Data is the new basis of competitive value
Data is growing exponentially and demands new system approaches (technology and strategy)
Data on the Rise and is the New Basis of Competitive Value

- The world is awash in data – sensor, modeling, social
- Pools of dark data – collected but un-analyzed

Oil and Gas

- 15 PBs of survey data
- 10+ months to process new survey data once acquired
- 100x compute needed for deep water imaging
- Network and high bandwidth storage intensive
- Long term storage needs
- Multi-TB data sets for visualization
- 1 TB per oilfield per day
- 2 TB per rig per day
- 80% Dark Data*

Genomics

- Next Gen Sequence data doubling every 5 months
- Some leading institutions @ >100PB in 1-2 years
- Projects increasingly National scale (UK, China, UAE, US)
- Large cluster and Large SMP needs
- High performance file system and scalable storage
- Multi-stage workflow process for personalized treatment

Personalized medicine

Financial Analysis

- 4 TB/day
- 10k to 100k databases
- Multi PB volume
- 400M tasks per day
- <100ms response required
- Tight coupling of near real time analytics and trading systems to underlying data sets.

Firms of all sizes are experiencing data challenges as they focus on insight

* Dark Data: Data that is uncategorized and not well understood
Massive data requirements drive a composable architecture for big data, complex analytics, modeling and simulation. The DCS architecture will appeal to segments experiencing an explosion of data and the associated computational demands.
OpenPOWER, a catalyst for Open Innovation

**Market Shifts**

- Moore’s law no longer satisfies performance gain
- Growing workload demands
- Numerous IT consumption models
- Mature Open software ecosystem

**OpenPOWER Strategy**

- Vibrant ecosystem through open development
- Accelerated innovation through collaboration of partners
- Amplified capabilities driving industry performance leadership

**Industry adoption, Open choice**

- **Cloud Computing**
  - Hyperscale & Large scale Datacenters
- **High Performance**
  - Computing & Analytics
- **Domestic IT Agendas**

OpenPOWER is an open development community, using the POWER Architecture to serve the evolving needs of customers.
OpenPOWER collaboration with HPC Advisory Council

OpenPOWER is pleased to announce our membership in HPCAC

• Furthering cross-community collaboration opportunities in HPC

Contribution of OpenPOWER systems to HPCAC lab for benchmarking and demonstration

• 4 systems 2x 10c with 256GB memory with dual NVIDIA K80 GPU acceleration
OpenPOWER is the Rebel Alliance of the industry.”

Dan Olds
HPC Analyst
Gabriel Consulting Group
OpenPOWER Development Community

OPEN Ecosystem Community

Development & Specification
- Open Source Software
- Linkages to other groups
- Development workgroups
- System Design Group
  - Specifications
  - Reference Design
- Chip Design Group
  - Open IP Blocks
  - Interface Specifications
- Development Groups

Store
- Fee Based Component Examples
  - Chip IP
  - IBM SW Stack
  - Member SW Stack
  - Power on a card or board
- To Ensure Compliance
  - All offers must be validated consistent with architecture and interface specifications

Numerous Participants

OpenPOWER Compliance

© 2016 OpenPOWER Foundation
Fueling the OpenPOWER Community
OpenPOWER Foundation reach

190+ members

20+ technologies revealed

24 countries
6 continents
100+ innovations under way
So what?

What difference does it make?
POWER8: Processor Performance Leadership & Accelerator Interfaces

**Faster Cores**
8 Threads Per Core

**Larger Caches**
Direct Accelerator Interconnect

**3x Higher Memory Bandwidth**
1 TB Memory per Socket

**POWER8**
- 12 Cores, 96 Threads
- 4 Level Large Caches
- Up to 1 TB per socket
- Up to 230 GB/s sustained
Application Benchmarks

POWER8: Up to 2x Faster on Applications over Intel Haswell x86 CPUs
Portfolio of HPC Solutions

**Processors & Systems**
- High Performance Processors & Systems
- Accelerator, networking, storage integration via CAPI & NVLink
- Innovative solutions like CAPI Flash

**HPC Software**
- Platform LSF & Symphony workflow and resource management
- Compilers: gcc, IBM XLC, PGI Fortran/C/C++, Java, OpenACC, OpenMP
- Debuggers, Profilers, Math libraries, MPI & HPC apps

