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Power API for HPC: Standardizing Power Measurement and Control

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Outline

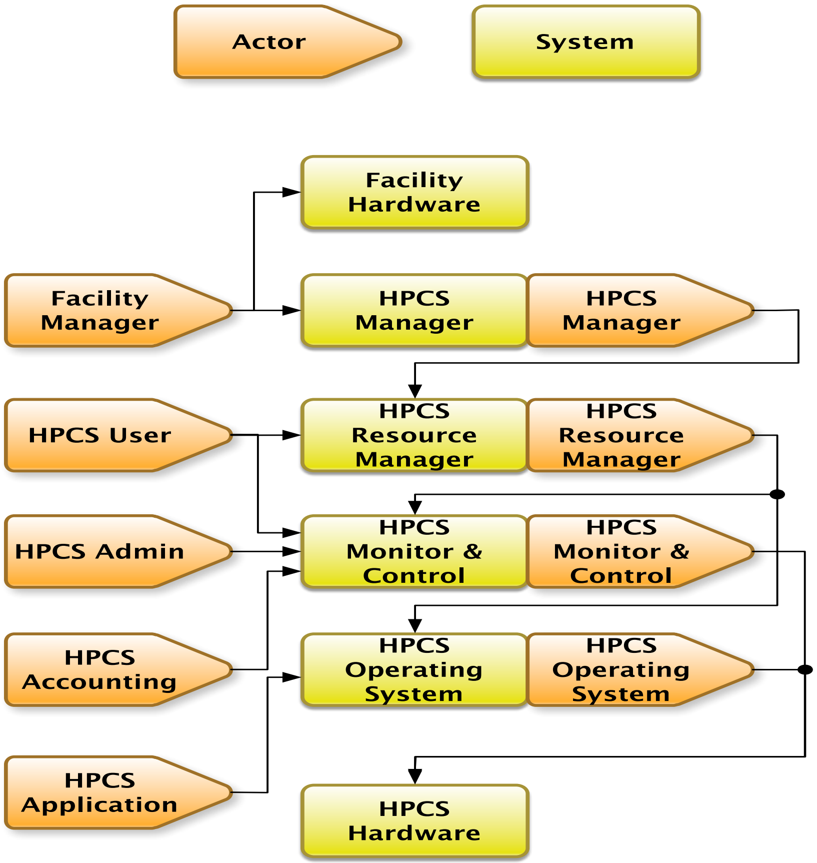
- What is the Power API?
- Overview of API Features and Interfaces
- Reference Implementation and Timeline

What is the Power API?

- The Power API is a comprehensive system software API for interfacing with power measurement and control hardware
- Designed to be comprehensive across many different levels of a data center
- Many different actors can interface with a single API to perform several different roles
- Encompasses facility level concerns down to low level software/hardware interfaces

What is the Power API?

- Broad scoped, portable API
- Multiple actors can interact with the system at different levels
- Each interaction represents an interface that is defined in the Power API



Example Use Cases

- Control power in a hardware overprovisioned system with a given MW power cap
- Accounting and prediction of power load for cooperation with power utilities
- Oversight entities wish to have long term historical power/ energy data for the platform
- Users wish to monitor their jobs on fine-grained scales to understand/improve power/energy consumption
- Enables studies of whole system power/energy consumption

