMBR=(5402),                     *
      PARTITION=((CSS(0),LP15),(CSS(1),LP30)),UNIT=FCP
```

Example: SCSI IPL of an LPAR

You can perform an IPL of an LPAR from a SCSI disk.

Procedure

Follow these steps to IPL an LPAR from a SCSI disk:

1. Once the SCSI IPL feature is active, the SE or HMC display an enhanced load panel as shown in Figure 10 on page 30.

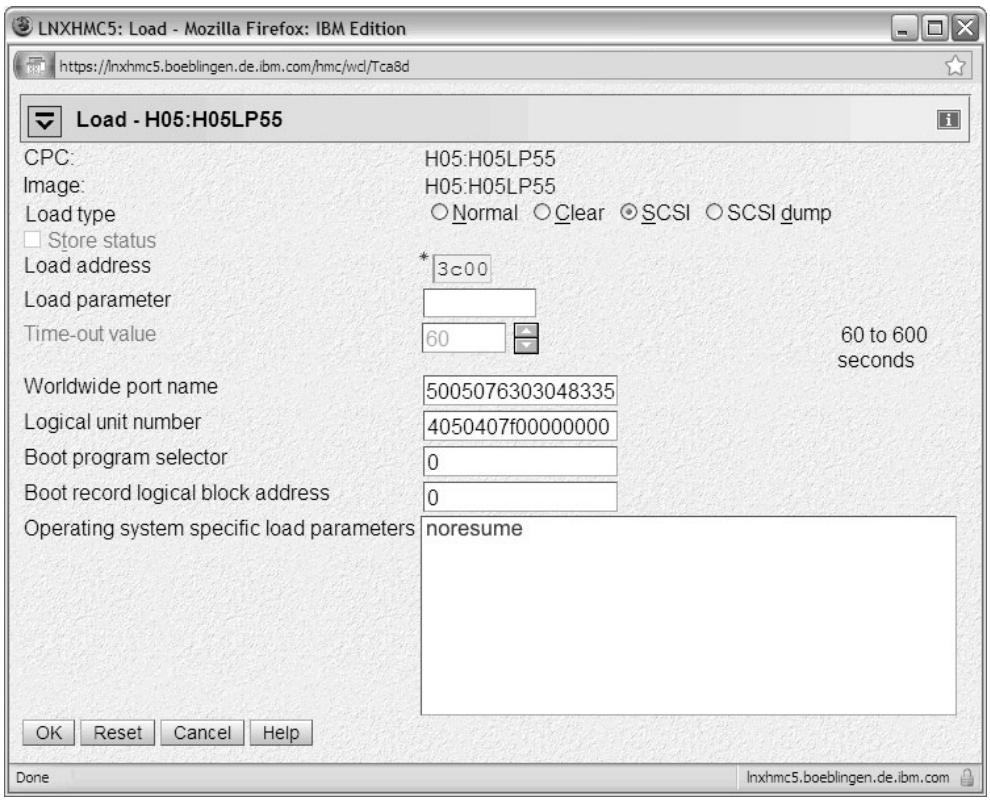


Figure 10. Load panel

(If the SCSI IPL feature is not enabled, some fields are not visible.) The SE remembers the last set of specified IPL parameters. It is also possible to set the SCSI IPL parameters within the activation profile.

2. Specify IPL parameters (see "SCSI IPL parameters" on page 24) and click **OK**. The operating system starts.

Results

The only difference to a system that uses CCW IPL are the two messages:

- MLOEVL012I: Machine loader up and running.
- MLOPDM003I: Machine loader finished, moving data to final storage location.

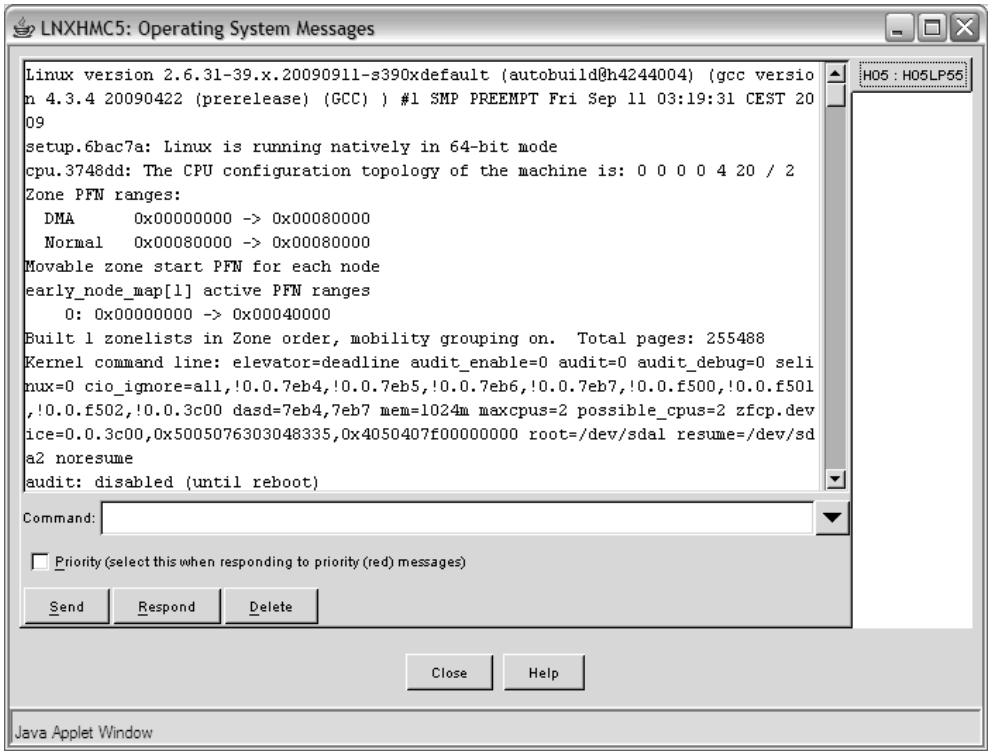


Figure 11. Example of a SCSI IPL

Figure 11 shows the boot messages.

The kernel parameters show that the root file system of this Linux instance is on a SCSI disk (`/dev/sda1`). Production systems should not use `/dev/sda1` as a root device, but use multi-pathing overlying the SCSI devices. See your distribution's documentation for how to set up multi-pathing.

In Figure 10 on page 30, `noresume` has been typed into the **Operating system specific load parameters** field. In Figure 11 this specification has been concatenated to the end of the existing boot parameters used by the boot configuration. This causes a regular boot process, even if the Linux instance had previously been suspended to a swap partition.

Example: SCSI IPL of a z/VM guest virtual machine

You can perform an IPL of a z/VM guest virtual machine from a SCSI device.

About this task

For SCSI IPL in a z/VM guest virtual machine, you specify some of the IPL parameters with the SET LOADDEV command. A subsequent IPL command with an FCP device as the IPL device uses these parameters. You can use the QUERY LOADDEV command to display the currently set IPL parameters for a SCSI IPL.

In this example, the WWPN of the remote port through which the SCSI boot disk can be accessed is set to `5005076300c20b8e` and the LUN of the SCSI boot disk to `5241000000000000`. The IPL process requires this information to locate the boot disk in the SAN fabric.

The example assumes that a menu configuration has been written to the boot disk and specifies the boot configuration (boot program in VM terminology) to be used. If this specification is omitted for a menu configuration, the default configuration is used.

The example also specifies a kernel parameter to be concatenated to the end of the existing kernel parameters that are used by the boot configuration. Specifying kernel parameters is optional.

Procedure

To IPL a z/VM guest virtual machine with the IPL parameters of the example:

1. Log in to a CMS session and attach the FCP device to your z/VM guest virtual machine.

```
att 50aa *
00: FCP 50AA ATTACHED TO LINUX18 50AA
Ready; T=0.01/0.01 13:16:20

q v fcp
00: FCP  50AA ON FCP   50AA CHPID 40 SUBCHANNEL = 000E
00:      50AA QDIO-ELIGIBLE       QIOASSIST-ELIGIBLE
Ready; T=0.01/0.01 13:16:24
```

   The FCP device is now available.

2. Set the target port and LUN of the SCSI boot disk.

```
set loaddev portname 50050763 00c20b8e lun 52410000 00000000
Ready; T=0.01/0.01 13:16:33
```

3. Specify the boot configuration.

```
set loaddev bootprog 2
```

4. Specify the kernel parameter that is to be concatenated at the end of the existing kernel parameters used by the boot configuration.

```
set loaddev scpdata 'noresume'
```

5. Confirm that the parameters have been set correctly.

```
q loaddev
PORTNAME 50050763 00C20B8E    LUN  52410000 00000000
BOOTPROG 2 BR_LBA   00000000 00000000

SCPDATA
         0----+----1----+----2----+----3----+----4----+----
    0000 NORESUME
Ready; T=0.01/0.01 13:16:38
```

6. IPL using the device number of the FCP device as parameter:

```
i 50aa
00: HCPLDI2816I Acquiring the machine loader from the processor controller.
00: HCPLDI2817I Load completed from the processor controller.
00: HCPLDI2817I Now starting machine loader.
00: MLOEVL012I: Machine loader up and running (version 0.15).
00: MLOPDM003I: Machine loader finished, moving data to final storage location.
Linux version 2.4.21 (root@tel15v18)(gcc version 3.3 (Red Hat Linux 8.0 3.3-5bb9))
         #3 SMP Mon Sep 15 15:28:42 CEST 2003
We are running under VM (64 bit mode)
On node 0 total pages: 32768
```

The Linux system comes up after the two SCSI IPL machine loader messages.

Further reading

These publications might be of interest.

- IBM Journal of Research and Development, Vol 48, No ¾, 2004 *SCSI initial program loading for zSeries* available from the journal archive at

  `www.ibm.com/research/journal/rdindex.html`
- Depending on your machine:
  - IBM Corporation, *Enterprise Systems Architecture/390 Principles of Operation, SA22-7201*.
  - IBM Corporation, *z/Architecture® Principles of Operation, SA22-7832*.

  Both are available through the IBM Publications Center at:

  `www.ibm.com/shop/publications/order`
- I. Adlung, G. Banzhaf, W. Eckert, G. Kuch, S. Mueller, and C. Raisch: *FCP for the IBM eServer™ zSeries Systems: Access to Distributed Storage*, IBM J. Res. & Dev. 46, No. 4/5, 487–502 (2002).
- IBM Corporation: *zSeries z990 System Overview, SA22-1032*. This book is available in PDF format by accessing Resource Link® at:

  `www.ibm.com/servers/resourcelink`
- IBM Corporation: *zSeries Input/Output Configuration Program User's Guide for ICP IOCP, SB10-7037*; available through the IBM Publications Center.
- ANSI/INCITS, Technical Committee T10: *Information Systems–Fibre Channel Protocol for SCSI*, Second Version (FCP-2), American National Standards Institute and International Committee for Information Standards, Washington, DC, 2001.
- *The Master Boot Record (MBR) and Why is it Necessary?*, available at:

  `www.dewassoc.com/kbase/index.html`
- R. Brown and J. Kyle: *PC Interrupts, A Programmer's Reference to BIOS, DOS, and Third-Party Calls*, Addison-Wesley Publishing Company, Boston, MA, 1994.

Chapter 7. Using SCSI tape and the lin_tape driver

To manage IBM TotalStorage or System Storage® devices, use the lin_tape Linux device driver.

The lin_tape Linux device driver replaces the IBMtape device driver. The lin_tape device driver is open source, but is essentially the same driver.

- The lin_tape device driver is available from the IBM Fix Central at:
  `http://www.ibm.com/support/fixcentral`

  For details about downloading the device driver, see Technote 1428656.
- For the IBM Tape device driver installation documentation, see the *IBM Tape Device Drivers Installation and User's Guide* available at:
  `http://www.ibm.com/support/docview.wss?rs=577&uid=ssg1S7002972`

Chapter 8. Logging using the SCSI logging feature

The SCSI logging feature is of interest primarily for software developers who are debugging software problems. It can also be useful for administrators who track down hardware or configuration problems.

The SCSI logging feature can log information such as:

- Initiation of commands
- Completion of commands
- Error conditions
- Sense data for SCSI commands

The information is written into the Linux log buffer and usually appears in `/var/log/messages`.

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 following logging areas are provided with the SCSI logging feature:

SCSI LOG ERROR RECOVERY
Messages regarding error recovery.

SCSI LOG TIMEOUT
Messages regarding timeout handling of SCSI commands.

SCSI LOG SCAN BUS
Messages regarding bus scanning.

SCSI LOG MLQUEUE
Messages regarding command handling in SCSI mid-level handling of SCSI commands.

SCSI LOG MLCOMPLETE
Messages regarding command completion in SCSI mid layer.

SCSI LOG LLQUEUE
Messages regarding command handling in low-level drivers (for example, sd, sg, or sr). (Not used in current vanilla kernel).

SCSI LOG LLCOMPLETE
Messages regarding command completion in low-level drivers. (Not used in current vanilla kernel).

SCSI LOG HLQUEUE
Messages regarding command handling in high-level drivers (for example, sd, sg, or sr).

SCSI LOG HLCOMPLETE
Messages regarding command completion in high-level drivers.

SCSI LOG IOCTL
Messages regarding handling of IOCTLs.

Each area has its own logging level. The logging levels can be changed by using a logging word, which can be passed from and to the kernel with a `sysctl`. The

logging levels can easily be read and set with the scsi_logging_level command (part of s390-tools). For a detailed description of the scsi_logging_level tool, see *Device Drivers, Features, and Commands, SC33-8411* available on the developerWorks website at:

`www.ibm.com/developerworks/linux/linux390/documentation_dev.html`

The following logging levels might be of interest for administrators:

- SCSI LOG MLQUEUE=2 traces opcodes of all initiated SCSI commands
- SCSI LOG MLCOMPLETE=1 traces completion (opcode, result, sense data) of SCSI commands that did not complete successfully in terms of the SCSI stack. Such commands either timed out, or need to be retried.
- SCSI LOG MLCOMPLETE=2 traces completion (opcode, result, sense data) of all SCSI commands
- SCSI LOG IOCTL=2 traces initiation of IOCTLs for SCSI disks (device, `ioctl`-command)

Examples

These examples show how to set the logging level for various problems.

- Example 1 shows how to set the log level for SCSI_LOG_MLCOMPLETE to 1 to log all non-successful completions and completions with sense data.

```
#>scsi_logging_level -s --mlcomplete 1
New scsi logging level:
dev.scsi.logging_level = 4096
SCSI_LOG_ERROR=0
SCSI_LOG_TIMEOUT=0
SCSI_LOG_SCAN=0
SCSI_LOG_MLQUEUE=0
SCSI_LOG_MLCOMPLETE=1
SCSI_LOG_LLQUEUE=0
SCSI_LOG_LLCOMPLETE=0
SCSI_LOG_HLQUEUE=0
SCSI_LOG_HLCOMPLETE=0
SCSI_LOG_IOCTL=0
```

  When you configure a new LUN for zfcp, additional messages appear (in bold):

```
May 17 12:03:58 t2945012 kernel:   Vendor: IBM       Model: 2107900          Rev: .203
May 17 12:03:58 t2945012 kernel:   Type:   Direct-Access                     ANSI SCSI revision: 05
May 17 12:03:58 t2945012 kernel: sd 0:0:0:0: done SUCCESS        2 sd 0:0:0:0:
May 17 12:03:58 t2945012 kernel:          command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:03:58 t2945012 kernel: : Current: sense key: Unit Attention
May 17 12:03:58 t2945012 kernel:     Additional sense: Power on, reset, or bus device reset occurred
May 17 12:03:58 t2945012 kernel: SCSI device sda: 10485760 512-byte hdwr sectors (5369 MB)
May 17 12:03:58 t2945012 kernel: sda: Write Protect is off
May 17 12:03:58 t2945012 kernel: SCSI device sda: drive cache: write back
May 17 12:03:58 t2945012 kernel: SCSI device sda: 10485760 512-byte hdwr sectors (5369 MB)
May 17 12:03:58 t2945012 kernel: sda: Write Protect is off
May 17 12:03:58 t2945012 kernel: SCSI device sda: drive cache: write back
May 17 12:03:58 t2945012 kernel:  sda: sda1 sda2
May 17 12:03:58 t2945012 kernel: sd 0:0:0:0: Attached scsi disk sda
```

- Example 2 shows how to set the log level for SCSI_LOG_MLCOMPLETE to 2 to log all command completions:

```
#>scsi_logging_level -s --mlcomplete 2
New scsi logging level:
dev.scsi.logging_level = 8192
SCSI_LOG_ERROR=0
SCSI_LOG_TIMEOUT=0
SCSI_LOG_SCAN=0
SCSI_LOG_MLQUEUE=0
SCSI_LOG_MLCOMPLETE=2
SCSI_LOG_LLQUEUE=0
SCSI_LOG_LLCOMPLETE=0
SCSI_LOG_HLQUEUE=0
SCSI_LOG_HLCOMPLETE=0
SCSI_LOG_IOCTL=0
```

When you configure a new LUN for zfcp, additional log messages appear (in bold):

```
May 17 12:06:01 t2945012 kernel:  1:0:0:0: done SUCCESS        0  1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Inquiry: 12 00 00 00 24 00
May 17 12:06:01 t2945012 kernel:  1:0:0:0: done SUCCESS        0  1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Inquiry: 12 00 00 00 a4 00
May 17 12:06:01 t2945012 kernel:   Vendor: IBM       Model: 2107900          Rev: .203
May 17 12:06:01 t2945012 kernel:   Type:   Direct-Access                      ANSI SCSI revision: 05
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        2 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:06:01 t2945012 kernel: : Current: sense key: Unit Attention
May 17 12:06:01 t2945012 kernel:     Additional sense: Power on, reset, or bus device reset occurred
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Read Capacity (10): 25 00 00 00 00 00 00 00 00 00
May 17 12:06:01 t2945012 kernel: SCSI device sdb: 10485760 512-byte hdwr sectors (5369 MB)
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Mode Sense (6): 1a 00 3f 00 04 00
May 17 12:06:01 t2945012 kernel: sdb: Write Protect is off
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Mode Sense (6): 1a 00 08 00 04 00
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Mode Sense (6): 1a 00 08 00 20 00
May 17 12:06:01 t2945012 kernel: SCSI device sdb: drive cache: write back
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Read Capacity (10): 25 00 00 00 00 00 00 00 00 00
May 17 12:06:01 t2945012 kernel: SCSI device sdb: 10485760 512-byte hdwr sectors (5369 MB)
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Mode Sense (6): 1a 00 3f 00 04 00
May 17 12:06:01 t2945012 kernel: sdb: Write Protect is off
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Mode Sense (6): 1a 00 08 00 04 00
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Mode Sense (6): 1a 00 08 00 20 00
May 17 12:06:01 t2945012 kernel: SCSI device sdb: drive cache: write back
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:06:01 t2945012 kernel:         command: Read (10): 28 00 00 00 00 00 00 00 08 00
May 17 12:06:01 t2945012 kernel:  sdb:sdb1 sdb2
May 17 12:06:01 t2945012 kernel: sd 1:0:0:0: Attached scsi disk sdb
...
```

- Example 3 shows how to set the log level for SCSI_LOG_MLQUEUE to 2 to log command queuing in the SCSI mid-layer.

```
#>scsi_logging_level -s --mlqueue 2
New scsi logging level:
dev.scsi.logging_level = 1024
SCSI_LOG_ERROR=0
SCSI_LOG_TIMEOUT=0
SCSI_LOG_SCAN=0
SCSI_LOG_MLQUEUE=2
SCSI_LOG_MLCOMPLETE=0
SCSI_LOG_LLQUEUE=0
SCSI_LOG_LLCOMPLETE=0
SCSI_LOG_HLQUEUE=0
SCSI_LOG_HLCOMPLETE=0
SCSI_LOG_IOCTL=0
```

The output shows Test Unit Ready commands that are issued by the path checker of **multipathd** (from multipath-tools):

```
May 17 12:07:36 t2945012 kernel: sd 0:0:0:0: send                  sd 0:0:0:0:
May 17 12:07:36 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:07:37 t2945012 kernel: sd 1:0:0:0: send                  sd 1:0:0:0:
May 17 12:07:37 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
```

- Example 4 shows how to set the log level for SCSI_LOG_MLQUEUE and SCSI_LOG_MLCOMPLETE to 2 to log command queuing and command completion in the SCSI mid-layer.

```
#>scsi_logging_level -s --mlqueue 2 --mlcomplete 2
New scsi logging level:
dev.scsi.logging_level = 9216
SCSI_LOG_ERROR=0
SCSI_LOG_TIMEOUT=0
SCSI_LOG_SCAN=0
SCSI_LOG_MLQUEUE=2
SCSI_LOG_MLCOMPLETE=2
SCSI_LOG_LLQUEUE=0
SCSI_LOG_LLCOMPLETE=0
SCSI_LOG_HLQUEUE=0
SCSI_LOG_HLCOMPLETE=0
SCSI_LOG_IOCTL=0
```

The output shows Test Unit Ready commands that are issued by the path checker of **multipathd** (from multipath-tools). In contrast to the previous example with additional messages (in bold):

```
May 17 12:07:56 t2945012 kernel: sd 0:0:0:0: send                  sd 0:0:0:0:
May 17 12:07:56 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:07:56 t2945012 kernel: sd 0:0:0:0: done SUCCESS        0 sd 0:0:0:0:
May 17 12:07:56 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:07:57 t2945012 kernel: sd 1:0:0:0: send                  sd 1:0:0:0:
May 17 12:07:57 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:07:57 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:07:57 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
```

- Example 5 shows how to set the log level for SCSI_LOG_MLQUEUE, SCSI_LOG_MLCOMPLETE and SCSI_LOG_IOCTL to 2 to log command queuing and command completion in the SCSI mid-layer and IOCTL information.

