Welcome To The 73\textsuperscript{rd} HPC User Forum Meeting September 9 to 11, 2019
Introduction: Logistics

We have a very tight agenda (as usual)
  ▪ Please help us keep on time!

Review handouts
  ▪ Note: We will post most of the presentations on the web site

Dinner events
Thank You To Our Sponsors!

**Platinum:**
- AMD
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- HPE
- Intel

**Gold:**
- Cray
- IBM
- Nvidia
- Panasas
- Supermicro

**Silver:**
- Altair
- Wave Computing
Benefits Of Joining The HPC User Forum

Hear about best practices (and lessons learned)

Access to a full information service: on HPC, HPDA, AI, cloud, QC, etc.

- Market results, forecasts, vendor shares
- Analysis of market developments & trends
- In-depth profiles of leading sites and achievements

Inquiry time with Hyperion Research analysts

- Topics of your choice
- Custom cuts from our data structures

For more information: http://hpcuserforum.com/
Important Dates For Your Calendar

2019 HPC USER FORUM MEETINGS:
- October 7 to 8, Lugano, Switzerland at CSCS
- October 10 to 11, Edinburgh, Scotland at EPCC

2020 U.S. EVENTS
- March 30 to April 1, Princeton Marriott at Forrestal, Princeton, New Jersey
- September 8 to 10, Loews Ventana Canyon, Tucson, Arizona
CHAIRMAN’S WELCOME
HPC User Forum Mission

To Improve The Health Of The High Performance Computing Industry
Through Open Discussions, Information-sharing And Initiatives Involving
HPC Users In Industry, Government And Academia
Along With HPC Vendors And Other Interested Parties
The HPC User Forum: 72 Meetings Worldwide Since 2000

Amsterdam, Netherlands (SARA)
Annecy, France
Bangalore, India (Indian Institute of Technology)
Beijing, China (Chinese Academy of Sciences)
Bologna, Italy (CINECA)
Bristol, UK
Bruyères-le-Châtel, France (Teratec)
Canberra, Australia
Geneva, Switzerland (CERN)
Kobe, Japan (RIKEN)
Lausanne, Switzerland (EPFL)
London, UK (Imperial College)

Manchester, UK (Manchester University)
Melbourne, Australia
Munich, Germany (LRZ)
New Delhi, India (Indian Institute of Science)
Paris, France (GENCI)
Seoul, Korea (National Institute of Supercomputing & Networking)
Stuttgart, Germany (HLRS)
Warsaw, Poland (University of Warsaw)
Yokohama, Japan (Earth Simulator Center)
Zurich, Switzerland (ETH Zurich)
United States (many locations)
Introduction
HPC User Forum Steering Committee

Paul Muzio
Chairman, Industry Expert

Rupak Biswas
NASA Ames
Vice Chairman

Earl Joseph
Executive Director, Hyperion Research

Vijay Agarwala
Virginia Tech.

Alex Akkerman
Ford Motor Company

Doug Ball
HPC Expert

Mike Bernhardt
Exascale Computing Project

Steve Conway
Vice President, Hyperion Research

Steve Finn
Emagine IT

Merle Giles
Moonshot Research

Keith Gray
BP

Arno Kolster
Providentia Worldwide

Doug Kothe
Oak Ridge National Laboratory

Jysoo Lee
KAUST

David Martin
Argonne National Laboratory

Jeff Broughton
NERSC/Lawrence Berkeley National Lab

Paul Buerger
Industry Expert

Clayton Chandler
Credit Suisse Group AG

Candace Culhane
Los Alamos National Labs

Sharan Kalwani
Industry Specialist Consultant

Simon Burbidge
University of Bristol (UK)

Michael Resch
HLRS, University of Stuttgart

Ryan Quick
Providentia Worldwide

Stephane Requena
GENCI

Vince Scarafino
Industry Expert

Suzy Tichenor
Oak Ridge National Laboratory

» SEE ALL BIO's
HPC Market Update
## The Hyperion Research Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earl Joseph</td>
<td>Research studies &amp; strategic consulting</td>
</tr>
<tr>
<td>Steve Conway</td>
<td>Strategic consulting, HPC UF, Big Data, AI</td>
</tr>
<tr>
<td>Bob Sorensen</td>
<td>Strategic research, government studies, QC</td>
</tr>
<tr>
<td>Alex Norton</td>
<td>Special studies, new data analysis, surveys</td>
</tr>
<tr>
<td>Mike Thorp</td>
<td>Global sales management</td>
</tr>
<tr>
<td>Kurt Gantrish</td>
<td>Global sales management</td>
</tr>
<tr>
<td>Jean Sorensen</td>
<td>Business manager</td>
</tr>
<tr>
<td>Tom Christian</td>
<td>Survey design &amp; executive interviews</td>
</tr>
<tr>
<td>Nishi Katsuya</td>
<td>Japan research and studies</td>
</tr>
</tbody>
</table>
Hyperion Research HPC Activities

