Power Systems Hardware: Today and Tomorrow

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POWER8 Chip
Processor Technology Roadmap

- **POWER4**: 180 nm, 130 nm, 90 nm
  - 2001
- **POWER5**: 65 nm
  - 2004
- **POWER6**: 45 nm
  - 2007
- **POWER7**: 22 nm
  - 2010
- **POWER8**
  - 2014
- **POWER9**: Or whatever it is named
- **POWER10**: Or whatever it is named
- **POWER11**: Or whatever it is named

Future
## Processor Chip Comparisons

<table>
<thead>
<tr>
<th>Technology</th>
<th>POWER5 2004</th>
<th>POWER6 2007</th>
<th>POWER7 2010</th>
<th>POWER7+ 2012</th>
<th>POWER8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology</strong></td>
<td>130nm SOI</td>
<td>65nm SOI</td>
<td>45nm SOI eDRAM</td>
<td>32nm SOI eDRAM</td>
<td>22nm SOI eDRAM</td>
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<tr>
<td><strong>Compute</strong></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Cores</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Threads</td>
<td>SMT2</td>
<td>SMT2</td>
<td>SMT4</td>
<td>SMT4</td>
<td>SMT8</td>
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<tr>
<td><strong>Caching</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-chip</td>
<td>1.9MB (L2)</td>
<td>8MB (L2)</td>
<td>2 + 32MB (L2+3)</td>
<td>2 + 80MB (L2+3)</td>
<td>6 + 96MB (L2+3)</td>
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<tr>
<td>Off-chip</td>
<td>36MB (L3)</td>
<td>32MB (L3)</td>
<td>None</td>
<td>None</td>
<td>128MB (L4)</td>
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<tr>
<td><strong>Bandwidth</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Sust. Mem.</td>
<td>15GB/s</td>
<td>30GB/s</td>
<td>100GB/s</td>
<td>100GB/s</td>
<td>230GB/s</td>
</tr>
<tr>
<td>Peak I/O</td>
<td>6GB/s</td>
<td>20GB/s</td>
<td>40GB/s</td>
<td>40GB/s</td>
<td>96GB/s</td>
</tr>
</tbody>
</table>
# Processor Designs

<table>
<thead>
<tr>
<th></th>
<th>POWER5+</th>
<th>POWER6</th>
<th>POWER7</th>
<th>POWER7+</th>
<th>POWER8</th>
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</thead>
<tbody>
<tr>
<td>Max cores</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>12</td>
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<tr>
<td>Technology</td>
<td>90nm</td>
<td>65nm</td>
<td>45nm</td>
<td>32nm</td>
<td>22nm</td>
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<tr>
<td>Size</td>
<td>245 mm²</td>
<td>341 mm²</td>
<td>567 mm²</td>
<td>567 mm²</td>
<td>650 mm²*</td>
</tr>
<tr>
<td>Transistors</td>
<td>276 M</td>
<td>790 M</td>
<td>1.2 B</td>
<td>2.1 B</td>
<td>4.2 B *</td>
</tr>
<tr>
<td>Frequencies</td>
<td>1.9 GHz</td>
<td>4 - 5 GHz</td>
<td>3 – 4 GHz</td>
<td>Up to 4.4 GHz</td>
<td>Up to 4.1 GHz **</td>
</tr>
<tr>
<td>SMT (threads)</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>L2 Cache</td>
<td>1.9MB Shared</td>
<td>4MB / Core</td>
<td>256KB / core</td>
<td>256KB / core</td>
<td>512KB/core</td>
</tr>
<tr>
<td>L3 Cache</td>
<td>36MB</td>
<td>32MB</td>
<td>4MB / Core On chip</td>
<td>10MB / Core On chip</td>
<td>8MB / Core On chip</td>
</tr>
<tr>
<td>L4 Cache</td>
<td>--</td>
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<td>--</td>
<td>--</td>
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</tr>
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</tr>
<tr>
<td>Sust memory</td>
<td>6GB/s</td>
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</table>

* with 12-core chip
** announced so far
# Processor Designs

<table>
<thead>
<tr>
<th>Feature</th>
<th>POWER4</th>
<th>POWER4+</th>
<th>POWER5</th>
<th>POWER5+</th>
<th>POWER6</th>
<th>POWER7</th>
<th>POWER7+</th>
<th>POWER8</th>
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<tr>
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<td>22nm</td>
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<td>Size</td>
<td>412mm²</td>
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* with 12-core chip
Innovation Drives Performance

- IBM plans for future 22 nm technology are subject to change.
POWER8 Chip Packaging

Technology
- 22nm SOI, eDRAM, 650mm2
- 15-layers = great bandwidth
World Class 22nm Semiconductor Technology

Silicon On Insulator
- Faster Transistor, Less Noise

On-chip eDRAM
- 6x latency improvement
- No off-chip signaling rqmt
- 8x bandwidth improvement
- 3x less area than SRAM
- 5x less energy than SRAM

22nm eDRAM Cell

Dense interconnect
- Faster connections
- Low latency distance paths
- High density complex circuits
- 2X wire per transistor
IBM 22nm Technology

Low level wires used for dense local circuit interconnect.

