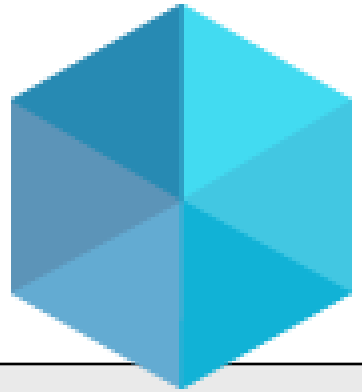
OpenPOWER™

OpenPOWER Foundation

Opportunities for Education, Research and Collaboration

June 2015

Misty Decker
Strategic University Alliances
misty@us.ibm.com



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™

Open Development

open software, open hardware

Collaboration of thought leaders

simultaneous innovation, multiple disciplines

Performance of POWER architecture

amplified capability

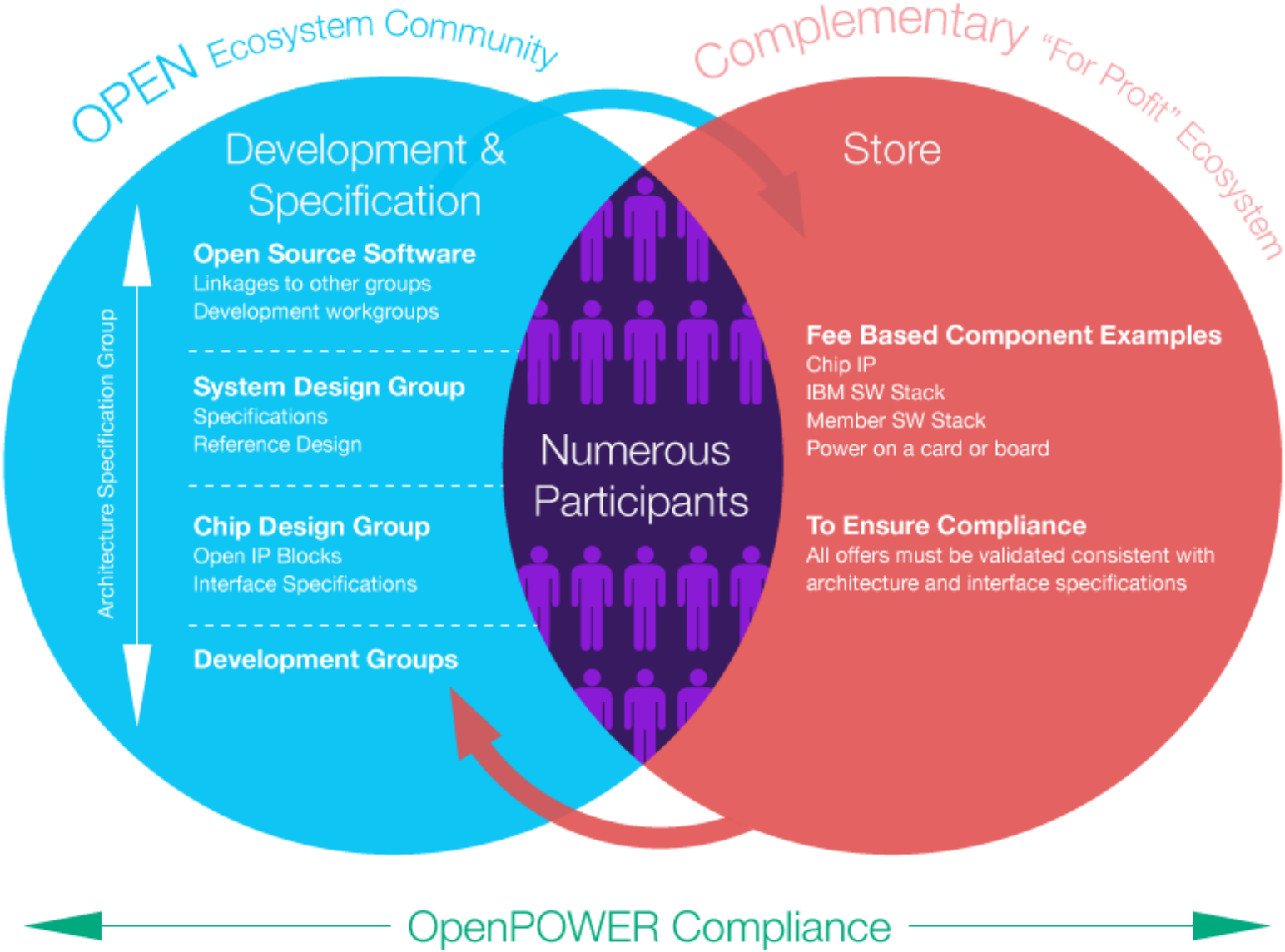
New Open Innovation

- Rich software ecosystem
- Spectrum of power servers
- Multiple hardware options
- Derivative POWER chips

Feeds back … resulting in client choice

OpenPOWER is an open development community,
using the POWER Architecture to serve the evolving needs of customers.

OpenPOWER Development Community



A Fast Start for OpenPOWER!

August
Announced intent to form OpenPOWER

January
First two Chinese members joined

July
IBM, with contributions from Google, released 420,000 lines of firmware code

October
Multiple offerings made available from Altera, Canonical, IBM, Nvidia, Redis Labs, OVH and Tyan

November
Department of Energy chose OpenPOWER design for $325M supercomputing contract

March
OpenPOWER kicks off first Summit
- 50+ member presentations
- 10+ product reveals
- **110+ members**

2013 | 2014 | 2015

December
Incorporated Foundation and elected officers; **five members**

April
Public launch of web-site, members and demonstrations (Tyan and Google planars)

October
China government endorsed and supported OpenPOWER ecosystem through the formation of China Power Technology Alliance

November
Nallatech CAPI Developer Kit released

December
Seven work groups chartered; Rackspace declares Open Compute, OpenPOWER strategy

March
SoftLayer announces world's first OpenPOWER bare metal as a service offering

The year ahead

- Collaborative solutions, standards, and reference designs available
- Independent members solutions and systems
- Sector growth in technical computing and cloud
- Global growth with increasing depth in all layers
- Broad adoption across hardware, software, and end users

Fueling an Open Development Community

Collaborate with other Researchers

Arizona State
ASTRI
Bauman Moscow State Tech University
Cineca
Combatore Institute
Forschungszentrum Juelich
Freebsd Foundation
Hartree Centre Science & Technologies
IIIT Bangalore
IIIT Bombay
IIIT Roorkee
INAF Instituto Nazionale di Astrofisin
Institute of Communication and Computer Systems
Lawrence Livermore Labs
Louisianna State University
Max Planck Society
Northeastern Univ (S/W College) in Liaoning, China
Oak Ridge National Laboratory
Oregon State University
POSTECH (Gyungbuk, Korea)
Rice University
Sandia National Lab
Seoul National University
Shanghai Jiao Tong University
Symbiosis Inst Comp (SICSR)
Tohoku University
Tsinghua University
University of Arkansas
University of Campinas (Unicamp)
University of Central Florida
University of Hawaii
University of Hyderabad
University of Illinois
University of Oregon
University of Patras
University of Southern California
Waseda University

Collaborate with Industry Members

Platinum
Google
IBM
Nvidia
Altera
Canonical
Mellanox
Micron
Samsung
SK Hynic
Suzhou Power Core
Tyan

Gold
Avnet
Chuanghe Telco Tech
Hitachi
Huaxun Tech Company
Inspur
Res Inst of Jiangsu Industrial
Neu Cloud Orientale
VeriSilicon
Wistron
Zoom Networks
ZTE

Silver (partial list)
Algo-Logic Systems
Asetek
Celestica LLC
Chelsio Communications
Cirrascale
Convey Computer Corporation
DataDirect Networks
Exablaze
Fusion IO
GIS Federal
IDT
Inventec Corporation
KNS Group
Memblaze
Penguin Computing
Qlogic
Rackspace
Redis Labs Ltd.
Synapse Design
Xilinx

OpenPOWER™

No-Cost Access to Linux on Power
for OpenPOWER Foundation Academic Members

Venue	How to access	Technical Details
SuperVessel	**Intended for Chinese Universities, Individual Developers and Ecosystem Partners** Request access: ptopenlab.com Facebook group: SuperVessel OpenPOWER QQ group: SuperVessel	FPGA GPU (future) Priority Access given to Chinese applicants
Brno University of Technology, Czech Republic	**Intended for Universities, Individual Developers and Ecosystem Partners** Request access: https://fit-rhlab.rhcloud.com/powerlinux-openpower-development-hosting/	Power8
UNICAMP São Paulo, Brasil	**Intended for Universities, Individual Developers and Ecosystem Partners** Request access: http://openpower.ic.unicamp.br/minicloud/index.html	Duration: 1 month, can be extended upon request OS: Ubuntu, Fedora
OSU Open Source Lab	**Intended for Universities, Researchers, Open Source Developers** IBM Linux Technology Center sponsored projects Request access: osuosl.org/services/powerdev/request_hosting	VM Size: 1-8 CPU, 2-16GB RAM, 20-120GB disk Duration: 1 day to indefinite OS: Ubuntu, Fedora, Debian, OpenSUSE

