System Software Research for Extreme-Scale Computing

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Sandia National Labs

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Team Members

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Outline of Our Plans for the INCITE Allocation

INCITE provides platforms necessary to continue research in system software

- Research Activities Briefly
  - **Lightweight Kernel OS and Virtualization**
    - Kitten (Sandia) and Palacios VMM (from North Western University)
      - Less than 5% performance impact on applications
  - **Resilience**
    - Redundant MPI
      - At very large scale reduces runtime and total resource usages
  - **Scalable I/O**
    - Leverage available compute/service node resources for I/O caching and data processing
  - **Power Efficiency and Utilization**
    - Goal: Reduce power use while maintaining performance
  - **Debugging**
    - Fast debugging capability for light-weight kernels

Application Power and Frequency Analysis

Motivation

- Power is one of or the most important considerations in fielding current and next generation HPC systems.
- HPC application power use and factors impacting this use are not well studied.
- Power saving techniques used in commodity operating systems will greatly impact HPC application performance.

Modifications to RAS and Catamount to support power savings

- RAS
  - Added instrumentation and collection capabilities to RAS
- Catamount
  - Power savings during OS idle, per core
  - OS-level frequency scaling capability
  - User space library interface to frequency scaling
  - MPI profiling layer instrumentation

Power Frequency and Analysis

Phase 1

Based on previous power analysis studies

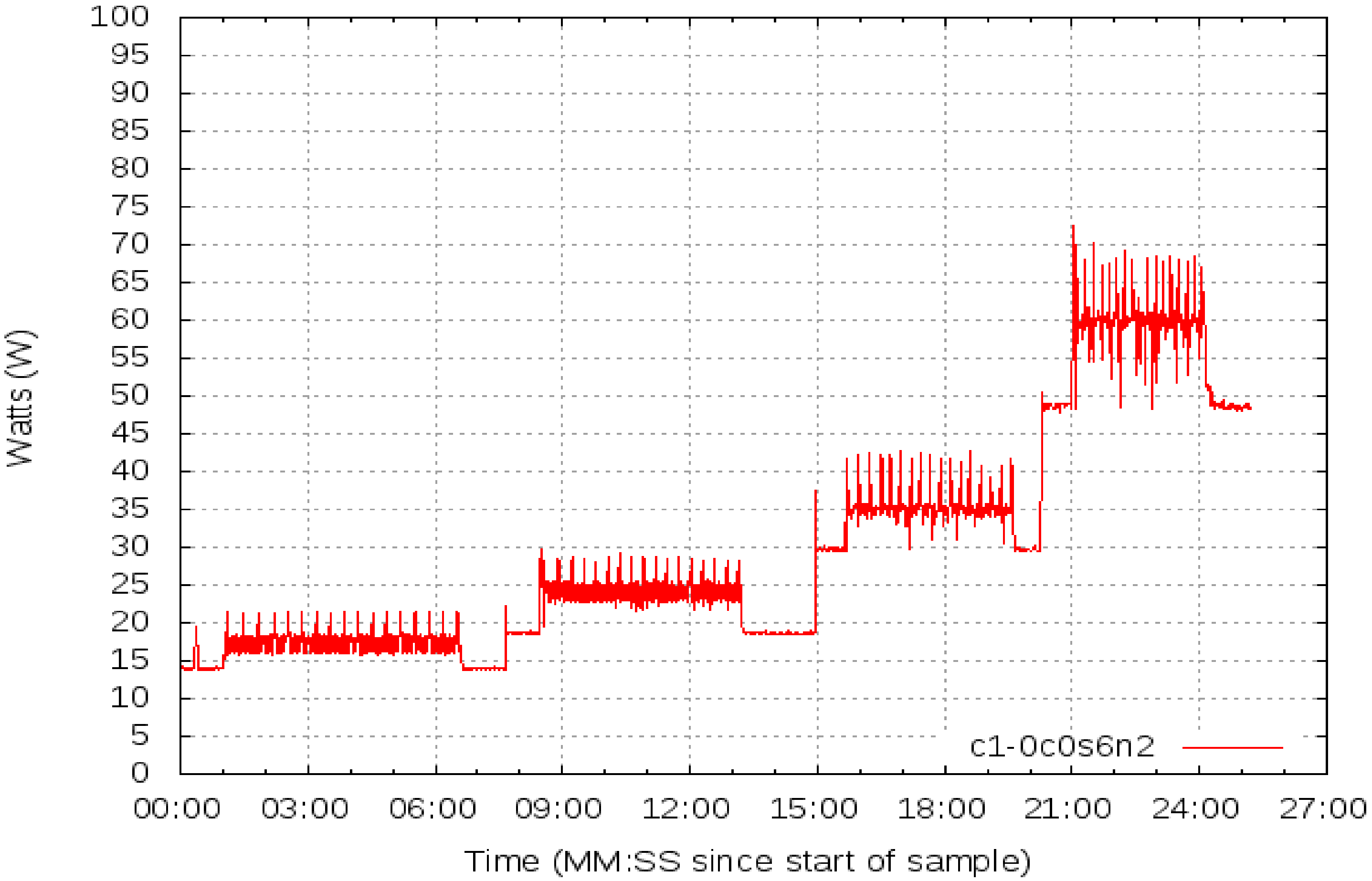
- Laros et.al. *“Topics on Measuring Real Power Usage on High Performance Computing Platforms”*

Analyze performance vs. power efficiency (at scale)

- **STATIC** frequency modification during application run-time.
- Procedure
  - Execute application suite using a range of Pstates defining both frequency and input voltage of CPU.
  - Collect power usage during runs and analyze total energy use vs. application run-time
  - Our early results show a very favorable trade-off!!

Power Frequency Analysis: LAAMPs

Small scale results of multiple LAAMPs runs



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Power Frequency and Analysis

Phase 2

Analyze performance vs. power efficiency (at scale)

- **DYNAMIC** frequency modification during application run-time
- DYNAMIC frequency modification defined as deterministic frequency change driven by application characteristics. Pstate change during MPI barrier for example

Phase 3 testing, if necessary, will be based on Phase 1 and 2 analysis

Additionally, power data will be collected during a range of other systems software testing accomplished as part of this overall project

Additional Information

For information about the other research topics mentioned see:

https://cfwebprod.sandia.gov/cfdocs/CCIM/main.cfm