Top level wires used for power distribution, clocks, and off-chip signaling.
POWER8 Chip Packaging

**Cores**
- 12 cores (SMT8)
- 8 dispatch, 10 issue, 16 exec pipe
- 2X internal data flows/queues
- Enhanced prefetching

**Caches**
- 64K Data cache (L1)
- 512 KB SRAM L2 / core
- 96 MB eDRAM shared L3
- Up to 128 MB eDRAM L4 (off-chip)

**Accelerators**
- Crypto & memory expansion
- Transactional Memory
- Data Move / VM Mobility

**Bus Interfaces**
- Integrated PCIe Gen3
- SMP Interconnect
- CAPI

**Energy Management**
- On-chip Power Management Micro-controller
- Integrated Per-core VRM
- Critical Path Monitors

**Memory**
- Dual memory Controllers
- 230 GB/sec Sustained bandwidth
POWER8 Memory Buffer Chip

Intelligence Moved into Memory
• Previously on POWER7+ chip onto buffer

Processor Interface
• High speed interface

Performance Value
Memory Bandwidth per Socket

- POWER7
- POWER6
- POWER5

GB/Sec
Memory Bandwidth per Socket

POWER5
POWER6
POWER7

GB/Sec

Reset the scale
POWER8 Memory Bandwidth per Socket

GB/Sec

POWER8
POWER7
POWER6
POWER5
POWER8 Integrated PCI Gen 3

POWER7 Chip

I/O Bridge

GX Bus

PCIe Gen2

PCI Devices

POWER8 Chip

PCle Gen3

PCI Device
Power 770/780 Node I/O Bandwidth
(System node or processor enclosure or CEC drawer)
Power 770/780 Node I/O Bandwidth
(System node or processor enclosure or CEC drawer)

POWER6 570
POWER7 770
POWER7+ 770

GB/Sec

Reset the scale
E870/E880 Node I/O Bandwidth
(System node or processor enclosure or CEC drawer)
IO Bandwidth Comparing 2-Socket Servers

- POWER6
- POWER7
- POWER7+
- POWER8

GB/Sec

Reset the scale
POWER8 IO Bandwidth Comparing 2-Socket Servers

- POWER8
- POWER7+
- POWER7
- POWER6

GB/Sec

0 50 100 150 200
POWER8 CAPI  (Coherent Accelerator Processor Interface)

Customizable Hardware / Application Accelerator
- Specific system SW, middleware, or user application
- Written to durable interface

Like an “extra” core for the POWER8 chip

FPGA or ASIC
First CAPI Solution Example

High speed, fast response, social application – example Twitter

Enabled by in-memory NoSQL, distributed hash tables

Was initially implemented on x86 servers, but limited DRAM memory meant LOTS of servers resulting in a costly, complex infrastructure

24 : 1

One 2-socket, 2U server PLUS one FlashSystem Drawer replaced 24 x86 servers

- Much lower cost of acquisition
- Much smaller foot print, less energy
- Much lower operational cost
Example: CAPI Attached Flash Optimization

Application

Read/Write Syscall

FileSystem

strategy()

iodone()

LVM

strategy()

iodone()

Disk & Adapter DD

Pin buffers,
Translate,
Map DMA,
Start I/O

Interrupt,
unmap,
unpin, iodone

scheduling

20K Instructions
Example: CAPI Attached Flash Optimization

- Issues Read/Write Commands from applications to **eliminate 97% of instruction path length**
- CAPI Flash controller Operates in User Space
- Saves 10 Cores per 1M IOPs
POWER8 Leapfrogs

Memory Bandwidth

I/O Bandwidth

PCle Gen3

PLUS ....

- CAPI
- Accelerators
- Transactional Memory
- Scaleability
- Smart use of energy
- ... and more
## Scale-out CPW Comparisons

### 720 POWER7+ (1 socket)
- 4-core 3.6 GHz  28,400
- 6-core 3.6 GHz  42,400
- 8-core 3.6 GHz  56,300

### S814 (1 socket)
- 4-core 3.0 GHz  39,500
- 6-core 3.0 GHz  59,500
- 8-core 3.7 GHz  85,500

### 740 POWER7+ (1 or 2 socket)
- 6-core 4.2 GHz  49,000
- 12-core 4.2 GHz  91,700
- 8-core 3.6 GHz  56,300
- 16-core 3.6 GHz  106,500
- 8-core 4.2 GHz  64,500
- 16-core 4.2 GHz  120,000

### S824 (1 or 2 socket)
- 6-core 3.8 GHz  72,000
- 12-core 3.8 GHz  130,000
- 8-core 4.1 GHz  94,500
- 16-core 4.1 GHz  173,500
- 12-core 1-socket not offered
- 24-core 3.5 GHz  230,500

+40%  +50% ~ GHz  +60%  +90%
### POWER7+ 770
- 16-core 3.8 GHz  110,000
- 32-core 3.8 GHz  191,500
- 48-core 3.8 GHz  290,500
- 64-core 3.8 GHz  379,300
- 12-core 4.2 GHz  90,000
- 24-core 4.2 GHz  154,800
- 36-core 4.2 GHz  242,600
- 48-core 4.2 GHz  306,600

### E870
- 32-core 4.02 GHz  359,000
- 64-core 4.02 GHz  711,000
- 40-core 4.19 GHz  460,000
- 80-core 4.19 GHz  911,000

+87% ~ GHz, fewer core ~ GHz
+50% ~ GHz, fewer core ~ GHz
+80% per core ~ GHz

### POWER7+ 780
- 16-core 4.4 GHz  123,500
- 32-core 4.4 GHz  214,000
- 48-core 4.4 GHz  326,100
- 64-core 4.4 GHz  424,400
- 32-core 3.7 GHz  209,500
- 64-core 3.7 GHz  414,900
- 96-core 3.7 GHz  622,300
- 128-core 3.7 GHz  829,800

