What would you do?

Performance  Cost
The only constant is change...
Houston, we have a problem...
IT Efficiency

1970’s
CLOCK ERA
Scaling Single thread

~2004
Multi-Core Multi-Thread

CLOUD ERA
The graph illustrates the evolution of IT efficiency over time, highlighting three major eras:

- **CLOCK ERA (1970's)**: Scaling Single Thread
- **CLOUD ERA (~2004)**: Multi-Core Multi-Thread
- **WOS ERA (~2015)**: Workload Optimised Systems

The X-axis represents time, with significant milestones indicating the transition from one era to another.
Introducing the OpenPOWER Foundation…
5 Founding members in 2013
What's OpenPOWER all about?

Vibrant ecosystem through open development

Accelerated innovation through collaboration of partners

Driving industry performance leadership

OpenPOWER is an open development community using the POWER Architecture
This is what a revolution looks like
Open allows you to create what you need
Cross community engagement drives mutual progress
What's so special about POWER anyway?
POWER8 Processor – the low down...

Up to 12 Cores, up to 96 Threads
L1, L2, L3 + L4 Caches
Up to 1 TB per socket
Up to 230 GB/s sustained memory bandwidth
## Workload accelerators and POWER

<table>
<thead>
<tr>
<th>Description</th>
<th>Field Programmable Gate Array</th>
<th>Graphics Processing Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Reconfigurable hardware</td>
<td>1000s of simple cores</td>
</tr>
<tr>
<td></td>
<td>Task customized, low latency, low power</td>
<td>High bandwidth, floating point, and parallelism</td>
</tr>
<tr>
<td><strong>Example Use Cases</strong></td>
<td>Compression, encryption, high speed streaming, search, Monte Carlo simulations</td>
<td>Deep neural networks, speech recognition, chemistry, simulations, JAVA, Hadoop, graphics</td>
</tr>
<tr>
<td><strong>Power Chip Integration</strong></td>
<td>Coherent Accelerator Processor Interface (CAPI)</td>
<td>NVIDIA NVLink</td>
</tr>
</tbody>
</table>

© 2016 OpenPOWER Foundation
NVIDIA NVLink Technology

NVIDIA Tesla GPU

NVIDIA Tesla GPU with NVLink

POWER8

PCIe x16

16+16 GB/s

System Memory

Graphics Memory

PCle GPU Attach

80 GB/s Peak*

40+40 GB/s

40+40 GB/s

POWER8 with NVLink

NVLink GPU Attachment

40+40 GB/s

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Typical I/O Model Flow

Flow with a Coherent Model

Coherent Accelerator Processor Interface (CAPI)
So what's new?
Vision

Opening the door, a license to innovate
Vision

Opening the door, a license to innovate

Execution

Game changing solutions

Incorporated December 2013

OpenPOWER Summit March 2015

OpenPOWER Summit April 2016
Vision

Opening the door, a license to innovate

Execution

Game changing solutions

Adoption

From proof of concept to industry revolution

Incorporated December 2013

OpenPOWER Summit March 2015

OpenPOWER Summit April 2016

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So much going on...

250+ members

60+ technologies revealed

24 countries 6 continents

100s innovations under way
POWER9 – dual memory subsystems

**Scale Out**
- **Direct Attach Memory**

**8 Direct DDR4 Ports**
- Up to 120 GB/s of sustained bandwidth
- Low latency access
- Commodity packaging form factor
- Adaptive 64B / 128B reads

**Scale Up**
- **Buffered Memory**

**8 Buffered Channels**
- Up to 230GB/s of sustained bandwidth
- Extreme capacity – up to 8TB / socket
- Superior RAS with chip kill and lane sparing
- Compatible with POWER8 system memory
- Agnostic interface for alternate memory innovations
POWER9 – all about acceleration

- Extreme Processor / Accelerator Bandwidth and Reduced Latency
- Coherent Memory and Virtual Addressing Capability for all Accelerators
- OpenPOWER Community Enablement – Robust Accelerated Compute Options