**High Performance File System & Storage**
- Highest Performance HPC Storage: Elastic Storage Server
- High Performance Spectrum Scale (GPFS) Parallel File System
- Flash Storage
IBM Research Paving the Path to Next-Generation HPC

Data Centric System Node, & Processor Innovations

Programming Models for Exascale

Enhancing Open Interconnects

Scalable High Performance Storage & File Systems
Cross community collaboration is essential
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
Accelerates software innovation

- Over 2,200 Linux ISVs developing on Power
- 50 IBM Innovation Centers
- Compelling PoCs
- Support for little endian applications

<table>
<thead>
<tr>
<th>HPC</th>
<th>Cloud</th>
<th>Big Data &amp; Machine Learning</th>
<th>Mobile Enterprise</th>
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<tbody>
<tr>
<td>CHARMM</td>
<td>miniDFT</td>
<td>hadoop</td>
<td>Zend</td>
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<td>CTH</td>
<td>Apache</td>
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<td>Chef</td>
<td>OpenFOAM</td>
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<td>OpenSource</td>
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<td>STAC-A2</td>
<td>Chef</td>
<td>Ilog</td>
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<td>SHOC</td>
<td>Chef</td>
<td>Graph500</td>
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<tr>
<td>AMG2013</td>
<td>Graph500</td>
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<tr>
<td>OpenFOAM</td>
<td>Ilog</td>
<td>Chef</td>
<td>Xilix</td>
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</table>

Major Linux Distros

- Ubuntu
- SUSE
- Red Hat
- FreeBSD
Superior Cloud economics, powering Hyperscale datacenters

SoftLayer Bare Metal POWER cloud

Rackspace joins OpenPOWER, declares Open Compute OpenPOWER system

Docker, OpenStack HEAT, and Chef Server for Power

Bluemix Cloud Integration and SQLDB Services with Power Systems for SOE/SOR integration

Power Cloud environments in Europe

IBM Watson Developer’s Cloud for cognitive computing

Power Dev Cloud free POWER access to ISVs for Porting
hwww.ibm.com/partnerworld/wps/servlet/ContentHandler/stg_com_sys_power-development-platform
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.

**Develop**
- Develop collaborative innovations with compelling value

**Deliver**
- Deliver collaborative innovations with compelling value

**Deploy**
- Deploy collaborative innovations with compelling value
Thank you.

Calista Redmond
President, OpenPOWER Foundation
Director, IBM OpenPOWER Global Alliances

credmond@us.ibm.com
@Calista_Redmond
According to results shared at the STAC Summit on June 4, an IBM Power8-based system server delivered more than twice the performance of the best-in-class x86 counterpart when running a set of standard financial industry benchmarks. - [HPC Wire](#)

We estimate that a physical Power Systems server can support twice as many virtual environments – and therefore double the number of client systems – as a physical x86 server. - [Ubuntu](#)

The architectures of the last fifteen or more years are clearly not going to take us past the next several years, so there needs to be a step change and there are lots of options but for the workloads we’re looking at ahead, we are confident about this architecture. - Cliff Brereton, STFC

I still see the POWER8 processor as one of the most powerful processors in the industry – and with the accelerators being developed in the OpenPOWER ecosystem, it is going to be hard for other processors (including Intel and ARM silicon) to match some of the acceleration speeds that will be achieved by POWER8 and successive generations. - [Clabby Analytics](#)

People ask me if we would switch to Power, and the answer is absolutely,” Urs Hölzle, Google, said emphatically and unequivocally. “Even for a single generation.” - [The Platform](#)

The architectures of the last fifteen or more years are clearly not going to take us past the next several years, so there needs to be a step change and there are lots of options but for the workloads we’re looking at ahead, we are confident about this architecture.