Roles

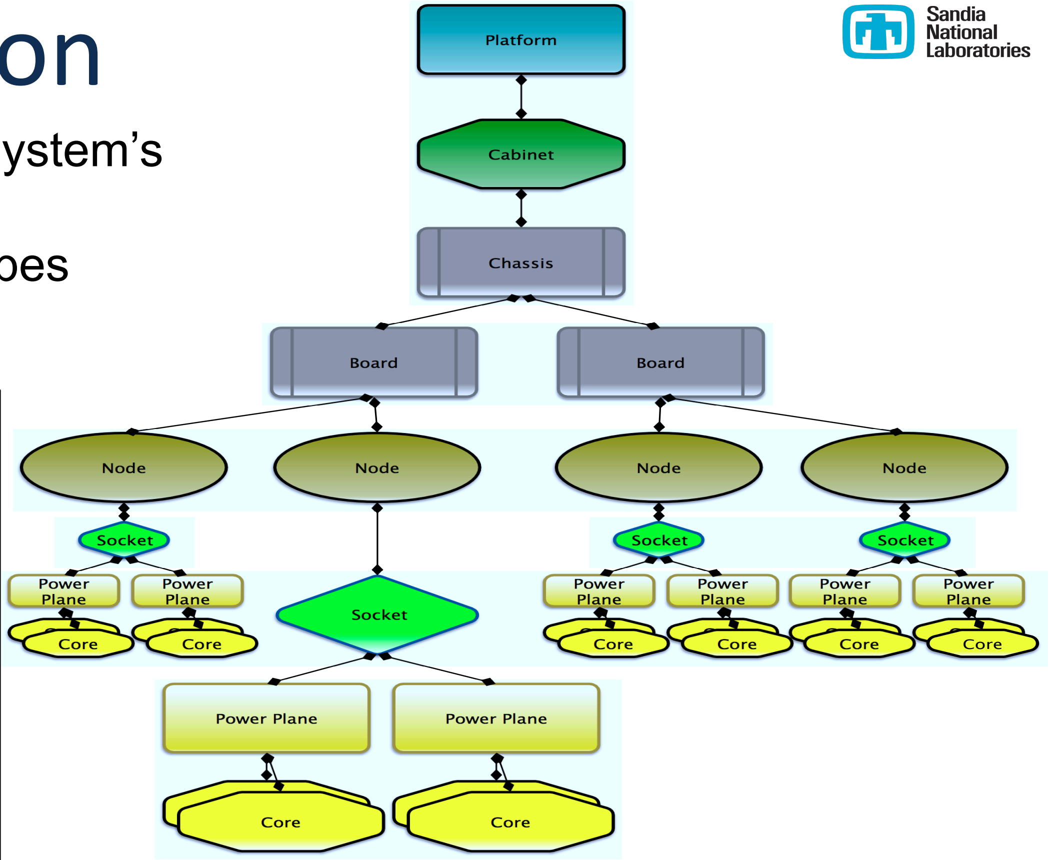
- Application – Application or application library executing on the compute resource; May include run-time components running in user space
- Monitor and Control -- Cluster management or Reliability Availability and Serviceability (RAS) systems, for example.
- Operating System -- Linux or specialized lightweight kernels and privileged portions of run-time systems.
- User -- The end user of the HPC platform.
- Resource Manager – Can include work load managers, schedulers, allocators and even portions of run-time systems that manage resources.
- Administrator – System administrator or day-to-day platform manager.
- HPCS Manager -- Responsible for managing policy for the HPC platform.
- Accounting – Individual/software that produces reports for the platform.

System Description

Presents a navigable view of the system’s hardware components

- Can extend to custom object types
- Can be heterogeneous

```
typedef enum {
        PWR_OBJ_PLATFORM = 0,
        PWR_OBJ_CABINET,
        PWR_OBJ_CHASSIS,
        PWR_OBJ_BOARD,
        PWR_OBJ_NODE,
        PWR_OBJ_SOCKET,
        PWR_OBJ_CORE,
        PWR_OBJ_POWER_PLANE,
        PWR_OBJ_MEM,
        PWR_OBJ_NIC,
        PWR_NUM_OBJ_TYPES,
        /* */
        PWR_OBJ_INVALID = -1,
        PWR_OBJ_NOT_SPECIFIED = -2,
} PWR_ObjType;
```



