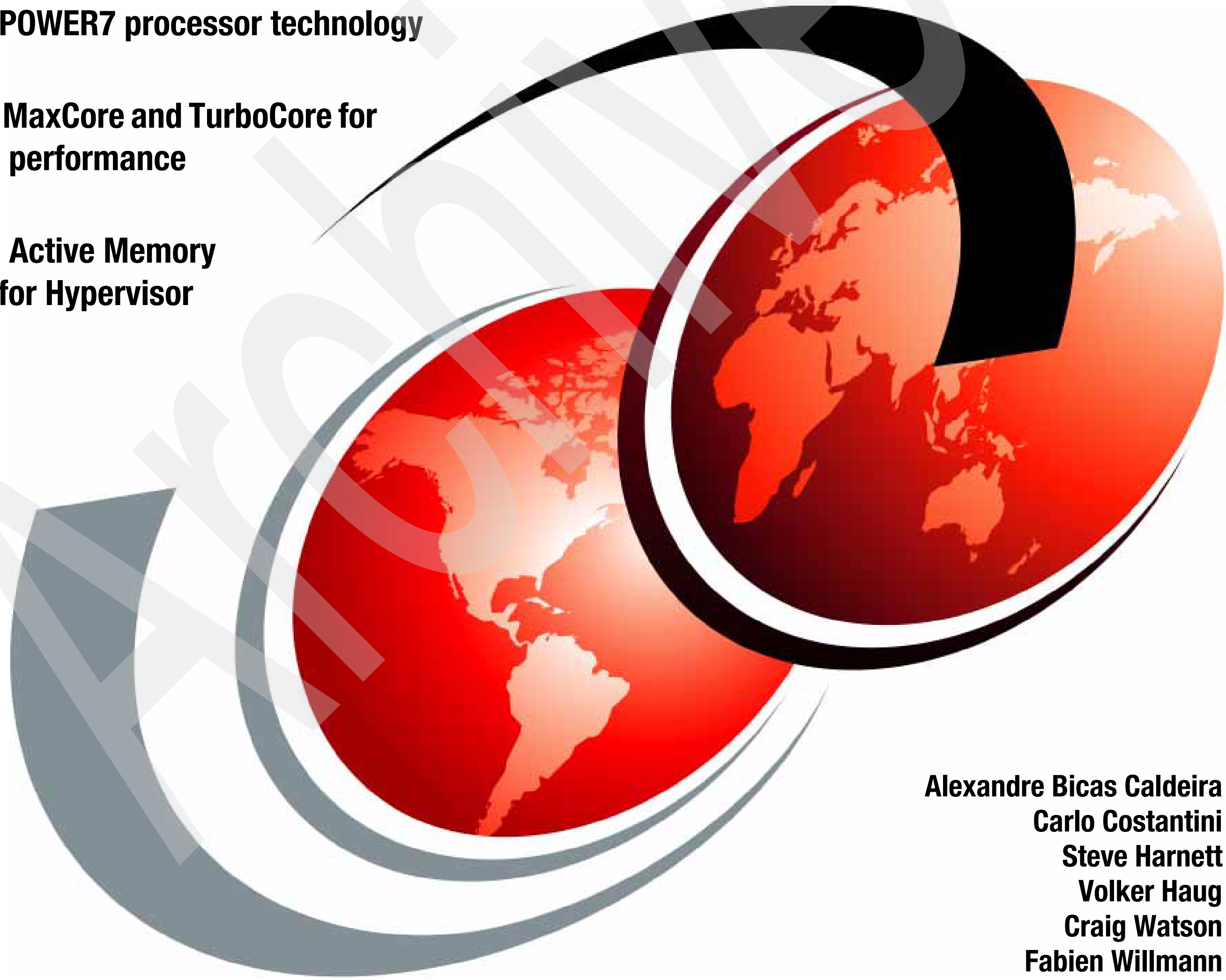
IBM Power 770 and 780 Technical Overview and Introduction

Features the 9117-MMC and 9179-MHC based on the latest POWER7 processor technology

Describes MaxCore and TurboCore for redefining performance

Discusses Active Memory Mirroring for Hypervisor



Alexandre Bicas Caldeira
Carlo Costantini
Steve Harnett
Volker Haug
Craig Watson
Fabien Willmann

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IBM Power 770 and 780 Technical Overview and Introduction

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Note: Before using this information and the product it supports, read the information in "Notices" on page vii.

First Edition (December 2011)

This edition applies to the IBM Power 770 (9117-MMC) and Power 780 (9179-MHC) Power Systems servers.

Contents

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Preface

This IBM® Redpaper™ publication is a comprehensive guide covering the IBM Power® 770 (9117-MMC) and Power 780 (9179-MHC) servers supporting IBM AIX®, IBM i, and Linux operating systems. The goal of this paper is to introduce the major innovative Power 770 and 780 offerings and their prominent functions, including these:

- The IBM POWER7® processor available at frequencies of 3.3 GHz, 3.44 GHz, 3.72 GHz, and 3.92 GHz, and 4.14 GHz
- The specialized IBM POWER7 Level 3 cache that provides greater bandwidth, capacity, and reliability
- The 1 Gb or 10 Gb Integrated Multifunction Card that provides two USB ports, one serial port, and four Ethernet connectors for a processor enclosure and does not require a PCI slot
- The new Active Memory™ Mirroring (AMM) for Hypervisor feature that mirrors the main memory used by the firmware
- IBM PowerVM® virtualization, including PowerVM Live Partition Mobility and PowerVM Active Memory Sharing
- Active Memory Expansion that provides more usable memory than what is physically installed on the system
- IBM EnergyScale™ technology that provides features such as power trending, power-saving, capping of power, and thermal measurement
- Enterprise-ready reliability, serviceability, and availability

Professionals who want to acquire a better understanding of IBM Power Systems™ products should read this Redpaper publication. The intended audience includes the following areas:

- Clients
- Sales and marketing professionals
- Technical support professionals
- IBM Business Partners
- Independent software vendors

This Redpaper publication expands the current set of IBM Power Systems documentation by providing a desktop reference that offers a detailed technical description of the Power 770 and Power 780 systems.

This paper does not replace the latest marketing materials and configuration tools. It is intended as an additional source of information that, together with existing sources, can be used to enhance your knowledge of IBM server solutions.

The team who wrote this paper

This paper was produced by a team of specialists from around the world working at the International Technical Support Organization, Poughkeepsie Center.

Alexandre Bicas Caldeira works on the Power Systems Field Technical Sales Support Team for IBM Brazil. He holds a degree in computer science from the Universidade Estadual Paulista (UNESP). Alexandre has more than 11 years of experience working for IBM and IBM

Business Partners on Power Systems hardware, AIX, and PowerVM virtualization products. He is also skilled on IBM System Storage®, IBM Tivoli® Storage Manager, IBM System x®, and VMware.

Carlo Costantini is a Certified IT Specialist for IBM and has over 33 years of experience with IBM and IBM Business Partners. He currently works in Italy Power Systems Platforms as Presales Field Technical Sales Support for IBM Sales Representatives and IBM Business Partners. Carlo has broad marketing experience, and his current areas of focus are competition, sales, and technical sales support. He is a Certified Specialist for Power Systems servers. He holds a master's degree in Electronic Engineering from Rome University.

Steve Harnett is a Senior Accredited Professional, Chartered IT Professional, and a member of the British Computing Society. He works as a pre-sales Technical Consultant in the IBM Server and Technology Group in the UK. Steve has over 16 years of experience of working in post sales supporting Power Systems. He is a product Topgun and a recognized SME in Electronic Service Agent™, Hardware Management Console, and high-end Power Systems. He also has several years of experience in developing and delivering education to clients, IBM Business Partners, and IBMers.

Volker Haug is a certified Consulting IT Specialist within the IBM Systems and Technology Group based in Ehningen, Germany. He holds a bachelor's degree in business management from the University of Applied Studies in Stuttgart. His career has included more than 24 years working in the IBM PLM and Power Systems divisions as a RISC and AIX Systems Engineer. Volker is an expert in Power Systems hardware, AIX, and PowerVM virtualization. He is a POWER7 Champion and a member of the German Technical Expert Council, an affiliate of the IBM Academy of Technology. He has written several books and white papers about AIX, workstations, servers, and PowerVM virtualization.

Craig Watson has 15 years of experience working with UNIX-based systems in roles including field support, systems administration, and technical sales. He has worked in the IBM Systems and Technology group since 2003 and is currently working as a Systems Architect, designing complex solutions for customers that include Power Systems, System x, and Systems Storage. He holds a master's degree in electrical and electronic engineering from the University of Auckland.

Fabien Willmann is an IT Specialist working with Techline Power Europe in France. He has 10 years of experience with Power Systems, AIX, and PowerVM virtualization. After teaching hardware courses about Power Systems servers, he joined ITS as an AIX consultant, where he developed his compentencies in AIX, HMC management, and PowerVM virtualization. Building new Power Systems configurations for STG presales is his major area of expertise today. He recently gave a workshop on the econfig configuration tool, focused on POWER7 processor-based BladeCenters during the symposium for French Business Partners in Montpellier.

The project that produced this publication was managed by:

Scott Vetter, IBM Certified Project Manager and PMP.

Thanks to the following people for their contributions to this project:

Larry Amy, Gary Anderson, Sue Beck, Terry Brennan, Pat Buckland, Paul D. Carey, Pete Heyrman, John Hilburn, Dan Hurlimann, Kevin Kehne, James Keniston, Jay Kruemcke, Robert Lowden, Hilary Melville, Thoi Nguyen, Denis C. Nizinski, Pat O'Rourke, Jan Palmer, Ed Prosser, Robb Romans, Audrey Romonosky, Todd Rosedahl, Melanie Steckham, Ken Trusits, Al Yanes
IBM U.S.A.

Stephen Lutz
IBM Germany

Tamikia Barrow
International Technical Support Organization, Poughkeepsie Center

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General description

The IBM Power 770 (9117-MMC) and IBM Power 780 servers (9179-MHC) utilize the latest POWER7 processor technology designed to deliver unprecedented performance, scalability, reliability, and manageability for demanding commercial workloads.

The innovative IBM Power 770 and Power 780 servers with POWER7 processors are symmetric multiprocessing (SMP), rack-mounted servers. These modular-built system uses one to four enclosures. Each enclosure is four EIA units (4U) tall and is housed in a 19-inch rack.

New to the Power 770 and Power 780 models are two new, powerful POWER7 processor cards. Each drawer contains a powerful POWER7 processor card and an enhanced POWER7 I/O backplane.

1.1 Systems overview

You can find detailed information about the Power 770 and Power 780 systems within the following sections.

1.1.1 IBM Power 770 server

Each Power 770 processor card features 64-bit architecture designed with two single-chip module (SCM) POWER7 processors. Each POWER7 SCM enables up to either six or eight active processor cores with 2 MB of L2 cache (256 KB per core), 24 MB of L3 cache (4 MB per core) for the 6-core SCM, and 32 MB of L3 cache (4 MB per core) for the 8-core SCM.

A Power 770 server using 6-core SCM processors will enable up to 48 processor cores running at frequencies of 3.72 GHz. A system configured with up to four CEC enclosures using 8-core SCM processors will enable up to 64 processor cores running at frequencies up to 3.30 GHz. The Power 770 server is available starting as low as four active cores and incrementing one core at a time through built-in Capacity on Demand (CoD) functions to a maximum of 64 active cores.

A single Power 770 CEC enclosure is equipped with 16 DIMM slots running at speeds up to 1066 MHz. A system configured with four drawers and 64 GB DDR3 DIMMs supports up to a maximum of 4.0 TB of DDR3 memory. All POWER7 DDR3 memory uses memory architecture that provides increased bandwidth and capacity. This enables operating at a higher data rate for large memory configurations.

The Power 770 has two new integrated POWER7 I/O controllers that enhance I/O performance while supporting a maximum of six internal PCIe adapters and six internal small form-factor SAS DASD bays.

The Power 770 features Active Memory Mirroring (AMM) for Hypervisor, which is available as an optional feature. AMM guards against system-wide outages due to any uncorrectable error associated with firmware. Also available as an option is Active Memory Expansion, which enhances memory capacity.

Figure 1-1 shows a Power 770 with the maximum four enclosures, and the front and rear views of a single-enclosure Power 770.

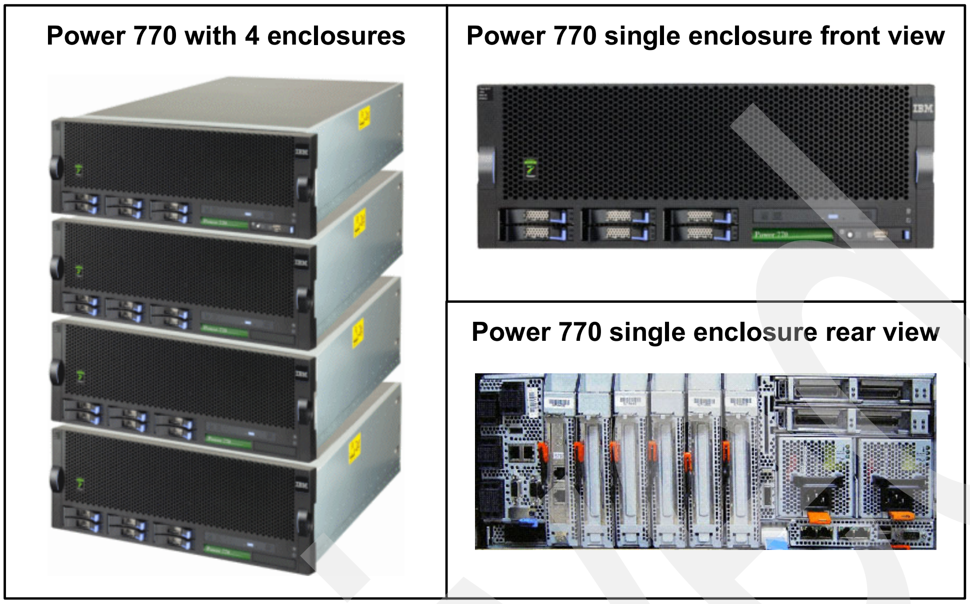

Figure 1-1 Four-enclosure Power 770, a single-enclosure Power 770 front and rear views

1.1.2 IBM Power 780 server

Each Power 780 processor card comprises either two single-chip module (SCM) POWER7 processors or four SCM POWER7 processors, each designed with 64-bit architecture. Each POWER7 SCM enables either up to six or eight active processor cores with 2 MB of L2 cache (256 KB per core, 24 MB of L3 cache (4 MB per core) for the 6-core SCM, and 32 MB of L3 cache (4 MB per core) for the 8-core SCM.

For the Power 780, each POWER7 SCM processor is available at frequencies of 3.44 GHz with six cores, 3.92 GHz with eight cores, or 4.14 GHz with four cores. The Power 780 server is available starting as low as four active cores and incrementing one core at a time through built-in Capacity on Demand (CoD) functions to a maximum of 96 active cores.

The Power 780 features the truly unique ability to switch between its standard throughput optimized mode and its unique TurboCore mode. In TurboCore mode performance per core is boosted with access to both additional cache and additional clock speed. Based on the user's configuration option, any Power 780 system can be booted in standard mode, enabling up to a maximum of 64 processor cores running at 3.92 GHz, or in TurboCore mode, enabling up to 32 processor cores running at 4.14 GHz and twice the cache per core.

Note: TurboCore mode is not supported on the 6-core processor card.

A single Power 770 CEC enclosure is equipped with 16 DIMM slots running at speeds up to 1066 MHz. A system configured with four drawers and 64 GB DDR3 DIMMs supports up to a maximum of 4.0 TB of DDR3 memory. All POWER7 DDR3 memory uses memory architecture that provides increased bandwidth and capacity. This enables operating at a higher data rate for large memory configurations.

The Power 780 has two new integrated POWER7 I/O controllers that enhance I/O performance while supporting a maximum of six internal PCIe adapters and six internal small form-factor SAS DASD bays.

The Power 780 features AMM for Hypervisor, which is available as a standard feature. AMM guards against system-wide outages due to any uncorrectable error associated with firmware. Also available as an option is Active Memory Expansion, which enhances memory capacity.

1.2 Operating environment

Table 1-1 lists the operating environment specifications for the servers.

Table 1-1 Operating environment for Power 770 and Power 780 (for one enclosure only)

Power 770 and Power 780 operating environment		
Description	**Operating**	**Non-operating**
Temperature	5 - 35 degrees C (41 to 95 degrees F)	5 - 45 degrees C (41 - 113 degrees F)
Relative humidity	20 - 80%	8 - 80%
Maximum dew point	29 degrees C (84 degrees F)	28 degrees C (82 degrees F)
Operating voltage	200 - 240 V ac	Not applicable
Operating frequency	50 - 60 +/- 3 Hz	Not applicable
Power consumption	Power 770: 1,600 watts maximum (per enclosure with 16 cores active) Power 780: 1,900 watts maximum (per enclosure with 24 cores active)	Not applicable
Power source loading	Power 770: 1.649 kVA maximum (per enclosure with 16 cores active) Power 780: 1.959 kVA maximum (per enclosure with 24 cores active)	Not applicable
Thermal output	Power 770: 5,461 Btu/hr maximum (per enclosure with 16 cores active) Power 780: 6,485 Btu/hr maximum (per enclosure with 24 cores active)	Not applicable
Maximum altitude	3048 m (10,000 ft)	Not applicable

Power 770 and Power 780 operating environment		
Description	**Operating**	**Non-operating**
Noise level for one enclosure	Power 770 (one enclosure with 16 active cores): 7.1 bels (operating/idle) 6.6 bels (operating/idle) with acoustic rack doors Power 780 (one enclosure with 24 active cores): 7.1 bels (operating/idle) 6.6 bels (operating/idle) with acoustic rack doors	
Noise level for four enclosures	Power 770 (four enclosure with 64 active cores): 7.6 bels (operating/idle) 7.1 bels (operating/idle) with acoustic rack doors Power 780 (four enclosure with 96 active cores): 7.6 bels (operating/idle) 7.1 bels (operating/idle) with acoustic rack doors	

1.3 Physical package

Table 1-2 lists the physical dimensions of an individual enclosure. Both servers are available only in a rack-mounted form factor. They are modular systems that can be constructed from one to four building-block enclosures. Each of these enclosures can take 4U (EIA units) of rack space. Thus, a two-enclosure system requires 8U, three enclosures require 12U, and four enclosures require 16U.

Table 1-2 Physical dimensions of a Power 770 and Power 780 enclosure

Dimension	Power 770 (Model 9117-MMC) single enclosure	Power 780 (Model 9179-MHC) single enclosure
Width	483 mm (19.0 in)	483 mm (19.0 in)
Depth	863 mm (32.0 in)	863 mm (32.0 in)
Height	174 mm (6.85 in), 4U (EIA units)	174 mm (6.85 in), 4U (EIA units)
Weight	70.3 kg (155 lb)	70.3 kg (155 lb)

Figure 1-2 shows the front and rear views of the Power 770 and Power 780.

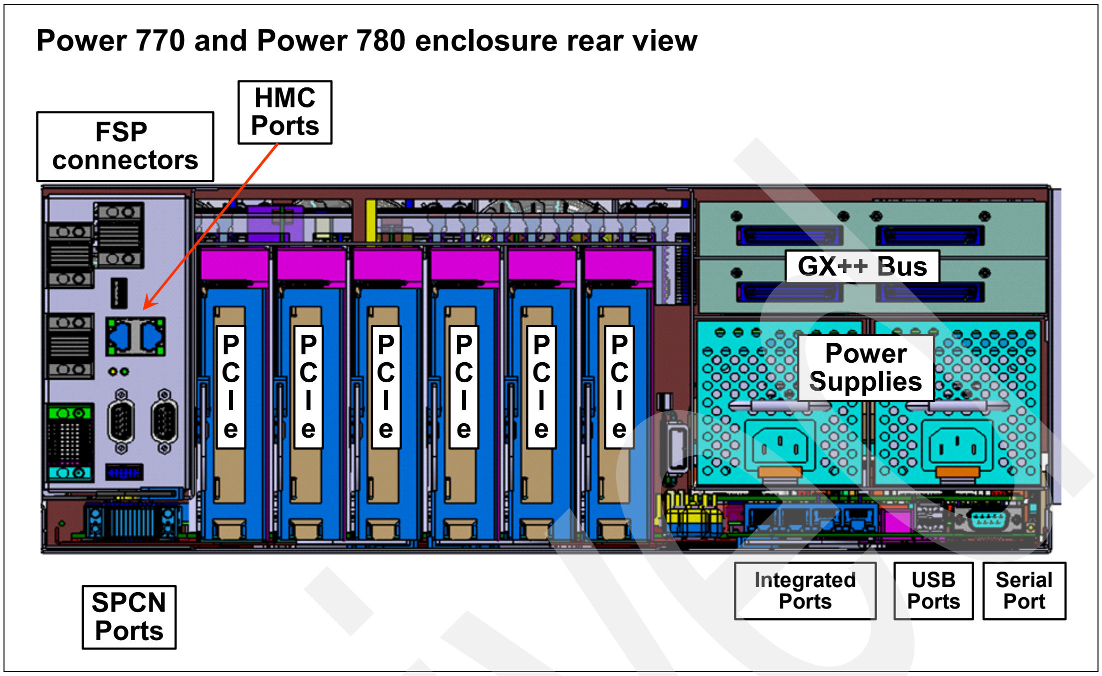

Figure 1-2 Front and rear views of the Power 770 and Power 780

1.4 System features

The Power 770 processor card features 64-bit architecture designed with two single-chip module (SCM) POWER7 processors. The Power 780 processor card comprises either two single-chip module (SCM) POWER7 processors or four SCM POWER7 processors, each designed with 64-bit architecture.

Each POWER7 SCM enables either up to six or eight active processor cores with 2 MB of L2 cache (256 KB per core), 24 MB of L3 cache (4 MB per core) for the 6-core SCM, and 32 MB of L3 cache (4 MB per core) for the 8-core SCM.

1.4.1 Power 770 system features

The following features are available on the Power 770:

- 4U 19-inch rack-mount system enclosure
- One to four system enclosures: 16U maximum system size
- One processor card feature per enclosure (includes the voltage regulator):
  - 0/12-core, 3.72 GHz processor card (#4983)
  - 0/16-core, 3.3 GHz processor card (#4984)
- POWER7 DDR3 Memory DIMMs (16 DIMM slots per CEC enclosure):
  - 0/32 GB (4 X 8 GB), 1066 MHz (#5600)
  - 0/64 GB (4 X 16 GB), 1066 MHz (#5601)
  - 0/128 GB (4 X 32 GB), 1066 MHz (#5602)
  - 0/256 GB (4 X 64 GB), 1066 MHz (#5564)
- Six hot-swappable, 2.5-inch, small form factor, SAS disk or SSD bays per enclosure

- One hot-plug, slim-line, SATA media bay per enclosure (optional)
- Redundant hot-swap AC power supplies in each enclosure
- Choice of Integrated Multifunction Card options; maximum one per enclosure:
  - Dual 10 Gb Copper and Dual 1 Gb Ethernet (#1768)
  - Dual 10 Gb Optical and Dual 1 Gb Ethernet (#1769)
- One serial port included on each Integrated Multifunction Card
- Two USB ports included on each Integrated Multifunction Card, plus another USB port on each enclosure (maximum nine usable per system)

> **Additional considerations:** Note the following considerations:
>
> - The Ethernet port of the Integrated Multifunction Card cannot be used for an IBM i console. Use separate Ethernet adapters that can be directly controlled by IBM i without the Virtual I/O server for IBM i LAN consoles if desired. Alternatively, an HMC can also be used for an IBM i console.
> - The first and second CEC enclosure must contain one Integrated Multifunction Card (#1768 or #1769). The Integrated Multifunction Card is optional for the third or fourth CEC enclosure.
> - Each Integrated Multifunction Card has four Ethernet ports, two USB ports, and one serial port. Usage of the serial port by AIX/Linux is supported for MODEM call home, TTY console, and snooping even if an HMC/SDMC is attached to the server. Usage by the serial port to communicate with a UPS is not supported.
> - The first and second CEC enclosures each have two HMC/SDMC ports on the service processor (#EU05). If there are two CEC enclosures, the HMC must be connected to both service processor cards.

- Two HMC ports per enclosure (maximum four per system)
- Eight I/O expansion slots per enclosure (maximum 32 per system)
  - Six Gen2 PCIe 8x slots plus two GX++ slots per enclosure
- Dynamic LPAR support, Processor and Memory CUoD
- PowerVM (optional)
  - Micro-Partitioning®
  - Virtual I/O Server (VIOS)
  - Automated CPU and memory reconfiguration support for dedicated and shared processor logical partition groups (dynamic LPAR)
  - Support for manual provisioning of resources, namely PowerVM Live Partition Migration (PowerVM Enterprise Edition)
- Optional PowerHA® for AIX, IBM i, and Linux
- 12X I/O drawer with PCI slots
  - Up to 16 PCIe I/O drawers (#5802 or #5877)
  - Up to 32 PCI-X DDR I/O drawers (7314-G30 or #5796)

- Disk-only I/O drawers
  - Up to 56 EXP24S SFF SAS I/O drawers on external SAS controller (#5887)
  - Up to 110 EXP12S SAS DASD/SSD I/O drawers on SAS PCI controllers (#5886)
  - Up to 60 EXP24 SCSI DASD Expansion drawers on SCSI PCI controllers (7031-D24)
- IBM Systems Director Active Energy Manager™

The Power 770 operator interface controls located on the front panel of the primary I/O drawer consist of a power ON/OFF button with a POWER® indicator, an LCD display for diagnostic feedback, a RESET button, and a disturbance or system attention LED.

1.4.2 Power 780 system features

The following features are available on the Power 780:

- 4U 19-inch rack-mount system enclosure
- One to four system enclosures: 16U maximum system size
- One processor card feature per enclosure (includes the voltage regulator):
  - 0/16 core, 3.92 GHz or 0/8 core, 4.14 GHz (TurboCore) processor card (#5003)
  - 0/24 core, 3.44 GHz processor card (#EP24)
- POWER7 DDR3 Memory DIMMs (16 DIMM slots per processor card):
  - 0/32 GB (4 X 8 GB), 1066 MHz (#5600)
  - 0/64 GB (4 X 16 GB), 1066 MHz (#5601)
  - 0/128 GB (4 X 32 GB), 1066 MHz (#5602)
  - 0/256 GB (4 X 64 GB), 1066 MHz (#5564)
- Six hot-swappable, 2.5-inch, small form factor, SAS disk or SSD bays per enclosure
- One hot-plug, slim-line, SATA media bay per enclosure (optional)
- Redundant hot-swap AC power supplies in each enclosure
- Choice of Integrated Multifunction Card options; maximum one per enclosure:
  - Dual 10 Gb Copper and Dual 1 Gb Ethernet (#1768)
  - Dual 10 Gb Optical and Dual 1 Gb Ethernet (#1769)
- One serial port included on each Integrated Multifunction Card
- Two USB ports included on each Integrated Multifunction Card plus another USB port on each enclosure (maximum nine usable per system)

Additional considerations: Note the following considerations:

- The Ethernet ports of the Integrated Multifunction Card cannot be used for an IBM i console. Separate Ethernet adapters that can be directly controlled by IBM i without the Virtual I/O server should be used for IBM i LAN consoles if desired. Alternatively, an HMC can also be used for an IBM i console.
- The first and second CEC enclosure must contain one Integrated Multifunction Card (#1768 or #1769). The Integrated Multifunction Card is optional for the third or fourth CEC enclosure.
- Each Integrated Multifunction Card has four Ethernet ports, two USB ports, and one serial port. Usage of the serial port by AIX/Linux is supported for MODEM call home, TTY console, and snooping even if an HMC/SDMC is attached to the server. Usage by the serial port to communicate with a UPS is not supported.
- The first and second CEC enclosures each have two HMC/SDMC ports on the service processor (#EU05). If there are two CEC enclosures, the HMC must be connected to both service processor cards.

- Two HMC ports per enclosure (maximum four per system)
- Eight I/O expansion slots per enclosure (maximum 32 per system)
  - Six Gen2 PCIe 8x slots plus two GX++ slots per enclosure
- Dynamic LPAR support, Processor and Memory CUoD
- PowerVM (optional):
  - Micro-Partitioning
  - Virtual I/O Server (VIOS)
  - Automated CPU and memory reconfiguration support for dedicated and shared processor logical partition (LPAR) groups
  - Support for manual provisioning of resources partition migration (PowerVM Enterprise Edition)
- Optional PowerHA for AIX, IBM i, and Linux
- 12X I/O drawer with PCI slots
  - Up to 16 PCIe I/O drawers (#5802 or #5877)
  - Up to 32 PCI-X DDR I/O drawers (7314-G30 or feature #5796)
- Disk-only I/O drawers
  - Up to 56 EXP24S SFF SAS I/O drawers on external SAS controller (#5887)
  - Up to 110 EXP12S SAS DASD/SSD I/O drawers on SAS PCI controllers (#5886)
  - Up to 60 EXP24 SCSI DASD Expansion drawers on SCSI PCI controllers (7031-D24)
- IBM Systems Director Active Energy Manager

The Power 780 operator interface/controls located on the front panel of the primary I/O drawer consist of a power ON/OFF button with a POWER indicator, an LCD display for diagnostic feedback, a RESET button, and a disturbance or system attention LED.

1.4.3 Minimum features

Each system has a minimum feature set in order to be valid. Table 1-3 shows the minimum system configuration for a Power 770.

Table 1-3 Minimum features for Power 770 system

Power 770 minimum features	Additional notes
1x CEC enclosure (4U)	► 1x System Enclosure with IBM Bezel (#5585) or OEM Bezel (#5586) ► 1x Service Processor (#5664) ► 1x DASD Backplane (#5652) ► 2x Power Cords (two selected by customer) – 2x A/C Power Supply (#5632) ► 1x Operator Panel (#1853) ► 1x Integrated Multifunction Card options (one of these): – Dual 10 Gb Copper and Dual 1 Gb Ethernet (#1768) – Dual 10 Gb Optical and Dual 1 Gb Ethernet (#1769)
1x primary operating system (one of these)	► AIX (#2146) ► Linux (#2147) ► IBM i (#2145)
1x Processor Card	► 0/12-core, 3.72 GHz processor card (#4983) ► 0/16-core, 3.3 GHz processor card (#4984)
4x Processor Activations (quantity of four for one of these)	► One Processor Activation for processor feature #4983 (#5329) ► One Processor Activation for processor feature #4984 (#5334)
2x DDR3 Memory DIMMs (one of these)	► 0/32 GB (4 X 8 GB), 1066 MHz (#5600) ► 0/64 GB (4 X 16 GB), 1066 MHz (#5601) ► 0/128 GB (4 X 32 GB), 1066 MHz (#5602) ► 0/256 GB (4 X 64 GB), 1066 MHz (#5564)
32x Activations of 1 GB DDR3 - POWER7 Memory (#8212)	-
For AIX and Linux: 1x disk drive For IBM i: 2x disk drives	Formatted to match the system Primary O/S indicator selected, or if using a Fibre Channel attached SAN (indicated by #0837) a disk drive is not required.
1X Language Group (selected by the customer)	-
1x Removable Media Device (#5762)	Optionally orderable, a standalone system (not network attached) would required this feature.
1x HMC	Required for every Power 770 (9117-MMC)

Power 770 minimum features	Additional notes
Note: Consider the following: ► A minimum number of four processor activations must be ordered per system. ► The minimum activations ordered with all initial orders of memory features #5600, #5601, and #5602 must be 50% of their installed capacity. ► The minimum activations ordered with MES orders of memory features #5600, #5601, and #5602 will depend on the total installed capacity of features #5600, #5601, and #5602. This allows newly ordered memory to be purchased with less than 50% activations when the currently installed capacity exceeds 50% of the existing features #5600, #5601, and #5602 capacity. ► The minimum activations ordered with all initial orders of memory feature #5564 must be 192 GB of 256 GB per each feature #5564 ordered (that is, 75% of the installed feature #5564 capacity). ► The minimum activations purchased with MES orders of feature #5564 memory, 0/256 GB, will depend on the total installed capacity of feature #5564. This allows MES orders of feature #5564 memory to be purchased with less than 192/256 GB per each feature #5564 ordered when the system activations currently installed exceed 75% of the existing feature #5564 capacity.	

Table 1-4 shows the minimum system configuration for a Power 780 system.

Table 1-4 Minimum features for Power 780 system

Power 780 minimum features	Additional notes
1x CEC enclosure (4U)	► 1x System Enclosure with IBM Bezel (#5595) or OEM Bezel (#5596) ► 1x Service Processor (#5664) ► 1x DASD Backplane (#5652) ► 2x Power Cords (two selected by customer) – 2x A/C Power Supply (#5532) ► 1x Operator Panel (#1853) ► 1x Integrated Multifunction Card options (one of these): – Dual 10 Gb Copper and Dual 1 Gb Ethernet (#1768) – Dual 10 Gb Optical and Dual 1 Gb Ethernet (#1769)
1x primary operating system (one of these)	► AIX (#2146) ► Linux (#2147) ► IBM i (#2145)
1x Processor Card (one of these)	► 0/16 core, 3.92 GHz or 0/8 core, 4.14 GHz (TurboCore) processor card (#5003) ► 0/24 core, 3.44 GHz processor card (#EP24)
4x Processor Activations for Processor Feature #4982 (#5469)	-
2x DDR3 Memory DIMM (one of these)	► 0/32 GB (4 X 8 GB), 1066 MHz (#5600) ► 0/64 GB (4 X 16 GB), 1066 MHz (#5601) ► 0/128 GB (4 X 32 GB), 1066 MHz (#5602) ► 0/256 GB (4 X 64 GB), 1066 MHz (#5564)
32x Activations of 1 GB DDR3 - POWER7 Memory (#8212)	-
For AIX and Linux: 1x disk drive For IBM i: 2x disk drives	Formatted to match the system Primary O/S indicator selected, or if using a Fibre Channel attached SAN (indicated by #0837) a disk drive is not required.
1X Language Group (selected by the customer)	-

<table>
<tr><th>Power 780 minimum features</th><th>Additional notes</th></tr>
<tr><td>1x Removable Media Device (#5762)</td><td>Optionally orderable, a standalone system (not network attached) requires this feature.</td></tr>
<tr><td>1x HMC</td><td>Required for every Power 780 (9179-MHC)</td></tr>
<tr><td colspan="2">Note the following considerations:
► A minimum number of four processor activations must be ordered per system.
► The minimum activations ordered with all initial orders of memory features #5600, #5601, and #5602 must be 50% of their installed capacity.
► The minimum activations ordered with MES orders of memory features #5600, #5601, and #5602 will depend on the total installed capacity of features #5600, #5601, and #5602. This allows newly ordered memory to be purchased with less than 50% activations when the currently installed capacity exceeds 50% of the existing features #5600, #5601, and #5602 capacity.
► The minimum activations ordered with all initial orders of memory feature #5564 must be 192 GB of 256 GB per each feature #5564 ordered (that is, 75% of the installed feature #5564 capacity).
► The minimum activations purchased with MES orders of feature #5564 memory, 0/256 GB, will depend on the total installed capacity of feature #5564. This allows MES orders of feature #5564 memory to be purchased with less than 192/256 GB per each feature #5564 ordered when the system activations currently installed exceed 75% of the existing feature #5564 capacity.</td></tr>
</table>

1.4.4 Power supply features

Two system AC power supplies are required for each CEC enclosure. The second power supply provides redundant power for enhanced system availability. To provide full redundancy, the two power supplies must be connected to separate power distribution units (PDUs).

A CEC enclosure will continue to function with one working power supply. A failed power supply can be hot-swapped but must remain in the system until the replacement power supply is available for exchange. The system requires one functional power supply in each CEC enclosure to remain operational.

Each Power 770 or Power 780 server with two or more CEC enclosures must have one Power Control Cable (#6006 or similar) to connect the service interface card in the first enclosure to the service interface card in the second enclosure.

1.4.5 Processor card features

Each of the four system enclosures contains one powerful POWER7 processor card feature, consisting of two single-chip module processors. Each of the POWER7 processors in the server has a 64-bit architecture, includes six or eight cores on a single-chip module, and contains 2 MB of L2 cache (256 KB per core), 24 MB of L3 cache (4 MB per core) for the 6-core SCM, and 32 MB of L3 cache (4 MB per core) for the 8-core SCM.

There are two types of Power 770 processor cards, offering the following features:

- Two 6-core POWER7 SCMs with 24 MB of L3 cache (12-cores per processor card, each core with 4 MB of L3 cache) at 3.72 GHz (#4983)
- Two 8-core POWER7 SCMs with 32 MB of L3 cache (16-cores per processor card, each core with 4 MB of L3 cache) at 3.3 GHz (#4984)

The Power 780 has two types of processor cards. One of these has two different processing modes (MaxCore and TurboCore).

The processor card houses the two or four POWER7 SCMs and the system memory. The Power 780 processor card offers the following features:

- Feature #5003 offers two 8-core POWER7 SCMs with 32 MB of L3 cache (16 cores per processor card are activated in MaxCore mode and each core with 4 MB of L3 cache) at 3.92 GHz.
- Feature #5003 also offers two 8-core POWER7 SCMs with 32 MB of L3 cache (8 cores per processor card are activated in TurboCore mode and each core is able to use 8 MB of L3 cache) at 4.14 GHz.
- Feature #EP24 offers four 6-core POWER7 SCMs with 24 MB of L3 cache (24 cores per processor card, each core with 4 MB of L3 cache) at 3.44 GHz.

Figure 1-3 shows the top view of the Power 770 and Power 780 system having two SCMs installed. The two POWER7 SCMs and the system memory reside on a single processor card feature.

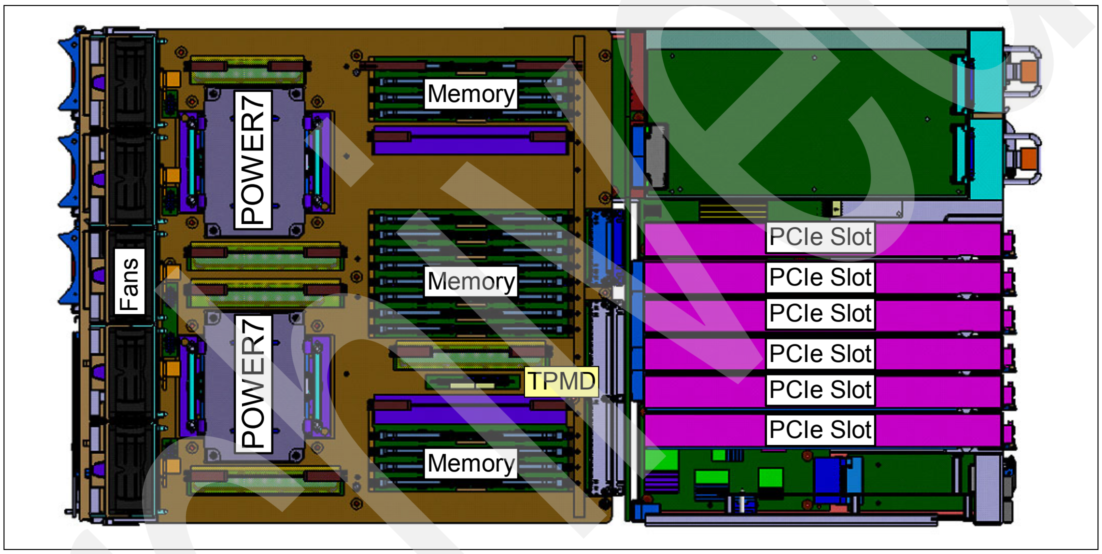

Figure 1-3 Top view of Power 770 and Power 780 system with two SCMs

Figure 1-4 shows the top view of the Power 780 system having four SCMs installed. The four POWER7 SCMs and the system memory reside on a single processor card feature.

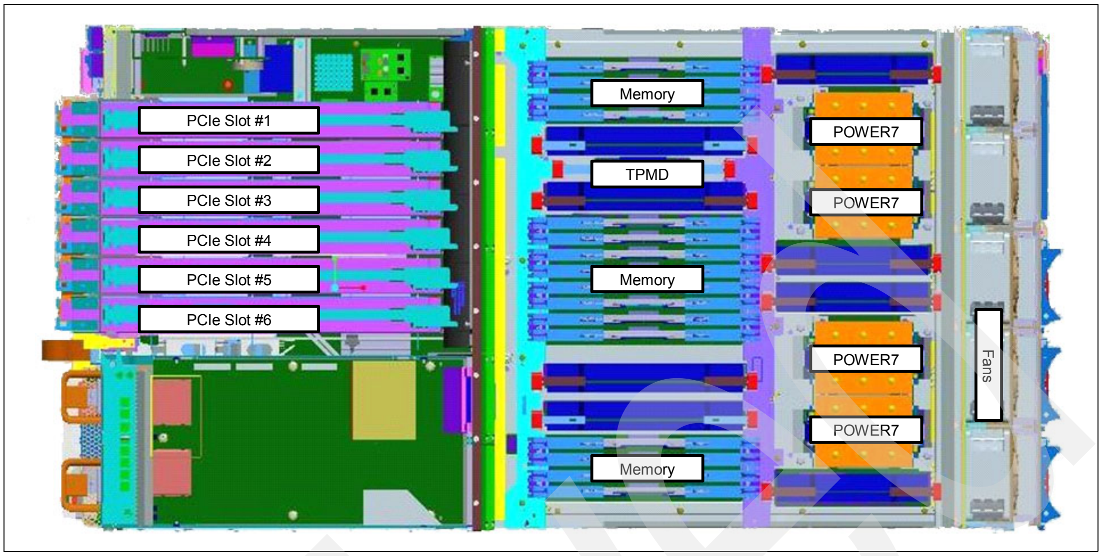

Figure 1-4 Top view of a Power 780 system with four SCMs

In standard or MaxCore mode, the Power 780 system uses all processor cores running at 3.92 GHz and has access to the full 32 MB of L3 cache. In TurboCore mode, only four of the eight processor cores are available, but at a higher frequency (4.14 GHz), and these four cores have access to the full 32 MB of L3 cache. Thus, in Turbo-core mode there are fewer cores running at a higher frequency and a higher core-to-L3-cache ratio.

Note: TurboCore mode is supported on the Power 780, but is not supported on the Power 770.

For a more detailed description of MaxCore and TurboCore modes, see 2.1.5, “Flexible POWER7 processor packaging and offerings” on page 44.

Several types of Capacity on Demand (CoD) processors are optionally available on the Power 770 and Power 780 servers to help meet changing resource requirements in an on demand environment by using resources installed on the system but not activated. CoD allows you to purchase additional permanent processor or memory capacity and dynamically activate it when needed.

More detailed information about CoD can be found in 2.4, “Capacity on Demand” on page 60.

1.4.6 Summary of processor features

Table 1-5 summarizes the processor feature codes for the Power 770.

Table 1-5 Summary of processor features for the Power 770

Feature code	Description	OS support
#4983	0/12-core 3.72 GHz POWER7 processor card: 12-core 3.72 GHz POWER7 CUoD processor planar containing two six-core processors. Each processor has 2 MB of L2 cache (256 KB per core) and 32 MB of L3 cache (4 MB per core). There are 16 DDR3 DIMM slots on the processor planar (8 DIMM slots per processor), which can be used as Capacity on Demand (CoD) memory without activating the processors. The voltage regulators are included in this feature code.	AIX IBM i Linux
#5329	One processor activation for processor #4983: Each occurrence of this feature permanently activates one processor on Processor Card #4983. One processor activation for processor feature #4983 with inactive processors.	AIX IBM i Linux
#5330	Processor CoD utility billing for #4983, 100 processor-minutes: Provides payment for temporary use of processor feature #4983 with supported AIX or Linux operating systems. Each occurrence of this feature will pay for 100 minutes of usage. The purchase of this feature occurs after the customer has 100 minutes of use on processor cores in the Shared Processor Pool that are not permanently active.	AIX Linux
#5331	Processor CoD utility billing for #4983, 100 processor-minutes: Provides payment for temporary use of processor feature #4983 with supported IBM i operating systems. Each occurrence of this feature will pay for 100 minutes of usage. The purchase of this feature occurs after the customer has 100 minutes of use on processor cores in the Shared Processor Pool that are not permanently active.	IBM i
#5332	One processor-day on/off billing for #4983: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/Off Processor Core Day Billing features and bill you. One #5332 must be ordered for each billable processor core day of feature #4983 used by a supported AIX or Linux operating system.	AIX Linux
#5333	One processor-day on/off billing for #4983: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/Off Processor Core Day Billing features and the client will be charged. One #5333 must be ordered for each billable processor core day of feature #4983 used by a supported IBM i operating system.	IBM i

Feature code	Description	OS support
#4984	0/16-core 3.3 GHz POWER7 processor card: 16-core 3.3 GHz POWER7 CUoD processor planar containing two eight-core processors. Each processor has 2 MB of L2 cache (256 KB per core) and 32 MB of L3 cache (4 MB per core). There are 16 DDR3 DIMM slots on the processor planar (8 DIMM slots per processor), which can be used as Capacity on Demand (CoD) memory without activating the processors. The voltage regulators are included in this feature code.	AIX IBM i Linux
#5334	One processor activation for processor #4984: Each occurrence of this feature will permanently activate one processor on Processor Card #4984. One processor activation for processor feature #4984 with inactive processors.	AIX IBM i Linux
#5335	Processor CoD utility billing for #4984, 100 processor-minutes: Provides payment for temporary use of processor feature #4984 with supported AIX or Linux operating systems. Each occurrence of this feature will pay for 100 minutes of usage. The purchase of this feature occurs after the customer has 100 minutes of use on processor cores in the Shared Processor Pool that are not permanently active.	AIX Linux
#5336	Processor CoD utility billing for #4984, 100 processor-minutes: Provides payment for temporary use of processor feature #4984 with supported IBM i operating systems. Each occurrence of this feature will pay for 100 minutes of usage. The purchase of this feature occurs after the customer has 100 minutes of use on processor cores in the Shared Processor Pool that are not permanently active.	IBM i
#5337	One processor-day on/off billing for #4984: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/Off Processor Core Day Billing features and the client will be charged. One #5337 must be ordered for each billable processor core day of feature #4984 used by a supported AIX or Linux operating system.	AIX Linux
#5338	One processor-day on/off billing for #4984: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/Off Processor Core Day Billing features and the client will be charged. One #5338 must be ordered for each billable processor core day of feature #4984 used by a supported IBM i operating system.	IBM i
#7951	On/off processor enablement: This feature can be ordered to enable your server for On/Off Capacity on Demand. After it is enabled, you can request processors on a temporary basis. You must sign an On/Off Capacity on Demand contract before you order this feature. Note: To renew this feature after the allowed 360 processor days have been used, this feature must be removed from the system configuration file and reordered by placing an MES order.	AIX Linux IBM i

Table 1-6 summarizes the processor feature codes for the Power 780.

Table 1-6 Summary of processor features for the Power 780

Feature code	Description	OS support
#5003	0/16 core 3.92 GHz / 4.14 GHz POWER7 Turbocore processor card: This feature has two modes. Standard mode utilizes all 16 cores at 3.92 GHz and TurboCore mode utilizes eight cores at 4.14 GHz. This feature is a POWER7 CUoD processor planar containing two 8-core processors. TurboCore mode utilizes cores one through eight with enhanced memory caching. TurboCore mode must be turned off when you want to utilize more than eight cores. Switching between modes requires a system reboot.	AIX IBM i Linux
#5333	1-core activation for processor feature #5003: Each occurrence of this feature will permanently activate one processor core on Processor Card #5003.	AIX IBM i Linux
#EP2L	100 on/off processor days of CoD billing for processor #5003: After the ON/OFF Processor function is enabled in a system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is provided to your sales channel. The sales channel will place an order on your behalf for the quantity of this feature that matches your reported use. One #EP2L provides 100 days of on/off processor billing for POWER7 CoD Processor Book #5003 for AIX/Linux.	AIX Linux
#EP2M	100 on/off processor days of CoD billing for processor #5003: After the ON/OFF Processor function is enabled in a system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is provided to your sales channel. The sales channel will place an order on your behalf for the quantity of this feature that matches your reported use. One #EP2M provides 100 days of on/off processor billing for POWER7 CoD Processor Book #5003 for IBM i.	IBM i
#5342	One processor day on/off billing for #5003: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/ Off Processor Core Day Billing features and the client will be charged. One #5342 must be ordered for each billable processor core day of feature #5003 used by a supported AIX or Linux operating system.	AIX Linux
#5343	One processor day on/off billing for #5003: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/ Off Processor Core Day Billing features and the client will be charged. One #5343 must be ordered for each billable processor core day of feature #5003 used by a supported IBM i operating system.	IBM i

Feature code	Description	OS support
#EP24	0/24 core 3.44 GHz POWER7 processor card: 24-core 3.44 GHz POWER7 CUoD processor planar containing four 6-core processors. Each processor has 2 MB of L2 cache (256 KB per core) and 32 MB of L3 cache (4 MB per core). There are 16 DDR3 DIMM slots on the processor planar (eight DIMM slots per processor), which can be used as CoD memory without activating the processors. The voltage regulators are included in this feature code.	AIX IBM i Linux
#EP25	1-core activation for processor feature #EP24: Each occurrence of this feature will permanently activate one processor core on Processor Card #EP24.	AIX Linux IBM i
#EP2N	100 on/off processor days of CoD billing for processor #EP24: After the ON/OFF Processor function is enabled in a system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is provided to your sales channel. The sales channel will place an order on your behalf for the quantity of this feature that matches your reported use. One #EP2N provides 100 days of on/off processor billing for POWER7 CoD Processor Book #EP24 for AIX/Linux.	AIX Linux
#EP2P	100 on/off processor days of CoD billing for processor #EP24: After the ON/OFF Processor function is enabled in a system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is provided to your sales channel. The sales channel will place an order on your behalf for the quantity of this feature that matches your reported use. One #EP2P provides 100 days of on/off processor billing for POWER7 CoD Processor Book #EP24 for IBM i.	IBM i
#EP28	One processor day on/off billing for #EP24: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/ Off Processor Core Day Billing features and the client will be charged. One #EP27 must be ordered for each billable processor core day of feature #EP24 used by a supported AIX or Linux operating system.	AIX Linux
#EP29	One processor day on/off billing for #EP24: After an On/Off Processor Enablement feature is ordered and the associated enablement code is entered into the system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is then provided to your sales channel. The sales channel will place an order for a quantity of On/ Off Processor Core Day Billing features and the client will be charged. One #EP29 must be ordered for each billable processor core day of feature #EP24 used by a supported IBM i operating system.	IBM i
#7951	On/Off Processor Enablement: This feature can be ordered to enable your server for On/Off Capacity on Demand. After it is enabled, you can request processors on a temporary basis. You must sign an On/Off Capacity on Demand contract before you order this feature. Note: To renew this feature after the allowed 360 processor days have been used, this feature must be removed from the system configuration file and reordered by placing an MES order.	AIX Linux IBM i

1.4.7 Memory features

In POWER7 systems, DDR3 memory is used throughout. The POWER7 DDR3 memory uses a memory architecture to provide greater bandwidth and capacity. This enables operating at a higher data rate for large memory configurations. All processor cards have 16 memory DIMM slots (eight per processor) running at speeds up to 1066 MHz and must be populated with POWER7 DDR3 Memory DIMMs.

Figure 1-5 outlines the general connectivity of an 8-core POWER7 processor and DDR3 memory DIMMS. The eight memory channels (four per memory controller) can be clearly seen.

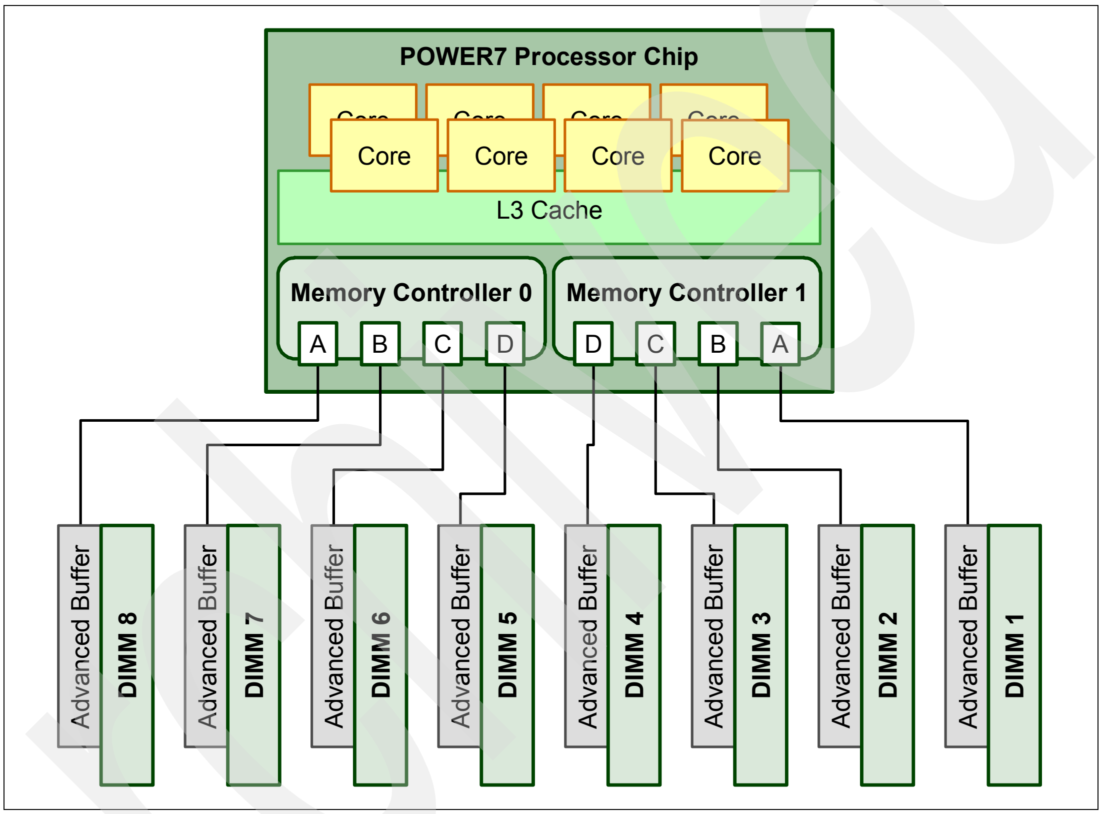

Figure 1-5 Outline of 8-core POWER7 processor connectivity to DDR3 DIMMs - Used in a 2-socket Power 770 and Power 780

On each processor card for the Power 770 and Power 780 there is a total of 16 DDR3 memory DIMM slots to be connected. When using two SCMs per card, eight DIMM slots are used per processor, and when using four SCMs per card in the Power 780 server, four DIMM slots are used per processor.

The quad-high (96 mm) DIMM cards can have an 8 GB, 16 GB, 32 GB, or 64 GB capacity and are connected to the POWER7 processor memory controller through an advanced memory buffer ASIC. For each DIMM, there is a corresponding memory buffer. Each memory channel into the POWER7 memory controllers is driven at 6.4 GHz.

Each DIMM (except the 64 GB DIMM) contains DDR3 x8 DRAMs in a configuration, with 10 DRAMs per rank, and plugs into a 276-pin DIMM slot connector. The 64 GB DIMM is an 8-rank DIMM using x4 parts (1024Kx4). The x4 DIMMs are 20 DRAMs per rank.

> **Note:** DDR2 DIMMs (used in POWER6®-based systems) are not supported in POWER7-based systems.

The Power 770 and Power 780 have memory features in 32 GB, 64 GB, 128 GB, and 256 GB capacities. Table 1-7 summarizes the capacities of the memory features and highlights other characteristics.

Table 1-7 Summary of memory features

Feature code	Memory technology	Capacity	Access rate	DIMMs	DIMM slots used
#5600	DDR3	32 GB	1066 MHz	4 x 8 GB DIMMs	4
#5601	DDR3	64 GB	1066 MHz	4 x 16 GB DIMMs	4
#5602	DDR3	128 GB	1066 MHz	4 x 32 GB DIMMs	4
#5564	DDR3	256 GB	1066 MHz	4 x 64 GB DIMM	4

None of the memory in these features is active. Feature number #8212 or #8213 must be purchased to activate the memory. Table 1-8 outlines the memory activation feature codes and corresponding memory capacity activations.

Table 1-8 CoD system memory activation features

Feature code	Activation capacity	Additional information	OS support
#8212	1 GB	Activation of 1 GB of DDR3 POWER7 memory. Each occurrence of this feature permanently activates 1 GB of DDR3 POWER7 memory.	AIX IBM i Linux
#8213	100 GB	Activation of 100 GB of DDR3 POWER7 memory. Each occurrence of this feature permanently activate 100 GB of DDR3 POWER7 memory.	AIX IBM i Linux
#7954	N/A	On/Off Memory Enablement: This feature can be ordered to enable your server for On/Off Capacity on Demand. After it is enabled, you can request memory on a temporary basis. You must sign an On/Off Capacity on Demand contract before this feature is ordered. To renew this feature after the allowed 999 GB Days have been used, this feature must be removed from the system configuration file and reordered by placing an MES order.	AIX IBM i Linux
#4710	N/A	On/Off 999 GB-Days, Memory Billing POWER7: After the ON/OFF Memory function is enabled in a system, you must report your on/off usage to IBM at least monthly. This information, used to compute your billing data, is provided to your sales channel. The sales channel will place an order on your behalf for the quantity of this feature that matches your reported use. One #4710 feature must be ordered for each 999 billable days for each 1 GB increment of POWER7 memory that was used.	AIX IBM i Linux

Feature code	Activation capacity	Additional information	OS support
#7377	N/A	On/Off, 1 GB-1Day, Memory Billing POWER7: After the ON/OFF Memory function is enabled in a system you must report the client’s on/off usage to IBM on a monthly basis. This information is used to compute IBM billing data. One #7377 feature must be ordered for each billable day for each 1 GB increment of POWER7 memory that was used. Note that inactive memory must be available in the system for temporary use.	AIX IBM i Linux
Note: ► All POWER7 memory features must be purchased with sufficient permanent memory activation features so that the system memory is at least 50% active. ► The minimum activations ordered with all initial orders of memory feature #5564 must be 192 GB of 256 GB per each feature #5564 ordered (that is, 75% of the installed feature #5564 capacity).			

> **Note:** Memory CoD activations activate memory hardware only for the system serial number for which they are purchased. If memory hardware is moved to another system, the memory might not be functional in that system until arrangements are made to move the memory activations or purchase additional memory activations.

1.5 Disk and media features

Each system building block features two SAS DASD controllers with six hot-swappable 2.5-inch Small Form Factor (SFF) disk bays and one hot-plug, slim-line media bay per enclosure. The SFF SAS disk drives and Solid State Drive (SSD) are supported internally. In a full configuration with four connected building blocks, the combined system supports up to 24 disk bays. SAS drives and SSD drives can share the same backplane.

Table 1-9 shows the available disk drive feature codes that each bay can contain.

Table 1-9 Disk drive feature code description

Feature code	Description	OS support
#1886	146 GB 15 K RPM SFF SAS Disk Drive	AIX, Linux
#1917	146 GB 15 K RPM SAS SFF-2 Disk Drive	AIX, Linux
#1995	177 GB SSD Module with eMLC	AIX, Linux
#1775	177 GB SFF-1 SSD with eMLC	AIX, Linux
#1793	177 GB SFF-2 SSD with eMLC	AIX, Linux
#1925	300 GB 10 K RPM SAS SFF-2 Disk Drive	AIX, Linux
#1885	300 GB 10 K RPM SFF SAS Disk Drive	AIX, Linux
#1880	300 GB 15 K RPM SAS SFF Disk Drive	AIX, Linux
#1953	300 GB 15 K RPM SAS SFF-2 Disk Drive	AIX, Linux

Feature code	Description	OS support
#1790	600 GB 10 K RPM SAS SFF Disk Drive	AIX, Linux
#1964	600 GB 10 K RPM SAS SFF-2 Disk Drive	AIX, Linux
#1947	139 GB 15 K RPM SAS SFF-2 Disk Drive	IBM i
#1888	139 GB 15 K RPM SFF SAS Disk Drive	IBM i
#1996	177 GB SSD Module with eMLC	IBM i
#1787	177 GB SFF-1 SSD with eMLC	IBM i
#1794	177 GB SFF-2 SSD with eMLC	IBM i
#1956	283 GB 10 K RPM SAS SFF-2 Disk Drive	IBM i
#1911	283 GB 10 K RPM SFF SAS Disk Drive	IBM i
#1879	283 GB 15 K RPM SAS SFF Disk Drive	IBM i
#1948	283 GB 15 K RPM SAS SFF-2 Disk Drive	IBM i
#1916	571 GB 10 K RPM SAS SFF Disk Drive	IBM i
#1962	571 GB 10 K RPM SAS SFF-2 Disk Drive	IBM i

Certain adapters are available for order in large quantities. Table 1-10 lists the disk drives available in a quantity of 150.

Table 1-10 Available disk drives in quantity of 150

Feature code	Description	OS support
#7550	Quantity 150 of #1790 (600 GB 10 K RPM SAS SFF Disk Drive)	AIX, Linux
#1928	Quantity 150 of #1880 (300 GB 15 K RPM SAS SFF Disk Drive)	AIX, Linux
#7547	Quantity 150 of #1885 (300 GB 10 K RPM SFF SAS Disk Drive)	AIX, Linux
#7548	Quantity 150 of #1886 (146 GB 15 K RPM SFF SAS Disk Drive)	AIX, Linux
#1866	Quantity 150 of #1917 (146 GB 15 K RPM SAS SFF-2 Disk Drive)	AIX, Linux
#1869	Quantity 150 of #1925 (300 GB 10 K RPM SAS SFF-2 Disk Drive)	AIX, Linux
#1929	Quantity 150 of #1953 (300 GB 15 K RPM SAS SFF-2 Disk Drive)	AIX, Linux
#1818	Quantity 150 of #1964 (600 GB 10 K RPM SAS SFF-2 Disk Drive)	AIX, Linux
#1926	Quantity 150 of #1879 (283 GB 15 K RPM SAS SFF Disk Drive)	IBM i
#7544	Quantity 150 of #1888 (139 GB 15 K RPM SFF SAS Disk Drive)	IBM i
#7557	Quantity 150 of #1911(283 GB 10 K RPM SFF SAS Disk Drive)	IBM i
#7566	Quantity 150 of #1916 (571 GB 10 K RPM SAS SFF Disk Drive)	IBM i
#1868	Quantity 150 of #1947 (139 GB 15 K RPM SAS SFF-2 Disk Drive)	IBM i
#1927	Quantity 150 of #1948 (283 GB 15 K RPM SAS SFF-2 Disk Drive)	IBM i
#1844	Quantity 150 of #1956 (283 GB 10 K RPM SAS SFF-2 Disk Drive)	IBM i
#1817	Quantity 150 of #1962 (571 GB 10 K RPM SAS SFF-2 Disk Drive)	IBM i

The Power 770 and Power 780 support both 2.5-inch and 3.5-inch SAS SFF hard disks. The 3.5-inch DASD hard disk can be attached to the Power 770 and Power 780 but must be located in a feature #5886 EXP12S I/O drawer, whereas 2.5-inch DASD hard files can be either mounted internally or in the EXP24S SFF Gen2-bay Drawer (#5887).

If you need more disks than available with the internal disk bays, you can attach additional external disk subsystems. For more detailed information about the available external disk subsystems, see 2.11, “External disk subsystems” on page 92.

SCSI disks are not supported in the Power 770 and 780 disk bays. However, if you want to use SCSI disks, you can attach existing SCSI disk subsystems.

The disk/media backplane feature #5652 provides six SFF disk slots and one SATA media slot. In a full configuration with four connected building blocks, the combined system supports up to four media devices with Media Enclosure and Backplane #5652. The SATA Slimline DVD-RAM drive (#5762) is the only supported media device option.

1.6 I/O drawers

The system has eight I/O expansion slots per enclosure, including two dedicated GX++ slots. If more PCI slots are needed, such as to extend the number of LPARs, up to 32 PCI-DDR 12X Expansion Drawers (#5796) and up to 16 12X I/O Drawer PCIe (#5802 and #5877) can be attached.