The $320 million deal [U.S. Department of Energy's Sierra and Summit supercomputers] is a validation of sorts of IBM’s recent strategic shift to open up its POWER computing architecture for license and use by other companies looking for alternatives to an Intel-controlled world. - [Forbes](#)

While other vendors are struggling to establish themselves in China, IBM seems to have found the secret with OpenPOWER. Not only does this seem to be cementing IBM inside the tough Chinese technology market but the benefits, such as SuperVessel, are now starting to be felt across the whole of IBM. - [Enterprise Times](#)
The IBM Power Systems Linux Portfolio

**Scale-Out, Linux-Only**
- **The LC Line**
  - Design and TCA cost optimized for cognitive workloads on scale out deployments (cloud and cluster)
  - Solutions for cognitive, HPC and Big Data

**Converged Infrastructure**
- **The L Line**
  - Enterprise level RAS for single system deployments
  - Solutions for Big Data & Analytics

**Enterprise & IFLs**
- **PurePower**
  - Converged infrastructure offering
  - Rapid time to value and simplicity of management

- Enterprise level robustness and IFL capability
- Solution editions for in memory databases
  - (HANA, DB2 BLU)

**Hosted cloud and hybrid cloud solutions**
- Rapid deployments and POCs

**Pipeline of innovation**
- IBM Support
- Community / 3rd Party Support

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OpenPOWER expands POWER opportunity

Customize and optimize infrastructure for most compelling business value

- FPGA acceleration, leveraging open CAPI processor connect
- GPU acceleration, will leverage NVLINK processor attach in 2016
- Advanced memory options from Samsung, Micron, SK Hynix
- Leadership interconnect from Mellanox

Cloud options expand adoption

- IBM Softlayer
- OVH and Online in Europe
- Rackspace Open Compute coming soon

Developer resources for custom tuning

- SuperVessel cloud system access with acceleration options in US and China
- Linux software porting and optimization
- OpenPOWER Foundation work groups and technical resources

Linux on Power dedicated ISV support

- Over 1,900 Linux ISVs developing on Power
- 50 IBM Innovation Centers
- Compelling Proof-of-Concepts
- Support for little endian applications

On-going engagements with nearly every major hyperscale client in the U.S. and China
8x faster than x86 Ivy Bridge on pattern extraction

10x faster text search than CPU only
GPUdb in-memory Accelerated Database
Ultrafast ingest and analysis of billions of objects

• In-memory distributed database using GPUs for processing

• Order of magnitude gains:
  • Performance over CPU solutions
  • Power reduction
  • Cost savings

• Anticipate order of magnitude gains with POWER based NVLink solutions in 2016
10x higher throughput, 10x lower latency accelerating NoSQL workloads

Turbo LAMP Stack for mobile and web apps

Dramatically less data center infrastructure

Dramatically faster responsiveness to customers
Storage Enablement for OpenPOWER

Series 7 & 8 – RAID/HBA Portfolio

- **Density**: Industry’s only 16-24 port native SAS/SATA adapters
- **Flexibility**: HBA, Caching HBA, or RAID
- **Performance**: Leading Throughput & IOPS

2-3x Port Density with 50% Lower Power

Ecosystem of Industry Solutions

- PMC Flashtec NVRAM
  - Up to 10M IOPS

- Samsung SSD
  - 2.5" 700K IOPS

- Memblaze SSD
  - PCIe Card
  - Up to 8TB

10x Performance over typical SATA SSD’s

© 2016 OpenPOWER Foundation
Up to 36x performance improvement for Key-Value Store acceleration

- Accelerated appliance with novel data-flow implementation of Memcached on FPGA.
- Up to 36x improved performance and power response times in microsecond range.
- CAPI integration of memory allows both host memory and coherent-attached flash to be used as value store.
Data Engine for NoSQL with 40TB CAPI-attached flash

24:1 server consolidation

3x lower cost per user

Before: NoSQL in memory (x86)

After: NoSQL POWER8 + CAPI Flash

Less is More
24:1 physical server consolidation = 6x less rack space
8x performance improvement

GPU acceleration for Java on segmentation using accelerated machine learning for clustering with Hadoop / Mahout

Best-in-class ingredients

- IBM POWER8
- IBM Java
- NVIDIA CUDA GPU acceleration
- Ubuntu Little Endian Linux for POWER
Critical workloads run on Linux on Power

- **Web, Java Apps and Infrastructure**
  - Highly threaded
  - Throughput oriented
  - Scale out capable
  - High quality of service

- **Business Applications**
  - High quality of service
  - Scalability
  - Flexible infrastructure
  - Large memory footprint

- **Analytics & Research**
  - Compute intensive
  - High memory bandwidth
  - Floating point
  - High I/O rates

- **Database**
  - Handle peak workloads
  - Scalability
  - High quality of service
  - Resiliency and security
Solution stacks continuing to grow

- ISV community of 1,900+
- All major Linux distros
- Open sourced POWER8 firmware stack
- Resources for porting and optimizing: OpenPOWERFoundation.org
Industry trends drive innovation beyond the chip

Microprocessors alone no longer drive sufficient Cost/Performance improvements

System stack innovations are required to drive Cost/Performance improvements.
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.