- Track all HPC servers sold each quarter
- 4 HPC User Forum meetings each year
- Publish 85 plus research reports each year
- Visit all major supercomputer sites & write reports
- Assist in collaborations between buyers/users/vendors
- Assist governments in HPC plans & strategies
- Assist buyers/users in planning and procurements
- Maintain 5 year forecasts in many areas/topics
- A worldwide ROI measurement system
- HPDA program (includes ML/DL/AI)
- HPC Cloud usage tracking
- Quarterly tracking of GPUs/accelerators
- Cyber Security
- Quantum Computing
Evolving Issues On Our Minds

New major growth areas require different types of systems and solutions
- AI, ML and DL
- Big Data (HPDA) and advanced analytics
- Non-traditional new HPC users from the enterprise space

Non-x86 processors could alter the landscape
- Both base processor and accelerators
- From China and Europe, plus ARM, AMD, and others

The race for exascale is driving up budgets for HPC

China has a larger impact than before
- i.e. new domestic processors
- i.e. Lenovo is expanding

HPC in the cloud is gaining traction
Top Trends in HPC

2018 was a very strong year with over 15% growth -- $13.7 billion (US$) in revenues!

- Supercomputers grew 23% = $5.4 billion in 2018

The top systems have started growing again after over 4 years of softness

- The profusion of Exascale announcements are generating a lot of buzz

Big data combined with HPC is creating new solutions

- Adding many new users/buyers to the HPC space
- AI/ML/DL & HPDA are the hot new areas
The Worldwide HPC Server Market: $13.7 Billion in 2018

- Record revenues!

- HPC Servers: $13.7B
  - Supercomputers (Over $500K): $5.4B
  - Divisional ($250K - $500K): $2.5B
  - Departmental ($250K - $100K): $3.9B
  - Workgroup (under $100K): $2.0B
<table>
<thead>
<tr>
<th>Application</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-Sciences</td>
<td>1,245,865</td>
</tr>
<tr>
<td>CAE</td>
<td>1,521,850</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>205,891</td>
</tr>
<tr>
<td>DCC &amp; Distribution</td>
<td>780,184</td>
</tr>
<tr>
<td>Economics/Financial</td>
<td>746,418</td>
</tr>
<tr>
<td>EDA / IT / ISV</td>
<td>984,887</td>
</tr>
<tr>
<td>Geosciences</td>
<td>1,029,041</td>
</tr>
<tr>
<td>Mechanical Design</td>
<td>63,137</td>
</tr>
<tr>
<td>Defense</td>
<td>1,403,164</td>
</tr>
<tr>
<td>Government Lab</td>
<td>2,616,822</td>
</tr>
<tr>
<td>University/Academic</td>
<td>2,420,440</td>
</tr>
<tr>
<td>Weather</td>
<td>560,631</td>
</tr>
<tr>
<td>Other</td>
<td>127,757</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>13,706,088</td>
</tr>
</tbody>
</table>

Source: Hyperion 2019
## HPC Market By Vendor Shares

<table>
<thead>
<tr>
<th>OEM</th>
<th>2018 Sales ($ Millions)</th>
<th>Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPE/HP</td>
<td>4,766</td>
<td>34.8%</td>
</tr>
<tr>
<td>Dell EMC</td>
<td>2,857</td>
<td>20.8%</td>
</tr>
<tr>
<td>IBM</td>
<td>971</td>
<td>7.1%</td>
</tr>
<tr>
<td>Lenovo</td>
<td>957</td>
<td>7.0%</td>
</tr>
<tr>
<td>Inspur</td>
<td>788</td>
<td>5.8%</td>
</tr>
<tr>
<td>Sugon (Dawning)</td>
<td>462</td>
<td>3.4%</td>
</tr>
<tr>
<td>Cray</td>
<td>313</td>
<td>2.3%</td>
</tr>
<tr>
<td>Fujitsu</td>
<td>269</td>
<td>2.0%</td>
</tr>
<tr>
<td>Penguin</td>
<td>244</td>
<td>1.8%</td>
</tr>
<tr>
<td>NEC</td>
<td>201</td>
<td>1.5%</td>
</tr>
<tr>
<td>Atos</td>
<td>150</td>
<td>1.1%</td>
</tr>
<tr>
<td>Other</td>
<td>1,728</td>
<td>12.6%</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>13,706</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
High Growth Areas: HPDA-AI

