

Energy Efficient High Performance Computing Working Group 2/9/16 Meeting Report

INTRODUCTION

The EE HPC WG held a meeting on 2/9/16. This Working Group is composed of members representing major Federal departments and independent agencies, private sector representatives, and members of the academic community. More information can be found at the working group's website, <https://eehpcwg.llnl.gov/>.

NEXT MEETING: Tuesday April 12th, 9:00-10:00AM Pacific Time

Introductions and Announcements: *Natalie Bates, EE HPC WG*

We are delighted to announce that Michael Patterson from Intel Corporation and Torsten Wilde from the Leibniz Supercomputing Centre (LRZ, Germany) will assume responsibility as Conferences Co-Leads for the Energy Efficient HPC Working Group (EE HPC WG). Both Michael and Torsten have been actively involved with the EE HPC WG and have shown technical and group leadership. Please help me to welcome Mike and Torsten in their new positions.

Marriann Silveira is passing the baton as Conferences Co-Lead. Marriann has been a leader for the EE HPC WG since its inception, but her day-job at Lawrence Livermore National Laboratory has shifted and she is no longer working solely in the HPC environment. She will continue to work on some HPC projects but will branch out to support the Laboratory in other areas requiring her mechanical engineering expertise. We will miss Marriann's technical leadership as well as her cheerful disposition and good sense of humor. A special recognition and thanks to Marriann for her contribution to the EE HPC WG.

Anna Maria Bailey will also step down as Conferences Co-Lead, but will remain as Co-Chair of the EE HPC WG.

Conferences Sub-group Update: *Torsten Wilde, Leibniz Supercomputing Centre (LRZ, Germany)*

ISC16

- The Demand Response Team submitted a full paper to ISC16. More on this in the Systems Update.
- Birds of Feather submissions are due 15 February and there are no current plans for submission this year.

HPPAC (Workshop on High Performance Power Aware Computing)

- The Dashboard Team submitted a 4 page paper to the High Performance Power Aware Computing Workshop 2016. More on this in the Infrastructure Update.

SC16

- Workshop submission is due 14 February.
 - Two workshop submissions in flight – Standard full day EE HPC WG workshop, our 7th!
☺ We also are working on a joint submission with ASHRAE on liquid cooling. 4 hours, looking at liquid cooling from the supplier and end-user perspective.
- Booth is reserved, thank you OSISoft for your support
- Other upcoming deadlines:
 - Paper, Apr 3
 - Tutorial, Apr 17
 - Panel, Apr 24
 - Poster, Jul 15
 - Birds of Feather, Jul 31
 - Emerging Tech, Jul 31

SC15

Below is a report summarizing the Energy Efficient HPC Working Group presence at SC15. Presentation material can be found on our website: <https://eehpcwg.llnl.gov/>

REPORT: EE HPC WG and SC15

The EE HPC WG has worked collaboratively with standards bodies on guidelines for liquid cooling design and commissioning as well as power measurement methodologies. It has also published reports on energy efficiency considerations for procurement documents. Finally, it is developing best practices on energy efficiency and controls as well as dynamic power management. The purpose of the SC15 activities is to solicit feedback and participation from the broader community as well as serve as a face-to-face collaborative forum. This report shall document the results of these activities.

The EE HPC WG presence at SC15 included a workshop, 3 birds of feather sessions and a technical paper publication/presentation. Participation was strong in all of these sessions. Thanks to all who participated. For those who couldn't make it, presentations are posted (or in some cases will be posted) on the EE HPC WG website. Also, some of the EE HPC WG organized events will be repeated as webinars in upcoming months.

WORKSHOP:

The 6th Annual EE HPC WG SC15 Workshop was held on Monday, November 16th from 9:00 to 5:30. There were ~100 participants in the room at any point in time with ~150 different individuals attending at some point during the day. Presentation material from the workshop is posted on the EE HPC WG website: https://eehpcwg.llnl.gov/pages/conf_sc15a.htm.

Justin Rattner, former Intel Senior Fellow, Chief Technology Officer (CTO) and Vice President of Intel Corporation, delivered the keynote address. He presented an architectural 5-year perspective on exascale computing and provided evidence that material technology advances will sustain Moore's Law. Citing a 2010 research paper, Justin showed an evolution of quantum well field effect transistors. "Non-planar, multi-gate InGaAs quantum well field effect transistors with high-k gate dielectric and ultra-scaled gate-to-drain/gate-to-source separation [allow] for low power."