- The OpenPOWER Foundation is a Not-for-profit entity with a Board of Directors and a Technical Steering Committee.
  - Membership levels provide either a default Board of Director position (Platinum) or an opportunity to be elected to the Board (Gold, Silver, and Assoc/Academic members). The Bylaws include additional governance detail.
  - Technical Steering Committee is formed from Work group Leads and Platinum members.

- Membership options include Platinum, Gold, Silver, and Associate / Academic memberships
  - Annual fee and dedicated full-time equivalent (FTEs) - verification of FTEs on honor system
  - Contributors, committers, Work group leads and project leads influence Technical Steering Committee
  - Associate / Academic level is not available to corporations

<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>
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</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 Includes TSC 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>
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<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>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>

Membership agreement, Bylaws, and IP Rights Policy available for review
www.openpowerfoundation.org
OpenPOWER Open Software and University Cloud Environments

- Oregon State North America
  - OpenPOWER Platforms
  - Open Stack Software
  - University research
  - Open Development & Ecosystem Support
  - [http://osuosl.org/services/powerdev](http://osuosl.org/services/powerdev)

- Brno University / RedHat, Czech Republic
  - [https://fit-rhlab.rhcloud.com](https://fit-rhlab.rhcloud.com)

- UNICAMP Brazil, SA
  - [http://openpower.ic.unicamp.br/mini cloud/index.html](http://openpower.ic.unicamp.br/mini cloud/index.html)

- SuperVessel
  - USA and China
  - [www.ptopenlab.com](http://www.ptopenlab.com)

- IIT Bombay, India
  - 3Q, 2015

- HPC Center
  - University of Texas- TACC
  - 3Q, 2015
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/wps/servlet/ContentHandler/pw_com_pwp_partnerworld-program

**IBM Migration Factory**
Premier migration services for large applications
www.ibm.com/systems/power/migratetoibm/index.html

**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/wps/servlet/ContentHandler/stg_com_sys_power-development-platform

**IBM DeveloperWorks**
Technical resources, community, blogs, toolkits, How to articles, beta code
www.ibm.com/developerworks/linux/

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

**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

**Site Ox**
Free On-demand cloud-based development platform using Linux on POWER8 for 2 weeks
www.siteox.com

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IBM Innovation Centers provide training and one-to-one guidance from building to marketing your solution.

- Technical skills and hardware access across multiple platforms, local or remote, at little or no cost for migration to IBM platforms
- Qualify "Ready for" marks to broaden marketing reach
- Workshops, seminars, and more conducted by trained subject matter experts.

All 50+ Innovation and Client Centers worldwide support Linux on Power

For more information ibm.com/partnerworld/iic  For questions, send an email to iici@us.ibm.com
Data Centric: Minimizing Data Movement, Optimizing Workflows

• Locate Computing where the data resides and relative to the task required
  • Within the system
  • Within the Data Center / Cloud location, or across locations as optimal

• Shifting from algorithms to workflows

Seismic Data Processing Workflow and Data Lifecycle
Different Solutions for Different Types of Workflows

Conceptual View of Data
Fusion/Uncertainty Quantification Workflow

Floating Point
OPS

High Spatial
Locality

Region defined by LINPACK

Low Spatial
Locality

Integer
OPS

Conceptual View of Data Intensive with Floating Point Workflow

Data Centric Applications

Compute Centric Applications
DCS Workflows: Mixed Compute Capabilities Required

Analytics Capability:

- Complex code
- Data Dependent Code Paths / Computation
- Lots of indirection / pointer chasing
- Often Memory System Latency Dependent
- C++ templated codes
- Limited opportunity for vectorization
- Limited scalability
- Limited threading opportunity

Massively Parallel Compute Capability:

- Simple kernels,
- Ops dominated (e.g. DGEMM, Linpack)
- Simple data access patterns.
- Can be preplanned for high performance.