The Power 770 and the Power 780 servers support the following 12X attached I/O drawers, providing extensive capability to expand the overall server expandability and connectivity:

- Feature #5802 provides PCIe slots and SFF SAS disk slots.
- Feature #5877 provides PCIe slots.
- Feature #5796 provides PCI-X slots.
- The 7314-G30 drawer provides PCI-X slots (supported, but no longer orderable).

Disk-only I/O drawers are also supported, providing large storage capacity and multiple partition support:

- Feature #5886 EXP 12S holds a 3.5-inch SAS disk or SSD.
- Feature #5887 EXP 24S SFF Gen2-bay Drawer for high-density storage holds SAS Hard Disk drives.
- The 7031-D24 holds a 3.5-inch SCSI disk (supported but no longer orderable).
- The 7031-T24 holds a 3.5-inch SCSI disk (supported but no longer orderable).

1.6.1 PCI-DDR 12X Expansion Drawers (#5796)

The PCI-DDR 12X Expansion Drawer (#5796) is a 4U tall (EIA units) drawer and mounts in a 19-inch rack. Feature #5796 takes up half the width of the 4U (EIA units) rack space. Feature #5796 requires the use of a #7314 drawer mounting enclosure. The 4U vertical enclosure can hold up to two #5796 drawers mounted side by side in the enclosure. A maximum of four #5796 drawers can be placed on the same 12X loop.

The I/O drawer has the following attributes:

- A 4U (EIA units) rack-mount enclosure (#7314) holding one or two #5796 drawers
- Six PCI-X DDR slots: 64-bit, 3.3 V, 266 MHz (blind-swap)
- Redundant hot-swappable power and cooling units

1.6.2 12X I/O Drawer PCIe (#5802 and #5877)

The #5802 and #5877 expansion units are 19-inch, rack-mountable, I/O expansion drawers that are designed to be attached to the system using 12X double data rate (DDR) cables. The expansion units can accommodate 10 generation 3 cassettes. These cassettes can be installed and removed without removing the drawer from the rack.

A maximum of two #5802 drawers can be placed on the same 12X loop. Feature #5877 is the same as #5802, except it does not support disk bays. Feature #5877 can be on the same loop as #5802. Feature #5877 cannot be upgraded to #5802.

The I/O drawer has the following attributes:

- Eighteen SAS hot-swap SFF disk bays (only #5802)
- Ten PCI Express (PCIe) based I/O adapter slots (blind-swap)
- Redundant hot-swappable power and cooling units

Note: Mixing #5802 or 5877 and #5796 on the same loop is not supported.

1.6.3 EXP 12S SAS Drawer

The EXP 12S SAS drawer (#5886) is a 2 EIA drawer and mounts in a 19-inch rack. The drawer can hold either SAS disk drives or SSD. The EXP 12S SAS drawer has twelve 3.5-inch SAS disk bays with redundant data paths to each bay. The SAS disk drives or SSDs contained in the EXP 12S are controlled by one or two PCIe or PCI-X SAS adapters connected to the EXP 12S via SAS cables.

1.6.4 EXP 24S SFF Gen2-bay Drawer

The EXP24S SFF Gen2-bay Drawer is an expansion drawer supporting up to twenty-four 2.5-inch hot-swap SFF SAS HDDs on POWER6 or POWER7 servers in 2U of 19-inch rack space. The EXP24S bays are controlled by SAS adapters/controllers attached to the I/O drawer by SAS X or Y cables.

The SFF bays of the EXP24S are different from the SFF bays of the POWER7 system units or 12X PCIe I/O drawers (#5802 and #5803). The EXP24S uses Gen2 or SFF-2 SAS drives that physically do not fit in the Gen1 or SFF-1 bays of the POWER7 system unit or 12X PCIe I/O Drawers, or vice versa.

1.6.5 I/O drawers and usable PCI slot

The I/O drawer model types can be intermixed on a single server within the appropriate I/O loop. Depending on the system configuration, the maximum number of I/O drawers that is supported differs.

Table 1-11 summarizes the maximum number of I/O drawers supported and the total number of PCI slots available when expansion consists of a single drawer type.

Table 1-11 Maximum number of I/O drawers supported and total number of PCI slots

System drawers	Max #5796 drawers	Max #5802 and #5877 drawers	Total number of slots			
			#5796		#5802 and #5877	
			PCI-X	PCIe	PCI-X	PCIe
1 drawer	8	4	48	6	0	46
2 drawers	16	8	96	12	0	92
3 drawers	24	12	144	18	0	138
4 drawers	32	16	192	24	0	184

Table 1-12 summarizes the maximum number of disk-only I/O drawers supported.

Table 1-12 Maximum number of disk only I/O drawers supported

Server	Max #5886 drawers	Max #5887 drawers
Power 770	110	56
Power 780	110	56

1.7 Comparison between models

The Power 770 offers configuration options, where the POWER7 processor can have one of two different processor cards installed. Both contain two Single Chip Module (SCM) cards. These cards can contain the following processor configurations:

- Two socket card: Eight cores at 3.3 GHz
- Two socket card: Six cores at 3.72 GHz.

Both of these Power 770 models are available starting as low as four active cores and incrementing one core at a time through built-in CoD functions to a maximum of 48 active cores with the 3.72 GHz processor or 64 active cores with the 3.3 GHz processor.

The Power 780 offers configuration options where the POWER7 processor can have one of two processor cards installed. These are either a two-socket SCM card or four SCM cards. These processor cards contain the following processor configurations:

- Two socket card: Eight cores at 3.92 GHz (MaxCore mode) or four cores at 4.14 GHz (TurboCore mode)
- Four socket card: Six cores at 3.44 GHz

Both of these Power 780 models are available starting as low as four active cores and incrementing one core at a time through built-in CoD functions to a maximum of 64 active cores with the 3.92 GHz processor or 96 active cores with the 3.44 GHz processor.

Table 1-13 summarizes the processor core options and frequencies and matches them to the L3 cache sizes for the Power 770 and Power 780.

Table 1-13 Summary of processor core counts, core frequencies, and L3 cache sizes

System	Cores per POWER7 SCM	Frequency (GHz)	L3 cache[a]	Enclosure summation[b]	System maximum (cores)[c]
Power 770	6	3.72	24 MB	12-cores and 48 MB L3 cache	48
Power 770	8	3.30	32 MB	16-cores and 64 MB L3 cache	64
Power 780	6	3.44	24 MB	24-cores and 96 MB L3 cache	96
Power 780 in MaxCore mode[d]	8	3.92	32 MB	16-cores and 64 MB L3 cache	64
Power 780 in TurboCore mode[e]	4 activated	4.14	32 MB	8-cores active and 64 MB L3 cache	32

a. The total L3 cache available on the POWER7 SCM, maintaining 4 MB per processor core.
b. The total number of processor cores and L3 cache within a populated enclosure.
c. The maximum number of cores with four CEC enclosures and all cores activated.
d. MaxCore mode applies to Power 780 only. Each POWER7 SCM has eight active cores and 32 MB L3 cache.
e. TurboCore mode applies to Power 780 only. Each POWER SCM uses four of the eight cores but at a higher frequency and 32 MB L3 cache.

1.8 Build to Order

You can perform a *Build to Order* (also called *a la carte*) configuration using the IBM Configurator for e-business (e-config), where you specify each configuration feature that you want on the system.

This is the only configuration method for the IBM Power 770 and Power 780 servers.

1.9 IBM Editions

IBM Edition offerings are not available for the IBM Power 770 and Power 780 servers.

1.10 Model upgrade

You can upgrade the 9117-MMA with IBM POWER6 or POWER6+™ processors to the IBM Power 770 and Power 780 with POWER7 processors. For upgrades from POWER6 or POWER6+ processor-based systems, IBM will install new CEC enclosures to replace the enclosures that you currently have. Your current CEC enclosures will be returned to IBM in exchange for the financial consideration identified under the applicable feature conversions for each upgrade.

Clients taking advantage of the model upgrade offer from a POWER6 or POWER6+ processor-based system are required to return all components of the serialized MT-model that were not ordered through feature codes. Any feature for which a feature conversion is used to obtain a new part must be returned to IBM also. Clients can keep and reuse any features from the CEC enclosures that were not involved in a feature conversion transaction.

Upgrade considerations

Feature conversions have been set up for:

- POWER6 and POWER6+ processors to POWER7 processors
- DDR2 memory DIMMS to DDR3 memory DIMMS
- Trim kits (A new trim kit is needed when upgrading to a 2-door, 3-door, or 4-door system.)
- Enterprise enablement

The following features that are present on the current system can be moved to the new system:

- DDR3 memory DIMMs (#5600, #5601, and #5602)
- Active Memory Expansion Enablement (#4791)
- FSP/Clock Pass Through Card (#5665)
- Service Processor (#5664) o 175 MB Cache RAID - Dual IOA Enablement Card (#5662)
- Operator Panel (#1853)
- Disk/Media Backplane (#5652)
- PCIe adapters with cables, line cords, keyboards, and displays
- PowerVM Standard edition (#7942) or PowerVm Enterprise edition (#7995)
- I/O drawers (#5786, #5796, #5802, #5877, and #5886)
- Racks (#0551, #0553, and #0555)
- Doors (#6068 and #6069)
- SATA DVD-RAM (#5762)

The Power 770 and Power 780 can support the following drawers:

- #5802 and #5877 PCIe 12X I/O drawers
- #5797 and #7413-G30 PCI-X (12X) I/O Drawer
- #5786 and #7031-D24 TotalStorage EXP24 SCSI Disk Drawer
- #5886 EXP12S SAS Disk Drawer

The Power 770 and Power 780 support only the SAS DASD SFF hard disks internally. The existing 3.5-inch DASD hard disks can be attached to Power 770 and Power 780, but must be located in an I/O drawer such as #5886.

For POWER6 or POWER6+ processor-based systems that have the On/Off CoD function enabled, you must reorder the On/Off enablement features (#7951and #7954) when placing the upgrade MES order for the new Power 770 or 780 system to keep the On/Off CoD function active. To initiate the model upgrade, the On/Off enablement features should be removed from the configuration file before the Miscellaneous Equipment Shipment (MES) order is started. Any temporary use of processors or memory owed to IBM on the existing system must be paid before installing the new Power 770 model MMC or Power 780 model MHC.

Features #8018 and #8030 are available to support migration of the PowerVM features #7942 or #7995 during the initial order and build of the MMC or MHC upgrade MES order. Customers can add feature #8018 or #8030 to their upgrade orders in a quantity not to exceed the quantity of feature #7942 or #7995 obtained for the system being upgraded. Feature #7942 or #7995 must be migrated to the new configuration report in a quantity that equals feature #8018 or #8030. Additional #7942 or #7995 features can be ordered during the upgrade.

Clients can add feature #8018 to their upgrade orders in a quantity not to exceed the quantity of feature #7942 obtained for the system being upgraded. Feature #7942 must be migrated to the new configuration report in a quantity that equals feature #8018. Additional #7942 features can be ordered during the upgrade.

1.11 Hardware Management Console models

The Hardware Management Console (HMC) is required for managing the IBM Power 770 and Power 780. It provides a set of functions that are necessary to manage the system, including:

- Creating and maintaining a multiple partition environment
- Displaying a virtual operating system session terminal for each partition
- Displaying a virtual operator panel of contents for each partition
- Detecting, reporting, and storing changes in hardware conditions
- Powering managed systems on and off
- Acting as a service focal point for service representatives to determine an appropriate service strategy

The IBM Power 770 and Power 780 are not supported by the Integrated Virtualization Manager (IVM).

Several HMC models are supported to manage POWER7-based systems. Two models (7042-C08 and 7042-CR6) are available for ordering at the time of writing, but you can also use one of the withdrawn models listed in Table 1-14.

Table 1-14 HMC models supporting POWER7 processor technology-based servers

Type-model	Availability	Description
7310-C05	Withdrawn	IBM 7310 Model C05 Desktop Hardware Management Console
7310-C06	Withdrawn	IBM 7310 Model C06 Deskside Hardware Management Console
7042-C06	Withdrawn	IBM 7042 Model C06 Deskside Hardware Management Console
7042-C07	Withdrawn	IBM 7042 Model C07 Deskside Hardware Management Console
7042-C08	Available	IBM 7042 Model C08 Deskside Hardware Management Console
7310-CR3	Withdrawn	IBM 7310 Model CR3 Rack-Mounted Hardware Management Console
7042-CR4	Withdrawn	IBM 7042 Model CR4 Rack-Mounted Hardware Management Console
7042-CR5	Withdrawn	IBM 7042 Model CR5 Rack-Mounted Hardware Management Console
7042-CR6	Available	IBM 7042 Model CR6 Rack mounted Hardware Management Console

At the time of writing, base Licensed Machine Code Version 7 Revision 7.4.0 or later is required to support the Power 770 and Power 780.

Existing HMC models 7310 can be upgraded to Licensed Machine Code Version 7 to support environments that might include POWER5, POWER5+, POWER6, POWER6+, and POWER7 processor-based servers. Licensed Machine Code Version 6 (#0961) is not available for 7042 HMCs.

If you want to support more than 254 partitions in total, then the HMC might require a memory upgrade to 4 GB.

1.12 System racks

The Power 770 and its I/O drawers are designed to be mounted in the 7014-T00, 7014-T42, 7014-B42, 7014-S25, #0551, #0553, or #0555 rack. The Power 780 and I/O drawers can be ordered only with the 7014-T00 and 7014-T42 racks. These are built to the 19-inch EIA standard. An existing 7014-T00, 7014-B42, 7014-S25, 7014-T42, #0551, #0553, or #0555 rack can be used for the Power 770 and Power 780 if sufficient space and power are available.

The 36U (1.8-meter) rack (#0551) and the 42U (2.0-meter) rack (#0553) are available for order on MES upgrade orders only. For initial system orders, the racks must be ordered as machine type 7014, models T00, B42, S25, or T42.

If a system is to be installed in a rack or cabinet that is not IBM, it must meet requirements.

> **Note:** The client is responsible for ensuring that the installation of the drawer in the preferred rack or cabinet results in a configuration that is stable, serviceable, safe, and compatible with the drawer requirements for power, cooling, cable management, weight, and rail security.

1.12.1 IBM 7014 model T00 rack

The 1.8-meter (71-in.) model T00 is compatible with past and present IBM Power systems. The features of the T00 rack are as follows:

- It has 36U (EIA units) of usable space.
- It has optional removable side panels.
- It has an optional highly perforated front door.
- It has optional side-to-side mounting hardware for joining multiple racks.
- It has standard business black or optional white color in OEM format.
- It has increased power distribution and weight capacity.
- It supports both AC and DC configurations.
- The rack height is increased to 1926 mm (75.8 in.) if a power distribution panel is fixed to the top of the rack.
- Up to four power distribution units (PDUs) can be mounted in the PDU bays (Figure 1-6 on page 31), but others can fit inside the rack. See 1.12.7, “The AC power distribution unit and rack content” on page 31.
- Weights are:
  - T00 base empty rack: 244 kg (535 lb)
  - T00 full rack: 816 kg (1795 lb)

1.12.2 IBM 7014 model T42 rack

The 2.0-meter (79.3-inch) Model T42 addresses the client requirement for a tall enclosure to house the maximum amount of equipment in the smallest possible floor space. The features that differ in the model T42 rack from the model T00 include:

- It has 42U (EIA units) of usable space (6U of additional space).
- The model T42 supports AC only.
- Weights are:
  - T42 base empty rack: 261 kg (575 lb)
  - T42 full rack: 930 kg (2045 lb)

> **Note:** A special door (#6250) and side panels (#6238) are available to make the rack appear as a high-end server (but in a 19-inch rack format instead of a 24-inch rack).

1.12.3 IBM 7014 model S25 rack

The 1.3-meter (49-inch) model S25 rack has the following features:

- 25U (EIA units)
- Weights:
  - Base empty rack: 100.2 kg (221 lb)
  - Maximum load limit: 567.5 kg (1250 lb)

The S25 racks do not have vertical mounting space that accommodate feature number 7188 PDUs. All PDUs required for application in these racks must be installed horizontally in the rear of the rack. Each horizontally mounted PDU occupies 1U of space in the rack, and therefore reduces the space available for mounting servers and other components.

> **Note:** The Power 780 cannot be ordered with a S25 or B25 rack.

1.12.4 Feature number 0555 rack

The 1.3-meter rack (#0555) is a 25U (EIA units) rack. The rack that is delivered as #0555 is the same rack delivered when you order the 7014-S25 rack. The included features might differ. The #0555 is supported, but it is no longer orderable.

1.12.5 Feature number 0551 rack

The 1.8-meter rack (#0551) is a 36U (EIA units) rack. The rack that is delivered as #0551 is the same rack delivered when you order the 7014-T00 rack. The included features might differ. Several features that are delivered as part of the 7014-T00 must be ordered separately with the #0551.

1.12.6 Feature number 0553 rack

The 2.0-meter rack (#0553) is a 42U (EIA units) rack. The rack that is delivered as #0553 is the same rack delivered when you order the 7014-T42 or B42 rack. The included features might differ. Several features that are delivered as part of the 7014-T42 or B42 must be ordered separately with the #0553.

1.12.7 The AC power distribution unit and rack content

For rack models T00 and T42, 12-outlet PDUs are available. These include PDUs Universal UTG0247 Connector (#9188 and #7188) and Intelligent PDU+ Universal UTG0247 Connector (#7109).

Four PDUs can be mounted vertically in the back of the T00 and T42 racks. Figure 1-6 shows the placement of the four vertically mounted PDUs. In the rear of the rack, two additional PDUs can be installed horizontally in the T00 rack and three in the T42 rack. The four vertical mounting locations will be filled first in the T00 and T42 racks. Mounting PDUs horizontally consumes 1U per PDU and reduces the space available for other racked components. When mounting PDUs horizontally, use fillers in the EIA units occupied by these PDUs to facilitate proper air flow and ventilation in the rack.

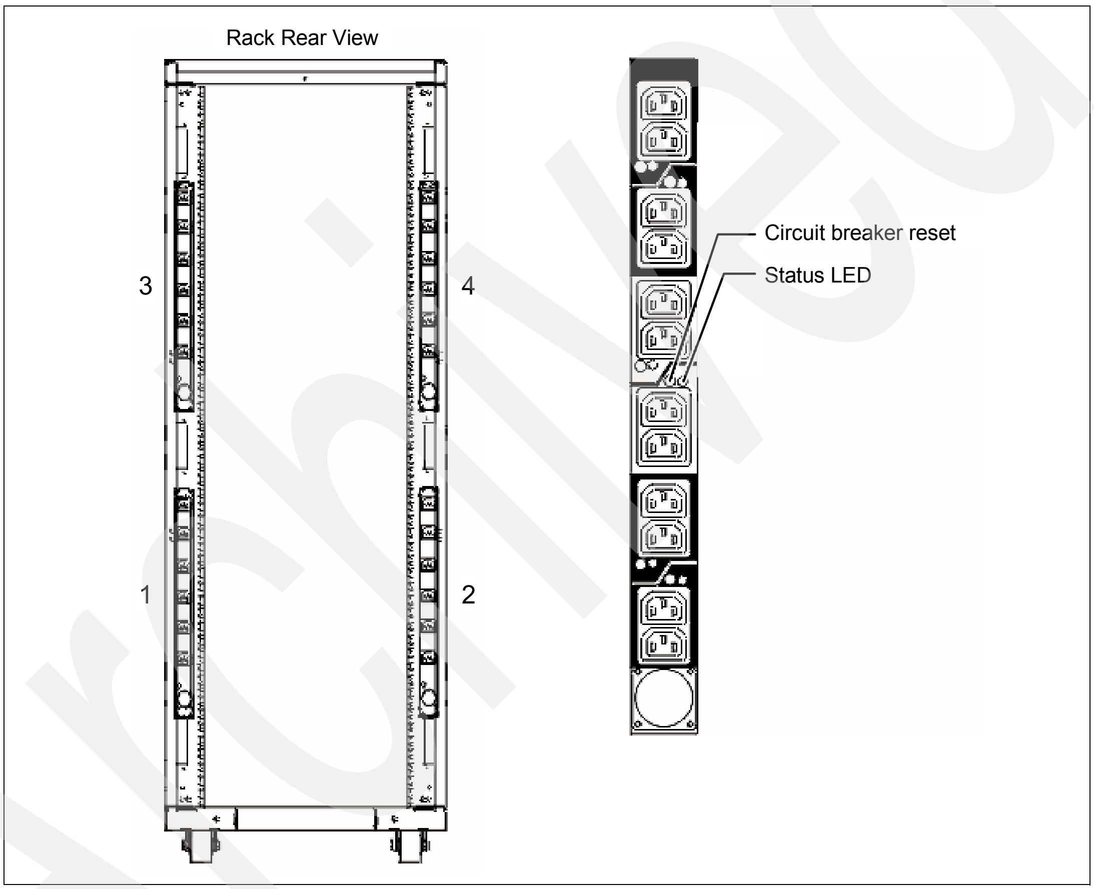

Figure 1-6 PDU placement and PDU view

For the Power 770 and Power 780 installed in IBM 7014 or #055x racks, the following PDU rules apply:

- For PDU #7188 and #7109 when using power cord #6654, #6655, #6656, #6657, or #6658: Each pair of PDUs can power up to two Power 770 and Power 780 CEC enclosures.
- For PDU #7188 and #7109 when using power cord #6489, 6491, #6492, or #6653: Each pair of PDUs can power up to 4-5 Power 770 and Power 780 CEC enclosures.

For detailed power cord requirements and power cord feature codes, see the IBM Power Systems Hardware Information Center website:

http://publib.boulder.ibm.com/infocenter/systems/scope/hw/index.jsp

> **Note:** Ensure that the appropriate power cord feature is configured to support the power being supplied.

The Base/Side Mount Universal PDU (#9188) and the optional, additional, Universal PDU (#7188) and the Intelligent PDU+ options (#7109) support a wide range of country requirements and electrical power specifications. The PDU receives power through a UTG0247 power line connector. Each PDU requires one PDU-to-wall power cord. Various power cord features are available for different countries and applications by varying the PDU-to-wall power cord, which must be ordered separately. Each power cord provides the unique design characteristics for the specific power requirements. To match new power requirements and save previous investments, these power cords can be requested with an initial order of the rack or with a later upgrade of the rack features.

The PDU has 12 client-usable IEC 320-C13 outlets. There are six groups of two outlets fed by six circuit breakers. Each outlet is rated up to 10 amps, but each group of two outlets is fed from one 15 amp circuit breaker.

The Universal PDUs are compatible with previous models.

> **Notes:** Based on the power cord that is used, the PDU can supply from 4.8 - 19.2 kVA. The total kilovolt ampere (kVA) of all the drawers that are plugged into the PDU must not exceed the power cord limitation.
>
> Each system drawer to be mounted in the rack requires two power cords, which are not included in the base order. For maximum availability, be sure to connect power cords from the same system to two separate PDUs in the rack, and to connect each PDU to independent power sources.

1.12.8 Rack-mounting rules

The system consists of one to four CEC enclosures. Each enclosure occupies 4U of vertical rack space. The primary considerations to account for when mounting the system into a rack are:

- For configurations with two, three, or four drawers, all drawers must be installed together in the same rack, in a contiguous space of 8 U, 12 U, or 16 U within the rack. The uppermost enclosure in the system is the base enclosure. This enclosure will contain the active service processor and the operator panel. If a second CEC enclosure is part of the system, the backup service processor is contained in the second CEC enclosure.
- The 7014-T42, -B42, or #0553 rack is constructed with a small flange at the bottom of EIA location 37. When a system is installed near the top of a 7014-T42, -B42, or #0553 rack, no system drawer can be installed in EIA positions 34, 35, or 36. This approach is to avoid interference with the front bezel or with the front flex cable, depending on the system configuration. A two-drawer system cannot be installed above position 29. A three-drawer system cannot be installed above position 25. A four-drawer system cannot be installed above position 21. (The position number refers to the bottom of the lowest drawer.)
- When a system is installed in an 7014-T00, -T42, -B42, #0551, or #0553 rack that has no front door, a Thin Profile Front Trim Kit must be ordered for the rack. The required trim kit for the 7014-T00 or #0551 rack is #6263. The required trim kit for the 7014-T42, -B42, or #0553 rack is #6272. When upgrading from a 9117-MMA, trim kits #6263 or #6272 can be used for one drawer enclosures only.

- The design of the Power 770 and Power 780 is optimized for use in a 7014-T00, -T42, -B42, -S25, #0551, or #0553 rack. Both the front cover and the processor flex cables occupy space on the front left side of an IBM 7014, #0551, and #0553 rack that might not be available in typical non-IBM racks.
- Acoustic door features are available with the 7014-T00, 7014-B42, 7014-T42, #0551, and #0553 racks to meet the lower acoustic levels identified in the specification section of this document. The acoustic door feature can be ordered on new T00, B42, T42, #0551, and #0553 racks or ordered for the T00, B42, T42, #0551, and #0553 racks that you already own.

1.12.9 Useful rack additions

This section highlights several available solutions for IBM Power Systems rack-based systems.

IBM 7214 Model 1U2 SAS Storage Enclosure

The IBM System Storage 7214 Tape and DVD Enclosure Express is designed to mount in one EIA unit of a standard IBM Power Systems 19-inch rack and can be configured with one or two tape drives, or either one or two Slim DVD-RAM or DVD-ROM drives in the right-side bay.

The two bays of the 7214 Express can accommodate the following tape or DVD drives for IBM Power servers:

- DAT72 36 GB Tape Drive: Up to two drives
- DAT72 36 GB Tape Drive: Up to two drives
- DAT160 80 GB Tape Drive: Up to two drives
- Half-high LTO Ultrium 4 800 GB Tape Drive: Up to two drives
- DVD-RAM Optical Drive: Up to two drives
- DVD-ROM Optical Drive: Up to two drives

IBM System Storage 7214 Tape and DVD Enclosure

The IBM System Storage 7214 Tape and DVD Enclosure is designed to mount in one EIA unit of a standard IBM Power Systems 19-inch rack and can be configured with one or two tape drives, or either one or two Slim DVD-RAM or DVD-ROM drives in the right-side bay.

The two bays of the IBM System Storage 7214 Tape and DVD Enclosure can accommodate the following tape or DVD drives for IBM Power servers:

- DAT72 36 GB Tape Drive: Up to two drives
- DAT72 36 GB Tape Drive: Up to two drives
- DAT160 80 GB Tape Drive: Up to two drives
- Half-high LTO Ultrium 4 800 GB Tape Drive: Up to two drives
- DVD-RAM Optical Drive: Up to two drives
- DVD-ROM Optical Drive: Up to two drives

IBM System Storage 7216 Multi-Media Enclosure

The IBM System Storage 7216 Multi-Media Enclosure (Model 1U2) is designed to attach to the Power 770 and the Power 780 through a USB port on the server or through a PCIe SAS adapter. The 7216 has two bays to accommodate external tape, removable disk drive, or DVD-RAM drive options.

The following optional drive technologies are available for the 7216-1U2:

- DAT160 80 GB SAS Tape Drive (#5619
- DAT320 160 GB SAS Tape Drive (#1402)
- DAT320 160 GB USB Tape Drive (#5673)
- Half-high LTO Ultrium 5 1.5 TB SAS Tape Drive (#8247)
- DVD-RAM - 9.4 GB SAS Slim Optical Drive (#1420 and #1422)
- RDX Removable Disk Drive Docking Station (#1103)

Note: The DAT320 160 GB SAS Tape Drive (#1402) and the DAT320 160 GB USB Tape Drive (#5673) are no longer available as of July 15, 2011.

To attach a 7216 Multi-Media Enclosure to the Power 770 and Power 780, consider the following cabling procedures:

- Attachment by an SAS adapter

  A PCIe Dual-X4 SAS adapter (#5901) or a PCIe LP 2-x4-port SAS Adapter 3 Gb (#5278) must be installed in the Power 770 and Power 780 server to attach to a 7216 Model 1U2 Multi-Media Storage Enclosure. Attaching a 7216 to a Power 770 and Power 780 through the integrated SAS adapter is not supported.

  For each SAS tape drive and DVD-RAM drive feature installed in the 7216, the appropriate external SAS cable will be included.

  An optional Quad External SAS cable is available by specifying (#5544) with each 7216 order. The Quad External Cable allows up to four 7216 SAS tape or DVD-RAM features to attach to a single System SAS adapter.

  Up to two 7216 storage enclosure SAS features can be attached per PCIe Dual-X4 SAS adapter (#5901) or the PCIe LP 2-x4-port SAS Adapter 3 Gb (#5278).

- Attachment by a USB adapter

  The Removable RDX HDD Docking Station features on 7216 only support the USB cable that is provided as part of the feature code. Additional USB hubs, add-on USB cables, or USB cable extenders are not supported.

  For each RDX Docking Station feature installed in the 7216, the appropriate external USB cable will be included. The 7216 RDX Docking Station feature can be connected to the external, integrated USB ports on the Power 770 and Power 780 or to the USB ports on 4-Port USB PCI Express Adapter (# 2728).

  The 7216 DAT320 USB tape drive or RDX Docking Station features can be connected to the external, integrated USB ports on the Power 770 and Power 780.

The two drive slots of the 7216 enclosure can hold the following drive combinations:

- One tape drive (DAT160 SAS or Half-high LTO Ultrium 5 SAS) with second bay empty
- Two tape drives (DAT160 SAS or Half-high LTO Ultrium 5 SAS) in any combination
- One tape drive (DAT160 SAS or Half-high LTO Ultrium 5 SAS) and one DVD-RAM SAS drive sled with one or two DVD-RAM SAS drives
- Up to four DVD-RAM drives
- One tape drive (DAT160 SAS or Half-high LTO Ultrium 5 SAS) in one bay, and one RDX Removable HDD Docking Station in the other drive bay
- One RDX Removable HDD Docking Station and one DVD-RAM SAS drive sled with one or two DVD-RAM SAS drives in the right bay
- Two RDX Removable HDD Docking Stations

Figure 1-7 shows the 7216 Multi-Media Enclosure.

Figure 1-7 7216 Multi-Media Enclosure

In general, the 7216-1U2 is supported by the AIX, IBM i, and Linux operating system. However, the RDX Removable Disk Drive Docking Station and the DAT320 USB Tape Drive are not supported with IBM i.

Flat panel display options

The IBM 7316 Model TF3 is a rack-mountable flat panel console kit consisting of a 17-inch 337.9 mm x 270.3 mm flat panel color monitor, rack keyboard tray, IBM Travel Keyboard, support for IBM keyboard/video/mouse (KVM) switches, and language support. The IBM 7316-TF3 Flat Panel Console Kit offers:

- Slim, sleek, lightweight monitor design that occupies only 1U (1.75 inches) in a 19-inch standard rack
- A 17-inch, flat screen TFT monitor with truly accurate images and virtually no distortion
- The ability to mount the IBM Travel Keyboard in the 7316-TF3 rack keyboard tray
- Support for IBM keyboard/video/mouse (KVM) switches that provide control of as many as 128 servers, and support of both USB and PS/2 server-side keyboard and mouse connections

2

Architecture and technical overview

The IBM Power 780 offers two versions of CEC enclosure. The first is a 2-socket CEC enclosure, populated with 8-core POWER7 processor cards. This architecture (Figure 2-1 on page 38) enables a maximum system configuration of 64 processors. The Power 780 also offers a 4-socket CEC enclosure, populated with 6-core POWER7 processor cards (Figure 2-2 on page 39), enabling a maximum system configuration of 96 cores.

The IBM Power 770 offers a 2-socket CEC enclosure, populated with 6-core or 8-core POWER7 processors.

This chapter provides an overview of the system architecture and its major components. The bandwidths that are provided are theoretical maximums used for reference.

The speeds shown are at an individual component level. Multiple components and application implementation are key to achieving the best performance.

Always do the performance sizing at the application workload environment level and evaluate performance using real-world performance measurements and production workloads.

Figure 2-1 shows the logical system diagram of the 2-socket Power 770 and Power 780.

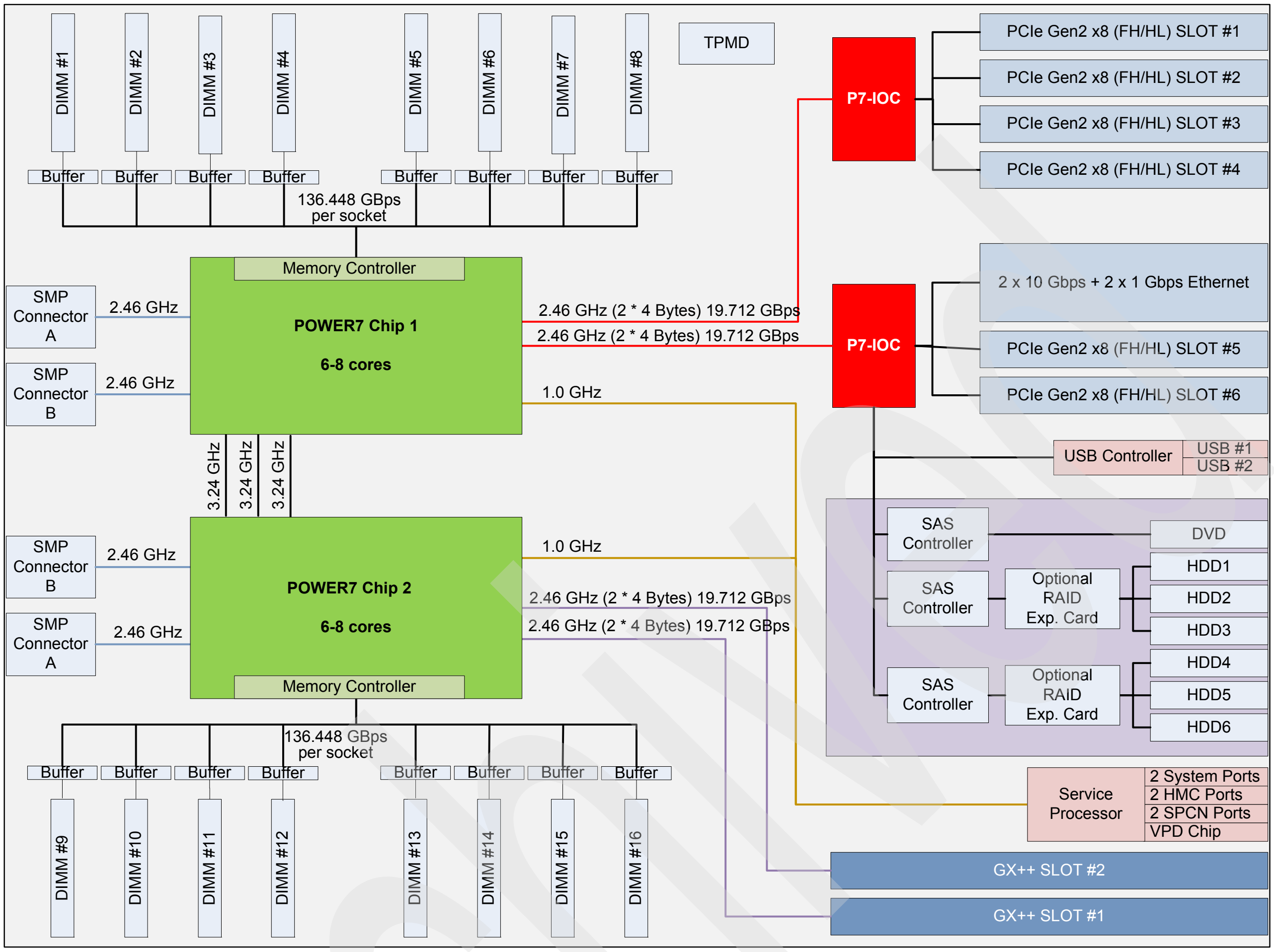

Figure 2-1 Two-socket IBM Power 770 and Power 780 logical system diagram

Figure 2-2 shows the logical system diagram of the 4-socket Power 780.

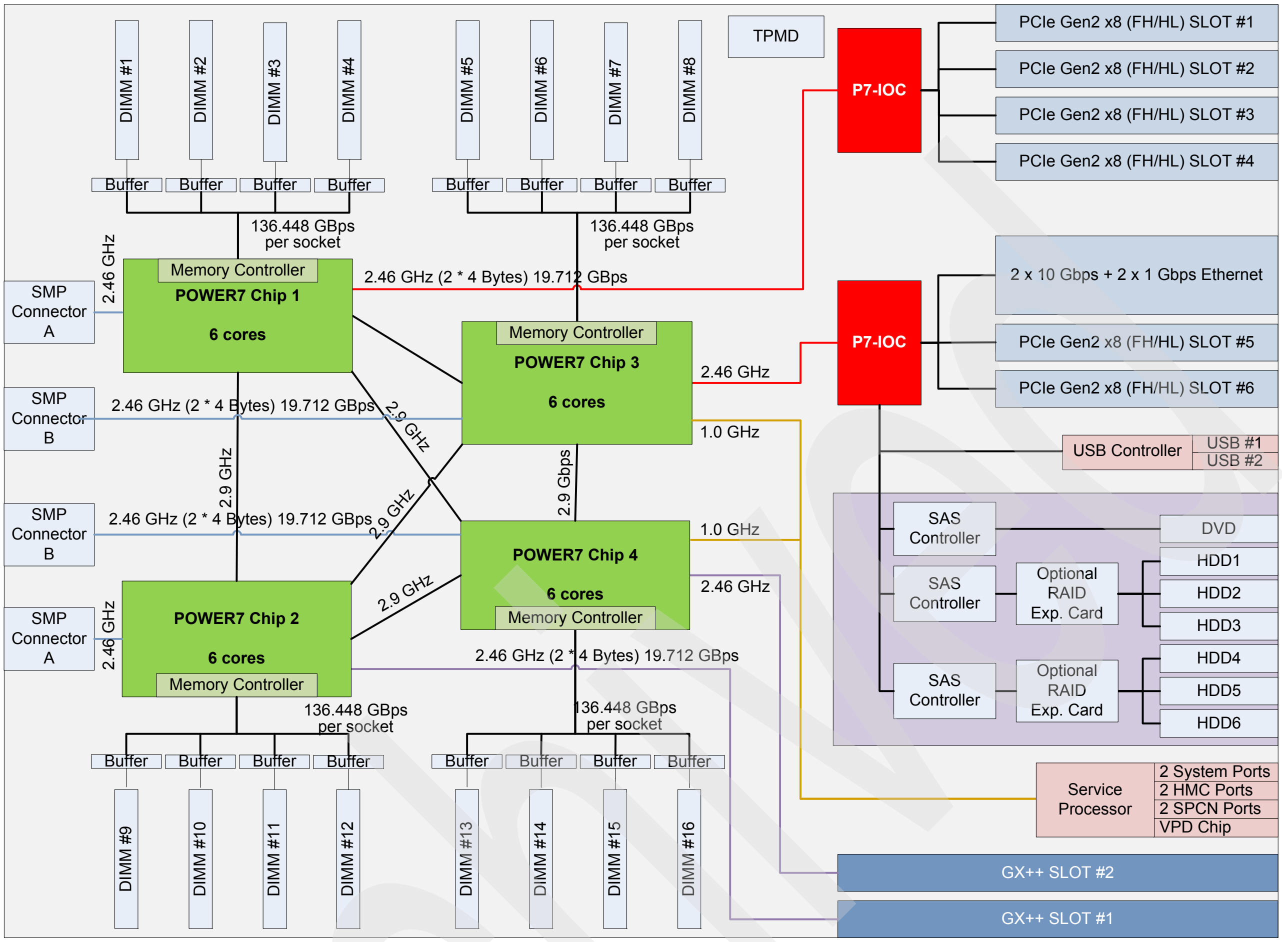

Figure 2-2 Four-socket IBM Power 780 logical system diagram

2.1 The IBM POWER7 processor

The IBM POWER7 processor represents a leap forward in technology achievement and associated computing capability. The multi-core architecture of the POWER7 processor has been matched with innovation across a wide range of related technologies to deliver leading throughput, efficiency, scalability, and RAS.

Although the processor is an important component in delivering outstanding servers, many elements and facilities have to be balanced on a server to deliver maximum throughput. As with previous generations of systems based on POWER processors, the design philosophy for POWER7 processor-based systems is one of system-wide balance in which the POWER7 processor plays an important role.

In many cases, IBM has been innovative in order to achieve required levels of throughput and bandwidth. Areas of innovation for the POWER7 processor and POWER7 processor-based systems include (but are not limited to) these:

- On-chip L3 cache implemented in embedded dynamic random access memory (eDRAM)
- Cache hierarchy and component innovation
- Advances in memory subsystem
- Advances in off-chip signaling
- Exploitation of long-term investment in coherence innovation

The superscalar POWER7 processor design also provides a variety of other capabilities:

- Binary compatibility with the prior generation of POWER processors
- Support for PowerVM virtualization capabilities, including PowerVM Live Partition Mobility to and from POWER6 and POWER6+ processor-based systems

Figure 2-3 shows the POWER7 processor die layout with the major areas identified:

- Processor cores
- L2 cache
- L3 cache and chip interconnection
- Simultaneous multiprocessing (SMP) links
- Memory controllers.

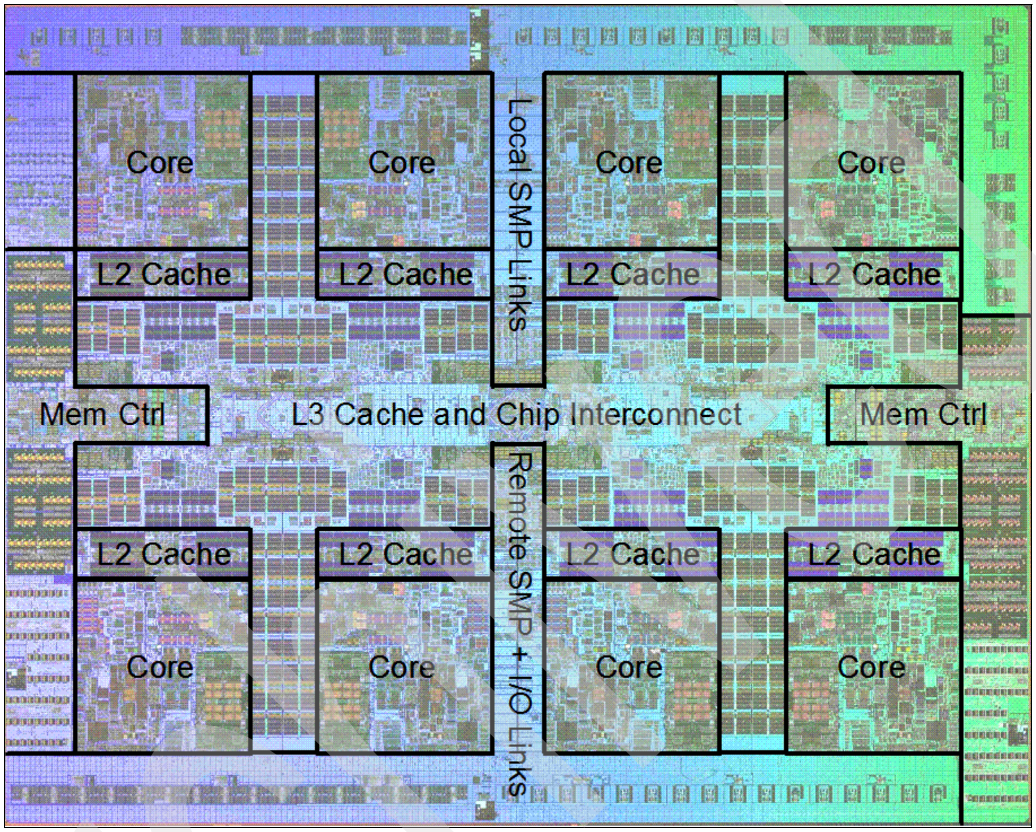

Figure 2-3 POWER7 processor die with key areas indicated

2.1.1 POWER7 processor overview

The POWER7 processor chip is fabricated using the IBM 45 nm Silicon-On-Insulator (SOI) technology using copper interconnect and implements an on-chip L3 cache using eDRAM.

The POWER7 processor chip is 567 mm^2 and is built using 1.2 billion components (transistors). Eight processor cores are on the chip, each with 12 execution units, 256 KB of L2 cache, and access to up to 32 MB of shared on-chip L3 cache.

For memory access, the POWER7 processor includes two DDR3 (double data rate 3) memory controllers, each with four memory channels. To be able to scale effectively, the POWER7 processor uses a combination of local and global SMP links with very high coherency bandwidth and takes advantage of the IBM dual-scope broadcast coherence protocol.

Table 2-1 summarizes the technology characteristics of the POWER7 processor.

Table 2-1 Summary of POWER7 processor technology

Technology	POWER7 processor
Die size	567 mm^2
Fabrication technology	► 45 nm lithography ► Copper interconnect ► Silicon-on-Insulator ► eDRAM
Components	1.2 billion components/transistors offering the equivalent function of 2.7 billion (For further details see 2.1.6, "On-chip L3 cache innovation and Intelligent Cache" on page 46.)
Processor cores	4, 6, or 8
Max execution threads core/chip	4/32
L2 cache core/chip	256 KB/2 MB
On-chip L3 cache core/chip	4 MB/32 MB
DDR3 memory controllers	1 or 2
SMP design-point	32 sockets with IBM POWER7 processors
Compatibility	With prior generation of POWER processor

2.1.2 POWER7 processor core

Each POWER7 processor core implements aggressive out-of-order (OoO) instruction execution to drive high efficiency in the use of available execution paths. The POWER7 processor has an Instruction Sequence Unit that is capable of dispatching up to six instructions per cycle to a set of queues. Up to eight instructions per cycle can be issued to the instruction execution units. The POWER7 processor has a set of 12 execution units:

- Two fixed point units
- Two load store units
- Four double precision floating point units
- One vector unit
- One branch unit
- One condition register unit
- One decimal floating point unit

These caches are tightly coupled to each POWER7 processor core:

- Instruction cache: 32 KB
- Data cache: 32 KB
- L2 cache: 256 KB, implemented in fast SRAM

2.1.3 Simultaneous multithreading

An enhancement in the POWER7 processor is the addition of the SMT4 mode to enable four instruction threads to execute simultaneously in each POWER7 processor core. Thus, these are the instruction thread execution modes of the POWER7 processor:

- SMT1: Single instruction execution thread per core
- SMT2: Two instruction execution threads per core
- SMT4: Four instruction execution threads per core

SMT4 mode enables the POWER7 processor to maximize the throughput of the processor core by offering an increase in processor-core efficiency. SMT4 mode is the latest step in an evolution of multithreading technologies introduced by IBM. Figure 2-4 shows the evolution of simultaneous multithreading in the industry.

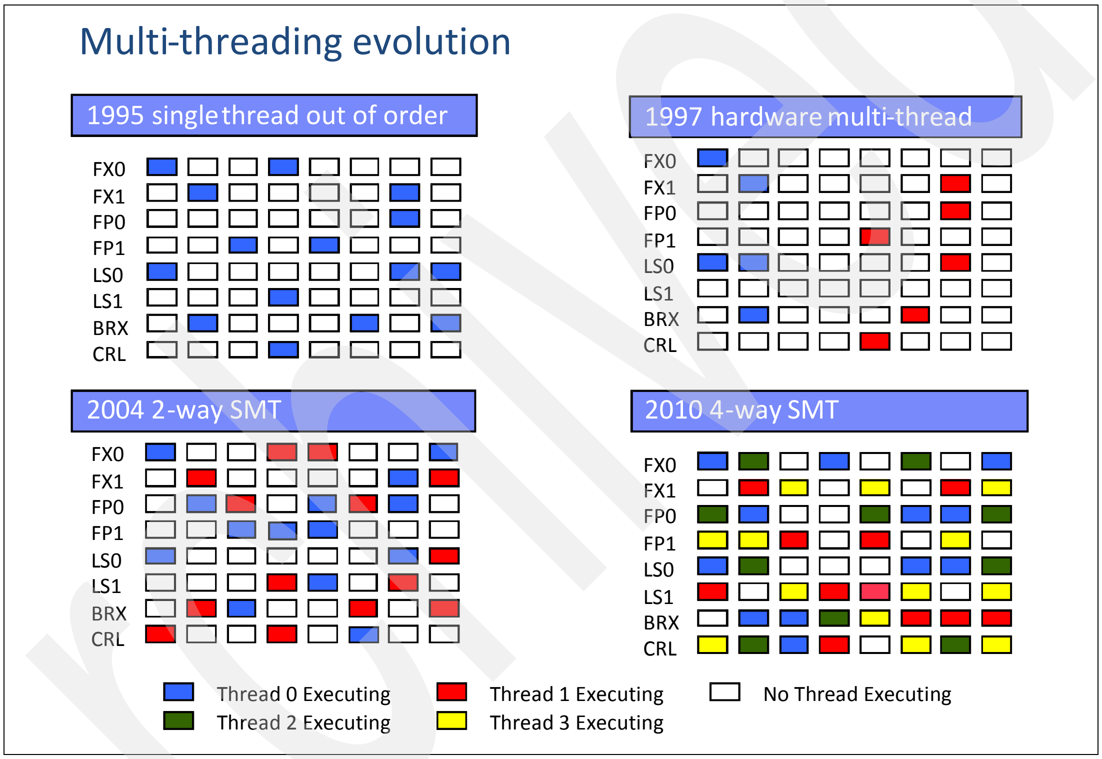

Figure 2-4 Evolution of simultaneous multi-threading

The various SMT modes offered by the POWER7 processor allow flexibility, enabling users to select the threading technology that meets an aggregation of objectives such as performance, throughput, energy use, and workload enablement.

Intelligent Threads

The POWER7 processor features Intelligent Threads that can vary based on the workload demand. The system either automatically selects (or the system administrator can manually select) whether a workload benefits from dedicating as much capability as possible to a single thread of work, or if the workload benefits more from having capability spread across two or four threads of work. With more threads, the POWER7 processor can deliver more total capacity as more tasks are accomplished in parallel. With fewer threads, those workloads that need very fast individual tasks can get the performance that they need for maximum benefit.

2.1.4 Memory access

Each POWER7 processor chip has two DDR3 memory controllers, each with four memory channels (enabling eight memory channels per POWER7 processor). Each channel operates at 6.4 GHz and can address up to 32 GB of memory. Thus, each POWER7 processor chip is capable of addressing up to 256 GB of memory.

> **Note:** In certain POWER7 processor-based systems, one memory controller is active with four memory channels being used.

Figure 2-5 gives a simple overview of the POWER7 processor memory access structure.

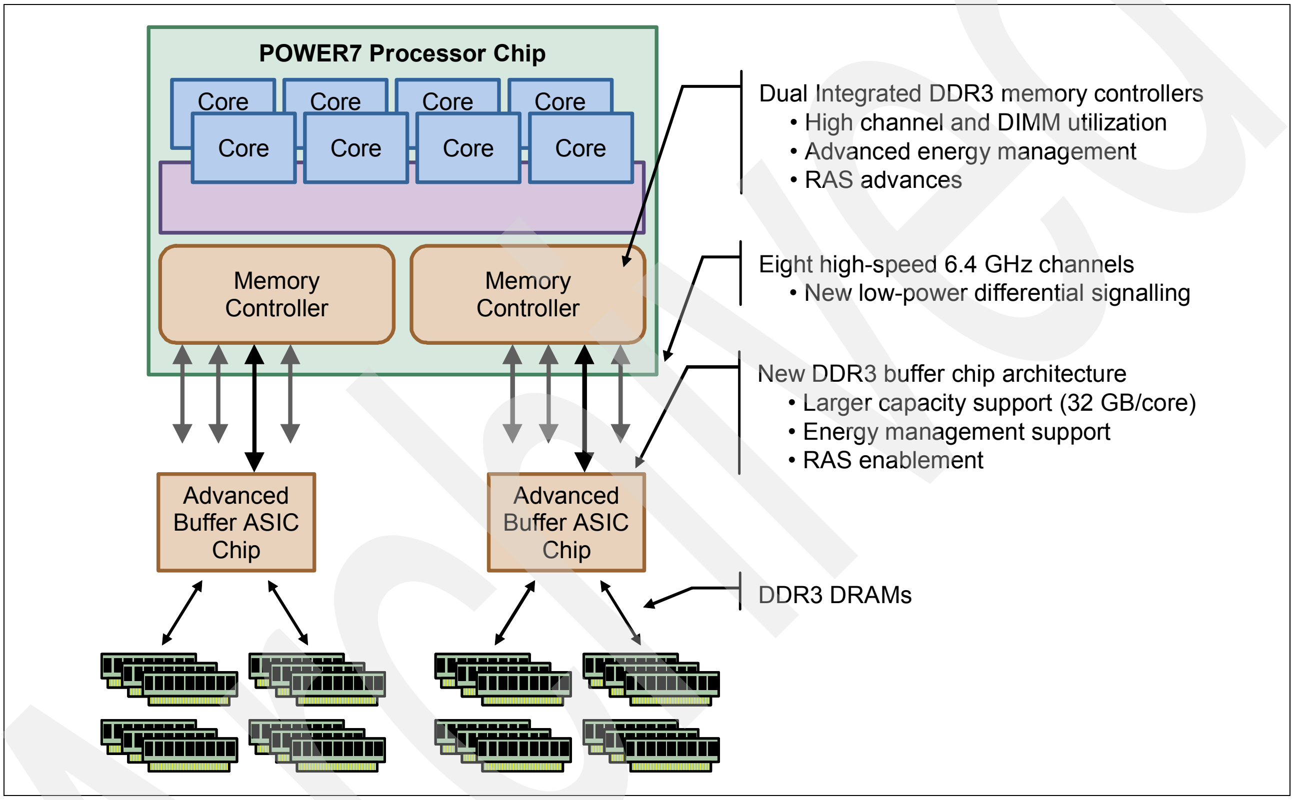

Figure 2-5 Overview of POWER7 memory access structure

2.1.5 Flexible POWER7 processor packaging and offerings

POWER7 processors have the unique ability to optimize to various workload types. For example, database workloads typically benefit from very fast processors that handle high transaction rates at high speeds. Web workloads typically benefit more from processors with many threads that allow the breaking down of web requests into many parts and handle them in parallel. POWER7 processors uniquely have the ability to provide leadership performance in either case.

TurboCore mode

Users can opt to run selected servers in TurboCore mode. It uses four cores per POWER7 processor chip with access to the full 32 MB of L3 cache (8 MB per core) and at a faster processor core frequency, which might save on software costs for those applications that are licensed per core.

Note: TurboCore is available on the Power 780 and Power 795.

MaxCore mode

MaxCore mode is for workloads that benefit from a higher number of cores and threads handling multiple tasks simultaneously that take advantage of increased parallelism. MaxCore mode provides up to eight cores and up to 32 threads per POWER7 processor.

POWER7 processor 4-core and 6-core offerings

The base design for the POWER7 processor is an 8-core processor with 32 MB of on-chip L3 cache (4 MB per core). However, the architecture allows for differing numbers of processor cores to be active, 4 cores or 6 cores, as well as the full 8-core version.

In most cases (MaxCore mode), the L3 cache associated with the implementation is dependant on the number of active cores. For a 6-core version, this typically means that 6 x 4 MB (24 MB) of L3 cache is available. Similarly, for a 4-core version, the L3 cache available is 16 MB.

Note: The 4-core processor is not available on the Power 770 and Power 780.

Optimized for servers

The POWER7 processor forms the basis of a flexible compute platform and can be offered in a number of guises to address differing system requirements.

The POWER7 processor can be offered with a single active memory controller with four channels for servers where higher degrees of memory parallelism are not required.

Similarly, the POWER7 processor can be offered with a variety of SMP bus capacities that are appropriate to the scaling-point of particular server models.

Figure 2-6 outlines the physical packaging options that are supported with POWER7 processors.

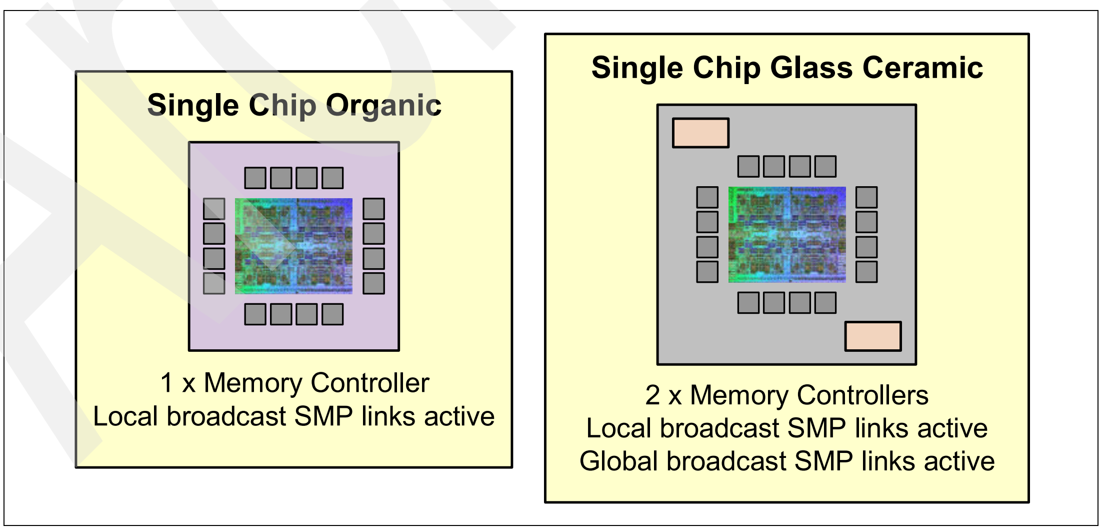

Figure 2-6 Outline of the POWER7 processor physical packaging

2.1.6 On-chip L3 cache innovation and Intelligent Cache

A breakthrough in material engineering and microprocessor fabrication has enabled IBM to implement the L3 cache in eDRAM and place it on the POWER7 processor die. L3 cache is critical to a balanced design, as is the ability to provide good signaling between the L3 cache and other elements of the hierarchy, such as the L2 cache or SMP interconnect.

The on-chip L3 cache is organized into separate areas with differing latency characteristics. Each processor core is associated with a Fast Local Region of L3 cache (FLR-L3) but also has access to other L3 cache regions as shared L3 cache. Additionally, each core can negotiate to use the FLR-L3 cache associated with another core, depending on reference patterns. Data can also be cloned to be stored in more than one core's FLR-L3 cache, again depending on reference patterns. This *Intelligent Cache* management enables the POWER7 processor to optimize the access to L3 cache lines and minimize overall cache latencies.

Figure 2-7 shows the FLR-L3 cache regions for each of the cores on the POWER7 processor die.

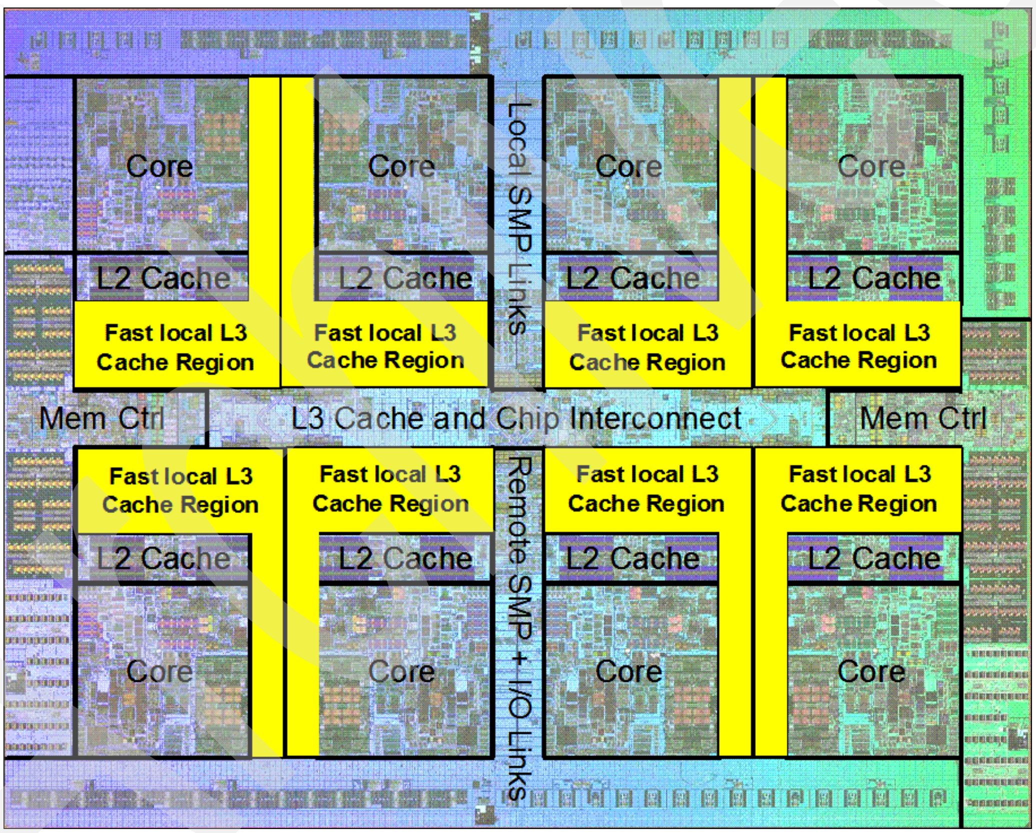

Figure 2-7 Fast local regions of L3 cache on the POWER7 processor

The innovation of using eDRAM on the POWER7 processor die is significant for several reasons:

- Latency improvement

  A six-to-one latency improvement occurs by moving the L3 cache on-chip compared to L3 accesses on an external (on-ceramic) ASIC.

- Bandwidth improvement

  A 2x bandwidth improvement occurs with on-chip interconnect. Frequency and bus sizes are increased to and from each core.

- No off-chip driver or receivers

  Removing drivers or receivers from the L3 access path lowers interface requirements, conserves energy, and lowers latency.

- Small physical footprint

  The performance of eDRAM when implemented on-chip is similar to conventional SRAM but requires far less physical space. IBM on-chip eDRAM uses only a third of the components used in conventional SRAM, which has a minimum of six transistors to implement a 1-bit memory cell.

- Low energy consumption

  The on-chip eDRAM uses only 20% of the standby power of SRAM.

2.1.7 POWER7 processor and Intelligent Energy

Energy consumption is an important area of focus for the design of the POWER7 processor, which includes Intelligent Energy features that help to dynamically optimize energy usage and performance so that the best possible balance is maintained. Intelligent Energy features like EnergyScale work with IBM Systems Director Active Energy Manager to dynamically optimize processor speed based on thermal conditions and system utilization.

2.1.8 Comparison of the POWER7 and POWER6 processors

Table 2-2 shows comparable characteristics between the generations of POWER7 and POWER6 processors.

Table 2-2 Comparison of technology for the POWER7 processor and the prior generation

	POWER7	POWER6+	POWER6
Technology	45 nm	65 nm	65 nm
Die size	567 mm^2	341 mm^2	341 mm^2
Maximum cores	8	2	2
Maximum SMT threads per core	4 threads	2 threads	2 threads
Maximum frequency	4.25 GHz	5.0 GHz	4.7 GHz
L2 Cache	256 KB per core	4 MB per core	4 MB per core
L3 Cache	4 MB of FLR-L3 cache per core with each core having access to the full 32 MB of L3 cache, on-chip eDRAM	32 MB off-chip eDRAM ASIC	32 MB off-chip eDRAM ASIC
Memory support	DDR3	DDR2	DDR2
I/O bus	Two GX++	One GX++	One GX++
Enhanced cache mode (TurboCore)	Yes[a]	No	No
Sleep and nap mode[b]	Both	Nap only	Nap only

a. Not supported on the Power 770 and Power 780 4-socket systems.

b. For more information about sleep and nap modes, see 2.15.1, “IBM EnergyScale technology” on page 114.

2.2 POWER7 processor cards

IBM Power 770 and Power 780 servers are modular systems built using one to four CEC enclosures. The processor and memory subsystem in each CEC enclosure is contained on a single processor card. The processor card contains either two or four processor sockets and 16 fully buffered DDR3 memory DIMMs.

The IBM Power 770 supports the 2-socket processor cards, populated with 6-core or 8-core POWER7 processors. This enables a maximum system configuration of 64-cores, built from four CEC enclosures.

The IBM Power 780 supports both the 2-socket and 4-socket processor cards. The 4-socket processor cards are populated with 6-core POWER7 processors, enabling a maximum system configuration of 96 cores.

Note: Mixing 2-socket and 4-socket CEC enclosures within a Power 780 is not supported.

