

Linux on POWER Overview for IBM System p5, @server p5 and pSeries

February 14, 2006

Abstract

This paper is intended to introduce the Linux® and Linux on POWER™ operating systems, as supported on the IBM System p5™, @server® p5, pSeries®, OpenPower™ and BladeCenter® JS20 and JS21, to clients, IBM Business Partners, sales, marketing and technical teams. IBM's plans as put forth in this document are subject to change without notice.

References and Prerequisite Reading

For an overview of Linux and a discussion of IBM's Linux strategy and products, the following background reading is recommended:

- The Linux on System p5, @server p5, and pSeries platforms external Web site at <http://www.ibm.com/systems/p/linux>
- The Linux on POWER external Web site at http://www.ibm.com/systems/p/openpower/index.html?ca=LoP&met=callout&me=W&P_Site=pSeries
- The Linux on OpenPower external Web site at <http://www.ibm.com/servers/eserver/openpower/>
- The IBM external Linux Web site at <http://www.ibm.com/linux>
- “Linux at IBM” booklet from the IBM Linux Marketing team. This can be ordered as publication G325-5315-00 or browsed at <http://www.ibm.com/eserver/linux/brochure.pdf>
- More on the history of Linux can be found <http://www.cnn.com/2000/TECH/computing/02/11/mini.linux.history.idg> at
- Information on the *AIX® Toolbox for Linux Applications* product can be found at <http://www.ibm.com/servers/aix/products/aixos/linux/index.html>
- Information and download of the Linux on POWER service and productivity tools at <http://techsupport.services.ibm.com/server/lopdiags>

Overview of Linux

Linux is an operating system that is based on a development approach that delivers innovation and portability. It is an open, reliable and efficient operating system that runs on virtually any platform from embedded systems to mainframes.

The Linux operating system (OS) is the creation of Linus Torvalds, a Finnish computer science student, who developed it while a student at the University of Helsinki in 1991. The architecture is similar to the UNIX® operating system. It provides a “free”, UNIX OS-like implementation across many computer architectures. After doing the initial development work, Torvalds made the source code available on the Internet for use, feedback, and further development by others who were interested in helping to evolve Linux.

As an open source technology, Linux is not owned or controlled by any individual or company, but rather it is maintained by the open source community -- a dedicated group of independent developers collaborating to make it the most open operating system. Being open source, the Linux kernel, like other open source technologies, can be acquired at no cost.

The GNU Project (<http://www.gnu.org/gnu/the-gnu-project.html>) was launched in 1984 to develop a complete clone of the UNIX operating system which is free software: the GNU system. (GNU is a recursive acronym for “GNU’s Not UNIX” and is pronounced “guh-NEW”.) Variants of the GNU operating environment which use the Linux kernel are now widely used; though these systems are often referred to as “Linux”, they are perhaps more accurately called GNU/Linux systems.

Clients are benefiting from the rapid innovation and enhancements made to Linux, enabled by the open source development approach. Linux is licensed under the terms of the GNU General Public License (<http://www.fsf.org/copyleft/gpl.html>) or GPL. The GPL requires, among other things, that the source code be made freely available to all who receive the program and that all modifications to the code be licensed using the GPL as well. This requirement ensures that all changes and even derivative works remain open source. As a result, innovations are rapidly fed back into Linux for the benefit of all users.

The current version of the Linux kernel is 2.6. This version became available in October 2003 and is available as a download from <http://www.kernel.org>. The commercially available latest distributions from Red Hat, Inc.: Red Hat Enterprise Linux AS 4 for POWER (RHEL AS 4) and Novell SUSE Linux: SUSE Linux Enterprise Server 9 for POWER (SLES 9) support the IBM POWER4™, POWER5™, POWER5+™ and PowerPC® 970 architectures and are based on the 2.6 kernel. (Odd numbered versions such as 2.5 are for development only and are not usually used for production.) Also supported is the 2.4 kernel version of Red Hat Enterprise Server AS 3 (RHEL AS 3) which features increased performance, scalability, and stability over previous releases based on selective code being backported from the 2.5 and 2.6 kernels into that distribution. One item specifically referenced is the new NTPL (New POSIX Thread Library). Clients can use either the RHEL AS 3 or RHEL AS 4 versions to support POWER5 processor-based systems or use Novell SLES 9 to support POWER5 processor-based systems. POWER5+ processor-based systems will require RHEL AS 4 or SLES 9. All of these Linux distribution releases also support POWER4 processor-based systems and the JS20 and JS21 blade.

Linux and UNIX

While Linux is a “UNIX OS-like”, it is not the same as UNIX. The similarity begins and ends with the fact that Linux is based on the same design principles and standards as UNIX, and it is derived from that heritage. The Linux source code is distinct from that of UNIX and offers compatibility, portability, and horizontal scalability across many architected platforms.

Today, UNIX has split into a series of competing operating systems derived from the original code. Standards such as POSIX and UNIX 98 have been promulgated to specify many of the APIs and features of the various UNIX offerings. Linux is a single source operating system available to all, and as such has common APIs and capabilities regardless of the system it executes on.

Through the GPL, developers must contribute their modifications back to the community, which also continues the system singularity as Linux progresses in capabilities.

IBM’s Role in the Linux Community

IBM has made an extensive commitment to support Linux as an open computing environment. Contributions based on IBM developed technology, the “opening” of IBM patents and developed subsystems, and being committee members and leaders are just some of the ways IBM is contributing to the advancement of Linux. IBM understands that the open computing business model supports client flexibility and choice. Linux is the epitome of flexibility and choice, at least

in the terms of an operating system. Linux continues to scale and address larger computing tasks, and IBM is doing its part to speed this process along by optimizing IBM System p5 and @server p5 platforms to work synergistically with Linux for clients who need to support evolving mission-critical workloads on Linux.

Through its Linux Technology Center (LTC) (<http://ltc.linux.ibm.com>), IBM is working with the open source community on a variety of committees and projects to enhance the value of Linux for clients. The LTC has over 300 people devoted to developing and improving open source. IBM is also a participant in several industry-led efforts, such as the Linux Standard Base (<http://www.linuxbase.org>), Free Standards Group (<http://www.freestandards.org>), and the Open Source Development Lab (<http://www.osdlab.org>).

Linux Distributors

As the Linux operating system gained popularity, a number of companies formed to distribute it along with a variety of additional value-added kernel extensions (for example backporting from development releases, automated install processes, operation interfaces, etc), device driver inclusions, software packages and services. There are now over 100 companies doing various not-for-profit and for-profit distributions for a variety of hardware platforms. IBM is working with Red Hat, Inc., Novell SUSE Linux and ASIANUX (in China, Japan, and Korea) as Linux Distribution Companies (LDCs) to deliver the appropriate Linux solutions that support IBM's various hardware and software platforms including IBM System p5, @server p5, pSeries, OpenPower servers and JS20 and JS21 blades.

More information on Linux distributors who are providing products for the POWER processor-based servers are detailed in a later section. IBM is not and has no plans to become a Linux Distribution Company.

