Lenovo HPC Strategy

Luigi Brochard – Distinguished Engineer, WW HPC & AI, DCPG
Lenovo Proven T1 HPC Partner

First

WARM WATER COOLED SUPER COMPUTER

Co-Innovation with LRZ

Largest

SUPER COMPUTER IN EMEA

Number 12 on TOP500
World’s #3 KNL/OPA System

Fastest

GROWING TOP 500 HPC

#2 WW – 99 listings
#1 China
Multiple PFLOP+ SKL wins

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Lenovo Goal – Be the #1 Trusted HPC Partner

- Resurgence of Specialization
  - Artificial Intelligence
  - Modular designs
  - SW Defined HPC
  - Be fast and agile

- Open Everything
  - Open source focus
  - Partner openness
  - Open/Shared IP
  - Lead w/ communities

- Co-Design is Mandatory
  - Innovation centers
  - Deep Skills/Experts
  - STIC and R&T
  - Global arch. reviews

- Limited Budgets; Higher Demands
  - MFG/Supply Chain
  - Energy Mgmt
  - DC IoT
  - Warm Water Cooling
  - Benchmark Centers
AI and Machine Learning is part of HPC Lenovo

Machine Learning workflow requires specialized architectures for each process step:

- **Data**
  - Storage
  - Preparation
  - Feeding
  - Hadoop/Spark

- **Train**
  - HPC characteristics
    - Compute intensive
    - Scale up and out
    - Accelerators/high-speed networks

- **Deploy**
  - Classification
  - Detection
  - Segmentation

- **Inference/Scoring**
  - Enterprise/device computing
  - Scale out architectures
  - Xeon+FPGA

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HPC PORTFOLIO AND ROADMAP
**Lenovo Scalable Infrastructure (LeSI)**

Lenovo Scalable Infrastructure (LeSI) is a framework for development, configuration, build, delivery and support of integrated data center solutions

- Complete HPC data center portfolio with the best-of-breed partner technology
- Collaborate on OpenSource HPC software in true commitment to Openess
- End-to-end expert-designed, tested, integrated and supported HPC solutions

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<th>Scalable Infrastructure</th>
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<td>Scalable Infrastructure Components</td>
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<td>HPC Network systems/options</td>
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<td>Networking</td>
<td>Infrastructure options</td>
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<td>Options</td>
<td>OpenSource HPC Software (LiCO, xCAT/Confluent, Antilles, ...)</td>
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<tr>
<td>Software</td>
<td>Scalable Infrastructure Solutions</td>
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<td>ThinkAgile HPC</td>
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<td>Distributed Storage Solution for IBM Spectrum Scale</td>
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</table>

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ThinkAgile HPC

From Complete Portfolio to Results Driven Designs

Best of the Lenovo Portfolio + Scalable Infrastructure OEM Portfolio + Scalable Infrastructure HPC Support + Factory Integration Services = ThinkAgile HPC

Selection from off-the-shelf HPC proven Lenovo Portfolio
- Server
- Storage
- Networking
- Options
- Software

Bringing in best-of-breed HPC partner components, especially HPC switches and adapters
- Mellanox FDR/EDR Infiniband
- Intel Omnipath 100 Series

Testing hardware and software interoperability resulting in best recipe code level:
- SLES, RHEL
- MOFED, IFS
- xCat/Confluent, Spectrum Scale

1410 physical rack ship racked/cabled testing power & redundancy, p2p cabling, best recipe, factory settings, run Linpack and load client xCat image

A single cluster, end2end designed & configured, built and shipped ready to accept the client images through xCAT or alternatives.