**State of the Art I/O and Acceleration Attachment Signaling**
- PCIe Gen 4 x 48 lanes – 192 GB/s duplex bandwidth
- 25G Link x 48 lanes – 300 GB/s duplex bandwidth

**Robust Accelerated Compute Options with OPEN standards**
- On-Chip Acceleration – Gzip x1, 842 Compression x2, AES/SHA x2
- CAPI 2.0 – 4x bandwidth of POWER8 using PCIe Gen 4
- NVLink 2.0 – Next generation of GPU/CPU bandwidth and integration
- New CAPI – High bandwidth, low latency and open interface using 25G Link
Current IBM “LC” Power Systems for Linux

**S822LC HPC**
- **CPU**: 2x POWER8 CPU
  - 10 cores each, 2.9-3.3 GHz
  - Up to 1TB Memory
- **Memory**: 230 GB/s Memory Bandwidth
- **GPU**: 2x NVIDIA Tesla K80 GPUs

**S822LC**
- **CPU**: 2x POWER8 CPU
  - 10 cores each, 2.9-3.3 GHz
  - Up to 1TB Memory
- **Memory**: 230 GB/s Memory Bandwidth
- **Opt. CAPI-attached accelerators**

**S812LC**
- **CPU**: 1x POWER8 CPU
  - 10 cores, 2.9-3.3 GHz
  - Up to 1TB Memory
- **Memory**: 115 GB/s Memory Bandwidth
- **Drives**: 14 Drives (84TB, HDD, SSD)

**Built for GPU Acceleration**

**Built for CPU Performance, CAPI Differentiation**

**Optimized for Hadoop, Spark**
Potential new IBM LC servers

- IBM Supermicro servers
  - 2U, 2S, K80 x2, 512 GB memory, up to 12 LFF / SFF
  - 1U, 2S, K80 x1, 512 GB memory, up to 4 LFF / SFF

- IBM Wistron server – Minsky
  - 2U, 2S, NVidia P100 x4 + NVLink
  - Based on Wistron Polaris Plus

OpenPOWER and Open Compute Project are teaming to deliver price performance advantage on Power

- Contributing OpenPOWER Open Compute reference design via collaboration between IBM and Rackspace.

- Contributing OpenPOWER firmware from IBM to ensure fully open opportunity for OpenPOWER Open Compute system

- Engaging cross community opportunities via Open Compute role on advisory group to OpenPOWER Foundation along with joint activities
Coming soon: Barreleye

In partnership with Avago, IBM, Mellanox, PMC & Samsung
Zaius 1.25 OU

- 2 POWER9 CPUS
- 32 DDR4 DIMM SLOTS
- 2X G4 PCIE X16 FHFL SLOTS
- 1X G4 X16 HHHL SLOT
- 1X G4 X16 OCP MEZ
- 1X M.2 SATA PORT
- 1X SATA PORT
- 15X 2.5” SAS/SATA/NVME SLOTS
- BMC W/GBE LOM
- “DISKLESS” OPTION
Introducing OpenPOWER Ready

- Products / solutions may display badge
- Participants request to use it
- Compatibility
- Not Certification or Compliance
- OpenPOWER Ready™ List

http://openpowerfoundation.org/technical/openpower-ready/

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Why Develop on OpenPOWER?

- **Maximum Performance, Minimum Change**
  From highly parallelised languages to memory-intensive apps, running the same code on POWER can dramatically increase performance – and with all major Linux distros supported, switching is easy.

- **Work Less, Do More**
  With better performance and scale, you can spend less time building / testing / optimising and more time developing the next new thing.

- **Accelerate Beyond Limits**
  POWER’s deeply integrated accelerator support means code can push beyond the limits of what’s possible with standard processors.