- HPDA is growing faster than overall HPC market
- AI subset is growing faster than all HPDA

Table 1
Forecast: Worldwide HPC-Based AI Revenues vs Total HPDA Revenues ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>CAGR 18-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW HPC Server Revenues</td>
<td>13,706</td>
<td>14,495</td>
<td>15,780</td>
<td>17,376</td>
<td>18,983</td>
<td>19,947</td>
<td>7.8%</td>
</tr>
<tr>
<td>Total WW HPDA Server Revenues</td>
<td>3,153</td>
<td>3,598</td>
<td>3,932</td>
<td>4,737</td>
<td>5,467</td>
<td>6,450</td>
<td>15.4%</td>
</tr>
<tr>
<td>Total HPC-Based AI (ML, DL, and Other)</td>
<td>747</td>
<td>938</td>
<td>1,094</td>
<td>1,399</td>
<td>1,810</td>
<td>2,725</td>
<td>29.5%</td>
</tr>
</tbody>
</table>

Source: Hyperion Research 2019

Table 2
Forecast: Worldwide ML, DL & Other AI HPC-Based Revenues ($ Millions)

<table>
<thead>
<tr>
<th></th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>CAGR 18-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML in HPC</td>
<td>532</td>
<td>675</td>
<td>875</td>
<td>1130</td>
<td>1479</td>
<td>1940</td>
<td>29.5%</td>
</tr>
<tr>
<td>DL in HPC</td>
<td>177</td>
<td>216</td>
<td>301</td>
<td>392</td>
<td>510</td>
<td>665</td>
<td>30.3%</td>
</tr>
<tr>
<td>Other AI in HPC</td>
<td>38</td>
<td>47</td>
<td>66</td>
<td>80</td>
<td>95</td>
<td>120</td>
<td>25.9%</td>
</tr>
<tr>
<td>Total</td>
<td>747</td>
<td>938</td>
<td>1,242</td>
<td>1,602</td>
<td>2,084</td>
<td>2,725</td>
<td>29.5%</td>
</tr>
</tbody>
</table>

Source: Hyperion Research 2019
# HPC Market Forecasts

<table>
<thead>
<tr>
<th>Worldwide THPC Revenue Forecasts</th>
<th>2018</th>
<th>2023</th>
<th>CAGR 18-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supercomputer</td>
<td>5,361,603</td>
<td>8,029,838</td>
<td>8.4%</td>
</tr>
<tr>
<td>Divisional</td>
<td>2,449,270</td>
<td>3,527,414</td>
<td>7.6%</td>
</tr>
<tr>
<td>Departmental</td>
<td>3,879,445</td>
<td>5,536,962</td>
<td>7.4%</td>
</tr>
<tr>
<td>Workgroup</td>
<td>2,015,770</td>
<td>2,884,803</td>
<td>7.4%</td>
</tr>
<tr>
<td>Total</td>
<td>13,706,088</td>
<td>19,979,016</td>
<td>7.8%</td>
</tr>
</tbody>
</table>

Source: Hyperion 2019
HPC Market Ecosystem Forecast ($000 USD)

<table>
<thead>
<tr>
<th>Revenues by the Broader HPC Market Areas</th>
<th>2018</th>
<th>2023</th>
<th>CAGR 18-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>13,706,088</td>
<td>19,979,016</td>
<td>7.8%</td>
</tr>
<tr>
<td>Storage</td>
<td>5,547,188</td>
<td>7,771,184</td>
<td>7.0%</td>
</tr>
<tr>
<td>Middleware</td>
<td>1,582,892</td>
<td>2,217,801</td>
<td>7.0%</td>
</tr>
<tr>
<td>Applications</td>
<td>4,627,492</td>
<td>6,413,592</td>
<td>6.7%</td>
</tr>
<tr>
<td>Service</td>
<td>2,229,921</td>
<td>2,858,820</td>
<td>5.1%</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td><strong>27,693,580</strong></td>
<td><strong>39,240,413</strong></td>
<td><strong>7.2%</strong></td>
</tr>
</tbody>
</table>