Satoshi Matsuoka from the Tokyo Institute of Technology opened the workshop and moderated the first workshop session with three speakers from Japanese Supercomputing Centers; Kazuo Minami from Riken, Toshio Endo from Tokyo Institute of Technology and Hiroshi Nakamura from Tokyo University.

- The March 2011 earthquake in Japan affected 18/26 Japanese Top500 supercomputers. All had to be stopped due to rolling blackouts.
- The K Computer at Riken is subject to a power constraint and occasionally jobs are stopped to avoid additional penalty charges due to exceeding limit.
- Tsubame 2.5 at Tokyo Institute of Technology implemented static power capping from 2011-2013 and transitioned to dynamic power capping in 2014.
- Tokyo University has a research collaboration with Tokyo Institute of Technology and LLNL on operating a supercomputer under a power budget.

The workshop hosted a session with a panel of representatives from the Oil and Gas Industry with presentations from Total, BP, Hess and CGG. CGG's experiences with oil immersion were particularly interesting, including cost savings for both capital and operations (within site-specific constraints and considerations).

Josip Loncaric then led a session proposing standards for liquid cooling facility hook-ups. Today, every platform has unique hook-ups that require facility modifications. With standards, preparation for each platform would be more rapid and less costly.

The next session was about energy efficiency related lessons learned from past, present and future installations (NREL, LANL and Dresden, respectively).

- Four lessons learned from NREL highlight building commissioning challenges prior to installation of the computer system.
- LANL's presentation show innovative best practices in their facility design.
- Dresden has implemented extensive and integrated data collection for monitoring and controlling their system and facility.

The final session at the workshop was a hot topic for the EE HPC WG at SC15 and repeated in several forums; that of protocols, application programming interfaces (APIs) and frameworks that allow for power monitoring and controls.

- The Sandia Power API is a proposed "de-facto" standard power API that endeavors to cover the entire software space, from generic hardware interfaces to the input from the computer facility manager.
- Redfish is an open industry standard specification that will specify retrieval of "IPMI class" data including temperature sensors, fans, power supplies, power consumption and power thresholds.
- Power Data Aggregation Monitor (PowerDAM) developed by LRZ is a tool that allows for the collection and evaluation of sensor data from different systems and physical sensors.

BIRDS OF FEATHER:

Presentations from all of the Birds of Feather are made available on the EE HPC WG website. https://eehpcwg.llnl.gov/pages/conf_sc15b.htm

The EE HPC WG organized a Birds of Feather called "Dynamic Liquid Cooling, Telemetry and Controls; Opportunity for Improved TCO?" This Birds of Feather continued and extended the discussion on power monitoring and controls that had begun during the workshop.

The EE HPC WG collaborated with the Green500 and Top500 in organizing a Birds of Feather called "Green500 List and its Continuing Evolution." An announcement was made at this BoF detailing changes in workload power measurement methodology for the Green500 and Top500.

The EE HPC WG also collaborated with Oak Ridge National Laboratory, the US DOE Federal Energy Management Program and “The EE HPC WG also collaborated with Oak Ridge National Laboratory, the US DOE Federal Energy Management Program, and the Leibniz Supercomputing Centre (LRZ, Germany) ” on a Birds of Feather called “Identifying a Few, High-Leverage Energy Efficiency Metrics.” The BoF participants were asked to complete a survey giving their feedback on proposed metrics. The results of this survey will be compiled and published as a report/paper.

TECHNICAL PAPERS:

The Power Measurement Methodology Team presenting a paper on “Node Power Variability: Implications for System Power Measurement Methodologies”.

Thomas Scogland, Jonathan Azose, David Rohr, Natalie Bates, Suzanne Rivoire, Daniel Hackenberg, Torsten Wilde, James H. Rogers, “Node Variability in Large-Scale Power Measurements: Perspectives from the Green500, Top500 and EEHPCWG”.SC'15 Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis Article No. 74.
<http://dl.acm.org/citation.cfm?id=2807591&picked=prox>

BOOTH:

We didn't host a booth this year because we missed the deadline for exhibitor booth space. In order to secure a booth for SC16, however, we attended the Exhibitor booth space allocation meeting and reserved a space.