### E880
- 32-core 4.35 GHz  381,000
- 64-core 4.35 GHz  755,000
- 96-core 4.35 GHz  1,144,000
- 128-core 4.35 GHz  1,523,000
- 48-core 4.02 GHz  518,000
- 96-core 4.02 GHz  1,034,000
- 144-core 4.02 GHz  1,551,000
- 192-core 4.02 GHz  2,069,000

Measured using SMT8
SMT4 would be somewhat lower

+150%
### POWER7 795

- 48-core 3.7 GHz     288,500
- 96-core 3.7 GHz
- 144-core 3.7 GHz
- 192-core 3.7 GHz
- 64-core 4.0 GHz     399,200
- 128-core 4.0 GHz
- 192-core 4.0 GHz
- 256-core 4.0 GHz
- 32-core 4.25 GHz    218,400
- 64-core 4.25 GHz
- 96-core 4.25 GHz
- 128-core 4.25 GHz

### E880

- 32-core 4.35 GHz    381,000
- 64-core 4.35 GHz    755,000
- 96-core 4.35 GHz    1,144,000
- 128-core 4.35 GHz   1,523,000
- 48-core 4.02 GHz    518,000
- 96-core 4.02 GHz    1,034,000
- 144-core 4.02 GHz   1,551,000
- 192-core 4.02 GHz   2,069,000

Measured using SMT8
SMT4 would be somewhat lower
“Single-thread-oriented” Workloads and POWER8 Technology

Good news

Because per core performance improving ..

Compared to POWER7/POWER7+, POWER8 chips with similar GHz run 20-25% faster from a wall clock perspective …… ASSUMING NOT I/O BOUND
A New Generation of IBM Power Systems

Open Innovation to put data to work

- Designed for Big Data
- Superior Cloud Economics
- Open Innovation Platform
OpenPOWER Consortium

- Collaborative innovation for highly advanced systems
- Produce open hardware, software, firmware and tools
- Expand industry skills and investment for Power ecosystem
- Provide alternative architectures
Google® Mother Board using POWER8 Technology

Development board previewed by Google at April 2014 POWER8 announcement
Building collaboration and innovation at all levels

Complete member list at
www.openpowerfoundation.org
OpenPower Article in eWEEK - March 2015

OpenPower Group Puts Initial Hardware Products on Display

By Jeffrey Burl | Posted 2015-03-19 | Print

SAN JOSE, Calif.—OpenPower Foundation officials used the group's first conference to show off more than a dozen new pieces of hardware from its members, to talk about how the consortium operates and try to recruit new members, and to position itself as an alternative to Intel in the data center. OpenPower was launched in December 2013 as a way of leveraging IBM's Power architecture to build products that address demands from hyperscale and Web-scale organizations for greater performance and efficiency. IBM has opened the Power architecture to allow the more than 110 OpenPower members to build products atop the platform. At the OpenPower Summit here—run in conjunction with the GPU Technology Conference 2015—foundation officials stressed that the open development business model enables faster innovation than Intel's way of doing the design, development, and manufacturing work itself. "Without a community, we don't get innovation," said Randall Ross, a foundation official and Ubuntu Core engineer. "This is a community that's built around the idea that we need to build something better together. We need to build something that's not just an improvement over what we're currently doing, but something that's new and different and exciting."

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1Q 2014 Portfolio: POWER7/POWER7+

Power 710+/730+
Power 720+/740+
Power 750+/760+
Power 770+
Power 780+
Power 795

IBM PureFlex System
P460+
p260+
p24L
2Q 2014 Portfolio: POWER8/POWER7/POWER7+

POWER8 Scale-out Servers

POWER8 Scale-out Servers

IBM PureFlex System

Power 795

Power 780+

Power 770+

Power 750+/760+

PowerLinux 7R4+

P460+

p260+

p24L
4Q 2014 Portfolio: POWER8/POWER7/POWER7+

POWER8 Scale-out Servers
- Power 710+/730+
- Power 740+/760+
- PowerLinux 7R4+

POWER8 Enterprise Servers
- Power 750+/760+

IBM PureFlex System
- P460+
- p260+
- p24L
2Q 2015 Portfolio: POWER8 /POWER7/POWER7+

POWER8 Enterprise Servers

POWER8 Scale-out Servers

POWER8 4-Socket

PowerLinux 7R4+

PurePower

IBM PureFlex System

p260+
p24L
4Q2015 Portfolio: POWER8

POWER8 Scale-out Servers

POWER8 Scale-out Servers

POWER8 Scale-out LC servers

POWER8 4-Socket

POWER8 Enterprise Servers

PurePower

p260+
p24L
POWER8 Product Line 4Q 2015

- Power S822
- Power S814, S824
- Power E870
- Power E850
- Power E880
- PurePower
  Built with Scale-out servers

- S812LC
- S822LC
- Power S812L
- S822L
- Power S824L
POWER8 Product Line – IBM i Focus

- Power S822
- Power S814, S824
- Power E870
- Power E850
- Power E880
- S812LC
- PurePower
  Built with Scale-out servers
- S822LC
- Power S812L
- Power S824L
Scale-out
Scale-out Servers  (LC line not shown)

- S824  (2 socket, 4U)
- S824L  (1 socket, 4U)
- S814  (1 socket, 4U)
- S812L  (1 socket, 2U)
- S822  (2 socket, 2U)
- S822L  (2 socket, 2U)
Linux Cluster Models Announcing October 2015

Bringing the benefits of the OpenPOWER Community to the IBM Power Systems Portfolio