Coming Soon: Indian Institute of Technology, NC State University, Texas Advanced Computing Center

Contribute to Workgroups

Work Group	Projects	Participants
25G IO Interoperability Mode	Specification of a 25 Gbps operating mode	Member
Accelerator	PSL to AFU specification OpenCL SDK to OpenPower Platform interface API for access to system interface services via CAIA	Member
Application Software (Open Source)	System Operating Environment — OpenPOWER Software Ecosystem enablement Toolchain	Public
Compliance	Compliance	Member
Hardware Architecture	OpenPOWER profile of architecture — Power8 ISA Book 1, 2, 3 Coherent Accelerator Interface Architecture (CAIA)	Member
IO Work Group	I/O related specifications required for OpenPOWER System Design I/O Enablement guides and tools	Member
Memory	1. Define memory bus protocol/interface f 2. Define Memory component potential line up	Member
Open Server Development Platform	POWER 8 Developer Board POWER 8 Reference Design	Member
System Software (Open Source)	Linux LE, KVM Firmware (OpenPOWER FW Interface) POWER LE ABI	Public
FSI (Full Service Interface) WG (Open Source)	Develop OpenPOWER FSI Specification version 1.0 and version 2.0 Establish context documents referencing to system control options using OpenPOWER FSI	Member

Source: http://openpowerfoundation.org/technical/working-groups/

A Wealth of Information

Documentation
- Available without an NDA
- Request specific materials

Discussion Groups
- Access to experts
- Ask your questions
- Find colleagues with ideas

Proposed Workshop
- Nov 12-13 in Austin TX
- Prior to Supercomputing Conference
- Technical Knowledge
- Explore Collaboration

Future OpenPOWER Webinars
- Performance analysis
- Performance counters
- Multi-threading optimization
- Vectorization of codes
- Mathematical libraries
- Optimization for memory bandwidth
- XL compilers
- Optimization of application XY
- Optimization of GPU computing
- Introduction to CAPI

Information accessible from Members area of OpenPowerFoundation.org

Join us!

"The level of support behind the OpenPOWER Foundation leads me to believe **that IBM has a real chance at ending Intel's server chip monopoly**." [*IBM is the real threat to Intel's server dominance*, Motley Fool]

"Up to **100x** the power of a classic x86 setup

OVH.COM

http://labs.runabove.com/power8/

"… doubling the performance of its already powerful predecessor, Power7+. **The POWER8 specs are mind boggling.** [Microprocessor report]

Data-centric supercomputers based on POWER for Department of Energy, Oak Ridge National Labs & Lawrence Livermore to advance innovation and discovery in science, engineering and national defense in ***$325M deal***

"Both the current results and future potential are so promising that we are preparing to build an OpenPOWER-based, Open Compute platform. And it will run OpenStack services.

rackspace

http://www.rackspace.com/blog/openpower-opening-the-stack-all-the-way-down/

"The new systems incorporate technologies from IBM and other providers that are part of OpenPOWER…which allow you to achieve **unprecedented computing performance**. [Cloud Times]

"IBM's **huge advantages in multithreading and memory bandwidth** favor POWER8 when running larger test suites that more closely reflect real-world enterprise applications.

The Linley Group

http://www.linleygroup.com/newsletters/newsletter_detail.php?num=5275

How to Join

http://openpowerfoundation.org/membership/how-to-join/

Review the Membership Kit

Signature of the Membership Agreement

IP Agreement

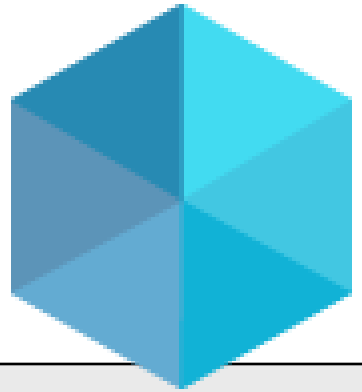
Any IP submitted is shared with Foundation Members

IP developed outside of Foundation owned by University

Individual Membership option also available

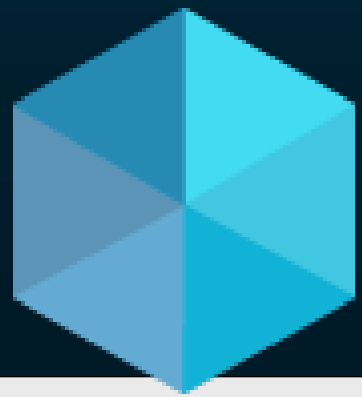
OpenPOWER™

Back-up



So what?

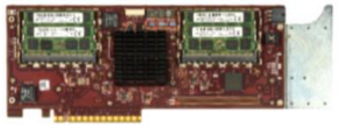
What difference does it make?



New Chips & Components

IBM, ALTERA

DMI connection between an Altera Stratix V FPGA accelerator and a POWER8 CPU



XILINX, CONVEY COMPUTER™

Convey's CAPI developer kit based on the company's Xilinix-based co-processors

IBM, POWERCORE

***First** China "local" POWER derivative chip, CP1*

Components & Systems

TYAN

***First** commercially available OpenPOWER third-party server*

Mellanox TECHNOLOGIES

New CAPI-based solution: the ConnectX-4 adapter card by Mellanox

Nallatech, ALTERA

Nallatech's OpenPOWER CAPI Developer Kit

New Systems & Platforms

rackspace HOSTING

***First** Open server specification and motherboard combining OpenPOWER, OpenCompute and OpenStack (mock-up)*

IBM, NVIDIA, Cirrascale

***First** GPU-accelerated OpenPOWER developer platform*

IBM, NVIDIA, Mellanox TECHNOLOGIES, wistron

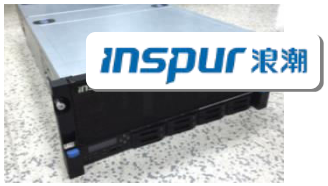
Prototype of a new high-performance server on the path to exascale

TYAN, Mellanox TECHNOLOGIES

***First** commercially available OpenPOWER server*

中大超越, BYOSOFT

RedPower, the first China OpenPOWER 2-socket system coming to market in 2015



inspur 浪潮

Inspur 2-socket POWER8 Server

TYAN, 创和通讯

ChuangHe China-branded OpenPOWER system with POWER8

Bringing It All Together

redislabs, ALTERA, Nallatech, ubuntu, IBM

Data Engine for NoSQL with 40TB CAPI-attached flash

24:1 Server consolidation for 3x lower cost per user

Clustering + ***Open Source Redis***

192 Vcores + CAPI + ***40TB in 2U***

Altera FPGA acceleration and IBM CAPI

Monte Carlo
250x faster

than POWER8 core alone, reduced C code 40x over non-CAPI FPGA

IBM ALTERA® ubuntu Supported by Canonical

Over 1,400 Linux ISVs developing on Power

- Support for little endian applications
- PoCs available through the Power Development Platform
- 50 IBM Innovation Centers and Client Centers Worldwide

ubuntu® SUSE redhat.