OTHER CONFERENCES:

See the links and events page on the EE HPC WG website for a list of many other very interesting conferences, workshops and special editions with a focus on Energy Efficiency.
<https://eehpcwg.llnl.gov/pages/events.htm>

Infrastructure Sub-Group Update: *David Grant, ORNL and Dave Martinez, SNL*

ASHRAE UPDATE

TC9.9 - Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment had a biannual meeting at the 2016 ASHRAE Winter Conference and the AHR Expo.

January 24th - Programs/Handbook/Research

- CFD Modeling Guidance
- Gaseous Contamination & High Humidity Impact
- Develop Improved and Integrated Energy Modeling Software for Data Centers – ON HOLD

January 25th - General Meeting

- New website - <http://tc0909.ashraetcs.org/>
- Anyone can become involved, even those who are not ASHRAE members. See website and click “Membership” for more information.
- SPC 90.4 has approved the third Independent Substantive Change public review of BSR/ASHRAE Standard 90.4P, *Energy Standard for Data Centers*

- Working out details on the definition of a data center and consistency issues between 90.4 and 90.1.
- 90.1-2013 – Addendum addition is currently out for public review.
- The public review of 90.4 and 90.1 will be from January 29, 2016 until midnight Eastern Time on March 14, 2016. Go to <https://osr.ashrae.org/default.aspx> to see the current documents under review. Keep in mind that only specific parts are under review and open to comment.
- Planning on revising the “Datacom Equipment Power Trends and Cooling Applications”. A survey will be going out for comments.
- New book “Server Efficiency—Metrics for Computer Servers and Storage”

TC 9.9 Sponsored Talks

- Seminar – “New CFD Techniques for Design of Air Distribution Systems”
- Technical Paper – “Data Center Energy Performance Metrics”
- Conference Paper – “Achieving Net-Zero Energy Use in Data Centers”
- Seminar – “Pursuing Energy Efficiency May Put Your Data Center IT At Risk”

LIQUID COOLING CONTROLS TEAM:

Our Controls Sub-group is in the process of investigating the industry to gain insights into what has been done and where should things go as it pertains to monitoring and controlling super computers and how the operation of these HPC systems translates to energy use by a facility’s cooling infrastructure. This investigation hopes to identify opportunities to improve energy efficiency and TCO in the operation of HPC systems.

As mentioned earlier in the Conferences Update, we organized a Birds of Feather called “Dynamic Liquid Cooling, Telemetry and Controls; Opportunity for Improved TCO?” This Birds of Feather continued and extended the discussion on power monitoring and controls that had begun during the workshop. It was very productive in the sense that we highlighted some specific areas that present challenges as well as opportunities to improve. Some of these areas include procurement, integrated design collaboration between facilities and system integrators, and the opportunity to standardize the method of communication between facilities controls and the HPC system.

There were at least 50 people in attendance and 16 of them completed a survey we passed out. There were 70% of respondents who found it very valuable, 20% who found it somewhat valuable and only 10% who found it only a little valuable. Four respondents said they would be willing to do a case study and 9 said 'maybe'.

We’d appreciate the opportunity to hear about your system and experiences. Feel free to call me or email me with the contact information provided below to discuss further.

Currently, the Controls Team is preparing to replicate the BoF panel discussion with other industry players. We are going to start with liquid cooling vendors, like Asetek and Iceotope. We may then move to building controls vendors, like Siemens and JCI. We are hoping that these panels will not only provide outreach to recruit new members, but will continue to build the knowledge and experience base of the regular team participants.

DASHBOARD TEAM:

The Dashboard Team has been resurrected after a hiatus of several years. The impetus for the current activity started with discussion at the 1st Workshop on HPC Power Management, organized by Neena

Imam from Oak Ridge National Laboratory. That workshop spawned a Birds of Feather at SC15 that was mentioned earlier in the Conferences Update.

An EE HPC WG survey of the major United States Department of Energy (DOE) National Laboratory HPC data centers was completed in early 2012. Only a few DOE labs reported having energy performance dashboards and those were described as partial, piecemeal and under construction. As a result of the 2012 survey, the Energy Efficient HPC Working Group published recommendations for energy and power elements of an HPC data center dashboard. Another survey was completed as part of a 'Birds of Feather' Session at SC15. This survey tested the relevance of the recommendations. This paper provides an update on recommendations to help select or tailor the energy and power elements or parameters of an HPC data center dashboard. The results of the SC15 BoF Survey largely supported the earlier recommendations of the EE HPC WG. The majority of the survey respondents also assessed most of the elements considered high priority by the EE HPC WG as high priority.