Value Add Choice:
- Installation Services
- Managed Services
- Full HPC SW Suite

Customizing solutions for each client’s unique needs

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Lenovo DCG Portfolio Spans the Entire Data Center

World Class, end-to-end Data Center portfolio, delivered as Discrete or as Integrated offerings

### Server
- Rack & Tower
- Mission Critical: X6
- Dense: NeXtScale & ThinkServer
- Blades: Flex System

### Storage
- SAN: S Series, V Series
- SDS: DX8000C, DX8000N
- AFA: Coming soon
- Scale-out: GSS
- Direct Attach & Archive

### Hyper-converged
- ROBO: HX1000
- SMB: HX2000
- Compute Heavy: HX3000
- Storage Heavy: HX5000
- High-Performance: HX7000

### Networking
- Embedded
- Top of Rack
- Campus and Core
- Storage Switches
- Networking OS

### Engineered Solutions
- Cloud
- Big Data
- Client Virtualization
- Database & Analytics

### HPC/AI
- CAE & EDA
- Academia
- Weather & Climate
- Cluster & Storage
- Machine Learning

### Hyperscale
- Rack Scale Arch.
- Compute & Warm Storage
- Application Optimized

### Discrete offerings
- 1. Broad datacenter offerings; servers, storage, networking
- 2. Highest configuration flexibility
- 3. Open and optional networking
- 4. Simplified and open mgmt

End to end services that span from basic to consultative engagements

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Moving forward into a decade of dense HPC

iDataPlex – Air / DWC
- dx360 - Harpertown
- dx360M2 - Nehalem
- dx360M3 - Westmere
- dx360M4 - Sandy Bridge

NeXtScale – Air / DWC
- nx360M4 - Sandy Bridge/Ivy Bridge
- nx360M5 - Haswell/Broadwell

Stark – Air
- sd530 - Skylake/Icelake

NeXtScale – DWC
- sd650 - Skylake/Icelake

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Deliver Results Faster With HPC

Helping Researchers and Companies Make Immediate Impact

Challenge What is Possible  
Best cost, speed and skill  
Deliver Unique Thinking

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COOLING TECHNOLOGIES
Lenovo Choice of Cooling

**Air Cooled**
- Standard air flow with internal fans
- Fits in any datacenter
- Maximum flexibility
- Broadest choice of configurable options supported
- Supports Native Expansion nodes (Storage NeX, PCI NeX)

PUE ~2 – 1.5  
ERE ~2 – 1.5

**Indirect Water Cooled**
- Air cool, supplemented with RDHX door on rack
- Uses chilled water with economizer (18°C water)
- Enables extremely tight rack placement

PUE ~1.4 – 1.2  
ERE ~ 1.4 – 1.2

**Direct Water Cooled**
- Direct water cooling without fans
- Higher performance per watt
- Free cooling (inlet up to 50°C water)
- **Energy re-use**
- Densest footprint and high TDP SKU
- Ideal for geos with high electricity costs and new data centers

PUE ~ 1.1  
ERE < 1 (with hot water)

Choose for broadest choice of customizable options  
Choose for compromise between flexibility and energy efficiency  
Choose for highest performance and energy efficiency
NeXtScale System with Water Cool Technology (WCT)

- Water Cooled Node & Chassis
  - Full wide, 2-node compute tray
  - 6U Chassis, 6 bays (12 nodes/chassis)
  - Manifolds deliver water directly to nodes
  - Water circulated through cooling tubes for component level cooling
  - Intel E5-2600 v4 CPUs
  - 16x DDR4 DIMM slots
  - InfiniBand FDR/EDR and OPA support
  - 6x 900W or 1300W PSU
  - No fans except PSUs
  - Drip sensor / Error LEDs

→ Up to 85% heat to water ratio
DWC reduces Processor Temperature on Xeon 2697v4

Conclusion: Direct Water Cooling lowers processor power consumption by about 5% or allows higher performance

NXT with 2 socket 2697v4, 128 GB 2400 MHz DIMM Inlet Water temperature is 28°C
Value of Direct Water Cooling

• Any temperature:
  – Lower processor power consumption (~6%), No fan per node (~4%)
  – Higher TDP processor
  – Higher performance (~5%)
    - In this case, processor power consumption is not reduced

• Hot water temperature
  – Provides free cooling all year long
    - ~20% power savings on compression chillers to generate chilled water
    - potentially no/less chillers