Source: Hyperion 2019

HPC cloud (CSP) usage raises forecast to $44 billion
Tipping Points: How Quickly HPC Buyers Can Change

Source: Hyperion Research, 2018
IN SUMMARY:
SOME PREDICTIONS
Our Prediction On When & Where Exascale Systems Will Be Installed

<table>
<thead>
<tr>
<th>Year Accepted</th>
<th>China</th>
<th>EU</th>
<th>Japan</th>
<th>US</th>
<th>Total Installations</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>1 pre-exascale</td>
<td>1 pre-exascale</td>
<td>1 pre-exascale</td>
<td>1 pre-exascale</td>
<td>3-4</td>
<td>~$750 Million</td>
</tr>
<tr>
<td>2021</td>
<td>1 pre-exascale</td>
<td>1 pre-exascale</td>
<td>1 (Post K Accepted)</td>
<td>1 pre-exascale</td>
<td>4-5</td>
<td>~$1,900 Million</td>
</tr>
<tr>
<td>2022</td>
<td>1 or 2 exascale</td>
<td>1 near-</td>
<td>?</td>
<td>2 exascale</td>
<td>4-5</td>
<td>~$1,700 Million</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exascale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2023</td>
<td>1 exascale</td>
<td>1 exascale</td>
<td>1 near-exascale ($100 million)</td>
<td>1 or 2 exascale</td>
<td>4</td>
<td>~$1,500 Million</td>
</tr>
<tr>
<td>2024</td>
<td>1 exascale</td>
<td>1 exascale</td>
<td>?</td>
<td>2 exascale</td>
<td>4</td>
<td>~$1,400 Million</td>
</tr>
<tr>
<td>2025</td>
<td>2 exascale</td>
<td>1 or 2 exascale</td>
<td>1 near-exascale ($100 million)</td>
<td>1 exascale</td>
<td>5-6</td>
<td>~$1,600 Million</td>
</tr>
</tbody>
</table>

Source: Hyperion Research 2019
Choices of processing elements (CPUs, accelerators) will increase

- x86 will remain the dominant HPC CPU, but indigenous CPUs will gain ground
- **New processors from Japan, China and Europe are being developed**

**NVIDIA is the dominant accelerator today, but many companies are developing very targeted accelerators**

- AI startups and large companies are developing processors designed for specific workloads

**Processors exploiting ARM IP are planned for Europe (EPI), Japan (Post-K computer) and China!**
The global Exascale race is boosting funding for the Supercomputers market segment and creating widespread interest in HPC

Exascale systems are being designed for HPC, AI, HPDA, etc.

- This will drive new processor types, new memories, new system designs, new software, etc.

In some cases HPC has become too strategic to depend on foreign sources

- This has led to indigenous technology initiatives
The AI market is at an early stage but already highly useful (e.g., visual and voice recognition)

- Once better understood, there are many high value use cases that will drive adoption

The trust (transparency) issue that strongly affects AI today will be overcome in time

Learning models (ML, DL) have garnered most of the AI attention, but graph analytics will also play a crucial role with its unique ability to handle temporal and spatial relationships
Conclusions

**HPC is a high growth market**
- Growing recognition of HPC’s strategic value

**HPDA, AI, ML & DL are growing very quickly**
- The HPDA, AI, ML & DL markets will expand opportunities for vendors

**Vendor share positions shifted greatly in 2015, 2016, 2017 & again in 2019 and may continue to shift**
- e.g., HPE acquisition of Cray

**Software continues to lag hardware**
- New systems designs and system complexity is making software even further behind
- Applications will need major redesign
Questions?