Power S812LC

Linux-only server with rich memory and storage
Great fit for applications such as Hadoop
2U, 1 socket up to 10 cores, up to 1TB memory, up to 14 disk/SSD (up to 112TB), 4 PCIe slots
Power KVM or bare metal

Power S822LC

Linux-only server with rich memory a focus on GPU capability
2U, 2 socket up to 20 cores, up to 1TB memory, up to two GPU, 5 PCIe slots
Power KVM or bare metal
Scale-out Servers with IBM i support  (or AIX/Linux support)

**S814**  (1 socket, 4U)
- 4 core  (P05 IBM i software tier)
- 6 or 8 core  (P10 IBM i software tier)

**S824**  (2 socket, 4U)
- 6/12 or 8/16 or 24 core
- P20 IBM i software tier

**S822**  (2 socket, 2U)
- 6/8/10 or 12/16/20 core
- P10 IBM i software tier
POWER8 4U 2-Socket Server

- 4U Form Factor
- 1 to 2 Sockets (Up 24 Cores)
- Up to 2TB Memory
  - With 8GB DDR3 DIMMs
- 11 PCIe Gen3 Slots / Hot Plug
  - Hot plug support
  - 1 PCIe slot reserved for Ethernet
- Up to 18 SFF Bays
  - Optional RAID support
- Up to 8 1.8” SSDs
- Integrated PCIe Gen3 SAS controller w/ optional write cache
2S2U Scale-out System

Power S822

- Single Socket populated
  - Cores: 6 (3.8 GHz) or 10 (3.4 GHz) or 8 (4.1 GHz)
  - Memory: Up to 512 GB *
  - PCIe Slots: 6 PCIe Gen3 LP (Hotplug)

- Both Sockets populated
  - Cores: 12 (3.8 GHz) or 20 (3.4 GHz) or 16 (4.1 GHz)
  - Memory: Up to 1 TB *
  - PCIe Slots: 9 PCIe Gen3 LP (Hotplug)

- Ethernet: Choice of 1Gb or 10Gb PCIe adapter
- Integrated ports: USB (4), Serial (1), HMC (2)
- Internal Storage
  - DVD
  - 12 SFF Bays -- Split Backplane: 6 + 6
  - or 8 SFF Bays & 6 1.8” SSD Bays with Easy Tier with 7GB write cache

- Hypervisor: PowerVM
- OS: AIX, Linux (IBM i added Oct 2015)

* Half this memory maximum with 4.1GHz cores (no 64GB DIMMs) due to air cooling limitations. See following chart with additional cooling limitations and for SOD for water cooling.
POWER8 4U Scale-out System

Power S814/S824
- Form Factor: 4U or Tower*
- One or two sockets **
  - Cores: 1 socket: 4–8, 2 socket: 6-24
  - GHz: 3.0 – 4.1
- Memory: Up to 1TB per socket***
- PCIe Slots: 7 or 11 PCIe Gen3 Full-high (Hotplug)
  - PCIe I/O drawer: adds up to 20 more slots (Hotplug)**
- Integrated Storage
  - POWERFUL SAS controllers – up to 7GB cache
  - 12 – 18 SFF Bays*** + 8 SSD Bays****
  - Optional add 24 more SAS bays***
  - DVD
- Hypervisor: PowerVM
- OS: AIX, IBM i, Linux
  - IBM i 7.1 or later (P05 – P20 software tier)

* Tower only for 4-core or 6-core S814
** See model specifics for valid combinations of sockets, cores, GHz
*** 4-core S814 has entry level server limitation
**** 8 SSD bays only with 2-socket server
POWER8 1S4U Scale-out System

Power S814

- Form Factor: 4U or Tower
- Single Socket
  - Cores: 4 (3.0 GHz), 6 (3.0 GHz) or 8 (3.7 GHz)
  - Memory: Up to 512 GB (6-core or 8-core)
  - Slots: 7 PCIe Gen3 Full-high (Hotplug)

- PCIe Gen3 I/O Drawer adds 10 PCIe slots (6-core or 8-core)
- Ethernet: Quad 1 Gbt in PCIe slot
- Integrated ports: USB (4/5), Serial (1), HMC (2)
- Internal Storage
  - DVD
  - 12 SFF Bays -- Split Backplane: 6 + 6
  - or 18 SFF Bays with 7GB write cache

- Hypervisor: PowerVM
- OS: AIX, IBM i 7.1 or later (P05/P10 software tier), Linux

3 Yr Warranty
POWER8 2S4U Scale-out System

Power S824

- Single Socket populated
  - Cores: 6 (3.8 GHz) or 8 (4.1 GHz)
  - Memory: Up to 1TB
  - Slots: 7 PCIe Gen3 full-high (Hotplug)

- Both Sockets populated
  - Cores: 12 (3.8 GHz), 16 (4.1 GHz), or 24 (3.5 GHz)
  - Memory: Up to 2TB
  - Slots: 11 PCIe Gen3 full-high (Hotplug)

- * PCIe Gen3 I/O drawer adds up to 20 PCIe slots
- Ethernet: Quad 1 Gbt in PCIe slot
- Integrated ports: USB (4/5), Serial (1), HMC (2)
- Internal Storage
  - DVD
  - 12 SFF Bays -- Split Backplane: 6 + 6
  - or 18 SFF bays & 8 SSD bays with 7GB write cache