The Linux kernel is freely available as well as a variety of open source applications and the GPL license does not allow a distributor to charge for Linux per se. The Linux kernel is available at <http://www.kernel.org> and can be downloaded and compiled by anyone. The resultant binary, however, is not totally useful since it is usually missing key device drivers, a system programmer interface, and an installation process. This is where the distributors provide value through creating a "complete" operating system, with an accompanying charge for the media, documentation, packaging, shipping, maintenance (sometimes referred to as subscriptions) and support of their distributions. Source code to all distributions is available free of charge and is usually included on the distribution CD-ROMs. The Linux operating system binary is compiled to a specific architecture, such as POWER or x86-32, or S/390® and is only "compiled" to run on that platform. As such, each distribution company may have several versions, each supporting different system architectures. Regardless of platform, as mentioned, there is programming consistency between the platforms and if applications are written to the APIs of the Linux kernel, the applications should be source compatible between different architectures.

Linux and AIX 5L

The AIX 5L™ platform is, and will continue to be, the premier operating system from IBM on System p5, @server p5 and pSeries servers. AIX 5L is also available for the JS20 and JS21 blades. In order to enhance solution interchangeability between the Linux and AIX 5L operating systems, IBM has ported a collection of open source and GNU software tools from the Linux world and bundled them into a toolbox for users of AIX 5L. The AIX Toolbox for Linux Applications is one

of IBM's efforts to provide AIX 5L and Linux interchangeability by allowing open source Linux applications to be compiled and run on AIX 5L.

For clients of AIX 5L, AIX Toolbox for Linux Applications opens up a range of Linux applications, development tools, and utilities. Linux users running Intel® Architecture machines have the option to move applications up to larger systems. And for Linux developers, the toolkit introduces a way to expand the target for applications to AIX 5L.

The toolbox contains a collection of open source and GNU software that works with AIX 5L. Some of those applications include recompiled versions of the Gnome and KDE desktop environments and system utilities including Emacs, Samba, shells, GNU base utilities and application development tools such as compilers and software installers.

Once compiled with the toolkit, the original Linux source applications become native AIX 5L applications, meaning they can take advantage of the same scalability and performance as any other AIX 5L application. Note that these applications that are compiled using the toolkit are AIX 5L binaries. They cannot be run on Linux on System p5, @server p5, pSeries, OpenPower servers JS20 or JS21 blades. Similarly, applications developed on Linux on System p5, @server p5, pSeries, OpenPower or JS20/JS21 do not run in binary form on AIX 5L.

Linux on POWER support for ISVs

ISVs developing Linux solutions have a unique opportunity to create a single source tree and then compile it to various platforms. This single source tree and multiple platform capability of Linux provides very good support for clients who wish to deploy applications on the platform that best meets their performance, reliability, scaling factors and costs needs. To assist ISVs (and corporate developers) in minimizing development costs for a cross platform application, IBM has created a Web site with tools, guides, Redbooks, etc. IBM has also introduced a program for ISVs called IBM eServer™ Application Advantage for Linux to assist in creating cross platform consistent source code. Also called Chiphopper™, this and other key data is available on <http://www.ibm.com/developerworks/linux/power>.

Ordering Linux on the System p5, @server p5, and OpenPower

To make it easy to get started with Linux on POWER, IBM has introduced a number of easy to configure and order servers with financial savings. IBM System p5 Express Edition offerings and @server p5 Value Paks are offered to add simplicity to the ordering process and deliver an unbeatable server proposition. Express Editions and Value Paks are easy-to-order, flexible configurations that provide financial savings for entry and mid-range POWER5+ and POWER5 processor-based System p5 and @server p5 servers with specified minimum amounts of system resources—processors, memory and disk drives. Check the Web site (<http://www.ibm.com/systems/p/>) for System p5 Express Edition configurations and information. Check (<http://www.ibm.com/servers/eserver/pseries/hardware/value.html>) for Value Pak configurations and offering information.

The IBM @server OpenPower family, models 710 and 720, are POWER5 processor-based systems specifically tuned for Linux. They are designed with a low entry price but highly powerful Linux capabilities. The OpenPower 710 is available as a 1- to 2-core 2U rack package while the OpenPower 720 is available in a 1- to 4-core 4U rack or deskside package. The OpenPower servers can run Linux distributions from either Novell SUSE or Red Hat, Inc. which can be

included with initial orders. OpenPower servers are available with many options from internal disk, dual Ethernet controllers, large memory (up to 64GB in the OpenPower 720 and up to 32GB in the OpenPower 710), and virtualization options. In addition, OpenPower Express offerings are available in selected configurations for ease of ordering. These Express offerings are pre-defined popular configurations that can be ordered using a single order number which will result in a defined amount of memory, processors, and disk and offered at a discount over a “standard ordering process” configuration.

Clients wishing to have an entry into the POWER5 processor-based family with upward binary compatibility of Linux applications can start with an OpenPower server and as application needs increase, grow into the higher scaling System p5 and @server p5 families with Linux and AIX 5L capabilities. This “migration” from OpenPower to System p5 or @server p5 servers is very easy: implement the same Linux distribution running on the OpenPower server on the System p5 or @server p5 server using the same installation procedure (or load into a partition); install the same application running on the OpenPower server on the System p5 or @server p5 server and then move the data associated with the application by re-directing the disk connect or moving the actual disk device.

Check the OpenPower Web site for additional information on OpenPower servers:

<http://www.ibm.com/eservers/openpower>

Linux on POWER Distributions

A Linux port for the PowerPC Architecture™ has been available for several years. As with the ports to other architectures, it was started by members of the open source community. More background on this effort may be found at the Linux PowerPC community Web pages at <http://penguinppc.org/> and <http://www.penguinppc64.org>.

IBM became involved in Linux on PowerPC initially by contributing IBM RS/6000® equipment and some technical expertise to the effort. The initial port supported only the PowerPC chips, not the current POWER4, POWER5, and POWER5+ processors. Many of the PowerPC distributions such as Novell SUSE Linux and Yellow Dog work on Apple Power Macs as well as PowerPC systems from IBM. There has also been a large effort around Linux on embedded PowerPC processors such as found in game boxes.

In order to implement Linux as the operating environment on System p5, @server p5, pSeries, OpenPower servers or JS20/JS21 blades, a client would need to have the server and a copy of Linux. For all System p5, @server p5, pSeries servers and JS20/JS21 blades and the OpenPower 710 and 720 and their Express offerings, clients can order Linux distributions developed by Novell SUSE Linux or Red Hat, Inc. with their initial system order. More details on this ordering process are found in the “Red Hat, Inc.” or “Novell SUSE Linux” sections below.

For the convenience of clients, IBM offers the ability to accept orders and payment for the Novell SUSE Linux and Red Hat, Inc. Linux distributions. This includes shipping program media with initial System p5, @server p5, pSeries and OpenPower orders. Clients or authorized business partners are responsible for the installation of the Linux OS, with orders handled pursuant to license agreements between the client and the Linux distributor.