TUE TEAM:

There isn't any news from the TUE Team.

LIQUID COOLED COMMISSIONING TEAM:

There isn't any news from the Liquid Cooled Commissioning Team.

If you are interested in participating more actively in any of these efforts or on any of these teams, please contact David Grant, Dave Martinez or Natalie Bates.

Systems Sub-group Update: *Natalie Bates, EE HPC WG*

SYSTEM WORKLOAD POWER MEASUREMENT METHODOLOGY:

The Energy Efficient High Performance Computing Power Measurement Methodology Version 1 was published in 2012. Since then, the EE HPC WG, Green500 and the Top500 have been soliciting, collecting, reviewing and responding to feedback from the broader community. This has resulted in publication of Version 2. Version 2 includes some editorial improvements and minor changes, but is mostly focused on fixing some major issues and concerns with V1. Major issues affect the outcome, the way it is done, the intended result.

The Methodology includes three levels of quality for power measurements. Level 3 is the highest quality and defined by the current best measurement capabilities of major supercomputing centers. Level 1 is the lowest quality and defined as minimally acceptable capabilities that can reasonably be met. Level 2 is in-between Levels 1 and 3.

Most of the major issues and concerns with V1 that are addressed by V2 address the Level 1, the lowest quality level. The most significant change in V2 is a requirement that Level 1 power is measured over the full core phase of the run.

- *Level 1 requires a measurement of the full core phase (before only 20%)*

Another major change in V2 is a requirement that Level 1 power includes both the compute and the interconnect subsystems.

- *Level 1 requires measurement or estimation of the network (before only compute subsystem was measured)*

Finally, the fraction of the system that must be measured for a Level 1 submission has been increased in V2. Also, the options for measurement have been expanded.

- *Level 1 requires whichever is largest of: a minimum of 2kw of power (V1 was 1kw,) or 1/10th of the system (V1 was 1/64th), or 15 nodes (V1 didn't include a node minimum)*
- *or Level 1 requires a measurement of at least 40kw (V1 didn't include minimum power limit)*
- *or Level 1 requires a measurement of the entire system (V1 didn't include the entire system)*

The fraction of the system that must be measured for a Level 2 submission has also been expanded in V2.

- *Level 2 requires whichever is largest of: a minimum of 10kw of power or 1/8th of the system, or 15 nodes (V1 didn't include a node minimum)*
- *or Level 2 requires a measurement of the entire system (V1 didn't include the entire system)*

There is one major issue addressed with V2 that cut across all three quality levels; that is, the power meter accuracy is now defined as a requirement.

- *We now specify explicit minimum guaranteed accuracies for power meters (1% for L3, 2% for L2, 5% for L1, relaxed constraints if multiple power meters are used) (no such requirement before).*
- *We now specify how well the power measurement and the core phase must be synchronized (L3 enforces no more than 10 seconds to be not covered at max, L1 and L2 allow up to 10%) (No such requirement before)*
- *Minimum sampling rate for L3 AC raised to 5 KHz (was 120 Hz before)*

HPC AND GRID INTEGRATION:

This team submitted a paper to ISC High Performance 2016, to be held in Frankfurt Germany in June. Below is the abstract. Author notification is March 7th.

Supercomputing Centers (SCs) have high and variable power demands, which increase the challenges of the Electricity Service Providers (ESPs) with regards to efficient electricity distribution and reliable grid operation. High penetration of renewable energy generation further exacerbates this problem. In order to develop a symbiotic relationship between the SCs and their ESPs and to support effective power management at all levels, it is critical to understand and analyze how the existing relationships were formed and how these are expected to evolve.

In this paper, we first present results from a detailed, quantitative survey-based analysis and compare the perspectives of the European grid and SCs to the ones of the United States (US). We then show that contrary to the expectation, SCs in the US are more open toward cooperating and developing demand-management strategies with their ESPs. In order to validate this result and to enable a thorough comparative study, we also conduct a qualitative analysis by interviewing three large-scale, geographically-distributed sites: Oak Ridge National Laboratory (ORNL), Lawrence Livermore National Laboratory (LLNL), and the Leibniz Supercomputing Center (LRZ). We conclude that perspectives on demand management are dependent on the electricity market and pricing in the geographical region and on the degree of control that a particular SC has in terms of power-purchase negotiation.

PARTICIPANTS INCLUDED

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