2.2.1 Two-socket processor card

The 2-socket processor card (Figure 2-8) is supported in both the Power 770 and the Power 780 system. Each processor is connected to eight DIMMs via two memory controllers (four DIMMS on each).

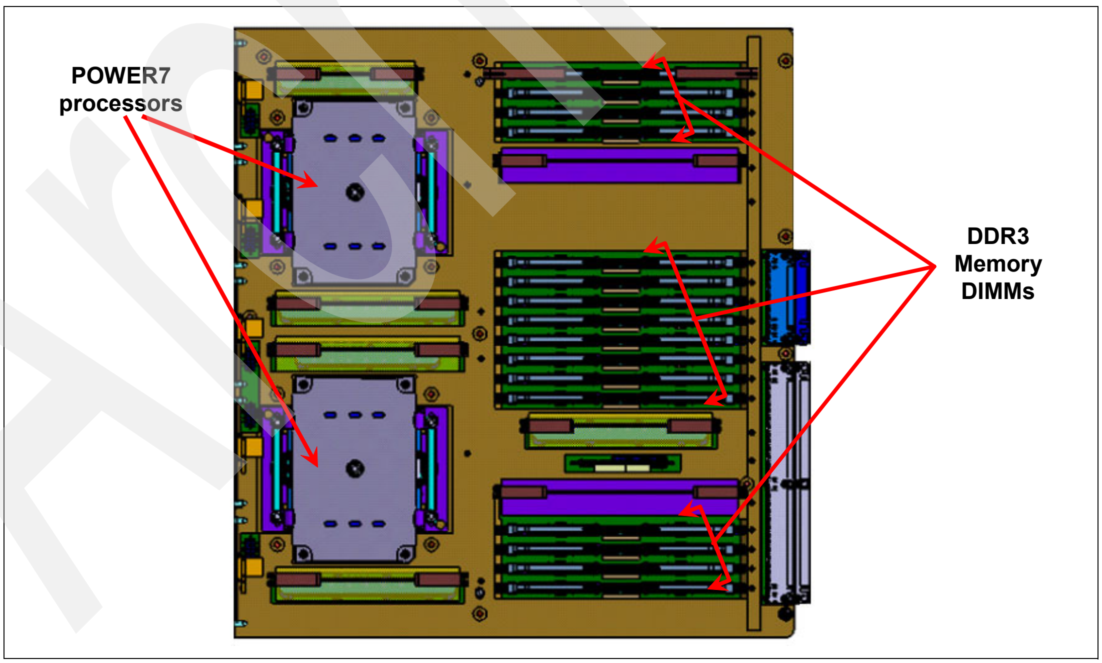

Figure 2-8 IBM Power 770 and Power 780 2-socket processor card

Power 770 systems

IBM Power 770 systems support two POWER7 processor options of varying clock speed and core counts. Table 2-3 summarizes these options.

Table 2-3 Summary of POWER7 processor options for the Power 770 server

Cores per POWER7 processor	Frequency	L3 cache size available per POWER7 processor
6	3.72 GHz	24 MB
8	3.30 GHz	32 MB

With two POWER7 processors in each enclosure, systems can be equipped as follows:

- Using 6-core POWER7 processors:
  - 12 cores
  - 24 cores
  - 36 cores
  - 48 cores
- Using 8-core POWER7 processors:
  - 16-cores
  - 32-cores
  - 48-cores
  - 64-cores

Power 780 systems

The IBM Power 780 2-socket CEC enclosures offer POWER7 processors with 8 cores. However, the system can be booted on one of two modes:

- MaxCore mode
- TurboCore mode

In MaxCore mode, all eight cores of each POWER7 processor are active, run at 3.92 GHz, and have full access to the 32 MB of L3 cache. In TurboCore mode the system uses just four of the POWER7 processor cores, but runs at the higher frequency of 4.14 GHz and has access to the full 32 MB of L3 cache.

Table 2-4 summarizes the POWER7 processor and mode options for the Power 780 system.

Table 2-4 Summary of POWER7 processor options and modes for the Power 780 server

Active cores per POWER7 processor	System mode	Frequency	L3 cache size available per POWER7 processor
8	MaxCore	3.92 GHz	32 MB
4	TurboCore	4.14 GHz	32 MB

With two POWER7 processors in each enclosure, systems can be equipped as follows:

- MaxCore mode:
  - 16 cores
  - 32 cores
  - 48 cores
  - 64 cores
- TurboCore mode:
  - 8 cores
  - 16 cores
  - 24 cores
  - 32 cores

2.2.2 Four-socket processor card

A 4-socket processor card is supported on the Power 780 (Figure 2-9), enabling a maximum system configuration of 96 cores (6-core processors). Each POWER7 processor is connected to four memory DIMMs through a single memory controller.

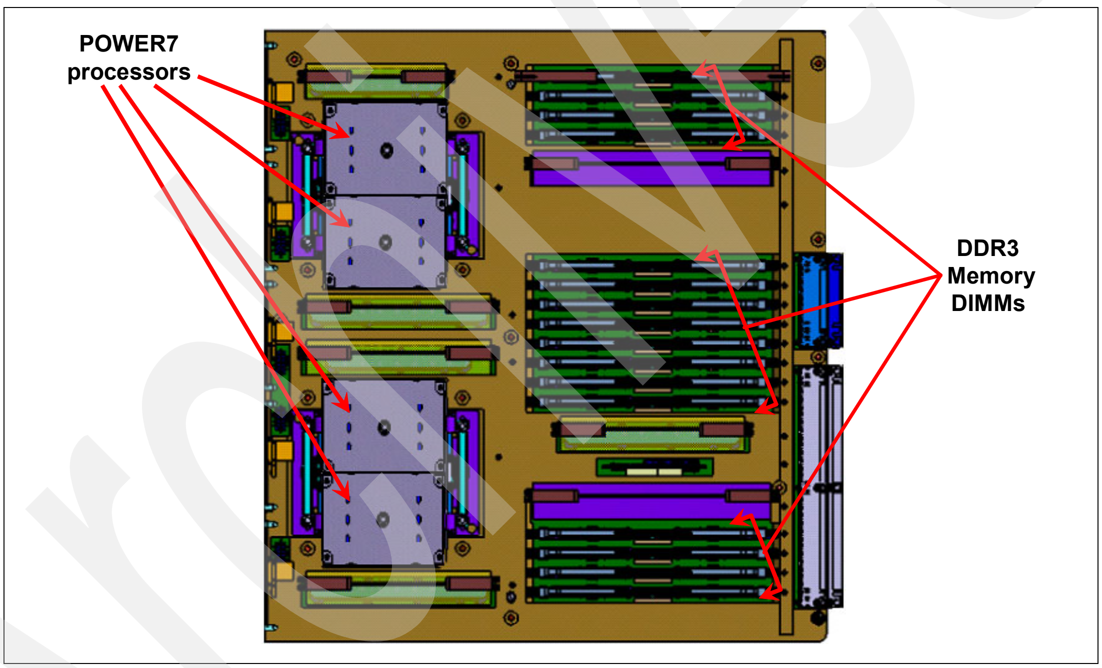

Figure 2-9 IBM Power 780 4-socket processor card

Power 780 Systems

Table 2-5 summarizes the POWER7 processor options for the Power 780 4-socket system.

Table 2-5 Summary of POWER7 processor options and modes for the Power 780 server

Cores per POWER7 processor	Frequency	L3 cache size available per POWER7 processor
6	3.44 GHz	24 MB

The TurboCore option is not supported with the 4-socket processor cards.

2.2.3 Processor comparison

The 2-socket and 4-socket processor cards available for the Power 780 utilize slightly different POWER7 processors. Table 2-6 shows a comparison.

Table 2-6 Comparison of processors used with 2-socket and 4-socket processor cards

Area	POWER7 processor used on 2-socket CPU card	POWER7 processor used on 4-socket CPU card
Technology	45 nm	45 nm
Die size	567 mm^2	567 mm^2
Power	250 W	150 W
Cores	8	6
Max frequency	3.92 GHz (4.14 GHz with TurboCore)	3.44 GHz
L2/L3	256 K/4 MB per core	256 K/4 MB per core
Memory support	DDR3	DDR3
Fabric Bus	Star Fabric Bus	Star Fabric Bus
I/O Bus	Two GX++	Two GX++
TurboCore mode	Yes	No
Sleep/nap mode	Yes	Yes

The most significant difference between the processors are the interconnects. On the 2-socket processor card, the POWER7 processor has two memory controllers, each connected to four memory DIMMs (Figure 2-10).

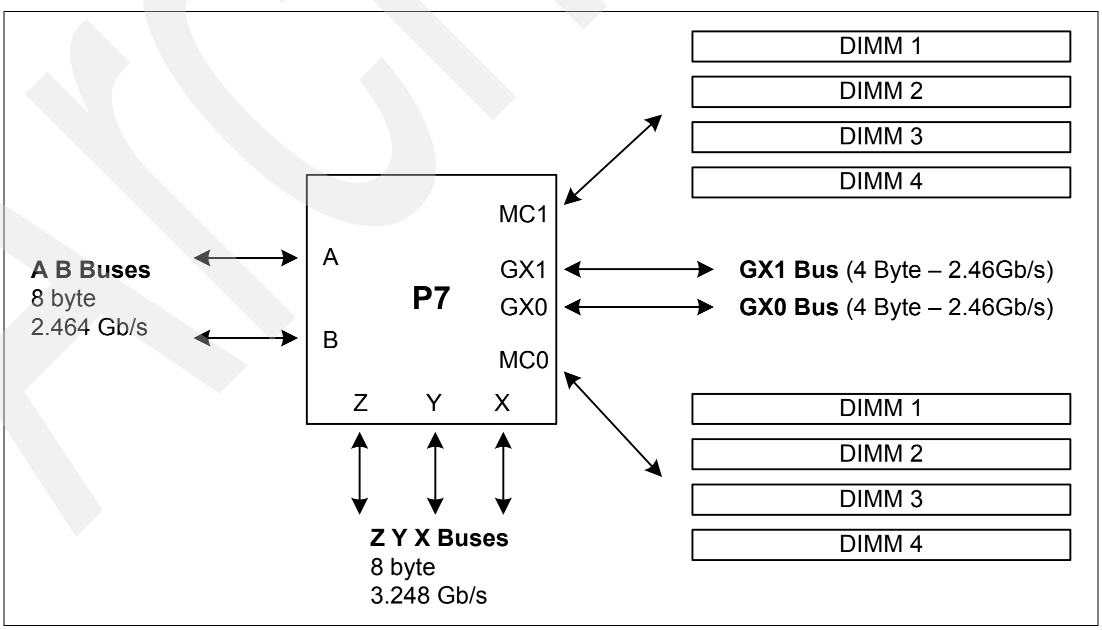

Figure 2-10 Processor interconnects on 2-socket processor card

The POWER7 processor used on the 4-socket processor card also has two memory controllers, but only one is used. This results in four DIMMs per memory controller, the same as the processor used on the 2-socket processor card.

Similarly, the processor used on the 4-socket CPU card has two GX++ buses, but only one is used (Figure 2-11).

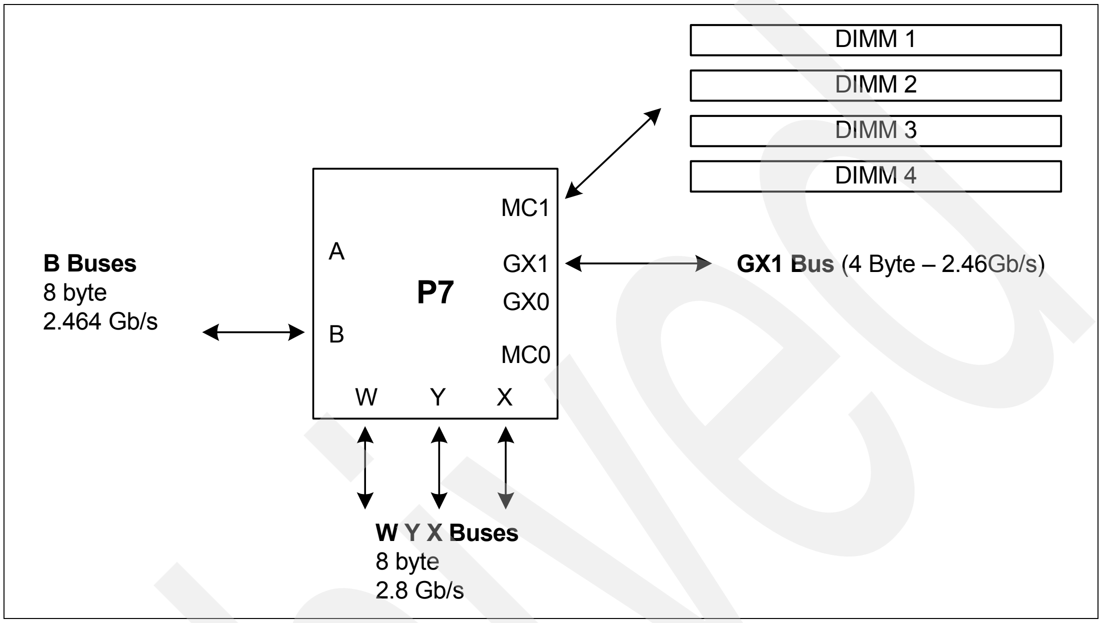

Figure 2-11 Processor interconnects on 4-socket processor card

2.3 Memory subsystem

On the Power 770 and Power 780 servers, independently of using two or four Single Chip Modules (SCMs), each enclosure houses 16 DDR3 DIMM slots. The DIMM cards for the Power 770 and Power 780 are 96 mm tall, fully buffered, and placed in one of the 16 DIMM slots on the processor card.

2.3.1 Fully buffered DIMM

Fully buffered DIMM technology is used to increase reliability, speed, and density of memory subsystems. Conventionally, data lines from the memory controllers have to be connected to the data lines in every DRAM module. As memory width and access speed increases, the signal decays at the interface of the bus and the device. This effect traditionally degrades either the memory access times or memory density. Fully buffered DIMMs overcome this effect by implementing an advanced buffer between the memory controllers and the DRAMs with two independent signaling interfaces. This technique decouples the DRAMs from the bus and memory controller interfaces, allowing efficient signaling between the buffer and the DRAM.

2.3.2 Memory placement rules

The minimum DDR3 memory capacity for the Power 770 and Power 780 systems is 64 GB of installed memory.

All the memory DIMMs for the Power 770 and Power 780 are Capacity Upgrade on Demand capable and must have a minimum of 50% of its physical capacity activated. For example, the minimum installed memory for both servers is 64 GB RAM, whereas they can have a minimum of 32 GB RAM active.

Note: DDR2 memory (used in POWER6 processor-based systems) is not supported in POWER7 processor-based systems.

Figure 2-12 shows the physical memory DIMM topology for the Power 770 and Power 780 with two single-chip-modules (SCMs).

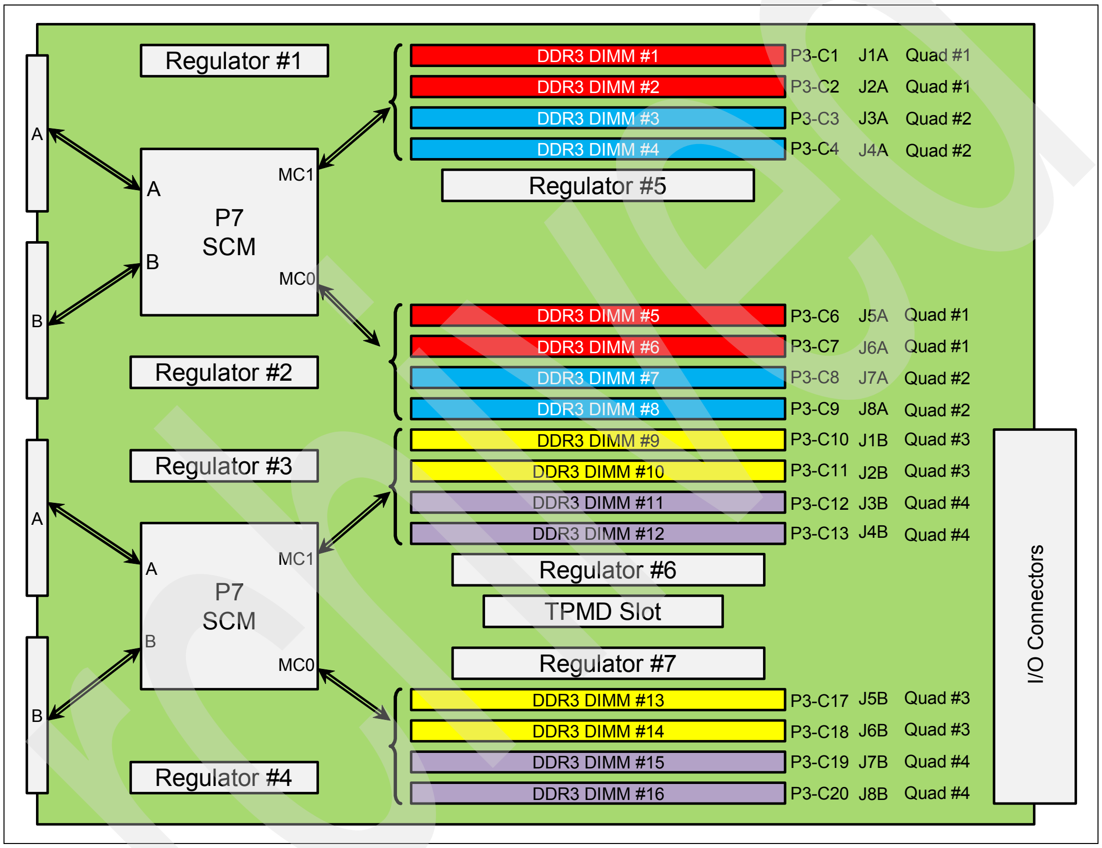

Figure 2-12 Physical memory DIMM topology for the Power 770 and Power 780 with two SCMs

For the POWER 770 and POWER 780 server models with two SCMs, there are 16 buffered DIMM slots:

- DIMM slots J1A to J8A are connected to the memory controllers on POWER7 processor 0.
- DIMM slots J1B to J8B are connected to the memory controllers on POWER7 processor 1.

These DIMMs slots are divided into four Quads, each Quad having four DIMMs.

Figure 2-13 shows the physical memory DIMM topology for the Power 780 with four single-chip-modules (SCMs).

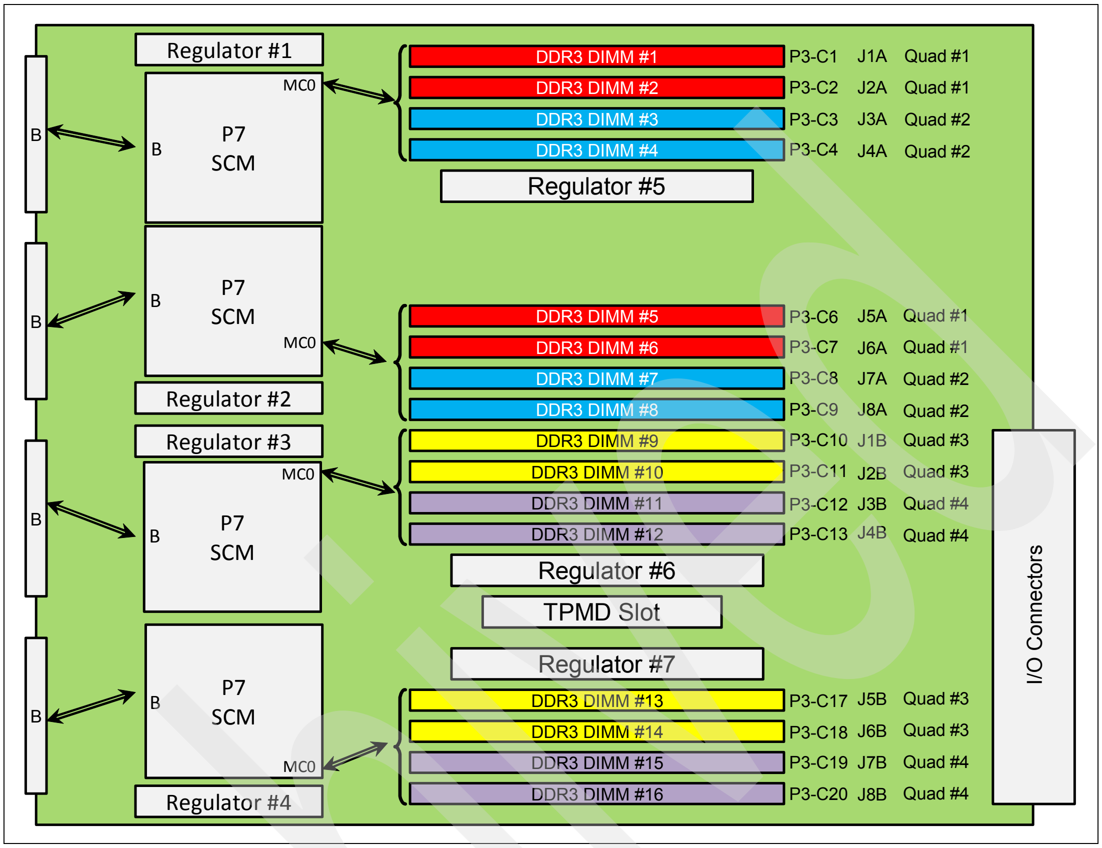

Figure 2-13 Physical memory DIMM topology for the Power 780 with four SCMs

For the POWER 780 with the four SCMs, there are 16 buffered DIMM slots available:

- DIMM slots J1A to J4A are connected to the memory controller on POWER7 processor 0.
- DIMM slots J5A to J8A are connected to the memory controller on POWER7 processor 1.
- DIMM slots J1B to J4B are connected to the memory controller on POWER7 processor 2.
- DIMM slots J5B to J8B are connected to the memory controller on POWER7 processor 3.

The memory plugging rules are as follows:

- Plug sequence will always allow for memory mirroring (for example, no Feature Code needs to be specified for memory mirroring). The green cells in the following tables indicate the AMM (Active Memory Mirroring) base configuration.
- DIMMs must be installed 4x DIMMs at a time, referred to as a DIMM-quad and identified in Table 2-7 on page 55 and Table 2-8 on page 55 by colors.
- DIMM-quads must be homogeneous. (Only DIMMs of the same capacity are allowed on the same Quad.)
- A DIMM-quad is the minimum installable unit for subsequent upgrades.
- Although each drawer can have different capacity memory DIMMs, for maximum memory performance, the total memory capacity on each memory controller should be equivalent.
- The DIMM-quad placement rules for a single enclosure are as follows (see Figure 2-12 on page 53 for the physical memory topology):
  - Quad 1: J1A, J2A, J5A, J6A (mandatory minimum for each enclosure)

– Quad 2: J3A, J4A, J7A, J8A (mandatory minimum for each enclosure)
– Quad 3: J1B, J2B, J5B, J6B
– Quad 4: J3B, J4B, J7B, J8B

Table 2-7 shows the optimal placement of each DIMM-quad within a single enclosure system. Each enclosure *must have* at least DIMM-quads installed in slots J1A, J2A, J5A, J6A, and J5A, J6A, J7A, and J8A, as shown with the highlighted color.

Table 2-7 Optimum DIMM-quad placement for a single enclosure system

Enclosure 0															
POWER7 processor 0								**POWER7 processor 1**							
Memory controller 1				Memory controller 0				Memory controller 1				Memory controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q1	Q1	Q2	Q2	Q1	Q1	Q2	Q2	Q3	Q3	Q4	Q4	Q3	Q3	Q4	Q4
Quads Q1 and Q2 must be identical to each other. Note: For maximum memory performance, the total memory capacity on each memory controller should be equivalent.															

When populating a multi-enclosure system with DIMM-quads, each enclosure must have at least two DIMM-quads installed in slots J1A, J2A, J5A, J6A, J3A, J4A, J7A, and J8A.. After the mandatory requirements and memory-plugging rules are followed, there is an optimal approach to populating the systems.

Table 2-8 shows the optimal placement of each DIMM-quad within a dual-enclosure system. Each enclosure must have at least two DIMM-quads installed.

Table 2-8 Optimum DIMM-quad placement for a dual enclosure system

Enclosure 0															
POWER7 processor 0								**POWER7 processor 1**							
Memory controller 1				Memory controller 0				Memory controller 1				Memory controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q1	Q1	Q2	Q2	Q1	Q1	Q2	Q2	Q5	Q5	Q8	Q8	Q5	Q5	Q8	Q8
Enclosure 1															
POWER7 Processor 0								**POWER7 Processor 1**							
Memory Controller 1				Memory Controller 0				Memory Controller 1				Memory Controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q3	Q3	Q4	Q4	Q3	Q3	Q4	Q4	Q6	Q6	Q7	Q7	Q6	Q6	Q7	Q7
Quads Q1 and Q2 must be identical to each other. Quads Q3 and Q4 must be identical to each other. Note: For maximum memory performance, the total memory capacity on each memory controller should be equivalent.															

Table 2-9 shows the optimal placement of each DIMM-quad within a three-enclosure system. Each enclosure *must have* at least two DIMM-quads installed.

Table 2-9 Optimum DIMM-quad placement for a three-enclosure system

Enclosure 0															
POWER7 processor 0								**POWER7 processor 1**							
Memory controller 1				Memory Controller 0				Memory controller 1				Memory controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q1	Q1	Q2	Q2	Q1	Q1	Q2	Q2	Q7	Q7	Q12	Q12	Q7	Q7	Q12	Q12
Enclosure 1															
POWER7 Processor 0								**POWER7 Processor 1**							
Memory Controller 1				Memory Controller 0				Memory Controller 1				Memory Controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q3	Q3	Q4	Q4	Q3	Q3	Q4	Q4	Q8	Q8	Q11	Q11	Q8	Q8	Q11	Q11
Enclosure 2															
POWER7 Processor 0								**POWER7 Processor 1**							
Memory Controller 1				Memory Controller 0				Memory Controller 1				Memory Controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q5	Q5	Q6	Q6	Q5	Q5	Q6	Q6	Q9	Q9	Q10	Q10	Q9	Q9	Q10	Q10
Quads Q1 and Q2 must be identical to each other. Quads Q3 and Q4 must be identical to each other. Quads Q5 and Q6 must be identical to each other. Note: For maximum memory performance, the total memory capacity on each memory controller should be equivalent.															

Table 2-10 shows the optimal placement of each DIMM-quad within a four-enclosure system. Each enclosure must have at least two DIMM-quads installed.

Table 2-10 Optimum DIMM-quad placement for a four-enclosure system

Enclosure 0															
POWER7 processor 0								**POWER7 processor 1**							
Memory controller 1				Memory controller 0				Memory controller 1				Memory controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q1	Q1	Q2	Q2	Q1	Q1	Q2	Q2	Q9	Q9	Q16	Q16	Q9	Q9	Q16	Q16
Enclosure 1															
POWER7 Processor 0								**POWER7 Processor 1**							
Memory Controller 1				Memory Controller 0				Memory Controller 1				Memory Controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q3	Q3	Q4	Q4	Q3	Q3	Q4	Q4	Q10	Q10	Q15	Q15	Q10	Q10	Q15	Q15
Enclosure 2															
POWER7 Processor 0								**POWER7 Processor 1**							
Memory Controller 1				Memory Controller 0				Memory Controller 1				Memory Controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q5	Q5	Q6	Q6	Q5	Q5	Q6	Q6	Q11	Q11	Q14	Q14	Q11	Q11	Q14	Q14
Enclosure 3															
POWER7 Processor 0								**POWER7 Processor 1**							
Memory Controller 1				Memory Controller 0				Memory Controller 1				Memory Controller 0			
J1A	J2A	J3A	J4A	J5A	J6A	J7A	J8A	J1B	J2B	J3B	J4B	J5B	J6B	J7B	J8B
Q7	Q7	Q8	Q8	Q7	Q7	Q8	Q8	Q12	Q12	Q13	Q13	Q12	Q12	Q13	Q13
Quads Q1 and Q2 must be identical to each other. Quads Q3 and Q4 must be identical to each other. Quads Q5 and Q6 must be identical to each other. Quads Q7 and Q8 must be identical to each other. Note: For maximum memory performance, the total memory capacity on each memory controller should be equivalent.															

2.3.3 Memory throughput

POWER7 has exceptional cache, memory, and interconnect bandwidths. Table 2-11 shows the bandwidth estimate for the Power 770 system running at 3.3 GHz.

Table 2-11 Power 770 memory bandwidth estimates for POWER7 cores running at 3.3 GHz

Memory	Bandwidth
L1 (data) cache	158.4 Gbps
L2 cache	158.4 Gbps
L3 cache	105.6 Gbps
System memory: 4x enclosures:	136.44 Gbps per socket 1091.58 Gbps
Inter-node buses (four enclosures)	158.02 Gbps
Intra-node buses (four enclosures)	415.74 Gbps

With an increase in frequency, the Power 780 running at 3.92 GHz generates higher cache bandwidth (Table 2-12).

Table 2-12 Power 780 memory bandwidth estimates for POWER7 cores running at 3.92 GHz

Memory	Bandwidth
L1 (data) cache	188.16 Gbps
L2 cache	188.16 Gbps
L3 cache	125.44 Gbps
System memory: 4x enclosures:	136.45 Gbps per socket 1091.58 Gbps
Inter-node buses (4 enclosures)	158.02 Gbps
Intra-node buses (4 enclosures)	415.74 Gbps

In TurboCore mode, the Power 780 will have its cores running at 4.14 GHz generating even higher cache bandwidth (Table 2-13).

Table 2-13 Power 780 memory bandwidth estimates for POWER7 cores running at 4.14 GHz

Memory	Bandwidth
L1 (data) cache	198.72 Gbps
L2 cache	198.72 Gbps
L3 cache	132.48 Gbps
System memory: 4x enclosures:	136.45 Gbps per socket 1091.58 Gbps
Inter-node buses (4 enclosures)	158.02 Gbps
Intra-node buses (4 enclosures)	415.74 Gbps

2.3.4 Active Memory Mirroring

Power 770 and Power 780 servers have the ability to provide mirroring of the hypervisor code among different memory DIMMs. This feature will enhance the availability of a server and keep it operable in case a DIMM failure occurs in one of the DIMMs that hold the hypervisor code.

The hypervisor code, which resides on the initial DIMMs (J1A to J8A), will be mirrored on the same group of DIMMs to allow for more usable memory. Table 2-9 on page 56 shows the DIMMs involved on the Memory Mirroring operation.

Figure 2-14 shows how Active Memory Mirroring uses different DIMMs.

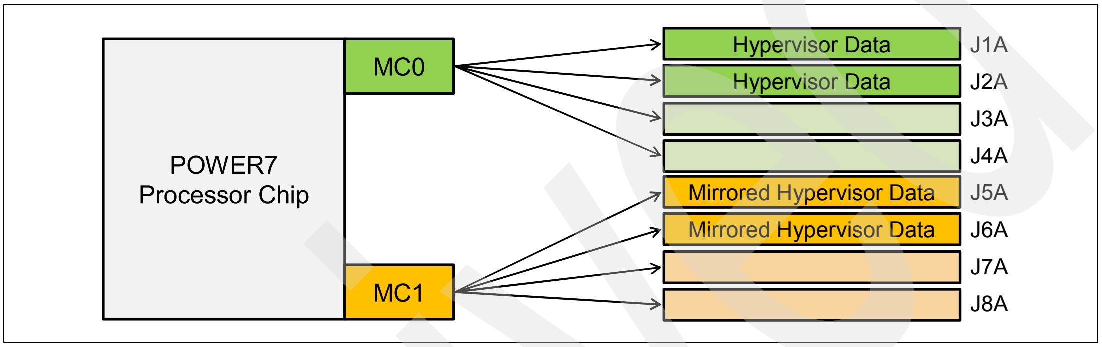

Figure 2-14 Memory Mirroring among different DIMMs

To enable the Active Memory Mirroring (AMM) feature, the server must have 8x DIMMs of the same size populated on slots J1A to J8A. It is also mandatory that the server has enough free memory to accommodate the mirrored memory pages. Active Memory Mirroring is required and automatically enabled on the Power 780. However, on the Power 770 AMM is optional and is ordered and enabled via feature #4797.

Besides the hypervisor code itself, other components that are vital to the server operation are also mirrored:

- Hardware page tables (HPTs), responsible for tracking the state of the memory pages assigned to partitions
- Translation control entities (TCEs), responsible for providing I/O buffers for the partition's communications
- Memory used by the hypervisor to maintain partition configuration, I/O states, Virtual I/O information, and partition state

There are components that are not mirrored after they are not vital to the regular server operations and would require a larger amount of memory to accommodate its data:

- Advanced Memory Sharing Pool
- Memory used to hold the contents of platform dumps

Note: Active Memory Mirroring will *not* mirror partition data. It was designed to mirror only the hypervisor code and its components, allowing this data to be protected against a DIMM failure.

It is possible to check whether the Memory Mirroring option is enabled and change its current status via HMC, under the Advanced Tab on the CEC Properties Panel (Figure 2-15).

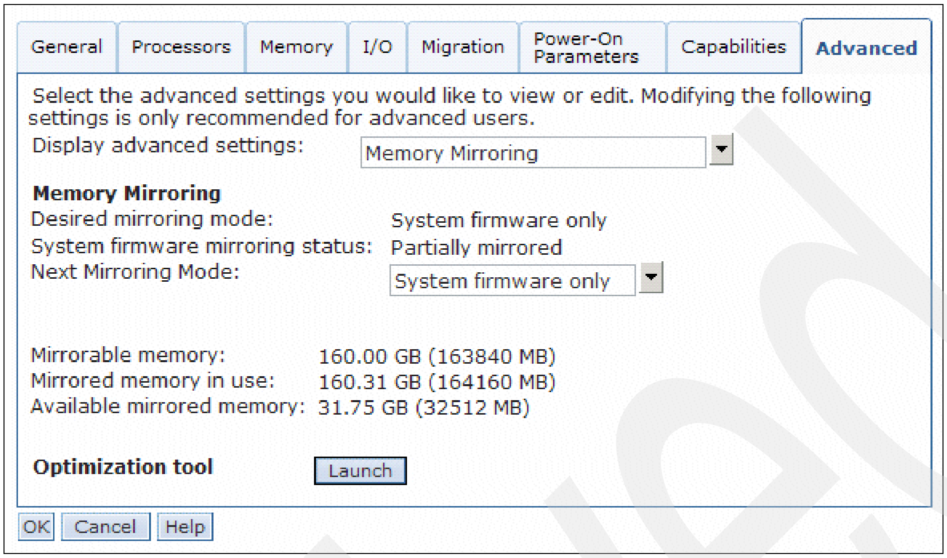

Figure 2-15 CEC Properties window on an HMC

After a failure on one of the DIMMs containing hypervisor data occurs, all the server operations remain active and the service processor will isolate the failing DIMMs. Because there are no longer eight functional DIMMs behind a memory controller, Active Memory Mirroring will not be available until this DIMM is replaced. Systems will stay in the partially mirrored state until the failing DIMM is replaced.

2.4 Capacity on Demand

Several types of Capacity on Demand (CoD) are optionally available on the Power 770 and Power 780 servers to help meet changing resource requirements in an on demand environment by using resources that are installed on the system but that are not activated.

2.4.1 Capacity Upgrade on Demand (CUoD)

CUoD allows you to purchase additional permanent processor or memory capacity and dynamically activate them when needed.

2.4.2 On/Off Capacity on Demand (On/Off CoD)

On/Off Capacity on Demand allows you to temporarily activate and deactivate processor cores and memory units to help meet the demands of business peaks such as seasonal activity, period-end, or special promotions. When you order an On/Off CoD feature, you receive an enablement code that allows a system operator to make requests for additional processor and memory capacity in increments of one processor day or 1 GB memory day. The system monitors the amount and duration of the activations. Both prepaid and post-pay options are available.

On the post-pay options, charges are based on usage reporting collected monthly. Processors and memory can be activated and turned off an unlimited number of times when additional processing resources are needed.

This offering provides a system administrator an interface at the HMC to manage the activation and deactivation of resources. A monitor that resides on the server records the usage activity. This usage data must be sent to IBM on a monthly basis. A bill is then generated based on the total amount of processor and memory resources utilized, in increments of processor and memory (1 GB) days.

Before using temporary capacity on your server, you must enable your server. To do this, an enablement feature (MES only) must be ordered, and the required contracts must be in place.

If a Power 770 or Power 780 server uses the IBM i operating system in addition to any other supported operating system on the same server, the client must inform IBM which operating system caused the temporary On/Off CoD processor usage so that the correct feature can be used for billing.

The features that are used to order enablement codes and support billing charges on the Power 770 and Power 780 can be seen in 1.4.6, "Summary of processor features" on page 15, and 1.4.7, "Memory features" on page 19.

The On/Off CoD process consists of three steps:

1. Enablement

   Before requesting temporary capacity on a server, you must enable it for On/Off CoD. To do this, order an enablement feature and sign the required contracts. IBM will generate an enablement code, mail it to you, and post it on the web for you to retrieve and enter on the target server.

   A *processor enablement* code allows you to request up to 360 processor days of temporary capacity. If the 360 processor-day limit is reached, place an order for another processor enablement code to reset the number of days that you can request back to 360.

   A *memory enablement* code lets you request up to 999 memory days of temporary capacity. If you have reached the limit of 999 memory days, place an order for another memory enablement code to reset the number of allowable days that you can request back to 999.

2. Activation requests

   When On/Off CoD temporary capacity is needed, simply use the HMC menu for On/Off CoD. Specify how many of the inactive processors or GB of memory are required to be temporarily activated for a certain number of days. You will be billed for the days requested, whether the capacity is assigned to partitions or left in the Shared Processor Pool.

   At the end of the temporary period (days that were requested), you must ensure that the temporarily activated capacity is available to be reclaimed by the server (not assigned to partitions), or you are billed for any unreturned processor days.

3. Billing

   The contract, signed by the client before receiving the enablement code, requires the On/Off CoD user to report billing data at least once a month (whether or not activity occurs). This data is used to determine the proper amount to bill at the end of each billing period (calendar quarter). Failure to report billing data for use of temporary processor or memory capacity during a billing quarter can result in default billing equivalent to 90 processor days of temporary capacity.

For more information regarding registration, enablement, and usage of On/Off CoD, visit:

http://www.ibm.com/systems/power/hardware/cod

2.4.3 Utility Capacity on Demand (Utility CoD)

Utility CoD automatically provides additional processor performance on a temporary basis within the Shared Processor Pool.

Utility CoD enables you to place a quantity of inactive processors into the server's Shared Processor Pool, which then becomes available to the pool's resource manager. When the server recognizes that the combined processor utilization within the Shared Processor Pool exceeds 100% of the level of base (purchased and active) processors assigned across uncapped partitions, then a Utility CoD Processor Minute is charged and this level of performance is available for the next minute of use.

If additional workload requires a higher level of performance, the system automatically allows the additional Utility CoD processors to be used, and the system automatically and continuously monitors and charges for the performance needed above the base (permanent) level.

Registration and usage reporting for Utility CoD is made using a public website, and payment is based on reported usage. Utility CoD requires PowerVM Standard Edition or PowerVM Enterprise Edition to be active.

If a Power 770 or Power 780 server uses the IBM i operating system in addition to any other supported operating system on the same server, the client must inform IBM which operating system caused the temporary Utility CoD processor usage so that the correct feature can be used for billing.

For more information regarding registration, enablement, and use of Utility CoD, visit:

http://www.ibm.com/systems/support/planning/capacity/index.html

2.4.4 Trial Capacity On Demand (Trial CoD)

A *standard request* for Trial CoD requires you to complete a form including contact information and vital product data (VPD) from your Power 770 or Power 780 system with inactive CoD resources.

A standard request activates two processors or 4 GB of memory (or both two processors and 4 GB of memory) for 30 days. Subsequent standard requests can be made after each purchase of a permanent processor activation. An HMC is required to manage Trial CoD activations.

An *exception request* for Trial CoD requires you to complete a form including contact information and VPD from your Power 770 or Power 780 system with inactive CoD resources. An exception request will activate all inactive processors or all inactive memory (or all inactive processor and memory) for 30 days. An exception request can be made only one time over the life of the machine. An HMC is required to manage Trial CoD activations.

To request either a Standard or an Exception Trial, visit:

https://www-912.ibm.com/tcod_reg.nsf/TrialCod?OpenForm

2.4.5 Software licensing and CoD

For software licensing considerations with the various CoD offerings, see the most recent revision of the *Capacity on Demand User's Guide* at:

http://www.ibm.com/systems/power/hardware/cod

2.5 CEC Enclosure interconnection cables

IBM Power 770 or 780 systems can be configured with more than one system enclosure. The connection between the processor cards in the separate system enclosures requires a set of processor drawer interconnect cables. Each system enclosure must be connected to each other through a flat flexible SMP cable. These cables are connected on the front of the drawers.

Furthermore, service processor cables are needed to connect the components in each system enclosure to the active service processor for system functions monitoring. These cables connect at the rear of each enclosure and are required for two-drawer, three-drawer, and four-drawer configurations.

The star fabric bus topology that connects the processors together in separate drawers is contained on SMP Flex cables that are routed external to the drawers. These flex cables attach directly to the CPU cards at the front of the drawer and are routed behind the front covers of the drawers.

For performance reasons, there will be multiple link connections between the CEC enclosures, and there will be differences in SMP Flex cabling between the two SCM processor card configurations (#4983, #4984, #5003) and the four SCM processor cards configurations (#EP24).

The SMP and FSP cable features described in Table 2-14 are required to connect the processors together when system configuration is made of two, three, or four CEC enclosures.

Table 2-14 Required flex cables feature codes

CEC enclosures	SMP cables for the 0-12 core (#4983) and 0-16 core (#4984) processor cards	SMP cables for the 0-24 core (#EP24) processor cards	FSP cables
Two	#3711 and #3712	#3715 and #3716	#3671
Three	#3712 and #3713	#3715, #3716, #3717	#3671 and #3672
Four	#3712, #3713, #3714	#3716, #3717, #3718	#3671, #3672, #3673

Note: The #3712 and #3716 provide two SMP cable sets, and #3714 and #3717 provide three SMP cable sets.

The cables are designed to support hot-addition of a system enclosure up to the maximum scalability. When adding a new drawer, existing cables remain in place and new cables are added. The only exception is for cable #3711, which is replaced when growing from a 2-drawer to a 3-drawer configuration.

The cables are also designed to allow the concurrent maintenance of the Power 770 or Power 780 in case the IBM service representative needs to extract a system enclosure from the rack. The design of the flexible cables allows each system enclosure to be disconnected without any impact on the other drawers.

To allow such concurrent maintenance operation, plugging in the SMP Flex cables in the order of their numbering is extremely important. Each cable is numbered (Figure 2-16).

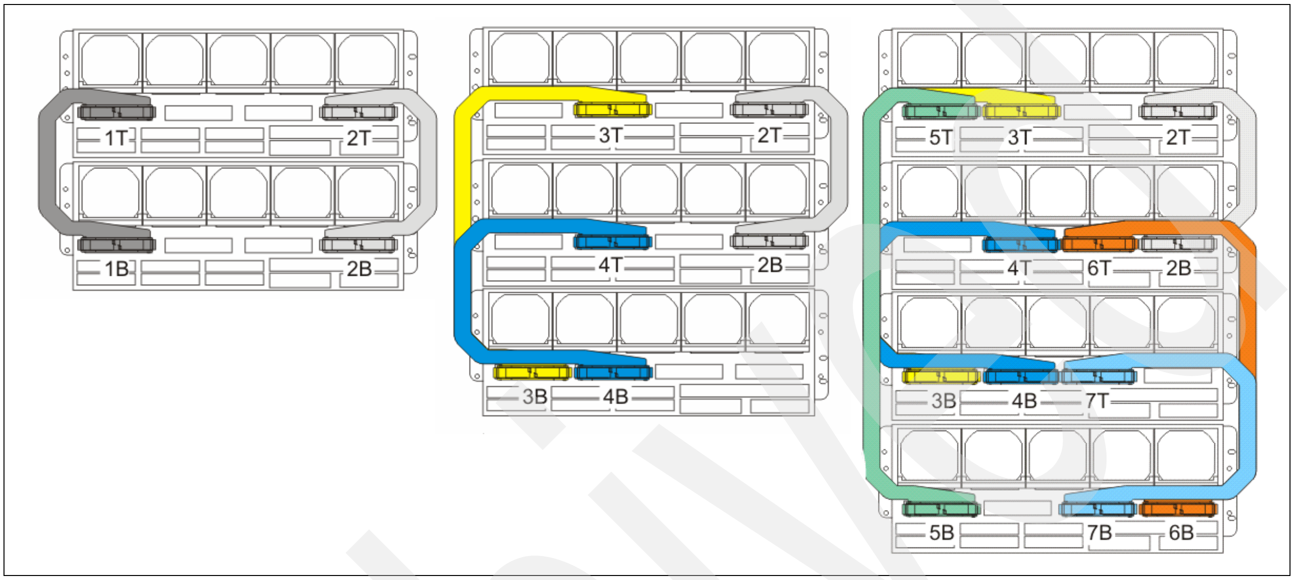

Figure 2-16 SMP cable installation order

Table 2-15 reports the SMP cable usage for two-enclosure or three-enclosure scenarios.

Table 2-15 SMP cable two and three enclosures scenario

Processor type	SMP cables	Cable number	From connector	To connector
Two CEC enclosures				
#4983, #4984, #5003, (0-12 core, 0-16 core)	#3711	1	U1-P3-T1	U2-P3-T1
	#3712	2	U1-P3-T4	U2-P3-T4
#EP24 (0-24 core)	#3715	1	U1-P3-T1	U2-P3-T1
	#3716	4	U1-P3-T2	U3-P3-T2
		2	U1-P3-T4	U2-P3-T4
Three CEC enclosures				
#4983, #4984, #5003, (0-12 core, 0-16 core)	#3712	2	U1-P3-T4	U2-P3-T4
	#3713	3	U1-P3-T2	U3-P3-T1
		4	U2-P3-T2	U3-P3-T2

Processor type	SMP cables	Cable number	From connector	To connector
#EP24 (0-24 core)	#3715	1	U1-P3-T1	U2-P3-T1
	#3716	4	U2-P3-T2	U3-P3-T2
		2	U1-P3-T4	U2-P3-T4
	#3717	7	U2-P3-T3	U3-P3-T3
		3	U1-P3-T2	U3-P3-T1
		6	U1-P3-T3	U3-P3-T4

Table 2-16 reports the SMP cable usage for the four-enclosure scenario.

Table 2-16 SMP cable four-enclosures scenario

Processor type	SMP cables	Cable number	From connector	To connector
#4983, #4984, #5003 (0-12 core, 0-16 core)	#3712	2	U1-P3-T4	U2-P3-T4
	#3713	3	U1-P3-T2	U3-P3-T1
		4	U2-P3-T2	U3-P3-T2
	#3714	5	U1-P3-T1	U4-P3-T4
		6	U2-P3-T3	U4-P3-T3
		7	U3-P3-T3	U4-P3-T3
#EP24 (0-24 core)	#3716	4	U2-P3-T2	U3-P3-T2
		2	U1-P3-T4	U2-P3-T4
	#3717	7	U3-P3-T3	U4-P3-T3
		3	U1-P3-T2	U3-P3-T1
		6	U2-P3-T3	U4-P3-T4
	#3718	5	U1-P3-T1	U4-P3-T1

When adding CEC enclosures in an MES upgrade, SMP cables will likely have to be added depending on how many enclosures are being added.

Adding more than one CEC enclosure to an existing configuration can be accomplished with a hot-add if the enclosures are added one at a time. The other option is to bring the entire system down and add all the additional enclosures at the same time. Depending on whether the hot-add option is desired, certain SMP cable features might or might not be necessary.

Similarly, the Flexible Service Processor (FSP) flex cables must be installed in the correct order (Figure 2-17), as follows:

1. Install a second node flex cable from node 1 to node 2.
2. Add a third node flex cable from node 1 and node 2 to node 3.
3. Add a fourth node flex cable from node 1 and node 2 to node 4.

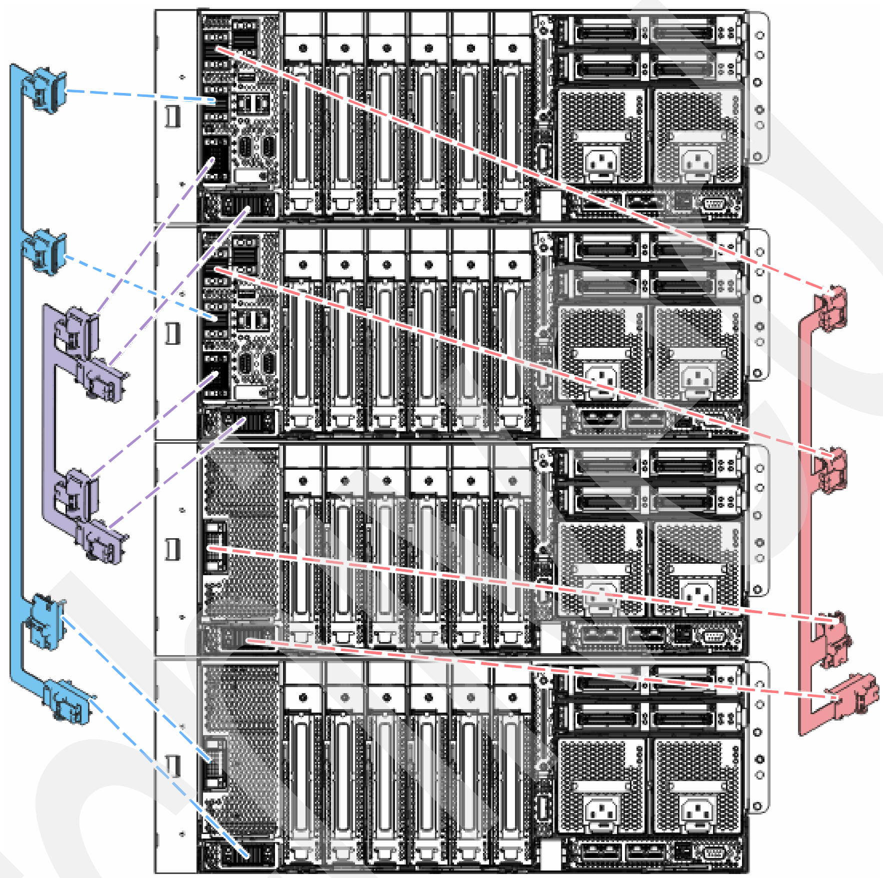

Figure 2-17 FSP flex cables

The design of the Power 770 and Power 780 is optimized for use in an IBM 7014-T00 or 7014-T42 rack. Both the front cover and the external processor fabric cables occupy space on the front left and right side of an IBM 7014 rack. Racks that are not from IBM might not offer the same room. When a Power 770 or Power 780 is configured with two or more system enclosures in a 7014-T42 or 7014-B42 rack, the CEC enclosures must be located in EIA 36 or below to allow space for the flex cables.

The total width of the server, with cables installed, is 21 inches (Figure 2-18).

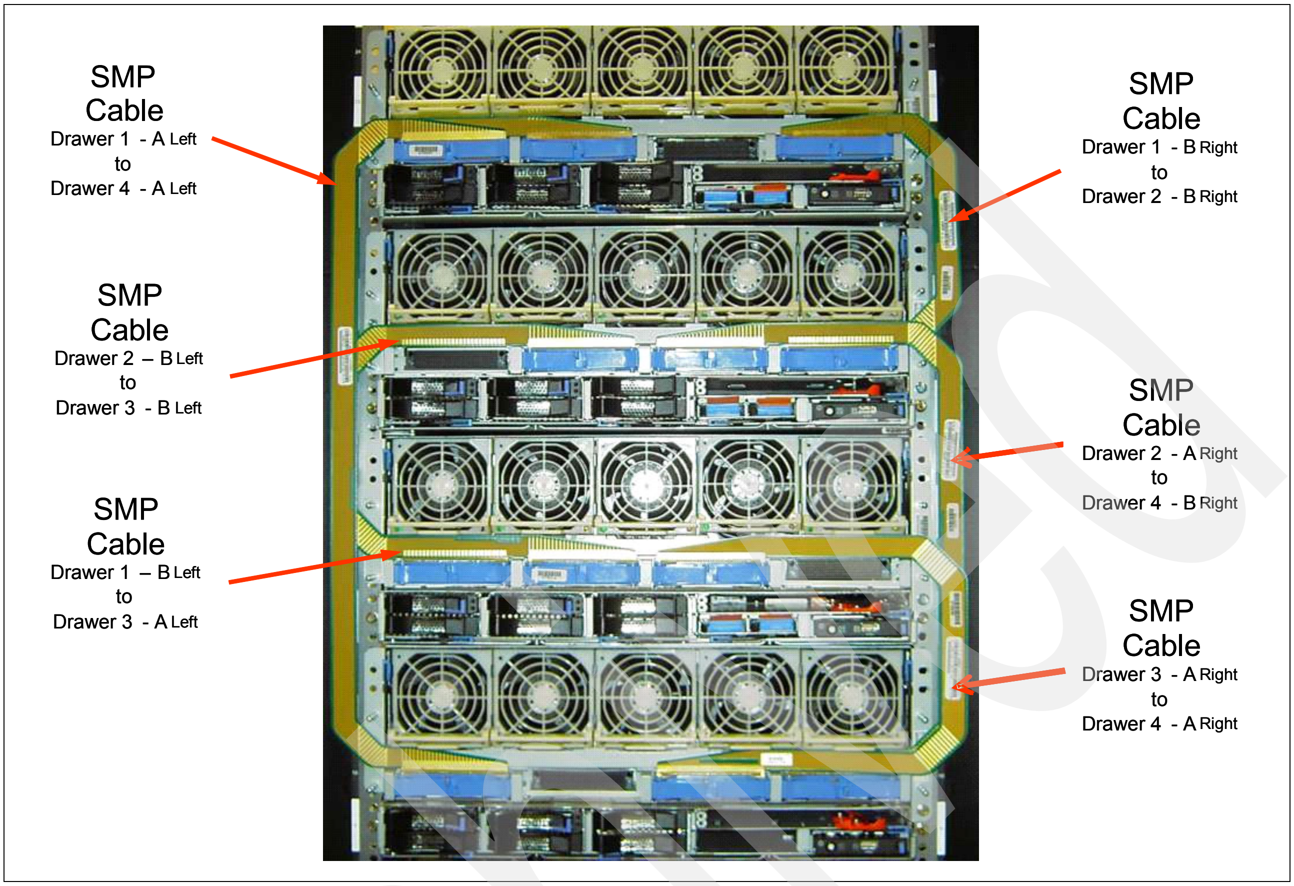

Figure 2-18 Front view of the rack with SMP cables overlapping the rack rails

In the rear of the rack, the FSP cables require only some room in the left side of the racks (Figure 2-19).

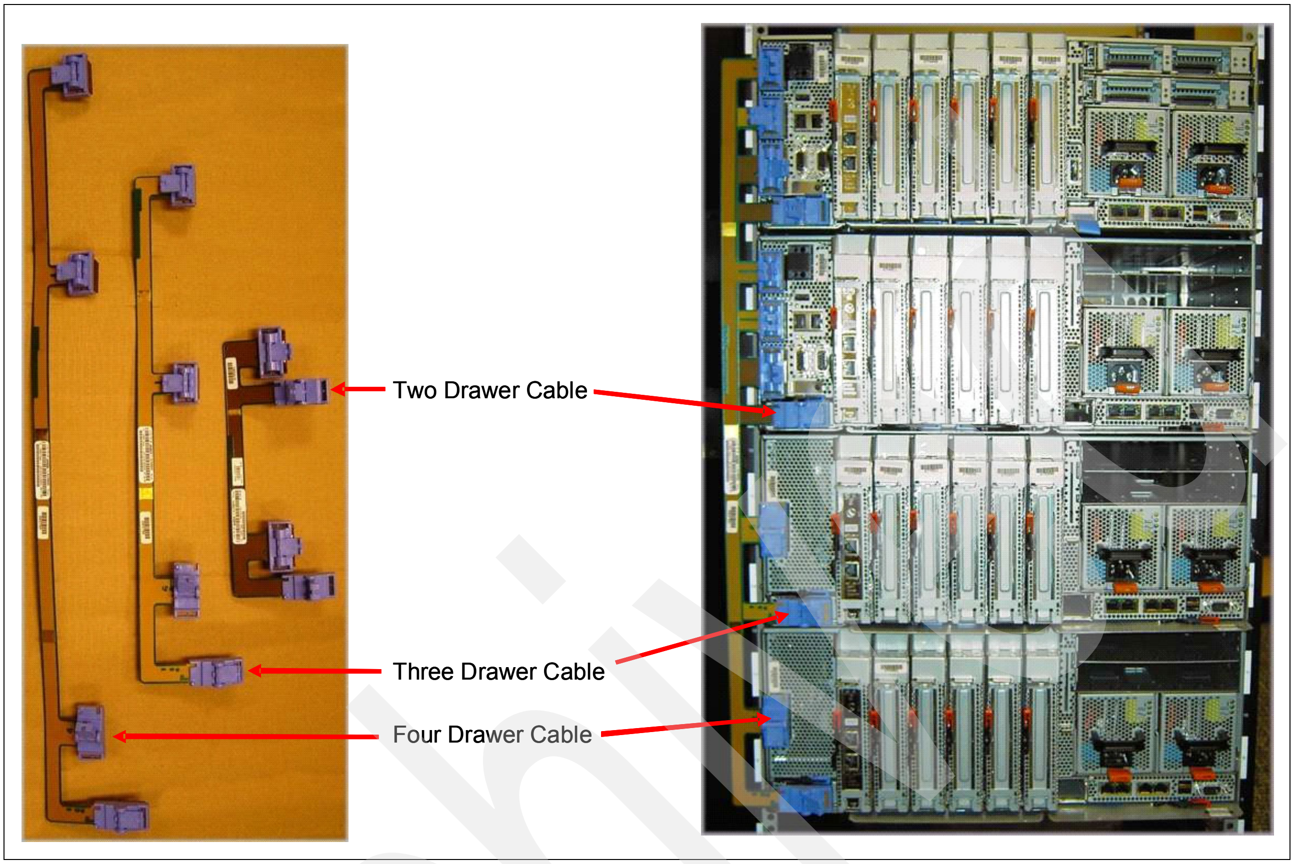

Figure 2-19 Rear view of rack with detail of FSP flex cables

2.6 System bus

This section provides additional information related to the internal buses.

2.6.1 I/O buses and GX++ card

Each CEC enclosure of the Power 770 and Power 780 contains one POWER7 processor card, where as each processor card comprises either two single-chip module POWER7 processors (#4983, #4984, or #5003) or, new to the Power 780, four single-chip module POWER7 processors (#EP24).

Within a CEC enclosure a total of four GX++ buses are available for I/O connectivity and expansion. Two GX++ buses off one of the two sockets are routed through the midplane to the I/O backplane and drive two POWER7 I/O chips (POWER7 IOC) on the I/O backplane. The two remaining GX++ buses from either of the two sockets are routed to the midplane and feed two GX++ adapter slots.

The optional GX++ 12X DDR Adapter Dual-port (#1808), which is installed in the GX++ adapter slot, enables the attachment of a 12X loop, which runs at either SDR or DDR speed depending upon the 12X I/O drawers attached. These GX++ adapter slots are hot-pluggable and do not share space with any of the PCIe slots.

Table 2-17 shows the I/O bandwidth for available processors cards.

Table 2-17 I/O bandwidth

Processor card	Slot description	Frequency	Device	Bandwidth (maximum theoretical)
#4983, #4984 or #5003	CPU Socket 0 (CP0) GX bus 1	2.464 Gbps	P7IOC-B	19.712 GBps
	CPU Socket 0 (CP0) GX bus 0	2.464 Gbps	P7IOC-A	19.712 GBps
	CPU Socket 1 (CP1) GX bus 1	2.464 Gbps	GX slot 2	19.712 GBps
	CPU Socket 1 (CP1) GX bus 0	2.464 Gbps	GX slot 1	19.712 GBps
Single enclosure				78.848 GBps
Total (4x enclosures)				315.392 GBps
#EP24	CPU Socket 0 (CP0) GX bus 1	2.464 Gbps	P7IOC-B	19.712 GBps
	CPU Socket 2 (CP2) GX bus 0	2.464 Gbps	P7IOC-A	19.712 GBps
	CPU Socket 3 (CP3) GX bus 0	2.464 Gbps	GX slot - lower	19.712 GBps
	CPU Socket 1 (CP1) GX bus 1	2.464 Gbps	GX slot - upper	19.712 GBps
Single enclosure				78.848 GBps
Total (4x enclosures)				315.392 GBps

2.6.2 Flexible Service Processor bus

The Flexible Service Processor (FSP) flex cable, which is located at the rear of the system, is used for FSP communication between the system drawers. A FSP card (#5664) is installed in system drawer 1 and system drawer 2, and the FSP/Clock Pass-Through card (#5665) is installed in system drawer 3 and system drawer 4 for connecting FSP flex cable. The FSP cable has been changed to point-to-point cabling similar to the processor drawer interconnect cable. When a system drawer is added, another FSP flex cable is added. A detailed cable configuration is discussed in 2.5, “CEC Enclosure interconnection cables” on page 63.

2.7 Internal I/O subsystem

The internal I/O subsystem resides on the I/O planar, which supports eight PCIe slots. All PCIe slots are hot-pluggable and enabled with enhanced error handling (EEH). In the unlikely event of a problem, EEH-enabled adapters respond to a special data packet that is generated from the affected PCIe slot hardware by calling system firmware, which examines the affected bus, allows the device driver to reset it, and continues without a system reboot.

Table 2-18 lists the slot configuration of the Power 770 and Power 780.

Table 2-18 Slot configuration of the Power 770 and 780

Slot number	Description	Location code	PCI host bridge (PHB)	Max. card size
Slot 1	PCIe Gen2 x8	P2-C1	P7IOC A PCIe PHB5	Full length
Slot 2	PCIe Gen2 x8	P2-C2	P7IOC A PCIe PHB4	Full length
Slot 3	PCIe Gen2 x8	P2-C3	P7IOC A PCIe PHB3	Full length
Slot 4	PCIe Gen2 x8	P2-C4	P7IOC A PCIe PHB2	Full length
Slot 5	PCIe Gen2 x8	P2-C5	P7IOC B PCIe PHB5	Full length
Slot 6	PCIe Gen2 x8	P2-C6	P7IOC B PCIe PHB4	Full length
Slot 7	GX++	P1-C2	-	-
Slot 8	GX++	P1-C3	-	-

2.7.1 Blind-swap cassettes

The Power 770 and Power 780 uses new fourth-generation blind-swap cassettes to manage the installation and removal of adapters. This new mechanism requires an interposer card that allows the PCIe adapters to plug in vertically to the system, allows more airflow through the cassette, and provides more room under the PCIe cards to accommodate the GX+ multifunctional host bridge chip heat sink height. Cassettes can be installed and removed without removing the CEC enclosure from the rack.

2.7.2 System ports

Each CEC enclosure is equipped with a Integrated Multifunction Card (#1768 or #1769). This integrated card provides two USB ports, one serial port, and four Ethernet connectors for a processor enclosure and does not require a PCIe slot. When ordering a Power 770 or Power 780, the following options can be selected:

- Dual 10 Gb Copper and Dual 1 Gb Ethernet (#1768)
- Dual 10 Gb Optical and Dual 1 Gb Ethernet (#1769)

All of the connectors are on the rear bulkhead of the CEC, and one Integrated Multifunction Card can be placed in an individual CEC enclosure. An Integrated Multifunction Card is required in CEC enclosures one and two, but it is not required in CEC enclosures three or four. On a multi-enclosure system, the Integrated Multifunction Card features can differ. The copper twinax ports support up to 5 m cabling distances. The RJ-45 ports support up to 100 m cabling distance using a Cat5e cable. The optical ports only support the 850 Nm optic cable (multi mode cable) and support up to 300 m cabling distances.

The Power 770 and Power 780 each support one serial port in the rear of the system. This connector is a standard 9-pin male D-shell, and it supports the RS232 interface. Because the Power 770 and Power 780 are managed by an HMC/SDMC, this serial port is always controlled by the operating system, and therefore is available in any system configuration. It is driven by the integrated PLX Serial chip, and it will support any serial device that has an operating system device driver. The FSP virtual console will be on the HMC /SDMC.

