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Power API User Experiences

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Outline

- Overview of Power API uses in 2017
- Steve Matin
  - Cray experiences in deploying and using the Power API
- Lee Ward
  - Experiences using the Power API for monitoring and control of production applications

Overview

- Power API 2.0 Implementation
  - Reference Implementation:

    100s of downloads in 2017

    Deployed in the Tri-lab Operating System – many significant sized clusters supported at LLNL, LANL and SNL
  - Cray Implementation:

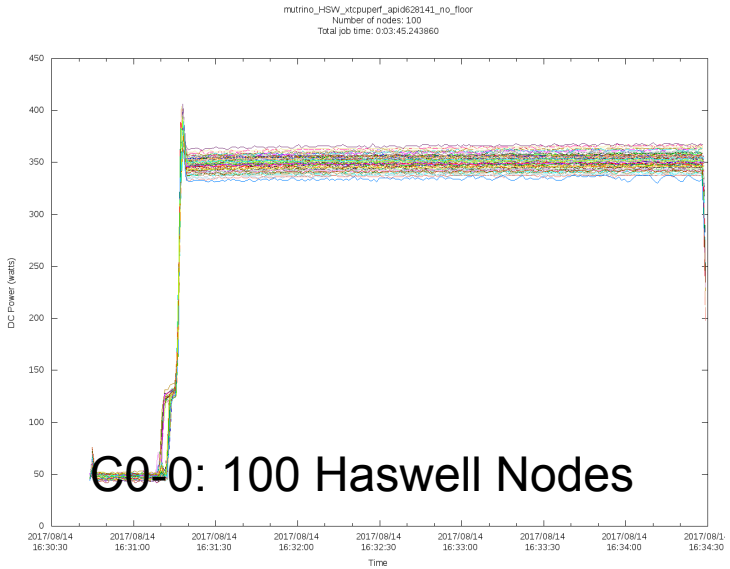
    Complete and functional

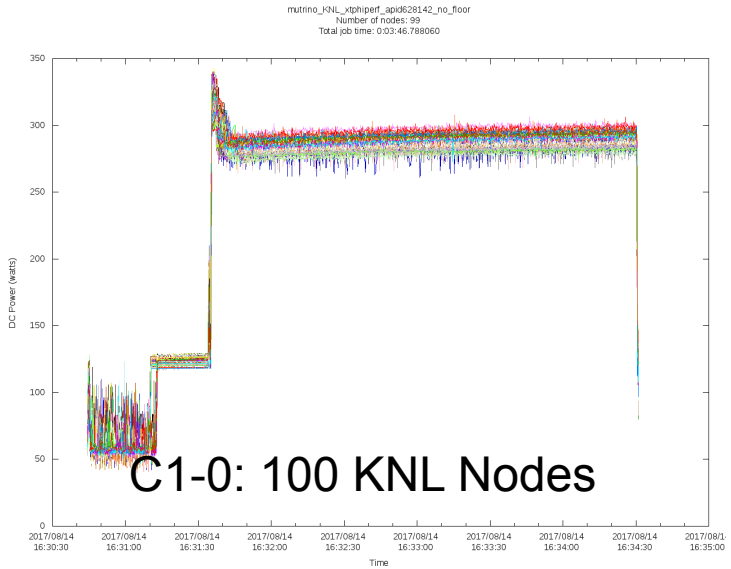
    Works with CAPMC

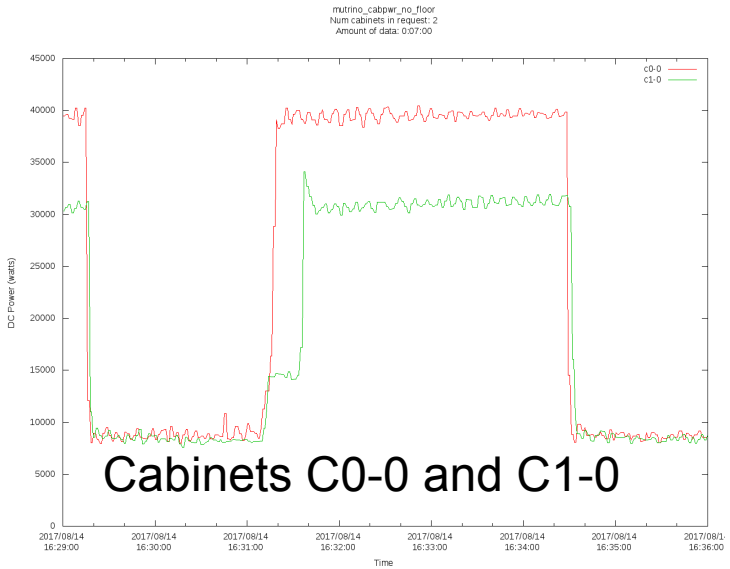
    Performance optimized for Cray XC systems

Use of Power API at Cray

- Cray implemented the Power API for XC series systems
- Used to test, evaluate and tune Power API implementation
- Several improvements discovered while optimizing library
  - Opportunities for tuning statistics interface for greater efficiency
  - Additional attributes to add to the specification







Use of Power API on Large Systems

-Lee Ward-

Workloads

- MiniMD
  - A molecular dynamics mini app representing LAMMPS
  - Supports Lennard-Jones pair interactions, equivalent to LJ liquid simulations
- LULESH
  - Unstructured mesh Lagrangian explicit shock hydrodynamics mini app