NVIDIA acceleration + IBM Power Systems

8x faster than x86 Ivy Bridge on pattern extraction

10x faster text search than CPU only

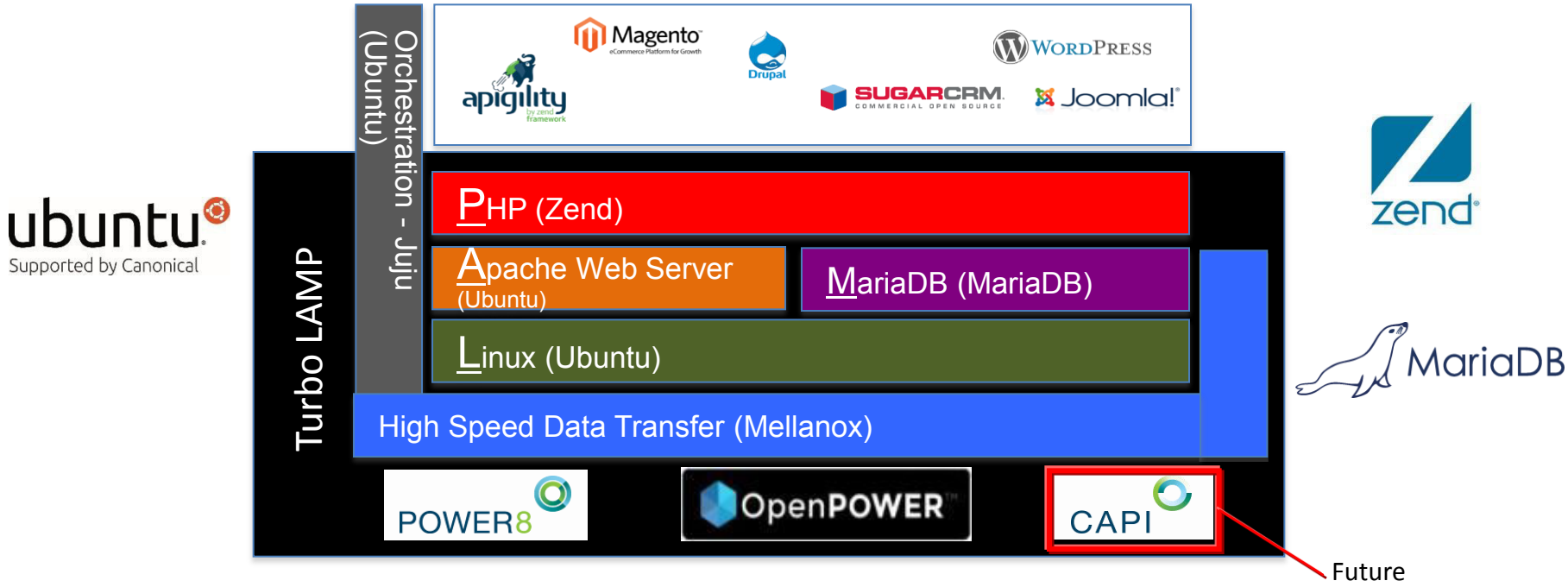
NVIDIA

IBM

Mellanox TECHNOLOGIES

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

PMC Storage Enablement for OpenPOWER™

adaptec by PMC

2-3x Port Density with 50% Lower Power

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

nvm EXPRESS™

10x Performance over typical SATA SSD's

Ecosystem of Industry Solutions

PMC Flashtec
NVRAM
Up to 10M IOPS

Samsung SSD
2.5"
700K IOPS

Memblaze SSD
PCIe Card
Up to 8TB

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.

XILINX®

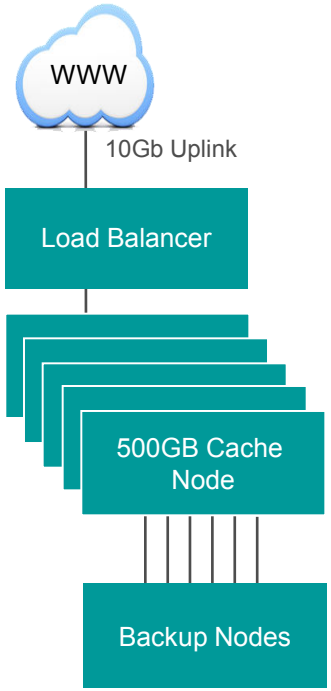
IBM

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

ubuntu Supported by Canonical

Power Systems

redis

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

mahout

hadoop

Java

ubuntu
Supported by Canonical

NVIDIA
TESLA

Power Systems

Critical workloads run on Linux on Power

Web, Java Apps and Infrastructure

- Highly threaded
- Throughput oriented
- Scale out capable
- High quality of service

Analytics & Research

HPC applications for Life Sciences

- Compute intensive
- High memory bandwidth
- Floating point
- High I/O rates

Business Applications

- High quality of service
- Scalability
- Flexible infrastructure
- Large memory footprint

Database

- Handle peak workloads
- Scalability
- High quality of service
- Resiliency and security

First OpenPOWER Developer System

- Single socket ATX form factor board, BMC based evaluation board
- Service subsystem identical to x86
- Reference System for ISV application and OpenPOWER partners
- OpenPOWER Software Stack

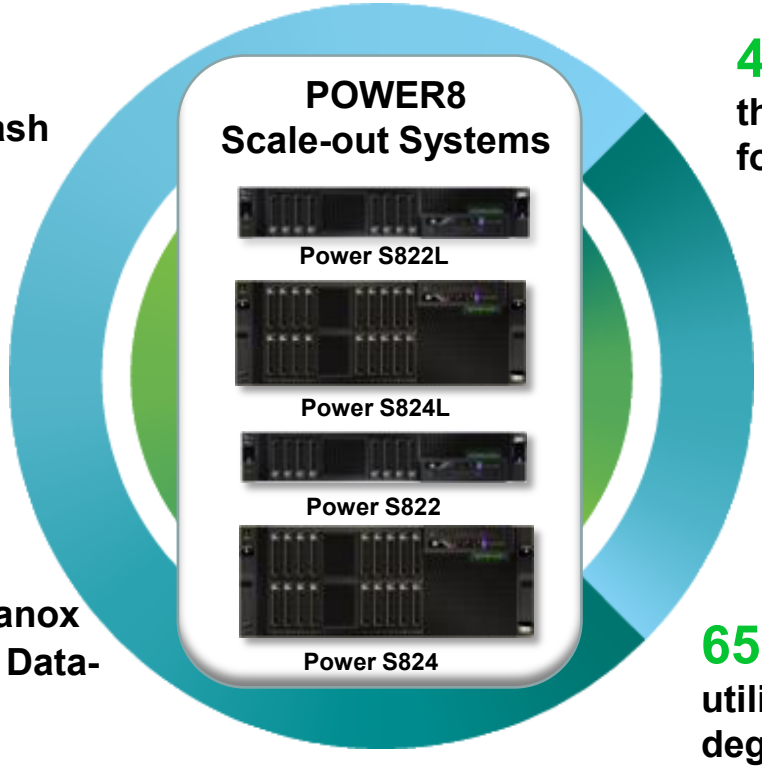
50x faster insights with POWER8 systems designed for Big Data and BLU

IBM

24:1 server footprint reduction through CAPI Flash for BD&A – no SQL

5x Watson scaling through Software Optimization and POWER8 for Cognitive

10x ops/sec via Mellanox Fabric exploitation for Data-centric workloads



4x reduction in storage through GPFS and compression for BD&A - Hadoop

Non-disruptive

Application mobility from P6/P7 to P8

65% Guaranteed system utilization without application degradation

8x IBM Java advantage through NVIDIA GPU acceleration

Superior Cloud Economics

New: SoftLayer Bare Metal POWER cloud

New: Rackspace joins OpenPOWER, declares Open Compute OpenPOWER system

New: Docker for Power Systems

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

Update: OpenStack HEAT and Chef Server for Power

Up to **100x**

the power of a classic x86 setup

http://labs.runabove.com/power8/

IBM, Mellanox, and NVIDIA awarded $325M U.S. Department of Energy's Super Computer bids

Two super computers for Oak Ridge and Lawrence Livermore Labs in 2017.

IBM Mellanox TECHNOLOGIES NVIDIA

Current DOE Leadership Computers

Titan (ORNL) 2012 - 2017

Sequoia (LLNL) 2012 - 2017

Mira (ANL) 2012 - 2017

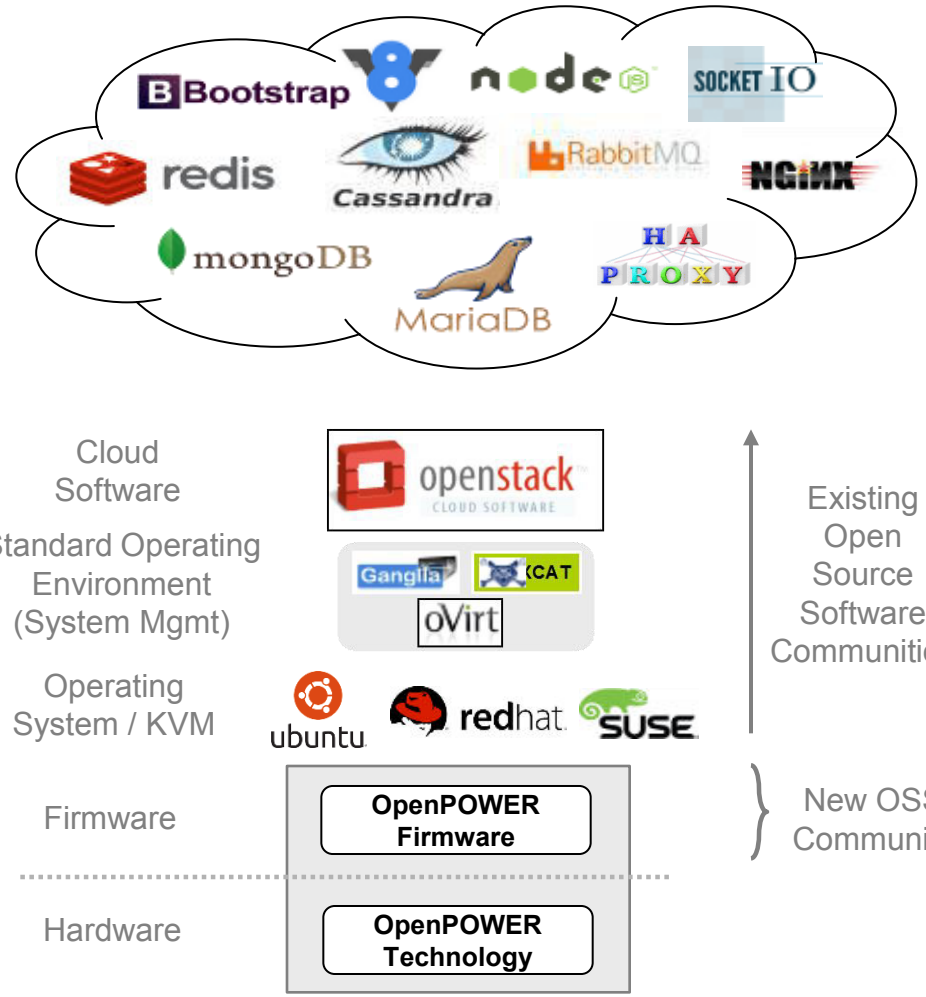
5x – 10x Higher Application Performance versus Current Systems

