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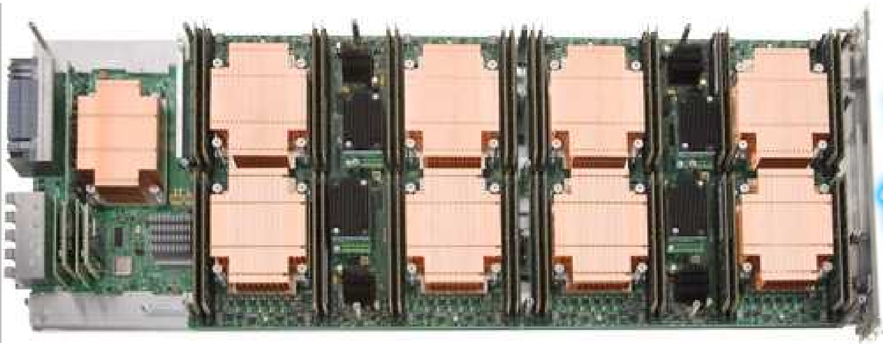

A Prototype of a Power API Framework

Speaker: David DeBonis

Power API Team: James H. Laros III (Lead), Kevin Pedretti, Suzanne M. Kelly, Micheal Levenhagen, David DeBonis, Stephen Olivier, Ryan E. Grant

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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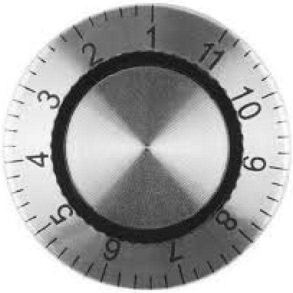
Motivation and Foundation

- Extreme Scale Power / Energy Aware Computing
  - Within power budgets
  - Turning it up to “eleven” is not maintainable
  - Power capping will be the norm

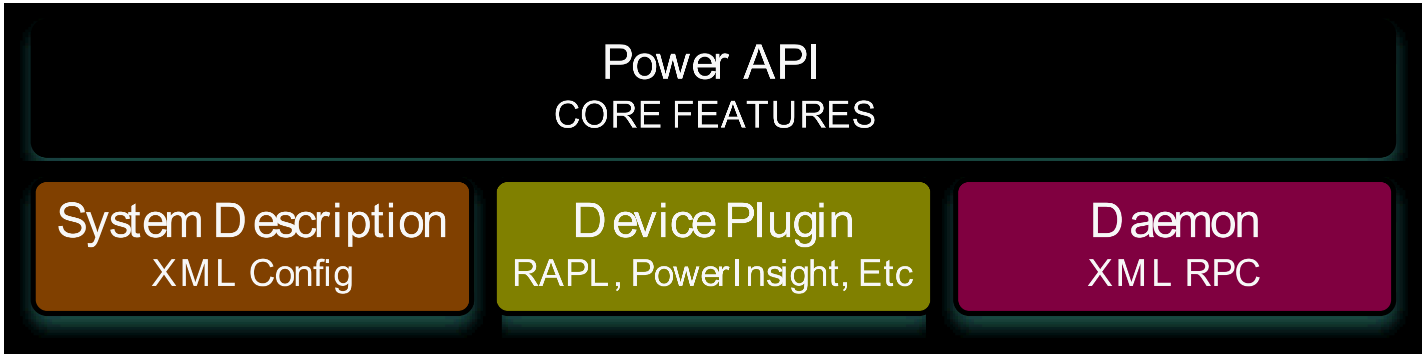


- Power API Specification
  - Effort at SNL to influence future systems procurement
  - Facilitate power-aware and energy-efficient computing at scale
  - Vendor and platform neutral
  - Unified measurement and control interface
  - Traversable hierarchy

Objectives

- Power API Prototyping Effort
  - Solidifying the Power API specifications
  - Enable communication between vendors and community
  - Explore implementation concepts
  - DISCLAIMER: NOT meant to be a production implementation