- **Rule the Stack - No black boxes**
  With OpenPOWER’s fully open architecture, developers rule the stack – hardware, firmware, and software are open and ready for optimisation.
Developer Resource Ecosystem

ACCESS | INSTANCE TYPE | ACCELERATOR | OS
---|---|---|---
OPENSTACK | POWERKVM | KVM | BAREMETAL
DOCKER | VIRTUAL MACHINE | KIMCHI

http://developers.openpowerfoundation.org/
SuperVessel

Type of Center: Open Community Development
Access Type: Open
Instance Type: OpenStack, PowerKVM, Baremetal, Docker
Accelerator: FPGA, GPU
OS: Fedora, Ubuntu, RHEL, I-Soft, Redflag
Location: Beijing, China
http://www.ptopenlab.com

SuperVessel cloud (www.ptopenlab.com) is the cloud platform built on top of POWER/OpenPOWER architecture technologies. It aims to provide the open remote access for all the ecosystem developers and university students. We (IBM Research China, IBM System Technology Lab in China and partners) have built and launched this cloud for more than 3 months, and rapidly attracted the public users from more than 30 universities, including those from GCG and the United States.

http://developers.openpowerfoundation.org/
Three tracks to challenge and win:

1. The Open Road Test
   - Port and optimize for OpenPOWER
   - Go faster with accelerators *(optional)*

2. The Spark Rally
   - Combine Apache Spark and GPU acceleration

3. The Cognitive Cup
   - Choose from multiple different Deep Learning problems, or solve your own

Register today
openpower.devpost.com

- **June 1st**: Submission periods opened
- **Sept 1st**: Submission period closes

Grand prizes include a trip to Supercomputing 2016
Other prizes include iPads, Apple Watches
A spectrum of “caring”...

“I couldn't care less about the platform”

“I want to change the specifics of <stack part>”
There is no cloud
it's just someone else's computer
A spectrum of “caring”...

“I couldn't care less about the platform”

“I want to change the specifics of <stack part>”
Come and find out more...

Co-located with the OpenStack European Summit & no cost to attend!

http://openpowerfoundation.org/openpower-summit-europe/
“OpenPOWER is the rebel alliance of the industry”

Dan Olds
HPC Analyst, Gabriel Consulting Group

http://bit.ly/1ludHXm

Join the rebellion!

Main website → openpowerfoundation.org
Overview → ibm.biz/openpower_overview

mandie_quartly@uk.ibm.com | @mandieq
Reference material
Engage in the OpenPOWER community

**Technology and Software Innovators**
- Discuss areas of collaboration and synergy in OpenPOWER.
- Sign up for membership and join a work group.
- Build technical and business relationships.

**Innovators, Integrators, and Partners**
- Deep understanding of workload demands and consumption preferences of end users.
- Team with innovators and end users to drive requirements, engage in specific projects.

**End Users**
- Strategic imperatives and workload demands for performance and cost optimization.
- Require open software and systems with choice and flexibility.
- Engage directly on system design options.
Anyone may participate in OpenPOWER. Membership levels are designed for those that are investing to grow and enhance the OpenPOWER community and its proliferation within the industry.

<table>
<thead>
<tr>
<th>Membership Level</th>
<th>Annual Fee $ USD</th>
<th>FTEs</th>
<th>Technical Steering Committee</th>
<th>Board / Voting position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>$100k</td>
<td>10</td>
<td>One seat per member not otherwise represented</td>
<td>Includes board position</td>
</tr>
<tr>
<td>Gold</td>
<td>$60k</td>
<td>3</td>
<td>May be on TSC if Work group lead</td>
<td>Gold members may elect one board representative per three gold members</td>
</tr>
<tr>
<td>Silver</td>
<td>$20k $5k if &lt;300 employees</td>
<td>0</td>
<td>May be on TSC if Work group lead</td>
<td>Silver members may elect one board representative for all silver members</td>
</tr>
<tr>
<td>Silver ISV</td>
<td>$0 if ISV is &lt;300 employees</td>
<td>0</td>
<td>May be on TSC if Work group lead</td>
<td>Silver members may elect one board representative for all silver members</td>
</tr>
<tr>
<td>Associate &amp; Academic</td>
<td>$0</td>
<td>0</td>
<td>May be on TSC if Work group lead</td>
<td>May be elected to one community observer, non-voting Board seat</td>
</tr>
</tbody>
</table>
Accelerates Infrastructure Standards