>100 PF, 2 GB/core main memory, local NVRAM,
Mellanox EDR 100Gb/s InfiniBand,
IBM POWER CPUs, NVIDIA Tesla GPUs

OAK RIDGE National Laboratory

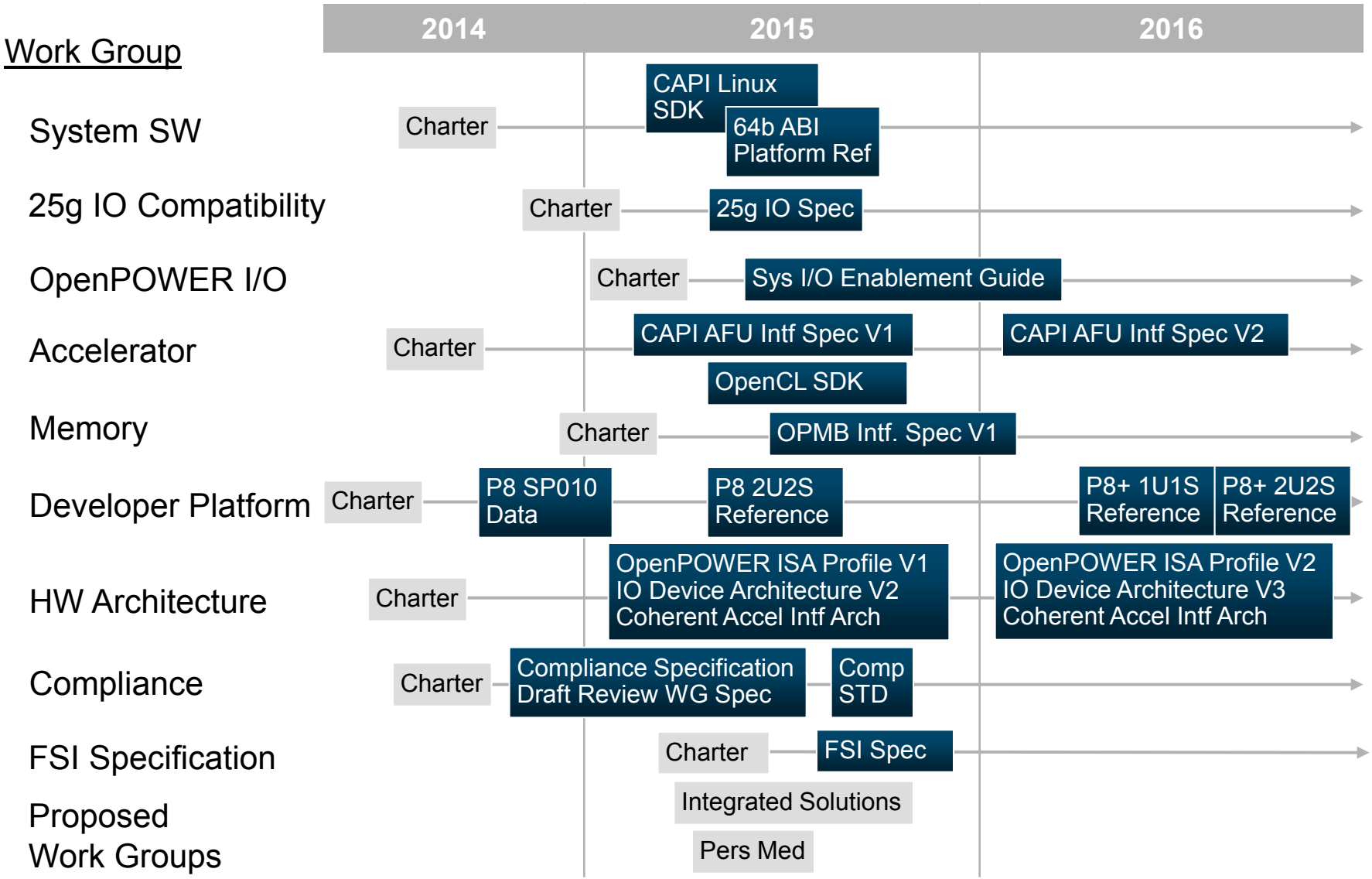
Lawrence Livermore National Laboratory

Solution stacks continuing to grow



- ISV community of 1,400+
- All major Linux distros
- Open sourced POWER8 firmware stack
- Resources for porting and optimizing: OpenPOWERFoundation.org

OpenPOWER Work Group Roadmap



SP010 – Tyan OpenPOWER Customer Reference System
CAPI – Coherent Accelerator Processor Interface
ABI – Application Binary Interface

AFU – Accelerator Function Unit
FSI – Field Replaceable Unit (FRU) Service Interface
SDK – Software Developer Kit

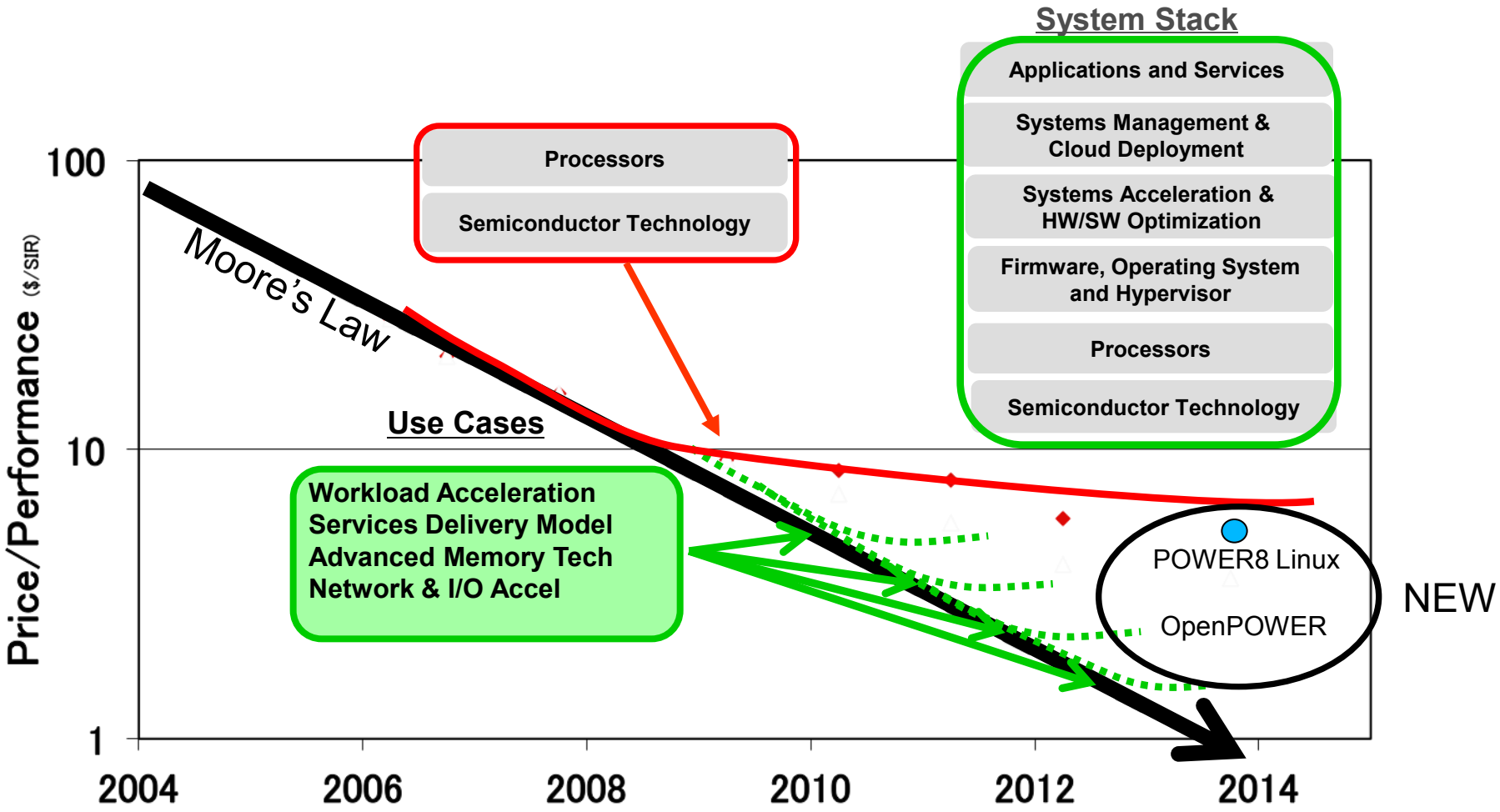
OPMB – OpenPOWER Memory Bus

Engage in the OpenPOWER community

	Technology and Software Innovators	Innovators, Integrators, and Partners	End Users
INTEREST			
ACTION	Discuss areas of collaboration and synergy in OpenPOWER. Sign up for membership and join a work group. Build technical and business relationships.	Deep understanding of workload demands and consumption preferences of end users. Team with innovators and end users to drive requirements, engage in specific projects.	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.
OUTCOME	**Develop** collaborative innovations with compelling value	**Deliver** collaborative innovations with compelling value	**Deploy** collaborative innovations with compelling value

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

Membership 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.