- Power API Prototype Framework



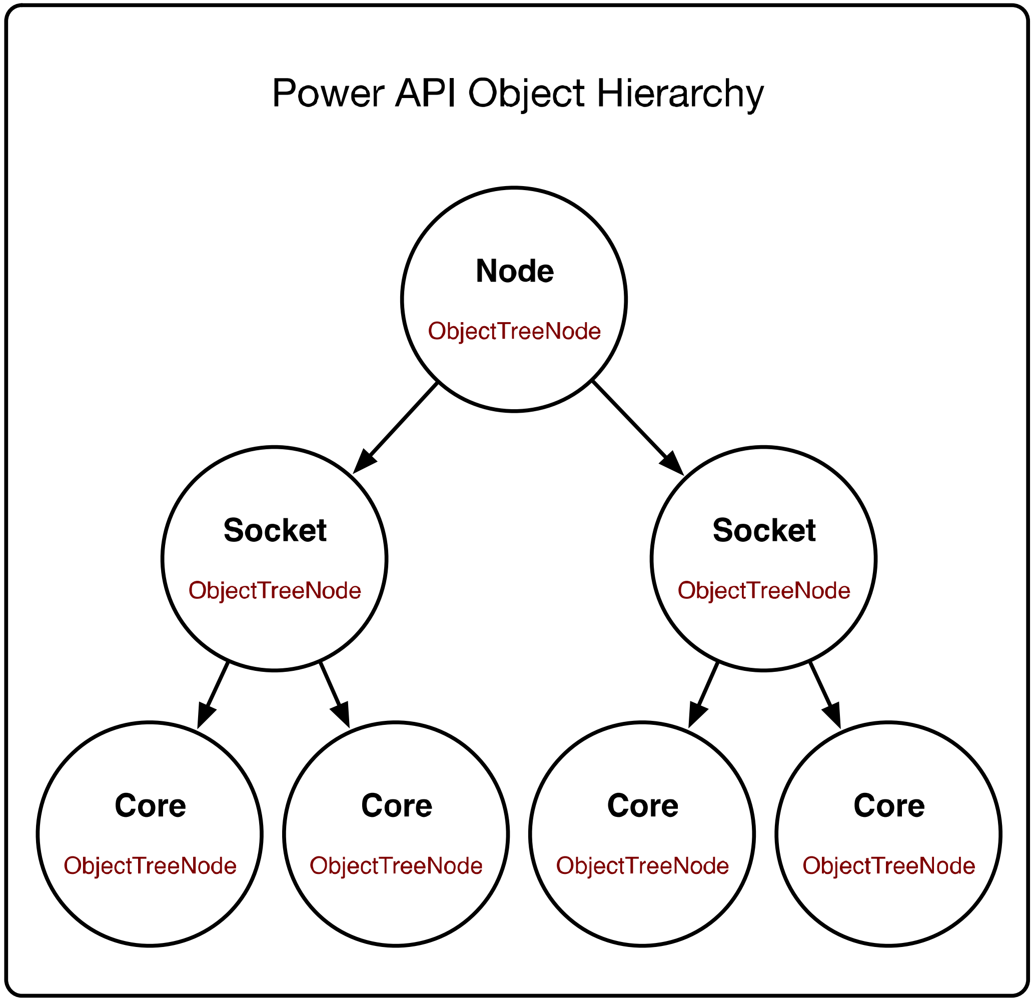
Power API
CORE FEATURES

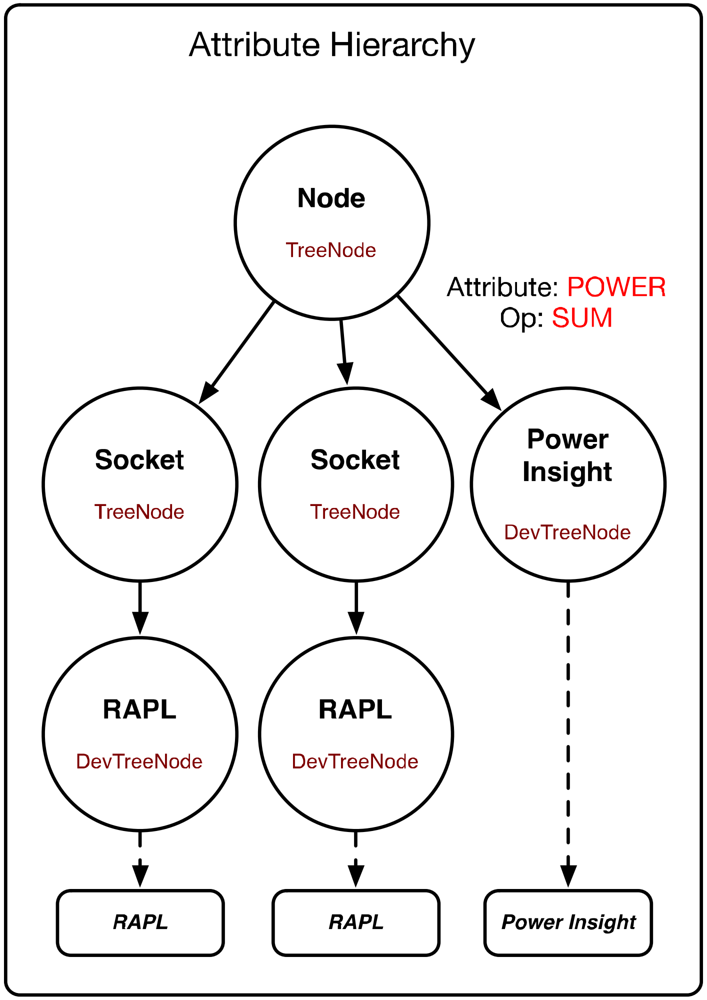
System Description
XML Config

Device Plugin
RAPL, PowerInsight, Etc

