Measuring Energy Efficiency for an HPC Center

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Energy efficiency metrics

$$PUE = \frac{mechanical + computing + other}{computing}$$

$$ITUE = \frac{total\ energy\ (that\ goes\ into\ the\ machine)}{energy\ into\ the\ computing\ nodes}$$

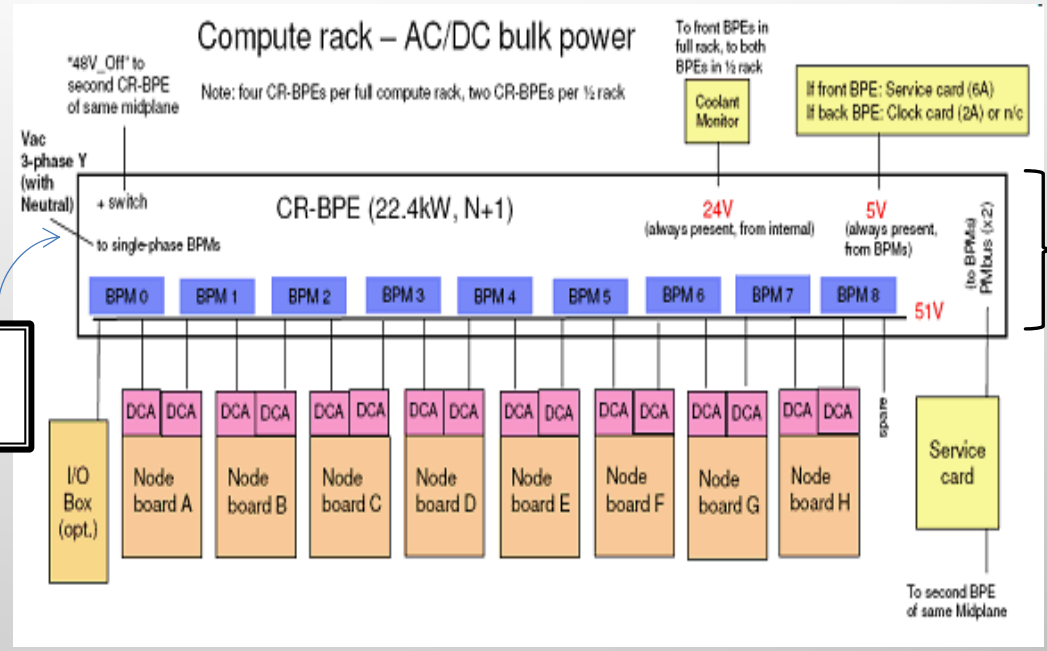
$$TUE = ITUE * PUE$$

Sequoia Parameters

- IBM Blue Gene*/Q architecture
- 98,304 nodes
- 1,572,864 cores
- 20 PF, 3rd on Top 500 – June 2013
- 96 racks
- 91% liquid cooled
- 30 gpm/rack at 62 F
- 9% air cooled
- 1700 cfm/rack at 70 F
- 4800 square feet

Sequoia ITUE

- No power from the rack AC connection is used to cool the racks
- Power to cool the racks is in the measured PUE
- Power lost is due to conversion efficiency
- Two levels
  - AC to DC (92.5%)
  - Regulation Module & Transformer (~87%)



$$\text{ITUE} = \frac{\text{Total Sequoia measured power}}{\text{Total Sequoia compute power}} = \frac{6118}{(6118)(0.925)(0.87)} = 1.24$$