- 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

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

Membership agreement, Bylaws, and IP Rights Policy available for review
www.openpowerfoundation.org

OpenPOWER™

No-Cost Access to Linux on Power
for IBM Business Partners and Open Source Developers

Venue	ISV	OSD	OS	How to access	Server size & access duration
PDP - Power Development Platform (Cloud)	P	P	Ubuntu RHEL SLES	**Intended for IBM PartnerWorld Members and Open Source Developers (beta)** Virtual Machines **for porting and testing** Offering Overview: ibm.com/partnerworld/pdp Request access: ibm.com/partnerworld/wps/ent/pdp/web/MyProgramAccess Send a note to pdpspt@us.ibm.com if questions or issues	VM Size: 1-2 vCPU, 2-4GB RAM, 35GB disk Duration: 2 weeks+ Longer when sponsored
IIC - IBM Innovation Center	P	S	Ubuntu RHEL SLES	**Intended for ISVs and Systems Integrators** For porting, integration and **performance testing** One-on-one engagement. Multiple and large systems possible Request access: ibm.com/partnerworld/iic	VM or bare metal, Hypervisor access, IBM Storage (e.g. Flash, Spectrom) Duration: 2 weeks+
OSU Open Source Lab	N	P	Ubuntu Fedora	**Intended for Universities, Researchers, Open Source Developers** IBM Linux Technology Center sponsored projects Request access: osuosl.org/services/powerdev/request_hosting	VM Size: 1-8 CPU, 2-16GB RAM, 20-120GB disk Duration: 1 day to indefinite

ISV=Independent Software Vendor
S=Secondary

OpenPOWER™

Current Fee Based or Sponsored Access to Linux on Power

Venue	OS	How to access	Server size & access duration
Site Ox	Ubuntu	**Intended for anyone** Virtual Machine rental for porting and testing Request access: www.siteox.com/lop	1 cpu, 2GB, 20GB Storage $2/day, $32/month 2-week free trial
OVH	Ubuntu Fedora	**Intended for anyone** Request access: cloud.runabove.com/signup/?launch=power8	S=8 threads, 4GB RAM, 10GB RAID $0.05/hour, capped at $32/month 2XL=178 threads, 48GB, 480GB RAID $1.08/hour, capped at $700/month
Center Express	Ubuntu RHEL SLES	**Intended for China users only with sponsor by an IBMer** Virtual Machine access for porting and testing Request access: https://w3-31.ibm.com/support/techline/gcg/tssapp/cscexpress/	1st 2 weeks free. Thereafter needs business justification.
Client Centers	Ubuntu RHEL SLES	**Intended for IBM Customers** One-on-one engagement. Multiple and large systems possible Requires an IBM sponsor (i.e. Request form is available inside IBM only) Request access: http://d27db001.rchland.ibm.com/b_dir/bcdcweb.nsf/mywork?OpenForm Send a note to PPSBENCH@us.ibm.com if questions or issues	VM or bare metal, Hypervisor access, IBM Storage (e.g. Flash, Spectrom) Duration: 2weeks+, defined by projects Fee paid by Sales team or Clients
Lease & Discount	Ubuntu RHEL SLES	**Intended for IBM PartnerWorld Developers** Request access: ibm.com/partnerworld/wps/servlet/ContentHandler/isv/hardwaremall	Physical systems Up to 50% discount on hardware and significant discount on software