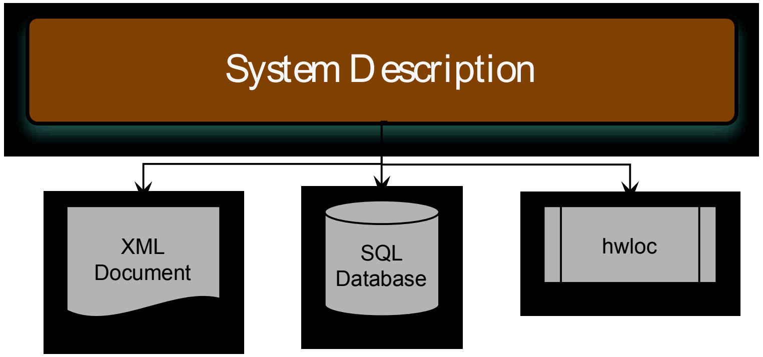
Daemon
XML RPC

Prototype Framework



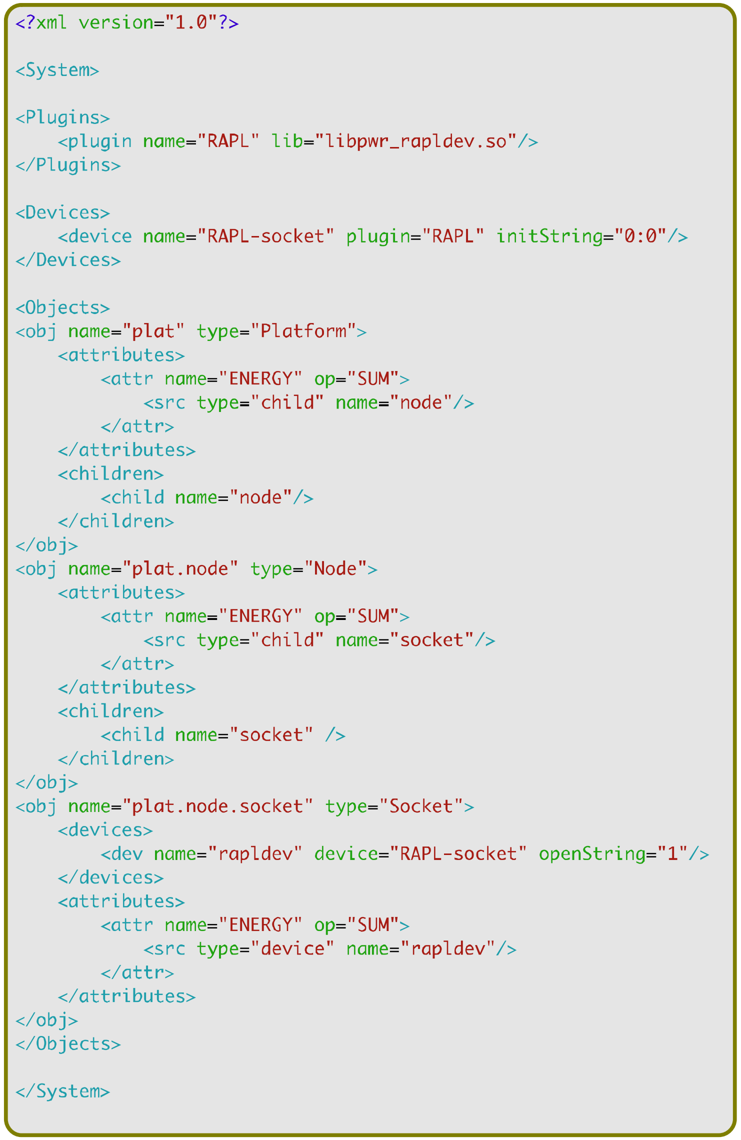


System Configuration Description



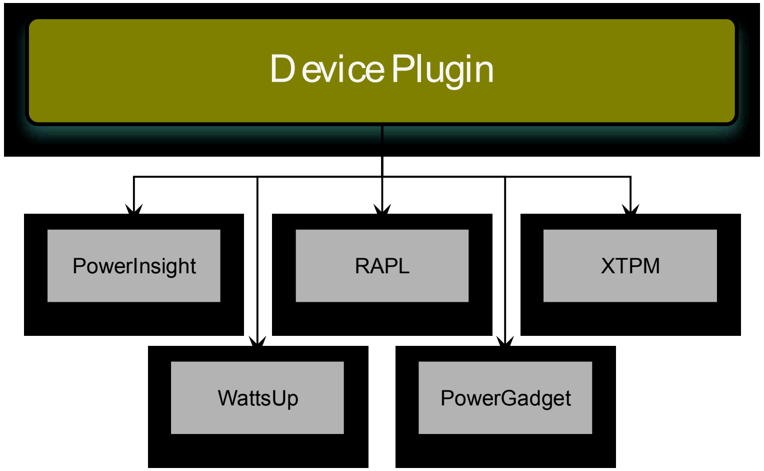
- Dynamically configurable system
  - Not tied to specific system
  - Definable or discoverable
  - Representation neutral

- XML based configuration file
  - Hierarchy and relationships
  - Plugins and mappings
  - Operation on attributes