11 Work Groups

- Personalised Medicine
- Integrated Solutions
- System SW
- 25g IO Compatibility
- OpenPOWER I/O
- Accelerator
- Memory
- FSI Specification
- Developer Platform
- HW Architecture
- Compliance

2014

- Charter
- P8 SP010 Data
- OpenPOWER ISA Profile V1
- Compliance Specification Draft Review WG Spec

2015

- Charter
- CAPI AFU Intf Spec V1
- OpenPOWER ISA Profile V2
- Compliance STD

2016

- Charter
- CAPI AFU Intf Spec V2
- OpenPOWER ISA Profile V2
- OPMB Intf. Spec V1
- Sys I/O Enablement Guide
- Pers Med
- Integrated Solutions
- CAPI Linux SDK
- 64b ABI Platform Ref
- 25g IO Spec
- 64b ABI
- Platform Ref
- 25g IO Spec
- Pers Med
- Integrated Solutions

SP010 – Tyan OpenPOWER Customer Reference System
AFU – Accelerator Function Unit
CAPI – Coherent Accelerator Processor Interface
FSI – Field Replaceable Unit (FRU) Service Interface
OPMB – OpenPOWER Memory Bus
ABI – Application Binary Interface
SDK – Software Developer Kit

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Choose from Three Different Tracks.

**Open Road Test**
- Port and optimize for OpenPOWER (existing or new application/package)
- Go faster with accelerators (optional)

**Spark Rally**
- Port an existing GPU accelerated application to Spark
- Create a new Spark application that uses GPU acceleration, or add GPU acceleration to an existing Spark application
- Use GPUs to accelerate Spark itself

**Cognitive Cup**
- ArtNet – Use Deep Learning to train Neural Networks to analyze paintings
- TuneNet – Guide programmer optimization using Deep Learning
- YourNet – define and solve your own Deep Learning problem
Register for the Challenge Now

Signing up takes a few seconds at: http://openpower.devpost.com/

Replay the Google Hangout June 10th

Join to learn more about the challenge, see how to get started, and ask questions about Spark, Machine Learning or Optimization. Add it to your calendar at: bit.ly/OPHangout

Find Us on Slack Anytime!

Register for the challenge, and then join our slack team to ask questions and chat with experts anytime! bit.ly/OPSlack
### POWER8 => built for performance

<table>
<thead>
<tr>
<th></th>
<th>Sandy Bridge EP E5-x6xx</th>
<th>Ivy Bridge EP E5-26xx v2</th>
<th>Ivy Bridge EX E7-88xx v2</th>
<th>Haswell EP E5-26xx v3</th>
<th>POWER 7+ Systems</th>
<th>POWER8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock rates (GHz)</td>
<td>1.8–3.6</td>
<td>1.7-3.7</td>
<td>1.9-3.4</td>
<td>1.6-3.5</td>
<td>3.1–4.4 GHz</td>
<td>3.0-4.1 GHz</td>
</tr>
<tr>
<td>SMT options</td>
<td>1,2*</td>
<td>1, 2*</td>
<td>1, 2*</td>
<td>1, 2*</td>
<td>1, 2, 4</td>
<td>1, 2, 4, 8</td>
</tr>
<tr>
<td>Max Threads / sock</td>
<td>16</td>
<td>24</td>
<td>30</td>
<td>36</td>
<td>32</td>
<td>96</td>
</tr>
<tr>
<td>Max L1 Cache</td>
<td>32KB</td>
<td>32KB*</td>
<td>32KB*</td>
<td>64 KB</td>
<td>32KB</td>
<td>64KB</td>
</tr>
<tr>
<td>Max L2 Cache</td>
<td>256 KB</td>
<td>256 KB</td>
<td>256 KB</td>
<td>256KB</td>
<td>256 KB</td>
<td>512 KB</td>
</tr>
<tr>
<td>Max L3 Cache</td>
<td>20 MB</td>
<td>30 MB</td>
<td>37.5 MB</td>
<td>45 MB</td>
<td>80 MB</td>
<td>96 MB</td>
</tr>
<tr>
<td>Max L4 Cache</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>128 MB</td>
</tr>
<tr>
<td>Memory Bandwidth</td>
<td>31.4-51.2 GB/s</td>
<td>42.6-59.7 GB/s</td>
<td>68-85** GB/s</td>
<td>51-68 GB/s</td>
<td>100 – 180 GB/sec</td>
<td>115 - 410 GB/sec</td>
</tr>
</tbody>
</table>