2.8 PCI adapters

This section covers the different types and functionalities of the PCI cards supported by IBM Power 770 and Power 780 systems.

2.8.1 PCIe Gen1 and Gen2

Peripheral Component Interconnect Express (PCIe) uses a serial interface and allows for point-to-point interconnections between devices (using a directly wired interface between these connection points). A single PCIe serial link is a dual-simplex connection that uses two pairs of wires, one pair for transmit and one pair for receive, and can transmit only one bit per cycle. These two pairs of wires are called a *lane*. A PCIe link can consist of multiple lanes. In such configurations, the connection is labeled as x1, x2, x8, x12, x16, or x32, where the number is effectively the number of lanes.

Two generations of PCIe interface are supported in Power 770 and Power 780 models:

- Gen1: Capable of transmitting at the extremely high speed of 2.5 Gbps, which gives a capacity of a peak bandwidth of 2 GBps simplex on an x8 interface
- Gen2: Double the speed of the Gen1 interface, which gives a capacity of a peak bandwidth of 4 GBps simplex on an x8 interface

PCIe Gen1 slots support Gen1 adapter cards and also most of the Gen2 adapters. In this case, where a Gen2 adapter is used in a Gen1 slot, the adapter will operate at PCIe Gen1 speed. PCIe Gen2 slots support both Gen1 and Gen2 adapters. In this case, where a Gen1 card is installed into a Gen2 slot, it will operate at PCIe Gen1 speed with a slight performance enhancement. When a Gen2 adapter is installed into a Gen2 slot, it will operate at the full PCIe Gen2 speed.

The IBM Power 770 and Power 780 CEC enclosure is equipped with six PCIe x8 Gen2 slots.

2.8.2 PCI-X adapters

IBM offers PCIe adapter options for the Power 770 and Power 780 CEC enclosure. If a PCI-extended (PCI-X) adapter is required, a PCI-X DDR 12X I/O Drawer (#5796) can be attached to the system by using a GX++ adapter loop. PCIe adapters use a different type of slot than PCI and PCI-X adapters. If you attempt to force an adapter into the wrong type of slot, you might damage the adapter or the slot. All adapters support Extended Error Handling (EEH).

2.8.3 IBM i IOP adapters

IBM i IOP adapters are not supported with the Power 770 and Power 780, which has these results:

- Existing PCI adapters that require an IOP are affected.
- Existing I/O devices are affected, such as certain tape libraries or optical drive libraries, or any HVD SCSI device.
- Twinax displays or printers cannot be attached except through an OEM protocol converter.

Before adding or rearranging adapters, use the System Planning Tool to validate the new adapter configuration. See the System Planning Tool website:

http://www.ibm.com/systems/support/tools/systemplanningtool/

If you are installing a new feature, ensure that you have the software required to support the new feature, and determine whether there are any existing PTF prerequisites to install. See the IBM Prerequisite website for information:

https://www-912.ibm.com/e_dir/eServerPreReq.nsf

2.8.4 PCIe adapter form factors

IBM POWER7 processor-based servers are able to support two form factors of PCIe adapters:

- PCIe low profile (LP) cards, which are used with the Power 710 and Power 730 PCIe slots. Low profile adapters are also used in the PCIe riser card slots of the Power 720 and Power 740 servers.
- PCIe full-height and full-high cards, which are plugged into the following servers slots:
  - Power 720 and Power 740 (Within the base system, five PCIe half-length slots are supported.)
  - Power 750
  - Power 755
  - Power 770
  - Power 780
  - Power 795
  - PCIe slots of the #5802 and #5877 drawers

Low-profile PCIe adapter cards are only supported in low-profile PCIe slots, and full-height and full-high cards are only supported in full-high slots.

Figure 2-20 lists the PCIe adapter form factors.

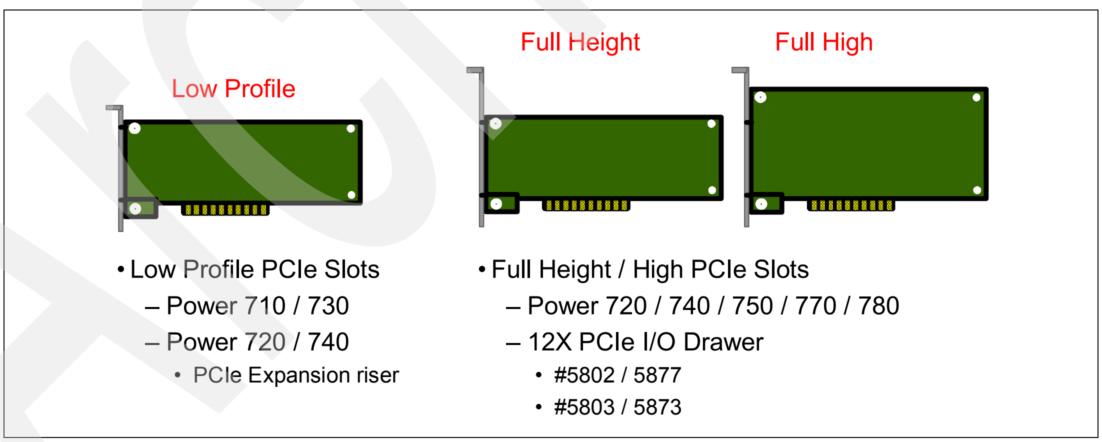

Figure 2-20 PCIe adapter form factors

Many of the full-height card features are available in low-profile format. For example, the #5273 8 Gb dual port Fibre Channel adapter is the low-profile adapter equivalent of the #5735 adapter full-height. They have equivalent functional characteristics.

Table 2-19 is a list of low-profile adapter cards and their equivalent in full height.

Table 2-19 Equivalent adapter cards

Low profile		Adapter description	Full height	
Feature code	**CCIN**		**Feature code**	**CCIN**
#2053	57CD	PCIe RAID and SSD SAS Adapter 3 Gb Low Profile	#2054 or #2055	57CD or 57CD
#5269		POWER GXT145 PCI Express Graphics Accelerator (LP)	#5748	5748
#5270		10 Gb FCoE PCIe Dual Port adapter (LP)	#5708	2BCB
#5271		4-Port 10/100/1000 Base-TX PCI-Express adapter	#5717	5717
#5272		10 Gigabit Ethernet-CX4 PCI Express adapter (LP)	#5732	5732
#5273		8 Gigabit PCI Express Dual Port Fibre Channel adapter (LP)	#5735	577D
#5274		2-Port Gigabit Ethernet-SX PCI Express adapter (LP)	#5768	5768
#5275		10 Gb ENet Fibre RNIC PCIe 8x	#5769	5769
#5276		4 Gigabit PCI Express Dual Port Fibre Channel adapter (LP)	#5774	5774
#5277		4-Port Async EIA-232 PCIe adapter (LP)	#5785	
#5278		SAS Controller PCIe 8x	#5901	57B3

Before adding or rearranging adapters, use the System Planning Tool to validate the new adapter configuration. See the System Planning Tool website:

`http://www.ibm.com/systems/support/tools/systemplanningtool/`

If you are installing a new feature, ensure that you have the software required to support the new feature and determine whether there are any existing update prerequisites to install. To do this, use the IBM Prerequisite website:

`https://www-912.ibm.com/e_dir/eServerPreReq.nsf`

The following sections discuss the supported adapters and provide tables of orderable feature numbers. The tables indicate operating support, AIX (A), IBM i (i), and Linux (L), for each of the adapters.

2.8.5 LAN adapters

To connect a Power 770 and Power 780 to a local area network (LAN), you can use the Integrated Multifunction Card. For more information see 2.7.2, “System ports” on page 70.

> **Note:** The Integrated Multifunction Card can be shared to LPARS using VIOS.

Other LAN adapters are supported in the CEC enclosure PCIe slots or in I/O enclosures that are attached to the system using a 12X technology loop. Table 2-20 lists the additional LAN adapters that are available.

Table 2-20 Available LAN adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
#5269		10 Gigabit Ethernet-SR PCI Express adapter	PCIe	Short,LP	A, L
#5287		PCIe2 2-port 10 GbE SR adapter	PCIe	Low profile Short	A, L
#5288		PCIe2 2-Port 10 GbE SFP+Copper adapter	PCIe	Full height Short	A, L
#5706	5706	IBM 2-Port 10/100/1000 Base-TX Ethernet PCI-X adapter	PCI-X	Full height Short	A, i, L
#5717	5717	4-Port 10/100/1000 Base-TX PCI Express adapter	PCIe	Full height Short	A, L
#5732	5732	10 Gigabit Ethernet-CX4 PCI Express adapter	PCIe	Full height Short	A, L
#5740		4-Port 10/100/1000 Base-TX PCI-X adapter	PCI-X	Full height Short	A, L
#5744	2B44	PCIe2 4-Port 10 GbE&1 GbE SR&RJ45 adapter	PCIe	Full high	L
#5745	2B43	PCIe2 4-Port 10 GbE&1 GbE SFP+Copper&RJ45 adapter	PCIe	Short	L
#5767	5767	2-Port 10/100/1000 Base-TX Ethernet PCI Express adapter	PCIe	Full height Short	A, i, L
#5768	5768	2-Port Gigabit Ethernet-SX PCI Express adapter	PCIe	Full height Short	A, i, L
#5769	5769	10 Gigabit Ethernet-SR PCI Express adapter	PCIe	Full height Short	A, L
#5772	576E	10 Gigabit Ethernet-LR PCI Express adapter	PCIe	Full height Short	A, i, L

2.8.6 Graphics accelerator adapters

The IBM Power 770 and Power 780 support up to eight graphics adapters (Table 2-21). They can be configured to operate in either 8-bit or 24-bit color modes. These adapters support both analog and digital monitors, and do not support hot-plug. The total number of graphics accelerator adapters in any one partition cannot exceed four.

Table 2-21 Available graphics accelerator adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
#2849[a]	2849	POWER GXT135P Graphics Accelerator with Digital Support	PCI-X	Short	A, L
#5748		POWER GXT145 PCI Express Graphics Accelerator	PCIe	Short	A, L

a. Supported, but no longer orderable.

2.8.7 SCSI and SAS adapters

To connect to external SCSI or SAS devices, the adapters that are listed in Table 2-22 are available to be configured.

Table 2-22 Available SCSI and SAS adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
#1912[a]	571A	PCI-X DDR Dual Channel Ultra320 SCSI adapter	PCI-X	Short	A, i, L
#2055	57CD	PCIe RAID and SSD SAS Adapter 3 Gb with Blind Swap Cassette	PCIe	Short	A, i, L
#5646		Blind Swap Type III Cassette- PCIe, Short Slot	PCIe	Short	N/A
#5647		Blind Swap Type III Cassette- PCI-X or PCIe, Standard Slot	PCI-X or PCIe	Short	N/A
#5736	571A	PCI-X DDR Dual Channel Ultra320 SCSI adapter	PCI-X	Short	A, i, L
#5901	57B3	PCIe Dual-x4 SAS adapter	PCIe	Short	A, i, L
#5903[a b]	574E	PCIe 380MB Cache Dual - x4 3 Gb SAS RAID adapter	PCIe	Short	A, i, L
#5908	575C	PCI-X DDR 1.5 GB Cache SAS RAID adapter (BSC)	PCI-X	Long	A, i, L
#5912	572A	PCI-X DDR Dual - x4 SAS adapter	PCI-X	Short	A, i, L
#5913[b]	57B5	PCIe2 1.8 GB Cache RAID SAS adapter Tri-port 6 Gb	PCIe		A, i, L
#7863		PCI Blind Swap Cassette Kit, Double Wide Adapters, Type III	PCI	Short	N/A

a. Supported, but no longer orderable.
b. A pair of adapters is required to provide mirrored write cache data and adapter redundancy

Table 2-23 compares Parallel SCSI to SAS attributes.

Table 2-23 Comparing Parallel SCSI to SAS

Items to compare	Parallel SCSI	SAS
Architecture	Parallel, all devices connected to shared bus	Serial, point-to-point, discrete signal paths
Performance	320 MBps (Ultra320 SCSI), performance degrades as devices are added to shared bus	3 Gbps, scalable to 12 Gbps, performance maintained as more devices are added
Scalability	15 drives	Over 16,000 drives
Compatibility	Incompatible with all other drive interfaces	Compatible with Serial ATA (SATA)
Max. cable length	12 meters total (must sum lengths of all cables used on bus)	8 meters per discrete connection, total domain cabling hundreds of meters
Cable from factor	Multitude of conductors adds bulk, cost	Compact connectors and cabling save space, cost
Hot pluggability	No	Yes
Device identification	Manually set, user must ensure no ID number conflicts on bus	Worldwide unique ID set at time of manufacture
Termination	Manually set, user must ensure proper installation and functionality of terminators	Discrete signal paths enable device to include termination by default

2.8.8 iSCSI adapters

iSCSI adapters in Power Systems provide the advantage of increased bandwidth through the hardware support of the iSCSI protocol. The 1 Gigabit iSCSI TOE (TCP/IP Offload Engine) PCI-X adapters support hardware encapsulation of SCSI commands and data into TCP, and transports them over the Ethernet using IP packets. The adapter operates as an iSCSI TOE. This offload function eliminates host protocol processing and reduces CPU interrupts. The adapter uses a small form factor LC type fiber optic connector or a copper RJ45 connector.

Table 2-24 lists the orderable iSCSI adapters.

Table 2-24 Available iSCSI adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
#5713	573B	1 Gigabit iSCSI TOE PCI-X on Copper Media Adapter	PCI-X	Short	A, i, L
#5714[a]	573C	1 Gigabit iSCSI TOE PCI-X on Optical Media Adapter	PCI-X		A, i, L

a. Supported, but no longer orderable

2.8.9 Fibre Channel adapter

The IBM Power 770 and Power 780 servers support direct or SAN connection to devices that use Fibre Channel adapters. Table 2-25 summarizes the available Fibre Channel adapters.

All of these adapters except #5735 have LC connectors. If you attach a device or switch with an SC type fibre connector, an LC-SC 50 Micron Fiber Converter Cable (#2456) or an LC-SC 62.5 Micron Fiber Converter Cable (#2459) is required.

Table 2-25 Available Fibre Channel adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
5729 [a] [b]		PCIe2 8 Gb 4-port Fibre Channel Adapter	PCIe		A, L
5735[b]	577D	8 Gigabit PCI Express Dual Port Fibre Channel Adapter	PCIe	Short	A, i, L
5749	576B	4 Gbps Fibre Channel (2-Port)	PCI-X	Short	i
5758	1910 280D 280E	4 Gb Single-Port Fibre Channel PCI-X 2.0 DDR Adapter	PCI-X	Short	A, L
5759	1910 5759	4 Gb Dual-Port Fibre Channel PCI-X 2.0 DDR Adapter	PCI-X	Short	A, L
5774	5774	4 Gigabit PCI Express Dual Port Fibre Channel Adapter	PCIe	Short	A, i, L

a. A Gen2 PCIe slot is required to provide the bandwidth for all four ports to operate at full speed.
b. N_Port ID Virtualization (NPIV) capability is supported through VIOS.

2.8.10 Fibre Channel over Ethernet

Fibre Channel over Ethernet (FCoE) allows for the convergence of Fibre Channel and Ethernet traffic onto a single adapter and converged fabric.

Figure 2-21 shows a comparison between an existing FC and network connection and a FCoE connection.

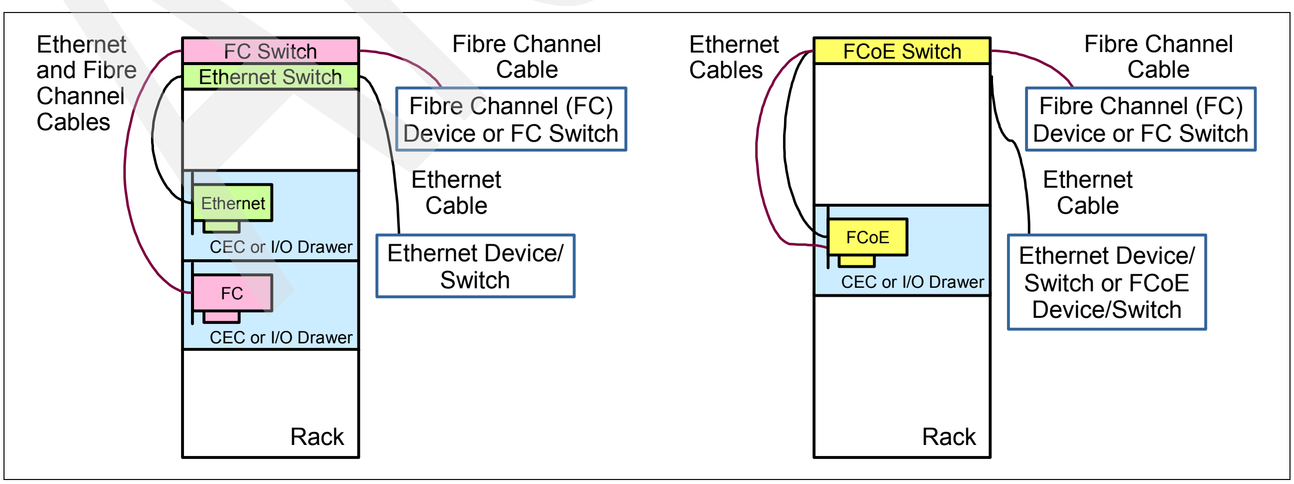

Figure 2-21 Comparison between existing FC and network connection and FCoE connection

For more information about FCoE, read *An Introduction to Fibre Channel over Ethernet, and Fibre Channel over Convergence Enhanced Ethernet*, REDP-4493.

IBM offers a 10 Gb FCoE PCIe Dual Port adapter (#5708). This is a high-performance 10 Gb dual port PCIe Converged Network Adapter (CNA) utilizing SR optics. Each port can provide Network Interface Card (NIC) traffic and Fibre Channel functions simultaneously. It is supported on AIX and Linux for FC and Ethernet.

2.8.11 InfiniBand Host Channel adapter

The InfiniBand Architecture (IBA) is an industry-standard architecture for server I/O and inter-server communication. It was developed by the InfiniBand Trade Association (IBTA) to provide the levels of reliability, availability, performance, and scalability necessary for present and future server systems with levels significantly better than can be achieved by using bus-oriented I/O structures.

InfiniBand (IB) is an open set of interconnect standards and specifications. The main IB specification has been published by the InfiniBand Trade Association and is available at:

http://www.infinibandta.org/

InfiniBand is based on a switched fabric architecture of serial point-to-point links, where these IB links can be connected to either host channel adapters (HCAs), used primarily in servers, or to target channel adapters (TCAs), used primarily in storage subsystems.

The InfiniBand physical connection consists of multiple byte lanes. Each individual byte lane is a four-wire, 2.5, 5.0, or 10.0 Gbps bidirectional connection. Combinations of link width and byte-lane speed allow for overall link speeds from 2.5 Gbps to 120 Gbps. The architecture defines a layered hardware protocol, as well as a software layer to manage initialization and the communication between devices. Each link can support multiple transport services for reliability and multiple prioritized virtual communication channels.

For more information about InfiniBand, read *HPC Clusters Using InfiniBand on IBM Power Systems Servers*, SG24-7767.

IBM offers the GX++ 12X DDR Adapter (#1808) that plugs into the system backplane (GX++ slot). There are two GX++ slots in each CEC enclosure. By attaching a 12X to 4X converter cable (#1828), an IB switch can be attached.

Table 2-26 lists the available InfiniBand adapters.

Table 2-26 Available Fibre Channel adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
#1808		GX++ 12X DDR adapter, Dual-port	GX++		A, L
#5285[a]		2-Port 4X IB QDR adapter 40 Gb	PCIe	Full high	A, L

a. Requires PCIe Gen2 full-high slot

2.8.12 Asynchronous adapter

Asynchronous PCI adapters provide connection of asynchronous EIA-232 or RS-422 devices.

Recent PowerHA releases no longer support heartbeats over serial connections.

Table 2-27 lists the available InfiniBand adapters.

Table 2-27 Available asynchronous adapters

Feature code	CCIN	Adapter description	Slot	Size	OS support
#2728	57D1	4-port USB PCIe adapter	PCIe	Short	A, L
#5785		4-Port Asynchronous EIA-232 PCIe adapter	PCIe	Short	A, L
#5289	2B42	2-Port Async EIA-232 PCIe adapter	PCIe	Short	A, L

2.9 Internal storage

Serial Attached SCSI (SAS) drives the Power 770 and Power 780 internal disk subsystem. SAS provides enhancements over parallel SCSI with its point-to-point high frequency connections. SAS physical links are a set of four wires used as two differential signal pairs. One differential signal transmits in one direction. The other differential signal transmits in the opposite direction. Data can be transmitted in both directions simultaneously.

The Power 770 and Power 780 CEC enclosures have an extremely flexible and powerful backplane for supporting hard disk drives (HDD) or solid-state drives (SSD). The six small form factor (SFF) bays can be configured in three ways to match your business needs. There are two integrated SAS controllers that can be optionally augmented with a 175 MB Cache RAID - Dual IOA Enablement card (Figure 2-22 on page 81). These two controllers provide redundancy and additional flexibility. The optional 175 MB Cache RAID - Dual IOA Enablement Card (#5662) enables dual 175 MB write cache and provides dual batteries for protection of that write cache.

There are two PCIe integrated SAS controllers under the POWER7 I/O chip and also the SAS controller that is directly connected to the DVD media bay (Figure 2-22 on page 81).

Power 770 and Power 780 supports various internal storage configurations:

- Dual split backplane mode: The backplane is configured as two sets of three bays (3/3).
- Triple split backplane mode: The backplane is configured as three sets of two bays (2/2/2).
- Dual storage IOA configuration using internal disk drives (Dual RAID of internal drives only): The backplane is configured as one set of six bays.
- Dual storage IOA configuration using internal disk drives and external enclosure (Dual RAID of internal drives and external drives).

Configuration options will vary depending on the controller options and the operating system selected. The controllers for the dual split backplane configurations are always the two embedded controllers. But if the triple split backplane configuration is used, the two integrated SAS controllers run the first two sets of bays and require a #5901 PCIe SAS adapter located in a PCIe slot in a CEC enclosure. This adapter controls the third set of bays. By having three controllers, you can have three boot drives supporting three partitions.

Note: These solid-state drives (SSD) or hard disk drive (HDD) configuration rules apply:

- You can mix SSD and HDD drives when configured as one set of six bays.
- If you want to have both SSDs and HDDs within a dual split configuration, you must use the same type of drive within each set of three. You cannot mix SSDs and HDDs within a subset of three bays.
- If you want to have both SSDs and HDDs within a triple split configuration, you must use the same type of drive within each set of two. You cannot mix SSDs and HDDs within a subset of two bays. The #5901 PCIe SAS adapter that controls the remaining two bays in a triple split configuration does not support SSDs.

You can configure the two embedded controllers together as a pair for higher redundancy or you can configure them separately. If you configure them separately, they can be owned by different partitions or they could be treated independently within the same partition. If configured as a pair, they provide controller redundancy and can automatically switch over to the other controller if one has problems. Also, if configured as a pair, both can be active at the same time (active/active) assuming that there are two or more arrays configured, providing additional performance capability as well as redundancy. The pair controls all six small form factor (SFF) bays and both see all six drives. The dual split (3/3) and triple split (2/2/2) configurations are not used with the paired controllers. RAID 0 and RAID 10 are supported, and you can also mirror two sets of controller/drives using the operating system.

Power 770 and Power 780, with more than one CEC enclosure, support enclosures with different internal storage configurations.

Adding the optional 175 MB Cache RAID - Dual IOA Enablement Card (#5662) causes the pair of embedded controllers in that CEC drawer to be configured as dual controllers, accessing all six SAS drive bays. With this feature you can get controller redundancy, additional RAID protection options, and additional I/O performance. RAID 5 (a minimum of three drives required) and RAID 6 (a minimum of four drives required) are available when configured as dual controllers with one set of six bays. Feature #5662 plugs in to the disk or media backplane and enables a 175 MB write cache on each of the two embedded RAID adapters by providing two rechargeable batteries with associated charger circuitry.

The write cache can provide additional I/O performance for attached disk or solid-state drives, particularly for RAID 5 and RAID 6. The write cache contents are mirrored for redundancy between the two RAID adapters, resulting in an effective write cache size of 175 MB. The batteries provide power to maintain both copies of write-cache information in the event that power is lost.

Without feature #5662, each controller can access only two or three SAS drive bays.

Another expansion option is an SAS expansion port (#1819). The SAS expansion port can add more SAS bays to the six bays in the system unit. A # 5886 EXP 12S SAS disk drawer is attached using a SAS port on the rear of the processor drawer, and its two SAS bays are run by the pair of embedded controllers. The pair of embedded controllers is now running 18 SAS bays (six SFF bays in the system unit and twelve 3.5-inch bays in the drawer). The disk drawer is attached to the SAS port with a SAS YI cable, and the embedded controllers are connected to the port using a feature #1819 cable assembly. In this 18-bay configuration, all drives must be HDDs.

IBM i supports configurations using one set of six bays but does not support logically splitting the backplane into split (dual or triple). Thus, the 175 MB Cache RAID - Dual IOA Enablement Card (#5662) is required if IBM is to access any of the SAS bays in that CEC enclosure. AIX and Linux support configurations using two sets of three bays (3/3) or three sets of two bays

(2/2/2) without feature 5662. With feature #5662, they support dual controllers running one set of six bays.

Figure 2-22 shows the internal SAS topology overview.

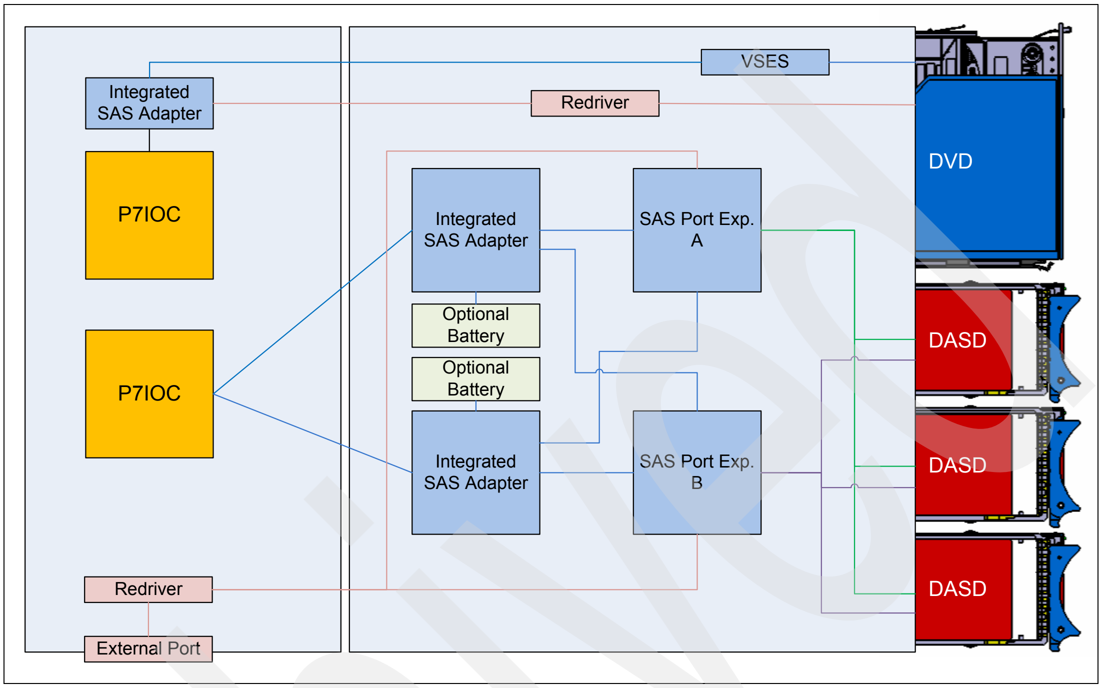

Figure 2-22 Internal SAS topology overview

The system backplane also includes a third embedded controller for running the DVD-RAM drive in the CEC enclosure. Because the controller is independent from the two other SAS disk/SSD controllers, it allows the DVD to be switched between multiple partitions without impacting the assignment of disks or SSDs in the CEC drawer.

Table 2-28 summarizes the internal storage combination and the feature codes required for any combination.

Table 2-28 SAS configurations summary

SAS subsystem configuration	#5662	External SAS components	SAS port cables	SAS cables	Notes
Two-way split backplane	No	None	None	N/A	IBM i does not support this combination. Connecting to an external disk enclosure is not supported.
Three-way split backplane	No	Dual x4 SAS adapter (#5901)	Internal SAS port (#1815) SAS cable for three-way split backplane	AI cable (#3679) - Adapter to internal drive (1 meter)	IBM i does not support this combination. An I/O adapter can be located in another enclosure of the system.

SAS subsystem configuration	#5662	External SAS components	SAS port cables	SAS cables	Notes
Dual storage IOA with internal disk	Yes	None	None	N/A	Internal SAS port cable (#1815) cannot be used with this or HA RAID configuration.
Dual storage IOA with internal disk and external disk enclosure	Yes	Requires an external disk enclosure (#5886)	Internal SAS port (#1819) SAS cable assembly for connecting to an external SAS drive enclosure	#3686 or #3687	#3686 is a 1-meter cable. #3687 is a 3-meter cable.

2.9.1 Dual split backplane mode

Dual split backplane mode offers two set of three disks and is the standard configuration. If desired, one of the sets can be connected to an external SAS PCIe or PCI-X adapter if #1819 is selected. Figure 2-23 shows how the six disk bays are shared with the dual split backplane mode. Although solid-state drives (SSDs) are supported with a dual split backplane configuration, mixing SSDs and hard disk drives (HDDs) in the same split domain is not supported. Also, mirroring SSDs with HDDs is not possible, or vice versa.

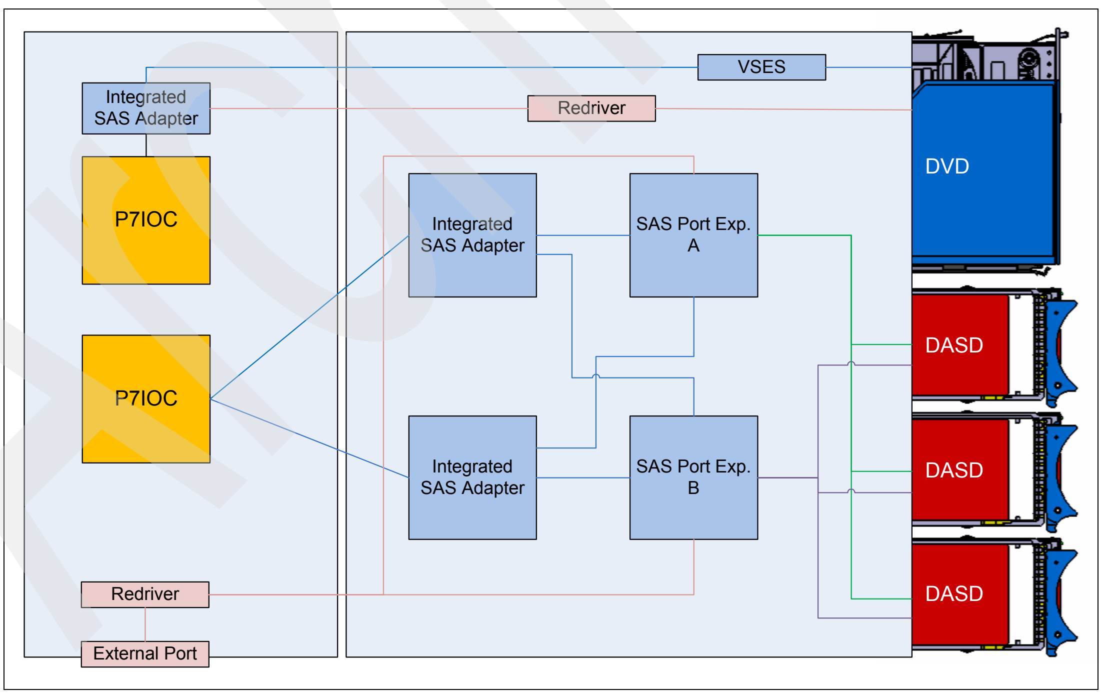

Figure 2-23 Dual split backplane overview

2.9.2 Triple split backplane

The triple split backplane mode offers three sets of two disk drives each. This mode requires #1815 internal SAS cable, a SAS cable #3679, and a SAS controller, such as #5901. Figure 2-24 shows how the six disk bays are shared with the triple split backplane mode. The PCI adapter that drives two of the six disks can be located in the same Power 770 (or Power 780) CEC enclosure as the disk drives or adapter, even in a different system enclosure or external I/O drawer.

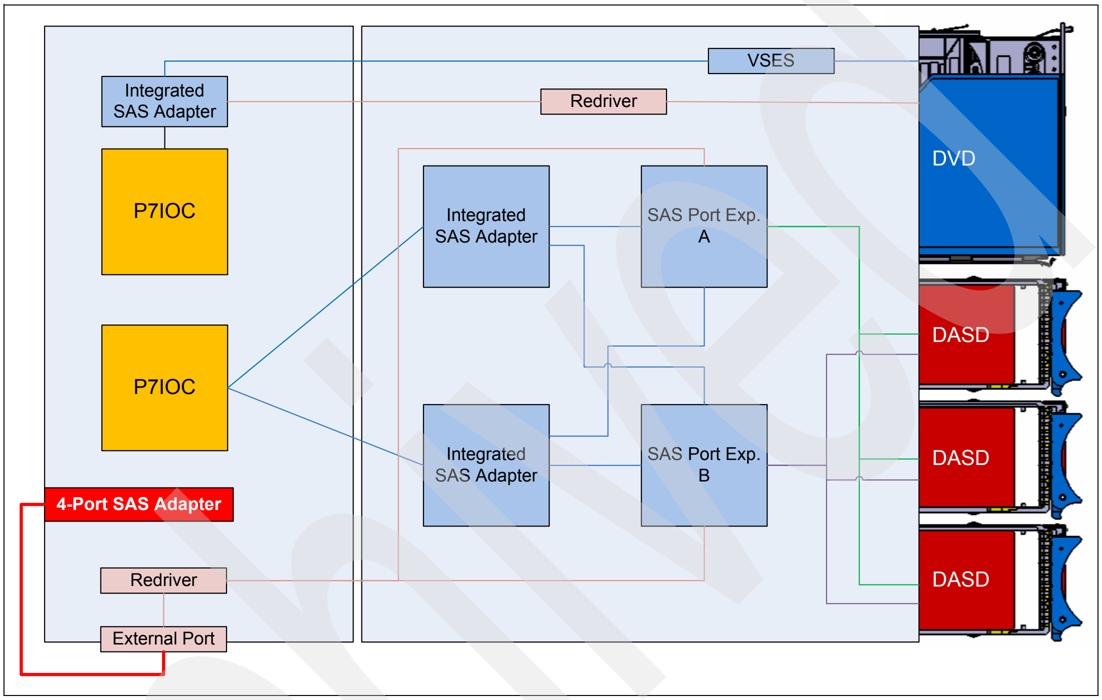

Figure 2-24 Triple split backplane overview

Although SSDs are supported with a triple split backplane configuration, mixing SSDs and HDDs in the same split domain is not supported. Also, mirroring SSDs with HDDs is not possible.

2.9.3 Dual storage IOA configurations

The dual storage IOA configurations are available with internal or internal with external disk drives from another I/O drawer. Solid-state drive (SSD) are not supported with this mode.

If #1819 is selected for an enclosure, selecting SAS cable #3686 or #3687 to support RAID internal and external drives is necessary (Figure 2-25 on page 84). If #1819 is not selected for the enclosure, the RAID supports only enclosure internal disks.

This configuration increases availability using dual storage IOA or high availability (HA) to connect multiple adapters to a common set of internal disk drives. It also increases the performance of RAID arrays. These rules apply to this configuration:

- This configuration uses the 175 MB Cache RAID - Dual IOA enablement card.
- Using the dual IOA enablement card, the two embedded adapters can connect to each other and to all six disk drives, as well as the 12 disk drives in an external disk drive enclosure if one is used.

- The disk drives are required to be in RAID arrays.
- There are no separate SAS cables required to connect the two embedded SAS RAID adapters to each other. The connection is contained within the backplane.
- RAID 0, 10, 5, and 6 support up to six drives.
- Solid-state drives (SSD) and HDDs can be used, but can never be mixed in the same disk enclosure.
- To connect to the external storage, you need to connect to the #5886 disk drive enclosure.

Figure 2-25 shows the topology of the RAID mode.

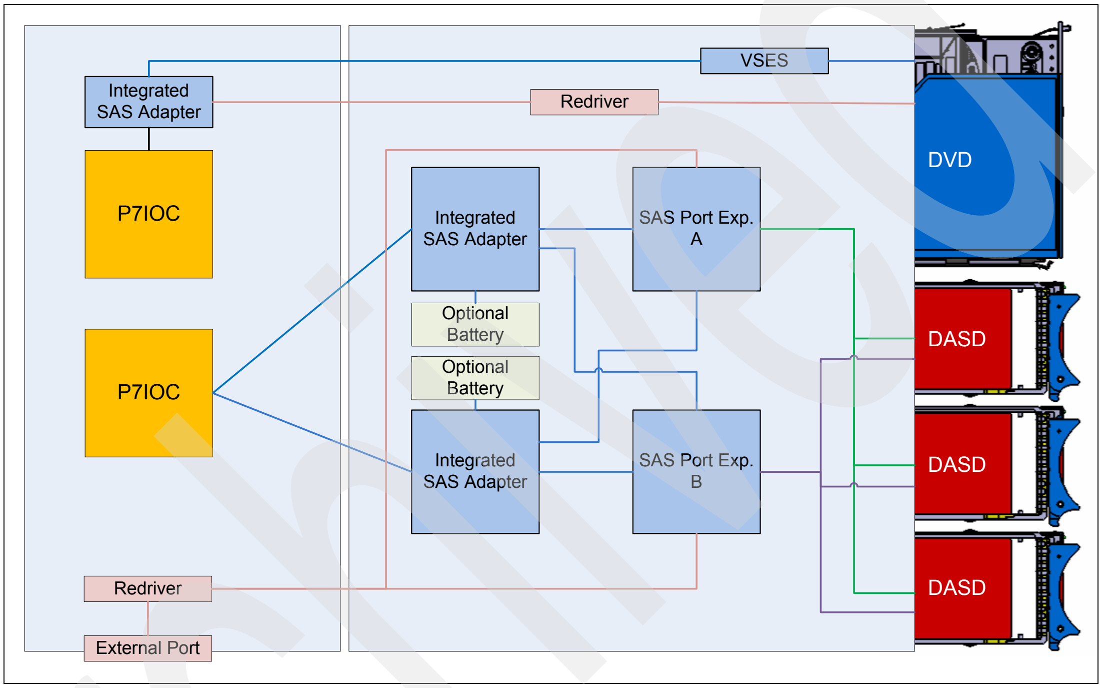

Figure 2-25 RAID mode (external disk drives option)

2.9.4 DVD

The DVD media bay is directly connected to the integrated SAS controller on the I/O backplane and has a specific chip (VSES) for controlling the DVD LED and power. The VSES appears as a separate device to the device driver and operating systems (Figure 2-22 on page 81).

Because the integrated SAS controller is independent from the two SAS disk/SSD controllers, it allows the DVD to be switched between multiple partitions without impacting the assignment of disks or SSDs in the CEC enclosure.

2.10 External I/O subsystems

This section describes the external 12X I/O subsystems that can be attached to the Power 770 and Power 780, listed as follows:

- PCI-DDR 12X Expansion Drawer (#5796)
- 12X I/O Drawer PCIe, small form factor (SFF) disk (#5802)
- 12X I/O Drawer PCIe, No Disk (#5877)

Table 2-29 provides an overview of all the supported I/O drawers.

Table 2-29 I/O drawer capabilities

Drawer feature code	DASD	PCI slots	Requirements for the Power 770 and Power 780
#5796	-	6 x PCI-X	GX++ adapter card #1808
#5802	18 x SAS disk drive bays	10 x PCIe	GX++ adapter card #1808
#5877	-	10 x PCIe	GX++ adapter card #1808

The two GX++ buses from the second processor card feed two GX++ Adapter slots. An optional GX++ 12X DDR Adapter, Dual-port (#1808), which is installed in GX++ Adapter slot, enables the attachment of a 12X loop, which runs at either SDR or DDR speed depending on the 12X I/ O drawers that are attached.

2.10.1 PCI-DDR 12X Expansion drawer

The PCI-DDR 12X Expansion Drawer (#5796) is a 4U (EIA units) drawer and mounts in a 19-inch rack. Feature #5796 is 224 mm (8.8 in.) wide and takes up half the width of the 4U (EIA units) rack space. The 4U enclosure can hold up to two #5796 drawers mounted side-by-side in the enclosure. The drawer is 800 mm (31.5 in.) deep and can weigh up to 20 kg (44 lb).

The PCI-DDR 12X Expansion Drawer has six 64-bit, 3.3 V, PCI-X DDR slots, running at 266 MHz, that use blind-swap cassettes and support hot-plugging of adapter cards. The drawer includes redundant hot-plug power and cooling.

Two interface adapters are available for use in the #5796 drawer:

- Dual-Port 12X Channel Attach Adapter Long Run (#6457)
- Dual-Port 12X Channel Attach Adapter Short Run (#6446)

The adapter selection is based on how close the host system or the next I/O drawer in the loop is physically located. Feature #5796 attaches to a host system CEC enclosure with a 12X adapter in a GX++ slot through SDR or DDR cables (or both SDR and DDR cables). A maximum of four #5796 drawers can be placed on the same 12X loop. Mixing #5802/5877 and #5796 on the same loop is not supported.

A minimum configuration of two 12X cables (either SDR or DDR), two AC power cables, and two SPCN cables is required to ensure proper redundancy.

Figure 2-26 shows the back view of the expansion unit.

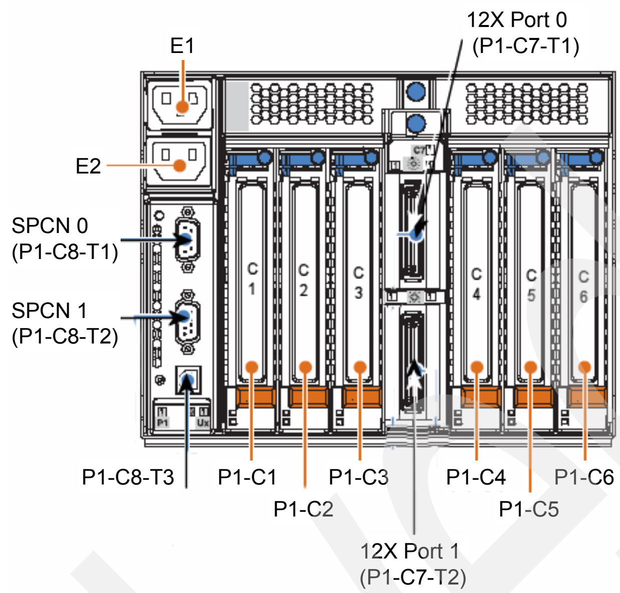

Figure 2-26 PCI-X DDR 12X Expansion Drawer rear side

2.10.2 12X I/O Drawer PCIe

The 12X I/O Drawer PCIe is a 19-inch I/O and storage drawer. It provides a 4U-tall (EIA units) drawer containing 10 PCIe-based I/O adapter slots and 18 SAS hot-swap Small Form Factor disk bays, which can be used for either disk drives or SSD (#5802). The adapter slots use blind-swap cassettes and supports hot-plugging of adapter cards.

A maximum of two #5802 drawers can be placed on the same 12X loop. Feature #5877 is the same as #5802 except that it does not support any disk bays. Feature #5877 can be on the same loop as #5802. Feature #5877 cannot be upgraded to #5802.

The physical dimensions of the drawer are 444.5 mm (17.5 in.) wide by 177.8 mm (7.0 in.) high by 711.2 mm (28.0 in.) deep for use in a 19-inch rack.

A minimum configuration of two 12X DDR cables, two AC power cables, and two SPCN cables is required to ensure proper redundancy. The drawer attaches to the host CEC enclosure with a 12X adapter in a GX++ slot through 12X DDR cables that are available in various cable lengths:

- 0.6 m (#1861)
- 1.5 m (#1862)
- 3.0 m (#1865)
- 8 m (#1864)

The 12X SDR cables are not supported.

Figure 2-27 shows the front view of the 12X I/O Drawer PCIe (#5802).

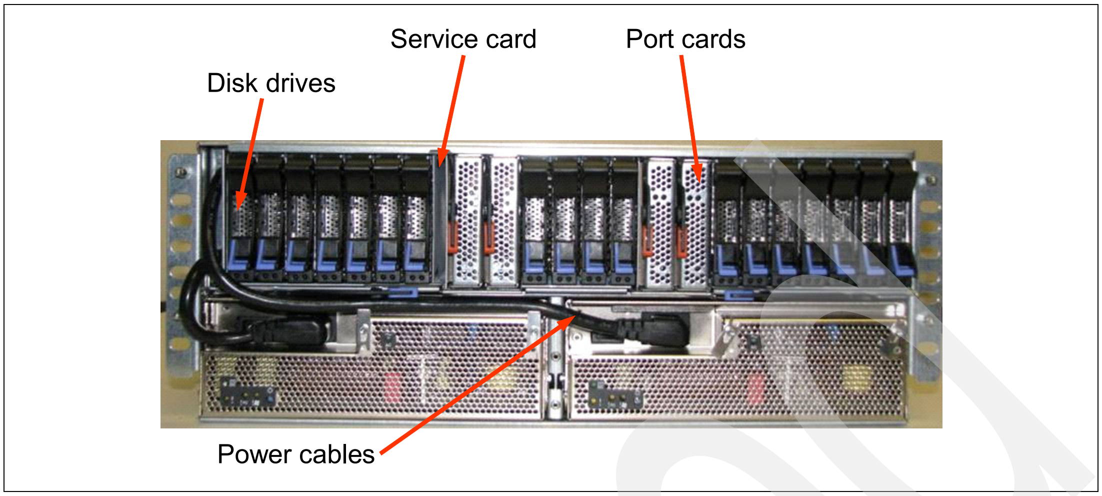

Figure 2-27 Front view of the 12X I/O Drawer PCIe

Figure 2-28 shows the rear view of the 12X I/O Drawer PCIe (#5802).

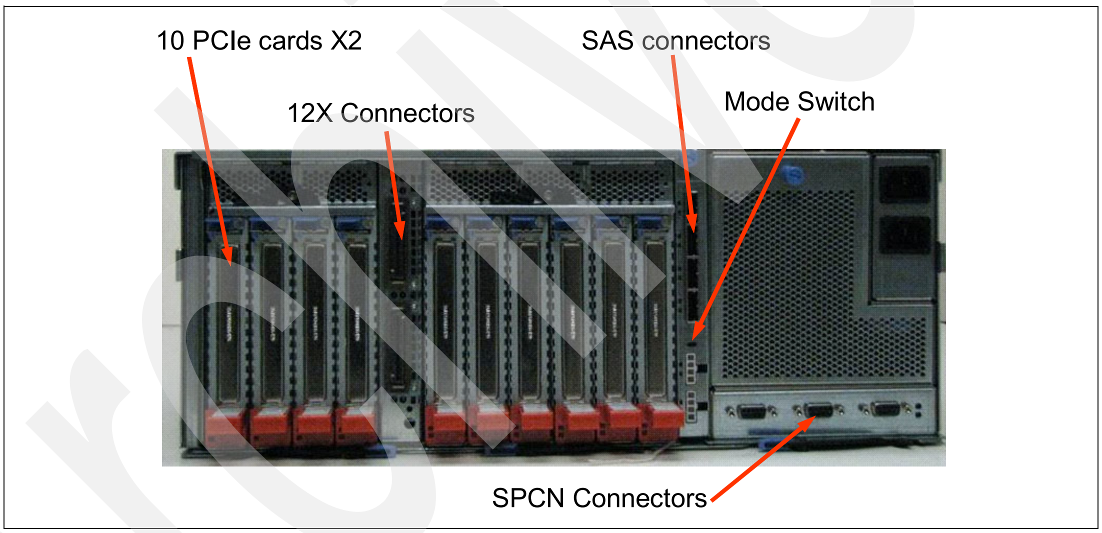

Figure 2-28 Rear view of the 12X I/O Drawer PCIe

2.10.3 Dividing SFF drive bays in 12X I/O drawer PCIe

Disk drive bays in the 12X I/O drawer PCIe can be configured as one, two, or four sets. This allows for partitioning of disk bays. Disk bay partitioning configuration can be done via the physical mode switch on the I/O drawer.

Note: A mode change using the physical mode switch requires power-off/on of the drawer.

Figure 2-29 indicates the mode switch in the rear view of the #5802 I/O Drawer.

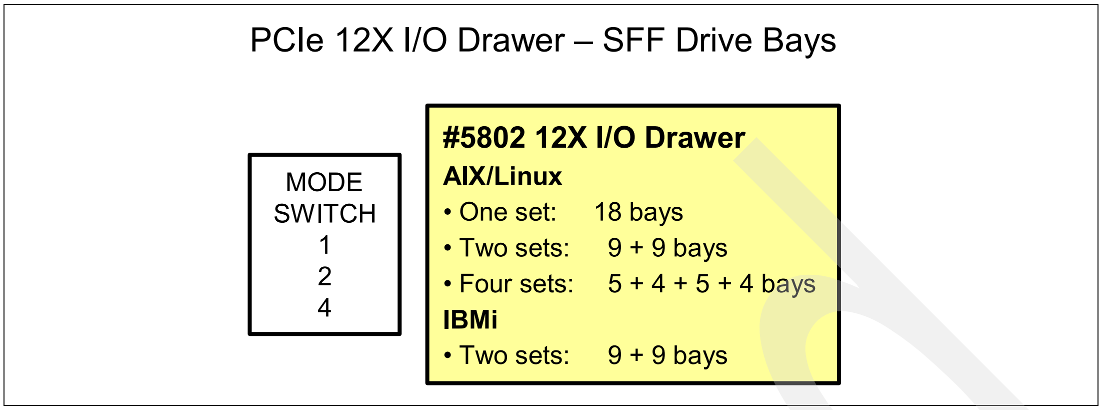

Figure 2-29 Disk bay partitioning in #5802 PCIe 12X I/O drawer

Each disk bay set can be attached to its own controller or adapter. The #5802 PCIe 12X I/O Drawer has four SAS connections to drive bays. It can connect to a PCIe SAS adapter or to controllers on the host system.

Figure 2-29 shows the configuration rule of disk bay partitioning in the #5802 PCIe 12X I/O Drawer. There is no specific feature code for mode switch setting.

Note: The IBM System Planning Tool supports disk bay partitioning. Also, the IBM configuration tool accepts this configuration from IBM System Planning Tool and passes it through IBM manufacturing using the Customer Specified Placement (CSP) option.

The SAS ports, as associated with the mode selector switch map to the disk bays, have the mappings shown in Table 2-30.

Table 2-30 SAS connection mappings

Location code	Mappings	Number of bays
P4-T1	P3-D1 to P3-D5	5 bays
P4-T2	P3-D6 to P3-D9	4 bays
P4-T3	P3-D10 to P3-D14	5 bays
P4-T3	P3-D15 to P3-D18	4 bays

The location codes for the front and rear views of the #5802 I/O drawer are provided in Figure 2-30 and Figure 2-31.

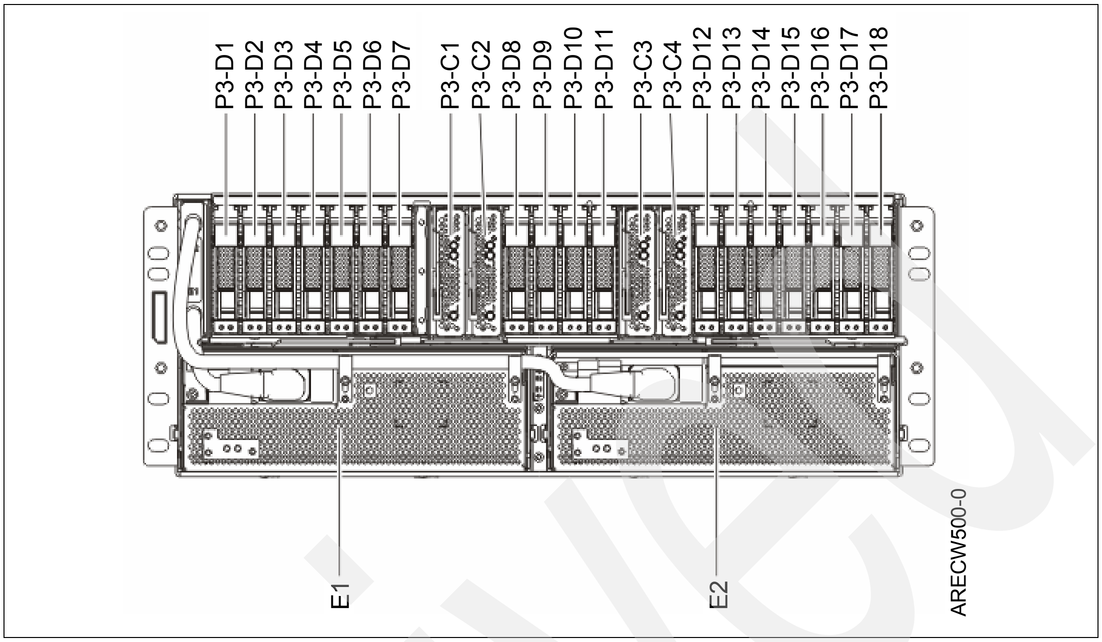

Figure 2-30   #5802 I/O drawer from view location codes

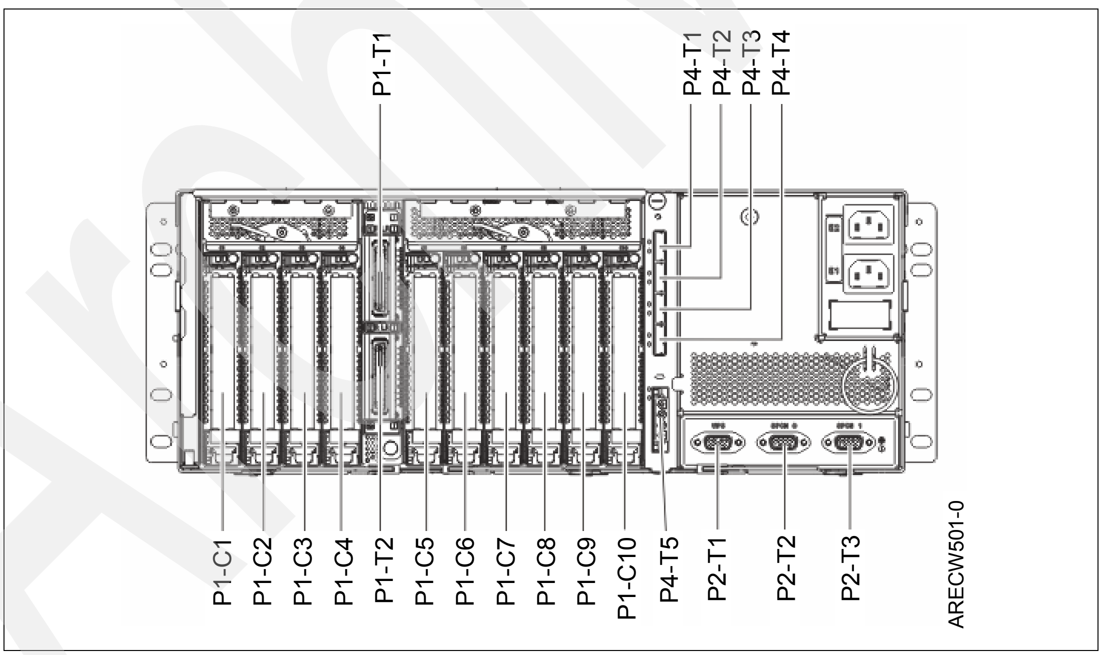

Figure 2-31   #5802 I/O drawer rear view location codes

Configuring the #5802 disk drive subsystem

The #5802 SAS disk drive enclosure can hold up 18 disk drives. The disks in this enclosure can be organized in several configurations depending on the operating system used, the type of SAS adapter card, and the position of the mode switch.

Each disk bay set can be attached to its own controller or adapter. The feature #5802 PCIe 12X I/O Drawer has four SAS connections to drive bays. It connects to PCIe SAS adapters or controllers on the host systems.

For detailed information about how to configure, see the IBM Power Systems Hardware Information Center:

http://publib.boulder.ibm.com/infocenter/powersys/v3r1m5/index.jsp

2.10.4 12X I/O Drawer PCIe and PCI-DDR 12X Expansion Drawer 12X cabling

I/O Drawers are connected to the adapters in the CEC enclosure with data transfer cables:

- 12X DDR cables for the #5802 and #5877 I/O drawers
- 12X SDR and/or DDR cables for the #5796 I/O drawers

The first 12X I/O Drawer that is attached in any I/O drawer loop requires two data transfer cables. Each additional drawer, up to the maximum allowed in the loop, requires one additional data transfer cable. Note the following information:

- A 12X I/O loop starts at a CEC bus adapter port 0 and attaches to port 0 of an I/O drawer.
- The I/O drawer attaches from port 1 of the current unit to port 0 of the next I/O drawer.
- Port 1 of the last I/O drawer on the 12X I/O loop connects to port 1 of the same CEC bus adapter to complete the loop.

Figure 2-32 shows typical 12X I/O loop port connections.

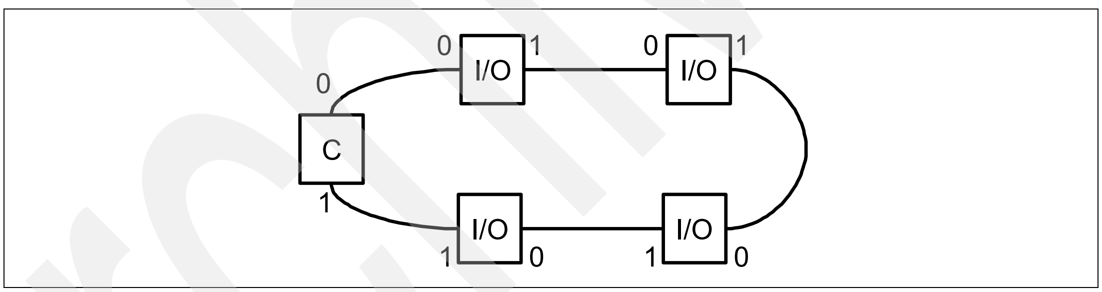

Figure 2-32 Typical 12X I/O loop port connections

Table 2-31 shows various 12X cables to satisfy the various length requirements.

Table 2-31 12X connection cables

Feature code	Description
#1861	0.6-meter 12X DDR cable
#1862	1.5-meter 12X DDR cable
#1865	3.0-meter 12X DDR cable
#1864	8.0-meter 12X DDR cable

General rule for the 12X IO Drawer configuration

To optimize performance and distribute workload, use as many multiple GX++ buses as possible. Figure 2-33 shows several examples of a 12X IO Drawer configuration.

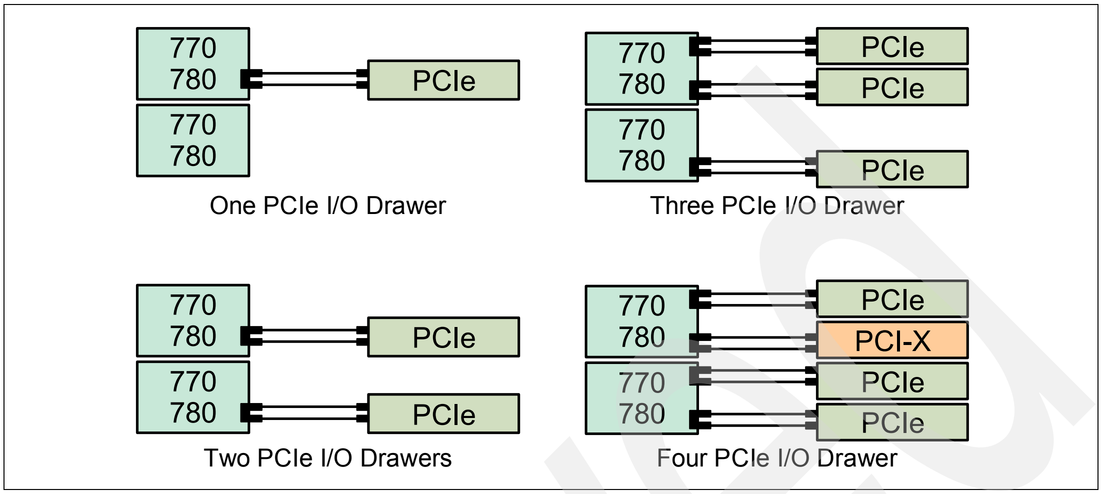

Figure 2-33 12X IO Drawer configuration

Supported 12X cable length for PCI-DDR 12X Expansion Drawer

Each #5796 drawer requires one Dual Port PCI DDR 12X Channel Adapter, either Short Run (#6446) or Long Run (#6457). The choice of adapters is dependent on the distance to the next 12X Channel connection in the loop, either to another I/O drawer or to the system unit. Table 2-32 identifies the supported cable lengths for each 12X channel adapter. I/O drawers containing the short range adapter can be mixed in a single loop with I/O drawers containing the long range adapter. In Table 2-32, a Yes indicates that the 12X cable identified in that column can be used to connect the drawer configuration identified to the left. A No means that it cannot be used.

Table 2-32 Supported 12X cable lengths

Connection type	12X cable options			
	0.6 m	1.5 m	3.0 m	8.0 m
#5796 to #5796 with #6446 in both drawers	Yes	Yes	No	No
#5796 with #6446 adapter to #5796 with #6457 adapter	Yes	Yes	Yes	No
#5796 to #5796 with #6457 adapter in both drawers	Yes	Yes	Yes	Yes
#5796 with #6446 adapter to system unit	No	Yes	Yes	No
#5796 with #6457 adapter to system unit	No	Yes	Yes	Yes

2.10.5 12X I/O Drawer PCIe and PCI-DDR 12X Expansion Drawer SPCN cabling

System Power Control Network (SPCN) is used to control and monitor the status of power and cooling within the I/O drawer.

SPCN cables connect all ac-powered expansion units (Figure 2-34 on page 92):

1. Start at SPCN 0 (T1) of the first (top) CEC enclosure to J15 (T1) of the first expansion unit.
2. Cable all units from J16 (T2) of the previous unit to J15 (T1) of the next unit.

3. From J16 (T2) of the final expansion unit, connect to the second CEC enclosure, SPCN 1 (T2).
4. To complete the cabling loop, connect SPCN 1 (T2) of the topmost (first) CEC enclosure to the SPCN 0 (T1) of the next (second) CEC.
5. Ensure that a complete loop exists from the topmost CEC enclosure, through all attached expansions and back to the next lower (second) CEC enclosure.

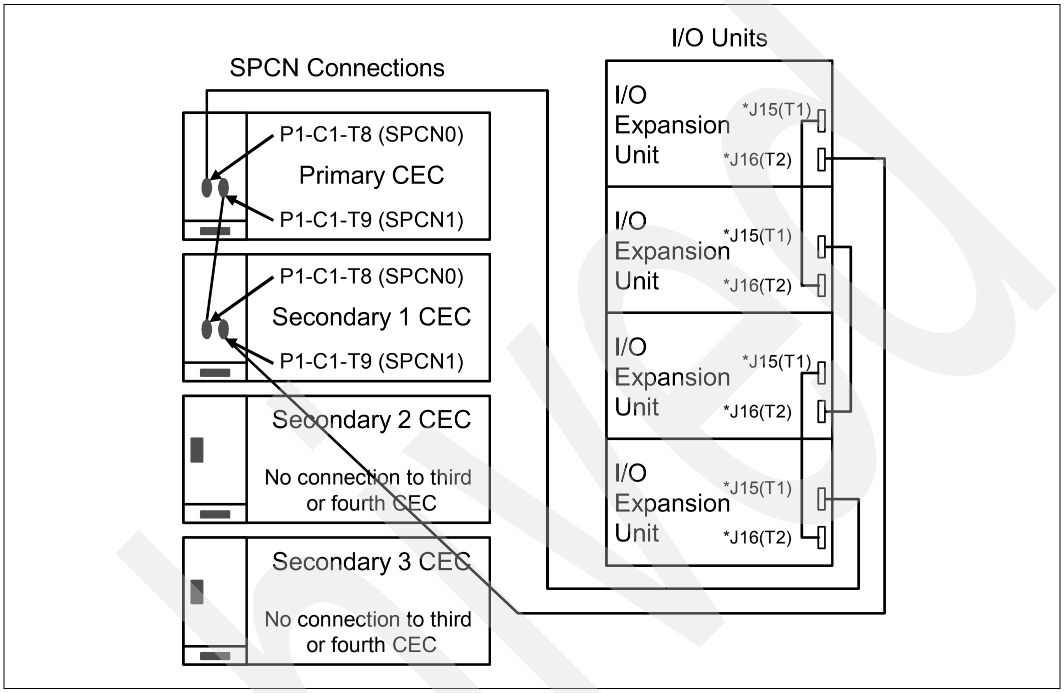

Figure 2-34 SPCN cabling examples

> **Note:** Only the first two CEC enclosures of a multi-CEC system are included in SPCN cabling with I/O expansion units. CEC enclosures number three and four are not connected.