```
#>scsi_logging_level -s --mlqueue 2 --mlcomplete 2 --ioctl 2
New scsi logging level:
dev.scsi.logging_level = 268444672
SCSI_LOG_ERROR=0
SCSI_LOG_TIMEOUT=0
SCSI_LOG_SCAN=0
SCSI_LOG_MLQUEUE=2
SCSI_LOG_MLCOMPLETE=2
SCSI_LOG_LLQUEUE=0
SCSI_LOG_LLCOMPLETE=0
SCSI_LOG_HLQUEUE=0
SCSI_LOG_HLCOMPLETE=0
SCSI_LOG_IOCTL=2
```

The output shows Test Unit Ready commands that are issued by the path checker of **multipathd** (from multipath-tools). In contrast to the previous example, this one has additional messages (in bold):

```
May 17 12:08:17 t2945012 kernel: sd_ioctl: disk=sda, cmd=0x2285
May 17 12:08:17 t2945012 kernel: sd 0:0:0:0: send                   sd 0:0:0:0:
May 17 12:08:17 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:08:17 t2945012 kernel: sd 0:0:0:0: done SUCCESS        0 sd 0:0:0:0:
May 17 12:08:17 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:08:18 t2945012 kernel: sd_ioctl: disk=sdb, cmd=0x2285
May 17 12:08:18 t2945012 kernel: sd 1:0:0:0: send                   sd 1:0:0:0:
May 17 12:08:18 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
May 17 12:08:18 t2945012 kernel: sd 1:0:0:0: done SUCCESS        0 sd 1:0:0:0:
May 17 12:08:18 t2945012 kernel:         command: Test Unit Ready: 00 00 00 00 00 00
```

- Example 6 shows how to switch off all SCSI logging levels:

```
#>scsi_logging_level -s -a 0
New 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
```

Chapter 9. Statistics available through sysfs

The zfcp device driver provides statistics through sysfs. This information is given for each FCP device.

The zfcp device driver queries the FCP channel directly for the requested information and in addition latency information is collected and summarized during the normal operation of the FCP channel. The statistics cannot be reset or activated or deactivated manually, however, a deactivate/activate cycle of the FCP device would cause this effect. See Table 1 for available statistic information.

Table 1. zfcp statistics available through sysfs

Type	Description
seconds_active	Seconds since the FCP device is active
requests	Number of requests that are processed since FCP device activation
megabytes	Number of megabytes transferred since FCP device activation
utilization	Utilization in percent over the last 2 seconds
cmd_latency	Latency for command requests processed
read_latency	Latency for read requests processed
write_latency	Latency for write requests processed

Accessing statistics in sysfs

You can read the statistics from the files attributes in the sysfs file system. Depending on the information type the location of the attributes varies.

The latencies are provided on a device level and are therefore located in the SCSI device section. The other statistics are on the FCP device level and are located in the SCSI host section. Reference the following list for a detailed description of the location of the zfcp statistics.

The zfcp statistics are located as follows:

- `/sys/class/scsi_host/host<n>/seconds_active`
- `/sys/class/scsi_host/host<n>/requests`
- `/sys/class/scsi_host/host<n>/megabytes`
- `/sys/class/scsi_host/host<n>/utilization`
- `/sys/class/scsi_device/<H:C:T:L/device/cmd_latency`
- `/sys/class/scsi_device/<H:C:T:L>/device/read_latency`
- `/sys/class/scsi_device/<H:C:T:L>/device/write_latency`

where

- *<n>* denotes an integer, for example host0 or host3 depending on how many FCP devices are configured for the system.
- *<H:C:T:L>* stands for Host, Channel, Target, and Lun and describes the referenced storage (for example, disk).

Example

To check for how long the host0 has been active, issue:

```
# cat /sys/class/scsi_host/host0/seconds_active
66
#
```

Reading from the file seconds_active with the cat command provides a value of 66 resulting in the information that the host0 is active for the last 66 seconds. Other attributes can be queried the same way, however, the content might need to be interpreted differently.

Interpreting the sysfs statistics

An example of a statistics report and the meaning of the values.

seconds_active

The attribute seconds_active is a single value attribute (see Table 1 on page 43) and simply gives the seconds the FCP device has been active.

requests

The attribute requests is a three-valued attribute that provides the number of requests that are processed since FCP device activation split into the areas of (in that order):

- Input
- Output
- Control

The following example shows that three input, ten output, and five control requests were issued since FCP device activation:

```
[root]# cat /sys/class/scsi_host/host0/requests
3 10 5
[root]#
```

megabytes

The attribute megabytes is a two-valued attribute that provides the number of megabytes transferred in and out. The following example shows that 3 MB were received and 6 MB were sent out since FCP device activation:

```
[root@T6360007 host0]# cat /sys/class/scsi_host/host0/megabytes
3 6
[root@T6360007 host0]#
```

utilization

The attribute utilization is a three-valued attribute, showing the utilization of the processor, bus, and FCP channel over the last two seconds. The FCP channel continuously refreshes the values covering the utilization of the individual sections over the past two seconds. These values cannot be reset manually.

cmd_latency, read_latency, and write_latency

Each latency provides seven values as follows:

1. value, minimum fabric latencies [microseconds]
2. value, maximum fabric latencies [microseconds]
3. value, summarized fabric latencies [microseconds]

4. value, minimum channel latencies [microseconds]
5. value, maximum channel latencies [microseconds]
6. value, summarized channel latencies [microseconds]
7. value, amount of requests

No interpretation or modification of the values is done by the zfcp device driver. The individual values are summed up during normal operation of the FCP device. An overrun of the variables is neither detected nor treated. You must read the latency twice to make a meaningful statement, because only the difference between the values of the two reads can be used.

Example: After reading the file twice, you have the following values:

Type	1st read	2nd read	Difference
Fabric	403	821	418
Channel	115	163	48
Count	21	23	2

The average fabric latency (see Figure 12) over two readings is

```
418/2 = 209 microseconds
```

The results for the other values can be calculated accordingly.

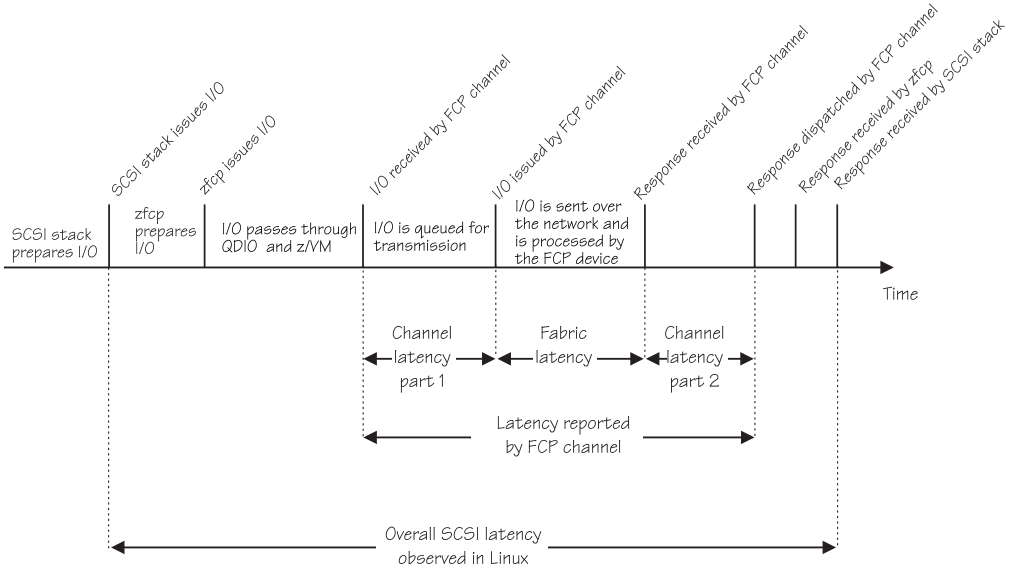


Figure 12. SCSI latency breakdown

Chapter 10. I/O tracing using blktrace

The Linux kernel can collect events about all state changes of I/O requests. Later, the blktrace utilities can derive data from these events.

Before you begin

I/O tracing with blktrace requires two parts:

- A Linux kernel with the config option CONFIG_BLK_DEV_IO_TRACE enabled.
- The blktrace userspace utilities, available from:

  ```
  git://git.kernel.dk/blktrace.git
  ```

  or

  ```
  http://brick.kernel.dk/snaps/
  ```

  The blktrace README file tells you where to get the sources, how to use blktrace and where to find the documentation.

About this task

You can collect data about I/O requests with the help of blktrace (see Figure 13).

Hint: While the I/O analysis can be run at the system where I/O is actually being traced, two Linux systems should be used: One that is being traced and the trace data is being redirected through a network connection to the second one for evaluation. This minimizes the impact on the system being traced.

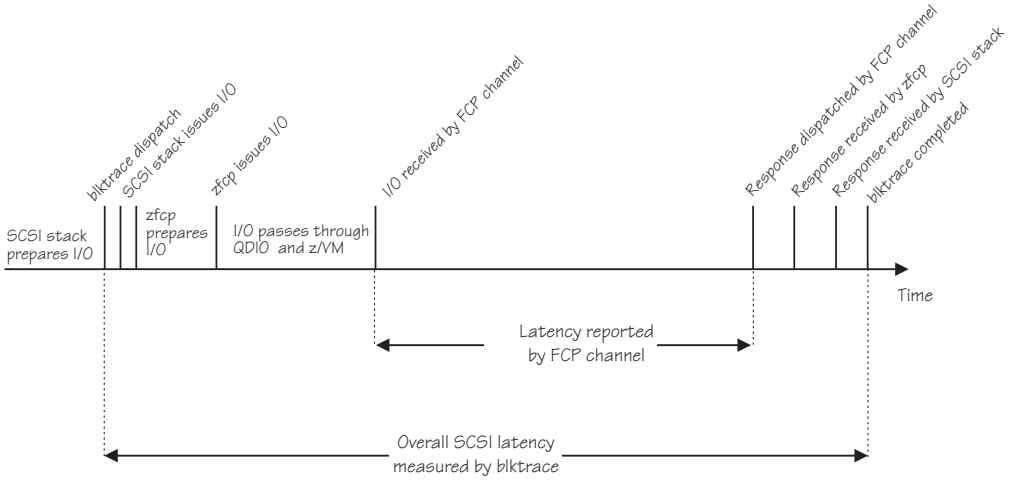


Figure 13. Latency reported by blktrace

Capturing and analyzing I/O data

A short overview of how to capture and to analyze the I/O trace data.

About this task

Capturing and analyzing the I/O data involves different tools:

blktrace
captures the data from the running kernel, optionally sends it over the network to minimize the impact on the running system and stores the data in a binary format.

blkparse
parses the data captured by blktrace, displays it in a readable format, adds a summary and creates data usable by btt.

btt does further analysis and can create histogram data for plotting with Grace4 or other plotting tools.

See the blktrace documentation for more examples of what data is available.

Capturing data on a remote system

To capture data on a remote system, run blktrace with different options on both the system that stores the data and the system to be traced.

Procedure

1. On the system where the captured data should be stored start blktrace in server mode. This system should have a good network connectivity to the system being traced:

```
# blktrace -l
```

2. On the system that is being traced run blktrace in client mode. For example to trace the SCSI disk on device `/dev/sda` and send the trace data to the system t6345030. . . run:

```
# blktrace -h t6345030.mysystem.com -d /dev/sda
blktrace: connecting to t6345030.mysystem.com
blktrace: connected!
```

   blktrace on the server side now shows that there is a connection from the system being traced:

```
server: connection from 9.152.37.153
```

3. Now run the I/O load that should be traced.

   Afterward, stop the blktrace client and then the blktrace server with Ctrl+C. Both acknowledge this by printing a summary of the data that was traced:

```
Device: sda
CPU 0:         0 events,              66471 KiB data
CPU 1:         0 events,              53906 KiB data
Total:         0 events (dropped 0), 120377 KiB data
```

Results

The trace data is now available on the system where the server side of blktrace was running:

```
# ls -l 9.152.37.153-2007-10-31-11\:38\:40/
total 120512
-rw-rw-r-- 1 schmichr schmichr 68065624 Oct 31 12:40 sda.blktrace.0
-rw-rw-r-- 1 schmichr schmichr 55199600 Oct 31 12:40 sda.blktrace.1
```

Parsing captured data

You can run captured data through blkparse.

Procedure

Run the created data through blkparse.