DC energy is measured through aem DC energy accumulator
TCO: return on investment for DWC vs RDHx

- New data centers: Water cooling has immediate payback.
- Existing air-cooled data center payback period strongly depends on electricity rate.
### Lenovo references with DWC (2012-2016)

<table>
<thead>
<tr>
<th>Sites</th>
<th>Nodes</th>
<th>Country</th>
<th>Instal date</th>
<th>Max. In. Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRZ SuperMUC</td>
<td>9298</td>
<td>Germany</td>
<td>2012</td>
<td>45°C</td>
</tr>
<tr>
<td>LRZ SuperMUC 2</td>
<td>3096</td>
<td>Germany</td>
<td>2014</td>
<td>45°C</td>
</tr>
<tr>
<td>LRZ SuperCool2</td>
<td>438</td>
<td>Germany</td>
<td>2015</td>
<td>50°C</td>
</tr>
<tr>
<td>NTU</td>
<td>40</td>
<td>Singapore</td>
<td>2012</td>
<td>45°C</td>
</tr>
<tr>
<td>Enercon</td>
<td>136</td>
<td>Germany</td>
<td>2013</td>
<td>45°C</td>
</tr>
<tr>
<td>US Army</td>
<td>756</td>
<td>Hawai</td>
<td>2013</td>
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<tr>
<td>Exxon Research</td>
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<tr>
<td>PIK</td>
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<tr>
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<tr>
<td>UNINET</td>
<td>964</td>
<td>Norway</td>
<td>2016</td>
<td>45°C</td>
</tr>
<tr>
<td>Peking U</td>
<td>204</td>
<td>China</td>
<td>2017</td>
<td>45°C</td>
</tr>
</tbody>
</table>

18,000 nodes up and running with DWC technology from Lenovo!
LENOVO HPC STORAGE
Key Component of our overall Data Center Success
Storage is Essential and We Have the Tools

Taking our off-the-shelf server and storage portfolio marrying it with leading HPC Storage Software

Distributed Storage Solution for IBM Spectrum Scale
DSS - G
Defined Solution especially for large capacity, high performance workloads in HPC environments

Distributed Storage Solution for SUSE Enterprise Storage
DSS - C
Defined Solution especially for interaction with Lenovo scale-out HANA solutions.*

Distributed Storage Architecture for SUSE Enterprise Storage / Red Hat Ceph Storage
DSA - C
Tested architecture as entry point and mid range CEPH offering in HPC environments.

Distributed Storage Architecture for Intel Lustre EE
DSA - L
Tested architecture as entry point and mid range Lustre offering in HPC environments.

*formerly published as „ThinkStorage for SAP HANA TDI“

Mid April Announcement
Future Plans

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**DSS Product Overview**

*Distributed Storage Solution for IBM Spectrum Scale™*

*A fully integrated data center solution fulfilled through Lenovo Scalable Infrastructure (LeSI)*

DSS is an LeSI solution for a selection of file and object storage offerings delivering high storage density and I/O performance with superior availability, reliability and resiliency.

**Project**

**DSS-G for IBM Spectrum Scale™**

<table>
<thead>
<tr>
<th>Project</th>
<th>DSS-G for IBM Spectrum Scale™</th>
</tr>
</thead>
</table>
| Solution Definition | 2 x3650 M5 HPIO Servers  
Software: RedHat Enterprise Linux, IBM Spectrum Scale for DSS Standard or Data Management Edition  
1-6 Storage Enclosures  
- Lenovo D3284 12Gb JBOD (5U84) or  
  - 4TB, 6TB, 8TB, 10TB  
- Lenovo D1224 12Gb JBOD (2U24)  
  - 0.3TB – 1.8TB SAS, 0.4TB – 3.8TB SSD |
| **Target Market** | HPC, BigData, Cloud |
| **Target Workloads** | HPC and Distributed File Systems |
| **Value Proposition** | High storage density and I/O performance with superior availability, reliability and resiliency |
| **License Model** | Licensed by drive/capacity, no add. server/client licenses |
| **Target GEO** | World Wide Product |
| **Target Launch** | Q2 2017 (SC’16 Public Disclosure 11/14) – Mid April Avail. |