The following sections describe the Linux distributors that are working with IBM to provide and support Linux for POWER servers. Each distributor is wholly responsible for the contents, availability and pricing of their offering. Regardless of how a Linux distribution is ordered, the

distributors offer maintenance and support. IBM also has support offerings from IBM Global Services for these distributions as described in a later section.



Red Hat, Inc.

Red Hat, Inc. (<http://www.redhat.com>) is the best known Linux provider and is the market leader as a Linux distributor. Red Hat Enterprise Linux AS 3 for POWER became generally available for @server pSeries in November 2003 and was updated to support @server p5 and OpenPower servers and JS20 blades in August 2004 with RHEL AS 3 Update 3. This is a full 64-bit kernel (based on the 2.4.21 kernel with selective code backported from the 2.6 kernel, such as the NTPL and simultaneous multithreading support) with 32- and 64-bit application support. As of February 2005, the current release, RHEL AS 4, is available from Red Hat, Inc. This release is based on the 2.6 kernel and includes Large Page support and the Preemptive kernel. This version supports POWER4 and POWER5 and POWER5+ processor-based servers and JS20/JS21 blades. (Note: the “ES” and “WS” packages of Red Hat Enterprise Linux 4 are not available for System p5, @server p5, pSeries, OpenPower or JS20/JS21 at this time although there are special price options to support up to 2-core systems and clusters of servers)

For the convenience of clients, IBM provides the ability to order a full distribution of RHEL AS 4 in conjunction with any new System p5, @server p5, pSeries, OpenPower servers or JS20/JS21 blades purchase, with any new processor upgrade or, as appropriate, with any activation of a Capacity Upgrade on Demand (CUoD) processor. IBM will accept the client’s order and will have the Linux distribution arrive with the server shipment at the client location. This feature (5639-RDH) is only available at the time of the initial System p5, @server p5, pSeries or OpenPower server order, processor upgrade or, as appropriate, CUoD activation. Clients always have the option of ordering directly from Red Hat, Inc. at any time from the Red Hat Web site or a Red Hat business partner. Red Hat Enterprise Linux is also available in an evaluation version from Red Hat.

Full information on this product, including pricing and support options, can be found at <http://www.redhat.com/software/rhel>.

Red Hat, Inc. also has a number of worldwide sales offices. The contact information is available at http://www.redhat.com/apps/webform.html?event_type=contact_sales&eid=1.



Novell SUSE Linux

SUSE Linux was the first of the IBM Linux Distribution Partners to release Linux for the pSeries and RS/6000. Since then, SUSE Linux was acquired by Novell and is now called Novell SUSE LINUX (<http://www.novell.com/linux>). The latest version of Novell SUSE Linux for enterprise clients, SUSE Linux Enterprise Server 9 (SLES 9) for POWER became available in August 2004 and contains the 64-bit Linux operating system based on the 2.6 kernel and supports both 32-bit and 64-bit applications. (Novell SUSE Linux is also currently available in the SLES 8 version which is based on the 2.4 kernel. This version only supports the POWER4 servers and JS20 blades. This version may be desired in certain circumstances where application certification for POWER is only available on SLES 8).

Full details on SLES 9 for @server p5, pSeries, OpenPower and JS20 are available directly from Novell at <http://www.novell.com/products/linuxenterpriseserver/quicklook.html>. Novell SUSE Linux also has a number of worldwide business partners. The contact information is available at <http://www.novell.com/partnerlocator>.

For the convenience of clients, IBM provides the ability to order a full retail distribution of SLES 8 or SLES 9 in conjunction with new System p5 (SLES 9 only), @server p5, pSeries, OpenPower server or JS20/JS21 blade purchases, processor upgrades or, as appropriate, CUoD activation. IBM will accept client orders and payment for Novell SUSE Linux and deliver the code with the respective systems. Maintenance and support can, for an additional charge, also be provided. The feature code for SLES 8 is 5639-LNX and for SLES 9, 5639-SLP. Clients always have the option of ordering directly from Novell SUSE Linux at any time per the information above, either via their Web site or from Novell SUSE Linux business partners. Pricing options of Novell SUSE Linux SLES 9 are available to support clusters. SLES 9 is also available in an evaluation version from Novell SUSE Linux.

Logical Partitioning of Linux on POWER4 Processor-based Systems

Linux is supported running in one or more static logical partitions (LPARs) on all pSeries (POWER4) servers which support logical partitioning. The AIX 5L and Linux operating systems can run concurrently in separate partitions on an LPAR-enabled system in any combination (i.e. zero or more Linux partitions along with zero or more AIX 5L partitions). This capability enables a client to consolidate workloads from several separate servers onto a single system and/or increase the system utilization. Since the partitioning is controlled by the Hypervisor firmware and the Hardware Management Console (HMC) for pSeries, the AIX 5L operating system is never required to run Linux¹.

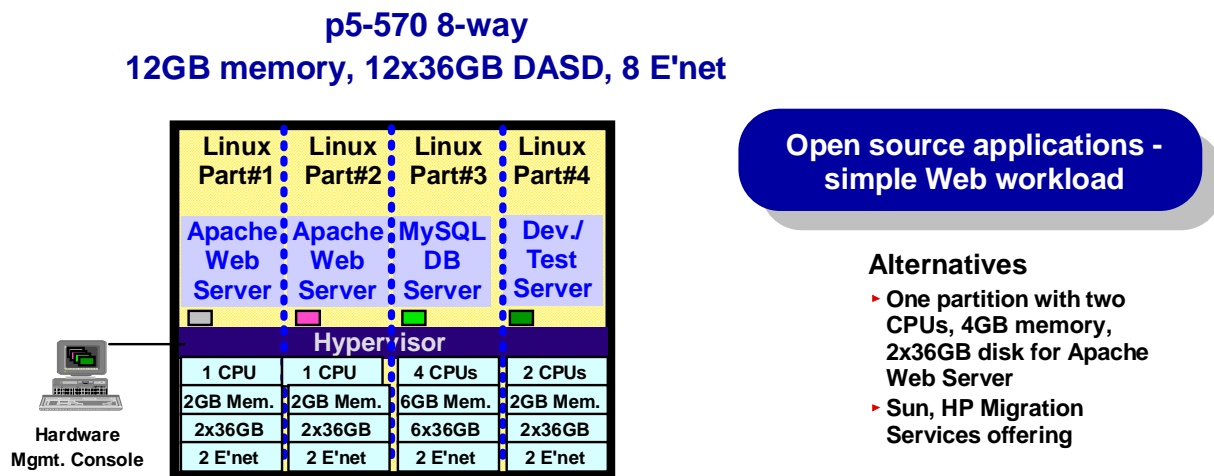
Dynamic LPAR is not supported by Linux 2.4 kernel-based distributions or on POWER4 processor-based systems. However, Linux partitions can be created on systems enabled for dynamic LPAR. The Linux partition will appear grayed out on the HMC and cannot be changed

¹ The pSeries 655 requires that AIX 5L be present in the system or network, to extract diagnostic information for service support.

dynamically. To reconfigure Linux in an LPAR environment, it must first be stopped, the partition reconfigured, and then Linux restarted.