Example System Description

Common Functionality

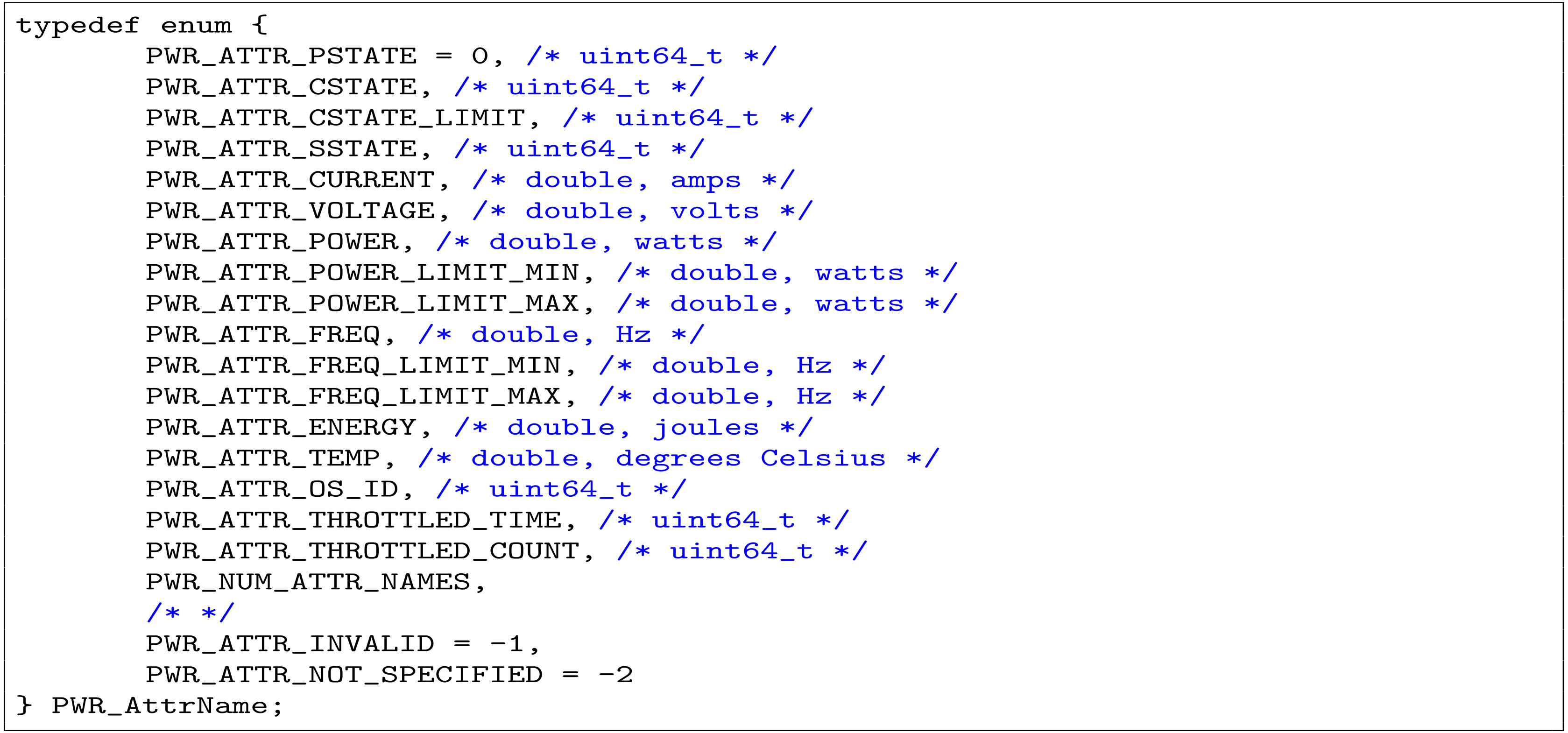
- Navigation across and grouping of objects in the system
- Attributes (e.g., power cap, voltage) for the objects can be accessed depending on role (e.g., user, app, OS, admin)
- Getters/setters enable basic measurement and control for the exposed object attributes
- Metadata interface provides information about quality, frequency, and other characteristics of measurement/control
- Statistics interface gathers data on one or more attributes for an object or group of objects over time

Navigation and Grouping of Objects

- Entry point into the system can depend on role
  - E.g., node level for an application and platform level for an admin
  - Functions are provided to navigate up to the parent object or down to child objects in in the hierarchy

- Many functions are provided to provide measurement and control of groups of objects
  - User of the API can create groups and perform set operations
  - Implementation may provide predefined groups for convenience

Attributes of Objects



```
typedef enum {
       PWR_ATTR_PSTATE = 0, /* uint64_t */
       PWR_ATTR_CSTATE, /* uint64_t */
       PWR_ATTR_CSTATE_LIMIT, /* uint64_t */
       PWR_ATTR_SSTATE, /* uint64_t */
       PWR_ATTR_CURRENT, /* double, amps */
       PWR_ATTR_VOLTAGE, /* double, volts */
       PWR_ATTR_POWER, /* double, watts */
       PWR_ATTR_POWER_LIMIT_MIN, /* double, watts */
       PWR_ATTR_POWER_LIMIT_MAX, /* double, watts */
       PWR_ATTR_FREQ, /* double, Hz */
       PWR_ATTR_FREQ_LIMIT_MIN, /* double, Hz */
       PWR_ATTR_FREQ_LIMIT_MAX, /* double, Hz */
       PWR_ATTR_ENERGY, /* double, joules */
       PWR_ATTR_TEMP, /* double, degrees Celsius */
       PWR_ATTR_OS_ID, /* uint64_t */
       PWR_ATTR_THROTTLED_TIME, /* uint64_t */
       PWR_ATTR_THROTTLED_COUNT, /* uint64_t */
       PWR_NUM_ATTR_NAMES,
       /* */
       PWR_ATTR_INVALID = -1,
       PWR_ATTR_NOT_SPECIFIED = -2
} PWR_AttrName;
```

Accessing Attributes of Objects

MEASURE

```
int PWR_ObjAttrGetValue( PWR_Obj object,
                         PWR_AttrName attr,
                         void* buf,
                         PWR_Time* ts);
```