x3650 M5

D3284
DSS-G Overview

Distributed Storage Solution Configurations Examples for IBM Spectrum Scale™

DSS G202

- SSD / SAS Option for High Performance / IOPS
- D1224
- x3650M5 HPIO
- D1224

DSS G204

- D1224
- x3650M5 HPIO
- x3650M5 HPIO

DSS G206

- D1224
- D1224
- x3650M5 HPIO
- x3650M5 HPIO

DSS G220

- D1224
- D1224
- D1224
- x3650M5 HPIO
- x3650M5 HPIO

DSS G240

- D1224
- D1224
- D1224
- x3650M5 HPIO
- x3650M5 HPIO

DSS G260

- D1224
- D1224
- D1224
- x3650M5 HPIO
- x3650M5 HPIO

Future Announce

DSS G280

- Capacity Optimized
- D3284
- D3284
- x3650M5 HPIO
- x3650M5 HPIO

Low Cost of Entry

Performance optimized

HPIO = High Performance I/O

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This module consists of a pair of clustered servers, loaded with Linux and the Lustre Metadata (MDS) component. The servers connect to a dedicated S3200 array via SAS connections, and to the file serving network via high speed InfiniBand.
LENOVO HPC SOFTWARE
Key Component of our overall Data Center Success
### Lenovo Suite for ThinkAgile HPC Cluster

**Lenovo OpenSource HPC Stack**

*An OpenSource IaaS suite to run and manage optimally and transparently HPC, Big Data and Workflows on a virtualized infrastructure adjusting dynamically to user and datacenter needs through energy policies*

- Bundle best-of-breed software
- Enhance with Lenovo configuration, plugins and scripts
- Add in Energy Aware run time
- All open and flexible

**A ready to use HPC Stack**

<table>
<thead>
<tr>
<th>Antilles Web Console GUI</th>
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<tbody>
<tr>
<td>Ganglia, Icinga</td>
</tr>
<tr>
<td>SLURM, Torque, Maui</td>
</tr>
<tr>
<td>xCAT / Confluent</td>
</tr>
<tr>
<td>OpenMPI, MVAPICH, MPICH</td>
</tr>
</tbody>
</table>

**Customer Application**

- Eclipse PTP, debugger, gdb
- GCC, Intel Parallel Studio, MKL, …

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```
Antilles Management
Admin guide / scripts
Deployment guide / scripts