Please email: ejoseph@hyperionres.com

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
</table>
| 8:00 AM| Welcome and HPC Market Update: Paul Muzio, Rupak Biswas, Earl Joseph and Steve Conway  
**Morning Session Chair: David Martin** |
| 8:15 AM| Welcome, Valerie Taylor, Director of Argonne's Mathematics and Computer Science Division |
| 8:30 AM| Welcome and Overview of HPC at Argonne National Laboratory, David Martin, ANL |
| 8:45 AM| AI for Science, Rick Stevens, ANL                                      |
| 9:30 AM| The Cray Shasta Architecture, Steve Scott, Cray                        |
| 10:00 AM| Networking Break                                                   |
| 10:30 AM| CSCS (Swiss National Supercomputing Center) Update, Thomas Schulthess, CSCS |
| 11:00 AM| ECP Applications Development, Andrew Siegel, ANL                      |
| 11:30 AM| Vendor Technology Update: Intel                                     |
| 11:45 AM| Vendor Technology Update: Dell EMC                                   |
| 12:00 PM| Networking Lunch                                                   |
Please Return
By 1:00 PM
Agenda: Tuesday Afternoon

Afternoon Session Chair: Paul Muzio

1:00 PM  The European Processor Initiative, Jean-Marc Denis, EPI
1:30 PM  Update on Exascale Computing Project (ECP), Doug Kothe, Director, ECP
2:00 PM  HPC and Data Down Under: The Pawsey Supercomputing Centre, Square Kilometre Array and HPC in Australia, Mark Stickells, The Pawsey Supercomputing Centre
2:30 PM  Vendor Technology Update: HPE
2:45 PM  Networking Break
3:15 PM  (Un)Obscured By Clouds - Applying Cloud Techniques To High Performance Systems Integrations, Arno Kolster, Providentia Worldwide
3:45 PM  Enabling Performance Portable Climate Simulations on Aurora, Nichols Romero, ANL
4:15 PM  The Cancer Computer, Roy Chartier, Cancer Computer
4:45 PM  Meeting Ends
5:30 PM  Special Dinner Event and Tour at the Advanced Photon Source (Building 402, near the Guest House). Note: There are three tour times starting at 5:30 PM.
Welcome To The Second Day Of The HPC User Forum Meeting
Thank You To Our Sponsors!

**Platinum:**
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- HPE
- Intel

**Gold:**
- Cray
- IBM
- Nvidia
- Panasas
- Supermicro

**Silver:**
- Altair
- Wave Computing
Innovative Technologies Panel: Process

Panelists are asked to present in under 5 minutes an innovative technology that could change the HPC industry.

Each presenter is asked to address 4 questions:
1. What is the innovative technology?
2. Why it is disruptive?
3. What does it do for the end user?
4. What could you use from buyers/partners/others to bring this technology to market sooner or make it better?
Agenda: Wednesday Morning

8:00 AM  Welcome: Paul Muzio, Rupak Biswas, Earl Joseph and Steve Conway

Morning Session Chair: Rupak Biswas

8:15 AM  HPDA-AI Research Findings: Steve Conway, Hyperion Research

8:30 AM  Research Using the Blue Waters Supercomputer, Brett Bode, NCSA

9:00 AM  HPC in Industry, Brendan McGinty, NCSA

9:30 AM  Using HPC for Engine Design Optimization, Pei Yuanjiang, Aramco Services

10:00 AM Networking Break

10:30 AM Innovative Technologies Panel Session, Earl Joseph, Hyperion Research (chair)

Panel members: Altair, AMD, Cray, IBM, Panasas, Red Hat, Supermicro

11:30 AM Vendor Technology Update: AMD

11:45 AM Vendor Technology Update: AWS

12:00 PM Networking Lunch
Please Return
By 1:00 PM
Agenda: Wednesday Afternoon

Afternoon Session Chair: Keith Gray

1:00 PM  HPC at BP, Keith Gray, BP
1:30 PM  ANL Exascale Training Program, Ray Loy, ANL
2:00 PM  How the Results of Summit and Sierra are Influencing Exascale, Al Geist, ORNL
2:30 PM  Vendor Technical Update: IBM Quantum Computing
2:45 PM  Vendor Technology Update: NEC
3:00 PM  Cloud Computing Research Findings, Alex Norton, Hyperion Research
3:15 PM  Networking Break
3:45 PM  HPC Edge Computing in Urban Environments, Nicola Ferrier, ANL
4:15 PM  Using Graphs for Unstructured Data, Keshav Pingali, TACC
4:45 PM  Computational Evaluation of Commercial Cloud HPC with a Global Atmospheric Model, Daniel Arevalo, Divine Consulting
5:15 PM  Meeting Wrap-Up, Paul Muzio, Rupak Biswas, Earl Joseph and Steve Conway
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Or check out: www.HyperionResearch.com
www.hpcuserforum.com