- Hypervisor: PowerVM
- OS: AIX, IBM i 7.1 or later (P20 software tier), Linux

3 Yr Warranty
## POWER8 4U 2-Socket Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>Power 740</th>
<th>POWER8 4U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>POWER7+</td>
<td>POWER8 4U</td>
</tr>
<tr>
<td>Sockets</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Cores</td>
<td>12 / 16</td>
<td>16 / 20 / 24</td>
</tr>
<tr>
<td>Maximum Memory</td>
<td>1 TB @ 1066 MHz</td>
<td>2 TB @ 1600 MHz</td>
</tr>
<tr>
<td>Memory Cache</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Memory Bandwidth</td>
<td>68 GB/sec</td>
<td>200 GB/sec</td>
</tr>
<tr>
<td>Memory DRAM Spare</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>IO Expansion Slots</td>
<td>Dual GX++</td>
<td>4 PCIe x16 G3 (SOD)</td>
</tr>
<tr>
<td>PCIe slots</td>
<td>5 PCIe x8 FH</td>
<td>7 PCIe x8 FH</td>
</tr>
<tr>
<td></td>
<td>4 PCIe x8 HH (opt)</td>
<td>4 PCIe x16 FH</td>
</tr>
<tr>
<td>PCIe Hot Plug Support</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>IO bandwidth</td>
<td>60 GB/sec</td>
<td>192 GB/sec</td>
</tr>
<tr>
<td>Base* Ethernet ports</td>
<td>Four 1 Gb</td>
<td>Four 1Gb or Two 10 Gb</td>
</tr>
<tr>
<td>SSD-only bays</td>
<td>N/A – use SFF bays</td>
<td>Up to 8 1.8-inch bays</td>
</tr>
<tr>
<td>SFF bays</td>
<td>6</td>
<td>12 or 18</td>
</tr>
<tr>
<td>Integrated SAS controller</td>
<td>PCIe Gen1 base</td>
<td>PCIe Gen3 base</td>
</tr>
<tr>
<td>SR-IOV Support</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Service Processor</td>
<td>Generation 1</td>
<td>Generation 2</td>
</tr>
</tbody>
</table>

* Base uses one PCIe slot
2S2U Scale-out System

**Power S822**

- **Single Socket populated**
  - Cores: 6 (3.8 GHz) or 10 (3.4 GHz) or 8 (4.1 GHz)
  - Memory: Up to 512 GB *
  - PCIe Slots: 6 PCIe Gen3 LP (Hotplug)

- **Both Sockets populated**
  - Cores: 12 (3.8 GHz) or 20 (3.4 GHz) or 16 (4.1 GHz)
  - Memory: Up to 1 TB *
  - PCIe Slots: 9 PCIe Gen3 LP (Hotplug)

- Ethernet: Choice of 1Gb or 10Gb PCIe adapter
- Integrated ports: USB (4), Serial (1), HMC (2)
- Internal Storage
  - DVD
  - 12 SFF Bays -- Split Backplane: 6 + 6
  - or 8 SFF Bays & 6 1.8” SSD Bays with Easy Tier with 7GB write cache

- Hypervisor: PowerVM
- OS: AIX, Linux (IBM i added Oct 2015)

* Half this memory maximum with 4.1GHz cores (no 64GB DIMMs) due to air cooling limitations. See following chart with additional cooling limitations and for SOD for water cooling.

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**Power S822 and IBM i**

- **IBM i 7.2 TR3 or IBM i 7.1 TR11**
- **Special terms/conditions**
  - Only P10 software tier  (P20 used on 2-socket S824)
  - S822 with or without PurePower
  - Max 2 cores per partition -- multiple partitions per server supported
  - All IBM i I/O virtualized through VIOS. No non-VIOS I/O.
    - No Async/Bisync PCIe adapters  (can use IBM i 7.2 with OEM LAN-attached box for Async including Fax/400)
    - No Crypto cards
    - If using disk/SSD in system unit or EXP24S I/O drawer for IBM i it must use 4k byte sectors, not 5xx byte sectors
- **CBU feature #0444 not announced Oct 2015**

Plus normal 2U limitations of smaller physical server vs 4U server -- smaller memory, fewer PCIe slots, fewer PCIe I/O drawers, subset of PCIe I/O card as full-high cards won’t fit including any PCIe SAS adapters with write cache.

Minimum code levels required: IBM i 7.2 TR 3 or IBM i 7.1 TR 11, VIOS 2.2.3.52, FW 840, if using HMC then HMC 840
Enterprise
Power E850 / E870 / E880 Enterprise Characteristics

- Increased performance and scale compared to previous generation servers
- Capacity on Demand
  - Elastic CoD
  - Utility CoD
  - Trial CoD
- Power Integrated Facility for Linux
- Active Memory Mirroring for Hypervisor *
- E870/E880: Power Enterprise Pools
- E870/E880: PowerVM Enterprise included
- E880: Large block no-charge days with initial purchase

* optional for E850
Capacity on Demand for E870/E880

- Processor cores and/or memory activations

- Separating activation pricing from physical hardware
  - Makes redundant hardware more affordable
  - Eases budgeting – buy when needed
  - Reduces planned downtime outages for upgrades

- Elastic CoD / Utility Cod
  - Use activations “by the day” or “by the minute” as needed
  - Elastic: pay quarterly if use; Utility pay after usage
  - Elastic example for Power E870 – 4.19 GHz
    - 1 add’l core + 16GB memory
    - 1 add’l cores licensing for IBM i and for other IBM Power System’s controlled software
    - 1 add’l core’s worth of 5250
    - ONLY $196 per day

Prices are USA list price and are subject to change. Reseller prices may vary. Note if other GHz core are used, list price can vary slightly. Add’l memory is $1 per GB. 5250 inclusion assumes at least one 5250 Enterprise Enablement already on the server.
Power Enterprise Pools for E870/E880