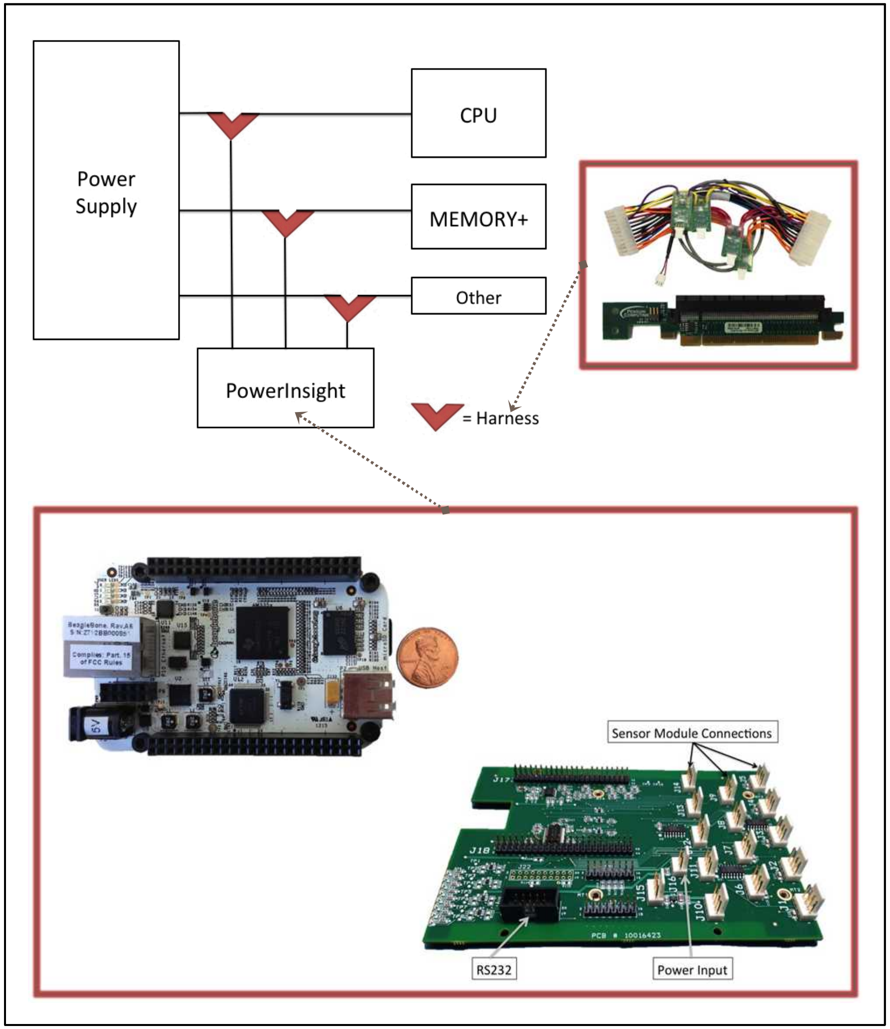


```xml
<?xml version="1.0"?>

<System>

<Plugins>
    <plugin name="RAPL" lib="libpwr_rapldev.so"/>
</Plugins>

<Devices>
    <device name="RAPL-socket" plugin="RAPL" initString="0:0"/>
</Devices>

<Objects>
<obj name="plat" type="Platform">
    <attributes>
        <attr name="ENERGY" op="SUM">
            <src type="child" name="node"/>
        </attr>
    </attributes>
    <children>
        <child name="node"/>
    </children>
</obj>
<obj name="plat.node" type="Node">
    <attributes>
        <attr name="ENERGY" op="SUM">
            <src type="child" name="socket"/>
        </attr>
    </attributes>
    <children>
        <child name="socket" />
    </children>
</obj>
<obj name="plat.node.socket" type="Socket">
    <devices>
        <dev name="rapldev" device="RAPL-socket" openString="1"/>
    </devices>
    <attributes>
        <attr name="ENERGY" op="SUM">
            <src type="device" name="rapldev"/>
        </attr>
    </attributes>
</obj>
</Objects>

</System>
```