  - Representing DOE hydrodynamics apps, especially ALE3D
- MiniFE
  - Implicit finite element (condition simulation using a conjugate gradient solver
  - Rectangular problem, represents broad class of FE apps, CG is generic

Job-wide Aggregate Information

- Fastest clock speeds are almost universally the most performant
  - Exception is HSW running MiniFE where non-turbo is slightly better
- FOM/Watt is not always straightforward
  - No information when job phase performance is related to energy usage
  - MiniFE, HSW shows 1.2Ghz best FOM/Watt but total runtime != FOM

		Figure of Merit Per Node			Average Watts Per Node			Figure of Merit Per Watt		
		Volta Ivy Bridge	Trinity Haswell	Trinity Phi KNL	Volta Ivy Bridge	Trinity Haswell	Trinity Phi KNL	Volta Ivy Bridge	Trinity Haswell	Trinity Phi KNL
MiniMD	Turbo	**2.08e7**	**3.01e7**	**5.92e7**	269	334	246	7.73e4	9.01e4	2.41e5
	No Turbo	1.84e7	2.56e7	5.66e7	213	236	228	**8.64e4**	**1.08e5**	2.48e5
	1.2 GHz	9.45e6	1.39e7	4.93e7	138	142	194	6.85e4	9.79e4	**2.54e5**
LULESH	Turbo	**1.36e4**	**1.85e4**	**1.51e4**	291	346	218	46.7	53.5	69.3
	No Turbo	1.24e4	1.75e4	1.43e4	236	295	208	**52.5**	59.3	68.8
	1.2 GHz	6.75e3	1.09e4	1.25e4	156	175	180	43.3	**62.3**	**69.4**
MiniFE	Turbo	**1.24e4**	1.42e4	**3.00e4**	185	212	138	67.0	67.0	217
	No Turbo	1.23e4	**1.43e4**	2.93e4	145	152	133	**84.8**	94.1	**220**
	1.2 GHz	8.37e3	1.41e4	2.76e4	104	104	127	80.5	**136**	217