Power E870 & 770+ Pool
- Max 48 servers
- In the same country
- Running 7.8 firmware or later
- Running any supported OS
- Max 1000 partitions

Power E880 & 780+ & 795 Pool
- Max 32 servers
- In the same country
- Running 7.8 firmware or later
- Running any supported OS
- Max 1000 partitions

Move processor and memory activations within a defined pool
Move quickly, dynamically, non-disruptively
Move at your convenience – without contacting IBM

PLUS also move specific Power software licensing entitlements
Power Integrated Facility for Linux

- For enterprise servers with processor cores and memory not permanently activated
  - Model E870 & Model E880
  - Model 770 & Model 780 & 795

- Package of activations & licensing
- Usable only for Linux workload

- Priced competitively vs. equivalent Linux stand-alone server

- Savings via lower priced activations, maintenance & licensing for Linux-only resource

*Example includes:*
- 4 cores activation
- 32 GB activations
- 4 PowerVM for Linux entitlements
- 4 RedHat Linux
- 3 yr 24x7 HWMA/SWMA

Prices are USA list price and are subject to change. Reseller prices may vary.
Why not provide IBM i support on Power E850?
750 vs S824 Hardware Comparison Highlights

- **CPW:** Given most IBM i clients who are using a Power 750 are using smaller configurations, there is lots of CPW growth in Power S824

- **Memory:** S824 has 4x more memory capacity – and it is 50% faster memory (1600MHz with L4 cache VS 1066MHz)

- **PCIe:**
  - S824 has newer, higher bandwidth PCIe Gen3 slots
  - Without considering PCIe I/O drawer, S824 has more PCIe slots
  - With PCIe I/O drawer, S824 has a very good number of high bandwidth slots (31), though less than the number of 750 2-4 socket maximum
  - S824 supports SR-IOV NIC

- **Integrated Storage**
  - S824 has optional integrated SAS controller with 7GB effectively write cache, more than 40X 750’s 175MB.
  - S824 has up to 26 SAS bays in system unit for HDD/SSD. 3X more than 750
  - S824 can have up to 50 SAS bays run by integrated SAS controllers 6X more than 750
POWER7 750 (B mdl) vs POWER8 S824

CPW

Except perhaps for the 32-core Power 750 – lot’s of room for CPW growth.
Power E870 & E880 Servers

Power E870:
- Up to 80 cores
- 256 to 8TB Memory
- 1 or 2 nodes per system

Power E880:
- Up to 192 cores @ 4.02 GHz
- 256 to 16TB Memory
- 1 to 4 nodes per system

✓ Enterprise RAS even for 1-node system
  - System Control Unit (“midplane”)
✓ Medium software tier
✓ 24x7 1-year warranty
POWER8 Enterprise Solutions

Architecture

Packaging
POWER8 Enterprise Solutions

No Primary Node
Midplane
- Service Processors
- Clocks
- Oscillators
Large Memory

19” Rack
Modular design
Up to 4 CEC drawers
Blindswap IO Adapters
POWER8 Processor Enclosure (CEC Drawer)

- Up to 32 DIMMs
- Up to 4TB
- PCIe Cassettes (contain PCIe adapter or Optical Interface to I/O drawer)
- POWER8 processors / Heat sinks
- Fans
- Power Supplies
- Linecord Assemblies
- 5U Enclosure
Power E870: 1 or 2 Nodes

12U in 19” rack

Node

MidPlane

Node
Power E880: 1, 2, 3 or 4 Nodes

22U in 19” rack

Node

Node

MidPlane

Node

Node

3- and 4-node configurations planned availability June 2015
Power Scale Perspective

Power 770

Power 780

Power 795
## POWER8 E870 Compares: 2-Node/Drawer System

<table>
<thead>
<tr>
<th></th>
<th>9117-MMD Power 770</th>
<th>POWER8 Enterprise 2 CEC Node-drawer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU Sockets per Node/Drawer</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Max processor nodes/Drawers</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Max number sockets</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Max Cores</td>
<td>64</td>
<td>64 or 80</td>
</tr>
<tr>
<td>Max Frequency</td>
<td>3.8 GHz</td>
<td>4 or 4.19 GHz</td>
</tr>
<tr>
<td>Max Memory</td>
<td>1 TB per CEC Drw</td>
<td>4 TB per CEC Drw</td>
</tr>
<tr>
<td>Memory per core</td>
<td>64 GB</td>
<td>62 or 50 GB</td>
</tr>
<tr>
<td>Memory Bandwidth (peak)</td>
<td>272 GB/s per CEC Drw</td>
<td>922 GB/s per CEC Drw</td>
</tr>
<tr>
<td>I/O Bandwidth (peak)</td>
<td>80 GB/s per CEC Drw (GX)</td>
<td>256 GB/s per CEC Drw (PCIe Gen3)</td>
</tr>
<tr>
<td>Max PCIe I/O drws</td>
<td>16 (4 per Node)</td>
<td>8 (4 per Node)</td>
</tr>
<tr>
<td>Max PCIe I/O Slots</td>
<td>160 - in IO drws</td>
<td>96 – in IO drws</td>
</tr>
<tr>
<td></td>
<td>24 - internal</td>
<td>0 - internal</td>
</tr>
<tr>
<td>IBM i levels supported</td>
<td>IBM i 6.1 and later</td>
<td>IBM i 7.1 and later</td>
</tr>
</tbody>
</table>

* SOD = statement of direction – represents IBM plans shared publicly. As always plans subject to change.
## POWER8 E880 Compares: 4-Node/Drawer System

