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A Power Application Programming Interface (API) Specification for High Performance Computers (HPC)

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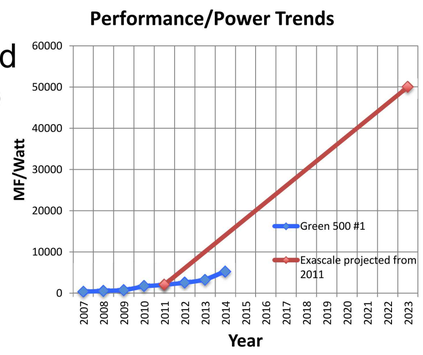
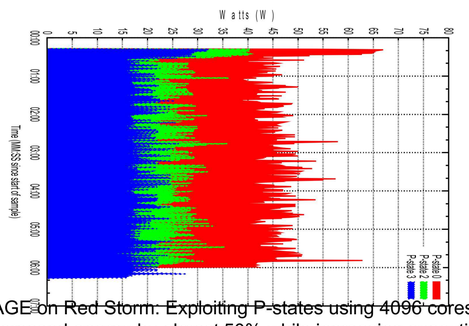
Problem

- DOE goal: Exascale under 20 MW
- Hardware efficiency gains are needed
- Advances in software are required to leverage hardware improvements
- Portable system wide power measurement and control must be developed





SAGE on Red Storm: Exploiting P-states using 4096 cores decreased energy by almost 50% while increasing execution time by less than 8%.

"The foundation for Cray's roadmap in Advanced Power Management was built on the pioneering research jointly conducted at Sandia Laboratories on the first Cray XT platform, Red Storm. In addition, Cray wants to acknowledge Sandia's leadership role in driving vendors to use common API's for power management and control."
-Peter Ungaro, President and CEO, Cray Inc.

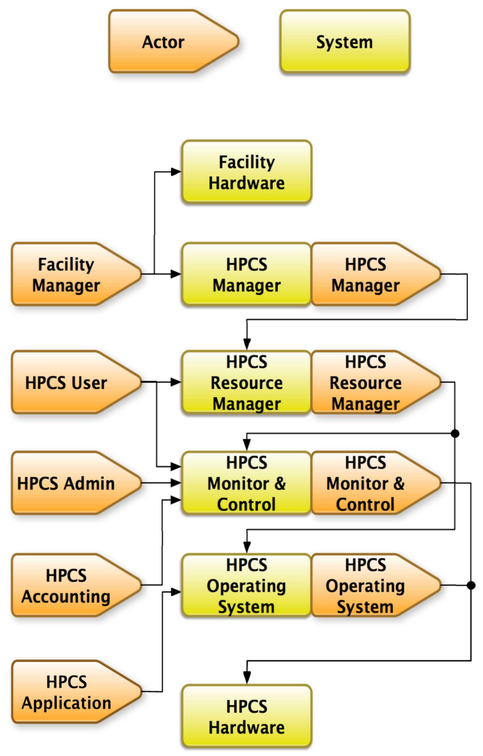
Approach

- Develop a vendor agnostic power measurement and control API for HPC
- Propose as a standard where none exists

- **Requirements Gathering:**
  - Problem analysis using ***Use Cases***
    - *Use case document developed - publically reviewed and released*
  - Identified the scope, roles and interfaces to be targeted

- **API Development:**
  - Provide a large-scale whole system solution to power management
  - Develop the API while actively prototyping to validate
  - Provide support for all layers of the HPC software stack
  - Design for consistency across API interface layers
  - Adaptable system model to support future architectures

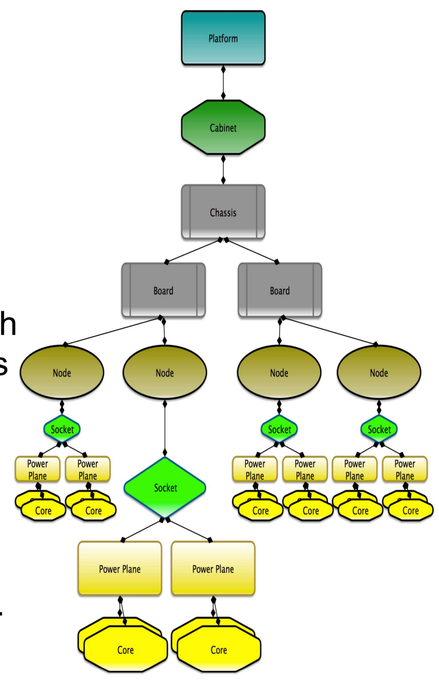
Community Engagement:
- Gather feedback from diverse community of experts from industry, government and academia
- Incorporate feedback in development



The Power API Interfaces and System Actors

Results

Specification Design Details:
- Power API design and specification based on objects and attributes
- Actors and systems from use case document mapped to roles and interfaces in the API
- **Discovery and Navigation:** heterogeneous system hierarchy
- **Measurement and Control:** through attribute reads and writes on objects or groups of objects
- **Statistics:** calls for either real-time measurements or gathering historical data
- **Metadata:** provided for detailed information on object attributes (e.g. internal sampling frequency)
- Easy, yet comprehensive access to power measurement and control



Power API Object Hierarchy

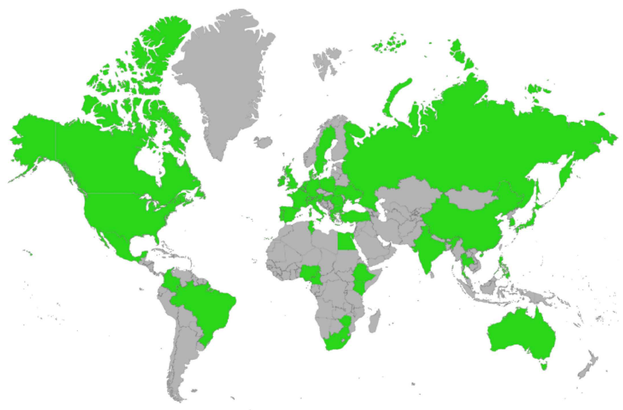
```
PWR_Cntxt cntxt = PWR_CntxtInit( PWR_CNTXT_DEFAULT, PWR_ROLE_ADMIN, "Admin CTX" );
PWR_Obj platform_obj = PWR_CntxtGetEntryPoint( cntxt );
PWR_Grp cab_grp = PWR_ObjGetChildren( platform_obj );
PWR_Obj cab0_obj = PWR_GrpGetObjByIndx( cab_grp, 0 );
PWR_Grp cab0_brd_grp = PWR_ObjGetChildren( cab0_obj );
PWR_Obj cab0_brd4 = PWR_GrpGetObjByIndx( cab0_brd_grp, 4 );

double value;
PWR_Time timeStamp;
PWR_ObjAttrGetValue( cab0_brd4, PWR_ATTR_MAX_PCAP, &value, &timeStamp );
if ( value > 500.0 ) {
    value = 500.0;
    PWR_ObjAttrSetValue( cab0_brd4, PWR_ATTR_MAX_PCAP, &value );
}
```

Interface code example illustrating the use of the Power API for a simple grouped power capping

Specification Publication and Public Participation:
- Invitation only external review of specification draft - July 2014
- *"High Performance Computing – Power Application Programming Interface Specification"* released August 2014
- First International community review - September 2014
- Power API open source prototype released to the community - December 2014

Significance

- Vendor-neutral standardization of power measurement and control with industry support
- Implementation planned for ASC/NNSA Trinity platform
- Successful community building around the API
  - SC14 Power API BoF
  - International community meeting in Denver, fall 2014
- Technical advance filed, Sandia is pursuing a patent



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