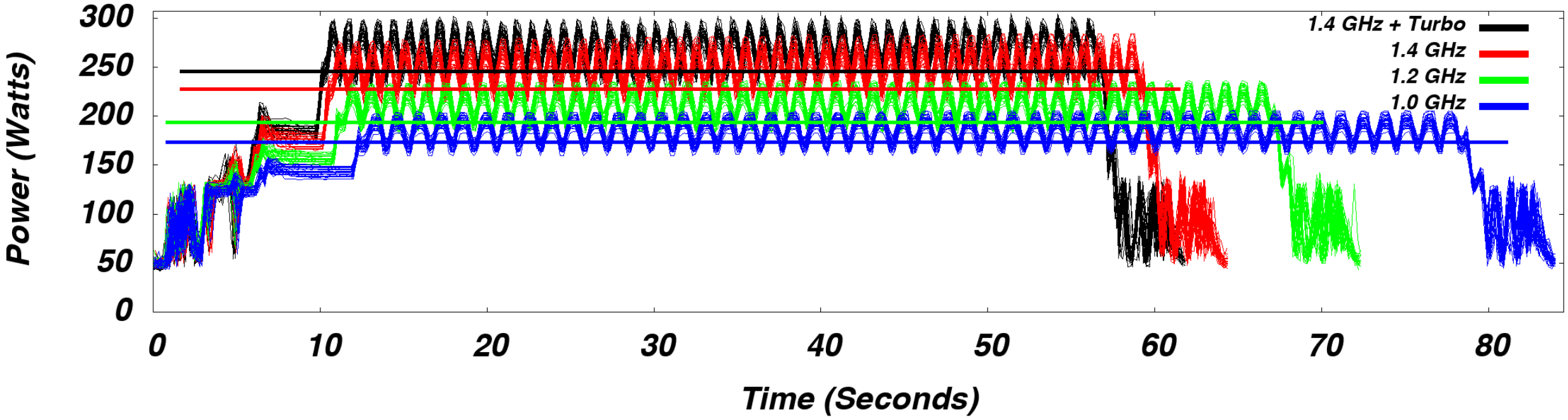
Overhead of Application Profiling

- Power profiling can be done through in-band measurement
  - Ex: calling PowerAPI or using RAPL directly
- The overhead of in-band measurement can be significant
  - Need to effectively quantify overhead
- Overhead found with in-band with region sampling of MiniMD and LULESH
  - 4-8% is significant for HPC apps
  - Overhead could increase running at extreme scale due to increased noise

		Power + Energy Region Profiling	Timestamps Only
MiniMD	Turbo	6.84%	-0.08%
	1.4 GHz	7.49%	-0.08%
	1.2 GHz	7.71%	0.08%
	1.0 GHz	8.15%	0.07%
LULESH	Turbo	4.84%	0.24%
	1.4 GHz	4.94%	0.35%
	1.2 GHz	5.23%	0.22%
	1.0 GHz	4.73%	-0.08%
MiniFE	Turbo	-1.22%	0.15%
	1.4 GHz	-0.59%	-0.95%
	1.2 GHz	-1.50%	-1.42%
	1.0 GHz	-1.26%	-1.96%