```
# blkparse -D 9.152.37.153-2007-10-31-11\:38\:40/ sda -d events.bin \
> events.txt
```

blkparse creates a text file with the I/O events and a summary. It optionally also creates a binary file for later processing with btt.
If only read requests or only write requests should be analyzed by blkparse or later by btt, `-a read` or `-a write` can be added to the blkparse command line. The end of the text log file shows as part of a summary the number of read and write requests and the total amount of read and written data. The same text file also lists all events related to I/O requests that have been captured by blktrace. The summary at the end looks like this:

```
Total (sda):
Reads Queued:         60,      240KiB Writes Queued:       1,257K,          5,030MiB
Read Dispatches:      60,      240KiB Write Dispatches:   15,153,          5,030MiB
Reads Requeued:        0       Writes Requeued:              75
Reads Completed:      60,      240KiB Writes Completed:   15,078,          5,030MiB
Read Merges:       0, 0KiB     Write Merges:               1,242K,          4,970MiB
IO unplugs:         1,193      Timer unplugs:               859

Throughput (R/W): 2KiB/s / 46,340KiB/s
```

Analyzing data and plotting histograms

To further analyze the data, you can use btt to create a summary, or create a data plot.

Procedure

You can run the binary file that is created by blkparse through btt for further analysis:

```
# btt -i events.bin -o btt.out
```

The file btt.out.avg now contains a summary of the data. The most interesting line is the one labeled D2C. It shows the latencies for SCSI requests from the point when they were dispatched to the device driver (D) to the completion of the request (C):

```
==================== All Devices ====================
       ALL           MIN            AVG         MAX            N
--------------- ------------ ------------ ------------ -----------
Q2Q               0.000000072   0.000086313   5.453721801   1257686
Q2I               0.000000359   0.000000516   0.023150311   1257687
I2D               0.000000933   0.003573727   0.487170508   1267275
D2C               0.000363719   0.034028080   0.708048174   1257687
Q2C               0.000395336   0.037609824   0.708064315   1257687
```

`btt.out_qhist.dat` has histogram data about the request sizes, more specifically these are the sizes of the request initially created. The unit of the histogram buckets are blocks counts, one block has 512 bytes in Linux. btt.out_dhist.dat

shows the same histogram but from the requests issued to the device driver, this means after adjacent requests have been merged. The data from btt can be plotted directly with the Grace plotting tool:

```
# xmgrace btt.out_qhist.dat
# xmgrace btt.out_dhist.dat
```

Since the output from btt is a histogram in a plain text file, the data can also be imported into other plotting tools. btt can also produce a listing showing the history of each I/O request:

```
btt -p per_io.dump -i events.bin -o btt.out
```

per_io.dump now lists this from the initial request creation (Q) to completion (C) with start address of the request on the block device (15926) and the number of 512 byte blocks (8):

```
8,0 : 108.544109552 Q     15926+8
      108.544112927 I     15926+8
      108.544111412 G     15926+8
      108.544115662 D     15926+8
      108.548892005 C     15926+8
```

A detailed description is available in the *blktrace User Guide*, available as blktrace.pdf in the blktrace userspace utilities.

Available data for I/O requests

Meaning of the information produced by blkparse or btt.

blkparse Reads summary
The output of blkparse contains a summary of the analyzed data. The "Reads" columns shows the number of read requests processed ("Queued", "Dispatched" and "Completed") together with the total amount of data read with these requests.

blkparse Writes summary
The same information as for the read requests is also provided for the write requests. The available data shows the number of write requests and the amount of data written.

Request sizes
The average size of read and write requests can be obtained from the blkparse summary by dividing the total amount of data by the number of requests. A histogram that shows the request sizes is available from the btt analysis tool.

Request latencies
The latencies of requests can be retrieved from the btt analysis tool. The D2C ("dispatched" to "completion") latency tracks the time from the request being issued to the device driver to the time of the request completion.

Queue depth
The listing per CPU in the blkparse summary also shows the maximum number of pending read and write requests in the "Read depth" and "Write depth" field.

Note: Only block devices like disks and CD-ROMs can be traced with blktrace. If the data was captured from a tape drive, then the data analysis with btt is not

available: btt uses the sector number of each I/O request for mapping the blktrace events to the originating requests. With tape drives, there are no sector numbers and the Linux block layer simply passes "0" for the sector of the blktrace events.

Chapter 11. Collecting FCP performance data with ziomon

The performance monitor ziomon collects data relevant to FCP performance, such as the FCP I/O configuration, I/O workload, and the utilization of FCP resources.

What you should know about ziomon

You can use ziomon for performance problem determination and capacity planning.

The ziomon monitor collects FCP performance relevant data over a specified period of time. The monitor uses a block I/O layer tracing tool, blktrace. Monitoring data is written to disk periodically. ziomon builds up a history of monitoring data, which can be consumed and analyzed by other tools.

The ziomon monitor determines the FCP device that is used to access a SCSI device. The monitor collects performance data for both SCSI devices and corresponding FCP devices.

Building a kernel with ziomon

The ziomon monitor has no kernel options of its own, but a dependency on the block I/O layer tracing option.

Kernel builders: This information is intended for those who want to build their own kernel. Be aware that both compiling your own kernel or recompiling an existing distribution usually means that you have to maintain your kernel yourself.

Select these options in the Linux configuration menu to include ziomon.

You need to select the kernel configuration option CONFIG_BLK_DEV_IO_TRACE to be able to monitor performance with ziomon.

```
Enable the block layer   (common code option)(CONFIG_BLOCK)
   Support for tracing block io actions      (CONFIG_BLK_DEV_IO_TRACE)
```

Preparing to use ziomon

When you collect traces with ziomon, you require 2 MB of Vmalloc space for each SCSI device node and CPU.

About this task

For instance, if you have a single SCSI device that is attached through multipathing as `/dev/sda`, `/dev/sdb` and `/dev/sdc` on a system with two CPUs, you would need 3×2×2 MB = 12 MB of Vmalloc space.

To check the amount of available Vmalloc space, issue the command:

```
cat /proc/meminfo | grep Vmalloc
```

The ziomon data collection process can be corrupted if the cpuplugd deamon is running. Disable cpuplugd during the data collection process. To check whether the cpuplugd deamon is running use:

```
service cpuplugd
```

See *Device Drivers, Features, and Commands, SC33-8411* for further details on cpuplugd.

Working with the ziomon monitor

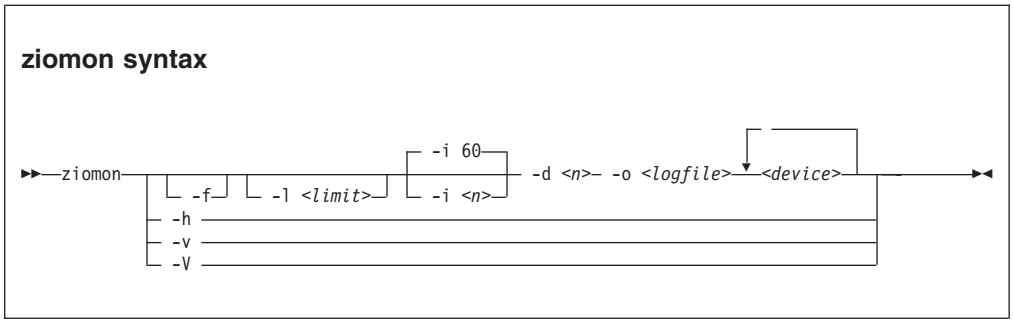
Typical tasks that you need to perform when working with the ziomon monitor include starting and stopping the monitor, and working with the results.

This section describes

- "Starting the monitor"
- "Stopping the monitor" on page 55
- "Working with the results of monitoring" on page 55

Starting the monitor

Use the **ziomon** command to start the monitor.



where:

-f or --force
forces the start of data collection even though there is insufficient free disk space.

-l or --size-limit
defines the upper limit of the output files. Must include one of the suffixes M (megabytes), G (gigabytes), or T (terabytes). Note that this value is only a tentative value that can be slightly exceeded.

-i or --interval-length
specifies the elapsed time between writing data to disk in seconds. Defaults to 60 seconds.

-d or --duration
specifies the monitoring duration in minutes. Must be a multiple of the interval length.

-o or --outfile
specifies the prefix for the log file, configuration file, and aggregation file.

<device>
denotes one or more device names separated by blanks. If <*device*> denotes a

device mapper device, ziomon resolves all of its paths, that is, all SCSI devices that are grouped to that multipathing device. For this purpose ziomon uses information that is provided by **multipath -l**. ziomon then monitors those SCSI devices. The device mapper device itself is not monitored.

-h or --help
displays help information for the command.

-v or --version
displays version information for the command.

-V or --verbose
displays more information for the command.

Examples

- Assume that data should be collected for devices `/dev/sda`, `/dev/sdg`, and `/dev/sdp` for 5 minutes. Data is to be sampled every 20 seconds. The collected data size should not exceed 50 MB. The output files should use the basename "trace_data":

```
ziomon -i 20 -d 5 -l 50M -o trace_data /dev/sda /dev/sdg /dev/sdp
```

- Assume that data should be collected for a SCSI tape device. To do this, use the corresponding SCSI generic device instead (for example `/dev/sg1`) since the actual tape device (for example `/dev/st0`) can be accessed by one process only:

```
ziomon -i 20 -d 5 -l 50M -o scsi_trace_data /dev/sg1
```

Stopping the monitor

The ziomon monitor will stop running after the period of time you specified when you started it.

If you need to stop the monitor before the time period runs out, press Ctrl+C.

Working with the results of monitoring

The ziomon monitor produces output files with a prefix that you specify when you start the monitor.

- <*filename*>`.cfg`, holds various configuration data from the system. This data is a snapshot of certain subtrees of the file system in `tgz` format, that is, `/sys` and `/proc`.
- <*filename*>`.log`, holds the raw data samples that are taken during the data collection phase in a binary format.
- <*filename*>`.agg` (optional). When <*filename*>`.log` threatens to become larger than the allowed limit, old sample data is aggregated into this file to make room for more recent data. This file is also in a binary format. If no limit was specified or the collected data takes less than the limit, this file is not created.

You can read the monitoring files on other systems than the one where data was collected. In particular, you can read and analyze data that is collected on z Systems on a different Linux architecture, such as x86 architecture.

Chapter 12. Creating FCP performance reports

Using the output from ziomon, you can create three performance reports by using the report commands.

- **ziorep_config**: Generates a report for the FCP I/O configuration.
- **ziorep_utilization**: Generates a report for FCP device utilization.
- **ziorep_traffic**: Generates a report for the I/O traffic of FCP devices.

For **ziorep_utilization** and **ziorep_traffic**, you can narrow the results down to a specific date range or aggregate data over time. Furthermore, **ziorep_traffic** allows more fine-grained device selection as well as aggregation of data on different device levels.

See the report man pages for detailed information about the reports. See Chapter 11, "Collecting FCP performance data with ziomon," on page 53 for information about ziomon.

Terminology note: Be aware that to the Linux SCSI stack, an FCP device is an adapter.

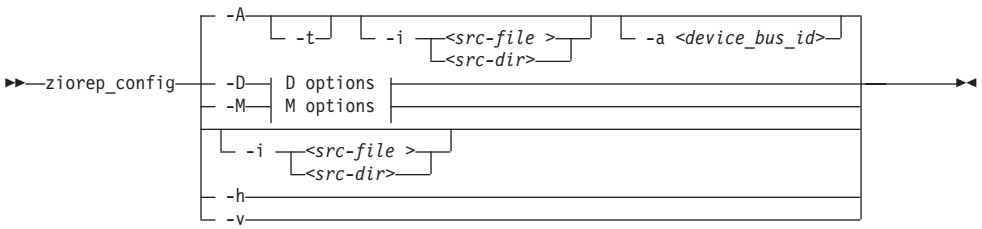
ziorep_config - Report on the multipath, SCSI, and FCP configuration

The purpose of the **ziorep_config** report is to visualize the SCSI-, FCP- and multipath-configuration of the system. You can control the report using command line switches.

The report is usable on both a preprocessed configuration file or configuration directory-tree and on a live system. The report is described in more detail in the example section.

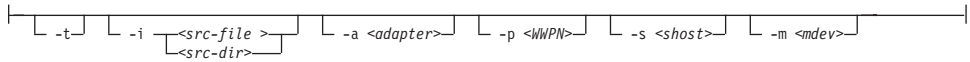
All parameters must be specified fully. Short versions, such as using 3c07 for the device bus ID, are not allowed. Hexadecimal values must be specified with a leading X'0x' and must always be lowercase. All WWPNs and LUNs must be specified as 16-digit hexadecimal values. Leading and trailing zeros are vital and must be included.

ziorep_config syntax



D options:

M options:



where:

-t or --topline
prints a header for column description. The default is to print no header, which is useful if the results are imported by another application. For example:

```
ziorep_config -D -t
```

-i or --input <*src-file* | *src-dir*>
specifies the configuration file created by **ziomon** as source.

-a or --adapter <*device_bus_id*>
limits the output to the list of FCP devices specified, for example:

```
ziorep_config -a 0.0.3c07 -a 0.0.3d07
```

-p or --port <*WWPN*>
limits the output to the list of target ports specified, for example:

```
ziorep_config -D -p 0x5005123456789000 -p 0x5005123456789001
```

-l or --lun <*LUN*>
limits the output to the list of FCP LUNs specified, for example:

```
ziorep_config -D -l 0x401040a600000000 -l 0x401040a700000000
```

-s or --scsi <*shost*>
limits the output to the list of SCSI hosts specified, for example:

```
ziorep_config -D --scsi host0 -s host1 -s host5
```

-d or --device <*sdev*>
limits the output to the list of SCSI devices specified, for example:

```
ziorep_config -D --device sda -d sdb -d sde
```

-m or --mdev <*mdev*>
limits the output to the list of multipath devices specified, for example:

```
ziorep_config -M -m 36005076303ffc56200000000000010a6
```

-A or --Adapter
prints the adapter (FCP device) report, this is the default.

-D or --Device
prints the SCSI device report.

-M or --Map
prints the multipath mapper report.

-h or --help
prints this help text.

-v or --version
prints version information.

Example: Adapter report

The first example shows the output of the adapter report. This is the default report.

The adapter report shows important information about the currently attached FCP devices.

```
# ziorep_config

Host:    host0
CHPID:   36
Adapter: 0.0.3c07
Sub-Ch.: 0.0.0010
Name:    0x5005076401a07163
P-Name:  0x5005076401a07163
Version: 0x0003
LIC:     0x0000c74c
Type:    NPort (fabric via point-to-point)
Speed:   2 Gbit
State:   Online

Host:    host1
CHPID:   37
Adapter: 0.0.3d07
Sub-Ch.: 0.0.0011
Name:    0x5005076401e07163
P-Name:  0x5005076401e07163
Version: 0x0003
LIC:     0x0000c74c
Type:    NPort (fabric via point-to-point)
Speed:   2 Gbit
State:   Online
```

The fields of the report are described in Table 2.

Table 2. Report fields and their meanings

Field	Meaning
Host:	SCSI host ID, see the **lsscsi** command.

Table 2. Report fields and their meanings (continued)

Field	Meaning
CHPID:	Channel path ID.
Adapter:	Device bus ID of the FCP device.
Sub-Ch.:	ID of the I/O subchannel.
Name:	The current WWPN of the FCP device.
P-Name:	The permanent WWPN of the FCP channel.
Version:	Version information for the FCP channel.
LIC:	Licensed internal code, microcode version.
Type:	Current connection type
Speed:	Current connection speed
State:	Current FCP device status (online or offline).

Example: SCSI device report

In the second example, the device report lists all configured SCSI devices with their corresponding FCP representation.

The example shows the output of the device report limiting the output to the two FCP devices 0.0.3c07 and 0.0.3d07 with an enabled first line (table header).

```
# ziorep_config -D -t -a 0.0.3c07 -a 0.0.3d07

adapter  remote port        LUN                SCSI  gen_dev  scsi_dev MM  type model vendor  H:C:T:L
=============================================================================================
0.0.3c07 0x500507630300c562 0x401040a600000000 host0 /dev/sg0 /dev/sda 8:0 Disk 2107900 IBM 0:0:0:1084637200
0.0.3c07 0x500507630300c562 0x401040a700000000 host0 /dev/sg1 /dev/sdb 8:16 Disk 2107900 IBM 0:0:0:1084702736
0.0.3c07 0x500507630300c562 0x401040a800000000 host0 /dev/sg2 /dev/sdc 8:32 Disk 2107900 IBM 0:0:0:1084768272
0.0.3c07 0x500507630300c562 0x401040a900000000 host0 /dev/sg3 /dev/sdd 8:48 Disk 2107900 IBM 0:0:0:1084833808
0.0.3c07 0x500308c141699001 0x0000000000000000 host0 /dev/sg4 /dev/st0 9:0 Tape ULT3580-TD2 IBM 0:0:23:0
0.0.3d07 0x500507630300c562 0x401040a600000000 host1 /dev/sg5 /dev/sde 8:64 Disk 2107900 IBM 1:0:10:1084637200
0.0.3d07 0x500507630300c562 0x401040a700000000 host1 /dev/sg6 /dev/sdf 8:80 Disk 2107900 IBM 1:0:10:1084702736
```

The fields of the report are described in Table 3.

Table 3. Report fields and their meanings

Field	Meaning
adapter:	Device bus ID of the FCP device.
remote port	WWPN of the target port
LUN	logical unit number of the SCSI device
SCSI	SCSI host ID
gen_dev	SCSI generic device
scsi_dev	SCSI device (block-, char-)
MM	major:minor number of the SCSI device
type	type of device (such as Disk, or Tape)
vendor	vendor of the corresponding storage device
H:C:T:L	Host:Channel:Target:LUN path mapping of the target device

Example: Mapper report

The mapper report displays the relation between the configured multipath devices and the corresponding SCSI- and FCP-devices.

The following example shows the output of the mapper report sorted in the order of multipath devices, remote ports and adapters. Multipath devices can be found in the sysfs under the directory `/dev/mapper` or displayed using the multipath utilities.

```
# ziorep_config -M -t

adapter  remote_port        scsi_dev multipath_device
=================================================
0.0.3c07 0x500507630300c562 /dev/sda /dev/mapper/36005076303ffc56200000000000010a6
0.0.3d07 0x500507630300c562 /dev/sde /dev/mapper/36005076303ffc56200000000000010a6
0.0.3c07 0x500507630300c562 /dev/sdb /dev/mapper/36005076303ffc56200000000000010a7
0.0.3d07 0x500507630300c562 /dev/sdf /dev/mapper/36005076303ffc56200000000000010a7
0.0.3c07 0x500507630300c562 /dev/sdc /dev/mapper/36005076303ffc56200000000000010a8
0.0.3c07 0x500507630300c562 /dev/sdd /dev/mapper/36005076303ffc56200000000000010a9
```

The fields of the report are described in Table 4.

Table 4. Report fields and their meanings

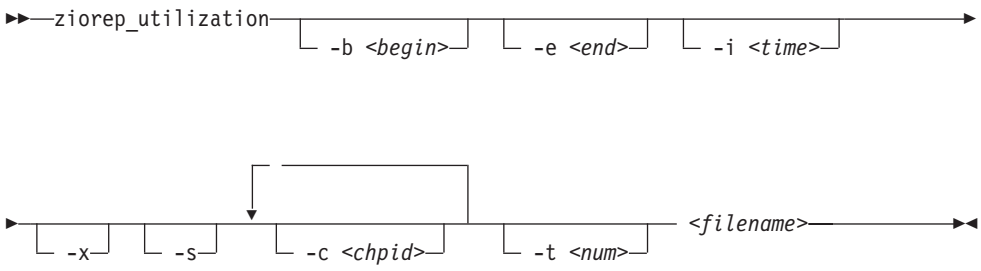
Field	Meaning
adapter	Device bus ID of the FCP device.
remote port	WWPN of the target port.
scsi_dev	Fully qualified path of the SCSI device.
multipath_device	Fully qualified path of the multipath device.

ziorep_utilization - Report on utilization details

The purpose of the **ziorep_utilization** report is to provide a central, detailed analysis of adapters' utilizations, errors, and queue fill levels.

The data can be aggregated over time, to make it easier to hunt down resource shortages and critical situations for further analysis. This report uses the data as collected by the ziomon performance monitor, see Chapter 11, "Collecting FCP performance data with ziomon," on page 53, and displays the data in a comprehensible manner.

ziorep_utilization syntax



where:

-b <*begin*> **or --begin=**<*begin*>
reports data starting from <*begin*>. Defaults to the start of available data. The format is `YYYY-MM-DD HH:MM[:SS]`, for example, `-b "2008-03-21 09:08"`. The actual dates used will be rounded to the nearest data collection frame. That is, if you started the data collection at 17:00:00 with an interval length of 15 seconds, a specified time of 17:01:32 would be rounded to 17:01:30.

-e <*end*> **or --end=**<*end*>
reports data ending at <*end*>. Defaults to end of available data. Format is `YYYY-MM-DD HH:MM[:SS]`, for example: `-e "2008-03-21 09:08:57"`

-i <*time*> **or--interval** <*time*>
sets the aggregation interval to <*time*> in seconds. Must be a multiple of the interval size of the source data. Set to 0 to aggregate over all data.

When the source data was collected using **ziomon**, a value was specified for the duration between two consecutive data samples. Using `-i` it is possible to aggregate that source data to achieve a more coarse resolution. Specifying anything other than a multiple or 0 will result in an error.

-s or --summary
shows a summary of the data.

-c or --chpid <*chpid*>
specifies the FCP channel as specified in the IODF. The format is a two-byte hexadecimal number, for example `-c 32a`. You can specify multiple FCP channels by using multiple -c command line switches.

-x or --export-csv
exports data to files in CSV format.

-t or --topline <*num*>
repeats topline after every 'num' frames. Specify 0 for no repeat (default).

<*filename*>
The name of the log file from which you want to generate the report.

-h or --help
displays short usage text on console. See the **ziorep_utilization** man page for more details.

-v or --version
displays version number on console, and exit.

-V or --verbose
displays more information while processing.

ziorep_utilization examples

Examples demonstrate the summary option, the end range option, and the interval option.

This example shows how the summary option lists the date ranges of the collected data, its interval length, and the involved hardware:

```
# ./ziorep_utilization -s multipath_stress.log

Data Summary
------------
Aggregated range: 2008-11-13 08:56:49 to 2008-11-13 16:12:53
Detailed range:   2008-11-13 16:12:57 to 2008-11-13 20:56:45
Interval length:  4 seconds
HBA/CHPID:        0.0.3c40/52
                  0.0.3c00/50
WWPN/LUN (dev):   500507630313c562/4013401500000000 (/dev/sda)
                  500507630303c562/4013401500000000 (/dev/sdb)
                  500507630313c562/4013401400000000 (/dev/sdc)
                  500507630303c562/4013401400000000 (/dev/sdd)
                  500507630313c562/4013401a00000000 (/dev/sde)
                  500507630303c562/4013401a00000000 (/dev/sdf)
                  500507630313c562/4013401c00000000 (/dev/sdg)
                  500507630303c562/4013401c00000000 (/dev/sdh)
                  500507630313c562/4013401800000000 (/dev/sdi)
                  500507630303c562/4013401800000000 (/dev/sdj)
                  500507630313c562/4013401b00000000 (/dev/sdk)
                  500507630303c562/4013401b00000000 (/dev/sdl)
                  500507630313c562/4013401700000000 (/dev/sdm)
                  500507630303c562/4013401700000000 (/dev/sdn)
```

This example shows the output from an input file containing data for two FCP channels with one FCP device hosted on each:

```
# ./ziorep_utilization multipath_stress -e "2008-11-13 16:13:09"
CHP|adapter in %-|--bus in %---|--cpu in %---|
ID min max    avg min max  avg min max avg
2008-11-13 16:12:53 Aggregated Frame
52  0  57     2.4 2   53  22.4 2   15  5.1
50  0  59     2.5 2   52  22.4 2   15  5.1
16:12:57
52  9    9     9.0 29  29  29.0 4   4  4.0
50 12  12    12.0 28  28  28.0 3    3  3.0
16:13:01
52  1    1     1.0 24  24  24.0 3   3  3.0
50  1    1     1.0 29  29  29.0 4   4  4.0
16:13:05
52 10  10     10.0 25  25  25.0 3   3  3.0
50  4   4      4.0 25  25  25.0 3   3  3.0
...
2008-11-14 00:00:01
...
CHP Bus-ID  |--qdio util.i.%--|queu|fail|-thp / MB/s--|I/O reqs-|
 ID            min   max   avg full erc      rd    wrt  rd  wrt
2008-11-13 16:12:53 Aggregated Frame
 50/0.0.3c00   0.0 100.0  96.7   28K  0   16.5    5.8 2.0M 455K
 52/0.0.3c40   0.0 100.0  96.6   28K  0   15.5    5.0 2.0M 463K
16:12:57
 50/0.0.3c00   0.0 100.0  97.2     0  0   10.4    6.2 4.4K 812
 52/0.0.3c40   0.0 100.0  96.8     0  0    8.1    6.4 5.2K 894
16:13:01
 50/0.0.3c00   0.0 100.0  97.3     0  0    9.9   12.1 3.5K 248
 52/0.0.3c40   0.0 100.0  97.7     0  0   10.1   14.5 2.5K 175
16:13:05
 50/0.0.3c00   0.0 100.0  98.5     0  0    8.2    7.2 3.5K 116
 52/0.0.3c40   0.0 100.0  98.0     0  0   10.3    8.1 3.7K 113
...
2008-11-14 00:00:01
...
```

Note that numbers can be abbreviated if space does not suffice. For example, 17 361 can be abbreviated to 17K.

The output comes in two parts: The first part gives the utilization of the whole FCP channels, while the second part gives data for all FCP devices.

The meaning of the columns is as follows:

CHPID
: The channel path ID of the device.

Bus-ID
: The eight-character device bus ID of the FCP device.

adapter, bus, and cpu
: The FCP channel, bus, and CPU utilizations as reported by the FCP channel statistics in percent. For example, a value of 37.2 represents a value of 37.2 percent.

fail erc
: The number of error recovery conditions.

qdio utilization
: The min, max and avg columns give the minimum, maximum and average outbound queue utilization respectively.

queu full
: The number of instances where a request to the FCP device could not be submitted due to no empty slots left in the outbound queue.

thp / MB/s
: This is the average throughput over time (volume transmitted / elapsed time) in megabytes per second, not over number of requests (sum over all request throughputs / number of requests)!

  This means that a long-running request with a significantly different throughput profile from the rest will have a bigger impact than a brief one with the same throughput profile would. This gives a better impression of the overall profile and especially makes requests with very low throughputs have a bigger impact, making it easier to detect anomalies.

  The abbreviations **rd** and **wrt** mean read and write throughput.

I/O reqs
: is the number of I/O requests processed in the interval.

  The abbreviations **rd** and **wrt** mean read and write requests.

Each new day and each new interval are marked by a line. All applicable FCP channels are then listed on individual lines for each timeslot. The label `Aggregated` highlights ranges in the data where the source data was already aggregated and hence cannot be processed further. If you select a timeframe that touches the range in which only aggregated data is available, the complete aggregated data will be reprinted. However, this can only be at most one dataset per device, and will only appear as the first line in the output.

In this example an interval length of 0 is chosen, causing all data in the specified timeframe to be aggregated into a single entry:

```
# ./ziorep_utilization multipath_stress.log -i 0
CHP|adapter in %-|--bus in %---|--cpu in %---|
 ID min max   avg min max   avg min max   avg
2008-11-13 20:56:45
 52   0  57   1.4  2  53   22.3   2  15   5.0
 50   0  59   1.5  2  52   22.3   2  15   5.0
CHP Bus-ID  |--qdio util.i.%--|queu|fail|-thp / MB/s--|I/O reqs-|
 ID           min    max   avg full  erc   rd      wrt   rd  wrt
2008-11-13 20:56:45
 50/0.0.3c00  0.0  100.0  96.7  30K    0 16.5      5.8 2.0M 455K
 52/0.0.3c40  0.0  100.0  96.6  31K    0 15.5      5.0 2.0M 463K
```

ziorep_traffic - Analyze systems I/O traffic through FCP channels

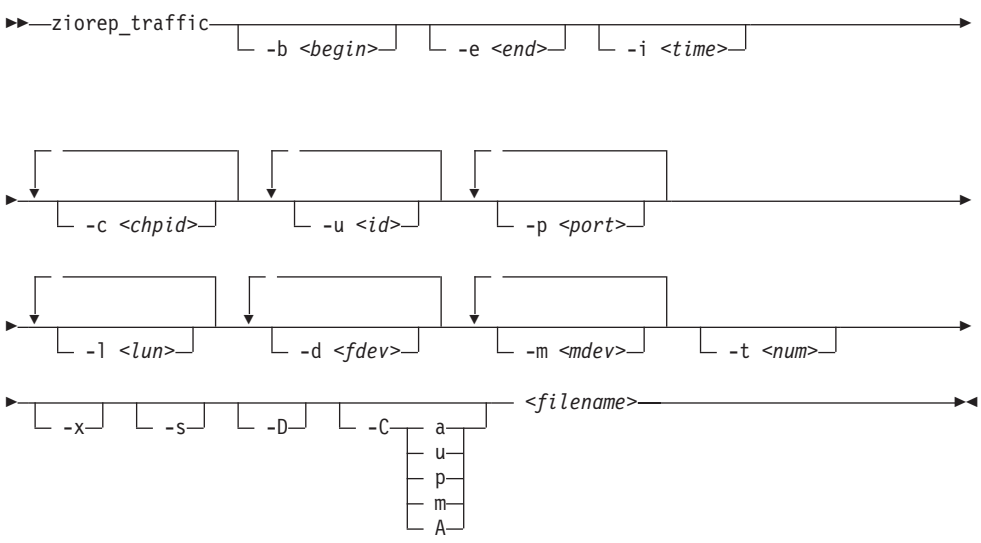
The **ziorep_traffic** command produces a report that provides a central, detailed analysis of the systems I/O traffic through FCP channels.

The main focus is on the latencies as they appear in the channel, fabric, or the whole I/O subsystem. The data can be:

- Aggregated over time
- Reduced to certain devices only

This report uses data as collected by the ziomon utility (see Chapter 11, "Collecting FCP performance data with ziomon," on page 53).

ziorep_traffic syntax



where:

-b <*begin*> **or --begin=**<*begin*>
reports data starting from <*begin*>. Defaults to the start of available data. The format is `YYYY-MM-DD HH:MM[:SS]`, for example, `-b "2008-03-21 09:08"`. The actual dates used will be rounded to the nearest data collection frame. That is, if you started the data collection at 17:00:00 with an interval length of 15 seconds, a specified time of 17:01:32 would be rounded to 17:01:30.

-e <*end*> **or --end=**<*end*>
reports data ending at <*end*>. Defaults to end of available data. Format is `YYYY-MM-DD HH:MM[:SS]`, for example: `-e "2008-03-21 09:08:57"`

-i <*time*> **or --interval** <*time*>
sets the aggregation interval to <*time*> in seconds. Must be a multiple of the interval size of the source data. Set to 0 to aggregate over all data.

When the source data was collected using ziomon, a value was specified for the duration between two consecutive data samples. Using `-i` it is

possible to aggregate that source data to achieve a more coarse resolution. Specifying anything other than a multiple or 0 will result in an error.

-c or --chpid *<chpid>*
specifies the FCP channel as specified in the IODF. The format is a two-byte hexadecimal number, for example `-c 32a`. You can specify multiple FCP channels by using -c multiple times.

-u or --bus-id *<ID>*
specifies a device bus ID of an FCP device, for example: `-u 0.0.7f1d`

-p or --port *<port>*
specifies by target port, for example: `-p 0x500507630040710b`

-l or --lun *<LUN>*
specifies by LUN, for example: `-l 0x4021402200000000`

-d or --device *<fdev>*
specifies by SCSI device, for example: `-d sda`

-m or --mdev *<mdev>*
selects by multipath device, for example: `-m 36005076303ffc1040002120`

-t or --topline *<num>*
repeats topline after every 'num' frames. Specify 0 for no repeat (default).

-x or --export-csv
exports data to files in CSV format.

-s or --summary
shows a summary of the data.

-D or --detailed
prints histograms instead of univariate statistics.

-C or --collapse *<val>*
collapses data for multiple instances of a device into a single one. See "Aggregating data" on page 67 for the a, u, p, m, and A options. See the **ziorep_traffic** man page for more details.

<filename>
The name of the log file from which you want to generate the report.

-h or --help
displays a short usage text on console. For more details, see the **ziorep_traffic** man page.

-v or --version
displays the version on the console, and exit.

-V or --verbose
displays more information while processing.

Selecting devices

The **ziorep_traffic** command offers a wide variety of options to specify which devices to consider.

These options, `-c, -u, -p, -l, -m` and `-d`, specify devices on different levels and can be freely combined. The resulting devices are the combination of all devices specified.

Examples:

- Use same-level selection criteria to select a combination of devices. For example, to select two bus IDs:

```
-u 0.0.7133 -u 0.0.7173
```

- Multipath devices specified using `-m` are resolved to all respective paths. For example, to specify all paths connecting through 36005076303ffc1040002120 as well as the devices sda, sdc and the lun 0x4021402200000000:

```
-m 36005076303ffc1040002120 -l 0x4021402200000000 -d sda -d sdc
```

- To specify intersecting devices, for example where portA is connected (among others) to busA, essentially all devices that are connected to busA are considered:

```
-u busA -p portA
```

Note: To select all LUNs on a specific storage server, it is necessary to specify all ports of that storage server.

Aggregating data

To aggregate the data, use the `-C` option.

No matter what option is being used to select devices, the result will have data of LUN granularity. The `-C` option takes one of the following parameters:

a Aggregate all data on a FCP channel level. That is, data for all LUNs that are connected through the same FCP channel will be aggregated.

u Aggregate all data on a FCP device level. That is, data for all LUNs that are connected through the same FCP device will be aggregated.

p Aggregate all data on a port level. That is, data for all LUNs that are connected through the same port will be aggregated.

m Aggregate all data on a multipath device level. Only useful when devices were specified through -d. That is, data for all paths available for a multipath device will be aggregated.

A Aggregate all data on a global level. That is, data for all specified LUNs will be aggregated.

If you select devices using `-c, -u, -p, -l, -m` or `-d`, only those devices will be considered for aggregation. For example, consider multipath device `36005076303ffc1040002120` with paths `sda` and `sdb`, and `36005076303ffc1040002121` with paths `sdc` and `sdd`.

Example: If you run:

```
-C m -m 36005076303ffc1040002120 -d sdc
```

all paths (namely `sda` and `sdb`) for device `36005076303ffc1040002120` will be aggregated, but only a single one for multipath device `36005076303ffc1040002121`.

Example: Summary (default) report

A traffic report shows, for example, request processing time, throughput of a device, and number of requests.

Table 5 on page 68 shows an example of the default report:

Table 5. Example of default report

```
# ./ziorep_traffic stress_single.log -e "2008-11-11 19:59:45" -l 40c1403100000000 -l 40c1403500000000
      WWPN            LUN         |I/O rt MB/s|thrp in MB/s|----I/O requests----|-I/O subs. lat. in us--|--channel lat. in ns---|---fabric lat. in us---|
                                    min   max    avg  stdev #reqs   rd  wrt bidi  min  max    avg  stdev  min  max    avg  stdev  min  max    avg  stdev
2008-11-11 19:57:37
50050763031b448e:40c1403100000000     0  103K   0.1  981.1   7357 6.0K 1.4K    0  360 3.0M 72.24K 71.05G    0  91M 284.3K 5.589T    0 3.0M 67.55K 64.19G
50050763031b448e:40c1403500000000     0  127K   0.1 1.130K   7838 6.1K 1.7K    0  323 3.5M 79.94K 72.32G    0  22M 287.9K 762.4G    0 3.5M 75.47K 69.29G
19:58:37
50050763031b448e:40c1403100000000     0  126K   0.1 1.709K   8611 7.8K  832    0  282  57M 94.52K 864.8G    0  66M 283.7K 3.462T    0 3.8M 76.98K 120.5G
50050763031b448e:40c1403500000000     0 94.1K   0.1 1.489K   7404 6.7K  740    0  318  70M 93.78K 1.396T    0  71M 219.1K 1.579T    0 4.1M 71.35K 99.01G
19:59:37
50050763031b448e:40c1403100000000     0 97.7K   0.1 1.695K   6280 4.9K 1.4K    0  324  45M 124.0K 434.8G    0  47M 363.7K 2.312T    0 3.4M 111.3K 104.1G
50050763031b448e:40c1403500000000     0  109K   0.1 1.153K   7440 5.6K 1.9K    0  383  64M 141.0K 652.3G    0  53M 343.9K 1.452T    0 3.4M 128.1K 107.4G
```

Note that numbers can be abbreviated if space does not suffice. For example, 3 489 345 is abbreviated as 3.5M.

The report columns have the following meanings:

first column
Device identifier, depends on the `-C` option.

I/O rt MB/s
Applies to an individual request and its total processing time, including channel latency. Specifies the I/O rate of the device during the interval the request was processed. The min and max entries give the minimum and maximum rate. Given in megabytes per second.

thrp in MB/s
Applies to the entire device and includes all requests. Measures the throughput of the device while active. The avg entry gives the average utilization and the stdev entry gives the standard deviation. Note that because multiple requests are processed at the same time it is possible for avg to be higher than max. Given in megabytes per second.

I/O requests
The number of requests. Bidi represents bi-directional requests.

I/O subsystem latencies
Latencies in the I/O subsystem.

channel latencies
Latencies on the FCP channel.

fabric latencies
Roundtrip time of the request in the fabric.

Example: Detailed report

A detailed traffic report shows, for example, request size, I/O subsystem latency, and fabric latency.

Table 6 on page 70 shows an example of a detailed report. Note that this report is additionally collapsed by port.

Table 6. Example of detailed report

```
# ./ziorep_traffic stress_single.log -e "2008-11-11 19:59:45" -l 40c1403100000000 -l 40c1403500000000 -D

                                |------------------------I/O request sizes in KBytes----------------------------|
                                   0    1   2   4   8   16   32   64   128   256   512   1K   2K   4K   8K  >8K
                                |------------------------I/O subsystem latency in us-----------------------------------------------------------------------|
                                   0    8  16  32  64  128  256  512    1K    2K    4K   8K  16K  32K  64K 128K  256K  512K  1M  2M  4M  8M  16M  32M   >32M
                                |------------------------channel latency in ns-------------------------------------------------------|
                                   0   1K  2K  4K  8K  16K  32K  64K  128K  256K  512K   1M   2M   4M   8M  16M   32M   64M 128M >128M
        WWPN          LUN       |------------------------fabric latency in us-----------------------------------------------------------------------|
                                   0    8  16  32  64  128  256  512    1K    2K    4K   8K  16K  32K  64K 128K  256K  512K  1M  2M  4M  8M  16M  32M  >32M
2008-11-11 19:57:37
50050763031b448e:40c1403100000000    0    0   0 779  63 1.5K  577 1.7K  1.6K   978   225    0    0    0    0    0
                                     0    0   0   0   0    0    0    2    19   124   562 2.1K 2.3K 1.3K  226  139   205   161 151  99  30   0    0    0     0
                                     0    0   0   0   0  414 3.3K 1.4K   461   617   608  277  145  113   30    7     3     4   4   0
                                     0    0   0   0   0    0    4   13    62   221   691 2.1K 2.3K 1.1K  159  128   206   133 148  99  28   0    0    0     0
50050763031b448e:40c1403500000000    0    0   0 762  76 1.5K  632 1.8K  1.6K  1.2K   239    0    0    0    0    0
                                     0    0   0   0   0    0    0    8    15   136   585 2.1K 2.4K 1.4K  202  143   238   253 186 132  18   0    0    0     0
                                     0    0   0   0   0  419 3.4K 1.3K   528   699   544  436  334  182   50    9     3     0   0   0
                                     0    0   0   0   0    0    3   12    66   240   750 2.1K 2.4K 1.2K  136  118   285   194 192 118  17   0    0    0     0
19:58:37
50050763031b448e:40c1403100000000    0    0   0 506 101 2.1K 1.1K 2.4K  1.1K  1.0K   273    0    0    0    0    0
                                     0    0   0   0   0    0    0   14    95   615  1.7K 2.8K 2.0K  622  108  125   164    80  91 204  61   0    0    0   34M
                                     0    0   0   0   0  532 4.0K 1.7K   595   595   477  276  225  124   43   14    13     7   0   0
                                     0    0   0   0   0    0   17   45   223   829  1.9K 2.7K 1.8K  474   31   83   163    70  89 204  56   0    0    0     0
50050763031b448e:40c1403500000000    0    0   0 466  97 1.9K 1.0K 2.0K   804   922   149    0    0    0    0    0
                                     0    0   0   0   0    0    0    6    60   492  1.4K 2.4K 1.6K  592   96  180   154    97 144 126  38   0    0    0   34M
                                     0    0   0   0   0  458 3.4K 1.4K   552   527   464  248  176   95   37    4     4     1   1   0
                                     0    0   0   0   0    0   11   54   216   708  1.6K 2.3K 1.4K  454   16  130   140    86 142 125  37   0    0    0     0
19:59:37
50050763031b448e:40c1403100000000    0    0   0 554  46 1.3K  271 1.4K  1.1K  1.2K   399    0    0    0    0    0
                                     0    0   0   0   0    0    0   10    68   250   652 1.7K 1.6K  757  284  100   286   140 183 291   6   0    0    0   17M
                                     0    0   0   0   0  272 2.5K 1.1K   375   530   542  450  233  136   61   13    10     3   0   0
                                     0    0   0   0   0    0    9   33   154   395   811 1.7K 1.5K  590  203   64   293   109 183 289   4   0    0    0     0
50050763031b448e:40c1403500000000    0    0   0 628  58 1.5K  500 1.8K  1.3K  1.4K   255    0    0    0    0    0
                                     0    0   0   0   0    0    0    2    21   196   726 1.9K 2.0K  823  290  149   371   302 436 237  22   0    0    0   17M
                                     0    0   0   0   0  285 2.7K 1.4K   542   625   692  557  421  196   29   11     4     1   0   0
                                     0    0   0   0   0    0   13   26   120   448   984 1.9K 1.8K  600  180   84   382   284 440 232  22   0    0    0     0
```

Chapter 13. Investigating the SAN fabric

As of version 2.1 the HBA API package includes two commands, **zfcp_ping** and **zfcp_show** that help you to investigate your SAN fabric.

The **zfcp_ping** and **zfcp_show** commands can probe ports and retrieve information about ports in the attached storage servers and in interconnect elements such as switches, bridges, and hubs.

Because the commands are processed by the SAN management server, information can be obtained about ports and interconnect elements that are not connected to your FCP channel. Thus, **zfcp_ping** and **zfcp_show** can help to identify configuration problems in a SAN.

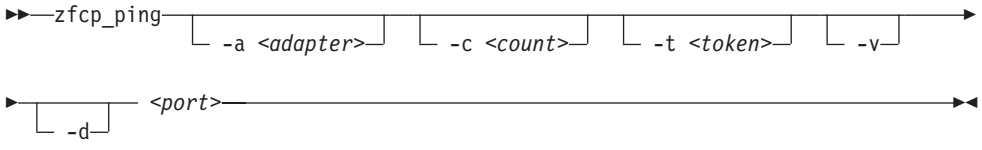
Before you begin

- The HBA API package, version 2.1 or later, must be installed and configured. See the readme file in the package for instructions. You can obtain the package at `www.ibm.com/developerworks/linux/linux390/zfcp-hbaapi.html`.
- At least one FCP device must be online.
- The management server of the SAN to be investigated must be accessible.

zfcp_ping - Probe a port

The **zfcp_ping** command uses the SAN management server to send one or more requests to a particular port within the SAN and to collect responses from the port.

zfcp_ping syntax



where:

-a *<adapter>*
: specifies the FCP channel through which the management server of the SAN is accessed. *<adapter>* can be the bus ID of the FCP device, the host name that is assigned to the FCP channel, the WWPN of the channel port, or the port ID of the channel port. If omitted, any configured FCP channel is used.

-c *<count>*
: specifies the number of requests to be sent. If omitted, three requests are sent.

-t *<token>*
: specifies a number to identify the first request. Consecutive numbers identify subsequent requests if more than one request is sent. *<token>* must be a hexadecimal number in the range 1 to 0x7FFFFFFF.

-v provides verbose output.

-d provides very detailed output; for expert users only.

<port>
specifies the port to be probed. *<port>* can be the WWPN or the ID of the port.

-h displays help information for the command. To view the man page, enter `man zfcp_ping`.

-V displays version information.

Example

This example probes a port with WWPN 0x50050763030b0562.

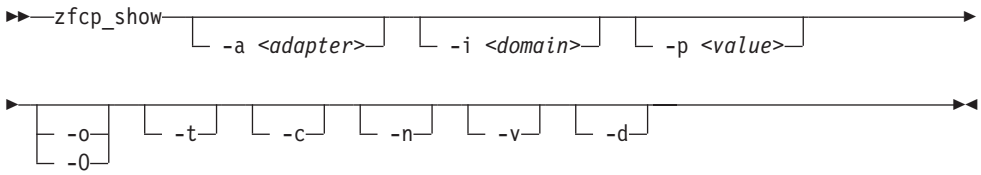
```
# zfcp_ping -t97 0x50050763030b0562
Sending PNG from BUS_ID = 0.0.3c02 speed=4 Gbit/s
echo received from WWPN (0x50050763030b0562) tok=97 time=1.365 ms
echo received from WWPN (0x50050763030b0562) tok=98 time=2.750 ms
echo received from WWPN (0x50050763030b0562) tok=99 time=2.058 ms
---------- ping statistics -----------
min/avg/max = 1.365/2.058/2.750 ms
--------------------------------------
```

zfcp_show - Retrieve SAN details

The **zfcp_show** command retrieves information about the SAN topology and details about the SAN components.

The command output can be extensive. Consider using command options to limit the scope of the command.

zfcp_show syntax



where:

-a *<adapter>*
specifies the FCP channel through which the management server of the SAN is accessed. *<adapter>* can be the bus ID of the FCP device, the host name that is assigned to the FCP channel, the WWPN of the channel port, or the port ID of the channel port. If omitted, any configured FCP channel is used.

-i *<domain>*
limits the output to a particular SAN domain.

-p *<value>*
limits the output to a particular port that is attached to the SAN switch, for example, a target port of a storage controller. *<value>* can be the WWPN or the port ID of the attached port.

-o limits the output to ports that are online.

-0 limits the output to ports that are offline.

-t shows the SAN topology only.

-c creates output in CSV format.

-n directs the command to the local name server and limits the output to information available to the local name server.

-v provides verbose output. The command output can be extensive even without verbose output.

-d provides very detailed output; for expert users only.

-h displays help information for the command. To view the man page, enter `man zfcp_show`.

-V displays version information.

Examples

- This example shows the beginning of the default command output for a SAN.