OpenPOWER™

OpenPOWER™

IBM

www.ptopenlab.com

SuperVessel: The Open Cloud Service for OpenPOWER

Yonghua Lin, Ling Shao

IBM

Facebook group: SuperVessel OpenPOWER

QQ group: SuperVessel

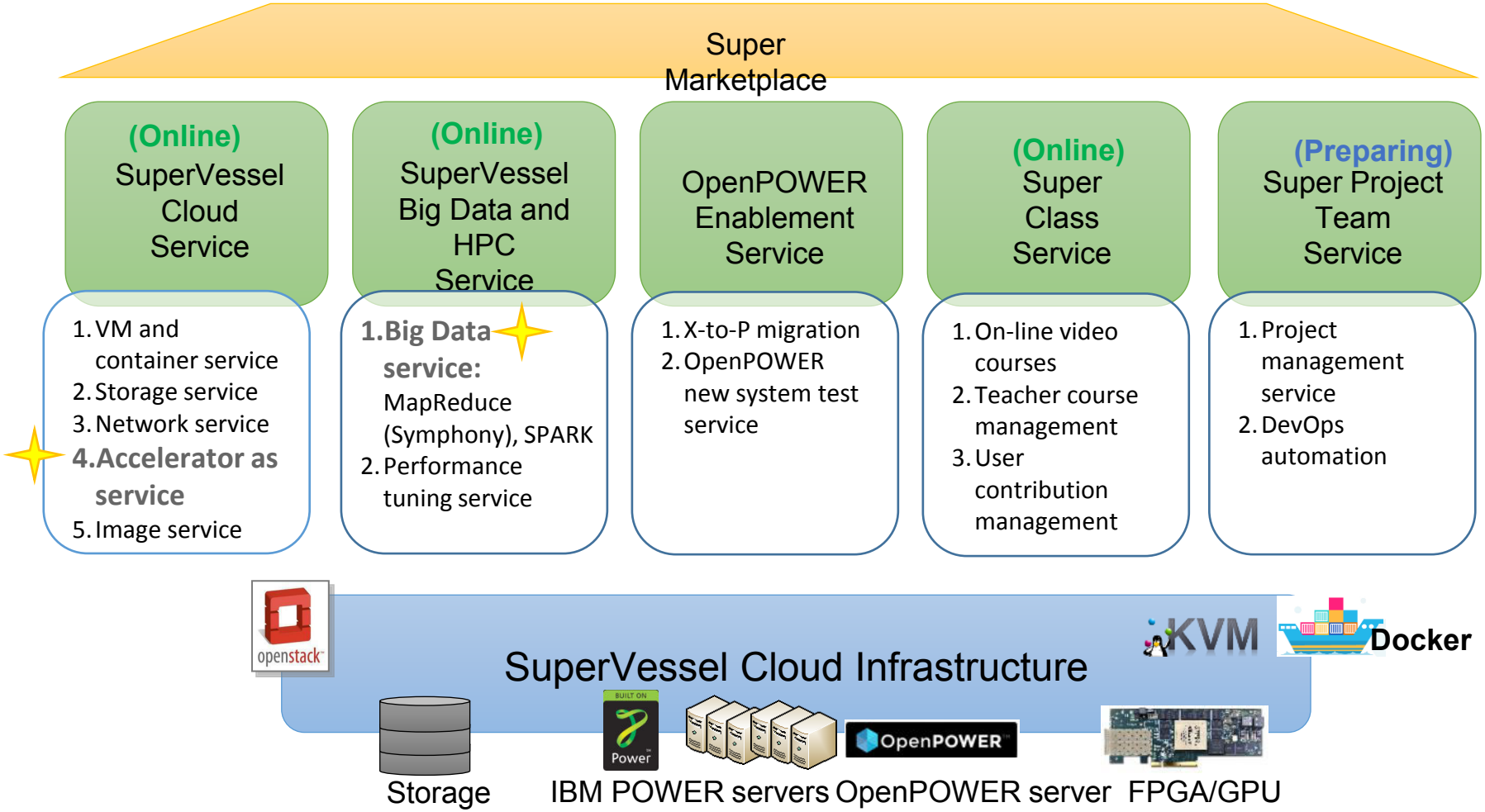
SuperVessel WeChat group

Why SuperVessel Cloud

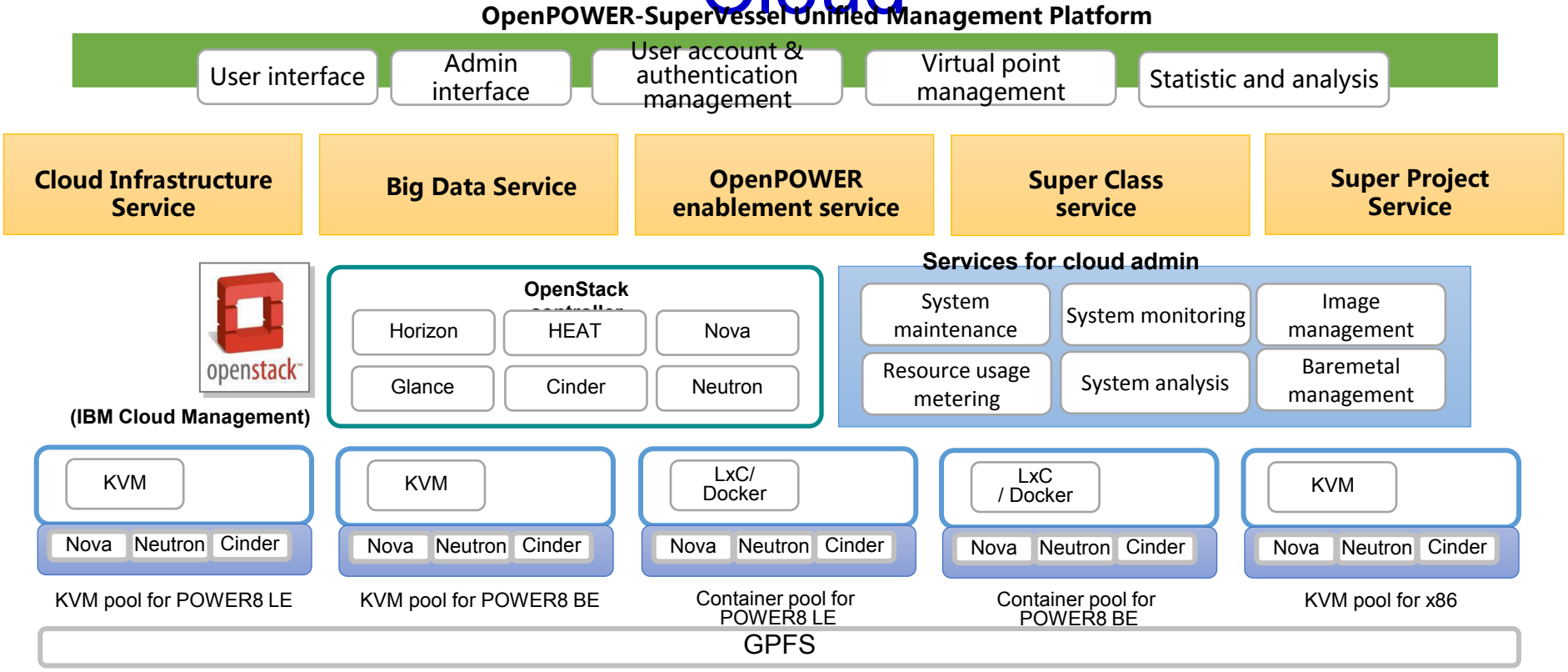
Motivation: To grow the number of developers on OpenPOWER in the world

- Freely opened to all the students in universities, individual developers and ecosystem partners for OpenPOWER.
- Built on the POWER7/POWER8 resource pool
- Built with open technologies, such as OpenStack
- Support advanced technology services, e.g. Docker service, big data service, cognitive computing service

Service Roadmap of SuperVessel

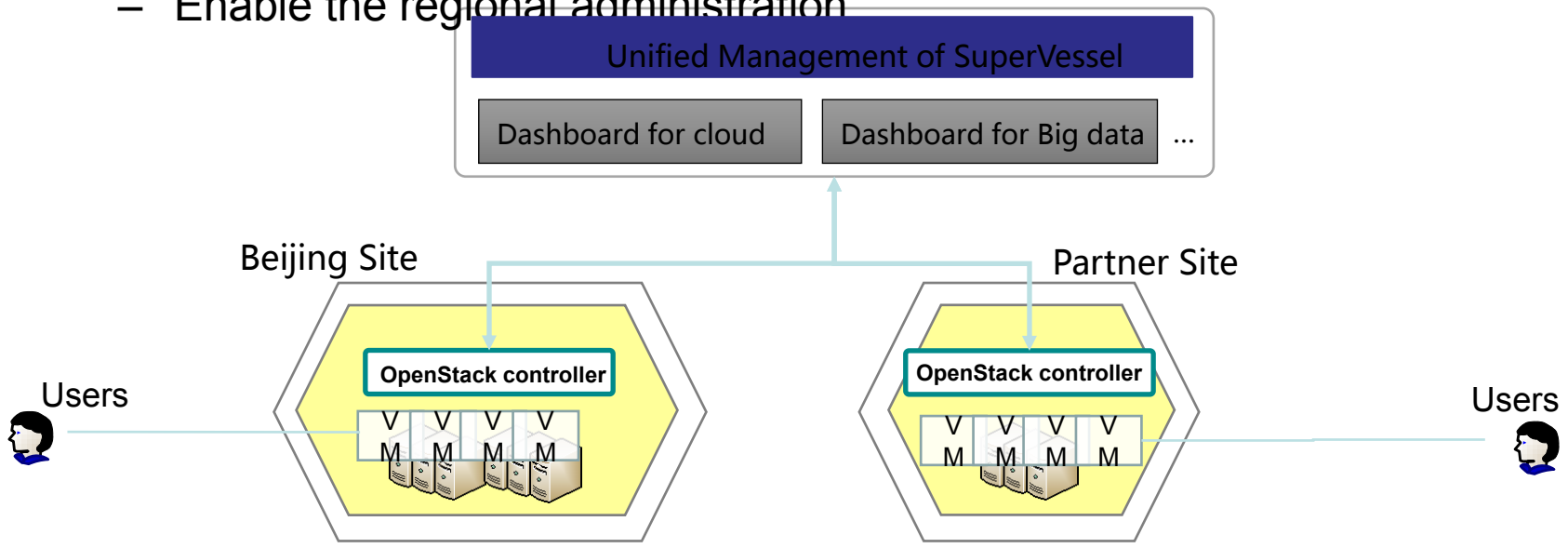


Architecture of SuperVessel Cloud



To expand the SuperVessel via collaboration with OpenPOWER partners

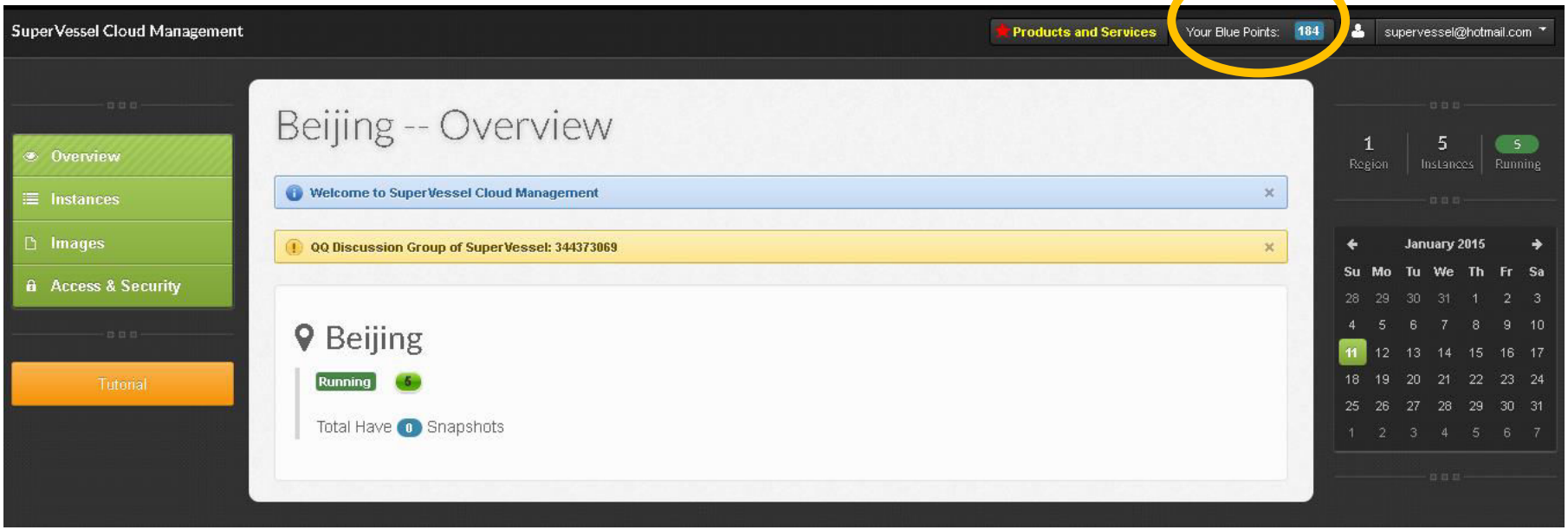
- Multi-site design : Using the multi-region in OpenStack to support multi-site management of SuperVessel cloud.
- We are designing the first multi-site for Jiangsu Development and Test cloud on POWER
  - Shared dashboard, Shared keystone, Shared object store (in future)
  - Enhance the cache design for performance optimization
  - Enable the regional administration