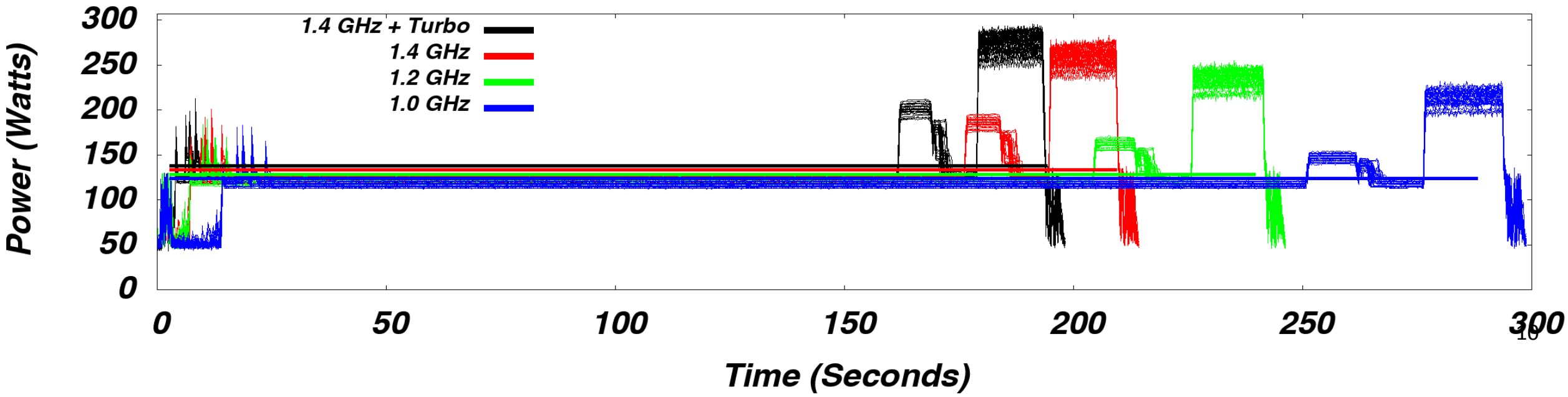
Out-of-Band Periodic Sampling- MiniMD

- Illustrates expected behavior in main solve region
- Periodic power consumption corresponds with known solver phases
- Each P-state shows the expected number of phases
- Lower P-state lengthens phases but does not alter power trends



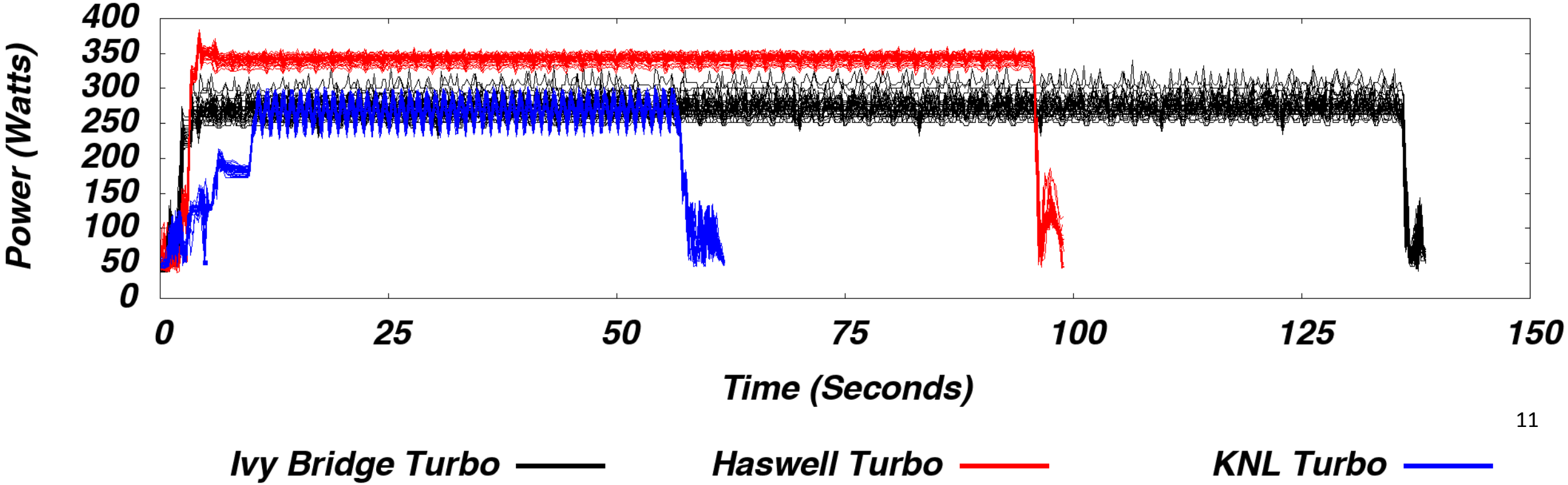
Out-of-Band Periodic Sampling- MiniFE

- MiniFE shows 2 phases well
  - Long, low-power Assembly phase
  - Short, high-power problem Solve phase (CG)
- P-state for Assembly has little effect power, but large effect on runtime
  - FOM calculated only on Solve phase