1 = The Micro-architecture features above contributed to premium performance for the POWER8 systems compared to Ivy Bridge systems

* Intel calls this Hyper-Threading Technology  (No HT and with HT)

**32KB running in “Non-RAS mode” 16KB results in better RAS

***85GB running in “Non-RAS mode” and dual-device error NOT supported
Linux support for POWER

- Same source and distribution release schedules as x86
- Simplified x86 application migration with little endian distributions
- Enterprise support for all three from IBM or distributors
OpenPOWER Open Compute Project systems coming to market

<table>
<thead>
<tr>
<th>Motherboard</th>
<th>Chassis</th>
<th>Rack</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mainboard Specs</strong></td>
<td><strong>Open Rack Form Factor</strong></td>
<td><strong>Dimensions</strong></td>
</tr>
<tr>
<td>– 2 Sockets</td>
<td>– 3 Bus Bar</td>
<td>– 42 U (~2200 mm) Height</td>
</tr>
<tr>
<td>– 8 Centaurs, 32 DIMM Slots</td>
<td>– 21” Width</td>
<td>– 1 Tile Wide (24”), 2 Tiles Deep (48”)</td>
</tr>
<tr>
<td><strong>I/O Board Specs</strong></td>
<td><strong>Serviceable Items</strong></td>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td>– 2 x8 OCP 2.0 Mez (Storage, Network)</td>
<td>– 15 2.5” SSD/HDD (Front Right)</td>
<td>– Up to 5U Network Devices</td>
</tr>
<tr>
<td>– 1 x16 FHFL Slot</td>
<td>– 6 External Hot Swap Fans (Rear)</td>
<td>– 24x Barreleye Units</td>
</tr>
<tr>
<td>– 1 x8 FLHH Slot</td>
<td></td>
<td><strong>Electrical</strong></td>
</tr>
<tr>
<td>– 1 x8 HHHL Slot</td>
<td></td>
<td>– 2x 16.8 kW Power Shelves (28 kW N-2)</td>
</tr>
<tr>
<td>– 2 GbE LOM, BMC, VGA, USB</td>
<td></td>
<td>– 4x 3-Phase AC Input, 8 Socket AC PDU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Integrated ATS for Fault Tolerance</td>
</tr>
</tbody>
</table>

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Accelerated software innovation

- Over 2,300 Linux ISVs developing on Power
- 50 IBM Innovation Centers
- Compelling PoCs
- Support for little endian applications
Lots of resources & support for Linux ISVs and Developers

**IBM PartnerWorld**
- Technical Support
- IBM Innovation Centers
- Free access to Power Hardware
- Free porting assistance
- Free Eclipse-based development environment

[www.ibm.com/partnerworld](http://www.ibm.com/partnerworld)

**IBM DeveloperWorks**
- Technical resources, community, blogs, toolkits, How to articles, beta code

**Regional Ecosystem Initiative – Recruiting Key Solutions**
- Greater China, North America, Europe
- Middleware and Industry Solutions

**IBM Migration Factory**
- Premier migration services for large applications

**IBM Watson Developer’s Cloud**
- Access to IBM Watson for developing cognitive computing applications

**IBM Power Development Cloud**
- Provide free access to Power hardware to ISVs for Porting
- [www.ibm.com/partnerworld](http://www.ibm.com/partnerworld)

**IBM Innovation Centers**
- All 50+ centers worldwide now support Linux on Power
- One-stop for ISVs, developers
- HW access, technical support, demos, toolkits, Hands-on labs
- [www.ibm.com/systems/power/software/linux/centers](http://www.ibm.com/systems/power/software/linux/centers)

**Site Ox**
- Free On-demand cloud-based development platform using Linux on POWER8 for 2 weeks
- [www.siteox.com](http://www.siteox.com)