Table 2-33 shows the SPCN cables to satisfy various length requirements.

Table 2-33 SPCN cables

Feature code	Description
#6006	SPCN cable drawer-to-drawer, 3 m
#6007	SPCN cable rack-to-rack, 15 m

2.11 External disk subsystems

This section describes the following external disk subsystems that can be attached to the Power 770 and Power 780:

- EXP 12S SAS Expansion Drawer (#5886) (supported, but no longer orderable)
- EXP24S SFF Gen2-bay Drawer for high-density storage (#5887)
- TotalStorage EXP24 Disk Drawer (#5786)

- IBM 7031 TotalStorage EXP24 Ultra320 SCSI Expandable Storage Disk Enclosure (no longer orderable)
- IBM System Storage

Table 2-29 on page 85 provides an overview of SAS external disks subsystems.

Table 2-34 I/O drawer capabilities

Drawer feature code	DASD	PCI slots	Requirements for a Power 770 and Power 780
#5886	12 x SAS disk drive bays	-	Any supported SAS adapter
#5887	24x	-	Any supported SAS adapter

2.11.1 EXP 12S Expansion Drawer

The EXP 12S (#5886) is an expansion drawer with twelve 3.5-inch form factor SAS bays. #5886 supports up to 12 hot-swap SAS HDDs or up to eight hot-swap SSDs. The EXP 12S includes redundant ac power supplies and two power cords. Though the drawer is one set of 12 drives, which is run by one SAS controller or one pair of SAS controllers, it has two SAS attachment ports and two service managers for redundancy. The EXP 12S takes up a 2 EIA space in a 19-inch rack. The SAS controller can be a SAS PCI-X or PCIe adapter or pair of adapters.

The drawer can either be attached using the backplane, providing an external SAS port, or using one of the following adapters:

- PCIe 380 MB Cache Dual -x4 3 Gb SAS RAID adapter (#5805)
- PCI-X DDR Dual -x4 SAS adapter (#5900 is supported but no longer orderable)
- PCIe Dual -x4 SAS adapter (#5901)
- PCIe 380 MB Cache Dual -x4 3 Gb SAS RAID adapter (#5903 is supported but no longer orderable)
- PCI-X DDR 1.5 GB Cache SAS RAID adapter (#5904)
- PCI-X DDR Dual -x4 SAS adapter (#5912)
- PCIe2 1.8 GB Cache RAID SAS Adapter (#5913)

The SAS disk drives or SSD contained in the EXP 12S Expansion Drawer are controlled by one or two PCIe or PCI-X SAS adapters connected to the EXP 12S Expansion Drawer through SAS cables. The SAS cable varies, depending on the adapter being used, the operating system being used, and the protection desired.

The large cache PCI-X DDR 1.5 GB Cache SAS RAID Adapter (#5904) and PCI-X DDR 1.5 GB Cache SAS RAID Adapter (BSC) (#5908) uses a SAS Y cable when a single port is running the EXP 12S Expansion Drawer. A SAS X cable is used when a pair of adapters is used for controller redundancy.

The medium cache PCIe 380 MB Cache Dual - x4 3 Gb SAS RAID Adapter (#5903) is always paired and uses a SAS X cable to attach the feature #5886 I/O drawer.

The zero cache PCI-X DDR Dual - x4 SAS Adapter (#5912) and PCIe Dual-x4 SAS Adapter (#5901) use a SAS Y cable when a single port is running the EXP 12S Expansion Drawer. A SAS X cable is used for AIX or Linux environments when a pair of adapters is used for controller redundancy.

The following SAS X cables are available for usage with a PCIe2 1.8 GB Cache RAID SAS adapter (#5913):

- 3 meters (#3454)
- 6 meters (#3455)
- 10 meters (#3456)

In all of these configurations, all 12 SAS bays are controlled by a single controller or a single pair of controllers.

A second EXP 12S Expansion Drawer can be attached to another drawer by using two SAS EE cables, providing 24 SAS bays instead of 12 bays for the same SAS controller port. This configuration is called cascading. In this configuration, all 24 SAS bays are controlled by a single controller or a single pair of controllers.

There is a maximum of up to 110 EXP 12S Expansion Drawer on SAS PCI controllers.

The #5886 can be directly attached to the SAS port on the rear of the Power 770 and 780, providing a very low-cost disk storage solution.

Adding the optional 175 MB Cache RAID - Dual IOA Enablement Card (#5662) to the Power 770 and Power 780 causes the pair of embedded controllers in that processor enclosure to be configured as dual controllers, accessing all six SAS bays. Using the internal SAS Cable Assembly for SAS Port (#1819) connected to the rear port, the pair of embedded controllers is now running 18 SAS bays (six SFF bays in the system unit and twelve 3.5-inch bays in the drawer). The disk drawer is attached to the SAS port with a SAS YI cable. In this 18-bay configuration, all drives must be HDD.

A second unit cannot be cascaded to a EXP 12S Expansion Drawer attached in this way.

Various disk options are available to be installed in the EXP 12S Expansion Drawer. Table 2-35 shows the available disk drive feature codes.

Table 2-35 Disk options for the EXP 12S drawer

Feature code	Description	OS support
#3586	69 GB 3.5" SAS Solid State Drive	AIX, Linux
#3646	73.4 GB 15K RPM SAS Disk Drive	AIX. Linux
#3647	146.8 GB 15K RPM SAS Disk Drive	AIX, Linux
#3648	300 GB 15 K RPM SAS Disk Drive	AIX, Linux
#3649	450 GB 15 K RPM SAS Disk Drive	AIX, Linux
#3587	69 GB 3.5” SAS Solid State Drive	IBM i
#3676	69.7 GB 15 K RPM SAS Disk Drive	IBM i
#3677	139.5 GB 15 K RPM SAS Disk Drive	IBM i
#3678	283.7 GB 15 K RPM SAS Disk Drive	IBM i
#3658	428.4 GB 15 K RPM SAS Disk Drive	IBM i

For detailed information about the SAS cabling, see the Serial-attached SCSI cable planning documentation:

http://publib.boulder.ibm.com/infocenter/powersys/v3r1m5/index.jsp?topic=/p7had/p7hadsascabling.htm

2.11.2 EXP24S SFF Gen2-bay Drawer

The EXP24S SFF Gen2-bay Drawer (#5887) is an expansion drawer supporting up to 24 hot-swap 2.5-inch SFF SAS HDDs on POWER6 or POWER7 servers in 2U of 19-inch rack space.

The SFF bays of the EXP24S are different from the SFF bays of the POWER7 system units or 12X PCIe I/O Drawers (#5802, #5803). The EXP 24S uses Gen-2 or SFF-2 SAS drives that physically do not fit in the Gen-1 or SFF-1 bays of the POWER7 system unit or 12X PCIe I/O Drawers, or vice versa.

The EXP24S SAS ports are attached to SAS controllers, which can be a SAS PCI-X or PCIe adapter or pair of adapters. The EXP24S SFF Gen2-bay Drawer can also be attached to an imbedded SAS controller in a server with an imbedded SAS port. Attachment between the SAS controller and the EXP24S SAS ports is via the appropriate SAS Y or X cables.

The SAS adapters/controllers that support the EXP24S are:

- PCI-X 1.5 GB Cache SAS RAID Adapter 3 Gb (#5904, #5906, #5908)
- PCIe 380 MB Cache SAS RAID Adapter 3 Gb (#5805, #5903)
- PCIe Dual-x4 SAS Adapter 3 Gb (#5901, #5278)
- PCIe2 1.8GB Cache RAID SAS Adapter (#5913)

The SAS disk drives contained in the EXP24S SFF Gen2-bay Drawer are controlled by one or two PCIe or PCI-X SAS adapters connected to the EXP24S through SAS cables. The SAS cable varies, depending on the adapter being used, the operating system being used, and the protection desired.

Note: The following consideration should be applied:

- The large cache PCI-X DDR 1.5 GB Cache SAS RAID Adapter (#5904) and PCI-X DDR 1.5 GB Cache SAS RAID Adapter (BSC) (#5908) use an SAS Y cable when a single port is running the EXP24S. A SAS X cable is used when a pair of adapters is used for controller redundancy.
- The medium cache PCIe 380 MB Cache Dual - x4 3 Gb SAS RAID Adapter (# 5903) is always paired and uses a SAS X cable to attach the feature #5887 I/O drawer.
- The zero cache PCI-X DDR Dual - x4 SAS Adapter (#5912) and PCIe Dual-x4 SAS Adapter (#5901) use a SAS Y cable when a single port is running the EXP24S. A SAS X cable is used for AIX or Linux environments when a pair of adapters is used for controller redundancy.
- The PCIe Gen2 1.8GB Cache RAID SAS Adapter (#5913) uses SAS YO cables.
- In all of these configurations, all 24 SAS bays are controlled by a single controller or a single pair of controllers.
- A second EXP24S drawer can be attached to another drawer by using two SAS EE cables, providing 48 SAS bays instead of 24 bays for the same SAS controller port. This configuration is called cascading. In this configuration, all 48 SAS bays are controlled by a single controller or a single pair of controllers.
- The EXP24S SFF Gen2-bay Drawer can be directly attached to the SAS port on the rear of the Power 770 and Power 780, providing a very low-cost disk storage solution.

Adding the optional 175 MB Cache RAID - Dual IOA Enablement Card (#5662) to the Power 770 and Power 780 causes the pair of embedded controllers in that processor enclosure to be configured as dual controllers, accessing all six SAS bays. Using the internal SAS Cable Assembly for SAS Port (#1819) connected to the rear port, the pair of embedded controllers is now running 30 SAS bays (six SFF bays in the system unit and twenty-four 2.5-inch bays in the drawer). The disk drawer is attached to the SAS port with a SAS YI cable. In this 30-bay configuration, all drives must be HDD.

A second unit cannot be cascaded to a EXP24S SFF Gen2-bay Drawer attached in this way.

The EXP24S SFF Gen2-bay Drawer can be ordered in one of three possible manufacturing-configured MODE settings (not customer set-up) of 1, 2 or 4 sets of disk bays.

With IBM AIX/Linux/VIOS, the EXP 24S can be ordered with four sets of six bays (mode4), two sets of 12 bays (mode 2), or one set of 24 bays (mode 1). With IBM i, the EXP24S can be ordered as one set of 24 bays (mode 1).

Note: Note the following information:

- The modes for the EXP24S SFF Gen2-bay Drawer are set by IBM Manufacturing. There is no option to reset after the drawer has been shipped.
- If you order multiple EXP24S, avoid mixing modes within that order. There is no externally visible indicator as to the drawer's mode.
- Several EXP24S cannot be cascaded on the external SAS connector. Only one #5887 is supported.
- The Power 770 or Power 780 supports up to 56 XP24S SFF Gen2-bay Drawers.

There are six SAS connectors on the rear of the XP24S SFF Gen2-bay Drawer to which SAS adapters/controllers are attached. They are labeled T1, T2, and T3, and there are two T1, two T2, and two T3 (Figure 2-35).

- In mode 1, two or four of the six ports are used. Two T2 are used for a single SAS adapter, and two T2 and two T3 are used with a paired set of two adapters or dual adapters configuration.
- In mode 2 or mode 4, four ports will be used, two T2 and two T3, to access all SAS bays.

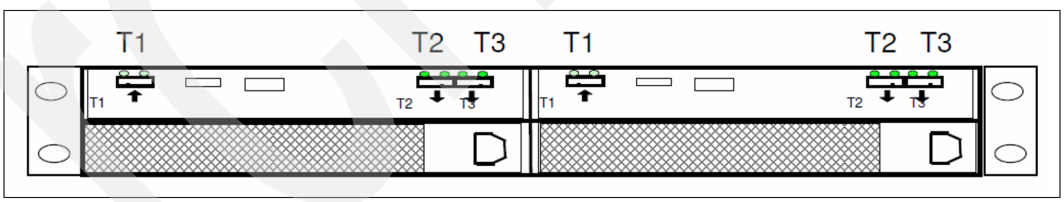

Figure 2-35 EXP24S SFF Gen2-bay Drawer rear connectors

An EXP24S SFF Gen2-bay Drawer in mode 4 can be attached to two or four SAS controllers and provide a great deal of configuration flexibility. An EXP24S in mode 2 has similar flexibility. Up to 24 HDDs can be supported with any of the supported SAS adapters/controllers.

Include the EXP24S SFF Gen2-bay Drawer no-charge specify codes with EXP24S orders to indicate to IBM Manufacturing the mode to which the drawer should be set and the adapter/controller/cable configuration that will be used. Table 2-36 lists the no-charge specify codes and the physical adapters/controllers/cables with their own chargeable feature numbers.

Table 2-36 EXP 24S Cabling

Feature code	Mode	Adapter/controller	Cable to drawer	Environment
#9360	1	Pair #5901	2 YO Cables	A, L, VIOS
#9361	2	Two #5901	2 YO Cables	A, L, VIOS
#9365	4	Four #5901	2 X Cable	A, L, VIOS
#9366	2	Two pair #5901	2 X Cables	A, L, VIOS
#9367	1	Pair #5903, #5805	2 YO Cables	A, i, L, VIOS
#9368	2	Four #5903, #5805	2 X Cables	A, L, VIOS
#9382	1	One #5904/06/08	1 YO Cable	A, i, L, VIOS
#9383	1	Pair #5904/06/08	2 YO Cables	A, i, L, VIOS
#9384	1	CEC SAS port	1 YI Cable	A, i, L, VIOS
#9385	1	Two #5913	2 YO Cables	A, i, L, VIOS
#9386	2	Four #5913	4 X Cables	A, L, VIOS

These cabling options for the EXP 24S Drawer are available:

- X cables for #5278
  - 3 m (#3661)
  - 6 m (#3662)'
  - 15 m (#3663)
- X cables for #5913 (all 6 Gb except for 15 m cable)
  - 3 m (#3454)
  - 6 m (#3455)
  - 10 m (#3456)
- YO cables for #5278
  - 1.5 m (#3691)
  - 3 m (#3692)
  - 6 m (#3693)
  - 15 m (#3694)
- YO cables for #5913 (all 6 Gb except for 15 m cable)
  - 1.5 m (#3450)
  - 3 m (#3451)
  - 6 m (#3452)
  - 10 m (#3453)
- YI cables for system unit SAS port (3 Gb)
  - 1.5 m (#3686)
  - 3 m (#3687)

Note: IBM plans to offer a 15-meter, 3 Gb bandwidth SAS cable for the #5913 PCIe2 1.8 GB Cache RAID SAS Adapter when attaching the EXP24S Drawer (#5887) for large configurations where the 10 meter cable is a distance limitation.

The EXP24S Drawer rails are fixed length and designed to fit Power Systems provided racks of 28 inches (711 mm) deep. EXP24S uses 2 EIA of space in a 19-inch wide rack. Other racks might have different depths, and these rails will not adjust. No adjustable depth rails are orderable at this time.

For detailed information about the SAS cabling, see the serial-attached SCSI cable planning documentation:

http://publib.boulder.ibm.com/infocenter/powersys/v3r1m5/index.jsp?topic=/p7had/p7hadsascabling.htm

2.11.3 TotalStorage EXP24 disk drawer and tower

The TotalStorage EXP24 is available as a 4 EIA unit drawer and mounts in a 19-inch rack (#5786). The front of the IBM TotalStorage EXP24 Ultra320 SCSI Expandable Storage Disk Enclosure has bays for up to 12 disk drives organized in two SCSI groups of up to six drives. The rear also has bays for up to 12 disk drives organized in two additional SCSI groups of up to six drives, plus slots for the four SCSI interface cards. Each SCSI drive group can be connected by either a Single Bus Ultra320 SCSI Repeater Card (#5741) or a Dual Bus Ultra320 SCSI Repeater Card (#5742). This allows the EXP24 to be configured as four sets of six bays, two sets of 12 bays, or two sets of six bays plus one set of 12 bays.

The EXP24 features #5786 and #5787 have three cooling fans and two power supplies to provide redundant power and cooling. The SCSI disk drives contained in the EXP24 are controlled by PCI-X SCSI adapters connected to the EXP24 SCSI repeater cards by SCSI cables. The PCI-X adapters are located in the Power 740 system unit or in an attached I/O drawer with PCI-X slots.

The 336 system maximum is achieved with a maximum of 24 disks in a maximum of 14 TotalStorage EXP24 disk drawers (#5786) or 14 TotalStorage EXP24 disk towers (#5787).

Note: The EXP24S SCSI disk drawer is an earlier technology drawer compared to the later SAS EXP12S drawer. It is used to house existing SCSI disk drives that are supported, but that are no longer orderable.

2.11.4 IBM TotalStorage EXP24

The IBM 7031 TotalStorage EXP24 Ultra320 SCSI Expandable Storage Disk Enclosure supports up to 24 Ultra320 SCSI Disk Drives arranged in four independent SCSI groups of up to six drives or in two groups of up to 12 drives. Each SCSI drive group can be connected by either a Single Bus Ultra320 SCSI Repeater Card or a Dual Bus Ultra320 SCSI Repeater Card, allowing a maximum of eight SCSI connections per TotalStorage EXP24.

The IBM 7031 Model D24 (7031-D24) is an Expandable Disk Storage Enclosure that is a horizontal 4 EIA by 19-inch rack drawer for mounting in equipment racks.

The IBM 7031 Model T24 (7031-T24) is an Expandable Disk Storage Enclosure that is a vertical tower for floor-standing applications.

Note: A new IBM 7031 TotalStorage EXP24 Ultra320 SCSI Expandable Storage Disk Enclosure cannot be ordered for the Power 720 and Power 740, and thus only existing 7031-D24 drawers or 7031-T24 towers can be moved to the Power 720 and 740 servers.

AIX and Linux partitions are supported along with the usage of a IBM 7031 TotalStorage EXP24 Ultra320 SCSI Expandable Storage Disk Enclosure.

2.11.5 IBM System Storage

The IBM System Storage Disk Systems products and offerings provide compelling storage solutions with superior value for all levels of business, from entry-level up to high-end storage systems.

IBM System Storage N series

The IBM System Storage N series is a Network Attached Storage (NAS) solution and provides the latest technology to customers to help them improve performance, virtualization manageability, and system efficiency at a reduced total cost of ownership. For more information about the IBM System Storage N series hardware and software, see:

http://www.ibm.com/systems/storage/network

IBM System Storage DS3000 family

The IBM System Storage DS3000 is an entry-level storage system designed to meet the availability and consolidation needs for a wide range of users. New features, including larger capacity 450 GB SAS drives, increased data protection features such as RAID 6, and more FlashCopies per volume, provide a reliable virtualization platform. For more information about the DS3000 family, see:

http://www.ibm.com/systems/storage/disk/ds3000/index.html

IBM System Storage DS5000

New DS5000 enhancements help reduce cost by introducing SSD drives. Also with the new EXP5060 expansion unit supporting 60 1 TB SATA drives in a 4U package, customers can see up to a one-third reduction in floor space over standard enclosures. With the addition of 1 Gbps iSCSI host attach, customers can reduce cost for their less demanding applications while continuing to provide high performance where necessary, utilizing the 8 Gbps FC host ports. With the DS5000 family, you get consistent performance from a smarter design that simplifies your infrastructure, improves your TCO, and reduces your cost. For more information about the DS5000 family, see:

http://www.ibm.com/systems/storage/disk/ds5000/index.html

IBM Storwize V7000 Midrange Disk System

IBM Storwize® V7000 is a virtualized storage system to complement virtualized server environments that provides unmatched performance, availability, advanced functions, and highly scalable capacity never seen before in midrange disk systems. Storwize V7000 is a powerful midrange disk system that has been designed to be easy to use and enable rapid deployment without additional resources. Storwize V7000 is virtual storage that offers greater efficiency and flexibility through built-in solid state drive (SSD) optimization and thin provisioning technologies. Storwize V7000 advanced functions also enable non-disruptive migration of data from existing storage, simplifying implementation and minimizing disruption to users. Storwize V7000 also enables you to virtualize and reuse existing disk systems, supporting a greater potential return on investment (ROI). For more information about Storwize V7000, see:

http://www.ibm.com/systems/storage/disk/storwize_v7000/index.html

IBM XIV Storage System

IBM offers a mid-sized configuration of its self-optimizing, self-healing, resilient disk solution, the IBM XIV® Storage System, storage reinvented for a new era. Now, organizations with mid-size capacity requirements can take advantage of the latest IBM technology for their most demanding applications with as little as 27 TB of usable capacity and incremental upgrades. For more information about XIV, see:

http://www.ibm.com/systems/storage/disk/xiv/index.html

IBM System Storage DS8000

The IBM System Storage DS8000® family is designed to offer high availability, multiplatform support, and simplified management tools. With its high capacity, scalability, broad server support, and virtualization features, the DS8000 family is well suited for simplifying the storage environment by consolidating data from multiple storage systems on a single system.

The high-end model DS8800 is the most advanced model in the IBM DS8000 family lineup and introduces new dual IBM POWER6-based controllers that usher in a new level of performance for the company's flagship enterprise disk platform. The DS8800 offers twice the maximum physical storage capacity than the previous model. For more information about the DS8000 family, see:

http://www.ibm.com/systems/storage/disk/ds8000/index.html

2.12 Hardware Management Console

The Hardware Management Console (HMC) is a dedicated workstation that provides a graphical user interface (GUI) for configuring, operating, and performing basic system tasks for the POWER7 processor-based systems (and the POWER5, POWER5+, POWER6, and POWER6+ processor-based systems) that function in either non-partitioned or clustered environments. In addition, the HMC is used to configure and manage partitions. One HMC is capable of controlling multiple POWER5, POWER5+, POWER6, and POWER6+, and POWER7 processor-based systems.

Several HMC models are supported to manage POWER7 processor-based systems. Two models (7042-C08, 7042-CR6) are available for ordering at the time of writing, but you can also use one of the withdrawn models listed in Table 2-37.

Table 2-37 HMC models supporting POWER7 processor technology-based servers

Type-model	Availability	Description
7310-C05	Withdrawn	IBM 7310 Model C05 Desktop Hardware Management Console
7310-C06	Withdrawn	IBM 7310 Model C06 Deskside Hardware Management Console
7042-C06	Withdrawn	IBM 7042 Model C06 Deskside Hardware Management Console
7042-C07	Withdrawn	IBM 7042 Model C07 Deskside Hardware Management Console
7042-C08	Available	IBM 7042 Model C08 Deskside Hardware Management Console
7310-CR3	Withdrawn	IBM 7310 Model CR3 Rack-mounted Hardware Management Console

Type-model	Availability	Description
7042-CR4	Withdrawn	IBM 7042 Model CR4 Rack-mounted Hardware Management Console
7042-CR5	Withdrawn	IBM 7042 Model CR5 Rack-mounted Hardware Management Console
7042-CR6	Available	IBM 7042 Model CR6 Rack-mounted Hardware Management Console

At the time of writing, the HMC must be running V7R7.4.0. It can also support up to 48 Power7 systems. Updates of the machine code, HMC functions, and hardware prerequisites, can be found on the Fix Central website:

http://www-933.ibm.com/support/fixcentral/

Note: An HMC is a mandatory requirement for the both the Power7 770 and 780 systems, but it is possible to share an HMC with other Power systems.

2.12.1 HMC functional overview

The HMC provides three groups of functions:

- Server
- Virtualization
- HMC management

Server management

The first group contains all functions related to the management of the physical servers under the control of the HMC:

- System password
- Status Bar
- Power On/Off
- Capacity on Demand
- Error management
  - System indicators
  - Error and event collection reporting
  - Dump collection reporting
  - Call Home
  - Customer notification
  - Hardware replacement (Guided Repair)
  - SNMP events
- Concurrent Add/Repair/Upgrade
- Redundant Service Processor
- Firmware Updates

Virtualization management

The second group contains all of the functions related to virtualization features, such as a partition configuration or the dynamic reconfiguration of resources:

- System Plans
- System Profiles
- Partitions (create, activate, shutdown)
- Profiles
- Partition Mobility
- DLPAR (processors, memory, I/O, and so on)
- Custom Groups

HMC Console management

The last group relates to the management of the HMC itself, its maintenance, security, and configuration, for example:

- Guided set-up wizard
- Electronic Service Agent set up wizard
- User Management
  - User IDs
  - Authorization levels
  - Customizable authorization
- Disconnect and reconnect
- Network Security
  - Remote operation enable and disable
  - User definable SSL certificates
- Console logging
- HMC Redundancy
- Scheduled Operations
- Back-up and Restore
- Updates, Upgrades
- Customizable Message of the day

The HMC provides both a graphical interface and command-line interface (CLI) for all management tasks. Remote connection to the HMC using a web browser (as of HMC Version 7; previous versions required a special client program called WebSM) is possible. The CLI is also available by using the Secure Shell (SSH) connection to the HMC. It can be used by an external management system or a partition to remotely perform many HMC operations.

2.12.2 HMC connectivity to the POWER7 processor-based systems

POWER5, POWER5+, POWER6, POWER6+, and POWER7 processor technology-based servers that are managed by an HMC require Ethernet connectivity between the HMC and the server's Service Processor. In addition, if Dynamic LPAR, Live Partition Mobility, or PowerVM Active Memory Sharing operations are required on the managed partitions, Ethernet connectivity is needed between these partitions and the HMC. A minimum of two Ethernet ports are needed on the HMC to provide such connectivity. The rack-mounted 7042-CR5 HMC default configuration provides four Ethernet ports. The deskside 7042-C07 HMC standard configuration offers only one Ethernet port. Be sure to order an optional PCIe adapter to provide additional Ethernet ports.

For any logical partition in a server it is possible to use a Shared Ethernet Adapter that is configured via a Virtual I/O Server. Therefore, a partition does not require its own physical adapter to communicate with an HMC.

For the HMC to communicate properly with the managed server, eth0 of the HMC must be connected to either the HMC1 or HMC2 ports of the managed server, although other network configurations are possible. You can attach a second HMC to HMC Port 2 of the server for redundancy (or vice versa). These must be addressed by two separate subnets. Figure 2-36 shows a simple network configuration to enable the connection from HMC to server and to enable Dynamic LPAR operations. For more details about HMC and the possible network connections, see *Hardware Management Console V7 Handbook*, SG24-7491.

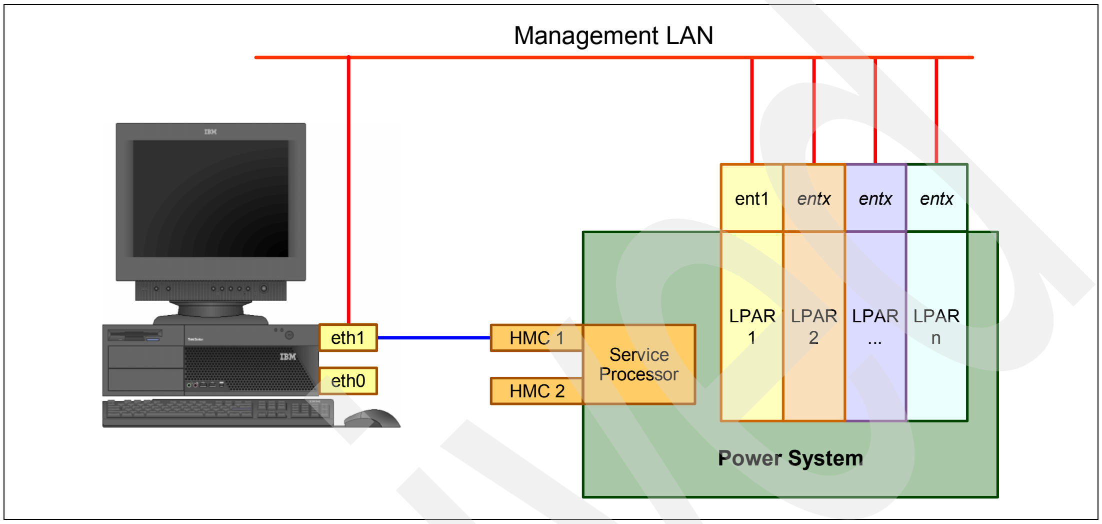

Figure 2-36 HMC to service processor and LPARs network connection

The default mechanism for allocation of the IP addresses for the service processor HMC ports is dynamic. The HMC can be configured as a DHCP server, providing the IP address at the time the managed server is powered on. In this case, the FSPs are allocated IP address from a set of address ranges predefined in the HMC software. These predefined ranges are identical for Version 710 of the HMC code and for previous versions.

If the service processor of the managed server does not receive a DHCP reply before time out, predefined IP addresses will be set up on both ports. Static IP address allocation is also an option. You can configure the IP address of the service processor ports with a static IP address by using the Advanced System Management Interface (ASMI) menus.

Note: The service processor is used to monitor and manage the system hardware resources and devices. The service processor offers two Ethernet 10/100 Mbps ports as connections. Note the following information:

- Both Ethernet ports are visible only to the service processor and can be used to attach the server to an HMC or to access the ASMI options from a client web browser using the HTTP server integrated into the service processor internal operating system.
- When not configured otherwise (DHCP or from a previous ASMI setting), both Ethernet ports of the first FSP have predefined IP addresses:
  - Service processor Eth0 or HMC1 port is configured as 169.254.2.147 with netmask 255.255.255.0.
  - Service processor Eth1 or HMC2 port is configured as 169.254.3.147 with netmask 255.255.255.0.

  For the second FSP of IBM Power 770 and 780, these default addresses are:
  - Service processor Eth0 or HMC1 port is configured as 169.254.2.146 with netmask 255.255.255.0.
  - Service processor Eth1 or HMC2 port is configured as 169.254.3.146 with netmask 255.255.255.0.

For more information about the service processor, see “Service processor” on page 169.

2.12.3 High availability using the HMC

The HMC is an important hardware component. When in operation, POWER7 processor-based servers and their hosted partitions can continue to operate when no HMC is available. However, in such conditions, certain operations cannot be performed, such as a DLPAR reconfiguration, a partition migration using PowerVM Live Partition Mobility, or the creation of a new partition. You might therefore decide to install two HMCs in a redundant configuration so that one HMC is always operational, even when performing maintenance of the other one, for example.

If redundant HMC function is desired, a server can be attached to two independent HMCs to address availability requirements. Both HMCs must have the same level of Hardware Management Console Licensed Machine Code Version 7 and installed fixes to manage POWER7 processor-based servers or an environment with a mixture of POWER5, POWER5+, POWER6, POWER6+, and POWER7 processor-based servers. The HMCs provide a locking mechanism so that only one HMC at a time has write access to the service processor. It is recommended that both HMCs are available on a public subnet to allow full syncronization of functionality. Depending on your environment, you have multiple options to configure the network.

Figure 2-37 shows one possible highly available HMC configuration managing two servers. These servers have only one CEC and therefore only one FSP. Each HMC is connected to one FSP port of all managed servers.

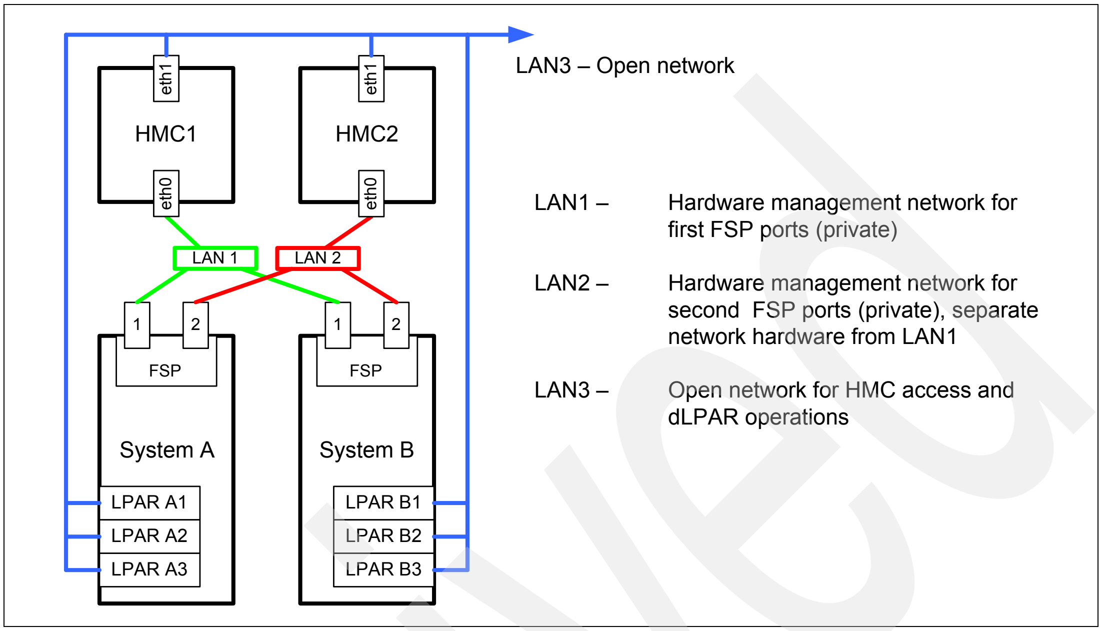

Figure 2-37 Highly available HMC and network architecture

Note that only hardware management networks (LAN1 and LAN2) are highly available (Figure 2-37) for simplicity. However, the management network (LAN3) can be made highly available by using a similar concept and adding more Ethernet adapters to LPARs and HMCs.

Both HMCs must be on a separate VLAN to protect from any network contention. Each HMC can be a DHCP server for its VLAN.

Redundant service processor connectivity

For the Power 770 and Power 780 with two or more CECs, two redundant service processors are installed in CEC enclosures 1 and 2. Redundant service processor function requires that each HMC must be attached to one Ethernet port in CEC enclosure 1 and one Ethernet port in CEC enclosure 2.

Figure 2-38 shows a redundant HMC and redundant service processor connectivity configuration.

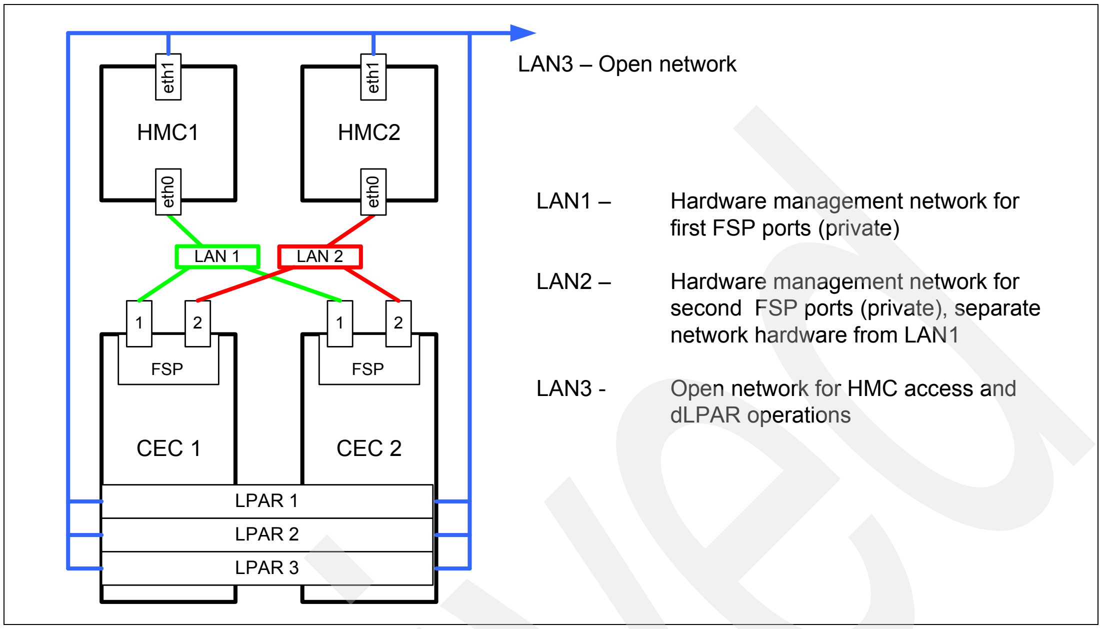

Figure 2-38 Redundant HMC connection and redundant service processor configuration

In a configuration with multiple systems or HMC, the customer is required to provide switches or hubs to connect each HMC to the server FSP Ethernet ports in each system:

- One HMC should connect to the port labeled HMC Port 1 on the first two CEC drawers of each system.
- A second HMC must be attached to HMC Port 2 on the first two CEC drawers of each system.

This solution provides redundancy for both the HMC and the service processors.

Figure 2-39 describes the four possible Ethernet connectivity options between the HMC and service processors.

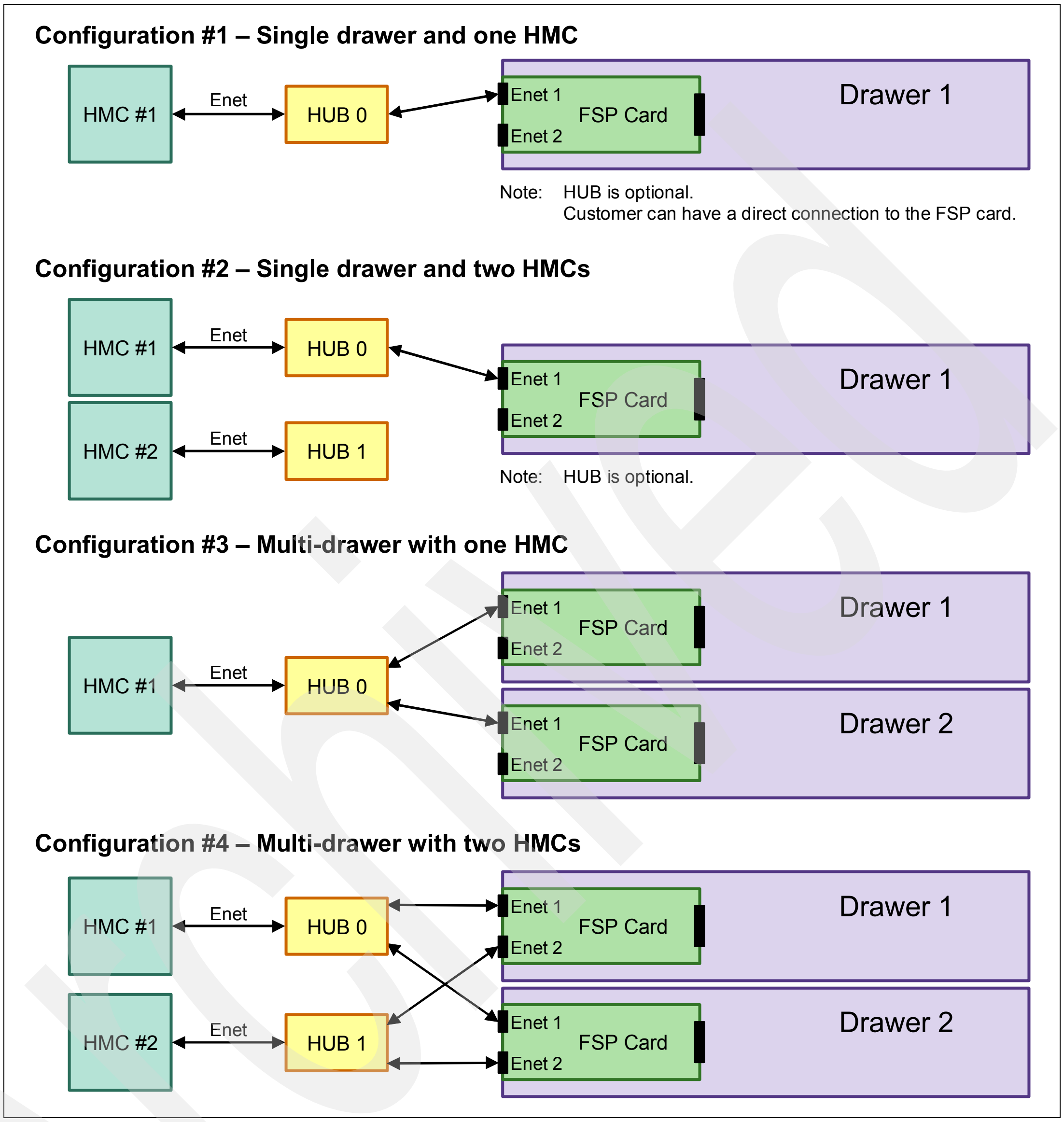

Figure 2-39 Summary of HMC to FSP configuration option depending on number of CEC

For details about redundant HMC, see *Hardware Management Console V7 Handbook*, SG24-7491.

HMC code level

The HMC code must be at V7R7.4.0 to support the Power 770 and Power 780 systems.

In a dual HMC configuration, both must be at the same version and release of the HMC.

Tips: Note the following tips:

- When upgrading the code of a dual HMC configuration, a good practice is to disconnect one HMC to avoid having both HMCs connected to the same server but running different levels of code. If no profiles or partition changes take place during the upgrade, both HMCs can stay connected. If the HMCs are at different levels and a profile change is made from the HMC at level V7R7.4.0, for example, the format of the data stored in the server could be changed, causing the HMC at a previous level (for example, 3.50) to possibly go into a recovery state because it does not understand the new data format.
- Compatibility rules exist between the various software that is executing within a POWER7 processor-based server environment:
  - HMC
  - VIO
  - System firmware
  - Partition operating systems

  To check which combinations are supported and to identify required upgrades, you can use the Fix Level Recommendation Tool web page:

  `http://www14.software.ibm.com/webapp/set2/flrt/home`

If you want to migrate an LPAR from a POWER6 processor-based server onto a POWER7 processor-based server using PowerVM Live Partition Mobility, consider this: If the source server is managed by one HMC and the destination server is managed by a different HMC, ensure that the HMC managing the POWER6 processor-based server is at V7R7.3.5 or later and the HMC managing the POWER7 processor-based server is at V7R7.4.0 or later.

2.13 IBM Systems Director Management Console

The newly released IBM Systems Director Management Console (SDMC) is intended to be used in the same manner as the HMC. It provides the same functionality, including hardware, service, and virtualization management, for Power Systems server and Power Systems blades. Because SDMC uses IBM Systems Director Express Edition, it also provides all Systems Director Express capabilities, such as monitoring of operating systems and creating event action plans.

No configuration changes are required when a client moves from HMC management to SDMC management.

Much of the SDMC function is equivalent to the HMC. This includes:

- Server (host) management.
- Virtualization management.
- Redundancy and high availability: The SDMC offers console redundancy similar to the HMC.

The scalability and performance of the SDMC matches that of a current HMC. This includes both the number of systems (hosts) and the number of partitions (virtual servers) that can be managed. Currently, 48 small-tier entry servers or 32 large-tier servers can be managed by the SDMC with up to 1,024 partitions (virtual servers) configured across those managed systems (hosts).

The SDMC can be obtained as a hardware appliance in the same manner as an HMC. Hardware appliances support managing all Power Systems servers. The SDMC can optionally be obtained in a virtual appliance format, capable of running on VMware (ESX/i 4, or later), and KVM (Red Hat Enterprise Linux (RHEL) 5.5). The virtual appliance is only supported or managing small-tier Power servers and Power Systems blades.

Note: At the time of writing, the SDMC is not supported for the Power 770 (9117-MMC) and Power 780 (9179-MHC) models.

IBM intends to enhance the IBM Systems Director Management Console (SDMC) to support the Power 770 (9117-MMC) and Power 780 (9179-MHC). IBM also intends for the current HMC 7042-CR6 to be upgradable to an IBM SDMC that supports the Power 770 (9117-MMC) and Power 780 (9179-MHC).

Table 2-38 and Table 2-38 detail whether the SDMC software appliance, hardware appliance, or both are supported for each model.

Table 2-38 Type of SDMC appliance support for POWER7-based server

POWER7 models	Type of SDMC appliance supported
7891-73X (IBM BladeCenter® PS703)	Hardware or software appliance
7891-74X (IBM BladeCenter PS704)	Hardware or software appliance
8202-E4B (IBM Power 720 Express)	Hardware or software appliance
8205-E6B (IBM Power 740 Express)	Hardware or software appliance
8406-70Y (IBM BladeCenter PS700)	Hardware or software appliance
8406-71Y (IBM BladeCenter PS701 and PS702)	Hardware or software appliance
8231-E2B (IBM Power 710 and IBM Power 730 Express)	Hardware or software appliance
8233-E8B (IBM Power 750 Express)	Hardware or software appliance
8236-E8C (IBM Power 755)	Hardware or software appliance
9117-MMB (IBM Power 770)	Hardware appliance only
9179-MHB (IBM Power 780)	Hardware appliance only
9119-FHB (IBM Power 795)	Hardware appliance only

The IBM SDMC Hardware Appliance requires an IBM 7042-CR6 Rack-mounted Hardware Management Console and IBM SDMC indicator (#0963).

Note: When ordering #0963, the features #0031(No Modem), #1946 (additional 4 GB memory), and #1998 (additional 500 GB SATA HDD) are being configured automatically. Feature #0963 replaces the HMC software with IBM Systems Director Management Console Hardware Appliance V6.7.3 (5765-MCH).

Neither an external modem (#0032) nor an internal modem (#0033) can be selected with IBM SDMC indicator (#0963).

To run HMC LMC (#0962), you cannot order the additional storage (#1998). However, you can order the additional memory (#1946).

The IBM SDMC Virtual Appliance requires an IBM Systems Director Management Console V6.7.3 (5765-MCV).

Note: If you want to use the software appliance, you have to provide the hardware and virtualization environment.

At a minimum, the following resources must be available to the virtual machine:

- 2.53 GHz Intel Xeon E5630, Quad Core processor
- 500 GB storage
- 8 GB memory

The following hypervisors are supported:

- VMware (ESXi 4.0 or later)
- KVM (RHEL 5.5)

SDMC on POWER6 processor-based servers and blades requires eFirmware level 3.5.7. SDMC on Power Systems POWER7 processor-based servers and blades requires eFirmware level 7.3.0.

For more detailed information about the SDMC, see *IBM Systems Director Management Console: Introduction and Overview*, SG24-7860.

2.14 Operating system support

The IBM POWER7 processor-based systems support three families of operating systems:

- AIX
- IBM i
- Linux

In addition, the Virtual I/O Server can be installed in special partitions that provide support to the other operating systems for using features such as virtualized I/O devices, PowerVM Live Partition Mobility, or PowerVM Active Memory Sharing.

Note: For details about the software available on IBM Power Systems, visit the Power Systems Software™ website:

`http://www.ibm.com/systems/power/software/index.html`

2.14.1 Virtual I/O Server

The minimum required level of Virtual I/O server for both the Power 770 and Power 780 is VIOS 2.2.1.0.

IBM regularly updates the Virtual I/O Server code. To find information about the latest updates, visit the Fix Central website:

`http://www-933.ibm.com/support/fixcentral/`

2.14.2 IBM AIX operating system

The following sections discuss the various levels of AIX operating system support.

IBM periodically releases maintenance packages (service packs or technology levels) for the AIX operating system. Information about these packages, downloading, and obtaining the CD-ROM is on the Fix Central website:

http://www-933.ibm.com/support/fixcentral/

The Fix Central website also provides information about how to obtain the fixes shipping on CD-ROM.

The Service Update Management Assistant, which can help you to automate the task of checking and downloading operating system downloads, is part of the base operating system. For more information about the **suma** command, go to following website:

http://www14.software.ibm.com/webapp/set2/sas/f/genunix/suma.html

IBM AIX Version 5.3

The minimum level of AIX Version 5.3 to support the Power 770 and Power 780 is AIX 5.3 with the 5300-12 Technology Level and Service Pack 5 or later.

A partition using AIX Version 5.3 will be executing in POWER6 or POWER6+ compatibility mode. This means that although the POWER7 processor has the ability to run four hardware threads per core simultaneously, using AIX 5.3 limits the number of hardware threads per core to two.

IBM AIX Version 6.1

The minimum level of AIX Version 6.1 to support the Power 770 and Power 780 is:

- AIX 6.1 with the 6100-07 Technology Level or later
- AIX 6.1 with the 6100-06 Technology Level and Service Pack 6 or later
- AIX 6.1 with the 6100-05 Technology Level and Service Pack 7 or later

A partition using AIX 6.1 with TL6 can run in POWER6, POWER6+, or POWER7 mode. It is best to run the partition in POWER7 mode to allow exploitation of new hardware capabilities such as SMT4 and Active Memory Expansion (AME).

IBM AIX Version 7.1

The minimum level of AIX Version 7.1 to support the Power 770 and Power 780 is:

- AIX 7.1 with the 7100-01 Technology Level or later
- AIX 7.1 with the 7100-00 Technology Level and Service Pack 4 or 1 later

A partition using AIX 7.1 can run in POWER6, POWER6+, or POWER7 mode. It is best to run the partition in POWER7 mode to allow exploitation of new hardware capabilities such as SMT4 and AME.

2.14.3 IBM i operating system

The IBM i operating system is supported on the Power 720 and Power 740 with these minimum required levels:

- IBM i Version 6.1 with i 6.1.1 machine code or later
- IBM i Version 7.1 or later

IBM periodically releases maintenance packages (service packs or technology levels) for the IBM i operating system. Information about these packages, downloading, and obtaining the CD-ROM is on the Fix Central website:

http://www-933.ibm.com/support/fixcentral/

2.14.4 Linux operating system

Linux is an open source operating system that runs on numerous platforms from embedded systems to mainframe computers. It provides a UNIX-like implementation across many computer architectures.

The supported versions of Linux on POWER7 processor-based servers are:

- SUSE Linux Enterprise Server 11 Service Pack 1, or later, with current maintenance updates available from SUSE to enable all planned functionality
- Red Hat Enterprise Linux AP 5 Update 7 for POWER, or later
- Red Hat Enterprise Linux 6.1 for POWER, or later

If you want to configure Linux partitions in virtualized Power Systems, you have to be aware of these conditions:

- Not all devices and features that are supported by the AIX operating system are supported in logical partitions running the Linux operating system.
- Linux operating system licenses are ordered separately from the hardware. You can acquire Linux operating system licenses from IBM to be included with the POWER7 processor-based servers, or from other Linux distributors.

For information about the features and external devices supported by Linux, go to:

http://www.ibm.com/systems/p/os/linux/index.html

For information about SUSE Linux Enterprise Server 10, go to:

http://www.novell.com/products/server

For information about Red Hat Enterprise Linux Advanced Server, go to:

http://www.redhat.com/rhel/features

2.14.5 Java supported versions

There are unique considerations when running Java 1.4.2 on POWER7 servers. For best exploitation of the outstanding performance capabilities and most recent improvements of POWER7 technology, IBM recommends upgrading Java-based applications to Java 7, Java 6, or Java 5 whenever possible. For more information, visit:

http://www.ibm.com/developerworks/java/jdk/aix/service.html

2.14.6 Boosting performance and productivity with IBM compilers

IBM XL C, XL C/C++, and XL Fortran compilers for AIX and for Linux exploit the latest POWER7 processor architecture. Release after release, these compilers continue to help improve application performance and capability, exploiting architectural enhancements made available through the advancement of the POWER technology.

IBM compilers are designed to optimize and tune your applications for execution on IBM POWER platforms, to help you unleash the full power of your IT investment, to create and maintain critical business and scientific applications, to maximize application performance, and to improve developer productivity.

The performance gain from years of compiler optimization experience is seen in the continuous release-to-release compiler improvements that support the POWER4 processors, through to the POWER4+, POWER5, POWER5+, and POWER6 processors, and now including the new POWER7 processors. With the support of the latest POWER7 processor chip, IBM advances a more than 20-year investment in the XL compilers for POWER series and PowerPC® series architectures.

XL C, XL C/C++, and XL Fortran features introduced to exploit the latest POWER7 processor include vector unit and vector scalar extension (VSX) instruction set to efficiently manipulate vector operations in your application, vector functions within the Mathematical Acceleration Subsystem (MASS) libraries for improved application performance, built-in functions or intrinsics and directives for direct control of POWER instructions at the application level, and architecture and tune compiler options to optimize and tune your applications.

COBOL for AIX enables you to selectively target code generation of your programs to either exploit POWER7 systems architecture or to be balanced among all supported POWER systems. The performance of COBOL for AIX applications is improved by means of an enhanced back-end optimizer. The back-end optimizer, a component common also to the IBM XL compilers lets your applications leverage the latest industry-leading optimization technology.

The performance of PL/I for AIX applications has been improved through both front-end changes and back-end optimizer enhancements. The back-end optimizer, a component common also to the IBM XL compilers, lets your applications leverage the latest industry-leading optimization technology. For PL/I it will produce code that is intended to perform well across all hardware levels, including POWER7 of AIX.

IBM Rational® Development Studio for IBM i 7.1 provides programming languages for creating modern business applications. This includes the ILE RPG, ILE COBOL, C, and C++ compilers as well as the heritage RPG and COBOL compilers. The latest release includes performance improvements and XML processing enhancements for ILE RPG and ILE COBOL, improved COBOL portability with a new COMP-5 data type, and easier Unicode migration with relaxed USC2 rules in ILE RPG. Rational has also released a product called Rational Open Access: RPG Edition. This product opens the ILE RPG file I/O processing, enabling partners, tool providers, and users to write custom I/O handlers that can access other devices like databases, services, and web user interfaces.

IBM Rational Developer for Power Systems Software provides a rich set of integrated development tools that support the XL C/C++ for AIX compiler, the XL C for AIX compiler, and the COBOL for AIX compiler. Rational Developer for Power Systems Software offers capabilities of file management, searching, editing, analysis, build, and debug, all integrated into an Eclipse workbench. XL C/C++, XL C, and COBOL for AIX developers can boost productivity by moving from older, text-based, command-line development tools to a rich set of integrated development tools.

The IBM Rational Power Appliance solution provides a workload-optimized system and integrated development environment for AIX development on IBM Power Systems. IBM Rational Power Appliance includes a Power Express server preinstalled with a comprehensive set of Rational development software along with the AIX operating system. The Rational development software includes support for Collaborative Application Lifecycle Management (C/ALM) through Rational Team Concert™, a set of software development tools from Rational Developer for Power Systems Software, and a choice between the XL C/C++ for AIX or COBOL for AIX compilers.

2.15 Energy management

The Power 770 and 780 servers are designed with features to help clients become more energy efficient. The IBM Systems Director Active Energy Manager exploits EnergyScale technology, enabling advanced energy management features to dramatically and dynamically conserve power and further improve energy efficiency. Intelligent Energy optimization capabilities enable the POWER7 processor to operate at a higher frequency for increased performance and performance per watt or dramatically reduce frequency to save energy.

2.15.1 IBM EnergyScale technology

IBM EnergyScale technology provides functions to help the user understand and dynamically optimize the processor performance versus processor energy consumption, and system workload, to control IBM Power Systems power and cooling usage.

On POWER7 processor-based systems, the thermal power management device (TPMD) card is responsible for collecting the data from all system components, changing operational parameters in components, and interacting with the IBM Systems Director Active Energy Manager (an IBM Systems Directors plug-in) for energy management and control.

IBM EnergyScale makes use of power and thermal information collected from the system in order to implement policies that can lead to better performance or better energy utilization. IBM EnergyScale features include:

- Power trending

  EnergyScale provides continuous collection of real-time server energy consumption. This enables administrators to predict power consumption across their infrastructure and to react to business and processing needs. For example, administrators can use such information to predict datacenter energy consumption at various times of the day, week, or month.

- Thermal reporting

  IBM Director Active Energy Manager can display measured ambient temperature and calculated exhaust heat index temperature. This information can help identify data center hot spots that need attention.

- Power saver mode

  Power saver mode lowers the processor frequency and voltage on a fixed amount, reducing the energy consumption of the system while still delivering predictable performance. This percentage is predetermined to be within a safe operating limit and is not user configurable. The server is designed for a fixed frequency drop of up to 30% down from nominal frequency (the actual value depends on the server type and configuration). Power saver mode is not supported during boot or re-boot, although it is a persistent condition that will be sustained after the boot when the system starts executing instructions.

- Dynamic power saver mode

  Dynamic power saver mode varies processor frequency and voltage based on the utilization of the POWER7 processors. Processor frequency and utilization are inversely proportional for most workloads, implying that as the frequency of a processor increases, its utilization decreases, given a constant workload. Dynamic power saver mode takes advantage of this relationship to detect opportunities to save power, based on measured real-time system utilization.

When a system is idle, the system firmware will lower the frequency and voltage to power energy saver mode values. When fully utilized, the maximum frequency will vary depending on whether the user favors power savings or system performance. If an administrator prefers energy savings and a system is fully utilized, the system is designed to reduce the maximum frequency to 95% of nominal values. If performance is favored over energy consumption, the maximum frequency can be increased to up to 109% of nominal frequency for extra performance.

Dynamic power saver mode is mutually exclusive with power saver mode. Only one of these modes can be enabled at a given time.

- Power capping

  Power capping enforces a user-specified limit on power usage. Power capping is not a power-saving mechanism. It enforces power caps by throttling the processors in the system, degrading performance significantly. The idea of a power cap is to set a limit that must never be reached but that frees up extra power never used in the data center. The *margined* power is this amount of extra power that is allocated to a server during its installation in a datacenter. It is based on the server environmental specifications that usually are never reached because server specifications are always based on maximum configurations and worst-case scenarios. The user must set and enable an energy cap from the IBM Director Active Energy Manager user interface.

- Soft power capping

  There are two power ranges into which the power cap can be set, power capping, as described previously, and soft power capping. Soft power capping extends the allowed energy capping range further, beyond a region that can be guaranteed in all configurations and conditions. If the energy management goal is to meet a particular consumption limit, then soft power capping is the mechanism to use.

- Processor core nap mode

  The IBM POWER7 processor uses a low-power mode called nap that stops processor execution when there is no work to do on that processor core. The latency of exiting nap mode is very small, typically not generating any impact on applications running. Because of that, the POWER Hypervisor™ can use nap mode as a general-purpose idle state. When the operating system detects that a processor thread is idle, it yields control of a hardware thread to the POWER Hypervisor. The POWER Hypervisor immediately puts the thread into nap mode. Nap mode allows the hardware to turn the clock off on most of the circuits inside the processor core. Reducing active energy consumption by turning off the clocks allows the temperature to fall, which further reduces leakage (static) power of the circuits causing a cumulative effect. Nap mode saves from 10 - 15% of power consumption in the processor core.

- Processor core sleep mode

  To be able to save even more energy, the POWER7 processor has an even lower power mode called sleep. Before a core and its associated L2 and L3 caches enter sleep mode, caches are flushed and transition lookaside buffers (TLB) are invalidated, and the hardware clock is turned off in the core and in the caches. Voltage is reduced to minimize leakage current. Processor cores inactive in the system (such as CoD processor cores) are kept in Sleep mode. Sleep mode saves about 35% power consumption in the processor core and associated L2 and L3 caches.

- Fan control and altitude input

  System firmware will dynamically adjust fan speed based on energy consumption, altitude, ambient temperature, and energy savings modes. Power Systems are designed to operate in worst-case environments, in hot ambient temperatures, at high altitudes, and with high power components. In a typical case, one or more of these constraints are not valid. When no power savings setting is enabled, fan speed is based on ambient temperature and assumes a high-altitude environment. When a power savings setting is enforced (either Power Energy Saver Mode or Dynamic Power Saver Mode), fan speed will vary based on power consumption, ambient temperature, and altitude available. System altitude can be set in IBM Director Active Energy Manager. If no altitude is set, the system will assume a default value of 350 meters above sea level.

- Processor folding

  Processor folding is a consolidation technique that dynamically adjusts, over the short term, the number of processors available for dispatch to match the number of processors demanded by the workload. As the workload increases, the number of processors made available increases. As the workload decreases, the number of processors made available decreases. Processor folding increases energy savings during periods of low to moderate workload because unavailable processors remain in low-power idle states (nap or sleep) longer.

- EnergyScale for I/O

  IBM POWER7 processor-based systems automatically power off hot pluggable PCI adapter slots that are empty or not being used. System firmware automatically scans all pluggable PCI slots at regular intervals, looking for those that meet the criteria for being not in use and powering them off. This support is available for all POWER7 processor-based servers and the expansion units that they support.

- Server power down

  If overall data center processor utilization is low, workloads can be consolidated on fewer numbers of servers so that some servers can be turned off completely. It makes sense to do this when there will be long periods of low utilization, such as weekends. AEM provides information, such as the power that will be saved and the time it will take to bring a server back online, that can be used to help make the decision to consolidate and power off. As with many of the features available in IBM Systems Director and Active Energy Manager, this function is scriptable and can be automated.

- Partition power management

  Available with Active Energy Manager 4.3.1 or later, and POWER7 systems with the 730 firmware release or later, is the capability to set a power savings mode for partitions or the system processor pool. As in the system-level power savings modes, the per-partition power savings modes can be used to achieve a balance between the power consumption and the performance of a partition. Only partitions that have dedicated processing units can have a unique power savings setting. Partitions that run in shared processing mode will have a common power savings setting, which is that of the system processor pool. This is because processing unit fractions cannot be power- managed.

  As in the case of system-level power savings, two Dynamic Power Saver options are offered:

  – Favor partition performance
  – Favor partition power savings

  The user must configure this setting from Active Energy Manager. When dynamic power saver is enabled in either mode, system firmware continuously monitors the performance and utilization of each of the computer's POWER7 processor cores that belong to the partition. Based on this utilization and performance data, the firmware will dynamically adjust the processor frequency and voltage, reacting within milliseconds to adjust workload performance and also deliver power savings when the partition is under-utilized.

  In addition to the two dynamic power saver options, the customer can select to have no power savings on a given partition. This option will leave the processor cores assigned to the partition running at their nominal frequencies and voltages.

A new power savings mode, called *inherit host setting*, is available and is only applicable to partitions. When configured to use this setting, a partition will adopt the power savings mode of its hosting server. By default, all partitions with dedicated processing units, and the system processor pool, are set to the inherit host setting.

On POWER7 processor-based systems, several EnergyScales are imbedded in the hardware and do not require an operating system or external management component. More advanced functionality requires Active Energy Manager (AEM) and IBM Systems Director.

Table 2-39 provides a list of all features supported, showing all cases in which AEM is not required. Table 2-39 also details the features that can be activated by traditional user interfaces (for example, ASMI and HMC).

Table 2-39 AEM support

Feature	Active Energy Manager (AEM) required	ASMI	HMC
Power Trending	Y	N	N
Thermal Reporting	Y	N	N
Static Power Saver	N	Y	Y
Dynamic Power Saver	Y	N	N
Power Capping	Y	N	N
Energy-optimized Fans	N	-	-
Processor Core Nap	N	-	-
Processor Core Sleep	N	-	-
Processor Folding	N	-	-
EnergyScale for I/O	N	-	-
Server Power Down	Y	-	-
Partition Power Management	Y	-	-

The Power 770 and Power 780 systems implement all the EnergyScale capabilities listed in 2.15.1, “IBM EnergyScale technology” on page 114.

2.15.2 Thermal power management device card

The thermal power management device (TPMD) card is a separate micro controller installed on some POWER6 processor-based systems, and on all POWER7 processor-based systems. It runs real-time firmware whose sole purpose is to manage system energy.

The TPMD card monitors the processor modules, memory, environmental temperature, and fan speed. Based on this information, it can act upon the system to maintain optimal power and energy conditions (for example, increase the fan speed to react to a temperature change). It also interacts with the IBM Systems Director Active Energy Manager to report power and thermal information and to receive input from AEM on policies to be set. The TPMD is part of the EnergyScale infrastructure.