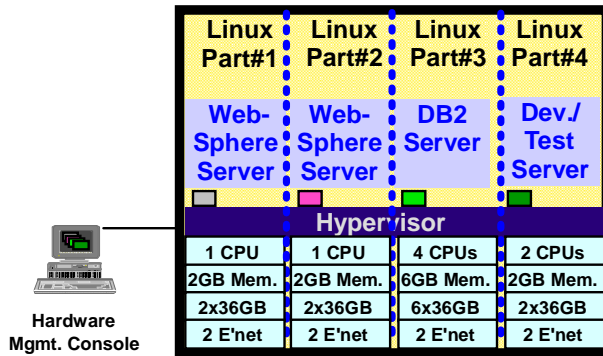
For example, consider a typical service provider or Web hosting environment. It is typically architected as a two or three tier model. In most installations, there are front-end systems (typically edge of network and appliance servers) to handle caching, proxy, DNS, etc. There may then be a second tier of mid-range servers (or larger or smaller based on workload) to do Web application serving using WebSphere® in conjunction with an ERP or CRM product. The third tier of servers could run a UNIX or Linux OS on a large symmetric multiprocessor (SMP) providing the backoffice and database management (DBMS) functions that require high performance and scalability. In many cases, the first and possibly second tiers are running Linux or Microsoft® Windows® operating systems. This setup results in a proliferation of servers and the need for more staff and expensive software to manage multiple platforms.

The pictures below illustrate some possible Linux LPAR configurations on System p5, @server p5 and pSeries servers. The first scenario shows all open source applications being used to consolidate what would normally be separate servers into multiple logical partitions.



The second configuration shows a similar Web serving consolidation using IBM software. Note that higher DBMS scalability could be achieved by using AIX 5L instead of Linux for Partition #3.

p670 8-way
12GB memory, 12x36GB DASD, 8 E'net

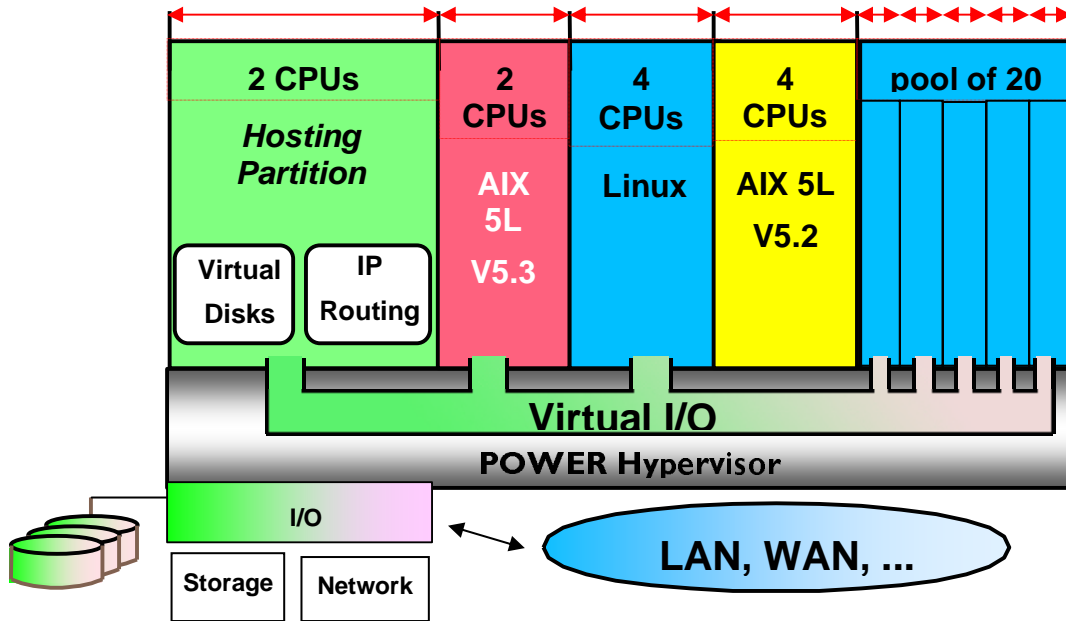


IBM SWG applications - complex Web workload

- Alternatives**
- ▶ AIX 5L for DB2 server partition
 - ▶ One partition with two CPUs, 4GB memory, 2x36GB disk for WebSphere Server
 - ▶ Sun, HP Migration Services offering

Virtualization Capabilities on POWER5+ and POWER5 Processor-based Systems

With the introduction of the POWER5+ and POWER5 architecture in the System p5, @server p5 and OpenPower servers, there has been advancement in the ability to virtualize servers and selective I/O devices within a single server, and this function is supported by Linux. First, the LPAR capability of POWER4 processor-based systems has been extended with dynamic LPAR capabilities (the ability to change processor allocation to partitions without having to reboot the partition) in POWER5 and POWER5+ processor-based systems and is currently supported by SLES 9 and RHEL AS 4. In addition to dynamic LPAR, another key feature enabled is to run partitions with processor allocations in fractional amounts. This capability is called Micro-Partitioning™ and can be used to provide a partition with less than a full processor (for example, a firewall or a DNS server partition). Partitions as small as 1/10th of a processor (internally managed in increments as small as 1/100th of a processor) may be defined. These partitions can reside and run within a pool of processors (shared processor pool) where the allocation of processors to the workload can dynamically change based on user defined parameters and “rules”. The “rules” may indicate that a partition can only have a maximum amount of processing power or can be unlimited in its ability to absorb all the unused processor capabilities. Other features in virtualization are Virtual I/O Server (VIOS) where several partitions can share a single physical adapter, thus saving the cost of multiple adapters when workloads allow the sharing. Today POWER5 and POWER5+ processor-based systems with Linux can share SCSI, Fibre Channel, and Ethernet adapters. Virtual LAN capabilities have also been added (AIX 5L V5.3 and Linux only) to allow inter-partition communications on a “virtual LAN” without the need for LAN adapters or cabling. This capability is shown below:



The virtualization capabilities in System p5, @server p5 servers and JS21 blades are partially included in the base system as a no charge feature code (providing LPAR, dynamic LPAR, VLAN) and an optionally charged for feature, Advanced POWER Virtualization (Virtual I/O Server and Micro-Partitioning). Both capabilities require partition management support either through a feature of VIOS called Integrated Virtualization Manager (IVM) or an HMC. This support is required to initialize and manage the virtualized environment. A single HMC can manage up to 64 different physical servers. The IVM feature is enabled through a Web browser and can only manage the system to which the Web browser is connected. In OpenPower servers, all the features mentioned require a charged for feature, named Advanced POWER Virtualization (APV) as well as the HMC (which can manage up to 64 POWER5 servers - all @server p5 servers, all OpenPower servers, or a mix of both) or IVM-managed Web browser. Without the APV feature, (feature code 1965), LPAR is not supported on OpenPower servers. At this date, the JS20 blade is not supported by virtualization capabilities but the JS21 is supported by APV.