```
# zfcp_show
Interconnect Element Name        0x100000051e4f7c00
Interconnect Element Domain ID   005
Interconnect Element Type        Switch
Interconnect Element Ports       224
       ICE Port 000 Online
               Attached Port [WWPN/ID] 0x50050763030b0562 / 0x650000 [N_Port]
       ICE Port 001 Online
               Attached Port [WWPN/ID] 0x50050764012241e5 / 0x650100 [N_Port]
       ICE Port 002 Online
               Attached Port [WWPN/ID] 0x5005076303008562 / 0x650200 [N_Port]
       ICE Port 003 Offline
       ICE Port 004 Online
               Attached Port [WWPN/ID] 0x5005076303140335 / 0x650400 [N_Port]
       ICE Port 005 Online
               Attached Port [WWPN/ID] 0x5005076303104562 / 0x650500 [N_Port]
...
```

  In the output, the lines that begin with “ICE Port” specify switch ports and the lines that begin with “Attached Port” specify the ports of the attached nodes.

- This example shows the verbose equivalent of the previous example.

```
# zfcp_show -v
Using adapter BUS_ID    0.0.3c02
              Name      0x5005076401a241e5
              N_Port_ID 0x657700
              OS-Device /dev/bsg/fc_host0
              Speed     4 GBit/s
Interconnect Element Name       0x100000051e4f7c00
Interconnect Element Domain ID  005
Interconnect Element Type       Switch
Interconnect Element Ports      224
Interconnect Element Vendor     Brocade Communications, Inc.
Interconnect Element Model      62.3
Interconnect Element Rel. Code  v6.2.0g
Interconnect Element Log. Name  fcsw14

       ICE Port 000 Online [0x200000051e4f7c00]
       ICE Port Type SFP with serial ID Short wave laser - SN (850nm) [F_Port]
               Attached Port [WWPN/ID] 0x50050763030b0562 / 0x650000 [N_Port]

       ICE Port 001 Online [0x200100051e4f7c00]
       ICE Port Type SFP with serial ID Short wave laser - SN (850nm) [F_Port]
               Attached Port [WWPN/ID] 0x50050764012241e5 / 0x650100 [N_Port]

       ICE Port 002 Online [0x200200051e4f7c00]
       ICE Port Type SFP with serial ID Short wave laser - SN (850nm) [F_Port]
               Attached Port [WWPN/ID] 0x5005076303008562 / 0x650200 [N_Port]

       ICE Port 003 Offline [0x200300051e4f7c00]

       ICE Port 004 Online [0x200400051e4f7c00]
       ICE Port Type SFP with serial ID Short wave laser - SN (850nm) [F_Port]
               Attached Port [WWPN/ID] 0x5005076303140335 / 0x650400 [N_Port]

       ICE Port 005 Online [0x200500051e4f7c00]
       ICE Port Type SFP with serial ID Short wave laser - SN (850nm) [F_Port]
               Attached Port [WWPN/ID] 0x5005076303104562 / 0x650500 [N_Port]
...
```

- This example shows part of the CSV equivalent of the previous examples.

```
# zfcp_show -c
...
ICE-name,domain,ICE-type,ppn,status,port name,port module type,
...port TX type,port type,att. port name,att. port ID,att. port type
0x100000051e4f7c00,005,Switch,000,Online,0x200000051e4f7c00,SFP with serial ID,
...Short wave laser - SN (850nm),F_Port,0x50050763030b0562,0x650000,N_Port
...
```

- This example shows information as provided by a local name server.

```
# zfcp_show -n
Local Port List:
0x500507630313c562 / 0x656000 [N_Port] proto = SCSI-FCP FICON
0x50050764012241e4 / 0x656100 [N_Port] proto = SCSI-FCP
0x5005076303048335 / 0x656300 [N_Port] proto = SCSI-FCP FICON
0x5005076401221b97 / 0x656400 [N_Port] proto = SCSI-FCP
0x500507630300c562 / 0x656500 [N_Port] proto = SCSI-FCP FICON
0x5005076401a23517 / 0x656700 [N_Port] proto = SCSI-FCP
0x5005076401a219a0 / 0x656800 [N_Port] proto = SCSI-FCP
0x5005076401a0b7bf / 0x656900 [N_Port] proto = SCSI-FCP
0x500507640120b9a3 / 0x656a00 [N_Port]
0x500507630310c562 / 0x657000 [N_Port] proto = SCSI-FCP FICON
0x5005076401a241e4 / 0x657100 [N_Port] proto = SCSI-FCP
...
```

Chapter 14. Hints and tips

Some common problems and ways to steer clear of trouble.

Setting up TotalStorage DS8000 and DS6000 for FCP

When you set up TotalStorage, you need to consider the LUN ID, the WWPN, access to the remote ports, and the zoning.

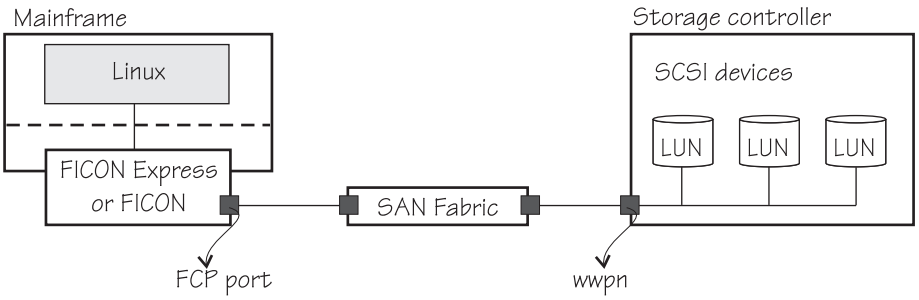


Figure 14. A storage system connected to a mainframe

You should be aware of the following when configuring the TotalStorage system:

- New mask: For the logical volume number X'abcd' the LUN ID will be: X'40ab40cd00000000'.
- Using the correct WWPN. Every port has a WWPN, but the one you need is the storage controller WWPN, as illustrated in Figure 14. Talk to the person who configures the switches to find out what the correct WWPN is.
- The "Host Ports" (nomenclature used by the storage description) at the storage side must be configured to allow the access from the port of the FCP channel. The FCP port is illustrated in Figure 14.
- The zoning of the switch (if the FCP channel is not directly connected to the storage's host ports) must be configured properly (see the documentation related to the switch being used).

Further information

- The IBM TotalStorage DS6000 Series: Concepts and Architecture, SG24-6471.
- The IBM TotalStorage DS8000 Series: Concepts and Architecture, SG24-6452.
- IBM System Storage DS8000: Host Systems Attachment Guide, SC26-7917.
- IBM System Storage DS6000: Host Systems Attachment Guide, GC26-7680.

Troubleshooting NPIV

If NPIV is not working as expected, there are several things you can check.

First, check whether the FCP channel supports NPIV.

If the FCP channel supports NPIV, check the error messages to find more details about what is wrong.

If NPIV is enabled on an FCP channel that is used by zfcp, some NPIV-specific messages may be logged on the system console and in `/var/log/messages`. The messages might help to understand the cause of the link down problem, for example on cable disconnect:

```
zfcp.7d6999: 0.0.c419: There is no light signal from the local fibre channel cable
```

When the link is restored, you might get the following message:

```
zfcp.ac341f: 0.0.c419: The local link has been restored
```

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Glossary

CIFS Common Internet File System.

Common Internet File System
A protocol that enables collaboration on the Internet by defining a remote file-access protocol that is compatible with the way applications already share data on local disks and network file servers.

FCP Fibre Channel Protocol.

Fibre Channel Protocol
The serial SCSI command protocol used on fibre-channel networks.

HBA Host bus adapter.

host bus adapter
An interface card that connects a host bus, such as a peripheral component interconnect (PCI) bus, to the storage area network (SAN).

logical unit number
In the SCSI standard, a unique identifier used to differentiate devices, each of which is a logical unit (LU).

LUN Logical unit number.

Network File System
A protocol, developed by Sun Microsystems, Incorporated, that allows a computer to access files over a network as if they were on its local disks.

NFS Network File System.

NPIV N_Port ID Virtualization.

N_Port ID Virtualization
The virtualization of target ports, where an HBA performs multiple logins to a Fibre Channel fabric using a single physical port (N_port), thereby creating a unique port name for each login. These virtualized Fibre Channel N_Port IDs allow a physical Fibre Channel port to appear as multiple, distinct ports.

port zoning
Defining a set of Fibre Channel ports where each Fibre Channel port is specified by the port number at the switch or fabric to which it is connected.

RAID Redundant Array of Independent Disks.

Redundant Array of Independent Disks
A collection of two or more disk physical drives that present to the host an image of one or more logical disk drives. In the event of a single physical device failure, the data can be read or regenerated from the other disk drives in the array due to data redundancy.

SAN storage area network.

Storage area network
A dedicated storage network tailored to a specific environment, combining servers, storage products, networking products, software, and services.

WWPN zoning
Defining a set of Fibre Channel ports where each Fibre Channel port is specified by its WWPN.

zoning
In fibre-channel environments, the grouping of multiple ports to form a virtual, private, storage network. Ports that are members of a zone can communicate with each other, but are isolated from ports in other zones.

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