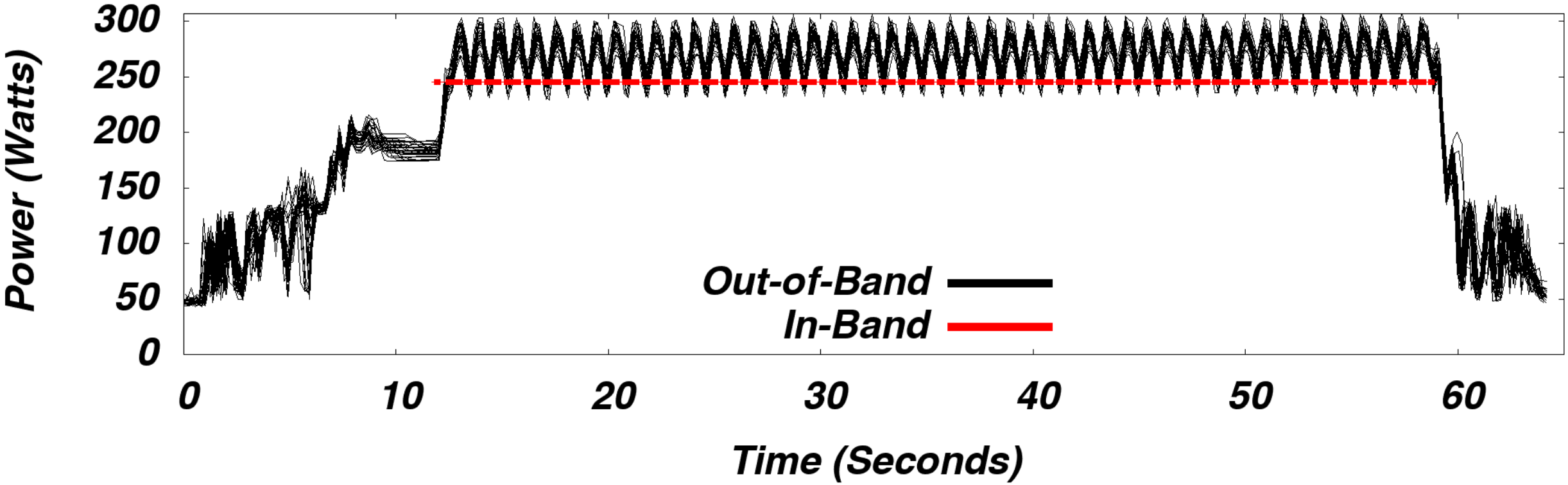
Sampling across 3 Platforms - MiniMD

- Can also compare all 3 platforms using out-of-band measurement
- See MiniMD periodic behavior in KNL, but IVB has more noise



In-band vs Out-of-Band Region Profiling

- Region profiling w/ timestamps and in-band power/energy profiling paired with the collection of out-of-band data allows for better insight
- See issue of resolution with in-band data sampled at region entry/exit
  - Periodicity missed with in-band sampling but seen in out-of-band sampling



Conclusion

- Detailed power profiling is possible on large—scale HPC systems
- The combination of application region profiling and out-of-band power measurement provides an accurate view of application power profiles with negligible overhead

Power API Meeting

- Power API Specification Community Meeting!
  - December 4th-5th, 2017
  - At Intel's Ronler Acres Campus in Hillsboro OR, USA
- Purpose
  - This group will propose, review and vote on changes to the Power API specification as a community effort
  - Consider the first proposals for changes to the specification
  - Interaction between, gov labs, vendors, and academia
- Agenda
  - Introductory tutorials on the Power API
  - Formulation of working group rules and procedures
  - Infrastructure discussion

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