<table>
<thead>
<tr>
<th></th>
<th>9117-MMD Power 770</th>
<th>9179-MHD Power 780</th>
<th>POWER8 Enterprise 4 CEC Node-drawer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU Sockets per Node/Drawer</strong></td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Max processor nodes/Drawers</strong></td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Max number sockets</strong></td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td><strong>Max Cores</strong></td>
<td>64</td>
<td>128</td>
<td>192</td>
</tr>
<tr>
<td><strong>Max Frequency</strong></td>
<td>3.8 GHz</td>
<td>3.7 GHz</td>
<td>4.35</td>
</tr>
<tr>
<td><strong>Max Memory</strong></td>
<td>1 TB per CEC Drw</td>
<td>1 TB per CEC Drw</td>
<td>4 TB per CEC Drw</td>
</tr>
<tr>
<td><strong>Memory per core</strong></td>
<td>64 GB</td>
<td>32 GB</td>
<td>128 or 85 GB</td>
</tr>
<tr>
<td><strong>Memory Bandwidth (peak)</strong></td>
<td>272 GB/s per CEC Drw</td>
<td>272 GB/s per CEC Drw</td>
<td>922 GB/s per CEC Drw</td>
</tr>
<tr>
<td><strong>Memory Bandwidth per core (peak)</strong></td>
<td>17 GB/sec</td>
<td>8.5 GB/sec</td>
<td>19 GB/sec</td>
</tr>
<tr>
<td><strong>I/O Bandwidth (peak)</strong></td>
<td>80 GB/s per CEC Drw (GX)</td>
<td>80 GB/s per CEC Drw (GX)</td>
<td>256 GB/s per CEC Drw (PCIe Gen3)</td>
</tr>
<tr>
<td><strong>Max PCIe I/O drws</strong></td>
<td>16 (4 per Node)</td>
<td>16 (4 per Node)</td>
<td>16 (4 per Node)</td>
</tr>
<tr>
<td><strong>Max PCIe I/O Slots</strong></td>
<td>160 - in IO drws 24 - internal</td>
<td>160 - in IO drws 24 - internal</td>
<td>192</td>
</tr>
<tr>
<td><strong>IBM i levels supported</strong></td>
<td>IBM i 6.1 and later</td>
<td>IBM i 6.1 and later</td>
<td>IBM i 7.1 and later</td>
</tr>
</tbody>
</table>
PCle I/O
Drawer
POWER8 PCIe Gen3 IO Drawer

- 4U in standard 19” rack
- 6 or 12 PCIe Gen3 slots
  - Full-High, Full-Length
  - 1/3rd x16 slots and 2/3rd x8 slots
- Dual fiber optic cables connect to POWER8 CEC
  - Connects to x16 slot in CEC
IO Bandwidth (Comparing I/O Drawers)

Total drawer GB/Sec

POWER8
#EMX0
One PCIe Gen3 Drawer (12 PCIe slots)

POWER7+
#5877
10 or 20 slots

POWER8 PCIe-attached Gen3 I/O drawer has two fan-out modules and each fan-out module has 32GB/s

POWER7 12X-attached PCIe I/O drawer = #5877 or #5802
One or two #5877 or #5802 can share a single GX++ slot's 20GB/s bandwidth
### I/O Loop (GX+) Technology Transitions

<table>
<thead>
<tr>
<th>POWER5</th>
<th>POWER6</th>
<th>POWER7</th>
<th>POWER8</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSL / RIO w/ PCI-X</td>
<td>HSL / RIO w/ PCI-X</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>12X SDR w/ PCI-X</td>
<td>12X SDR w/ PCI-X</td>
<td>12X SDR w/ PCI-X</td>
<td>---</td>
</tr>
<tr>
<td>12X DDR w/ PCIe</td>
<td>12X DDR with PCIe</td>
<td>12X DDR with PCIe</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PCIe3</td>
</tr>
</tbody>
</table>
Model Upgrades (Same Serial Number)

POWER6 → POWER7 → POWER8

- POWER6:
  - 595
  - 570
  - 560
  - 550
  - 520 4-core
  - 520 2-core
  - 520 1-core

- POWER7:
  - 795
  - 780
  - 770
  - 750
  - 740
  - 720 6/8 core
  - 720 4 core
  - 730
  - 710

- POWER8:
  - E880
  - E870
  - E850

Scale-out 1S / 2S
770/780 Model Upgrades (Same Serial Number)
DAS or SAN?

- Both options are strategic
- Both options have their strengths
- Can use both options on the same server
- Application independent
  - Ignoring operational options
DAS & SAN - Two Good Options

- Both options are strategic
  - Both options have their strengths
  - Can use both options on the same server

**DAS**
Direct Attached Storage ("internal")
- Fastest (lower latency)
- Typically lower cost hardware/software
- Often simpler config
- Easy Tier function

**SAN**
Storage Area Network ("external")
- Fast
- Multi-server sharing
- Advanced functions/values
  - Flash Copy, Metro/Global Mirror, Live Partition Mobility, Easy Tier,
  - data deduplication, compression
### POWER8 SAS SFF HDD Options as of Nov 2015