Supported Servers and Blades

The table below details the Linux distribution support for 64-bit systems. SLES 8, SLES 9 and RHEL AS 3 / AS 4 have a 64-bit kernel with support for either 32- or 64-bit applications. In practice, this is a very good feature as no performance degradation will be encountered when running 32-bit application on the 64-bit kernel on POWER processor-based systems, unlike other system architectures. Additionally to exploit 64-bit, database managers and many high performance computing applications tend to make use of 64-bit.

System p5, @server p5, OpenPower and pSeries, RS/6000 or JS20/JS21	SUSE Linux Enterprise Server 8³	SUSE Linux Enterprise Server 9	Red Hat Enterprise Linux AS 3¹ or AS 4
System p5 185 Express System p5 510 Express System p5 510Q Express System p5 520 Express System p5 520Q Express System p5 550 Express System p5 550Q Express System p5 560Q System p5 570 System p5 575	No	Yes	RHEL AS 4 only
p610 (7028-6C1) ⁵ p610 (7028-6E1) ⁵	Yes	No	No
p615 (7029-6C3) ⁵ p615 (7029-6E3) ⁵	Yes ⁴	Yes	Yes
p620 (7025-6F0) ⁵ p620 (7025-6F1) ⁵	Yes	No	No
p630 (7028-6C4) ⁵ p630 (7028-6E4) ⁵	Yes ¹	Yes ¹	Yes ¹
p640 (7026-B80) ⁵	Yes	No	No
p650 (7038-6M2) ⁵	Yes ¹	Yes ¹	Yes ¹
p655 (7039-651)	Yes ⁴	Yes ⁴	Yes ⁴
p660 (7026-6H0) ⁵ p660 (7026-6H1) ⁵	Yes	No	No
p660 (7026-6M1) ⁵	Yes	No	No
p670 (7040-671) ⁵	Yes ^{2,3}	Yes ²	Yes ²

System p5, @server p5, OpenPower and pSeries, RS/6000 or JS20/JS21	SUSE Linux Enterprise Server 8³	SUSE Linux Enterprise Server 9	Red Hat Enterprise Linux AS 3¹ or AS 4
p690 (7040-681) ⁵	Yes ²	Yes ²	Yes ²
JS20 blade JS21 blade	Yes	Yes	Yes
@server p5-510 @server p5-510 Express	No	Yes	Yes
@server p5-520 @server p5-520 Express	No	Yes	Yes
@server p5-550 @server p5-550 Express	No	Yes	Yes
@server p5-570 @server p5-570 Express	No	Yes	Yes
@server p5-575	No	Yes	Yes
@server p5-590 ²	No	Yes ²	Yes ²
@server p5-595 ²	No	Yes ²	Yes ²
OpenPower 710 OpenPower 710 Express	No	Yes	Yes
OpenPower 720 OpenPower 720 Express	No	Yes	Yes

¹ These LPAR-capable systems are supported either with or without the use of LPAR. Only statically-configured LPARs are supported, meaning that Linux must be stopped and restarted in order to change the partition configuration.

² These LPAR-capable systems are supported only in LPAR mode. Only statically-configured LPARs are supported, meaning that Linux must be stopped and restarted in order to change the partition configuration. LSRB approval is needed to run on greater than 16-core partitions.

³ A maximum of sixteen processors is recommended for each Linux LPAR on these systems. While Linux can be run successfully on systems/LPARs with more than sixteen processors, typical application workloads will only effectively utilize the equivalent of up to sixteen processors.

⁴ The p655 requires that AIX 5L be available either in the system or on the network to extract diagnostic information. This is only required when diagnostics are to be extracted and does not require full time connection.

⁵ These systems are no longer marketed by IBM but are supported by the indicated distributions.

I/O Device and Adapter Support

There are a large number of adapters and devices that can be attached to System p5, @server p5, pSeries, OpenPower servers and JS20/JS21 blades running the AIX 5L OS. While some of the devices (e.g. EMC attached disks) have Linux drivers for Intel as well as AIX 5L drivers, these cannot be utilized directly in Linux on POWER systems. In certain situations, these devices will be supported at the same level as AIX 5L when APV is used.

The supported adapters and storage devices are detailed in the *IBM System p5, eServer p5, and OpenPower I/O Features* document available at

<http://www.ibm.com/servers/eserver/pseries/hardware/factsfeatures.html>.

Other adapters not currently supported will obviously be required and some are already ported but not yet certified. These will be included in future Linux for POWER distributions, and IBM will work to help provide others as part of special bids to clients interested in testing/deploying Linux on System p5, @server p5, pSeries, OpenPower servers and JS20/JS21 blades.

Performance

IBM has enabled the IBM VisualAge® C++ and XL Fortran compilers to support Linux on POWER. These optimized compilers increase performance over the standard GNU compilers, especially for floating-point intensive applications. The compilers are generally available and more information on downloads and purchases can be found at

<http://www.ibm.com/software/awdtools/vacpp/features/vacpp-linux.html> and

<http://www.ibm.com/software/awdtools/fortran/xlfortran/features/linux/>

The IBM Developer Kit for Linux, Java™ 2 Technology Edition is a development kit and runtime environment that contains IBM's just-in-time compiler and an enhanced Java 2 virtual machine. This high-performance Java environment is available on Linux on POWER for SLES 8 and SLES 9. The kit is packaged with these distributions or can be downloaded from IBM's developerWorks® site at <http://www.ibm.com/developerworks/java/jdk/linux140>

The available benchmark data for Linux on @server p5, pSeries and OpenPower servers is published in the *IBM System p5, @server p5, pSeries OpenPower and IBM RS/6000 Performance Report* which is downloadable from http://www.ibm.com/systems/p/hardware/system_perf.html

Scalability

The Linux 2.6 kernel has been found to scale well up to 16 and in selected workloads to 32-core processors in an SMP system depending on the workload. This scaling makes it a good match for systems with 4-cores and up capabilities: p650, p655, p5-550, p5-550Q, p5-560Q, p5-570, p5-575, p5-590, p5-595 and OpenPower 720 servers as well as in LPARs on the p670 and p690.

Reliability, Availability and Serviceability (RAS) Features

A key attribute of Linux on POWER is mission-critical RAS features. Drawing from IBM's autonomic computing efforts, System p5, @server p5, pSeries and OpenPower servers continue to enhance the scope of their RAS capabilities. However, while Linux RAS capabilities continue to mature, many RAS features are only fully realized when running AIX 5L.

