Wu Feng, Virginia Tech & Green500
Erich Strohmaier, Berkeley Lab & TOP500

with

Natalie Bates, EE HPC Working Group
Tahir Cader, HP & The Green Grid
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SETTING TRENDS FOR ENERGY-EFFICIENT SUPERCOMPUTING

SC BoF; November 2010; New Orleans, LA, USA

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WHY WE ARE HERE

* Context
  + Power consumption of HPC and facility costs are increasing.
* "Can only improve what you can measure"
* What is needed?
  + Converge on a common basis between different research and industry groups for:
    * METRICS
    * WORKLOADS
    * METHODOLOGIES

    for energy-efficient supercomputing, so we can make progress towards solutions.

AGREEMENT IN PRINCIPAL

- Collaboration between Top500, Green500, Green Grid and EE HPC WG

- Improve methodology, metrics, instrumentation and testing

- Evaluate new technologies for HPC compute system energy efficiency

- Report progress at SC and ISC

COMPLIMENTARY METRICS

✖ Power Usage Effectiveness (PUE)
  + "Data Center" Measurement
  + PUE = Total Facility Power / IT Power

AND

Today's focus

✖ Workload/Productivity Metrics
  + "Compute System" Measurement
  + Useful Work / Energy Consumed

STAKEHOLDERS AND PURPOSE?

- Stakeholders
  - *HPC computer system designers and procurement decision makers*, including users, data center and facilities designers/managers
- Purpose
  - *Unite the community behind energy efficiency metric(s) for HPC systems* that form the basis for comparing and evaluating individual systems, product lines, architectures and vendors

WHAT IS A METRIC?

- A basis for comparison
- A reference point against which other things can be evaluated
- A measure

WHAT MAKES A METRIC EFFECTIVE ?

- ✖ Granular enough
  - + Individual components
  - + Analyzed in manageable chunks
  - + Assigned to specific parties for improvement
- ✖ Intuitive, obvious, and clear
- ✖ Scientifically accurate and used precisely
- ✖ Sufficiently flexible to respond to new technology developments
- ✖ Vendor-neutral
- ✖ Inexpensive and worthwhile

Stanley, J.R., Brill, K.G. and Koomey, J. "Four Metrics Define Data Center 'Greenness,'" Uptime Institute White Paper http://www.verneglobal.com/pdf/WP_FourMetrics.pdf

PROPOSED METRIC GRANULARITY

- Measure behavior of key system components including CPU, memory, storage and I/O
  - Capture idle as well as fully-loaded utilization

WHAT IS A WORKLOAD?

- The application or benchmark software designed to exercise the HPC system to the fullest capability possible

AGREEMENT TO USE WORKLOAD METRICS

- Use Workload-based Metrics to Represent HPC Energy Efficiency
  - Use workload-based for numerator and measured power during workload run for denominator
- Examples
  - Green500 "FLOPS per Watt"
  - SPEC FP / Measured Watt
  - Green Grid "Productivity Proxies"

- *Still need to decide upon exact metric*
  - *Classes of systems (e.g., Top50, Little500)*
  - *Multiple metrics or a single index*

PROPOSED WORKLOADS

- *Leverage well-established benchmarks*

- Use High Performance LINPACK (HPL) for measuring compute energy efficiency

- Use RandomAccess (Giga Updates Per second or GUPs) for measuring memory energy efficiency

- *Need to identify workloads for measuring energy efficiency of storage and I/O*

WHAT IS A METHODOLOGY?

- The system of methods followed

- A way of doing something, especially a systematic way; implies an orderly logical arrangement (usually in steps)

- A measurement procedure

UNIFY AND IMPROVE METHODOLOGY

- HPL and RandomAccess measurement methodologies are well established
- Green500 and TOP500 power-measurement methodologies
  - Similar, but not identical methodologies
  - Yield very similar results
- Issues and concerns
  - Define how to isolate integrated power/cooling systems from system power measurement
  - Need to increase vendor and/or supercomputing center power-measurement reporting
    - June 2010 Green500 List
      - 275 systems with measured #s, 225 systems with derived #s.

PROGRESS SINCE ISC BOF

- Stakeholders, purpose, and key definitions
- Focus only on compute system equipment in measurement (not facility or power/cooling)
- Workload categories are compute, memory, storage and I/O subsystems
  - Compute: HPL
  - Memory: RandomAccess
- Methodology for workloads are previously defined and documented
- Unify and continuously improve Green500 and TOP500 power measurement methodology

ISSUES TO RESOLVE

- *Identify workloads for measuring energy efficiency of storage and I/O*
- *Still need to decide upon exact metric*
  - *Classes of systems (e.g., Top50, Little500)*
  - *Multiple metrics or a single index*
- *Define how to isolate integrated power/cooling systems from system power measurement*
- *Need to increase vendor and/or SC center power measurement reporting*
  - *June 2010 Green500 List has 225 systems with derived power numbers*

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EXTRA SLIDES

THE GREEN GRID BOARD MEMBERS