3

Virtualization

As you look for ways to maximize the return on your IT infrastructure investments, consolidating workloads becomes an attractive proposition.

IBM Power Systems combined with PowerVM technology are designed to help you consolidate and simplify your IT environment with the following key capabilities:

- Improve server utilization and sharing I/O resources to reduce total cost of ownership and make better use of IT assets.
- Improve business responsiveness and operational speed by dynamically re-allocating resources to applications as needed, to better match changing business needs or handle unexpected changes in demand.
- Simplify IT infrastructure management by making workloads independent of hardware resources, thereby enabling you to make business-driven policies to deliver resources based on time, cost, and service-level requirements.

This chapter discusses the virtualization technologies and features on IBM Power Systems:

- POWER Hypervisor
- POWER Modes
- Partitioning
- Active Memory Expansion
- PowerVM
- System Planning Tool

3.1 POWER Hypervisor

Combined with features designed into the POWER7 processors, the POWER Hypervisor delivers functions that enable other system technologies, including logical partitioning technology, virtualized processors, IEEE VLAN compatible virtual switch, virtual SCSI adapters, virtual Fibre Channel adapters, and virtual consoles. The POWER Hypervisor is a basic component of the system's firmware and offers the following functions:

- Provides an abstraction between the physical hardware resources and the logical partitions that use them
- Enforces partition integrity by providing a security layer between logical partitions
- Controls the dispatch of virtual processors to physical processors (See "Processing mode" on page 131.)
- Saves and restores all processor state information during a logical processor context switch
- Controls hardware I/O interrupt management facilities for logical partitions
- Provides virtual LAN channels between logical partitions that help to reduce the need for physical Ethernet adapters for inter-partition communication
- Monitors the Service Processor and performs a reset or reload if it detects the loss of the Service Processor, notifying the operating system if the problem is not corrected

The POWER Hypervisor is always active, regardless of the system configuration and also when not connected to the managed console. It requires memory to support the resource assignment to the logical partitions on the server. The amount of memory required by the POWER Hypervisor firmware varies according to several factors. Factors influencing the POWER Hypervisor memory requirements include these:

- Number of logical partitions
- Number of physical and virtual I/O devices used by the logical partitions
- Maximum memory values specified in the logical partition profiles

The minimum amount of physical memory required to create a partition will be the size of the system's Logical Memory Block (LMB). The default LMB size varies according to the amount of memory configured in the CEC (Table 3-1).

Table 3-1 Configured CEC memory-to-default Logical Memory Block size

Configurable CEC memory	Default Logical Memory Block
Greater than 8 GB, up to 16 GB	64 MB
Greater than 16 GB, up to 32 GB	128 MB
Greater than 32 GB	256 MB

In most cases, however, the actual minimum requirements and recommendations of the supported operating systems are above 256 MB. Physical memory is assigned to partitions in increments of LMB.

The POWER Hypervisor provides the following types of virtual I/O adapters:

- Virtual SCSI
- Virtual Ethernet
- Virtual Fibre Channel
- Virtual (TTY) console

Virtual SCSI

The POWER Hypervisor provides a virtual SCSI mechanism for virtualization of storage devices. The storage virtualization is accomplished using two, paired adapters:

- A virtual SCSI server adapter
- A virtual SCSI client adapter

A Virtual I/O Server partition or a IBM i partition can define virtual SCSI server adapters. Other partitions are *client* partitions. The Virtual I/O Server partition is a special logical partition, as described in 3.4.4, "Virtual I/O Server" on page 137. The Virtual I/O Server software is included on all PowerVM Editions and when using the PowerVM Standard Edition and PowerVM Enterprise Edition, dual Virtual I/O Servers can be deployed to provide maximum availability for client partitions when performing Virtual I/O Server maintenance.

Virtual Ethernet

The POWER Hypervisor provides a virtual Ethernet switch function that allows partitions on the same server to use a fast and secure communication without any need for physical interconnection. The virtual Ethernet allows a transmission speed in the range of 1 - 3 Gbps, depending on the maximum transmission unit (MTU) size and CPU entitlement. Virtual Ethernet support began with IBM AIX Version 5.3, or an appropriate level of Linux supporting virtual Ethernet devices (see 3.4.9, "Operating system support for PowerVM" on page 148). The virtual Ethernet is part of the base system configuration.

Virtual Ethernet has the following major features:

- The virtual Ethernet adapters can be used for both IPv4 and IPv6 communication and can transmit packets with a size up to 65,408 bytes. Therefore, the maximum MTU for the corresponding interface can be up to 65,394 (65,390 if VLAN tagging is used).
- The POWER Hypervisor presents itself to partitions as a virtual 802.1Q-compliant switch. The maximum number of VLANs is 4096. Virtual Ethernet adapters can be configured as either untagged or tagged (following the IEEE 802.1Q VLAN standard).
- A partition can support 256 virtual Ethernet adapters. Besides a default port VLAN ID, the number of additional VLAN ID values that can be assigned per virtual Ethernet adapter is 20, which implies that each virtual Ethernet adapter can be used to access 21 virtual networks.
- Each partition operating system detects the virtual local area network (VLAN) switch as an Ethernet adapter without the physical link properties and asynchronous data transmit operations.

Any virtual Ethernet can also have connectivity outside of the server if a layer-2 bridge to a physical Ethernet adapter is set in one Virtual I/O Server partition (see 3.4.4, "Virtual I/O Server" on page 137, for more details about shared Ethernet), also known as Shared Ethernet Adapter.

Note: Virtual Ethernet is based on the IEEE 802.1Q VLAN standard. No physical I/O adapter is required when creating a VLAN connection between partitions, and no access to an outside network is required.

Virtual Fibre Channel

A virtual Fibre Channel adapter is a virtual adapter that provides client logical partitions with a Fibre Channel connection to a storage area network through the Virtual I/O Server logical partition. The Virtual I/O Server logical partition provides the connection between the virtual Fibre Channel adapters on the Virtual I/O Server logical partition and the physical Fibre Channel adapters on the managed system. Figure 3-1 depicts the connections between the client partition virtual Fibre Channel adapters and the external storage. For additional information, see 3.4.8, "N_Port ID virtualization" on page 147.

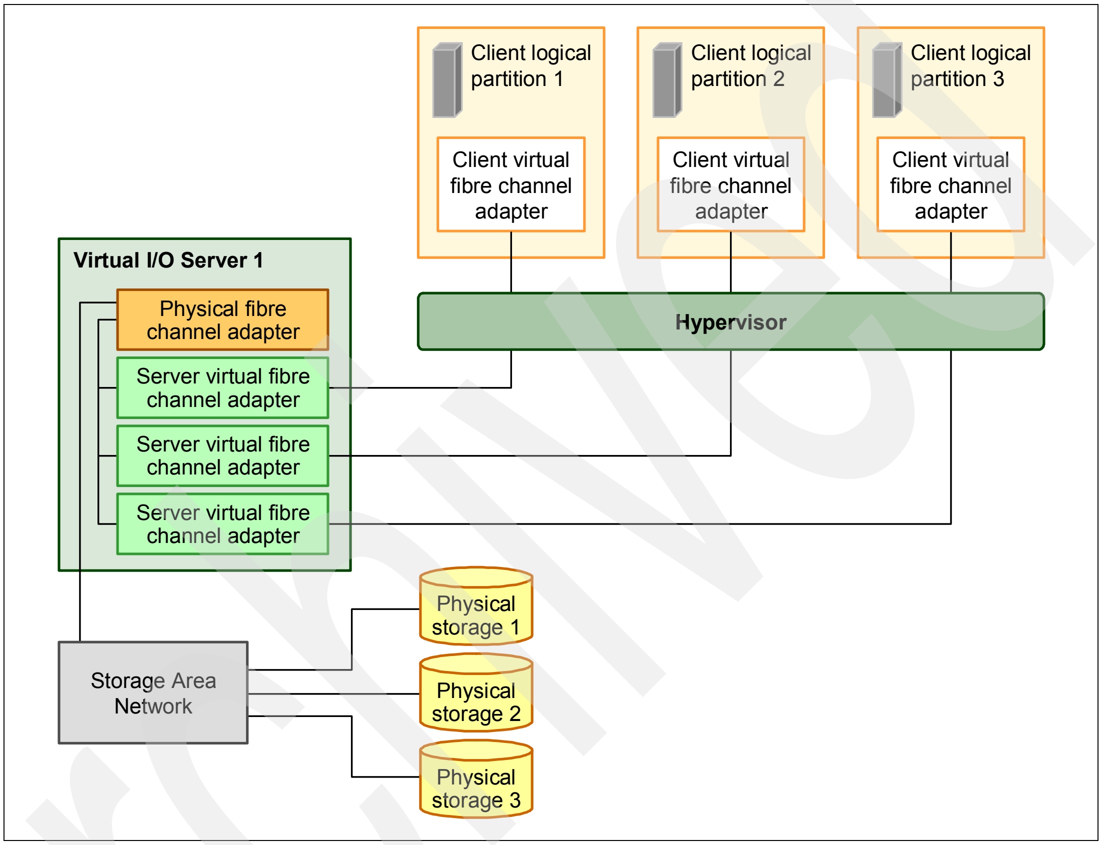

Figure 3-1 Connectivity between virtual Fibre Channels adapters and external SAN devices

Virtual (TTY) console

Each partition must have access to a system console. Tasks such as operating system installation, network setup, and various problem analysis activities require a dedicated system console. The POWER Hypervisor provides the virtual console by using a virtual TTY or serial adapter and a set of Hypervisor calls to operate on them. Virtual TTY does not require the purchase of any additional features or software, such as the PowerVM Edition features.

Depending on the system configuration, the operating system console can be provided by the Hardware Management Console virtual TTY, IVM virtual TTY, or from a terminal emulator that is connected to a system port.

3.2 POWER processor modes

Although, strictly speaking, not a virtualization feature, the POWER modes are described here because they affect various virtualization features.

On Power System servers, partitions can be configured to run in several modes, including:

- POWER6 compatibility mode

  This execution mode is compatible with Version 2.05 of the Power Instruction Set Architecture (ISA). For more information, visit the following address:

  http://www.power.org/resources/reading/PowerISA_V2.05.pdf

- POWER6+ compatibility mode

  This mode is similar to POWER6, with eight additional Storage Protection Keys.

- POWER7 mode

  This is the native mode for POWER7 processors, implementing the v2.06 of the Power Instruction Set Architecture. For more information, visit the following address:

  http://www.power.org/resources/downloads/PowerISA_V2.06_PUBLIC.pdf

The selection of the mode is made on a per-partition basis, from the managed console, by editing the partition profile (Figure 3-2).

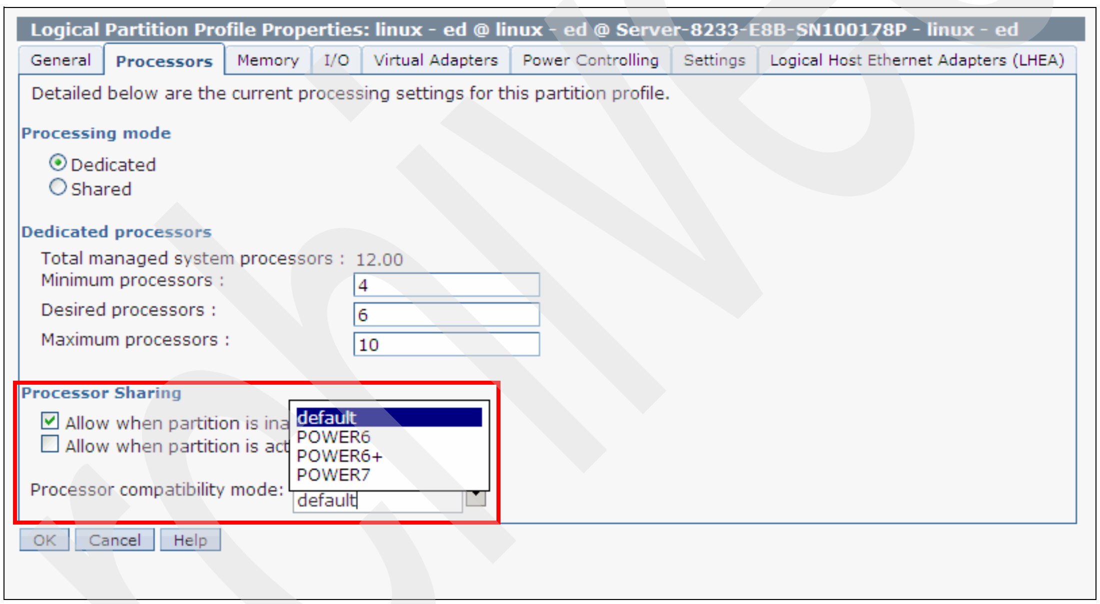

Figure 3-2 Configuring partition profile compatibility mode from the managed console

Table 3-2 lists the differences between these modes.

Table 3-2 Differences between POWER6 and POWER7 mode

POWER6 and POWER6+ mode	POWER7 mode	Customer value
2-thread SMT	4-thread SMT	Throughput performance, processor core utilization
Vector Multimedia Extension/ AltiVec (VMX)	Vector Scalar Extension (VSX)	High-performance computing
Affinity OFF by default	3-tier memory, Micropartition Affinity	Improved system performance for system images spanning sockets and nodes
► Barrier Synchronization ► Fixed 128-byte array, Kernel Extension Access	► Enhanced Barrier Synchronization ► Variable Sized Array, User Shared Memory Access	High-performance computing parallel programming synchronization facility
► 64-core and 128-thread scaling	► 32-core and 128-thread scaling ► 64-core and 256-thread scaling ► 256-core and 1024-thread scaling	Performance and scalability for large scale-up single system image workloads (such as OLTP, ERP scale-up, and WPAR consolidation)
EnergyScale CPU Idle	EnergyScale CPU Idle and Folding with NAP and SLEEP	Improved energy efficiency

3.3 Active Memory Expansion

Active Memory Expansion enablement is an optional feature of POWER7 processor-based servers that must be specified when creating the configuration in the e-Config tool, as follows:

IBM Power 770 #4791
IBM Power 780 #4791

This feature enables memory expansion on the system. Using compression/decompression of memory content can effectively expand the maximum memory capacity, providing additional server workload capacity and performance.

Active Memory Expansion is an innovative POWER7 technology that allows the effective maximum memory capacity to be much larger than the true physical memory maximum. Compression/decompression of memory content can allow memory expansion up to 100%, which in turn enables a partition to perform significantly more work or support more users with the same physical amount of memory. Similarly, it can allow a server to run more partitions and do more work for the same physical amount of memory.

Active Memory Expansion is available for partitions running AIX 6.1, Technology Level 4 with SP2, or later.

Active Memory Expansion uses CPU resource of a partition to compress/decompress the memory contents of this same partition. The trade-off of memory capacity for processor cycles can be an excellent choice, but the degree of expansion varies based on how compressible the memory content is, and it also depends on having adequate spare CPU capacity available for this compression/decompression. Tests in IBM laboratories, using sample work loads, showed excellent results for many workloads in terms of memory expansion per additional CPU utilized. Other test workloads had more modest results.

Clients have much control over Active Memory Expansion usage. Each individual AIX partition can turn on or turn off Active Memory Expansion. Control parameters set the amount of expansion desired in each partition to help control the amount of CPU used by the Active Memory Expansion function. An initial program load (IPL) is required for the specific partition that is turning memory expansion on or off. After turned on, monitoring capabilities are available in standard AIX performance tools, such as **`lparstat`**, **`vmstat`**, **`topas`**, and **`svmon`**.

Figure 3-3 represents the percentage of CPU that is used to compress memory for two partitions with separate profiles. The green curve corresponds to a partition that has spare processing power capacity. The blue curve corresponds to a partition constrained in processing power.

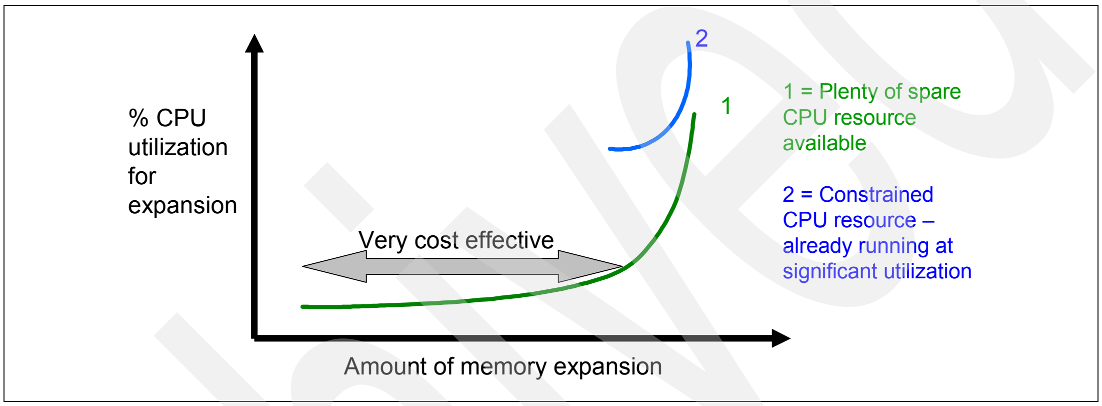

Figure 3-3 CPU usage versus memory expansion effectiveness

Both cases show that there is a knee-of-curve relationship for CPU resource required for memory expansion:

- Busy processor cores do not have resources to spare for expansion.
- The more memory expansion done, the more CPU resource required.

The knee varies depending on how compressible that the memory contents are. This example demonstrates the need for a case-by-case study of whether memory expansion can provide a positive return on investment.

To help you perform this study, a planning tool is included with AIX 6.1 Technology Level 4, allowing you to sample actual workloads and estimate how expandable the partition's memory is and how much CPU resource is needed. Any model Power System can run the planning tool. Figure 3-4 shows an example of the output returned by this planning tool. The tool outputs various real memory and CPU resource combinations to achieve the desired effective memory. It also recommends one particular combination. In this example, the tool recommends that you allocate 58% of a processor to benefit from 45% extra memory capacity.

```
Active Memory Expansion Modeled Statistics:
-----------------------
Modeled Expanded Memory Size :   8.00 GB

Expansion      True Memory       Modeled Memory       CPU Usage
 Factor        Modeled Size      Gain                 Estimate
---------     --------------    -----------------    -----------
  1.21          6.75 GB        1.25 GB [ 19%]          0.00
  1.31          6.25 GB        1.75 GB [ 28%]          0.20
  1.41          5.75 GB        2.25 GB [ 39%]          0.35
  1.51          5.50 GB        2.50 GB[ 45%]           0.58
  1.61          5.00 GB        3.00 GB [ 60%]          1.46

Active Memory Expansion Recommendation:
---------------------
The recommended AME configuration for this workload is to configure
the LPAR with a memory size of 5.50 GB and to configure a memory
expansion factor of 1.51.  This will result in a memory expansion of
45% from the LPAR's current memory size.  With this configuration,
the estimated CPU usage due to Active Memory Expansion is
approximately 0.58 physical processors, and the estimated overall
peak CPU resource required for the LPAR is 3.72 physical processors.
```

Figure 3-4   Output from Active Memory Expansion planning tool

After you select the value of the memory expansion factor that you want to achieve, you can use this value to configure the partition from the managed console (Figure 3-5).

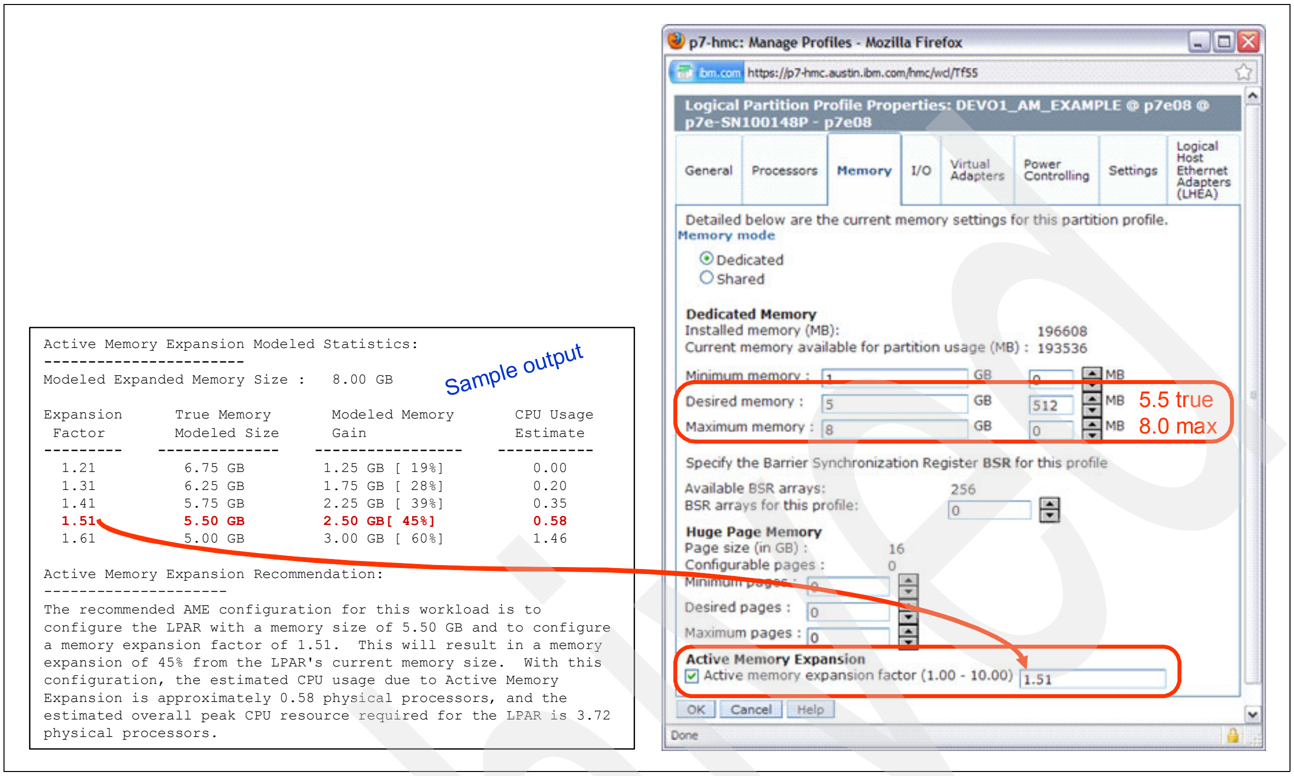

Figure 3-5 Using the planning tool result to configure the partition

On the HMC menu describing the partition, check the **Active Memory Expansion** box and enter true and maximum memory, and the memory expansion factor. To turn off expansion, clear the check box. In both cases, a reboot of the partition is needed to activate the change.

In addition, a one-time, 60-day trial of Active Memory Expansion is available to provide more exact memory expansion and CPU measurements. The trial can be requested using the Capacity on Demand web page:

http://www.ibm.com/systems/power/hardware/cod/

Active Memory Expansion can be ordered with the initial order of the server or as an MES order. A software key is provided when the enablement feature is ordered that is applied to the server. Rebooting is not required to enable the physical server. The key is specific to an individual server and is permanent. It cannot be moved to a separate server. This feature is ordered per server, independently of the number of partitions using memory expansion.

hypervisorFrom the HMC, you can view whether the Active Memory Expansion feature has been activated (Figure 3-6).

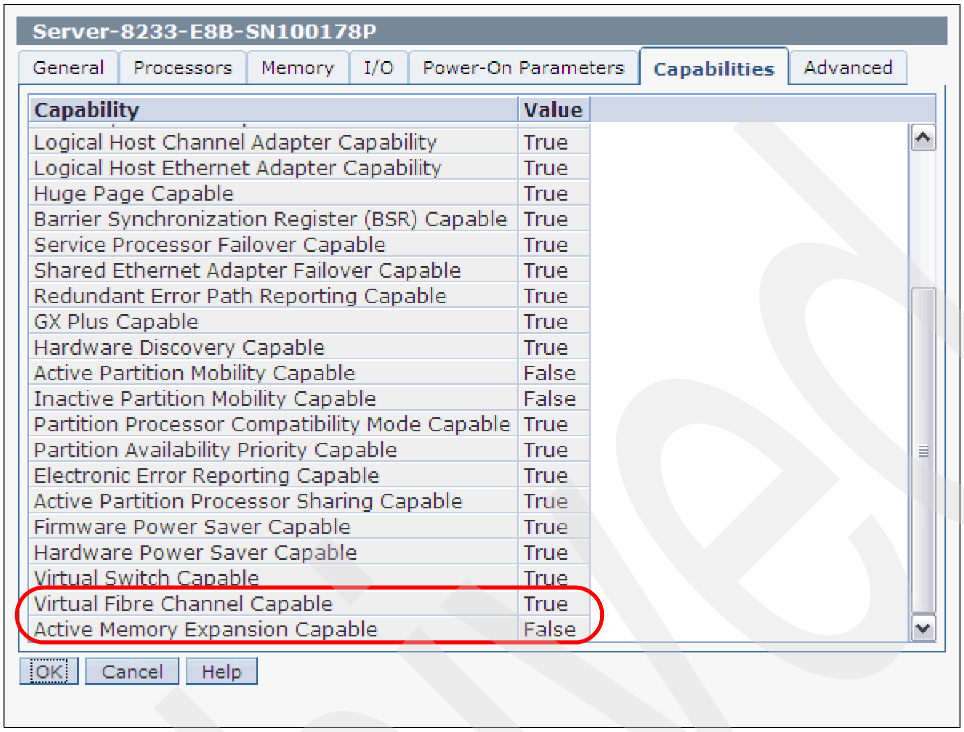

Figure 3-6 Server capabilities listed from the HMC

> **Note:** If you want to move an LPAR using Active Memory Expansion to a different system using Live Partition Mobility, the target system must support AME (the target system must have AME activated with the software key). If the target system does not have AME activated, the mobility operation fails during the pre-mobility check phase, and an appropriate error message displays to the user.

For detailed information regarding Active Memory Expansion, you can download the document *Active Memory Expansion: Overview and Usage Guide* from this location:

http://www-01.ibm.com/common/ssi/cgi-bin/ssialias?infotype=SA&subtype=WH&appname=STGE_PO_PO_USEN&htmlfid=POW03037USEN

3.4 PowerVM

The PowerVM platform is the family of technologies, capabilities, and offerings that deliver industry-leading virtualization on the IBM Power Systems. It is the new umbrella branding term for Power Systems Virtualization (Logical Partitioning, Micro-Partitioning, POWER Hypervisor, Virtual I/O Server, Live Partition Mobility, Workload Partitions, and more). As with Advanced Power Virtualization in the past, PowerVM is a combination of hardware enablement and value-added software. Section 3.4.1, “PowerVM editions” on page 129, discusses the licensed features of each of the three separate editions of PowerVM.

3.4.1 PowerVM editions

This section provides information about the virtualization capabilities of the PowerVM. The three editions of PowerVM are suited for various purposes, as follows:

- PowerVM Express Edition

  PowerVM Express Edition is designed for customers looking for an introduction to more advanced virtualization features at a highly affordable price, generally in single-server projects.

- PowerVM Standard Edition

  This edition provides advanced virtualization functions and is intended for production deployments and server consolidation.

- PowerVM Enterprise Edition

  This edition is suitable for large server deployments such as multi-server deployments and cloud infrastructure. It includes unique features like Active Memory Sharing and Live Partition Mobility.

Table 3-3 lists the version of PowerVM that are available on Power 770 and Power 780.

Table 3-3 Availability of PowerVM per POWER7 processor technology-based server model

PowerVM editions	Express	Standard	Enterprise
IBM Power 770	N/A	#7942	#7995
IBM Power 780	N/A	#7942	#7995

For more information about the features included on each version of PowerVM, see *IBM PowerVM Virtualization Introduction and Configuration*, SG24-7940-04.

Note: At the time of writing, the IBM Power 770 (9117-MMC) and Power 780 (9179-MHC) can only be managed by the Hardware Management Console.

3.4.2 Logical partitions (LPARs)

LPARs and virtualization increase utilization of system resources and add a new level of configuration possibilities. This section provides details and configuration specifications about this topic.

Dynamic logical partitioning

Logical partitioning was introduced with the POWER4 processor-based product line and the AIX Version 5.1 operating system. This technology offered the capability to divide a pSeries® system into separate logical systems, allowing each LPAR to run an operating environment on dedicated attached devices, such as processors, memory, and I/O components.

Later, dynamic logical partitioning increased the flexibility, allowing selected system resources, such as processors, memory, and I/O components, to be added and deleted from logical partitions while they are executing. AIX Version 5.2, with all the necessary enhancements to enable dynamic LPAR, was introduced in 2002. The ability to reconfigure dynamic LPARs encourages system administrators to dynamically redefine all available system resources to reach the optimum capacity for each defined dynamic LPAR.

Micro-Partitioning

Micro-Partitioning technology allows you to allocate fractions of processors to a logical partition. This technology was introduced with POWER5 processor-based systems. A logical partition using fractions of processors is also known as a Shared Processor Partition or micro-partition. Micro-partitions run over a set of processors called a Shared Processor Pool, and virtual processors are used to let the operating system manage the fractions of processing power assigned to the logical partition. From an operating system perspective, a virtual processor cannot be distinguished from a physical processor, unless the operating system has been enhanced to be made aware of the difference. Physical processors are abstracted into virtual processors that are available to partitions. The meaning of the term *physical processor* in this section is a *processor core*. For example, a 2-core server has two physical processors.

When defining a shared processor partition, several options have to be defined:

- The minimum, desired, and maximum processing units

  Processing units are defined as processing power, or the fraction of time that the partition is dispatched on physical processors. Processing units define the capacity entitlement of the partition.

- The Shared Processor Pool

  Pick one from the list with the names of each configured Shared Processor Pool. This list also displays the pool ID of each configured Shared Processor Pool in parentheses. If the name of the desired Shared Processor Pool is not available here, you must first configure the desired Shared Processor Pool using the Shared Processor Pool Management window. Shared processor partitions use the default Shared Processor Pool called DefaultPool by default. See 3.4.3, "Multiple Shared Processor Pools" on page 132, for details about Multiple Shared Processor Pools.

- Whether the partition will be able to access extra processing power to "fill up" its virtual processors above its capacity entitlement (selecting either to cap or uncap your partition)

  If there is spare processing power available in the Shared Processor Pool or other partitions are not using their entitlement, an uncapped partition can use additional processing units if its entitlement is not enough to satisfy its application processing demand.

- The weight (preference) in the case of an uncapped partition
- The minimum, desired, and maximum number of virtual processors

The POWER Hypervisor calculates partition processing power based on minimum, desired, and maximum values, processing mode, and is also based on requirements of other active partitions. The actual entitlement is never smaller than the processing unit's desired value, but can exceed that value in the case of an uncapped partition and up to the number of virtual processors allocated.

A partition can be defined with a processor capacity as small as 0.10 processing units. This represents 0.10 of a physical processor. Each physical processor can be shared by up to 10 shared processor partitions, and the partition's entitlement can be incremented fractionally by as little as 0.01 of the processor. The shared processor partitions are dispatched and time-sliced on the physical processors under control of the POWER Hypervisor. The shared processor partitions are created and managed by the HMC.

The IBM Power 770 supports up to 64 cores, and has the following maximums:

- Up to 64 dedicated partitions
- Up to 640 micro-partitions (10 micro-partitions per physical active core)

The Power 780 allows up to 96 cores in a single system, supporting the following maximums:

- Up to 96 dedicated partitions
- Up to 960 micro-partitions (10 micro-partitions per physical active core)

An important point is that the maximums stated are supported by the hardware, but the practical limits depend on application workload demands.

Additional information about virtual processors includes:

- A virtual processor can be running (dispatched) either on a physical processor or as standby waiting for a physical processor to became available.
- Virtual processors do not introduce any additional abstraction level. They are only a dispatch entity. When running on a physical processor, virtual processors run at the same speed as the physical processor.
- Each partition's profile defines CPU entitlement that determines how much processing power any given partition should receive. The total sum of CPU entitlement of all partitions cannot exceed the number of available physical processors in a Shared Processor Pool.
- The number of virtual processors can be changed dynamically through a dynamic LPAR operation.

Processing mode

When you create a logical partition you can assign entire processors for dedicated use, or you can assign partial processing units from a Shared Processor Pool. This setting defines the processing mode of the logical partition. Figure 3-7 shows a diagram of the concepts discussed in this section.

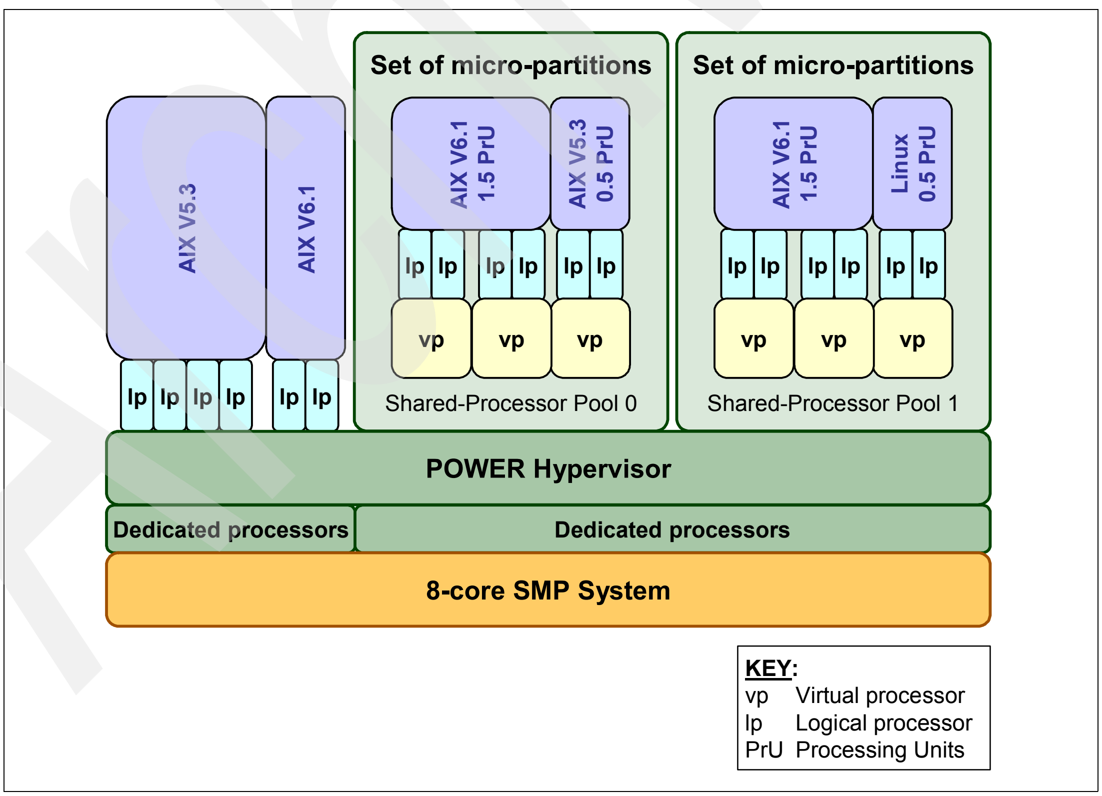

Figure 3-7 Logical partitioning concepts

Dedicated mode

In dedicated mode, physical processors are assigned as a whole to partitions. The simultaneous multithreading feature in the POWER7 processor core allows the core to execute instructions from two or four independent software threads simultaneously. To support this feature we use the concept of *logical processors*. The operating system (AIX, IBM i, or Linux) sees one physical processor as two or four logical processors if the simultaneous multithreading feature is on. It can be turned off and on dynamically while the operating system is executing (for AIX, use the **smtctl** command). If simultaneous multithreading is off, each physical processor is presented as one logical processor, and thus only one thread.

Shared dedicated mode

On POWER7 processor technology-based servers, you can configure dedicated partitions to become processor donors for idle processors that they own, allowing for the donation of spare CPU cycles from dedicated processor partitions to a Shared Processor Pool. The dedicated partition maintains absolute priority for dedicated CPU cycles. Enabling this feature can help to increase system utilization without compromising the computing power for critical workloads in a dedicated processor.

Shared mode

In shared mode, logical partitions use virtual processors to access fractions of physical processors. Shared partitions can define any number of virtual processors (the maximum number is 10 times the number of processing units assigned to the partition). From the POWER Hypervisor point of view, virtual processors represent dispatching objects. The POWER Hypervisor dispatches virtual processors to physical processors according to the partition's processing units entitlement. One processing unit represents one physical processor's processing capacity. At the end of the POWER Hypervisor's dispatch cycle (10 ms), all partitions receive total CPU time equal to their processing unit's entitlement. The logical processors are defined on top of virtual processors. So, even with a virtual processor, the concept of a logical processor exists and the number of logical processors depends whether the simultaneous multithreading is turned on or off.

3.4.3 Multiple Shared Processor Pools

Multiple Shared Processor Pools (MSPPs) is a capability supported on POWER7 processor and POWER6 processor-based servers. This capability allows a system administrator to create a set of micro-partitions with the purpose of controlling the processor capacity that can be consumed from the physical Shared Processor Pool.

To implement MSPPs, there is a set of underlying techniques and technologies. Figure 3-8 shows an overview of the architecture of Multiple Shared Processor Pools.

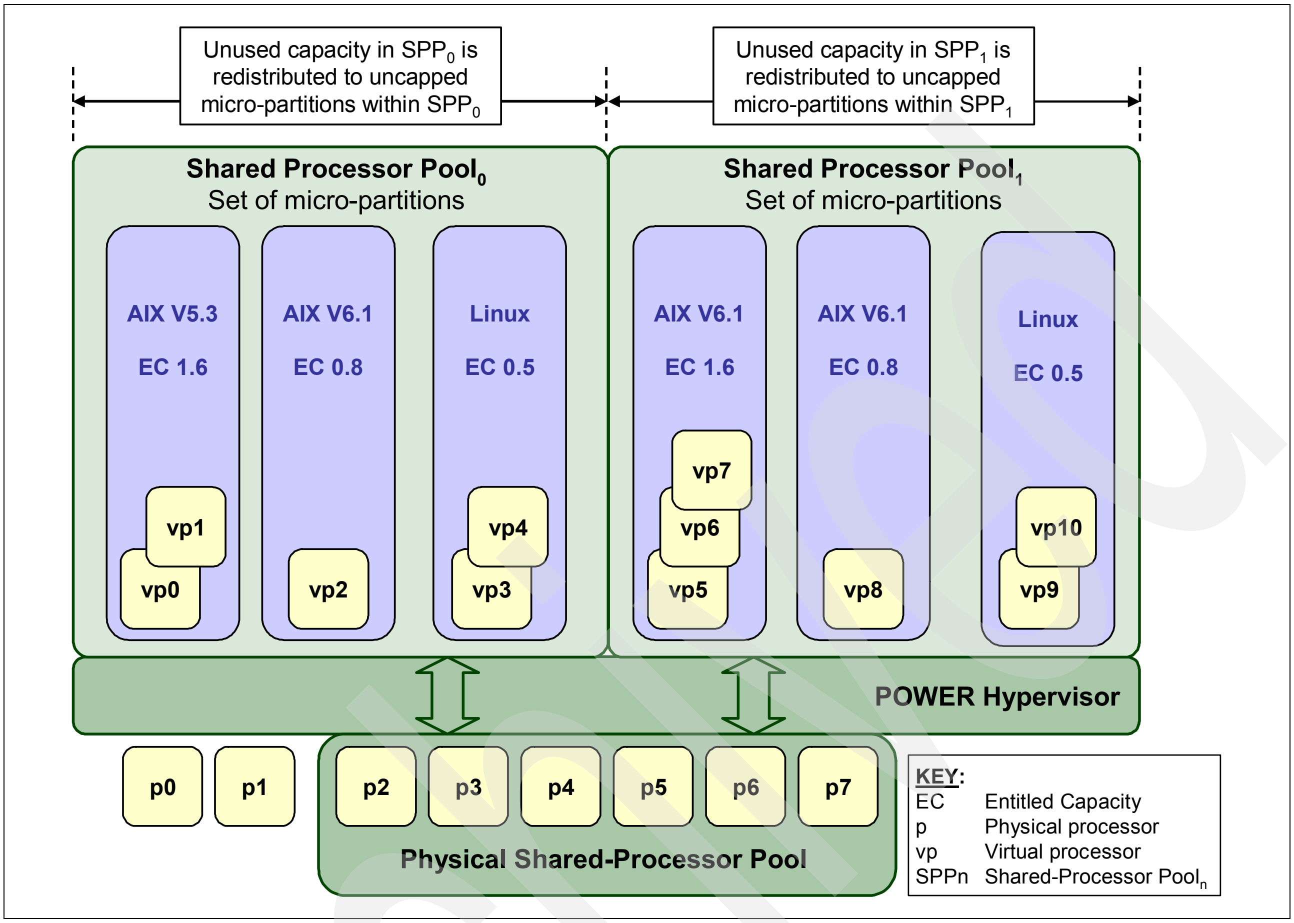

Figure 3-8 Overview of the architecture of Multiple Shared Processor Pools

Micro-partitions are created and then identified as members of either the default Shared Processor Pool$_0$ or a user-defined Shared Processor Pool$_n$. The virtual processors that exist within the set of micro-partitions are monitored by the POWER Hypervisor, and processor capacity is managed according to user-defined attributes.

If the Power Systems server is under heavy load, each micro-partition within a Shared Processor Pool is guaranteed its processor entitlement plus any capacity that it might be allocated from the reserved pool capacity if the micro-partition is uncapped.

If certain micro-partitions in a Shared Processor Pool do not use their capacity entitlement, the unused capacity is ceded and other uncapped micro-partitions within the same Shared Processor Pool are allocated the additional capacity according to their uncapped weighting. In this way, the entitled pool capacity of a Shared Processor Pool is distributed to the set of micro-partitions within that Shared Processor Pool.

All Power Systems servers that support the Multiple Shared Processor Pools capability will have a minimum of one (the default) Shared Processor Pool and up to a maximum of 64 Shared Processor Pools.

Default Shared Processor Pool (SPP_0)

On any Power Systems server supporting Multiple Shared Processor Pools, a default Shared Processor Pool is always automatically defined. The default Shared Processor Pool has a pool identifier of zero (SPP-ID = 0) and can also be referred to as SPP_0. The default Shared Processor Pool has the same attributes as a user-defined Shared Processor Pool except that these attributes are not directly under the control of the system administrator. They have fixed values (Table 3-4).

Table 3-4 Attribute values for the default Shared Processor Pool (SPP_0)

SPP_0 attribute	Value
Shared Processor Pool ID	0.
Maximum pool capacity	The value is equal to the capacity in the physical Shared Processor Pool.
Reserved pool capacity	0.
Entitled pool capacity	Sum (total) of the entitled capacities of the micro-partitions in the default Shared Processor Pool.

Creating Multiple Shared Processor Pools

The default Shared Processor Pool (SPP_0) is automatically activated by the system and is always present.

All other Shared Processor Pools exist, but by default are inactive. By changing the maximum pool capacity of a Shared Processor Pool to a value greater than zero, it becomes active and can accept micro-partitions (either transferred from SPP_0 or newly created).

Levels of processor capacity resolution

The two levels of processor capacity resolution implemented by the POWER Hypervisor and Multiple Shared Processor Pools are:

- $Level_0$

  The first level, $Level_0$, is the resolution of capacity within the same Shared Processor Pool. Unused processor cycles from within a Shared Processor Pool are harvested and then redistributed to any eligible micro-partition within the same Shared Processor Pool.

- $Level_1$

  This is the second level of processor capacity resolution. When all $Level_0$ capacity has been resolved within the Multiple Shared Processor Pools, the POWER Hypervisor harvests unused processor cycles and redistributes them to eligible micro-partitions regardless of the Multiple Shared Processor Pools structure.

Figure 3-9 shows the levels of unused capacity redistribution implemented by the POWER Hypervisor.

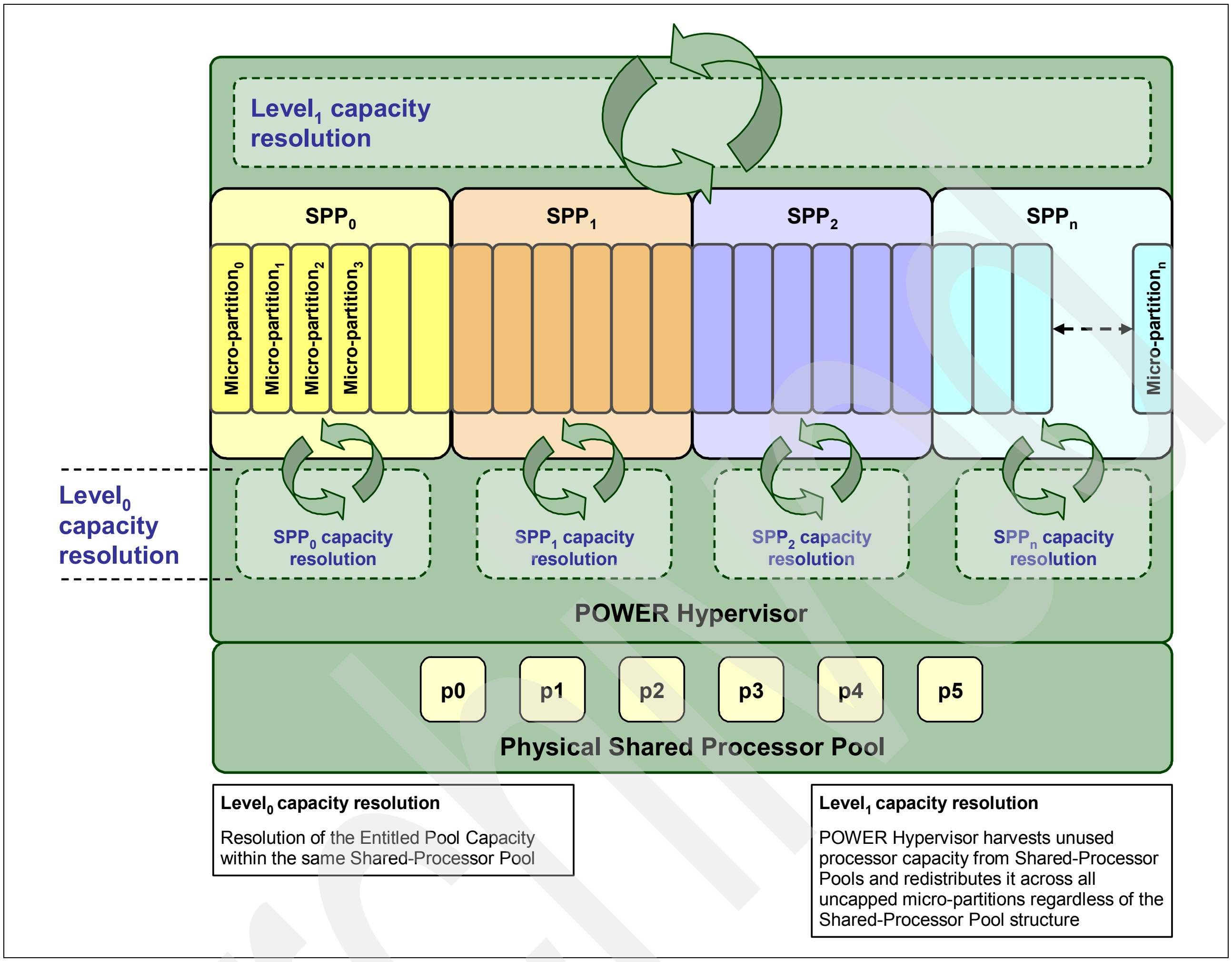

Figure 3-9 The levels of unused capacity redistribution

Capacity allocation above the entitled pool capacity (Level$_1$)

The POWER Hypervisor initially manages the entitled pool capacity at the Shared Processor Pool level. This is where unused processor capacity within a Shared Processor Pool is harvested and then redistributed to uncapped micro-partitions within the same Shared Processor Pool. This level of processor capacity management is sometimes referred to as Level$_0$ capacity resolution.

At a higher level, the POWER Hypervisor harvests unused processor capacity from the Multiple Shared Processor Pools that do not consume all of their entitled pool capacity. If a particular Shared Processor Pool is heavily loaded and several of the uncapped micro-partitions within it require additional processor capacity (above the entitled pool capacity), then the POWER Hypervisor redistributes some of the extra capacity to the uncapped micro-partitions. This level of processor capacity management is sometimes referred to as Level$_1$ capacity resolution.

To redistribute unused processor capacity to uncapped micro-partitions in Multiple Shared Processor Pools above the entitled pool capacity, the POWER Hypervisor uses a higher level of redistribution, Level$_1$.

Important: Level_1 capacity resolution: When allocating additional processor capacity in excess of the entitled pool capacity of the Shared Processor Pool, the POWER Hypervisor takes the uncapped weights of *all micro-partitions in the system* into account, *regardless of the Multiple Shared Processor Pool structure*.

Where there is unused processor capacity in under-utilized Shared Processor Pools, the micro-partitions within the Shared Processor Pools cede the capacity to the POWER Hypervisor.

In busy Shared Processor Pools, where the micro-partitions have used all of the entitled pool capacity, the POWER Hypervisor allocates additional cycles to micro-partitions, in which *all* of the following statements are true:

- The maximum pool capacity of the Shared Processor Pool hosting the micro-partition has not been met.
- The micro-partition is uncapped.
- The micro-partition has enough virtual-processors to take advantage of the additional capacity.

Under these circumstances, the POWER Hypervisor allocates additional processor capacity to micro-partitions on the basis of their uncapped weights independent of the Shared Processor Pool hosting the micro-partitions. This can be referred to as Level_1 capacity resolution. Consequently, when allocating additional processor capacity in excess of the entitled pool capacity of the Shared Processor Pools, the POWER Hypervisor takes the uncapped weights of all micro-partitions in the system into account, regardless of the Multiple Shared Processor Pool structure.

Dynamic adjustment of maximum pool capacity

The maximum pool capacity of a Shared Processor Pool, other than the default Shared Processor Pool_0, can be adjusted dynamically from the managed console, using either the graphical interface or the command-line interface (CLI).

Dynamic adjustment of reserved pool capacity

The reserved pool capacity of a Shared Processor Pool, other than the default Shared Processor Pool_0, can be adjusted dynamically from the managed console, using either the graphical interface or the CLI interface.

Dynamic movement between Shared Processor Pools

A micro-partition can be moved dynamically from one Shared Processor Pool to another using the managed console using either the graphical interface or the CLI interface. Because the entitled pool capacity is partly made up of the sum of the entitled capacities of the micro-partitions, removing a micro-partition from a Shared Processor Pool reduces the entitled pool capacity for that Shared Processor Pool. Similarly, the entitled pool capacity of the Shared Processor Pool that the micro-partition joins will increase.

Deleting a Shared Processor Pool

Shared Processor Pools cannot be deleted from the system. However, they are deactivated by setting the maximum pool capacity and the reserved pool capacity to zero. The Shared Processor Pool will still exist but will not be active. Use the managed console interface to deactivate a Shared Processor Pool. A Shared Processor Pool cannot be deactivated unless all micro-partitions hosted by the Shared Processor Pool have been removed.

Live Partition Mobility and Multiple Shared Processor Pools

A micro-partition can leave a Shared Processor Pool because of PowerVM Live Partition Mobility. Similarly, a micro-partition can join a Shared Processor Pool in the same way. When performing PowerVM Live Partition Mobility, you are given the opportunity to designate a destination Shared Processor Pool on the target server to receive and host the migrating micro-partition.

Because several simultaneous micro-partition migrations are supported by PowerVM Live Partition Mobility, it is conceivable to migrate the entire Shared Processor Pool from one server to another.

3.4.4 Virtual I/O Server

The Virtual I/O Server is part of all PowerVM Editions. It is a special-purpose partition that allows the sharing of physical resources between logical partitions to allow more efficient utilization (for example, consolidation). In this case, the Virtual I/O Server owns the physical resources (SCSI, Fibre Channel, network adapters, and optical devices) and allows client partitions to share access to them, thus minimizing the number of physical adapters in the system. The Virtual I/O Server eliminates the requirement that every partition owns a dedicated network adapter, disk adapter, and disk drive. The Virtual I/O Server supports OpenSSH for secure remote logins. It also provides a firewall for limiting access by ports, network services, and IP addresses. Figure 3-10 shows an overview of a Virtual I/O Server configuration.

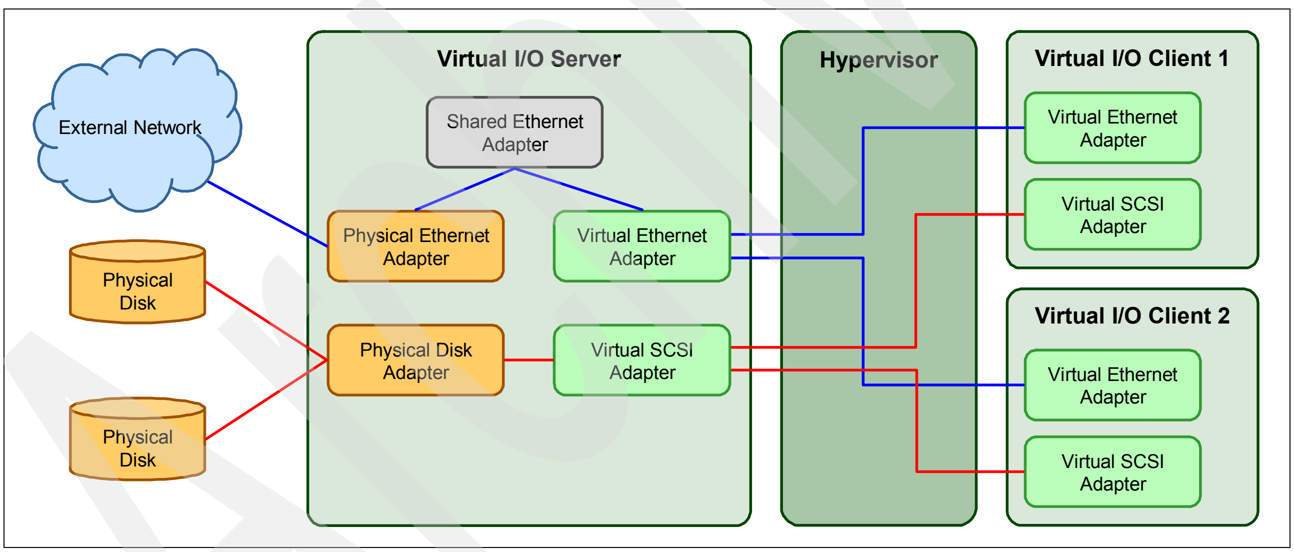

Figure 3-10 Architectural view of the Virtual I/O Server

Because the Virtual I/O Server is an operating system-based appliance server, redundancy for physical devices attached to the Virtual I/O Server can be provided by using capabilities such as Multipath I/O and IEEE 802.3ad Link Aggregation.

Installation of the Virtual I/O Server partition is performed from a special system backup DVD that is provided to clients who order any PowerVM edition. This dedicated software is only for the Virtual I/O Server (and IVM in case it is used) and is only supported in special Virtual I/O Server partitions. Three major virtual devices are supported by the Virtual I/O Server:

- Shared Ethernet Adapter
- Virtual SCSI
- Virtual Fibre Channel adapter

The Virtual Fibre Channel adapter is used with the NPIV feature, described in 3.4.8, “N_Port ID virtualization” on page 147.

Shared Ethernet Adapter

A Shared Ethernet Adapter (SEA) can be used to connect a physical Ethernet network to a virtual Ethernet network. The Shared Ethernet Adapter provides this access by connecting the internal hypervisor VLANs with the VLANs on the external switches. Because the Shared Ethernet Adapter processes packets at layer 2, the original MAC address and VLAN tags of the packet are visible to other systems on the physical network. IEEE 802.1 VLAN tagging is supported.

The Shared Ethernet Adapter also provides the ability for several client partitions to share one physical adapter. With an SEA, you can connect internal and external VLANs using a physical adapter. The Shared Ethernet Adapter service can only be hosted in the Virtual I/O Server, not in a general-purpose AIX or Linux partition, and acts as a layer-2 network bridge to securely transport network traffic between virtual Ethernet networks (internal) and one or more (EtherChannel) physical network adapters (external). These virtual Ethernet network adapters are defined by the POWER Hypervisor on the Virtual I/O Server.

Tip: A Linux partition can provide bridging function also, by using the `brctl` command.

Figure 3-11 shows a configuration example of an SEA with one physical and two virtual Ethernet adapters. An SEA can include up to 16 virtual Ethernet adapters on the Virtual I/O Server that share the same physical access.

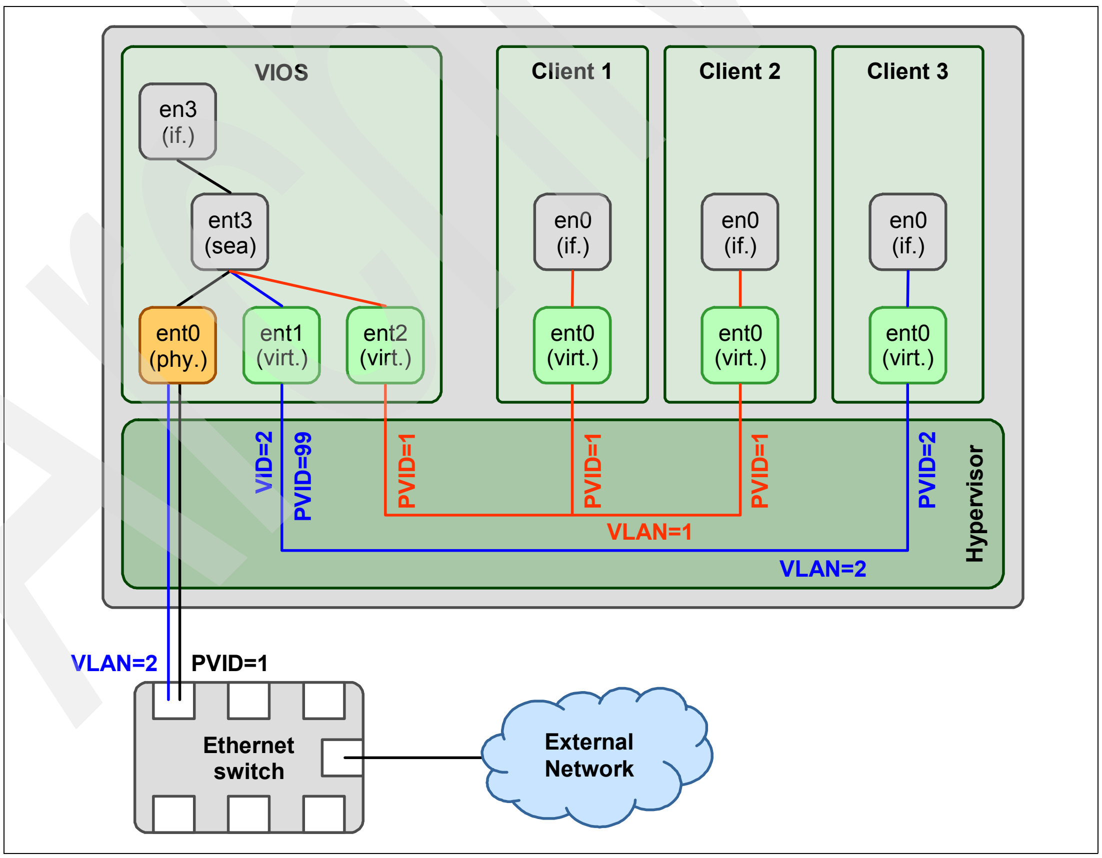

Figure 3-11 Architectural view of a Shared Ethernet Adapter

A single SEA setup can have up to 16 Virtual Ethernet trunk adapters and each virtual Ethernet trunk adapter can support up to 20 VLAN networks. Therefore, a possibility is for a single physical Ethernet to be shared between 320 internal VLAN networks. The number of shared Ethernet adapters that can be set up in a Virtual I/O Server partition is limited only by the resource availability, because there are no configuration limits.

Unicast, broadcast, and multicast are supported, so protocols that rely on broadcast or multicast, such as Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP), Boot Protocol (BOOTP), and Neighbor Discovery Protocol (NDP), can work on an SEA.

Note: A Shared Ethernet Adapter does not need to have an IP address configured to be able to perform the Ethernet bridging functionality. Configuring IP on the Virtual I/O Server is convenient because the Virtual I/O Server can then be reached by TCP/IP, for example, to perform dynamic LPAR operations or to enable remote login. This task can be done either by configuring an IP address directly on the SEA device or on an additional virtual Ethernet adapter in the Virtual I/O Server. This leaves the SEA without the IP address, allowing for maintenance on the SEA without losing IP connectivity in case SEA failover is configured.

For a more detailed discussion about virtual networking, see:

http://www.ibm.com/servers/aix/whitepapers/aix_vn.pdf

Virtual SCSI

Virtual SCSI is used to refer to a virtualized implementation of the SCSI protocol. Virtual SCSI is based on a client/server relationship. The Virtual I/O Server logical partition owns the physical resources and acts as a server or, in SCSI terms, a target device. The client logical partitions access the virtual SCSI backing storage devices provided by the Virtual I/O Server as clients.

The virtual I/O adapters (virtual SCSI server adapter and a virtual SCSI client adapter) are configured using a managed console or through the Integrated Virtualization Manager on smaller systems. The virtual SCSI server (target) adapter is responsible for executing any SCSI commands that it receives. It is owned by the Virtual I/O Server partition. The virtual SCSI client adapter allows a client partition to access physical SCSI and SAN attached devices and LUNs that are assigned to the client partition. The provisioning of virtual disk resources is provided by the Virtual I/O Server.

Physical disks presented to the Virtual/O Server can be exported and assigned to a client partition in a number of ways:

- The entire disk is presented to the client partition.
- The disk is divided into several logical volumes, which can be presented to a single client or multiple clients.
- As of Virtual I/O Server 1.5, files can be created on these disks, and file-backed storage devices can be created.

The logical volumes or files can be assigned to separate partitions. Therefore, virtual SCSI enables sharing of adapters and disk devices.

Figure 3-12 shows an example where one physical disk is divided into two logical volumes by the Virtual I/O Server. Each client partition is assigned one logical volume, which is then accessed through a virtual I/O adapter (VSCSI Client Adapter). Inside the partition, the disk is seen as a normal hdisk.

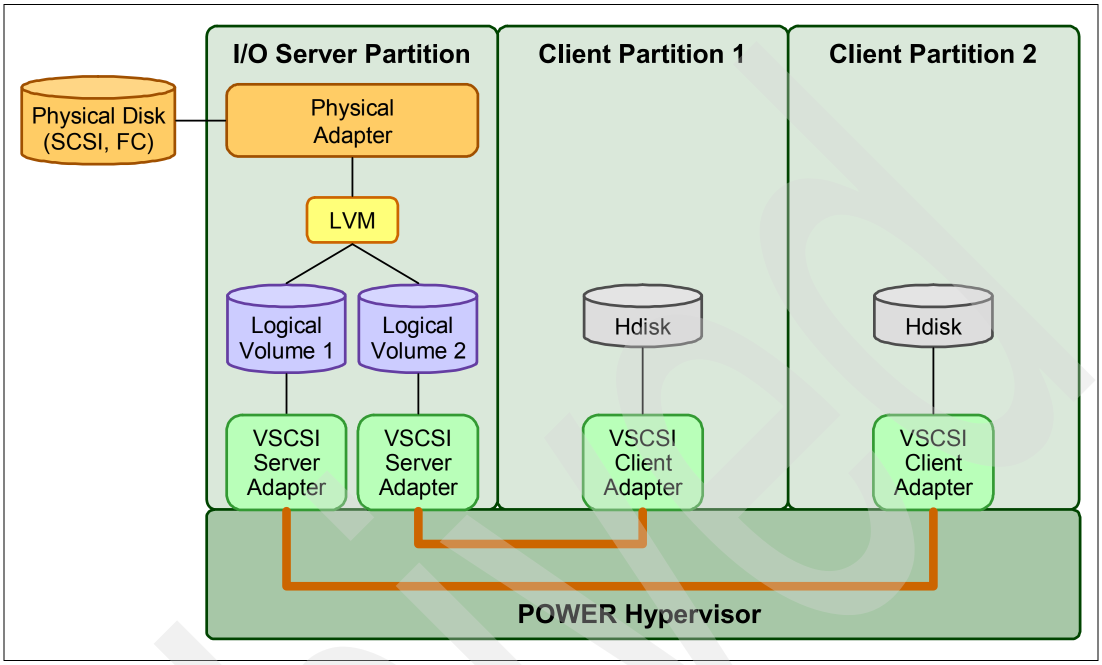

Figure 3-12 Architectural view of virtual SCSI

At the time of writing, virtual SCSI supports Fibre Channel, parallel SCSI, iSCSI, SAS, SCSI RAID devices, and optical devices, including DVD-RAM and DVD-ROM. Other protocols such as SSA and tape devices are not supported.