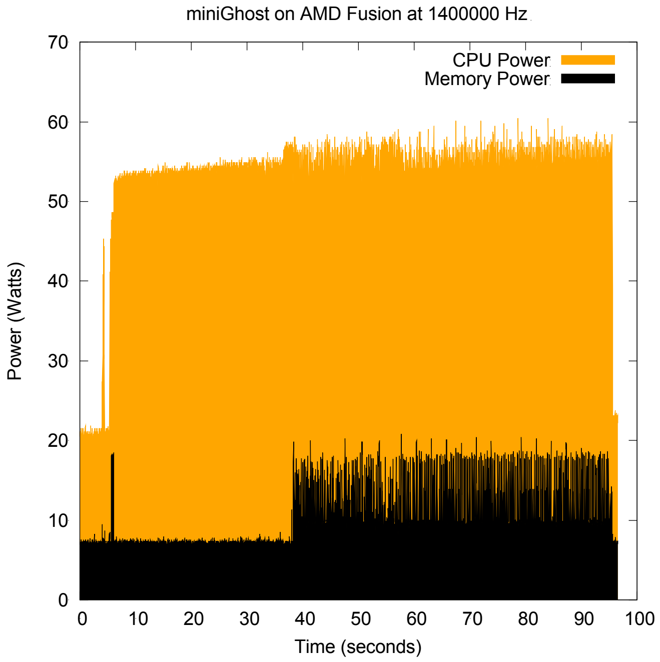
Plugin Capabilities

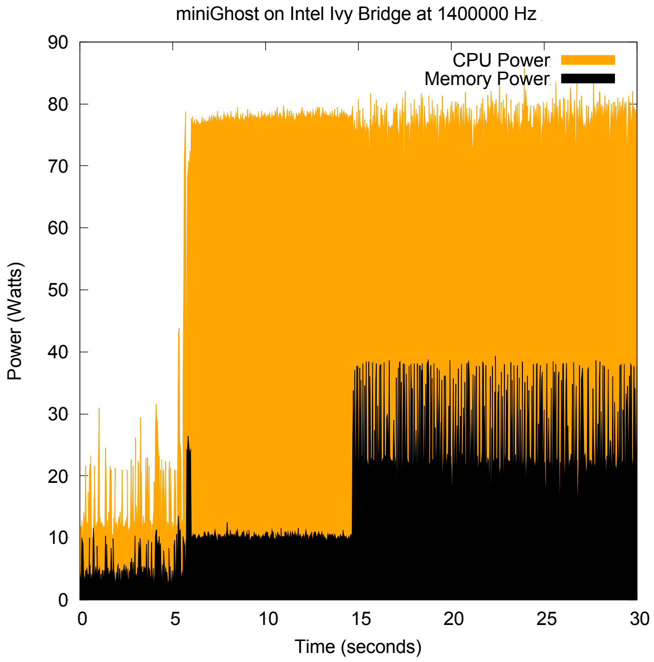


- Well-defined interface
  - POSIX-like semantics
- Penguin PowerInsight
  - Fine-grain per component
  - Out-of-band collection
  - Extended capabilities
    - offloaded calculations
    - embedded analysis