The following s RAS features are supported when running Linux:

- Chipkill™ and ECC memory
- Disk mirroring (software)
- Journalled file system (several available under Linux)
- PCI Extended Error detection
- Redundant, hot-plug power and cooling (where available)
- Error reporting to Service Focal Point
- Error log analysis
- Boot-time processor and memory deallocation
- First Failure Data Capture
- Service processor

Some of the POWER RAS features that are currently supported only with the Linux 2.6 kernel on POWER processor-based systems include:

- Hot-swapping of disk drives
- Dynamic Processor Deallocation
- Hot-plug PCI Disk
- PCI Extended Error recovery (device driver dependent)

To enable Linux to take advantage of the System p5, @server p5, pSeries and OpenPower servers' enhanced reliability support, a Service Aids Toolkit has been made available for download. This toolkit should greatly enhance Linux availability and serviceability when running on System p5, @server p5, pSeries and OpenPower servers. The toolkit information and download is at the following url:

<http://techsupport.services.ibm.com/lopdiags>.

Clustering and High Availability

IBM has announced the availability of Cluster Systems Management (CSM) technology, IBM Director and other tools supporting Linux on System p5, @server p5, pSeries and OpenPower servers.

The Beowulf clustering technology (<http://www.beowulf.org>) and other open source and some commercial products can be used to cluster POWER processor-based systems running Linux to provide compute or high-availability clusters. Myricom (<http://www.myri.com/>) has the Myrinet switch available for Linux on System p5, @server p5, pSeries and OpenPower servers. IBM has also announced the InfiniBand switch which is also supported by the Linux distributions. The Linux distributions that support the respective technologies also support the Myrinet switch and InfiniBand -- specifically SLES 8 for POWER4 processor-based systems, SLES 9 for POWER5+ and POWER5 processor-based systems, and RHEL AS 3 for POWER4 or POWER5 and RHEL AS 4 for POWER5+ processor-based systems. The Myrinet switch is also supported on JS20/JS21 blade servers selectively by SLES 8, SLES 9, and RHEL AS 3 and AS 4. It can be used as a high-speed interconnect to cluster systems of System p5, @server p5, pSeries and OpenPower servers running Linux. Gigabit or 10/100 Ethernet connections can also be used.

In the high availability arena, IBM is providing Tivoli® System Automation as one solution. This product is based on technology from IBM's mainframe z/OS® and AIX 5L high availability products. Other third-party solutions are also available today as well as open source solutions such as Linux-HA. The current Novell SUSE Linux product also has built in HA capabilities.

Internationalization

Each of the Linux distributions currently supports certain geographic regions and languages. This typically includes language translations and locale support. The Linux OS as a whole is moving to adopt the Open Internationalization Initiative (<http://www.openi18n.org/>) approach to providing standard national language support. Details on language/locale support can be found on each distributor's Web site.

IBM Software Availability

IBM has announced the availability and support of major components of the IBM software portfolio for Linux on POWER including WebSphere Application Server, WebSphere Commerce Suite, DB2® Universal Database™, IBM Fortran and C/C++ compilers and several Tivoli

products. IBM's Software Group will work with interested clients to assess requirements and provide no charge copies for evaluation.

Many of IBM's premiere software products including DB2 UDB V8.1, WebSphere Application Server V6.0.1, WebSphere Commerce Suite, IBM C/C++ and Fortran compilers, IBM Directory, Tivoli Storage Manager and other Tivoli solutions are available for Linux on POWER.

The IBM Developer Kit for Linux, Java 2 Technology Edition and IBM's Journaling File System (JFS) are also certified on the SLES 8. DB2, WebSphere, and other IBM applications for Linux on POWER can be found at the "Speed-start your Linux Applications" site at <http://www.ibm.com/developerworks/linux/power>.

ISV Applications

A wide variety of over 1800 open source applications and software packages are available on Linux on POWER systems. Each Linux distributor provides bundled applications with their product. These range from text editors to development environments to database managers to Web hosting utilities.

Many ISVs are quickly moving to support Linux; in fact, a number of ISVs such as Oracle and SAP have made the Linux OS their reference development platform. Given that the availability of software under Linux is growing rapidly, one needs to recheck for the availability of software on Linux on POWER on a regular basis. The most up-to-date information on ISV availability can be found on the Linux on POWER Web site which is listed below.

It is important to note that applications that are ported/recompiled and tested on Linux on System p5, @server p5, pSeries or OpenPower servers will work unmodified on Linux on IBM @server i5 and iSeries™ servers or BladeCenter JS20/JS21 blades unless there is some extremely low-level hardware interaction required. Likewise, applications running on the JS20 blade will run on other POWER processor-based systems as long as the SIMD instruction set is not used in the application source or binary. Similarly, Linux applications that have been migrated to work on Linux on @server i5 or iSeries servers will also run unmodified on Linux on System p5, @server p5, pSeries, OpenPower servers or JS20/JS21 blades.

For a full list of the currently available applications, please visit <http://www.ibm.com/servers/eserver/linux/power/apps/all.html>.

Software Service and Support

Linux support is readily available from many sources. It ranges from free support from the open source community at large (normally through e-mail or Web sites), to fee-based service contracts with service organizations and Linux distributors such as Linuxcare, Red Hat, Inc. and Novell SUSE Linux. Details on these offerings are available at the respective distributor's Web site. Maintenance contracts for software upgrades can also be obtained from the distributors. Initial installation and maintenance is usually bundled into a Linux distributor's product.

IBM IGS and IBM Technical Education Services has developed a comprehensive portfolio of Linux services, support and education offerings. These offerings currently include:

- Consulting, planning and implementation services:
 - Open Source Consulting
 - Linux Server Consolidation Services
 - Migration Services for Linux

- IBM Middleware Enablement Services for Linux
- Linux Cluster Implementation Services
- Worldwide remote 24x7 technical support:
 - SupportLine
 - Advanced Support
- Classroom and Web-based Education and Training

Local IBM Global Services consultants are available to help clients evaluate their Linux requirements and to assist in implementing and optimizing their Linux solutions. For further details, visit the IBM Global Services Web site at:

<http://www.ibm.com/services/us/index.wss/of/igs/a1002810?>

For education offerings visit:

[http://www.ibm.com/services/learning/ites.wss/us/en?pageType=page&contentID=a0000569.](http://www.ibm.com/services/learning/ites.wss/us/en?pageType=page&contentID=a0000569)

Frequently Asked Questions

Q: What are the license terms and conditions for Linux on POWER?

A: License terms and conditions are provided by the Linux distributor, but all base Linux operating systems are licensed under the GPL. This statement means that source code must be made available at no charge. Distributor pricing for Linux includes media, packaging/shipping and documentation costs, and they may offer additional programs under other licenses as well as bundled service and support.

Q: How much does Linux on POWER cost?

A: Each Linux distributor sets their own pricing for their distribution, service, and support. Please consult the distributor's Web site for information. Additionally, clients can check with their IBM representative or IBM Business Partner to determine the price of the Linux distributions through IBM and the prices of IBM support for Linux on POWER.

Q: Can Linux be ordered as a preload on System p5, @server p5, pSeries, OpenPower or JS20/JS21 systems?