For more information about the specific storage devices supported for Virtual I/O Server, see:

http://www14.software.ibm.com/webapp/set2/sas/f/vios/documentation/datasheet.html

Virtual I/O Server functions

The Virtual I/O Server has a number of features, including monitoring solutions:

- Support for Live Partition Mobility starting on POWER6 processor-based systems with the PowerVM Enterprise Edition. For more information about Live Partition Mobility, see 3.4.5, “PowerVM Live Partition Mobility” on page 141.
- Support for virtual SCSI devices backed by a file, which are then accessed as standard SCSI-compliant LUNs.
- Support for virtual Fibre Channel devices that are used with the NPIV feature.
- Virtual I/O Server Expansion Pack with additional security functions such as Kerberos (Network Authentication Service for users and client and server applications), Simple Network Management Protocol (SNMP) v3, and Lightweight Directory Access Protocol (LDAP) client functionality.
- System Planning Tool (SPT) and Workload Estimator, which are designed to ease the deployment of a virtualized infrastructure. For more information about the System Planning Tool, see 3.5, “System Planning Tool” on page 150.

- Includes IBM Systems Director agent and a number of pre-installed Tivoli agents, such as:
  - Tivoli Identity Manager (TIM), to allow easy integration into an existing Tivoli Systems Management infrastructure
  - Tivoli Application Dependency Discovery Manager (ADDM), which creates and automatically maintains application infrastructure maps including dependencies, change-histories, and deep configuration values
- vSCSI eRAS.
- Additional CLI statistics in **`svmon`**, **`vmstat`**, **`fcstat`**, and **`topas`**.
- Monitoring solutions to help manage and monitor the Virtual I/O Server and shared resources. New commands and views provide additional metrics for memory, paging, processes, Fibre Channel HBA statistics, and virtualization.

For more information about the Virtual I/O Server and its implementation, see *IBM PowerVM Virtualization Introduction and Configuration*, SG24-7940.

3.4.5 PowerVM Live Partition Mobility

PowerVM Live Partition Mobility allows you to move a running logical partition, including its operating system and running applications, from one system to another without any shutdown or without disrupting the operation of that logical partition. Inactive partition mobility allows you to move a powered-off logical partition from one system to another.

Partition mobility provides systems management flexibility and improves system availability, as follows:

- Avoid planned outages for hardware or firmware maintenance by moving logical partitions to another server and then performing the maintenance. Live Partition Mobility can help lead to zero downtime maintenance because you can use it to work around scheduled maintenance activities.
- Avoid downtime for a server upgrade by moving logical partitions to another server and then performing the upgrade. This approach allows your users to continue their work without disruption.
- Avoid unplanned downtime. With preventive failure management, if a server indicates a potential failure, you can move its logical partitions to another server before the failure occurs. Partition mobility can help avoid unplanned downtime.
- Take advantage of server optimization:
  - Consolidation: You can consolidate workloads running on several small, under-used servers onto a single large server.
  - Deconsolidation: You can move workloads from server to server to optimize resource use and workload performance within your computing environment. With active partition mobility, you can manage workloads with minimal downtime.

Mobile partition’s operating system requirements

The operating system running in the mobile partition has to be AIX or Linux. The Virtual I/O Server partition itself cannot be migrated. All versions of AIX and Linux supported on the IBM POWER7 processor-based servers also support partition mobility.

Source and destination system requirements

The source partition must be one that has only virtual devices. If there are any physical devices in its allocation, they must be removed before the validation or migration is initiated.

An N_Port ID virtualization (NPIV) device is considered virtual and is compatible with partition migration.

The hypervisor must support the Partition Mobility functionality (also called migration process) available on POWER 6 and POWER 7 processor-based hypervisors. Firmware must be at firmware level eFW3.2 or later. All POWER7 processor-based hypervisors support Live Partition Mobility. Source and destination systems can have separate firmware levels, but they must be compatible with each other.

A possibility is to migrate partitions back and forth between POWER6 and POWER7 processor-based servers. Partition Mobility leverages the POWER6 Compatibility Modes that are provided by POWER7 processor-based servers. On the POWER7 processor-based server, the migrated partition is then executing in POWER6 or POWER6+ Compatibility Mode.

If you want to move an active logical partition from a POWER6 processor-based server to a POWER7 processor-based server so that the logical partition can take advantage of the additional capabilities available with the POWER7 processor, perform these steps:

1. Set the partition-preferred processor compatibility mode to the default mode. When you activate the logical partition on the POWER6 processor-based server, it runs in the POWER6 mode.
2. Move the logical partition to the POWER7 processor-based server. Both the current and preferred modes remain unchanged for the logical partition until you restart the logical partition.
3. Restart the logical partition on the POWER7 processor-based server. The hypervisor evaluates the configuration. Because the preferred mode is set to default and the logical partition now runs on a POWER7 processor-based server, the highest mode available is the POWER7 mode. The hypervisor determines that the most fully featured mode that is supported by the operating environment installed in the logical partition is the POWER7 mode and changes the current mode of the logical partition to the POWER7 mode.

Now the current processor compatibility mode of the logical partition is the POWER7 mode, and the logical partition runs on the POWER7 processor-based server.

> **Tip:** The “Migration combinations of processor compatibility modes for active Partition Mobility” web page offers presentations of the supported migrations:
>
> http://publib.boulder.ibm.com/infocenter/powersys/v3r1m5/topic/p7hc3/iphc3pcmcombosact.htm

The Virtual I/O Server on the source system provides the access to the client resources and must be identified as a mover service partition (MSP). The Virtual Asynchronous Services Interface (VASI) device allows the mover service partition to communicate with the hypervisor. It is created and managed automatically by the managed console and will be configured on both the source and destination Virtual I/O Servers, which are designated as the mover service partitions for the mobile partition, to participate in active mobility. Other requirements include a similar time-of-day on each server, systems must not be running on battery power, and shared storage (external hdisk with reserve_policy=no_reserve). In addition, all logical partitions must be on the same open network with RMC established to the managed console.

The managed console is used to configure, validate, and orchestrate. You use the managed console to configure the Virtual I/O Server as an MSP and to configure the VASI device. An managed console wizard validates your configuration and identifies issues that can cause the migration to fail. During the migration, the managed console controls all phases of the process.

Improved Live Partition Mobility benefits

The possibility to move partitions between POWER6 and POWER7 processor-based servers greatly facilitates the deployment of POWER7 processor-based servers, as follows:

- Installation of the new server can be performed while the application is executing on a POWER6 server. After the POWER7 processor-based server is ready, the application can be migrated to its new hosting server without application down time.
- When adding POWER7 processor-based servers to a POWER6 environment, you get the additional flexibility to perform workload balancing across the entire set of POWER6 and POWER7 processor-based servers.
- When performing server maintenance, you get the additional flexibility to use POWER6 Servers for hosting applications usually hosted on POWER7 processor-based servers, and vice versa, allowing you to perform this maintenance with no application planned down time.

For more information about Live Partition Mobility and how to implement it, see *IBM PowerVM Live Partition Mobility*, SG24-7460.

3.4.6 Active Memory Sharing

Active Memory Sharing is an IBM PowerVM advanced memory virtualization technology that provides system memory virtualization capabilities to IBM Power Systems, allowing multiple partitions to share a common pool of physical memory.

Active Memory Sharing is only available with the Enterprise version of PowerVM.

The physical memory of an IBM Power System can be assigned to multiple partitions either in dedicated or shared mode. The system administrator has the capability to assign some physical memory to a partition and some physical memory to a pool that is shared by other partitions. A single partition can have either dedicated or shared memory:

- With a pure dedicated memory model, the system administrator's task is to optimize available memory distribution among partitions. When a partition suffers degradation because of memory constraints and other partitions have unused memory, the administrator can manually issue a dynamic memory reconfiguration.
- With a shared memory model, the system automatically decides the optimal distribution of the physical memory to partitions and adjusts the memory assignment based on partition load. The administrator reserves physical memory for the shared memory pool, assigns partitions to the pool, and provides access limits to the pool.

Active Memory Sharing can be exploited to increase memory utilization on the system either by decreasing the global memory requirement or by allowing the creation of additional partitions on an existing system. Active Memory Sharing can be used in parallel with Active Memory Expansion on a system running a mixed workload of several operating system. For example, AIX partitions can take advantage of Active Memory Expansion. Other operating systems take advantage of Active Memory Sharing.

For additional information regarding Active Memory Sharing, see *IBM PowerVM Virtualization Active Memory Sharing*, REDP-4470.

3.4.7 Active Memory Deduplication

In a virtualized environment, the systems might have a considerable amount of duplicated information stored on RAM after each partition has its own operating system, and some of them might even share the same kind of applications. On heavily loaded systems this might lead to a shortage of the available memory resources, forcing paging by the AMS partition operating systems, the AMD pool, or both, which might decrease overall system performance.

Figure 3-13 shows the standard behavior of a system without Active Memory Deduplication (AMD) enabled on its AMS shared memory pool. Identical pages within the same or different LPARs each require their own unique physical memory page, consuming space with repeated information.

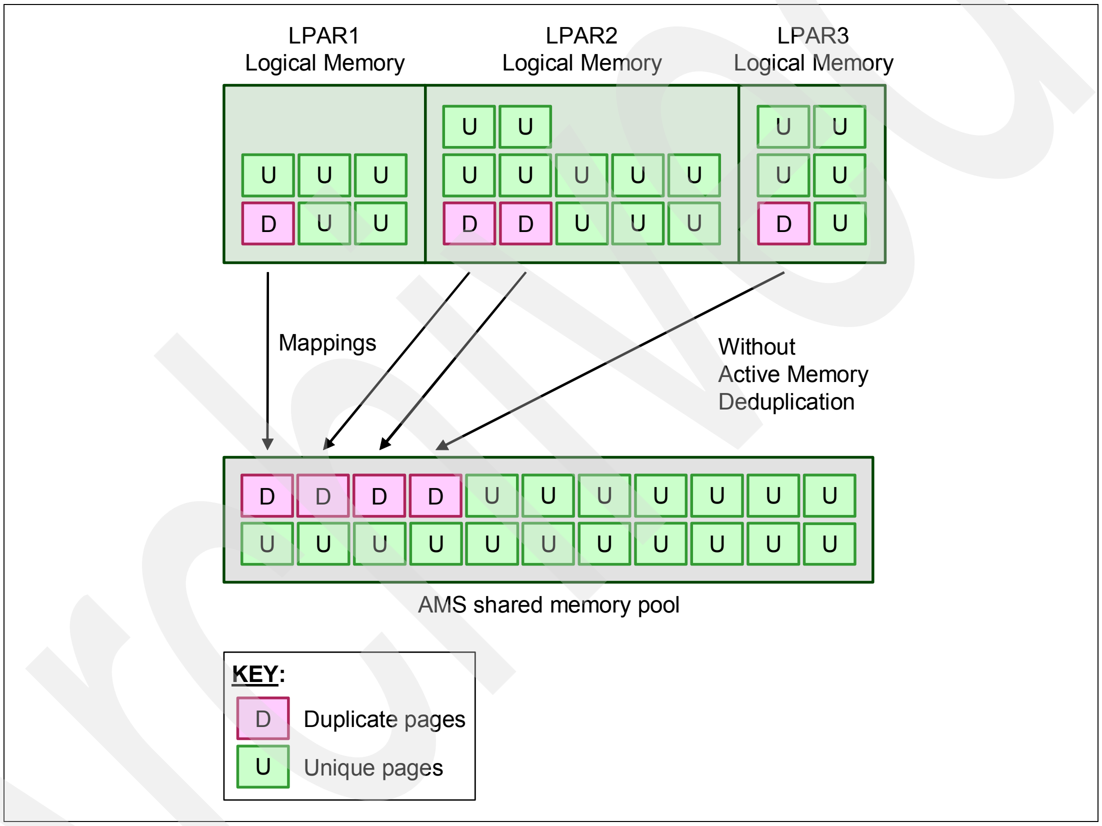

Figure 3-13 AMS shared memory pool without AMD enabled

Active Memory Deduplication allows the hypervisor to dynamically map identical partition memory pages to a single physical memory page within a shared memory pool. This enables a better utilization of the AMS shared memory pool, increasing the system's overall performance by avoiding paging. Deduplication can cause the hardware to incur fewer cache misses, which will also lead to improved performance.

Figure 3-14 shows the behavior of a system with Active Memory Deduplication enabled on its AMS shared memory pool. Duplicated pages from different LPARs are stored just once, providing the AMS pool with more free memory.

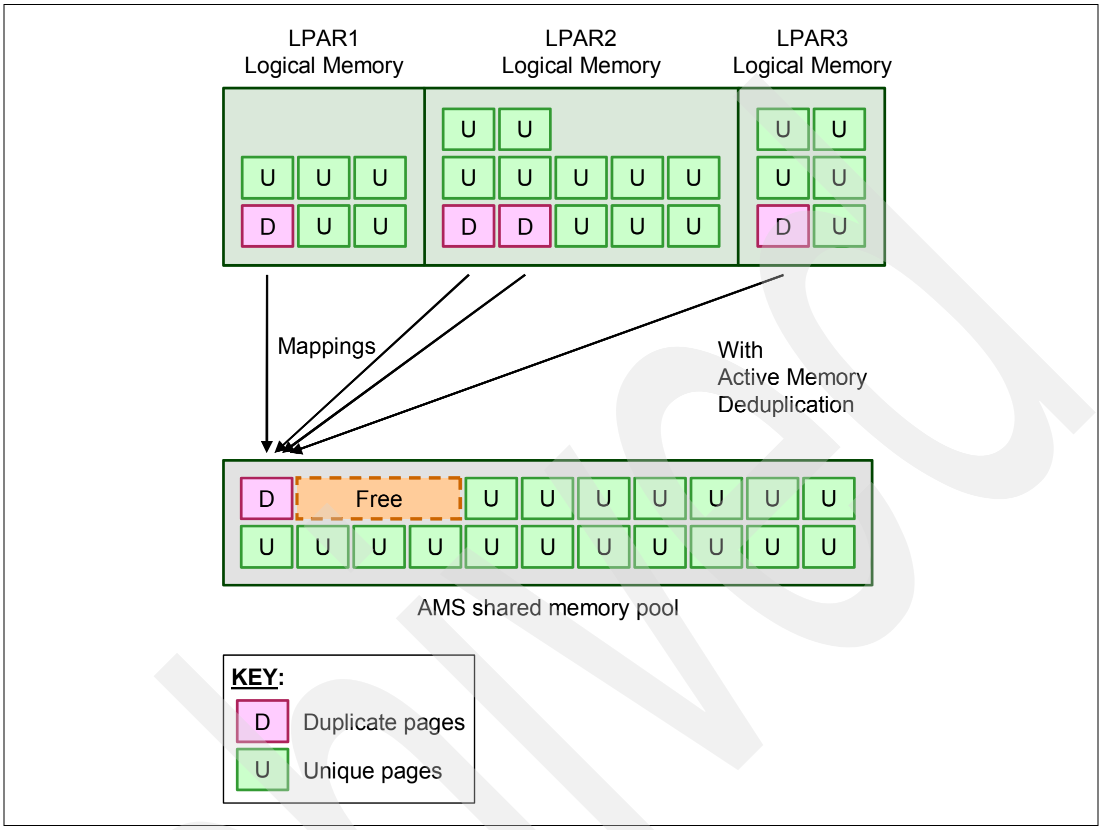

Figure 3-14 Identical memory pages mapped to a single physical memory page with Active Memory Duplication enabled

Active Memory Deduplication (AMD) depends on the Active Memory Sharing (AMS) feature to be available, and consumes CPU cycles donated by the AMS pool's VIOS partitions to identify deduplicated pages. The operating systems running on the AMS partitions can hint to the PowerVM Hypervisor that some pages (such as frequently referenced read-only code pages) are particularly good for deduplication.

To perform deduplication, the hypervisor cannot compare every memory page in the AMS pool with every other page. Instead, it computes a small signature for each page that it visits and stores the signatures in an internal table. Each time that a page is inspected, its signature is looked up against the known signatures in the table. If a match is found, the memory pages are compared to be sure that the pages are really duplicates. When a duplicate is found, the hypervisor remaps the partition memory to the existing memory page and returns the duplicate page to the AMS pool.

Figure 3-15 shows two pages being written in the AMS memory pool and having their signatures matched on the deduplication table.

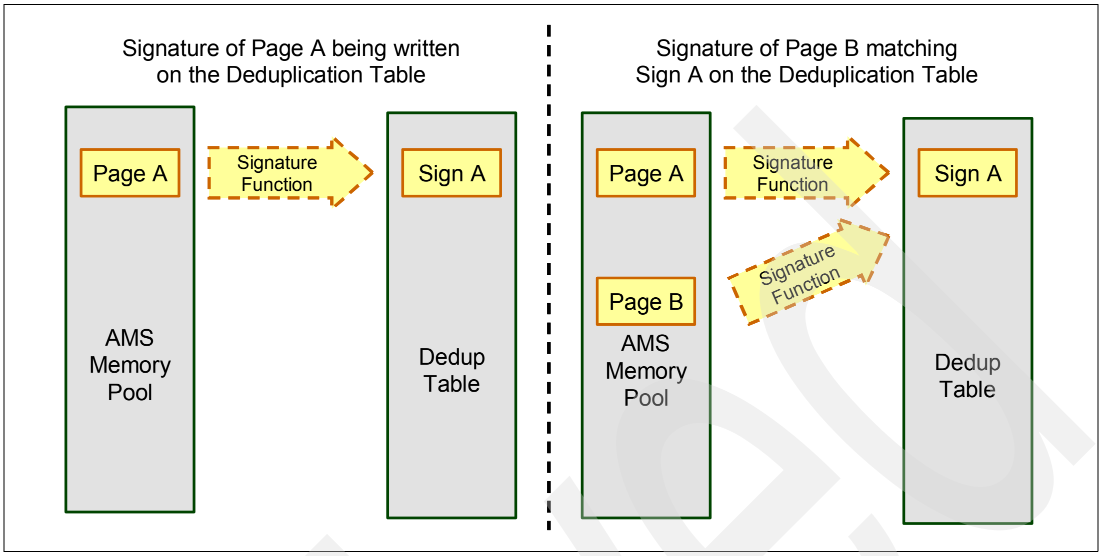

Figure 3-15 Memory pages having their signatures matched by Active Memory Deduplication

From the LPAR point of view, the AMD feature is completely transparent. If an LPAR attempts to modify a deduplicated page, the hypervisor grabs a free page from the AMS pool, copies the duplicate page contents into the new page, and maps the LPAR's reference to the new page so that the LPAR can modify its own unique page.

System administrators can dynamically configure the size of the deduplication table, ranging from 1/8192 up to 1/256 of the configured maximum AMS memory pool size. Having this table too small might lead to missed deduplication opportunities. Conversely, having a table that is too large might waste a small amount of overhead space.

The management of the Active Memory Deduplication feature is done via managed console, allowing administrators to take the following steps:

- Enable and disable Active Memory Deduplication at an AMS Pool level.
- Display deduplication metrics.
- Display and modify the deduplication table size.

Figure 3-16 shows the Active Memory Deduplication being enabled to a shared memory pool.

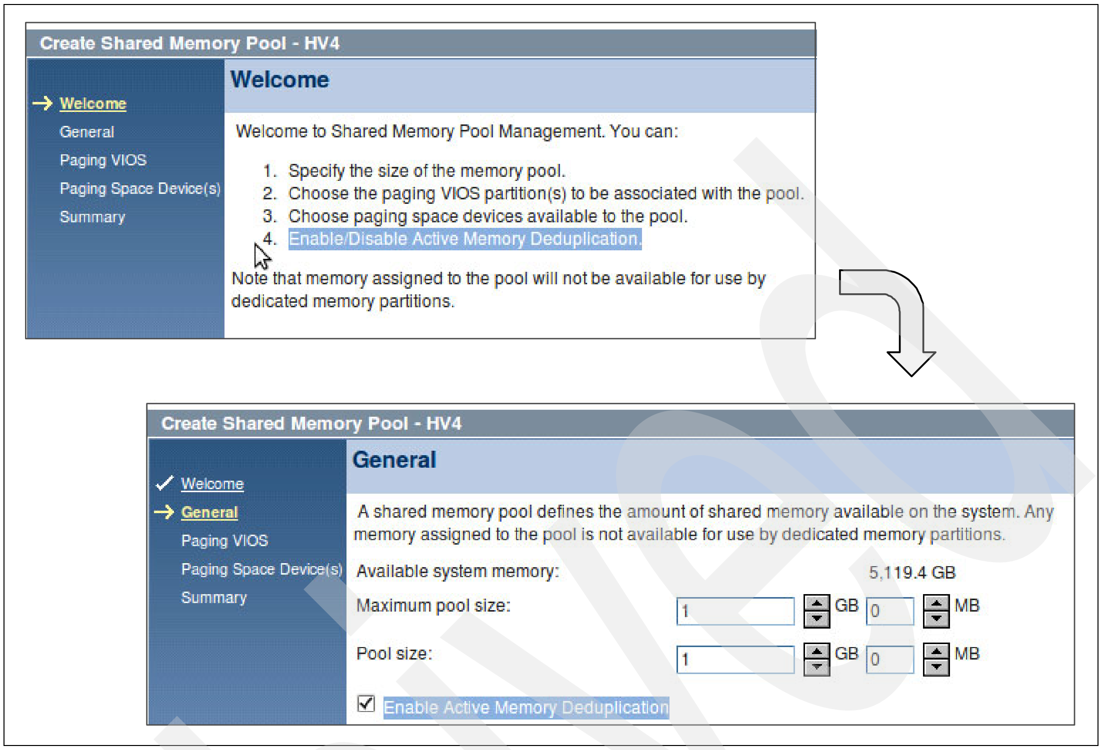

Figure 3-16 Enabling the Active Memory Deduplication for a shared memory pool

The Active Memory Deduplication feature requires the following minimum components:

- PowerVM Enterprise edition
- System firmware level 740
- AIX Version 6: AIX 6.1 TL7 or later
- AIX Version 7: AIX 7.1 TL1 SP1 or later
- IBM i: 7.14 or 7.2 or later
- SLES 11 SP2 or later
- RHEL 6.2 or later

3.4.8 N_Port ID virtualization

N_Port ID virtualization (NPIV) is a technology that allows multiple logical partitions to access independent physical storage through the same physical Fibre Channel adapter. This adapter is attached to a Virtual I/O Server partition that acts only as a pass-through, managing the data transfer through the POWER Hypervisor.

Each partition using NPIV is identified by a pair of unique worldwide port names, enabling you to connect each partition to independent physical storage on a SAN. Unlike virtual SCSI, only the client partitions see the disk.

For additional information and requirements for NPIV, see these resources:

- *PowerVM Migration from Physical to Virtual Storage*, SG24-7825
- *IBM PowerVM Virtualization Managing and Monitoring*, SG24-7590

NPIV is supported in PowerVM Standard and Enterprise Editions on the IBM Power 770 and Power 780 servers.

3.4.9 Operating system support for PowerVM

Table 3-5 summarizes the PowerVM features supported by the operating systems compatible with the POWER7 processor-based servers.

Table 3-5 PowerVM features supported by AIX, IBM i, and Linux

Feature	AIX V5.3	AIX V6.1	AIX V7.1	IBM i 6.1.1	IBM i 7.1	RHEL V5.7	RHEL V6.1	SLES V10 SP4	SLES V11 SP1
Virtual SCSI	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Virtual Ethernet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shared Ethernet Adapter	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Virtual Fibre Channel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Virtual Tape	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Logical Partitioning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DLPAR I/O adapter add/remove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DLPAR I/O processor add/remove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DLPAR I/O memory add	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DLPAR I/O memory remove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Micro-Partitioning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shared Dedicated Capacity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Multiple Shared Processor Pools	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Virtual I/O Server	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Suspend/Resume	No	Yes	Yes	No	No	No	No	No	No
Shared Storage Pools	Yes	Yes	Yes	Yes	Yes[a]	No	No	No	No
Thin Provisioning	Yes	Yes	Yes	Yes[b]	Yes[b]	No	No	No	No
Active Memory Sharing and Active Memory Deduplication	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Live Partition Mobility	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes

Feature	AIX V5.3	AIX V6.1	AIX V7.1	IBM i 6.1.1	IBM i 7.1	RHEL V5.7	RHEL V6.1	SLES V10 SP4	SLES V11 SP1
Simultaneous Multi-Threading (SMT)	Yes[c]	Yes[d]	Yes	Yes[e]	Yes	Yes[c]	Yes[c]	Yes[c]	Yes
Active Memory Expansion	No	Yes[f]	Yes	No	No	No	No	No	No

a. Requires IBM i 7.1 TR1.
b. Will become a fully provisioned device when used by IBM i.
c. Only supports two threads.
d. AIX 6.1 up to TL4 SP2 only supports two threads, and supports four threads as of TL4 SP3.
e. IBM i 6.1.1 and up support SMT4.
f. On AIX 6.1 with TL4 SP2 and later.

3.4.10 POWER7 Linux programming support

IBM Linux Technology Center (LTC) contributes to the development of Linux by providing support for IBM hardware in Linux distributions. In particular, the LTC makes tools and code available to the Linux communities to take advantage of the POWER7 technology and develop POWER7 optimized software.

Table 3-6 lists the support of specific programming features for various versions of Linux.

Table 3-6 Linux support for POWER7 features

Features	Linux releases				Comments
	SLES 10 SP4	SLES 11	RHEL 5.7	RHEL 6.1	
POWER6 compatibility mode	Yes	Yes	Yes	Yes	-
POWER7 mode	No	Yes	No	Yes	-
Strong Access Ordering	No	Yes	No	Yes	Can improve Lx86 performance
Scale to 256 cores/ 1024 threads	No	Yes	No	Yes	Base OS support available
4-way SMT	No	Yes	No	Yes	-
VSX support	No	Yes	No	Yes	Full exploitation requires Advance Toolchain.
Distro toolchain mcpu/mtune=p7	No	Yes	No	Yes	SLES11/GA toolchain has minimal P7 enablement necessary to support kernel build
Advance Toolchain support	Yes, execution restricted to Power6 instructions	Yes	Yes, execution restricted to Power6 instructions	Yes	Alternative IBM GNU Toolchain
64k base page size	No	Yes	Yes	Yes	-

Features	Linux releases				Comments
	SLES 10 SP4	SLES 11	RHEL 5.7	RHEL 6.1	
Tickless idle	No	Yes	No	Yes	Improved energy utilization and virtualization of partially to fully idle partitions

For information regarding Advance Toolchain, see the following website:

http://www.ibm.com/developerworks/wikis/display/hpccentral/How+to+use+Advance+Toolchain+for+Linux+on+POWER

Also see the University of Illinois Linux on Power Open Source Repository:

- http://ppclinux.ncsa.illinois.edu
- ftp://linuxpatch.ncsa.uiuc.edu/toolchain/at/at05/suse/SLES_11/release_notes.at05-2.1-0.html
- ftp://linuxpatch.ncsa.uiuc.edu/toolchain/at/at05/redhat/RHEL5/release_notes.at05-2.1-0.html

3.5 System Planning Tool

The IBM System Planning Tool (SPT) helps you design systems to be partitioned with logical partitions. You can also plan for and design non-partitioned systems by using the SPT. The resulting output of your design is called a *system plan*, which is stored in a `.sysplan` file. This file can contain plans for a single system or multiple systems. The `.sysplan` file can be used for the following reasons:

- To create reports
- As input to the IBM configuration tool (e-Config)
- To create and deploy partitions on your system (or systems) automatically

System plans that are generated by the SPT can be deployed on the system by the Hardware Management Console (HMC), Systems Director Management Console (SDMC), or Integrated Virtualization Manager (IVM).

> **Note:** Ask your IBM representative or Business Partner to use the Customer Specified Placement manufacturing option if you want to automatically deploy your partitioning environment on a new machine. SPT looks for the resource's allocation to be the same as that specified in your `.sysplan` file.

You can create an entirely new system configuration, or you can create a system configuration based on any of these items:

- Performance data from an existing system that the new system is to replace
- Performance estimates that anticipates future workloads that you must support
- Sample systems that you can customize to fit your needs

Integration between the SPT and both the Workload Estimator (WLE) and IBM Performance Management (PM) allows you to create a system that is based on performance and capacity data from an existing system or that is based on new workloads that you specify.

You can use the SPT before you order a system to determine what you must order to support your workload. You can also use the SPT to determine how you can partition a system that you already have.

Using the System Planning Tool is an effective way of documenting and backing up key system settings and partition definitions. It allows the user to create records of systems and export them to their personal workstation or backup system of choice. These same backups can then be imported back onto the same managed console when needed. This can be useful when cloning systems enabling the user to import the system plan to any managed console multiple times.

The SPT and its supporting documentation can be found on the IBM System Planning Tool site:

http://www.ibm.com/systems/support/tools/systemplanningtool/

4

Continuous availability and manageability

This chapter provides information about IBM reliability, availability, and serviceability (RAS) design and features. This set of technologies implemented on IBM Power Systems servers provides the possibility to improve your architecture's total cost of ownership (TCO) by reducing unplanned down time.

RAS can be described as follows:

- Reliability: Indicates how infrequently a defect or fault in a server manifests itself
- Availability: Indicates how infrequently the functionality of a system or application is impacted by a fault or defect
- Serviceability: Indicates how well faults and their impacts are communicated to users and services, and how efficiently and nondisruptively the faults are repaired

Each successive generation of IBM servers is designed to be more reliable than the previous server family. POWER7 processor-based servers have new features to support new levels of virtualization, help ease administrative burden, and increase system utilization.

Reliability starts with components, devices, and subsystems designed to be fault-tolerant. POWER7 uses lower voltage technology, improving reliability with stacked latches to reduce soft error (SER) susceptibility. During the design and development process, subsystems go through rigorous verification and integration testing processes. During system manufacturing, systems go through a thorough testing process to help ensure high product quality levels.

The processor and memory subsystem contain a number of features designed to avoid or correct environmentally induced, single-bit, intermittent failures, as well as handle solid faults in components, including selective redundancy to tolerate certain faults without requiring an outage or parts replacement.

IBM is the only vendor that designs, manufactures, and integrates its most critical server components, including:

- POWER processors
- Caches
- Memory buffers
- Hub-controllers
- Clock cards
- Service processors

Design and manufacturing verification and integration, as well as field support information, is used as feedback for continued improvement on the final products.

This chapter also includes a manageability section describing the means to successfully manage your systems.

Several software-based availability features exist that are based on the benefits available when using AIX and IBM i as the operating system. Support of these features when using Linux can vary.

4.1 Reliability

Highly reliable systems are built with highly reliable components. On IBM POWER processor-based systems, this basic principle is expanded upon with a clear design for reliability architecture and methodology. A concentrated, systematic, architecture-based approach is designed to improve overall system reliability with each successive generation of system offerings.

4.1.1 Designed for reliability

Systems designed with fewer components and interconnects have fewer opportunities to fail. Simple design choices, such as integrating processor cores on a single POWER chip, can dramatically reduce the opportunity for system failures. In this case, an 8-core server can include one-fourth as many processor chips (and chip socket interfaces) as with a double CPU-per-processor design. Not only does this case reduce the total number of system components, it reduces the total amount of heat generated in the design, resulting in an additional reduction in required power and cooling components. POWER7 processor-based servers also integrate L3 cache into the processor chip for a higher integration of parts.

Parts selection also plays a critical role in overall system reliability. IBM uses three grades of components, grade 3 defined as industry standard (off-the-shelf). As shown in Figure 4-1, using stringent design criteria and an extensive testing program, the IBM manufacturing team can produce grade 1 components that are expected to be 10 times more reliable than industry standard. Engineers select grade 1 parts for the most critical system components. Newly introduced organic packaging technologies, rated grade 5, achieve the same reliability as grade 1 parts.

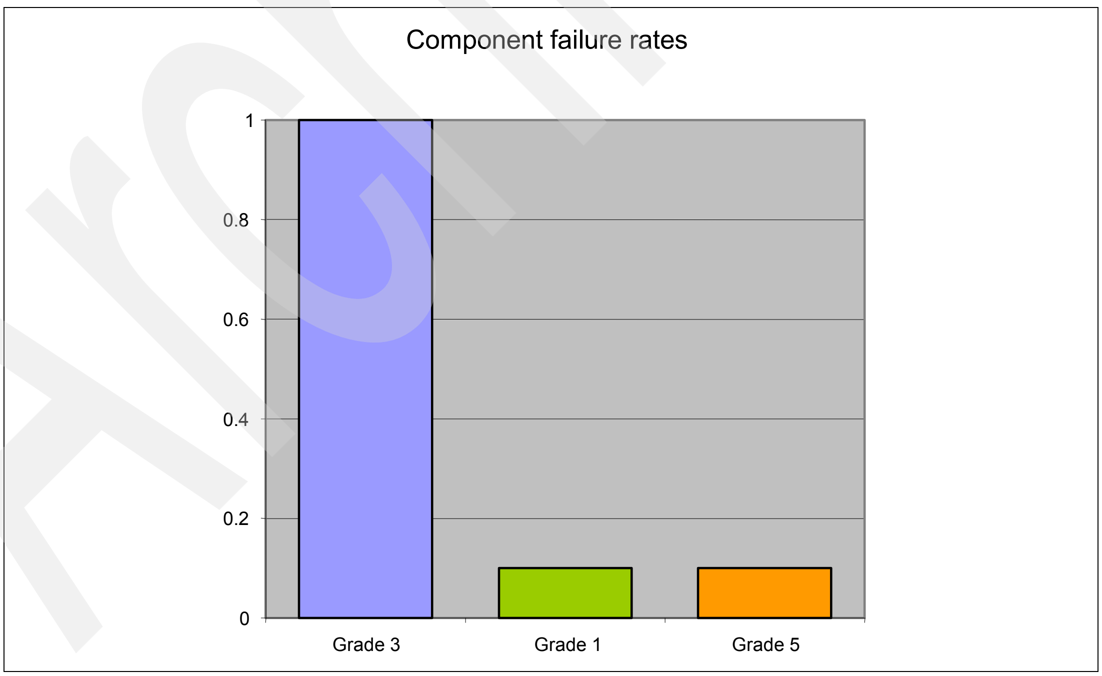

Figure 4-1 Component failure rates

4.1.2 Placement of components

Packaging is designed to deliver both high performance and high reliability. For example, the reliability of electronic components is directly related to their thermal environment, that is, large decreases in component reliability are directly correlated with relatively small increases in temperature. POWER processor-based systems are carefully packaged to ensure adequate cooling. Critical system components such as the POWER7 processor chips are positioned on printed circuit cards so that they receive fresh air during operation. In addition, POWER processor-based systems are built with redundant, variable-speed fans that can automatically increase output to compensate for increased heat in the central electronic complex.

4.1.3 Redundant components and concurrent repair

High-opportunity components, or those that most affect system availability, are protected with redundancy and the ability to be repaired concurrently.

The use of redundant parts allows the system to remain operational. Among the parts are:

- POWER7 cores, which include redundant bits in L1-I, L1-D, and L2 caches, and in L2 and L3 directories
- Power 770 and Power 780 main memory DIMMs, which contain an extra DRAM chip for improved redundancy
- Power 770 and 780 redundant system clock and service processor for configurations with two or more central electronics complex (CEC) drawers
- Redundant and hot-swap cooling
- Redundant and hot-swap power supplies
- Redundant 12X loops to I/O subsystem

For maximum availability, be sure to connect power cords from the same system to two separate Power Distribution Units (PDUs) in the rack and to connect each PDU to independent power sources. Deskside form factor power cords must be plugged into two independent power sources to achieve maximum availability.

> **Note:** Check your configuration for optional redundant components before ordering your system.

4.2 Availability

The IBM hardware and microcode capability to continuously monitor execution of hardware functions is generally described as the process of first-failure data capture (FFDC). This process includes the strategy of predictive failure analysis, which refers to the ability to track intermittent correctable errors and to vary components off-line before they reach the point of hard failure, causing a system outage, and without the need to re-create the problem.

The POWER7 family of systems continues to introduce significant enhancements that are designed to increase system availability and ultimately a high availability objective with hardware components that are able to perform the following functions:

- Self-diagnose and self-correct during run time.
- Automatically reconfigure to mitigate potential problems from suspect hardware.
- Self-heal or automatically substitute good components for failing components.

Note: POWER7 processor-based servers are independent of the operating system for error detection and fault isolation within the central electronics complex.

Throughout this chapter, we describe IBM POWER technology's capabilities that are focused on keeping a system environment up and running. For a specific set of functions that are focused on detecting errors before they become serious enough to stop computing work, see 4.3.1, "Detecting" on page 169.

4.2.1 Partition availability priority

Also available is the ability to assign availability priorities to partitions. If an alternate processor recovery event requires spare processor resources and there are no other means of obtaining the spare resources, the system determines which partition has the lowest priority and attempts to claim the needed resource. On a properly configured POWER processor-based server, this approach allows that capacity to first be obtained from a low-priority partition instead of a high-priority partition.

This capability is relevant to the total system availability because it gives the system an additional stage before an unplanned outage. In the event that insufficient resources exist to maintain full system availability, these servers attempt to maintain partition availability by user-defined priority.

Partition availability priority is assigned to partitions using a *weight value* or integer rating, the lowest priority partition rated at 0 (zero) and the highest priority partition valued at 255. The default value is set at 127 for standard partitions and 192 for Virtual I/O Server (VIOS) partitions. You can vary the priority of individual partitions.

Partition availability priorities can be set for both dedicated and shared processor partitions. The POWER Hypervisor uses the relative partition weight value among active partitions to favor higher priority partitions for processor sharing, adding and removing processor capacity, and favoring higher priority partitions for normal operation.

Note that the partition specifications for *minimum*, *desired*, and *maximum* capacity are also taken into account for capacity-on-demand options and if total system-wide processor capacity becomes disabled because of deconfigured failed processor cores. For example, if total system-wide processor capacity is sufficient to run all partitions, at least with the minimum capacity, the partitions are allowed to start or continue running. If processor capacity is insufficient to run a partition at its minimum value, then starting that partition results in an error condition that must be resolved.

4.2.2 General detection and deallocation of failing components

Runtime correctable or recoverable errors are monitored to determine if there is a pattern of errors. If these components reach a predefined error limit, the service processor initiates an action to deconfigure the faulty hardware, helping to avoid a potential system outage and to enhance system availability.

Persistent deallocation

To enhance system availability, a component that is identified for deallocation or deconfiguration on a POWER processor-based system is flagged for persistent deallocation. Component removal can occur either dynamically (while the system is running) or at boot time (IPL), depending both on the type of fault and when the fault is detected.

In addition, runtime unrecoverable hardware faults can be deconfigured from the system after the first occurrence. The system can be rebooted immediately after failure and resume operation on the remaining stable hardware. This way prevents the same faulty hardware from affecting system operation again. The repair action is deferred to a more convenient, less critical time.

Persistent deallocation functions include:

- Processor
- L2/L3 cache lines (cache lines are dynamically deleted)
- Memory
- Deconfigure or bypass failing I/O adapters

Processor instruction retry

As in POWER6, the POWER7 processor has the ability to retry processor instruction and alternate processor recovery for a number of core related faults. This ability significantly reduces exposure to both permanent and intermittent errors in the processor core.

Intermittent errors, often because of cosmic rays or other sources of radiation, are generally not repeatable.

With this function, when an error is encountered in the core, in caches and certain logic functions, the POWER7 processor first automatically retries the instruction. If the source of the error was truly transient, the instruction succeeds and the system continues as before.

On IBM systems prior to POWER6, this error caused a checkstop.

Alternate processor retry

Hard failures are more difficult, being permanent errors that are replicated each time that the instruction is repeated. Retrying the instruction does not help in this situation because the instruction will continue to fail.

As in POWER6, POWER7 processors have the ability to extract the failing instruction from the faulty core and retry it elsewhere in the system for a number of faults, after which the failing core is dynamically deconfigured and scheduled for replacement.

Dynamic processor deallocation

Dynamic processor deallocation enables automatic deconfiguration of processor cores when patterns of recoverable core-related faults are detected. Dynamic processor deallocation prevents a recoverable error from escalating to an unrecoverable system error, which might otherwise result in an unscheduled server outage. Dynamic processor deallocation relies on the service processor's ability to use FFDC-generated recoverable error information to notify the POWER Hypervisor when a processor core reaches its predefined error limit. Then the POWER Hypervisor dynamically deconfigures the failing core and is called out for replacement. The entire process is transparent to the partition owning the failing instruction.

If there are available inactivated processor cores or CoD processor cores, the system effectively puts a CoD processor into operation after an activated processor is determined to no longer be operational. In this way, the server remains with its total processor power.

If there are no CoD processor cores available system-wide, total processor capacity is lowered below the licensed number of cores.

Single processor checkstop

As in POWER6, POWER7 provides single-processor check-stopping for certain processor logic, command, or control errors that cannot be handled by the availability enhancements in the preceding section.

This way significantly reduces the probability of any one processor affecting total system availability by containing most processor checkstops to the partition that was using the processor at the time that the full checkstop goes into effect.

Even with all these availability enhancements to prevent processor errors from affecting system-wide availability, errors might result on a system-wide outage.

4.2.3 Memory protection

A memory protection architecture that provides good error resilience for a relatively small L1 cache might be very inadequate for protecting the much larger system main store. Therefore, a variety of protection methods is used in POWER processor-based systems to avoid uncorrectable errors in memory.

Memory protection plans must take into account many factors, including:

- Size
- Desired performance
- Memory array manufacturing characteristics

POWER7 processor-based systems have a number of protection schemes designed to prevent, protect, or limit the effect of errors in main memory. These capabilities include:

- 64-byte ECC code

  This innovative ECC algorithm from IBM research allows a full 8-bit device kill to be corrected dynamically. This ECC code mechanism works on DIMM pairs on a rank basis. (Depending on the size, a DIMM might have one, two, or four ranks.) With this ECC code, an entirely bad DRAM chip can be marked as bad (chip mark). After marking the DRAM as bad, the code corrects all the errors in the bad DRAM. It can additionally mark a 2-bit symbol as bad and correct the 2-bit symbol, providing a double-error detect or single-error correct ECC, or a better level of protection in addition to the detection or correction of a chipkill event.

  This improvement in the ECC word algorithm replaces the redundant bit steering used on POWER6 systems.

  The Power 770 and 780, and future POWER7 high-end machines, have a spare DRAM chip per rank on each DIMM that can be spared out. Effectively, this protection means that on a rank basis, a DIMM pair can detect and correct two and sometimes three chipkill events and still provide better protection than ECC, explained in the previous paragraph.

- Hardware scrubbing

  Hardware scrubbing is a method used to deal with intermittent errors. IBM POWER processor-based systems periodically address all memory locations. Any memory locations with a correctable error are rewritten with the correct data.

- CRC

  The bus that is transferring data between the processor and the memory uses CRC error detection with a failed operation-retry mechanism and the ability to dynamically retune bus parameters when a fault occurs. In addition, the memory bus has spare capacity to substitute a spare data bit-line, for that which is determined to be faulty.

- Chipkill

  Chipkill is an enhancement that enables a system to sustain the failure of an entire DRAM chip. Chipkill spreads the bit lines from a DRAM over multiple ECC words so that a catastrophic DRAM failure does not affect more of what is protected by the ECC code implementation. The system can continue indefinitely in this state with no performance degradation until the failed DIMM can be replaced. Figure 4-2 shows an example of how chipkill technology spreads bit lines across multiple ECC words.

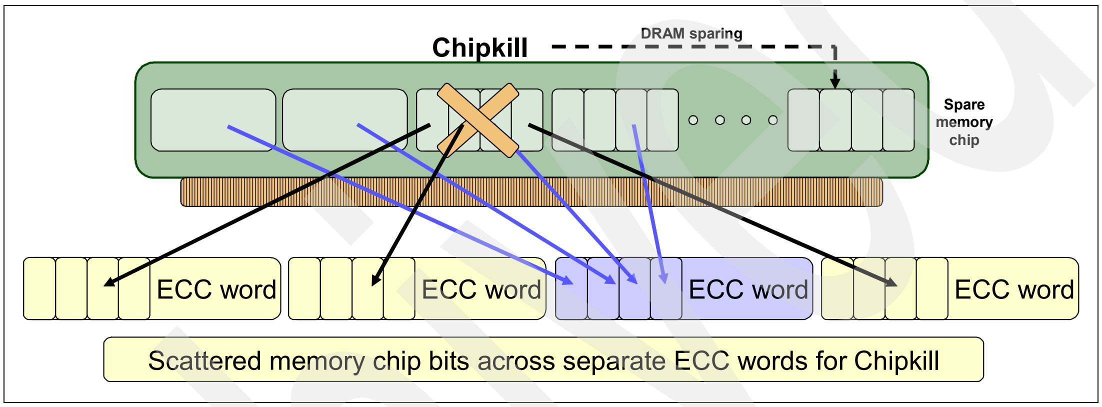

Figure 4-2 Chipkill in action with a spare memory DRAM chip on a Power 770 and Power 780

POWER7 memory subsystem

The POWER7 chip contains two memory controllers with four channels per memory controller. Each channel connects to a single DIMM, but because the channels work in pairs, a processor chip can address four DIMM pairs, two pairs per memory controller.

The bus transferring data between the processor and the memory uses CRC error detection with a failed operation-retry mechanism and the ability to dynamically retune bus parameters when a fault occurs. In addition, the memory bus has spare capacity to substitute a spare data bit-line, for that which is determined to be faulty.

Figure 4-3 shows a POWER7 chip, with its memory interface, consisting of two controllers and four DIMMs per controller. Advanced memory buffer chips are exclusive to IBM and help to increase performance, acting as read/write buffers. On the Power 770 and Power 780, the advanced memory buffer chips are integrated into the DIMM that they support.

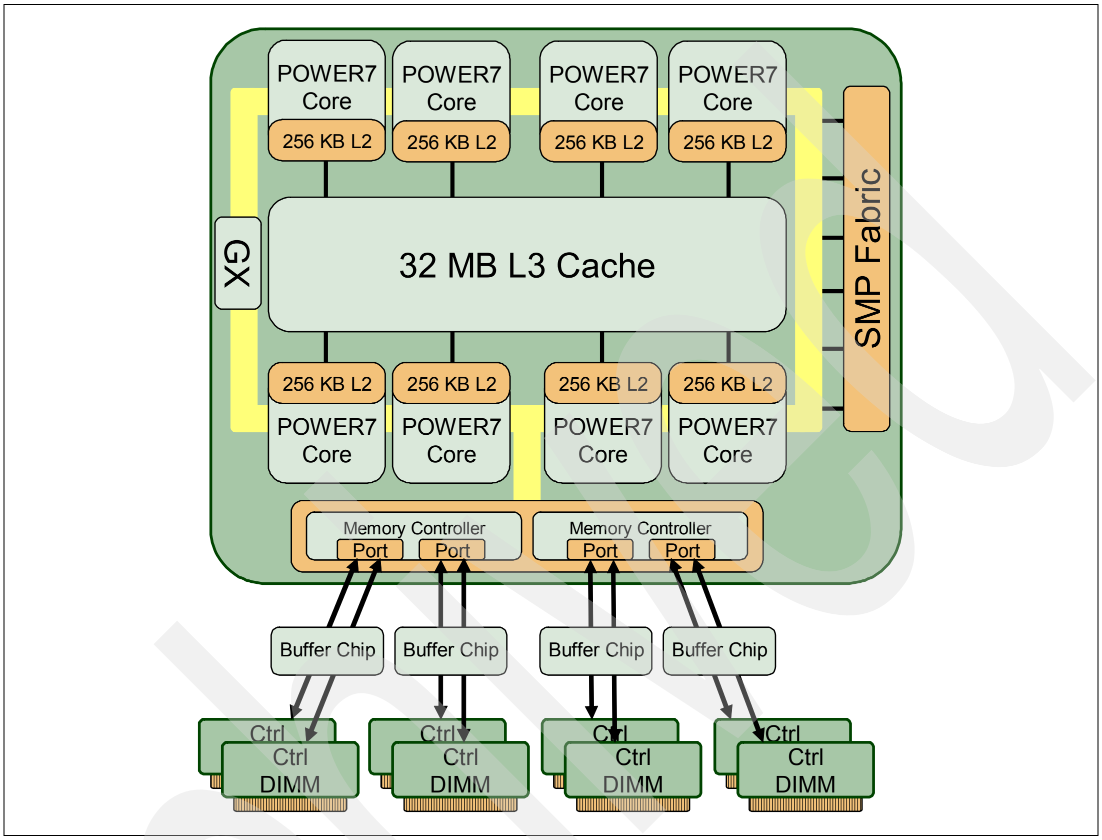

Figure 4-3 POWER7 memory subsystem

Memory page deallocation

Although coincident cell errors in separate memory chips are a statistic rarity, IBM POWER processor-based systems can contain these errors by using a memory page deallocation scheme for partitions that are running IBM AIX and IBM i operating systems, as well as for memory pages owned by the POWER Hypervisor. If a memory address experiences an uncorrectable or repeated correctable single cell error, the service processor sends the memory page address to the POWER Hypervisor to be marked for deallocation.

Pages used by the POWER Hypervisor are deallocated as soon as the page is released.

In other cases, the POWER Hypervisor notifies the owning partition that the page should be deallocated. Where possible, the operating system moves any data currently contained in that memory area to another memory area and removes the page (or pages) that are associated with this error from its memory map, no longer addressing these pages. The operating system performs memory page deallocation without any user intervention and is transparent to users and applications.

The POWER Hypervisor maintains a list of pages that are marked for deallocation during the current platform Initial Program Load (IPL). During a partition IPL, the partition receives a list of all the bad pages in its address space. In addition, if memory is dynamically added to a partition (through a dynamic LPAR operation), the POWER Hypervisor warns the operating system when memory pages are included that need to be deallocated.

Finally, if an uncorrectable error in memory is discovered, the logical memory block associated with the address with the uncorrectable error is marked for deallocation by the POWER Hypervisor. This deallocation takes effect on a partition reboot if the logical memory block is assigned to an active partition at the time of the fault.

In addition, the system deallocates the entire memory group that is associated with the error on all subsequent system reboots until the memory is repaired. This way is intended to guard against future uncorrectable errors while waiting for parts replacement.

Note: Memory page deallocation handles single cell failures, but because of the sheer size of data in a data bit line, it might be inadequate for dealing with more catastrophic failures.

Memory persistent deallocation

Defective memory that is discovered at boot time is automatically switched off. If the service processor detects a memory fault at boot time, it marks the affected memory as bad so that it is not to be used on subsequent reboots.

If the service processor identifies faulty memory in a server that includes CoD memory, the POWER Hypervisor attempts to replace the faulty memory with available CoD memory. Faulty resources are marked as deallocated, and working resources are included in the active memory space. Because these activities reduce the amount of CoD memory available for future use, schedule repair of the faulty memory as soon as convenient.

Upon reboot, if not enough memory is available to meet minimum partition requirements, the POWER Hypervisor reduces the capacity of one or more partitions.

Depending on the configuration of the system, the HMC Service Focal Point™, the OS Service Focal Point, or the service processor receives a notification of the failed component and triggers a service call.

4.2.4 Active Memory Mirroring for Hypervisor

Active Memory Mirroring (AMM) for Hypervisor is a hardware and firmware function of Power 770 and Power 780 systems that provides the ability of the POWER7 chip to create two copies of data in memory. Having two copies eliminates a system-wide outage due to an uncorrectable failure of a single DIMM in the main memory used by the hypervisor (also called System firmware). This capability is standard and enabled by default on the Power 780 server. On the Power 770 it is an optional chargeable feature.

What memory is mirrored

These are the areas of memory that are mirrored:

- Hypervisor data that is mirrored
  - Hardware Page Tables (HPTs) that are managed by the hypervisor on behalf of partitions to track the state of the memory pages assigned to the partition
  - Translation control entries (TCEs) that are managed by the hypervisor on behalf of partitions to communicate with partition I/O buffers for I/O devices
  - Hypervisor code (instructions that make up the hypervisor kernel)
  - Memory used by hypervisor to maintain partition configuration, I/O states, Virtual I/O information, partition state, and so on

- Hypervisor data that is not mirrored
  - Advanced Memory Sharing (AMS) pool
  - Memory used to hold contents of platform dump while waiting for offload to management console
- Partition data that is not mirrored
  - Desired memory configured for individual partitions is not mirrored.

To enable mirroring, the requirement is to have eight equally sized functional memory DIMMs behind at least one POWER7 chip in each CEC enclosure. The DIMMs will be managed by the same memory controller. The sizes of DIMMs might be different from one Power 7 chip to another.

A write operation in the memory begins on the first DIMM of a mirrored DIMM pair. When this write is complete, the POWER7 chip writes the same data to a second DIMM of the DIMM pair.

The read operations alternate between both DIMMs.

Figure 4-4 shows the hardware implementation of Memory Mirroring for Hypervisor.

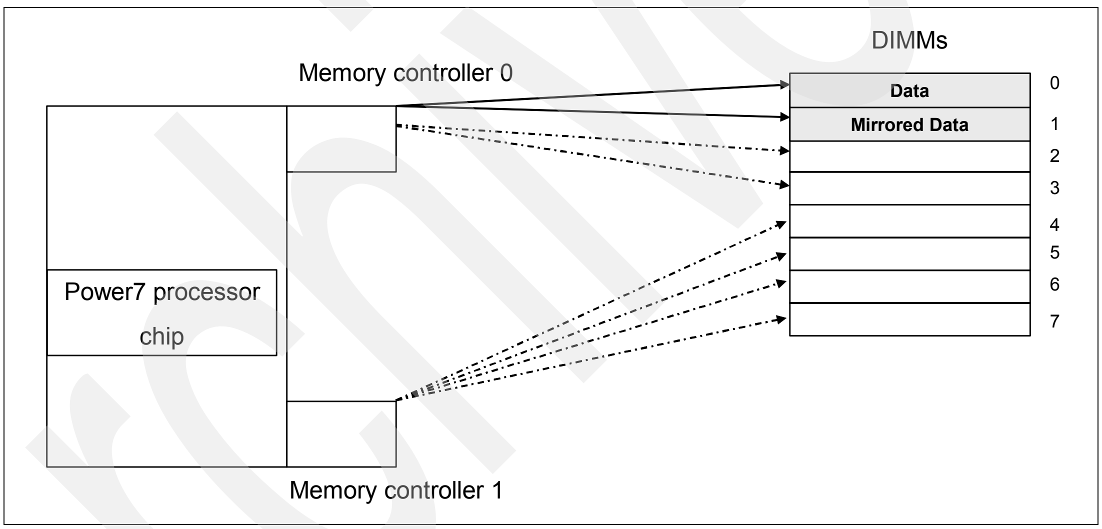

Figure 4-4 Hardware implementation of Memory Mirroring for Hypervisor

The impact on performance is very low. Whereas writes operations are slightly slower because two writes are actually done, reads are faster because two sources for the data are used. Measured commercial workloads show no gain or loss in performance due to mirroring. HPC workload performing huge amounts of string manipulation might see a slight performance effect.

The Active Memory Mirroring can be disabled or enabled on the management console using the Advanced tab of the server properties (Figure 4-5).

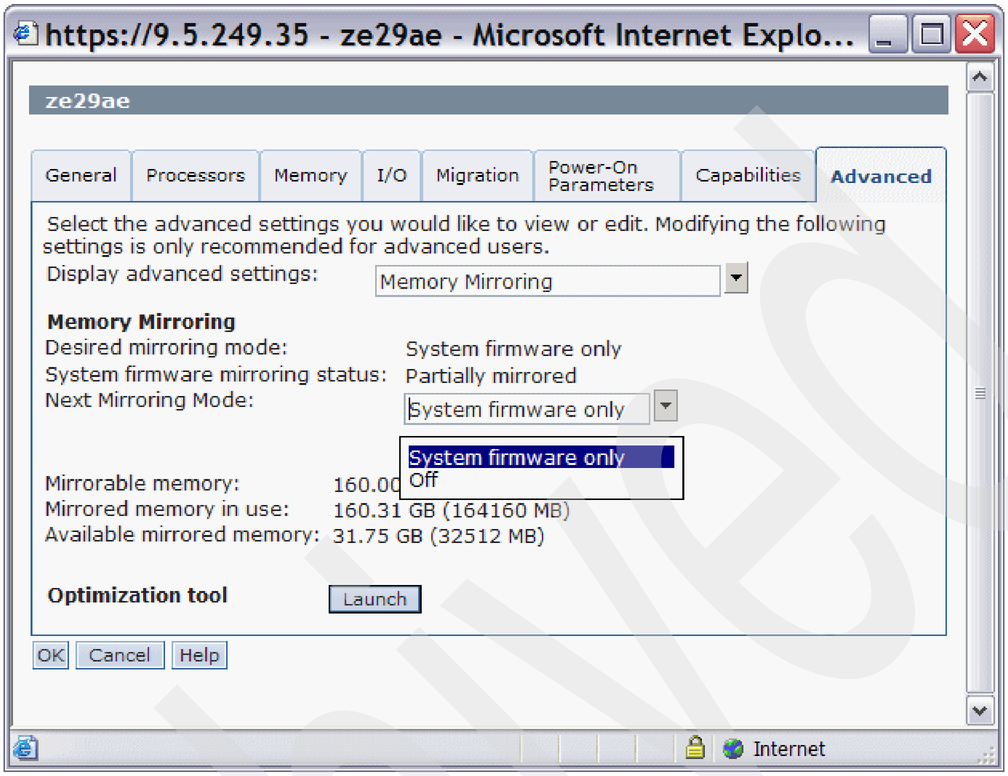

Figure 4-5 Enabling or disabling active memory sharing

The system must be entirely powered off and then powered on to change from mirroring mode to non-mirrored mode.

This same frame also gives informations about the mirroring status:

- Desired mirroring mode: Takes the values “Off” or “System firmware only”
- System firmware mirroring status
  - Fully mirrored: The mirroring is completely functional.
  - Partially functional: Due to uncorrectable memory failures, some of the hypervisor elements or objects are not mirrored. The system remains partially mirrored until DIMM is replaced and the system is rebooted.
  - Not mirrored: At the last power on of the system, the desired state was “mirroring off.’
- Mirrorable memory: Total amount of physical memory that can be mirrored, which is based on the DIMMs that are plugged
- Mirrored memory in use
- Available mirrored memory

Mirroring optimization

Hypervisor mirroring requires specific memory locations. Those locations might be assign to other purposes (for LPAR memory, for example) due to memory's management based on the logical memory block. To "reclaim" those memory locations, an optimization tool is available on the Advanced tab of the system properties (Figure 4-6).

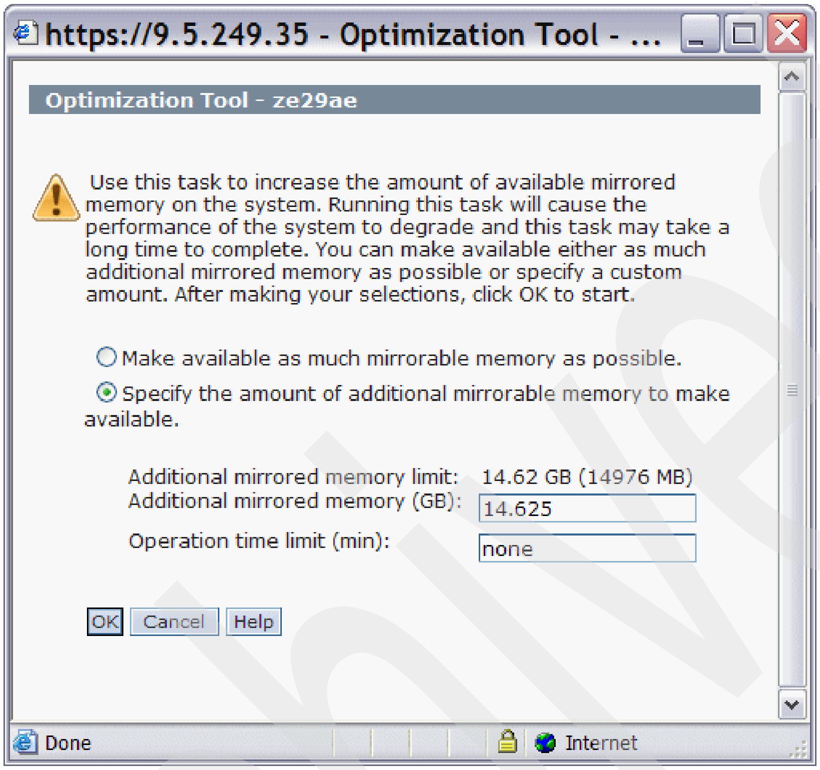

Figure 4-6 Optimization Tool

You can define the amount of memory available for mirroring by either selecting a custom value or making available as much mirrorable memory as possible. After selecting **OK**, this action copies the active partition's contents from one LMB to another to free pairs of mirrored memory. The copy operation will have a slight impact on performance while in progress.

The operation can be stopped by selecting **Cancel**. A time limit can also be specified.

DIMM guard at system boot

During system boot the FSP will guard a failing DIMM. Because there will not be eight functional DIMMs behind a memory controller, hypervisor mirroring is not possible on this chip. Then at boot time:

- If there are other chips in the book with mirrorable memory, the system will boot fully mirrored.
- If this was the only mirrorable memory in this book, hypervisor enters a partially mirrored state. Not all of the hypervisor objects are mirrored, and therefore are unprotected. Hypervisor will continue to mirror as much as possible to continue to provide protection. If a second uncorrectable error occurs in the same CEC while in partial mirror state, this will likely result in system failure. The system remains partially mirrored until the DIMM is replaced and the CEC is rebooted.

Advanced memory mirroring features

On the Power 770 server, the Advanced Memory Mirroring for Hypervisor function is an optional chargable feature. It must be selected in econfig.

On this server, the advanced memory mirroring is activated by entering an activation code (also called Virtualization Technology Code, or VET) in the management console. If the customer enables mirroring from the management console without entering the activation code, the system boots only to standby and will wait for the customer to enter the VET code (New SRC A700474A displays). If mirroring was enabled by mistake, you must disable it and power cycle the CEC, as mirroring state requires a CEC reboot to change. Hypervisor mirroring is disabled by default on the Power 770 server.

On the Power 780 server, this feature is standard. There is no individual feature code in econfig. The mirroring is enabled by default on the server.

4.2.5 Cache protection

POWER7 processor-based systems are designed with cache protection mechanisms, including cache-line delete in both L2 and L3 arrays, Processor Instruction Retry and Alternate Processor Recovery protection on L1-I and L1-D, and redundant *Repair* bits in L1-I, L1-D, and L2 caches, and in L2 and L3 directories.

L1 instruction and data array protection

The POWER7 processor's instruction and data caches are protected against intermittent errors by using Processor Instruction Retry and against permanent errors by Alternate Processor Recovery, both mentioned previously. L1 cache is divided into sets. POWER7 processor can deallocate all but one set before doing a Processor Instruction Retry.

In addition, faults in the Segment Lookaside Buffer (SLB) array are recoverable by the POWER Hypervisor. The SLB is used in the core to perform address translation calculations.

L2 and L3 array protection

The L2 and L3 caches in the POWER7 processor are protected with double-bit detect single-bit correct error detection code (ECC). Single-bit errors are corrected before being forwarded to the processor and are subsequently written back to L2 and L3.

In addition, the caches maintain a cache-line delete capability. A threshold of correctable errors detected on a cache line can result in the data in the cache line being purged and the cache line removed from further operation without requiring a reboot. An ECC uncorrectable error detected in the cache can also trigger a purge and deleting of the cache line. This results in no loss of operation because an unmodified copy of the data can be held on system memory to reload the cache line from main memory. Modified data is handled through Special Uncorrectable Error handling.