CONTROL

```
int PWR_ObjAttrSetValue( PWR_Obj object,
                         PWR_AttrName attr,
                         void* buf );
```

Statistics Interface

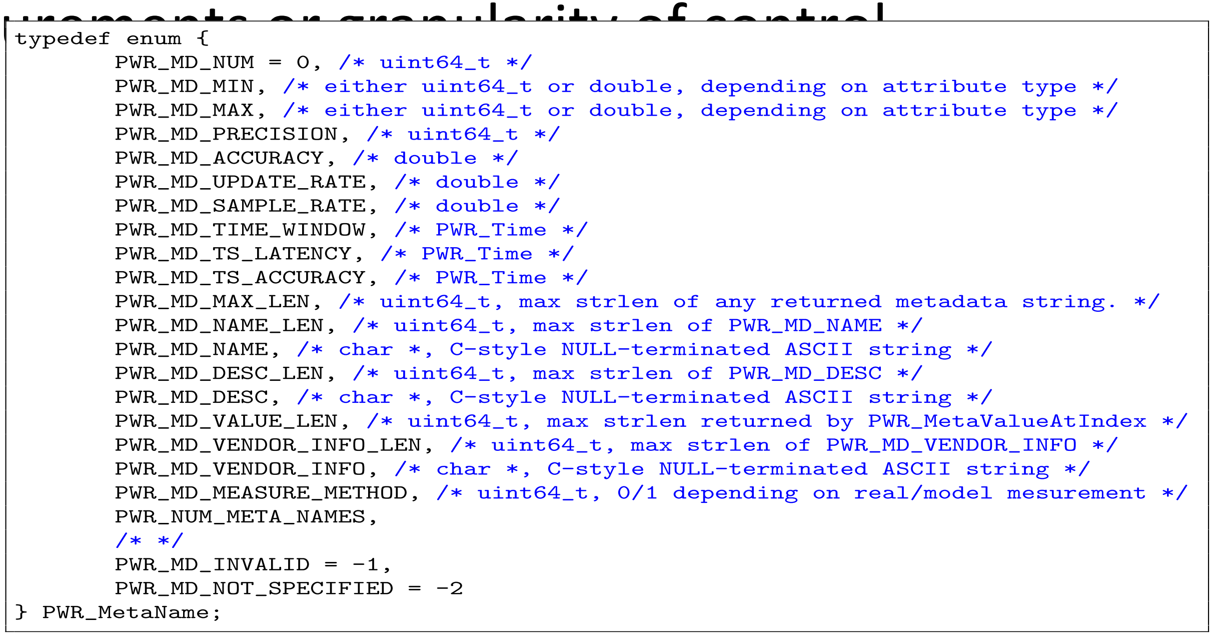
- While attribute getter functions return point values, the statistics interface gathers statistics from samples gathered over time

- Can specify min, max, average, standard deviation
  - Vendors may extend to support other statistics

- Provides functions to…
  - Start, stop, and reset statistics gathering
  - Get the calculated value(s) for the object or group of objects
  - Reduce the values calculated for objects in a group into a single value