A: No. However, new System p5, @server p5 or pSeries server orders, processor upgrades or CUoD activations have the option of ordering SLES 8, SLES 9 or RHEL AS 4.

Q: What version of AIX 5L is required to run Linux in an LPAR or dynamic LPAR?

A: AIX 5L is not required to run Linux, though it may be required to take advantage of certain diagnostic and support features on some systems. All LPAR/dynamic LPAR functions are controlled by the IVM function of VIOS or the HMC for System p5, @server p5, and OpenPower and the firmware on LPAR/dynamic LPAR-capable systems. Instances of AIX 5L and Linux run as peer operating systems in separate partitions. Linux is installed, booted, and runs independent of any use of AIX 5L.

Q: What testing and systems assurance is IBM providing to ensure a quality product?

A: Any warranty and support for the Linux operating system is provided by the Linux distributor. The Linux distributor is primarily responsible for testing and systems assurance. In addition, IBM is doing functional and regression testing of supported Linux distributions on designated System p5, @server p5, pSeries, OpenPower and JS20/JS21 hardware. IBM receives candidate releases from the supported Linux distributors and runs a system test to verify that the package will install, boot, and operate correctly on the designated hardware. Also, other IBM server and software organizations provide extensive testing of Linux capabilities.

Quality assurance for the hundreds of open source applications that are packaged with a Linux distribution is provided by the Linux distributor and the open source community.

Q: How do I get support for Linux on System p5, @server p5, pSeries, OpenPower and JS20/JS21?

A: Each of the Linux distributors has its own service offerings which may be purchased from that distributor. There is typically 90 days to one year of free installation support and maintenance included with a retail purchase of a distribution. The service/support contract can be extended.

IBM Global Services provides SupportLine services for Linux for POWER distributions. IBM Global Services can be engaged for any Linux services or support requirements. See <http://www.ibm.com/linux/services> for more details.

Q: When will older RS/6000 systems have Linux support?

A: The support of IBM systems is provided by the distributors and not IBM. However, IBM understands that the distributors do not plan to provide support for RS/6000 systems beyond those already listed. It would be almost impossible to develop and test all of the devices required for those older models. The focus is on enabling new System p5 and @server p5 platforms as they are announced. This approach is consistent with the other IBM System p5 and @server platforms which are only enabling their latest models. Individual Linux distributors may decide to support other RS/6000 models. Specific model support information should be obtained from the LDPs.

Q: What about other Linux distributions for systems based on the PowerPC or Power Architectures?

A: Terra Soft produces Yellow Dog Linux (<http://www.yellowdoglinux.com/>) which was one of the first commercial PowerPC distributions, covering not only the RS/6000 but systems from Apple and Motorola. Yellow Dog continues to make new versions of its PowerPC distribution available. However, there is no IBM service or support available to clients who choose to run Yellow Dog. Debian (<http://www.debian.org>) is another distribution for PowerPC systems, but like Yellowdog, has not been certified by IBM on POWER processor-based systems. These distributions may or may not work on System p5, pSeries, RS/6000, @server p5, OpenPower and JS20/JS21 hardware and are not supported by IBM. Consult the respective Linux distributor's Web site for more information.

Q: How does Linux help AIX 5L?

A: Linux is rapidly gaining momentum, having become the fastest growing server operating environment. By allowing Linux applications to be easily compiled for AIX 5L with the AIX Toolbox for Linux Applications, IBM has expanded the available application portfolio. Additionally, AIX 5L can now take advantage of the growing Linux skill base.

Q: Does Linux compete with AIX 5L?

A: Linux and AIX 5L are complementary operating systems. AIX 5L is the strategic, proven, mission-critical operating system for @server p5 and pSeries servers. Linux is a highly portable operating system which supports all System p5 and @server platforms. IBM expects to see many installations running Linux (on System p5, @server xSeries® or POWER processor-based hardware) as the front-end to mission-critical AIX 5L or Linux systems running DB2 and other enterprise applications.

Q: Will IBM continue its commitment to AIX 5L while integrating Linux into the POWER offerings?

A: Absolutely yes! The AIX 5L product roadmap is loaded with rich, client-validated enhancements far into the future. AIX 5L will continue as IBM's premier, enterprise-class UNIX, but it will also continue to be more closely aligned with Linux than any other UNIX operating system in the industry. AIX 5L also has broad application support and industry acceptance. Clients have invested millions of dollars in AIX applications and skills. IBM plans to enhance and support AIX 5L for years to come. Linux on POWER is a response to client requirements for

more flexibility and choice to address particular workload demands within an overall infrastructure.

Q: How does the System p5, @server p5 and pSeries AIX 5L and Linux flexibility play in terms of risk and cost?

A: The overall flexibility of System p5, @server p5 and pSeries servers with AIX 5L and Linux means clients have the low risk option to run AIX 5L and migrate to Linux in the future. IBM clients can buy very specific computing power to match workloads requirements. Depending on existing infrastructure, training and applications, administrators may choose a system with AIX 5L, Linux, or some combination of the two operating systems. IBM allows clients to make that decision at the time of purchase or any time thereafter, providing excellent investment protection. IBM System p5, @server p5 and pSeries servers offer the least amount of risk of all the UNIX operating system platforms. Because of this unique flexibility between AIX 5L and Linux to coexist on the same server clients get the best of both worlds - investment protection now and in the future.

Q: What if I like the Power Architecture, RAS features, performance, and scalability but do not wish to run AIX 5L?

A: On System p5, @server p5 and pSeries servers, the AIX 5L OS is not required. Another choice is the IBM @server OpenPower family and JS20/JS21 blades which run Linux.

Q: What is the advantage of running AIX 5L and Linux concurrently?

A: The ability to run both Linux and AIX 5L at the same time offers several advantages over a two system approach. Administrators running test and production applications may wish to run both within a single server rather than operating two separate systems with possible performance variances. A single common server is very useful during operating system and application migrations as it removes one less variable.

Selected System p5, @server p5 and pSeries servers can be partitioned into smaller virtual servers with logical partitioning (LPAR and dynamic LPAR). Consolidating many AIX 5L and Linux systems within one server using LPAR/dynamic LPAR greatly simplifies systems management, saves on space, increases flexibility and contributes to lower TCO since overall system resources are utilized more efficiently. This flexibility also lowers TCO as many applications currently run on Linux or AIX 5L, but not both. One System p5 or @server p5 or pSeries server can support the broadest portfolio of UNIX and Linux applications, saving clients from purchasing separate servers to run Linux and UNIX applications.

Q: What are some of the advantages of Linux on System p5, @server p5, pSeries, OpenPower or JS20/JS21 with POWER processors?

A: The System p5 and @server POWER processor-based servers are an ideal platform for 64-bit Linux applications. The POWER processor-based System p5, @server p5, pSeries, OpenPower and JS20 products offer a proven environment with leading-edge performance, scalability, reliability and autonomic computing manageability features. Linux on POWER leverages the competitive advantages of System p5, @server p5, pSeries, OpenPower and JS20/JS21 hardware while allowing administrators to utilize Linux applications.