SuperVessel Cloud Services

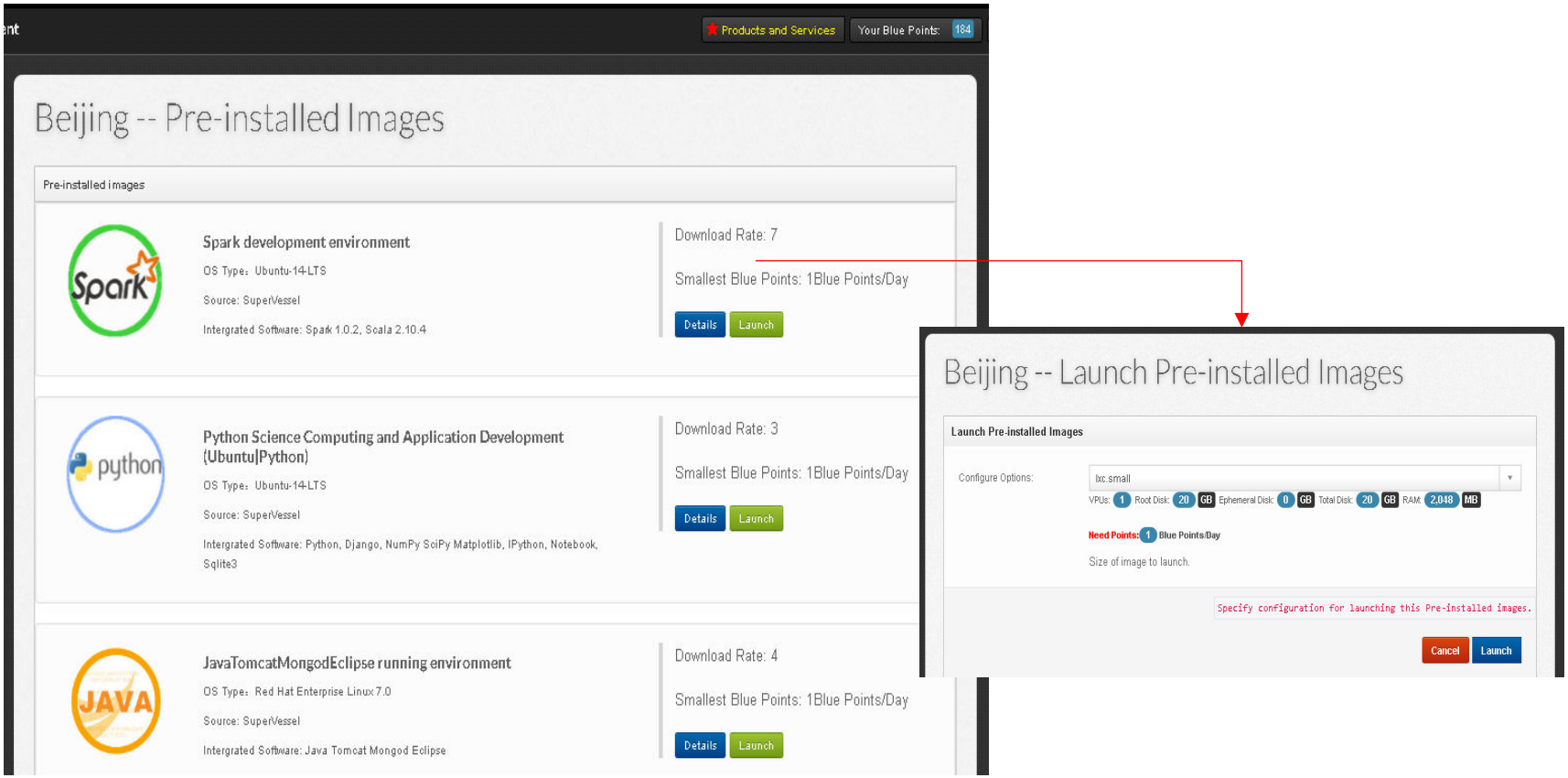
- Virtual machine and Docker services
- VPN management
- Pre-installed image service
- Multi-site support will be provided in next step

We use virtual points for resource management



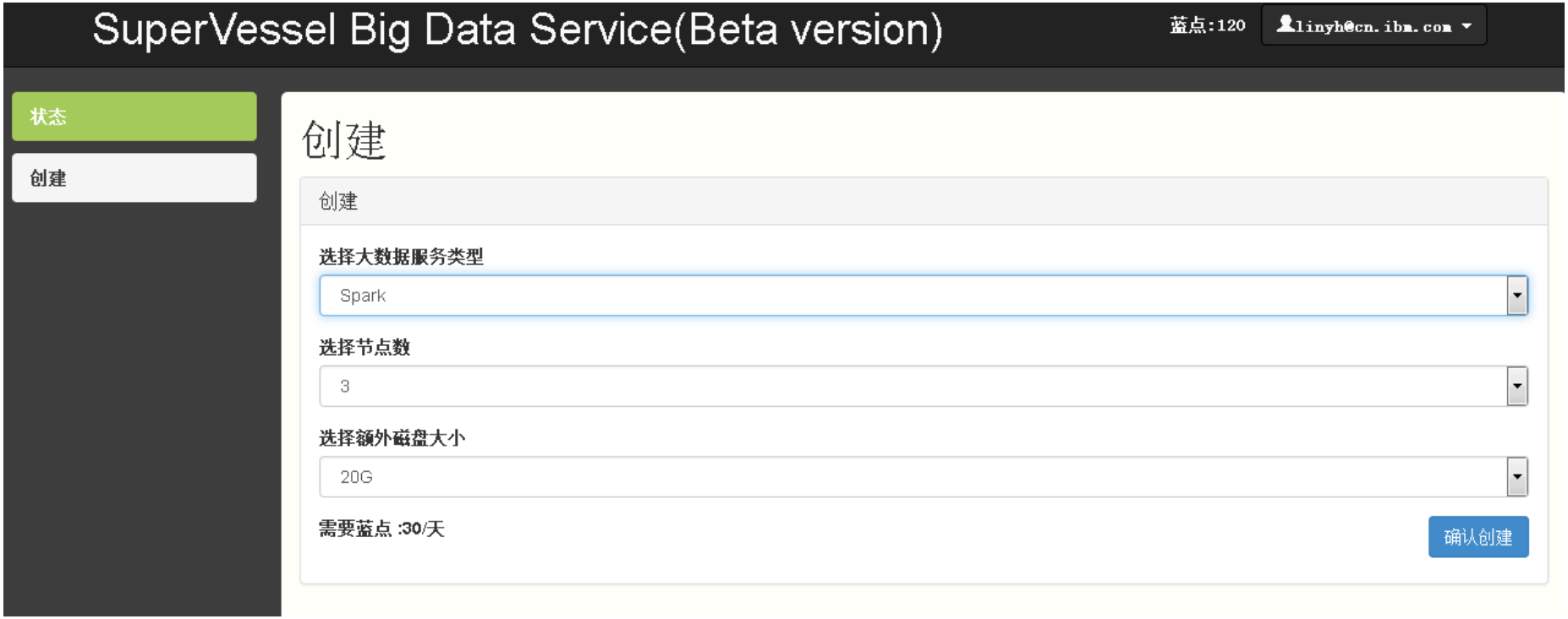
SuperVessel Cloud Services

- Pre-installed image service: It could very much make user easier to start development on POWER
  - Docker is used to provide the pre-installed environment.

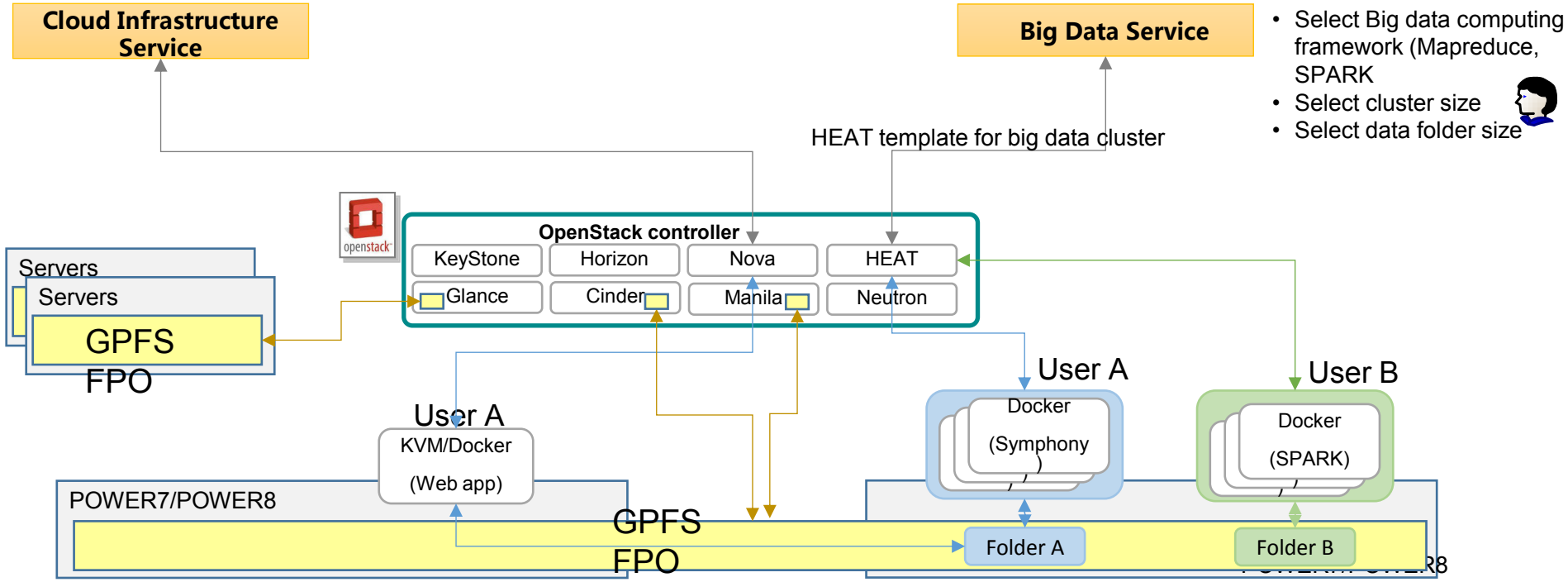


SuperVessel Big Data Services

- Support MapReduce and SPARK services
- Allow user to request different size of cluster