<table>
<thead>
<tr>
<th>SFF-3 HDD</th>
<th>Block size</th>
<th>Formatted with 512 or 4096 byte sectors *</th>
<th>Formatted with 528 or 4224 byte sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>10k</td>
<td>5xx</td>
<td>300 GB *</td>
<td>283 GB</td>
</tr>
<tr>
<td>10k</td>
<td>5xx</td>
<td>600 GB *</td>
<td>571 GB</td>
</tr>
<tr>
<td>10k</td>
<td>5xx</td>
<td>1.2 TB *</td>
<td>1.1 TB</td>
</tr>
<tr>
<td>10k</td>
<td>4k</td>
<td>600 GB *</td>
<td>571 GB</td>
</tr>
<tr>
<td>10k</td>
<td>4k</td>
<td>1.2 TB *</td>
<td>1.1 TB</td>
</tr>
<tr>
<td>10k</td>
<td>4k</td>
<td>1.8 TB *</td>
<td>1.7 TB</td>
</tr>
<tr>
<td>15k</td>
<td>5xx</td>
<td>146 GB *</td>
<td>139 GB</td>
</tr>
<tr>
<td>15k</td>
<td>5xx</td>
<td>300 GB *</td>
<td>283 GB</td>
</tr>
<tr>
<td>15k</td>
<td>5xx</td>
<td>600 GB *</td>
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</tr>
<tr>
<td>15k</td>
<td>4k</td>
<td>300 GB *</td>
<td>283 GB</td>
</tr>
<tr>
<td>15k</td>
<td>4k</td>
<td>600 GB *</td>
<td>571 GB</td>
</tr>
</tbody>
</table>

* POWER8 SFF HDD shipped from IBM formatted in 528 or 4224 byte sectors. They can be reformatted to 512 or 4096 by the client if the extra protection is not desired.

4k drives (HDD or SSD) can NOT be reformatted to 5xx drives.

4k drives and 5xx drives can NOT be mixed on the same array. True for both HDD and SSD.
## POWER8 SAS SFF HDD Options as of Nov 2015

<table>
<thead>
<tr>
<th>SFF-3 HDD</th>
<th>Block size</th>
<th>Formatted with 512 or 4096 byte sectors *</th>
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</tr>
</thead>
<tbody>
<tr>
<td>10k 5xx</td>
<td>300 GB *</td>
<td>Smaller capacity drives approaching end of marketing life</td>
<td></td>
</tr>
<tr>
<td>10k 5xx</td>
<td>600 GB *</td>
<td>571 GB</td>
<td></td>
</tr>
<tr>
<td>10k 5xx</td>
<td>1.2 TB *</td>
<td>1.1 TB</td>
<td></td>
</tr>
<tr>
<td>10k 4k</td>
<td>600 GB *</td>
<td>571 GB</td>
<td></td>
</tr>
<tr>
<td>10k 4k</td>
<td>1.2 TB *</td>
<td>4k more strategic than 5xx</td>
<td></td>
</tr>
<tr>
<td>10k 4k</td>
<td>1.8 TB *</td>
<td>1.7 TB</td>
<td></td>
</tr>
<tr>
<td>15k 5xx</td>
<td>146 GB</td>
<td>Smaller capacity drives approaching end of marketing life</td>
<td></td>
</tr>
<tr>
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# eMLC SSD Generations

<table>
<thead>
<tr>
<th>2.5-inch (SFF)</th>
<th>IO OPERATIONS PER SECOND (IOPS)</th>
<th>Throughput (MB/s)</th>
<th>Latency - Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSD</td>
<td>Random Read</td>
<td>Random Write</td>
<td>Random Mixed Read/Write</td>
</tr>
<tr>
<td>Gen 1 177GB</td>
<td>15 k</td>
<td>4 k</td>
<td>11 k (70%-30%)</td>
</tr>
<tr>
<td>Gen 2 387GB</td>
<td>39 k</td>
<td>22 k</td>
<td>24 k (70%-30%)</td>
</tr>
<tr>
<td>Gen 3 387GB 775GB</td>
<td>80 k</td>
<td>49 k</td>
<td>58 k (60%-40%)</td>
</tr>
</tbody>
</table>

For grins … 15k rpm HDD

| 0.12 - 0.4 k | 0.12 - 0.4 k | 0.12 - 0.4 k | ~175 MB | ~175 MB | 8.3 – 2.5 ms |

Note these are single drive specific measurements reflecting sustained drive workloads (not burst). The values assume 528 byte sectors running RAID-0 with no protection. Hypothetically if measured with unsupported 512 byte sectors, values would be higher. The values are highly workload dependent. Factors such as read/write mix, random/non-random data, drive cache hits/misses, data compressibility in the drive controller, large/small block, type of RAID or mirroring protection, etc will change these values. The choice of which SAS controller/adapter is running the drive can also impact these values. These values produced by a server with plenty of processor, memory and controller resources to push this much I/O into the SSD. Most client system applications don’t push SSD nearly this hard. Latency measurements using OLTP1 60/40 random 4k transfers.
SSD Driving SAS Adapter Technology

Comparing large cache SAS Adapters

80k IOPS

400k IOPS

980k IOPS

PCI-X SAS
2Q 2009
Est 70-80k IOPS
Up to 48-60 HDD ....
Also can do some SSD

PCI SAS – PCIe Gen 2
4Q 2011
1st SAS adapter designed for SSD
300-400k IOPS
Up to 72 HDD
Up to 24 SSD

PCIe SAS – PCIe Gen 3
1Q 2014
Designed for newest SSD
800k-ish IOPS in Gen1 slot *
Nearly 1M IOPS in Gen2 slot
Up to 96 HDD
Up to 48 SSD

SAS adapter technology – designed by IBM Power Systems with Power Systems reliability, ruggedness, integrity, performance,
FlashSystem and IBM i Support

- Native support with IBM i 7.2 TR2 or later for FlashSystem 900 or

- Also supported when “behind” an SVC (including FlashSystem V9000 … “non-native”
Power Hardware Update

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