Q: What type of workload will a UNIX client address with Linux and which workloads might benefit from a combination of both AIX 5L and Linux?

A: Typically e-infrastructure workloads like Web Java application serving, file-and-print serving, as well as high performance computing environments are best for Linux. Clients may choose Linux for availability of a specific application. Those clients who need to support database management/analysis and core business applications tend to prefer UNIX although Linux is rapidly gaining acceptance in DBMS environment. IBM is the only vendor that can provide both on a single server with UNIX and Linux partitions.

Q: Why are there some I/O devices not supported by Linux at this time?

A: Although today most I/O devices and adapters are supported on Linux, the supported list is not as complete as the list for AIX 5L devices. Support for I/O devices and adapters on POWER servers running Linux is determined by many factors, including the availability of open source drivers and IBM's testing and certification efforts with available Linux distributions. The first priority is to support I/O adapters integrated on system planars and key devices such as SCSI and LAN adapters. Over time, the set of supported I/O devices will be enhanced as additional device drivers become available and as testing can be performed. Additional information is available in the *IBM System p5, eServer p5, and OpenPower I/O Features* document available at <http://www.ibm.com/servers/eserver/pseries/hardware/factsfeatures.html>.

Q: Will an AIX binary or a binary produced using the AIX Toolbox run on Linux on POWER?

A: No. The executable formats are different between AIX 5L and Linux. Source compiled using the AIX 5L compilers or AIX Toolbox creates an AIX binary which is not compatible with the format Linux uses. The source code for the program must be recompiled on Linux on POWER.

Q: Can a Linux on POWER binary be run on AIX 5L?

A: No. As per the previous question, the executable formats are different. A Linux application must be compiled on AIX 5L using the AIX Toolbox in order to run.

Q: Can a Linux on POWER binary run on Linux on iSeries or @server i5?

A: Yes! The binary formats for Linux on these POWER/PowerPC systems are identical. An application compiled on one will work unmodified on the other series (except if the POWER binary exploits the SIMD instruction set – JS20/JS21 only). If moving between iSeries and pSeries or OpenPower, the same Linux distributions and versions should be the enabled OS.

Q: Are Linux on POWER binaries compatible across different Linux on POWER distributions? For example, can a program created using Red Hat Enterprise Linux AS 4 run on a pSeries server using SLES 9?

A: While it may be possible in many instances to run a binary built using one Linux distribution on a system running another at the same time there may be problems. Differences in compiler and runtime library levels as well as kernel levels and support may pose problems. In general, the source should be recompiled for each distribution and especially if they are at different kernel levels.

Q: Can a Linux binary created on an Intel system be run on Linux on POWER?

A: No. Linux binaries are not supported across hardware architectures. Since a compiled Linux program is actually machine-level instructions (rather than hardware-independent codes like a Java

program), the Linux source code must be recompiled for each target architecture. Linux binaries created for either iSeries, @server i5, System p5, @server p5, pSeries or OpenPower can be run on the other platform (with the same level of Linux distribution) since they are all PowerPC processor-based systems.

Q: Does Linux support the virtualization features and functions of System p5, @server p5 and OpenPower?

A: Yes with certain qualifications. One function not supported by Linux on POWER AS yet is the virtualization capability of Dynamic Memory and Partition Load Manager. Another fact that must be observed is that virtualization is supported on POWER5+ and POWER5 processor-based systems. In order to maximize this support, the 2.6 kernel should be used. RHEL AS 3 is based on the 2.4 kernel and as such does not support certain virtualization capabilities such as dynamic LPAR and hot-swappable disk. RHEL AS 4 does support full virtualization.

Q: When running virtualization on POWER5+ or POWER5 systems, are there any requirements?

A: Yes. Depending on the model of POWER5 processor-based servers, the APV feature (for selected System p5 and @server p5 servers) must be ordered as well as an HMC to manage the environment (or use the IVM feature of the VIOS function supported on selected models).

Q: Do the JS20 or JS21 support virtualization?

A: The JS20 does not support the APV feature. However, the JS21 is supported by APV.



© IBM Corporation 2006

IBM Corporation
Marketing Communications
Systems and Technology Group
Route 100
Somers, New York 10589

Produced in the United States of America
February 2006
All Rights Reserved

This document was developed for products and/or services offered in the United States. IBM may not offer the products, features, or services discussed in this document in other countries.

The information may be subject to change without notice. Consult your local IBM business contact for information on the products, features and services available in your area.

All statements regarding IBM future directions and intent are subject to change or withdrawal without notice and represent goals and objectives only.

IBM, the IBM logo, the e-business logo, @server, AIX, AIX 5L, BladeCenter, Chiphopper, Chipkill, DB2, DB2 Universal Database, developerWorks, eServer, iSeries, OpenPower, PowerPC, PowerPC Architecture, Power Architecture, POWER, POWER4, POWER5, pSeries, RS/6000, S/390, System p5, Tivoli, VisualAge, WebSphere, xSeries and z/OS are trademarks or registered trademarks of International Business Machines Corporation in the United States or other countries or both. A full list of U.S. trademarks owned by IBM may be found at <http://www.ibm.com/legal/copytrade.shtml>.

UNIX is a registered trademark of The Open Group in the United States other countries or both.

Linux is a trademark of Linus Torvalds in the United States other countries or both.

Microsoft and Windows are registered trademarks of the Microsoft Corporation.

Intel and Itanium are registered trademarks and Xeon is a trademark of Intel Corporation in the United States and/or other countries.

AMD Opteron is a trademark of Advanced Micro Devices, Inc. in the United States

Java and all Java-based trademarks and logos are trademarks of Sun Microsystems, Inc. In the United States and/or other countries.

SPECjbb is a trademark of Standard Performance Evaluation Corp (SPEC).

Other company, product, and service names may be trademarks or service marks of others.

IBM hardware products are manufactured from new parts, or new and used parts. Regardless, our warranty terms apply.

Photographs show engineering and design models. Changes may be incorporated in production models.

Copying or downloading the images contained in this document is expressly prohibited without the written consent of IBM.

This equipment is subject to FCC rules. It will comply with the appropriate FCC rules before final delivery to the buyer.

Information concerning non-IBM products was obtained from the suppliers of these products or other public sources. Questions on the capabilities of the non-IBM products should be addressed with the suppliers.

All performance information was determined in a controlled environment. Actual results may vary. Performance information is provided "AS IS" and no warranties or guarantees are expressed or implied by IBM.

The IBM home page on the Internet can be found at <http://www.ibm.com>.

The IBM Linux on POWER home page on the Internet can be found at <http://www.ibm.com/linux/power>.

The System p5 and @server p5 home page on the Internet can be found at <http://www.ibm.com/systems/p>.

The OpenPower home page on the Internet can be found at <http://www.ibm.com/linux/power/openpower>.

The BladeCenter JS20/JS21 home page on the Internet can be found at http://www.ibm.com/servers/eserver/bladecenter/is20/more_info.html.