Shared file system for Cloud and Big Data service



- HEAT will orchestrate docker instances, subnet and data folder based on user's request
- Manila provides the NFS service using GPFS as backend, and the folder will be mounted via nova-docker (with –v support)
- Folder created by Manila could be accessed by the KVM/docker instances created for big data and other purpose

SuperVessel Accelerator as Service

- Accelerator MarketPlace for developers to upload and compile the accelerators for SuperVessel POWER cloud
- Allow user to request different size of cluster

Fig.1 Accelerator MarketPlace for SuperVessel Cl

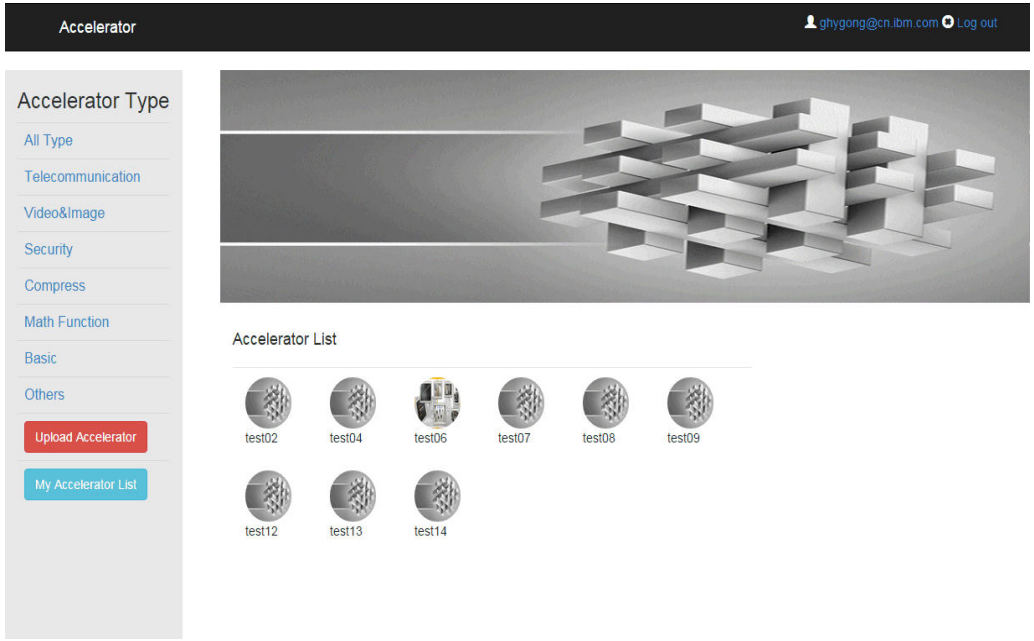
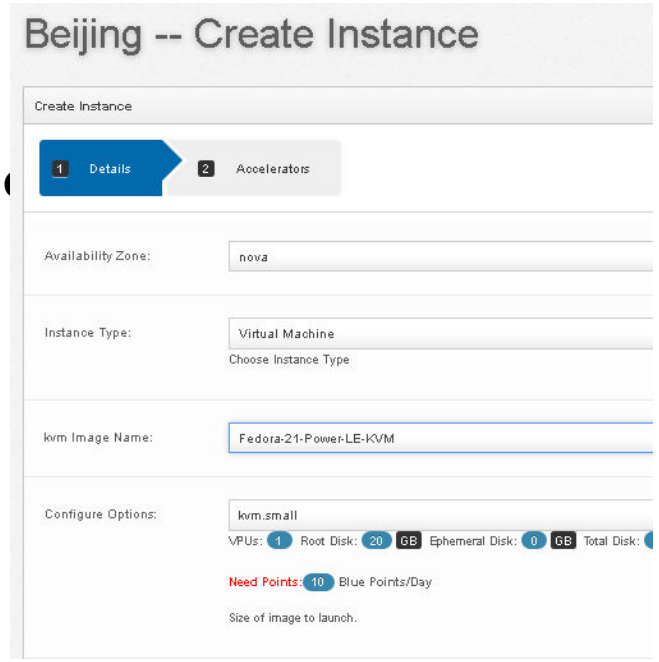
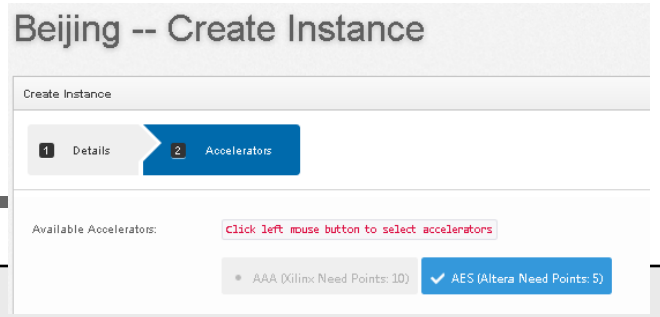


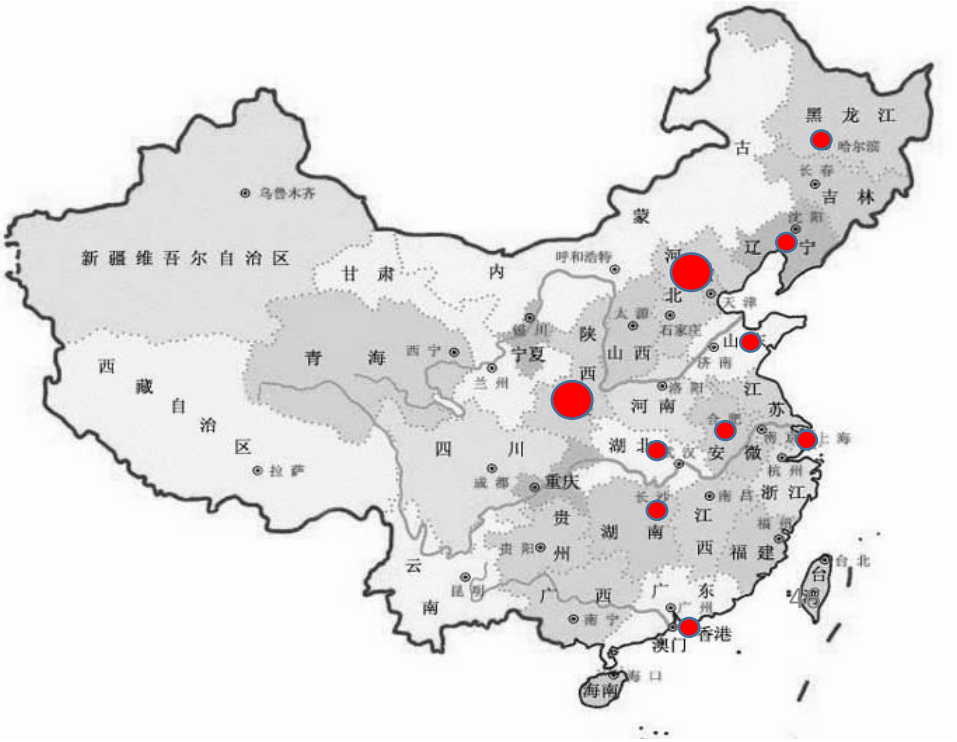
Fig.2 Cloud users could appl accelerator when creating V





Developer quickly grew in the past 100 days

- Users from **30** universities (including **3** from US)
- **6** university joint research projec
- Supported several courses from universities, e.g.
  - The Big Data course of Beijir Institute of Technology: **100** students with **38** big data clusters
  - The virtualization technology course from University of Delaware (US)



Our target is **100,000** users and **100** universities in 2015/2016.

IBM

Thank You !!

Call for your collaboration to build this CLOUD together

www.ptopenlab.com