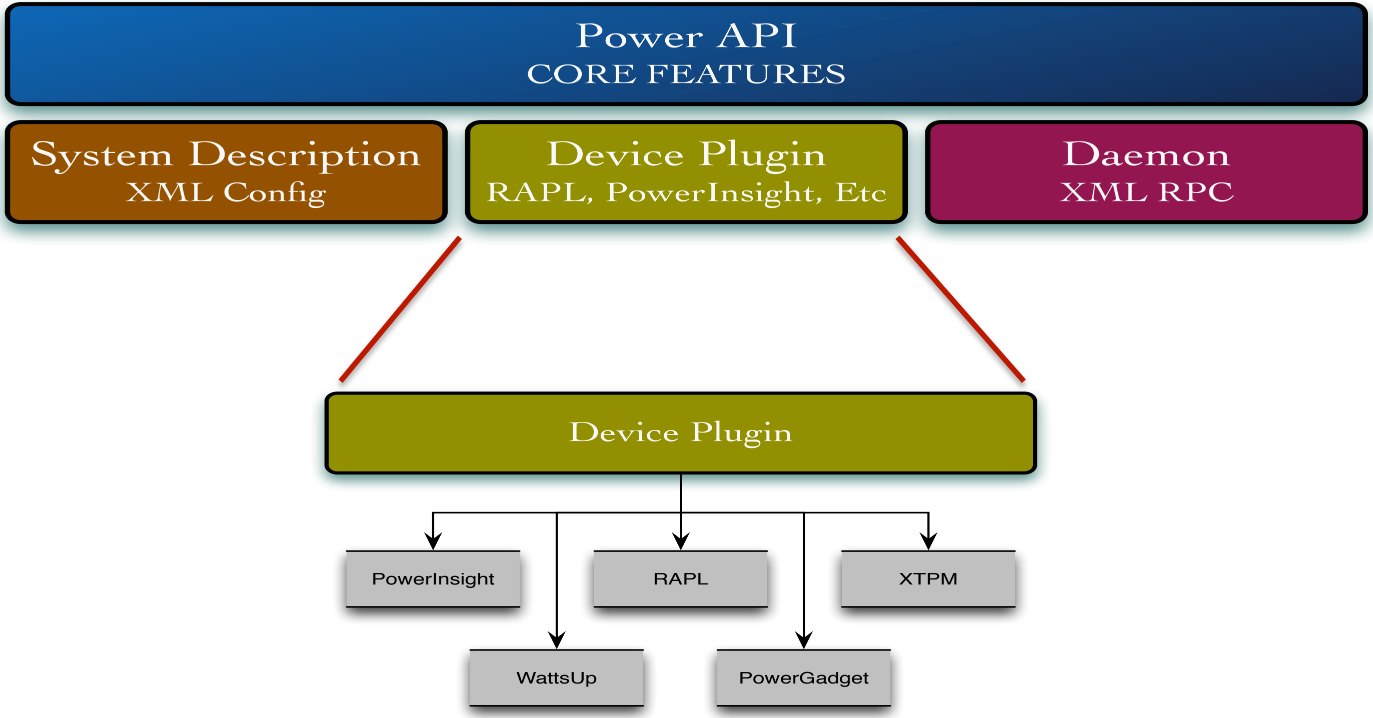
Metadata Interface

- Allows querying and, in some cases manipulation, of characteristics of objects and their attributes, e.g. quality of measurements or granularity of control



```
typedef enum {
        PWR_MD_NUM = 0, /* uint64_t */
        PWR_MD_MIN, /* either uint64_t or double, depending on attribute type */
        PWR_MD_MAX, /* either uint64_t or double, depending on attribute type */
        PWR_MD_PRECISION, /* uint64_t */
        PWR_MD_ACCURACY, /* double */
        PWR_MD_UPDATE_RATE, /* double */
        PWR_MD_SAMPLE_RATE, /* double */
        PWR_MD_TIME_WINDOW, /* PWR_Time */
        PWR_MD_TS_LATENCY, /* PWR_Time */
        PWR_MD_TS_ACCURACY, /* PWR_Time */
        PWR_MD_MAX_LEN, /* uint64_t, max strlen of any returned metadata string. */
        PWR_MD_NAME_LEN, /* uint64_t, max strlen of PWR_MD_NAME */
        PWR_MD_NAME, /* char *, C-style NULL-terminated ASCII string */
        PWR_MD_DESC_LEN, /* uint64_t, max strlen of PWR_MD_DESC */
        PWR_MD_DESC, /* char *, C-style NULL-terminated ASCII string */
        PWR_MD_VALUE_LEN, /* uint64_t, max strlen returned by PWR_MetaValueAtIndex */
        PWR_MD_VENDOR_INFO_LEN, /* uint64_t, max strlen of PWR_MD_VENDOR_INFO */
        PWR_MD_VENDOR_INFO, /* char *, C-style NULL-terminated ASCII string */
        PWR_MD_MEASURE_METHOD, /* uint64_t, 0/1 depending on real/model mesurement */
        PWR_NUM_META_NAMES,
        /* */
        PWR_MD_INVALID = -1,
        PWR_MD_NOT_SPECIFIED = -2
} PWR_MetaName;
```

Reference Implementation



Available online and open source: http://github.com/pwrapi

Power API Timeline

- 2013: Use case document prepared by SNL and NREL and reviewed by partners
- July 2014: Draft specification review meeting with cross-vendor panel of experts
- Aug. 2014: Specification v1.0 release (http://powerapi.sandia.gov/)
- Sept. 2014: Day-long community launch meeting with labs, industry, academia
- Jan. 2015: Prototype implementation release
- June 2015: Reference implementation release (http://github.com/pwrapi)
- Aug. 2015: Specification v1.1 release
- Oct. 2015: Specification v1.1a release (http://powerapi.sandia.gov/)

Who is Behind PowerAPI?

IBM

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Los Alamos
NATIONAL LABORATORY
EST. 1943

intel®

Lawrence Livermore
National Laboratory

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AMD

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hp

CRAY
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Thank you

Power API

http://powerapi.sandia.gov/

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Online Survey

Sandia National Laboratories

http://bit.ly/sc15bof

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