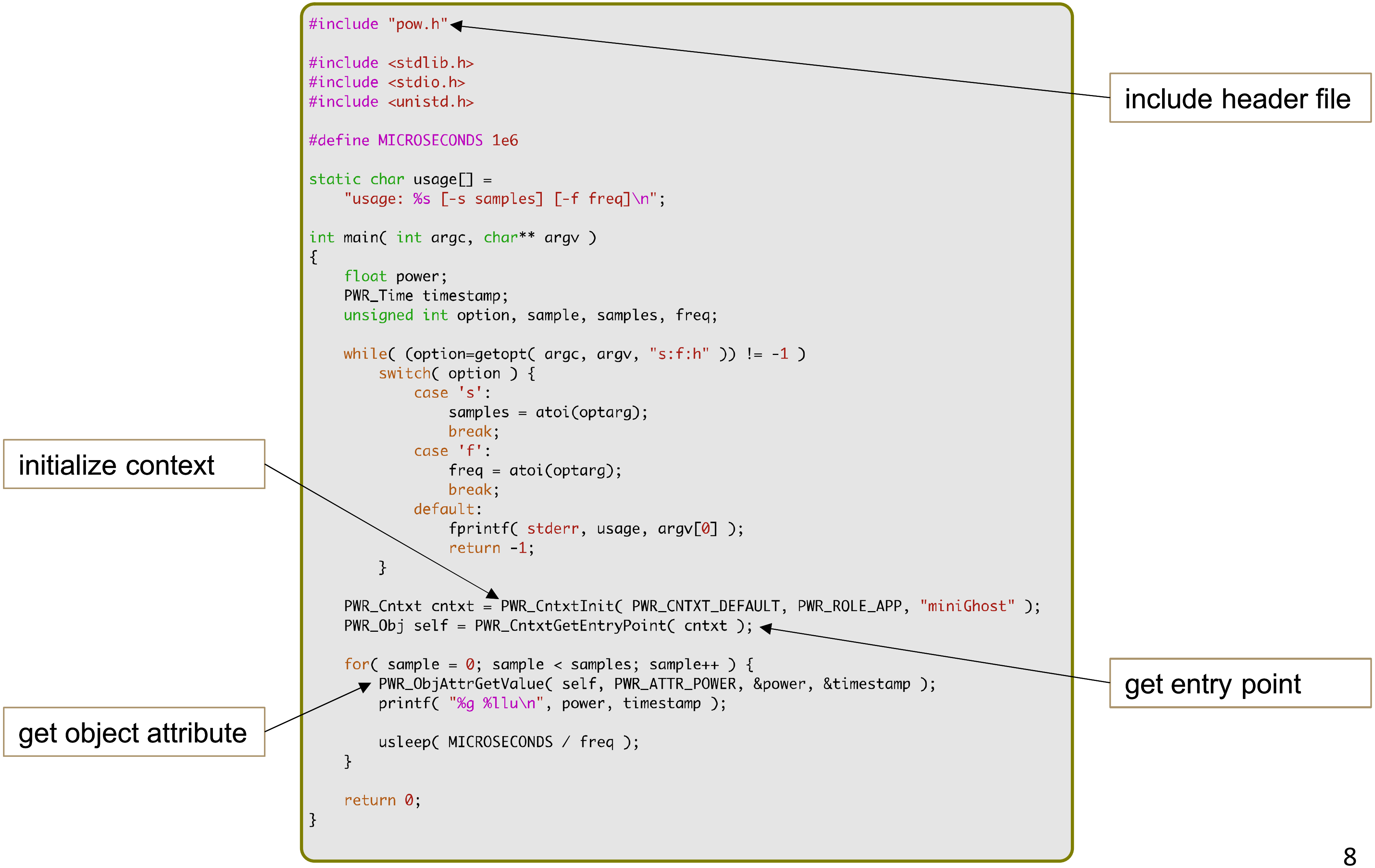
Study - Application Characterization





- Energy and power characteristics at various CPU frequencies
  - Frequency scaling using the Mantevo miniApps
  - Performed on Advanced Architecture Test Beds
  - Architectures: AMD APU, Intel Ivy Bridge, Haswell, Phi, Power8, ARM
  - Plugins: PowerInsight, WattsUp, XTPM, RAPL, CPU

Multi-Architecture Study Simplified



```c
#include "pow.h"

#include <stdlib.h>
#include <stdio.h>
#include <unistd.h>

#define MICROSECONDS 1e6

static char usage[] =
    "usage: %s [-s samples] [-f freq]\n";

int main( int argc, char** argv )
{
    float power;
    PWR_Time timestamp;
    unsigned int option, sample, samples, freq;

    while( (option=getopt( argc, argv, "s:f:h" )) != -1 )
        switch( option ) {
            case 's':
                samples = atoi(optarg);
                break;
            case 'f':
                freq = atoi(optarg);
                break;
            default:
                fprintf( stderr, usage, argv[0] );
                return -1;
        }

    PWR_Cntxt cntxt = PWR_CntxtInit( PWR_CNTXT_DEFAULT, PWR_ROLE_APP, "miniGhost" );
    PWR_Obj self = PWR_CntxtGetEntryPoint( cntxt );

    for( sample = 0; sample < samples; sample++ ) {
        PWR_ObjAttrGetValue( self, PWR_ATTR_POWER, &power, &timestamp );
        printf( "%g %llu\n", power, timestamp );

        usleep( MICROSECONDS / freq );
    }

    return 0;
}
```

include header file

initialize context

get entry point

get object attribute

Future Directions (in the works)

- Power API Core support
  - complete the statistics interface
  - complete the meta-data interface
- Additional Power API prototype plugins
- Python bindings
  - objects and attributes
- Power API Prototype at scale
  - distribution and aggregation

Acknowledgements

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- Power API
  - http://powerapi.sandia.gov
  - SC14 BoF – Power API for HPC (Nov. 19th from 12:15 – 1:15pm)
  - SC14 Poster – A Power API for the HPC Community
- Penguin Computing
  - http://penguincomputing.com
- Advanced Architecture Test Beds
  - http://www.sandia.gov/asc/computational_systems/HAAPS.html

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Advanced Architecture Test Beds

Host Name	Nodes	CPU	Accelerator / Co-Processor
Volta	56	Dual Socket Intel Xeon E5-2695 v2 (Ivy Bridge) 2.4 GHz 12-core	N / A
Compton	42	Dual Socket Intel Xeon E5-2670 (Sandy Bridge) 2.6 GHz 8-core	Intel Xeon Phi (2x) 1.1 GHz 57-core
Teller	104	AMD A10-5800K (Piledriver) 3.8GHz 4-core	Radeon HD-7660D 800MHz 384-core