L2-deleted and L3-deleted cache lines are marked for persistent deconfiguration on subsequent system reboots until the processor card can be replaced.

4.2.6 Special uncorrectable error handling

Although rare, an uncorrectable data error can occur in memory or a cache. IBM POWER7 processor-based systems attempt to limit, to the least possible disruption, the impact of an uncorrectable error using a well-defined strategy that first considers the data source.

Sometimes an uncorrectable error is temporary in nature and occurs in data that can be recovered from another repository. For example:

- Data in the instruction L1 cache is never modified within the cache itself. Therefore, an uncorrectable error discovered in the cache is treated like an ordinary cache-miss, and correct data is loaded from the L2 cache.
- The L2 and L3 cache of the POWER7 processor-based systems can hold an unmodified copy of data in a portion of main memory. In this case, an uncorrectable error simply triggers a reload of a cache line from main memory.

In cases where the data cannot be recovered from another source, a technique called Special Uncorrectable Error (SUE) handling is used to prevent an uncorrectable error in memory or cache from immediately causing the system to terminate. Instead, the system tags the data and determines whether it can ever be used again.

- If the error is irrelevant, it does not force a checkstop.
- If the data is used, termination can be limited to the program, kernel, or hypervisor owning the data, or a freezing of the I/O adapters that are controlled by an I/O hub controller if data is to be transferred to an I/O device.

When an uncorrectable error is detected, the system modifies the associated ECC word, thereby signaling to the rest of the system that the *standard* ECC is no longer valid. The service processor is then notified and takes appropriate actions. When running AIX V5.2 (or later) or Linux, and a process attempts to use the data, the operating system is informed of the error and might terminate, or only terminate a specific process associated with the corrupt data, depending on the operating system and firmware level and whether the data was associated with a kernel or non-kernel process.

Only when the corrupt data is being used by the POWER Hypervisor can the entire system be rebooted, thereby preserving overall system integrity. If Active Memory Mirroring is enabled, the entire system is protected and continues to run.

Depending on the system configuration and the source of the data, errors encountered during I/O operations might not result in a machine check. Instead, the incorrect data is handled by the PCI host bridge (PHB) chip. When the PHB chip detects a problem, it rejects the data, preventing data from being written to the I/O device. The PHB then enters a freeze mode, halting normal operations. Depending on the model and type of I/O being used, the freeze can include the entire PHB chip, or simply a single bridge, resulting in the loss of all I/O operations that use the frozen hardware until a power-on reset of the PHB. The impact to partitions depends on how the I/O is configured for redundancy. In a server that is configured for fail-over availability, redundant adapters spanning multiple PHB chips can enable the system to recover transparently, without partition loss.

4.2.7 PCI enhanced error handling

IBM estimates that PCI adapters can account for a significant portion of the hardware-based errors on a large server. Although servers that rely on boot-time diagnostics can identify failing components to be replaced by hot-swap and reconfiguration, runtime errors pose a more significant problem.

PCI adapters are generally complex designs involving extensive on-board instruction processing, often on embedded microcontrollers. They tend to use industry standard grade components with an emphasis on product cost that is relative to high reliability. In certain cases, they might be more likely to encounter internal microcode errors or many of the hardware errors described for the rest of the server.

The traditional means of handling these problems is through adapter internal-error reporting and recovery techniques, in combination with operating system device-driver management and diagnostics. In certain cases, an error in the adapter can cause transmission of bad data on the PCI bus itself, resulting in a hardware-detected parity error and causing a global machine check interrupt, eventually requiring a system reboot to continue.

PCI enhanced error handling-enabled adapters respond to a special data packet that is generated from the affected PCI slot hardware by calling system firmware, which examines the affected bus, allows the device driver to reset it, and continues without a system reboot. For Linux, enhanced error handling (EEH) support extends to the majority of frequently used devices, although various third-party PCI devices might not provide native EEH support.

To detect and correct PCIe bus errors, POWER7 processor-based systems use CRC detection and instruction retry correction. For PCI-X, it uses ECC.

Figure 4-7 shows the location and mechanisms used throughout the I/O subsystem for PCI-enhanced error handling.

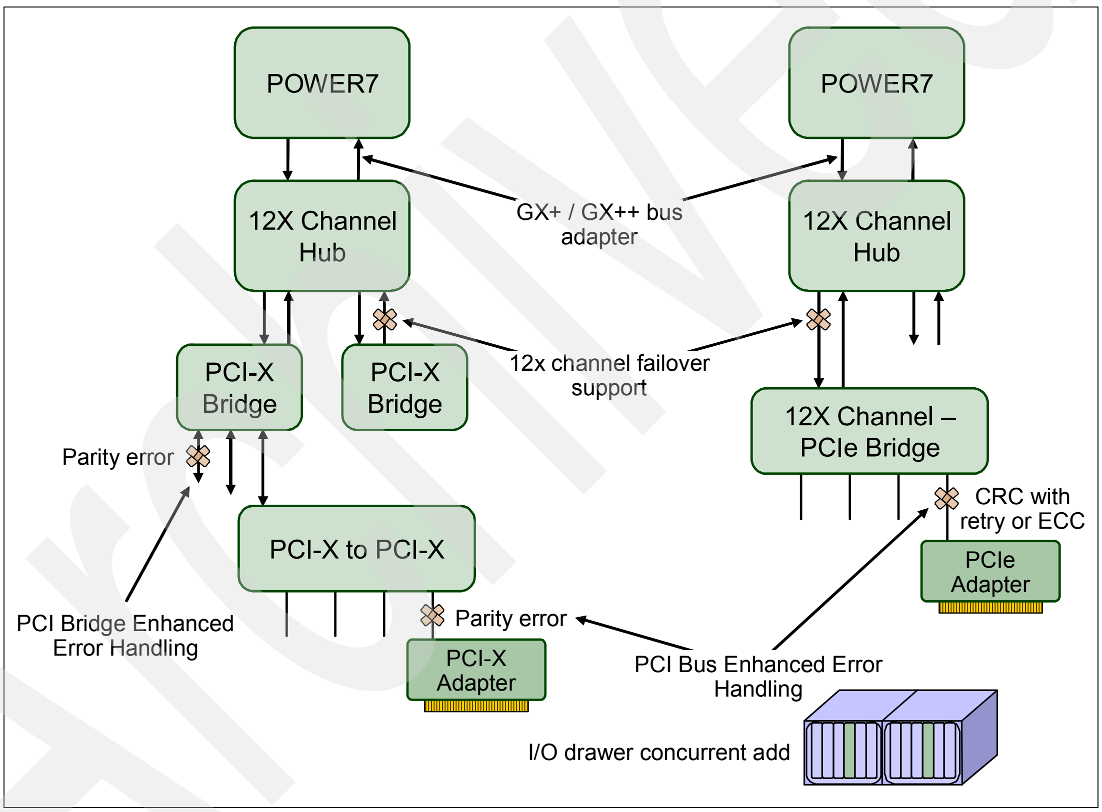

Figure 4-7 PCI-enhanced error handling

4.2.8 POWER7 I/O chip freeze behavior

The POWER7 I/O chip implements a “freeze behavior” for uncorrectable errors borne on the GX+ bus and for internal POWER7 I/O chip errors detected by the POWER7 I/O chip. With this freeze behavior, the chip refuses I/O requests to the attached I/O, but does not check stop the system. This allows systems with redundant I/O to continue operating without an outage instead of system checkstops seen in earlier chips, such as the POWER5 I/O chip used on POWER6 processor-based systems.

4.3 Serviceability

IBM Power Systems design considers both IBM and client needs. The IBM Serviceability Team has enhanced the base service capabilities and continues to implement a strategy that incorporates best-of-breed service characteristics from diverse IBM systems offerings.

Serviceability includes system installation, system upgrades and downgrades (MES), and system maintenance and repair.

The goal of the IBM Serviceability Team is to design and provide the most efficient system service environment that includes:

- Easy access to service components, design for Customer Set Up (CSU), Customer Installed Features (CIF), and Customer Replaceable Units (CRU)
- On demand service education
- Error detection and fault isolation (ED/FI)
- First-failure data capture (FFDC)
- An automated guided repair strategy that uses common service interfaces for a converged service approach across multiple IBM server platforms

By delivering on these goals, IBM Power Systems servers enable faster and more accurate repair and reduce the possibility of human error.

Client control of the service environment extends to firmware maintenance on all of the POWER processor-based systems. This strategy contributes to higher systems availability with reduced maintenance costs.

This section provides an overview of the progressive steps of error detection, analysis, reporting, notification, and repairing that are found in all POWER processor-based systems.

4.3.1 Detecting

The first and most crucial component of a solid serviceability strategy is the ability to accurately and effectively detect errors when they occur. Although not all errors are a guaranteed threat to system availability, those that go undetected can cause problems because the system does not have the opportunity to evaluate and act if necessary. POWER processor-based systems employ System z® server-inspired error detection mechanisms that extend from processor cores and memory to power supplies and hard drives.

Service processor

The service processor is a microprocessor that is powered separately from the main instruction processing complex. The service processor provides the capabilities for:

- POWER Hypervisor (system firmware) and Hardware Management Console connection surveillance
- Several remote power control options
- Reset and boot features
- Environmental monitoring

  The service processor monitors the server’s built-in temperature sensors, sending instructions to the system fans to increase rotational speed when the ambient temperature is above the normal operating range. Using an architected operating system interface, the service processor notifies the operating system of potential environmentally related problems so that the system administrator can take appropriate corrective actions before a critical failure threshold is reached.

The service processor can also post a warning and initiate an orderly system shutdown in the following circumstances:

- The operating temperature exceeds the critical level (for example, failure of air conditioning or air circulation around the system).
- The system fan speed is out of operational specification (for example, because of multiple fan failures).
- The server input voltages are out of operational specification.

The service processor can immediately shut down a system in the following circumstances:

- Temperature exceeds the critical level or remains above the warning level for too long.
- Internal component temperatures reach critical levels.
- Non-redundant fan failures occur.

- Placing calls

  On systems without a Hardware Management Console, the service processor can place calls to report surveillance failures with the POWER Hypervisor, critical environmental faults, and critical processing faults even when the main processing unit is inoperable.

- Mutual surveillance

  The service processor monitors the operation of the POWER Hypervisor firmware during the boot process and watches for loss of control during system operation. It also allows the POWER Hypervisor to monitor service processor activity. The service processor can take appropriate action, including calling for service, when it detects that the POWER Hypervisor firmware has lost control. Likewise, the POWER Hypervisor can request a service processor repair action if necessary.

- Availability

  The auto-restart (reboot) option, when enabled, can reboot the system automatically following an unrecoverable firmware error, firmware hang, hardware failure, or environmentally induced (AC power) failure.

Note: The auto-restart (reboot) option has to be enabled from the Advanced System Manager Interface or from the Control (Operator) Panel. Figure 4-8 shows this option using the ASMI.

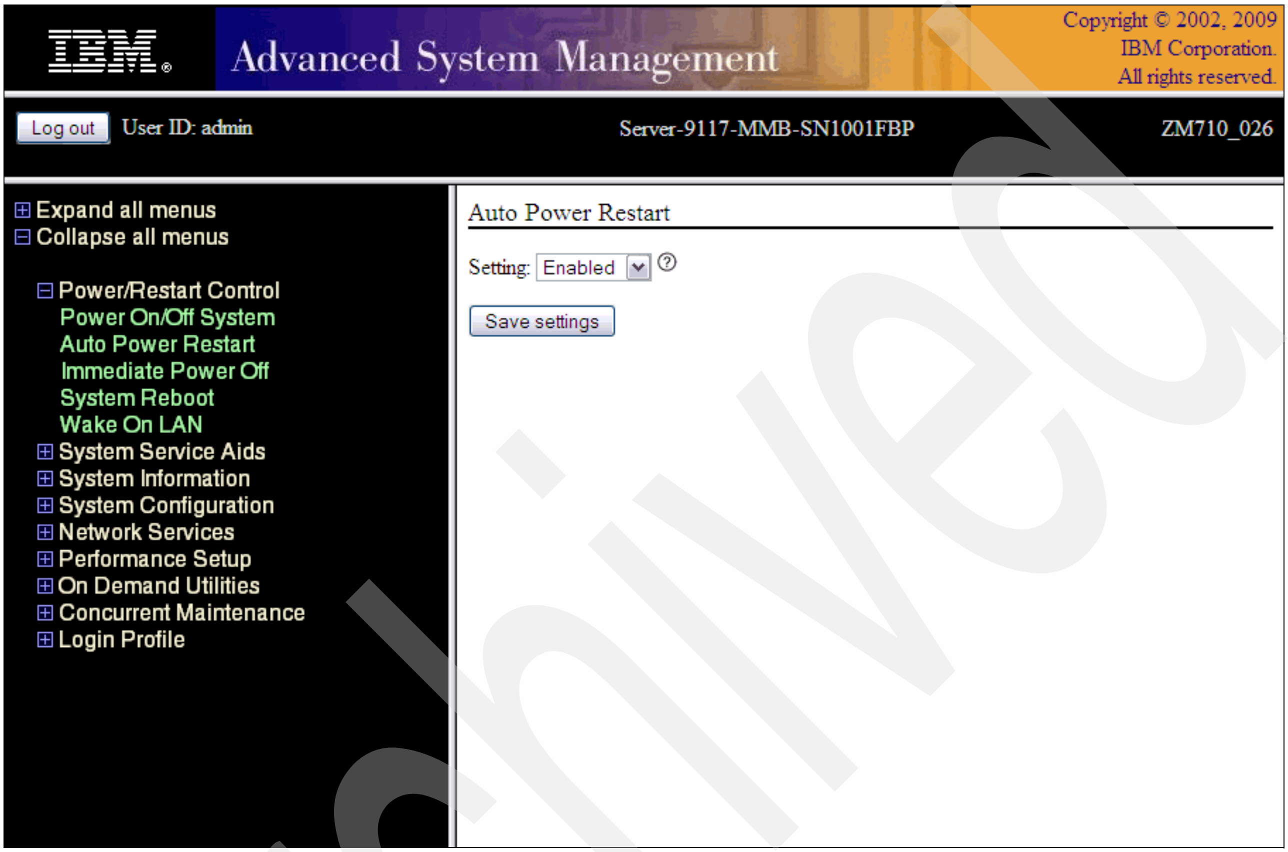

Figure 4-8 ASMI Auto Power Restart setting panel

- Fault monitoring

  Built-in self-test (BIST) checks processor, cache, memory, and associated hardware that is required for proper booting of the operating system, when the system is powered on at the initial installation or after a hardware configuration change (for example, an upgrade). If a non-critical error is detected or if the error occurs in a resource that can be removed from the system configuration, the booting process is designed to proceed to completion. The errors are logged in the system nonvolatile random access memory (NVRAM). When the operating system completes booting, the information is passed from the NVRAM to the system error log where it is analyzed by error log analysis (ELA) routines. Appropriate actions are taken to report the boot-time error for subsequent service, if required.

- Concurrent access to the service processors menus of the Advanced System Management Interface (ASMI)

  This access allows nondisruptive abilities to change system default parameters, interrogate service processor progress and error logs andset and reset server indicators (Guiding Light for midrange and high-end servers, Light Path for low-end servers), accessing all service processor functions without having to power down the system to the standby state. This allows the administrator or service representative to dynamically access the menus from any eeb browser-enabled console that is attached to the Ethernet service network, concurrently with normal system operation.

- Managing the interfaces for connecting uninterruptible power source systems to the POWER processor-based systems, performing Timed Power-On (TPO) sequences, and interfacing with the power and cooling subsystem

Error checkers

IBM POWER processor-based systems contain specialized hardware detection circuitry that is used to detect erroneous hardware operations. Error checking hardware ranges from parity error detection coupled with processor instruction retry and bus retry, to ECC correction on caches and system buses. All IBM hardware error checkers have distinct attributes:

- Continuous monitoring of system operations to detect potential calculation errors.
- Attempts to isolate physical faults based on run time detection of each unique failure.
- Ability to initiate a wide variety of recovery mechanisms designed to correct the problem. The POWER processor-based systems include extensive hardware and firmware recovery logic.

Fault isolation registers

Error checker signals are captured and stored in hardware fault isolation registers (FIRs). The associated logic circuitry is used to limit the domain of an error to the first checker that encounters the error. In this way, runtime error diagnostics can be deterministic so that for every check station, the unique error domain for that checker is defined and documented. Ultimately, the error domain becomes the field-replaceable unit (FRU) call, and manual interpretation of the data is not normally required.

First-failure data capture

FFDC is an error isolation technique, which ensures that when a fault is detected in a system through error checkers or other types of detection methods, the root cause of the fault will be captured without the need to re-create the problem or run an extended tracing or diagnostics program.

For the vast majority of faults, a good FFDC design means that the root cause is detected automatically without intervention by a service representative. Pertinent error data related to the fault is captured and saved for analysis. In hardware, FFDC data is collected from the fault isolation registers and from the associated logic. In firmware, this data consists of return codes, function calls, and so forth.

FFDC *check stations* are carefully positioned within the server logic and data paths to ensure that potential errors can be quickly identified and accurately tracked to a field-replaceable unit (FRU).

This proactive diagnostic strategy is a significant improvement over the classic, less accurate *reboot and diagnose* service approaches.

Figure 4-9 shows a schematic of a fault isolation register implementation.

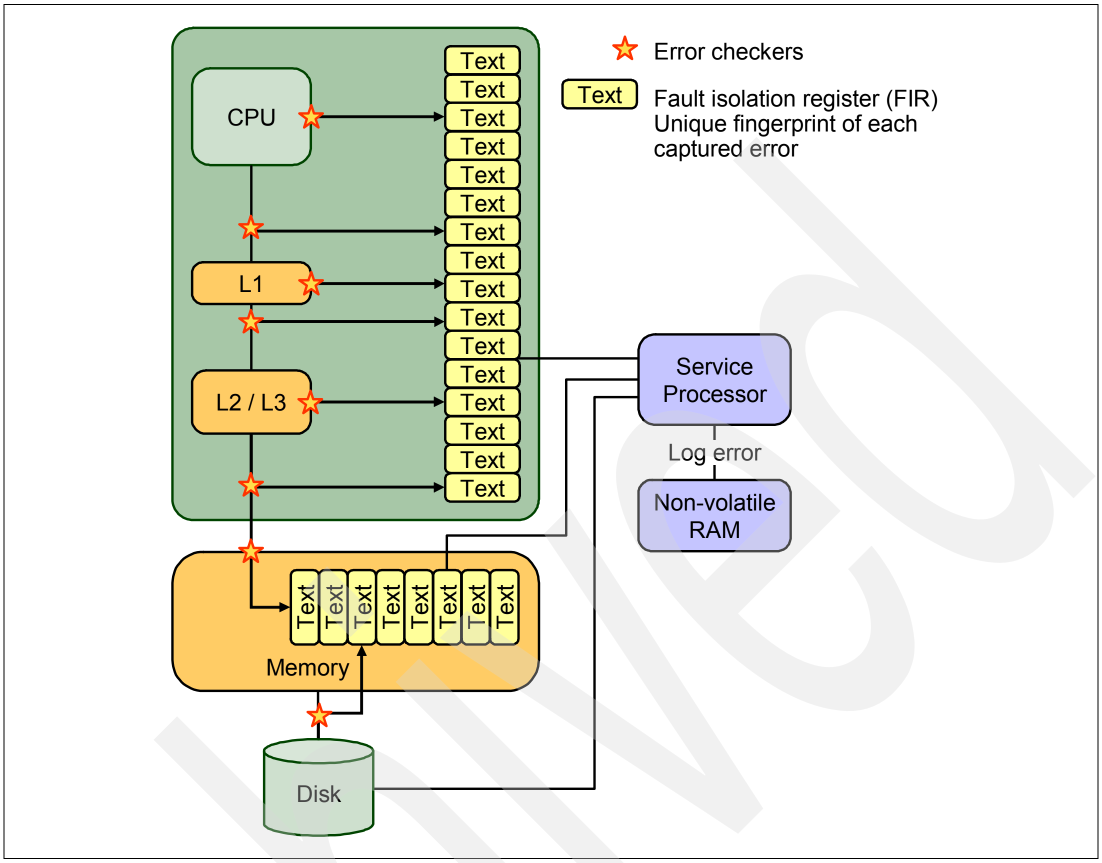

Figure 4-9 Schematic of FIR implementation

Fault isolation

The service processor interprets error data that is captured by the FFDC checkers (saved in the FIRs or other firmware-related data capture methods) to determine the root cause of the error event.

Root cause analysis might indicate that the event is recoverable, meaning that a service action point or need for repair has not been reached. Alternatively, it could indicate that a service action point has been reached, where the event exceeded a pre-determined threshold or was unrecoverable. Based on the isolation analysis, recoverable error threshold counts can be incremented. No specific service action is necessary when the event is recoverable.

When the event requires a service action, additional required information is collected to service the fault. For unrecoverable errors or for recoverable events that meet or exceed their service threshold, meaning that a service action point has been reached, a request for service is initiated through an error logging component.

4.3.2 Diagnosing

Using the extensive network of advanced and complementary error detection logic that is built directly into hardware, firmware, and operating systems, the IBM Power Systems servers can perform considerable self-diagnosis.

Boot time

When an IBM Power Systems server powers up, the service processor initializes the system hardware. Boot-time diagnostic testing uses a multi-tier approach for system validation, starting with managed low-level diagnostics that are supplemented with system firmware initialization and configuration of I/O hardware, followed by OS-initiated software test routines. Boot-time diagnostic routines include:

- Built-in self-tests (BISTs) for both logic components and arrays ensure the internal integrity of components. Because the service processor assists in performing these tests, the system is enabled to perform fault determination and isolation, whether or not the system processors are operational. Boot-time BISTs can also find faults undetectable by processor-based power-on self-test (POST) or diagnostics.
- Wire-tests discover and precisely identify connection faults between components such as processors, memory, or I/O hub chips.
- Initialization of components such as ECC memory, typically by writing patterns of data and allowing the server to store valid ECC data for each location, can help isolate errors.

To minimize boot time, the system determines which of the diagnostics are required to be started to ensure correct operation, based on the way that the system was powered off, or on the boot-time selection menu.

Run time

All Power Systems servers can monitor critical system components during run time, and they can take corrective actions when recoverable faults occur. IBM hardware error-check architecture provides the ability to report non-critical errors in an *out-of-band* communications path to the service processor without affecting system performance.

A significant part of IBM runtime diagnostic capabilities originate with the service processor. Extensive diagnostic and fault analysis routines have been developed and improved over many generations of POWER processor-based servers, and enable quick and accurate predefined responses to both actual and potential system problems.

The service processor correlates and processes runtime error information using logic derived from IBM engineering expertise to count recoverable errors (called thresholding) and predict when corrective actions must be automatically initiated by the system. These actions can include:

- Requests for a part to be replaced
- Dynamic invocation of built-in redundancy for automatic replacement of a failing part
- Dynamic deallocation of failing components so that system availability is maintained

Device drivers

In certain cases diagnostics are best performed by operating system-specific drivers, most notably I/O devices that are owned directly by a logical partition. In these cases, the operating system device driver often works in conjunction with I/O device microcode to isolate and recover from problems. Potential problems are reported to an operating system device driver, which logs the error. I/O devices can also include specific exercisers that can be invoked by the diagnostic facilities for problem recreation if required by service procedures.

4.3.3 Reporting

In the unlikely event that a system hardware or environmentally induced failure is diagnosed, IBM Power Systems servers report the error through a number of mechanisms. The analysis result is stored in system NVRAM. Error log analysis (ELA) can be used to display the failure cause and the physical location of the failing hardware.

With the integrated service processor, the system has the ability to automatically send out an alert through a phone line to a pager, or call for service in the event of a critical system failure. A hardware fault also illuminates the amber system fault LED located on the system unit to alert the user of an internal hardware problem.

On POWER7 processor-based servers, hardware and software failures are recorded in the system log. When a management console is attached, an ELA routine analyzes the error, forwards the event to the Service Focal Point (SFP) application running on the management console, and has the capability to notify the system administrator that it has isolated a likely cause of the system problem. The service processor event log also records unrecoverable checkstop conditions, forwards them to the Service Focal Point (SFP) application, and notifies the system administrator. After the information is logged in the SFP application, if the system is properly configured, a call-home service request is initiated and the pertinent failure data with service parts information and part locations is sent to the IBM service organization.This information will also contain the client contact information as defined in the Electronic Service Agent (ESA) guided set-up wizard.

Error logging and analysis

When the root cause of an error has been identified by a fault isolation component, an error log entry is created with basic data such as:

- An error code uniquely describing the error event
- The location of the failing component
- The part number of the component to be replaced, including pertinent data such as engineering and manufacturing levels
- Return codes
- Resource identifiers
- FFDC data

Data containing information about the effect that the repair will have on the system is also included. Error log routines in the operating system and FSP can then use this information and decide whether the fault is a call home candidate. If the fault requires support intervention, then a call will be placed with service and support and a notifcation sent to the contact defined in the ESA guided set-up wizard

Remote support

The Remote Management and Control (RMC) subsystem is delivered as part of the base operating system, including the operating system running on the Hardware Management Console. RMC provides a secure transport mechanism across the LAN interface between the operating system and the Hardware Management Console and is used by the operating system diagnostic application for transmitting error information. It performs a number of other functions also, but these are not used for the service infrastructure.

Service Focal Point

A critical requirement in a logically partitioned environment is to ensure that errors are not lost before being reported for service, and that an error should only be reported once, regardless of how many logical partitions experience the potential effect of the error. The Manage Serviceable Events task on the management console is responsible for aggregating duplicate error reports, and ensures that all errors are recorded for review and management.

When a local or globally reported service request is made to the operating system, the operating system diagnostic subsystem uses the Remote Management and Control Subsystem (RMC) to relay error information to the Hardware Management Console. For global events (platform unrecoverable errors, for example) the service processor will also forward error notification of these events to the Hardware Management Console, providing a redundant error-reporting path in case of errors in the RMC network.

The first occurrence of each failure type is recorded in the Manage Serviceable Events task on the management console. This task then filters and maintains a history of duplicate reports from other logical partitions on the service processor. It then looks at all active service event requests, analyzes the failure to ascertain the root cause and, if enabled, initiates a call home for service. This methodology ensures that all platform errors will be reported through at least one functional path, ultimately resulting in a single notification for a single problem.

Extended error data

Extended error data (EED) is additional data that is collected either automatically at the time of a failure or manually at a later time. The data collected is dependent on the invocation method but includes information like firmware levels, operating system levels, additional fault isolation register values, recoverable error threshold register values, system status, and any other pertinent data.

The data is formatted and prepared for transmission back to IBM to assist the service support organization with preparing a service action plan for the service representative or for additional analysis.

System dump handling

In certain circumstances, an error might require a dump to be automatically or manually created. In this event, it is off-loaded to the management console. Specific management console information is included as part of the information that can optionally be sent to IBM support for analysis. If additional information relating to the dump is required, or if it becomes necessary to view the dump remotely, the management console dump record notifies the IBM support center regarding on which management console the dump is located.

4.3.4 Notifying

After a Power Systems server has detected, diagnosed, and reported an error to an appropriate aggregation point, it then takes steps to notify the client, and if necessary the IBM support organization. Depending on the assessed severity of the error and support agreement, this could range from a simple notification to having field service personnel automatically dispatched to the client site with the correct replacement part.

Client Notify

When an event is important enough to report, but does not indicate the need for a repair action or the need to call home to IBM service and support, it is classified as Client Notify. Clients are notified because these events might be of interest to an administrator. The event might be a symptom of an expected systemic change, such as a network reconfiguration or failover testing of redundant power or cooling systems. Examples of these events include:

- Network events such as the loss of contact over a local area network (LAN)
- Environmental events such as ambient temperature warnings
- Events that need further examination by the client (although these events do not necessarily require a part replacement or repair action)

Client Notify events are serviceable events, by definition, because they indicate that something has happened that requires client awareness in the event that the client wants to take further action. These events can always be reported back to IBM at the client's discretion.

Call home

A correctly configured POWER processor-based system can initiate an automatic or manual call from a client location to the IBM service and support organization with error data, server status, or other service-related information. The call-home feature invokes the service organization in order for the appropriate service action to begin, automatically opening a problem report and, in certain cases, also dispatching field support. This automated reporting provides faster and potentially more accurate transmittal of error information. Although configuring call-home is optional, clients are strongly encouraged to configure this feature to obtain the full value of IBM service enhancements.

Vital product data (VPD) and inventory management

Power Systems store vital product data (VPD) internally, which keeps a record of how much memory is installed, how many processors are installed, the manufacturing level of the parts, and so on. These records provide valuable information that can be used by remote support and service representatives, enabling them to provide assistance in keeping the firmware and software on the server up-to-date.

IBM problem management database

At the IBM support center, historical problem data is entered into the IBM Service and Support Problem Management database. All of the information that is related to the error, along with any service actions taken by the service representative, is recorded for problem management by the support and development organizations. The problem is then tracked and monitored until the system fault is repaired.

4.3.5 Locating and servicing

The final component of a comprehensive design for serviceability is the ability to effectively locate and replace parts requiring service. POWER processor-based systems use a combination of visual cues and guided maintenance procedures to ensure that the identified part is replaced correctly, every time.

Packaging for service

The following service enhancements are included in the physical packaging of the systems to facilitate service:

- Color coding (touch points)
  - Terra-cotta-colored touch points indicate that a component (FRU or CRU) can be concurrently maintained.
  - Blue-colored touch points delineate components that are not concurrently maintained (those that require the system to be turned off for removal or repair).
- Tool-less design: Selected IBM systems support tool-less or simple tool designs. These designs require no tools or simple tools, such as flathead screw drivers to service the hardware components.
- Positive retention: Positive retention mechanisms help to ensure proper connections between hardware components, such as from cables to connectors, and between two cards that attach to each other. Without positive retention, hardware components run the risk of becoming loose during shipping or installation, preventing a good electrical

connection. Positive retention mechanisms such as latches, levers, thumb-screws, pop Nylatches (U-clips), and cables are included to help prevent loose connections and aid in installing (seating) parts correctly. These positive retention items do not require tools.

Light Path

The Light Path LED feature is for low-end systems, including Power Systems up to models 750 and 755, that can be repaired by clients. In the Light Path LED implementation, when a fault condition is detected on the POWER7 processor-based system, an amber FRU fault LED is illuminated, which is then rolled up to the system fault LED. The Light Path system pinpoints the exact part by turning on the amber FRU fault LED that is associated with the part to be replaced.

The system can clearly identify components for replacement by using specific component-level LEDs, and can also guide the servicer directly to the component by signaling (staying on solid) the system fault LED, enclosure fault LED, and the component FRU fault LED.

After the repair, the LEDs shut off automatically if the problem is fixed.

Guiding Light

Midrange and high-end systems, including models 770 and 780 and later, are usually repaired by IBM Support personnel.

The enclosure and system identify LEDs turn on solid and can be used to follow the path from the system to the enclosure and down to the specific FRU.

Guiding Light uses a series of flashing LEDs, allowing a service provider to quickly and easily identify the location of system components. Guiding Light can also handle multiple error conditions simultaneously, which might be necessary in some very complex high-end configurations.

In these situations, Guiding Light waits for the servicer’s indication of what failure to attend first and then illuminates the LEDs to the failing component.

Data centers can be complex places, and Guiding Light is designed to do more than identify visible components. When a component might be hidden from view, Guiding Light can flash a sequence of LEDs that extends to the frame exterior, clearly *guiding* the service representative to the correct rack, system, enclosure, drawer, and component.

Service labels

Service providers use these labels to assist them in performing maintenance actions. Service labels are found in various formats and positions, and are intended to transmit readily available information to the servicer during the repair process.

Several of these service labels and their purposes are described in the following list:

- Location diagrams are strategically located on the system hardware, relating information regarding the placement of hardware components. Location diagrams can include location codes, drawings of physical locations, concurrent maintenance status, or other data that is pertinent to a repair. Location diagrams are especially useful when multiple components are installed, such as DIMMs, sockets, processor cards, fans, adapter cards, LEDs, and power supplies.
- Remove or replace procedure labels contain procedures often found on a cover of the system or in other spots that are accessible to the servicer. These labels provide systematic procedures, including diagrams, detailing how to remove and replace certain serviceable hardware components.
- Numbered arrows are used to indicate the order of operation and serviceability direction of components. Various serviceable parts such as latches, levers, and touch points must be pulled or pushed in a certain direction and order so that the mechanical mechanisms can engage or disengage. Arrows generally improve the ease of serviceability.

The operator panel

The operator panel on a POWER processor-based system is a four-row by 16-element LCD display that is used to present boot progress codes, indicating advancement through the system power-on and initialization processes. The operator panel is also used to display error and location codes when an error occurs that prevents the system from booting. It includes several buttons, enabling a service support representative (SSR) or client to change various boot-time options and for other limited service functions.

Concurrent maintenance

The IBM POWER7 processor-based systems are designed with the understanding that certain components have higher intrinsic failure rates than others. The movement of fans, power supplies, and physical storage devices naturally make them more susceptible to wearing down or burning out. Other devices such as I/O adapters can begin to wear from repeated plugging and unplugging. For these reasons, these devices have been specifically designed to be concurrently maintainable when properly configured.

In other cases, a client might be in the process of moving or redesigning a data center or planning a major upgrade. At times like these, flexibility is crucial. The IBM POWER7 processor-based systems are designed for redundant or concurrently maintainable power, fans, physical storage, and I/O towers.

The most recent members of the IBM Power Systems family, based on the POWER7 processor, continue to support concurrent maintenance of power, cooling, PCI adapters, media devices, I/O drawers, GX adapter, and the operator panel. In addition, they support concurrent firmware fix pack updates when possible. The determination of whether a firmware fix pack release can be updated concurrently is identified in the `readme` file that is released with the firmware.

Hot-node add, hot-node repair, and memory upgrade

With the proper configuration and required protective measures, the Power 770 and Power 780 servers are designed for node add, node repair, or memory upgrade without powering down the system.

The Power 770 and Power 780 servers support the addition of another CEC enclosure (node) to a system (hot-node add) or adding more memory (memory upgrade) to an existing node. The additional Power 770 and Power 780 enclosure or memory can be ordered as a system upgrade (MES order) and added to the original system. The additional resources of the newly added CEC enclosure (node) or memory can then be assigned to existing OS partitions or new partitions as required. Hot-node add and memory upgrade enable the upgrading of a server by integrating a second, third, or fourth CEC enclosure or additional memory into the server, with reduced impact to the system operation.

In the unlikely event that CEC hardware (for example, processor or memory) experienced a failure, the hardware can be repaired by freeing the processors and memory in the node and its attached I/O resources (node evacuation) dependant on the partition configuration.

To guard against any potential impact to system operation during hot-node add, memory upgrade, or node repair, clients must comply with these protective measures:

- For memory upgrade and node repair, ensure that the system has sufficient inactive or spare processors and memory. Critical I/O resources must be configured with redundant paths.
- Schedule upgrades or repairs during non-peak operational hours.
- Move business applications to another server by using the PowerVM Live Partition Mobility feature or quiesce them. The use of LPM means that all critical applications must be halted or moved to another system before the operation begins. Non-critical applications can remain running. The partitions can be left running at the operating system command prompt.
- Back up critical application and system state information.
- Checkpoint the databases.

Blind-swap cassette

Blind-swap PCIe adapters represent significant service and ease-of-use enhancements in I/O subsystem design while maintaining high PCIe adapter density.

Blind-swap allows PCIe adapters to be concurrently replaced or installed without having to put the I/O drawer or system into a service position. Since first delivered, minor carrier design adjustments have improved an already well-thought-out service design.

For PCIe adapters on the POWER7 processor-based servers, blind-swap cassettes include the PCIe slot, to avoid the top to bottom movement for inserting the card on the slot that was required on previous designs. The adapter is correctly connected by just sliding the cassette in and actuacting a latch.

Firmware updates

System Firmware is delivered as a release level or a service pack. Release Levels support the general availability (GA) of new function or features, and new machine types or models. Upgrading to a higher release level is disruptive to customer operations. IBM intends to introduce no more than two new release levels per year. These release levels will be supported by service packs. Service packs are intended to contain only firmware fixes and not to introduce new function. A service pack is an update to an existing release level.

If the system is managed by a management console, you will use the management console for firmware updates. Using the management console allows you to take advantage of the Concurrent Firmware Maintenance (CFM) option when concurrent service packs are available. CFM is the IBM term used to describe the IBM Power Systems firmware updates that can be partially or wholy concurrent or non-disruptive. With the introduction of CFM, IBM is significantly increasing a client's opportunity to stay on a given release level for longer periods of time. Clients wanting maximum stability can defer until there is a compelling reason to upgrade, such as:

- A release level is approaching its end-of-service date (that is, it has been available for about a year and hence will go out of service support soon).
- Moving a system to a more standardized release level when there are multiple systems in an environment with similar hardware.
- A new release has new functionality that is needed in the environment.
- A scheduled maintenance action will cause a platform reboot. This provides an opportunity to also upgrade to a new firmware release.

The update and upgrade of system firmware is dependant on several factors, such as whether the system is standalone or managed by a management console, the current firmware installed, and what operating systems are running on the system. These scenarios and the associated installation instructions are comprehensively outlined in the firmware section of Fix Central:

http://www.ibm.com/support/fixcentral/

You might also want to review the best practice white papers, which can be found here:

http://www14.software.ibm.com/webapp/set2/sas/f/best/home.html

Repair and verify system

Repair and verify (R&V) is a system used to guide a service provider step-by-step through the process of repairing a system and verifying that the problem has been repaired. The steps are customized in the appropriate sequence for the particular repair for the specific system being repaired. Repair scenarios covered by repair and verify include:

- Replacing a defective field-replaceable unit (FRU) or a customer replacable unit (CRU)
- Reattaching a loose or disconnected component
- Correcting a configuration error
- Removing or replacing an incompatible FRU
- Updating firmware, device drivers, operating systems, middleware components, and IBM applications after replacing a part

Repair and verify procedures can be used by both service representative providers who are familiar with the task and those who are not. Education On Demand content is placed in the procedure at the appropriate locations. Throughout the repair and verify procedure, repair history is collected and provided to the Service and Support Problem Management Database for storage with the serviceable event, to ensure that the guided maintenance procedures are operating correctly.

If a server is managed by a management console, then many of the R&V procedures are performed from the management console. If the FRU to be replaced is a PCI adapter or an internal storage device, then the service action is always performed from the operating system of the partition owning that resource.

Clients can subscribe through the subscription services to obtain the notifications about the latest updates available for service-related documentation. The latest version of the documentation is accessible through the internet.

4.4 Manageability

Several functions and tools help manageability and enable you to efficiently and effectively manage your system.

4.4.1 Service user interfaces

The service interface allows support personnel or the client to communicate with the service support applications in a server using a console, interface, or terminal. Delivering a clear, concise view of available service applications, the service interface allows the support team to manage system resources and service information in an efficient and effective way.

Applications available through the service interface are carefully configured and placed to give service providers access to important service functions.

Various service interfaces are used, depending on the state of the system and its operating environment. The primary service interfaces are:

- Light Path and Guiding Light

  For more information, see “Light Path” on page 178 and “Guiding Light” on page 178.

- Service processor, Advanced System Management Interface (ASMI)
- Operator panel
- Operating system service menu
- Service Focal Point on the Hardware Management Console
- Service Focal Point Lite on Integrated Virtualization Manager

Service processor

The service processor is a controller that is running its own operating system. It is a component of the service interface card.

The service processor operating system has specific programs and device drivers for the service processor hardware. The host interface is a processor support interface that is connected to the POWER processor. The service processor is always working, regardless of the main system unit’s state. The system unit can be in these states:

- Standby (power off)
- Operating, ready to start partitions
- Operating with running logical partitions

The service processor is used to monitor and manage the system hardware resources and devices. The service processor checks the system for errors, ensuring that the connection to the management console for manageability purposes and accepting Advanced System Management Interface (ASMI) Secure Sockets Layer (SSL) network connections. The service processor provides the ability to view and manage the machine-wide settings by using the ASMI, and enables complete system and partition management from the management console.

With two CEC enclosures and more, there are two redundant FSP, one in each of the first CECs. While one is active, the second one is in standby mode. In case of a failure, there will be a automatic takeover.

> **Note:** The service processor enables a system that does not boot to be analyzed. The error log analysis can be performed from either the ASMI or the management console.

The service processor uses two Ethernet 10/100Mbps ports. Note the following information:

- Both Ethernet ports are only visible to the service processor and can be used to attach the server to an HMC or to access the ASMI. The ASMI options can be accessed through an HTTP server that is integrated into the service processor operating environment.
- Both Ethernet ports support only auto-negotiation. Customer selectable media speed and duplex settings are not available.
- Both Ethernet ports have a default IP address, as follows:
  - Service processor Eth0 or HMC1 port is configured as 169.254.2.147.
  - Service processor Eth1 or HMC2 port is configured as 169.254.3.147.
- When a redundant service processor is present, the default IP addresses are:
  - Service processor Eth0 or HMC1 port is configured as 169.254.2.146.
  - Service processor Eth1 or HMC2 port is configured as 169.254.3.146.

The functions available through service processor include:

- Call Home
- Advanced System Management Interface (ASMI)
- Error Information (error code, PN, Location Codes) menu
- View of guarded components
- Limited repair procedures
- Generate dump
- LED Management menu
- Remote view of ASMI menus
- Firmware update through USB key

Advanced System Management Interface (ASMI)

ASMI is the interface to the service processor that enables you to manage the operation of the server, such as auto-power restart, and to view information about the server, such as the error log and vital product data. Various repair procedures require connection to the ASMI.

The ASMI is accessible through the management console. It is also accessible by using a web browser on a system that is connected directly to the service processor (in this case, either a standard Ethernet cable or a crossed cable) or through an Ethernet network. ASMI can also be accessed from an ASCII terminal, but this is only available while the system is in the platform powered-off mode.

Use the ASMI to change the service processor IP addresses or to apply certain security policies and prevent access from undesired IP addresses or ranges.

You might be able to use the service processor's default settings. In that case, accessing the ASMI is not necessary. To access ASMI, use one of the following methods:

- Access the ASMI by using an management console.

  If configured to do so, the management console connects directly to the ASMI for a selected system from this task.

  To connect to the Advanced System Management interface from an management console, follow these steps:

  a. Open Systems Management from the navigation pane.

  b. From the work pane, select one or more managed systems to work with.

  c. From the System Management tasks list, select **Operations Advanced System Management** (ASM).

- Access the ASMI by using a web browser.

  At the time of writing, supported web browsers are Microsoft Internet Explorer (Version 7.0), Mozilla Firefox (Version 2.0.0.11), and Opera (Version 9.24). Later versions of these browsers might work but are not officially supported. The JavaScript language and cookies must be enabled.

  The web interface is available during all phases of system operation, including the initial program load (IPL) and run time. However, several of the menu options in the web interface are unavailable during IPL or run time to prevent usage or ownership conflicts if the system resources are in use during that phase. The ASMI provides a Secure Sockets Layer (SSL) web connection to the service processor. To establish an SSL connection, open your browser using this adress:

  `https://<ip_address_of_service_processor>`

  > **Note:** To make the connection through Internet Explorer, click **Tools Internet Options**. Clear the **Use TLS 1.0** check box, and click **OK**.

- Access the ASMI using an ASCII terminal.

The ASMI on an ASCII terminal supports a subset of the functions that are provided by the web interface and is available only when the system is in the platform powered-off mode. The ASMI on an ASCII console is not available during several phases of system operation, such as the IPL and run time.

The operator panel

The service processor provides an interface to the operator panel, which is used to display system status and diagnostic information.

The operator panel can be accessed in two ways:

- By using the normal operational front view.
- By pulling it out to access the switches and viewing the LCD display. Figure 4-10 shows that the operator panel on a Power 770 and Power 780 is pulled out.

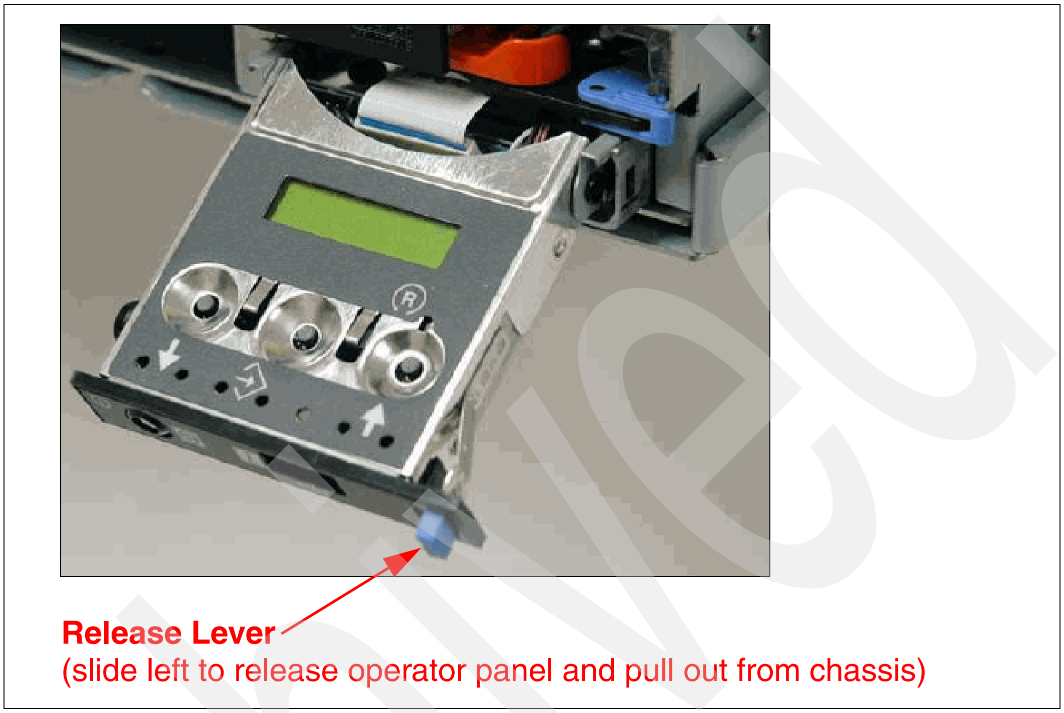

Figure 4-10 Operator panel is pulled out from the chassis

Several of the operator panel features include:

- A 2 x 16 character LCD display
- Reset, enter, power On/Off, increment, and decrement buttons
- Amber System Information/Attention, green Power LED
- Blue Enclosure Identify LED on the Power 770 and Power 780
- Altitude sensor
- USB Port
- Speaker/Beeper

The functions available through the operator panel include:

- Error Information
- Generate dump
- View Machine Type, Model, and Serial Number
- Limited set of repair functions

Operating system service menu

The system diagnostics consist of IBM i service tools, stand-alone diagnostics that are loaded from the DVD drive, and online diagnostics (available in AIX).

Online diagnostics, when installed, are a part of the AIX or IBM i operating system on the disk or server. They can be booted in single-user mode (service mode), run in maintenance mode, or run concurrently (concurrent mode) with other applications. They have access to the AIX error log and the AIX configuration data. IBM i has a service tools problem log, IBM i history log (QHST), and IBM i problem log.

These are the modes:

- Service mode

  Requires a service mode boot of the system and enables the checking of system devices and features. Service mode provides the most complete checkout of the system resources. All system resources, except the SCSI adapter and the disk drives used for paging, can be tested.

- Concurrent mode

  Enables the normal system functions to continue while selected resources are being checked. Because the system is running in normal operation, certain devices might require additional actions by the user or diagnostic application before testing can be done.

- Maintenance mode

  Enables the checking of most system resources. Maintenance mode provides the same test coverage as service mode. The difference between the two modes is the way that they are invoked. Maintenance mode requires that all activity on the operating system be stopped. The **shutdown -m** command is used to stop all activity on the operating system and put the operating system into maintenance mode.

The System Management Services (SMS) error log is accessible on the SMS menus. This error log contains errors that are found by partition firmware when the system or partition is booting.

The service processor's error log can be accessed on the ASMI menus.

You can also access the system diagnostics from a Network Installation Management (NIM) server.

> **Note:** When you order a Power System, a DVD-ROM or DVD-RAM might be optional. An alternate method for maintaining and servicing the system must be available if you do not order the DVD-ROM or DVD-RAM.

The IBM i operating system and associated machine code provide Dedicated Service Tools (DST) as part of the IBM i licensed machine code (Licensed Internal Code) and System Service Tools (SST) as part of the IBM i operating system. DST can be run in dedicated mode (no operating system loaded). DST tools and diagnostics are a superset of those available under SST.

The IBM i **End Subsystem** (ENDSBS *ALL) command can shut down all IBM and customer applications subsystems except the controlling subsystem QTCL. The **Power Down System** (PWRDWNSYS) command can be set to power down the IBM i partition and restart the partition in DST mode.

You can start SST during normal operations, which leaves all applications up and running using the IBM i **Start Service Tools** (STRSST) command (when signed onto IBM i with the appropriately secured user ID).

With DST and SST you can look at various logs, run various diagnostics, or take several kinds of system dumps or other options.

Depending on the operating system, these are the service-level functions that you typically see when using the operating system service menus:

- Product activity log
- Trace Licensed Internal Code
- Work with communications trace
- Display/Alter/Dump
- Licensed Internal Code log
- Main storage dump manager
- Hardware service manager
- Call Home/Customer Notification
- Error information menu
- LED management menu
- Concurrent/Non-concurrent maintenance (within scope of the OS)
- Managing firmware levels
  - Server
  - Adapter
- Remote support (access varies by OS)

Service Focal Point on the Hardware Management Console

Service strategies become more complicated in a partitioned environment. The Manage Serviceable Events task in the management console can help to streamline this process.

Each logical partition reports errors that it detects and forwards the event to the Service Focal Point (SFP) application that is running on the management console, without determining whether other logical partitions also detect and report the errors. For example, if one logical partition reports an error for a shared resource, such as a managed system power supply, other active logical partitions might report the same error.

By using the Manage Serviceable Events task in the management console, you can avoid long lists of repetitive call-home information by recognizing that these are repeated errors and consolidating them into one error.

In addition, you can use the Manage Serviceable Events task to initiate service functions on systems and logical partitions, including the exchanging of parts, configuring connectivity, and managing dumps.

4.4.2 IBM Power Systems firmware maintenance

The IBM Power Systems Client-Managed Microcode is a methodology that enables you to manage and install microcode updates on Power Systems and associated I/O adapters.

The system firmware consists of service processor microcode, Open Firmware microcode, SPCN microcode, and the POWER Hypervisor.

The firmware and microcode can be downloaded and installed from a management console, a running partition, or USB port number 1 on the rear of a Power 770 and Power 780, if that system is not managed by a management console.

Power Systems has a permanent firmware boot side, or A side, and a temporary firmware boot side, or B side. New levels of firmware must be installed on the temporary side first in order to test the update's compatibility with existing applications. When the new level of firmware has been approved, it can be copied to the permanent side.

For access to the initial web pages that address this capability, see the Support for IBM Systems web page:

http://www.ibm.com/systems/support

For Power Systems, select the **Power** link (Figure 4-11).

Figure 4-11 Support for Power servers web page

Although the content under the Popular links section can change, click **Firmware and HMC updates** to go to the resources for keeping your system’s firmware current.

If there is a management console to manage the server, the management console interface can be use to view the levels of server firmware and power subsystem firmware that are installed and are available to download and install.

Each IBM Power Systems server has the following levels of server firmware and power subsystem firmware:

- Installed level

  This level of server firmware or power subsystem firmware has been installed and will be installed into memory after the managed system is powered off and then powered on. It is installed on the temporary side of system firmware.

- Activated level

  This level of server firmware or power subsystem firmware is active and running in memory.

- Accepted level

  This level is the backup level of server or power subsystem firmware. You can return to this level of server or power subsystem firmware if you decide to remove the installed level. It is installed on the permanent side of system firmware.

IBM provides the Concurrent Firmware Maintenance (CFM) function on selected Power Systems. This function supports applying nondisruptive system firmware service packs to the system concurrently (without requiring a reboot operation to activate changes). For systems that are not managed by an management console, the installation of system firmware is always disruptive.

The concurrent levels of system firmware can, on occasion, contain fixes that are known as *deferred*. These deferred fixes can be installed concurrently but are not activated until the next IPL. For deferred fixes within a service pack, only the fixes in the service pack, which cannot be concurrently activated, are deferred. Table 4-1 shows the file-naming convention for system firmware.

Table 4-1 Firmware naming convention

PPNNSSS_FFF_DDD			
PP	Package identifier	01	-
		02	-
NN	Platform and class	AL	Low End
		AM	Mid Range
		AS	IH Server
		AH	High End
		AP	Bulk Power for IH
		AB	Bulk Power
SSS	Release indicator		
FFF	Current fix pack		
DDD	Last disruptive fix pack		

The following example uses the convention:

```
01AM710_086_063 = Managed System Firmware for 9117-MMB Release 710 Fixpack 086
```

An installation is disruptive if the following statements are true:

- The release levels (SSS) of currently installed and new firmware differ.
- The service pack level (FFF) and the last disruptive service pack level (DDD) are equal in new firmware.

Otherwise, an installation is concurrent if the service pack level (FFF) of the new firmware is higher than the service pack level currently installed on the system and the conditions for disruptive installation are not met.

4.4.3 Electronic Services and Electronic Service Agent

IBM has transformed its delivery of hardware and software support services to help you achieve higher system availability. Electronic Services is a web-enabled solution that offers an exclusive, no-additional-charge enhancement to the service and support available for IBM servers. These services provide the opportunity for greater system availability with faster problem resolution and preemptive monitoring. The Electronic Services solution consists of two separate, but complementary, elements:

- Electronic Services news page

  The Electronic Services news page is a single internet entry point that replaces the multiple entry points that are traditionally used to access IBM internet services and support. The news page enables you to gain easier access to IBM resources for assistance in resolving technical problems.

- Electronic Service Agent

  The Electronic Service Agent is software that resides on your server. It monitors events and transmits system inventory information to IBM on a periodic, client-defined timetable. The Electronic Service Agent automatically reports hardware problems to IBM.

Early knowledge about potential problems enables IBM to deliver proactive service that can result in higher system availability and performance. In addition, information that is collected through the Service Agent is made available to IBM service support representatives when they help answer your questions or diagnose problems. Installation and use of IBM Electronic Service Agent for problem reporting enables IBM to provide better support and service for your IBM server.

To learn how Electronic Services can work for you, visit:

https://www.ibm.com/support/electronic/portal

4.5 Operating system support for RAS features

Table 4-2 gives an overview of features for continuous availability that are supported by the various operating systems running on the Power 770 and Power 780 systems.

Table 4-2 Operating system support for RAS features

RAS feature	AIX 5.3	AIX 6.1	AIX 7.1	IBM i	RHEL 5.7	RHEL 6.1	SLES11 SP1
System deallocation of failing components							
Dynamic Processor Deallocation	X	X	X	X	X	X	X
Dynamic Processor Sparing	X	X	X	X	X	X	X

RAS feature	AIX 5.3	AIX 6.1	AIX 7.1	IBM i	RHEL 5.7	RHEL 6.1	SLES11 SP1
Processor Instruction Retry	X	X	X	X	X	X	X
Alternate Processor Recovery	X	X	X	X	X	X	X
Partition Contained Checkstop	X	X	X	X	X	X	X
Persistent processor deallocation	X	X	X	X	X	X	X
GX++ bus persistent deallocation	X	X	X	X	-	-	X
PCI bus extended error detection	X	X	X	X	X	X	X
PCI bus extended error recovery	X	X	X	X	Most	Most	Most
PCI-PCI bridge extended error handling	X	X	X	X	-	-	-
Redundant RIO or 12x Channel link	X	X	X	X	X	X	X
PCI card hot-swap	X	X	X	X	X	X	X
Dynamic SP failover at run time	X	X	X	X	X	X	X
Memory sparing with CoD at IPL time	X	X	X	X	X	X	X
Clock failover runtime or IPL	X	X	X	X	X	X	X
Memory availability							
64-byte ECC code	X	X	X	X	X	X	X
Hardware scrubbing	X	X	X	X	X	X	X
CRC	X	X	X	X	X	X	X
Chipkill	X	X	X	X	X	X	X
L1 instruction and data array protection	X	X	X	X	X	X	X
L2/L3 ECC and cache line delete	X	X	X	X	X	X	X
Special uncorrectable error handling	X	X	X	X	X	X	X
Active Memory Mirroring	X	X	X	X	X	X	X
Fault detection and isolation							
Platform FFDC diagnostics	X	X	X	X	X	X	X
Run-time diagnostics	X	X	X	X	Most	Most	Most
Storage Protection Keys	-	X	X	X	-	-	-
Dynamic Trace	X	X	X	X	-	-	X
Operating System FFDC	-	X	X	X	-	-	-
Error log analysis	X	X	X	X	X	X	X
Freeze mode of I/O Hub	X	X	X	X	-	-	-
Service Processor support for:							
Built-in-Self-Tests (BIST) for logic and arrays	X	X	X	X	X	X	X
Wire tests	X	X	X	X	X	X	X

RAS feature	AIX 5.3	AIX 6.1	AIX 7.1	IBM i	RHEL 5.7	RHEL 6.1	SLES11 SP1
Component initialization	X	X	X	X	X	X	X
Serviceability							
Boot-time progress indicators	X	X	X	X	Most	Most	Most
Electronic Service Agent Call Home from management console	X	X	X	X	X	X	X
Firmware error codes	X	X	X	X	X	X	X
Operating system error codes	X	X	X	X	Most	Most	Most
Inventory collection	X	X	X	X	X	X	X
Environmental and power warnings	X	X	X	X	X	X	X
Hot-plug fans, power supplies	X	X	X	X	X	X	X
Extended error data collection	X	X	X	X	X	X	X
I/O drawer redundant connections	X	X	X	X	X	X	X
I/O drawer hot add and concurrent repair	X	X	X	X	X	X	X
Concurrent RIO/GX adapter add	X	X	X	X	X	X	X
SP mutual surveillance with POWER Hypervisor	X	X	X	X	X	X	X
Dynamic firmware update with management console	X	X	X	X	X	X	X
Electronic Service Agent Call Home Application	X	X	X	X	-	-	-
Guiding light LEDs	X	X	X	X	X	X	X
System dump for memory, POWER Hypervisor, SP	X	X	X	X	X	X	X
Infocenter / Systems Support Site service publications	X	X	X	X	X	X	X
System Support Site education	X	X	X	X	X	X	X
Operating system error reporting to management console SFP	X	X	X	X	X	X	X
RMC secure error transmission subsystem	X	X	X	X	X	X	X
Health check scheduled operations with management console	X	X	X	X	X	X	X
Operator panel (real or virtual)	X	X	X	X	X	X	X
Concurrent operator panel maintenance	X	X	X	X	X	X	X
Redundant management consoles	X	X	X	X	X	X	X
Automated server recovery/restart	X	X	X	X	X	X	X
High availability clustering support	X	X	X	X	X	X	X
Repair and Verify Guided Maintenance	X	X	X	X	Most	Most	Most
Concurrent kernel update	-	X	X	X	X	X	X
Concurrent Hot Add/Repair Maintenance	X	X	X	X	X	X	X

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this paper.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only.

- *IBM BladeCenter PS700, PS701, and PS702 Technical Overview and Introduction*, REDP-4655
- *IBM BladeCenter PS703 and PS704 Technical Overview and Introduction*, REDP-4744
- *IBM Power 710 and 730 Technical Overview and Introduction*, REDP-4796
- *IBM Power 720 and 740 Technical Overview and Introduction*, REDP-4797
- *IBM Power 750 and 755 Technical Overview and Introduction*, REDP-4638
- *IBM Power 795 Technical Overview and Introduction*, REDP-4640
- *IBM PowerVM Virtualization Introduction and Configuration*, SG24-7940
- *IBM PowerVM Virtualization Managing and Monitoring*, SG24-7590
- *IBM PowerVM Live Partition Mobility*, SG24-7460
- *IBM System p Advanced POWER Virtualization (PowerVM) Best Practices*, REDP-4194
- *PowerVM Migration from Physical to Virtual Storage*, SG24-7825
- *IBM System Storage DS8000: Copy Services in Open Environments*, SG24-6788
- *IBM System Storage DS8700 Architecture and Implementation*, SG24-8786
- *PowerVM and SAN Copy Services*, REDP-4610
- *SAN Volume Controller V4.3.0 Advanced Copy Services*, SG24-7574

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

These publications are also relevant as further information sources:

- IBM Power Systems Facts and Features POWER7 Blades and Servers

  http://www.ibm.com/systems/power/hardware/reports/factsfeatures.html
- Specific storage devices supported for Virtual I/O Server

  http://www14.software.ibm.com/webapp/set2/sas/f/vios/documentation/datasheet.html

- IBM Power 710 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03048usen/POD03048USEN.PDF
- IBM Power 720 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03048usen/POD03048USEN.PDF
- IBM Power 730 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03050usen/POD03050USEN.PDF
- IBM Power 740 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03051usen/POD03051USEN.PDF
- IBM Power 750 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03034usen/POD03034USEN.PDF
- IBM Power 755 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03035usen/POD03035USEN.PDF
- IBM Power 770 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03035usen/POD03035USEN.PDF
- IBM Power 780 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03032usen/POD03032USEN.PDF
- IBM Power 795 server Data Sheet
  http://public.dhe.ibm.com/common/ssi/ecm/en/pod03053usen/POD03053USEN.PDF
- *Active Memory Expansion: Overview and Usage Guide*
  http://public.dhe.ibm.com/common/ssi/ecm/en/pow03037usen/POW03037USEN.PDF
- Migration combinations of processor compatibility modes for active Partition Mobility
  http://publib.boulder.ibm.com/infocenter/powersys/v3r1m5/topic/p7hc3/iphc3pcmcombosact.htm
- Advance Toolchain for Linux website
  http://www.ibm.com/developerworks/wikis/display/hpccentral/How+to+use+Advance+Toolchain+for+Linux+on+POWER

Online resources

These websites are also relevant as further information sources:

- IBM Power Systems Hardware Information Center
  http://publib.boulder.ibm.com/infocenter/systems/scope/hw/index.jsp
- IBM System Planning Tool website
  http://www.ibm.com/systems/support/tools/systemplanningtool/
- IBM Fix Central website
  http://www.ibm.com/support/fixcentral/
- Power Systems Capacity on Demand website
  http://www.ibm.com/systems/power/hardware/cod/

- Support for IBM Systems website

  http://www.ibm.com/support/entry/portal/Overview?brandind=Hardware~Systems~Power

- IBM Power Systems website

  http://www.ibm.com/systems/power/

- IBM Storage website

  http://www.ibm.com/systems/storage/

Help from IBM

IBM Support and downloads

ibm.com/support

IBM Global Services

ibm.com/services

IBM Power 770 and 780 Technical Overview and Introduction

Redpaper™

Features the 9117-MMC and 9179-MHC based on the latest POWER7 processor technology

Describes MaxCore and TurboCore for redefining performance

Discusses Active Memory Mirroring for Hypervisor

This IBM Redpaper publication is a comprehensive guide covering the IBM Power 770 (9117-MMC) and Power 780 (9179-MHC) servers supporting IBM AIX, IBM i, and Linux operating systems. The goal of this paper is to introduce the major innovative Power 770 and Power 780 offerings and their prominent functions, including:

- The IBM POWER7 processor available at frequencies of 3.3 GHz, 3.44 GHz, 3.72 GHz, and 3.92 GHz, and 4.14 GHz
- The specialized IBM POWER7 Level 3 cache that provides greater bandwidth, capacity, and reliability
- The 1 Gb or 10 Gb Integrated Multifunction Card that provides two USB ports, one serial port, and four Ethernet connectors for a processor enclosure and does not require a PCI slot
- The new Active Memory Mirroring (AMM) for Hypervisor feature that mirrors the main memory used by the firmware
- IBM PowerVM virtualization, including PowerVM Live Partition Mobility and PowerVM Active Memory Sharing
- Active Memory Expansion that provides more usable memory than what is physically installed on the system
- IBM EnergyScale technology that provides features such as power trending, power-saving, capping of power, and thermal measurement
- Enterprise-ready reliability, serviceability, and availability

Professionals who want to acquire a better understanding of IBM Power Systems products should read this paper. This paper expands the current set of IBM Power Systems documentation by providing a desktop reference that offers a detailed technical description of the Power 770 and Power 780 systems.

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