Lenovo HPC Stack
Open Source / 3rd Party SW
Lenovo / 3rd Party HW
```

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* collaborating w/ Greg Kurtzer from Lawrence Berkeley National Lab

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Lenovo OpenSource Initiatives and OpenHPC

• Status of Lenovo OpenHPC Engagement
  - Since May 2016, OpenHPC as an organization have been having Technical Steering Committee (TSC) meetings to help create processes, rules and procedures to help organize the group to function smoothly.
  - Meeting minutes are posted for everyone to see
  - xCAT and Confluent was submitted as future system management components into OpenHPC and this was accepted by OpenHPC TSC in October 2016.
  - Lenovo will help integrate and validate xCAT and Confluent into OpenHPC
    - Expected timeline is first half of 2017

• All Lenovo OpenSource HPC Engagements
  - Antilles
  - xCat
  - Confluent
  - Singularity/Capsules

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Antilles - Simplified Web Portal for HPC

• Antilles – Web Portal Goals
  – Allow users to access the system from any client environment
  – Enable easy deployment of jobs to the cluster
  – Give a clean and simplified view of jobs running on the cluster

• Integration with xCAT/Confluent
  – Built on xCAT/Confluent
  – Paves the way for future enhancements of xCAT/Confluent
  – Delivers a graphical user experience
  – Allows easier access for operators and system administrators
Confluent @Lenovo Stuttgart Innovation Center
LENNOVO INNOVATIONS
Key Component of our overall Data Center Success
A Strong Footprint for Lenovo R&D

- $1.7B investment globally
- 8,000 Global Researchers/Engineers

2-tier R&D System

Corporate Level

Research & Technology

BU development

BU Level

R&T
- Leading Innovation
- Core Technology
- New Opportunity Incubation
- Build Tech Platform

BU development
- Lead System Integration
- Product Development
- Engineering & Quality Control
- Systems Technology Innovation Center (STIC)

Lenovo Development (& Systems Technology Innovation Center)
Lenovo Research & Technology (co-located with development)
Forging Dreams into Reality

• HPC Innovation Centers
  – Focused HPC team bringing best of breed x86 technology and excellent talent with passion to innovate
  – Collaboration is Key to Success
  – Industry leaders bring together the newest technology and skills
  – Visionary client partners bring focused knowledge & deep skills in specific areas of science

• Parallel Benchmarking System in Stuttgart, Germany
  – A benchmarking system available to Lenovo, our clients and our partners.
  – A broad ecosystem of technologies & skills to help clients and partners move/optimize/demo their applications
Lenovo HPC Innovation Center Stuttgart - Partners

**Technology Partners (HW/SW)**

- Intel – Scalable Systems Framework
- Mellanox – High Speed Networking
- Samsung – High Performance Memory
- Nvidia – Graphic Processing Acceleration
- Seagate – Storage subsystems
- DDN – Lustre solutions
- IBM – File System and Workload Mgmt
- SUSE – Operating System
- NICE – Remote Visualization
- Allinea – Performance Analytics

**Client Partners and Projects**

Focused knowledge and deep skills advance the science of HPC

- MPCDF – Advancing Material Science
- STFC Hatree – New Technologies (ARM)
- BSC – Capsules, Energy Runtime & Big Data
- CINECA – Manycores and FET4HPC
- LRZ – Energy Efficient Systems
- FZJ – HPC Storage Technologies
- Oxford – HPC Software Stack
- ARC – Open Source & Energy Efficiency
- CERFACS – Code optimization (AVBP)
AI Innovation Center

• **Goals**
  • Demonstrate leadership by collaborating with universities, partners, and customers making advances in AI
  • Make customers experience the value of AI through demos

• **Activities**
  • Give access to the latest hardware and software
  • Provide training on machine/deep learning by experts from Lenovo and partners
  • Give visibility at important AI events
  • Demonstrating AI applications to wider audience for impact
    • *Demos at our briefing centers, events etc.*

• **Location**
  • Physical labs in Stuttgart and Morrisville. WW Remote access
## Lenovo HPC & AI platform concept

### Industry verticals
- Healthcare
- Finance
- Academia
- Hyperscale
- Manufacturing

### Applications
- Big data analytics
- Image/video recognition
- Voice recognition
- Text recognition
- Language processing

### Developer tools
- Intel Deep Learning SDK
- C/C++
- Python
- R
- Java

### Frameworks
- Caffe
- TensorFlow
- Theano
- Spark
- Microsoft CNTK

### Low-level libraries
- NVIDIA cuDNN
- NVIDIA CUDA
- Intel® MKL-DNN
- Intel® Math Kernal Library

### System management
- xCAT/Confluence/Antilles
- Lenovo Open HPC

### Hardware
- System components

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Services

• Implementation
  – Project Management
  – Physical Setup
  – Software Setup

• Operation Support
  – Onsite Managed Service
  – Remote Managed Service

• Application Support
  – Onsite Application Service

• Maintenance Support
  – Based on the classification of components
Services – Continuing a successful way

- We will subcontract IBM for maintenance services during whole contract lifecycle
  - You still have ONE contract partner - Lenovo

Customer opens a call
  - via phone
  - via internet

IBM Frontdesk
Searches for already known solutions
Routes to 2nd/3rd level

2nd / 3rd Level
Finds the root cause
Routes to field service to replace failing device

Field Service
Replaces failing device

Lenovo quality control / Customer satisfaction

= Tasks subcontracted to IBM

= Tasks done by Lenovo

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thanks.