Sequoia TUE

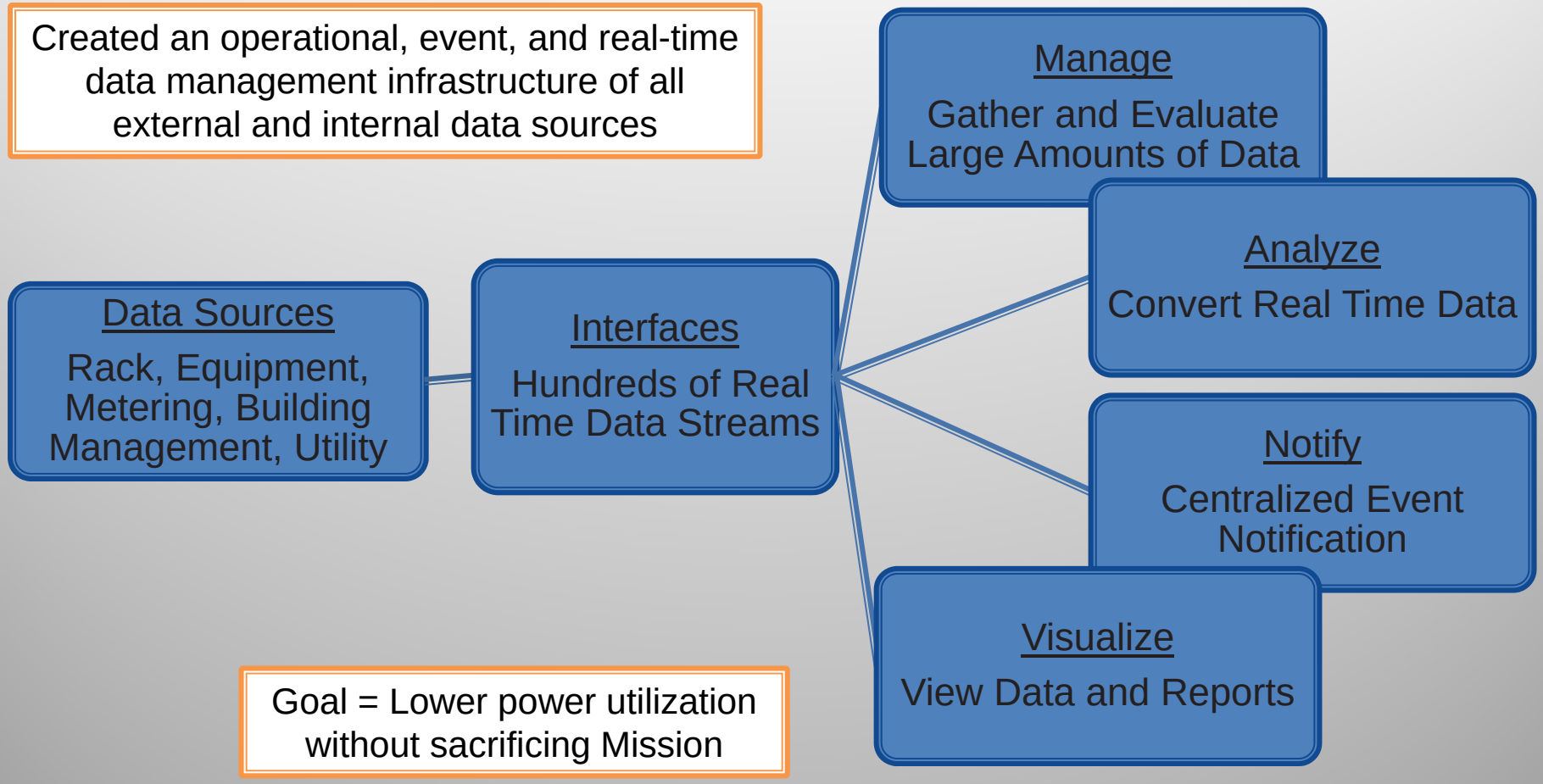
- TUE (Sequoia) = ITUE(Sequoia) x PUE(Facility)
- ITUE (Sequoia) = 1.24
- PUE (Facility) = 1.27

Metric	Measured	Estimated
ITUE		Estimated based on vendor efficiency estimates
PUE	Fully metered per rack, system and facility	

TUE = 1.24 × 1.27 = 1.57

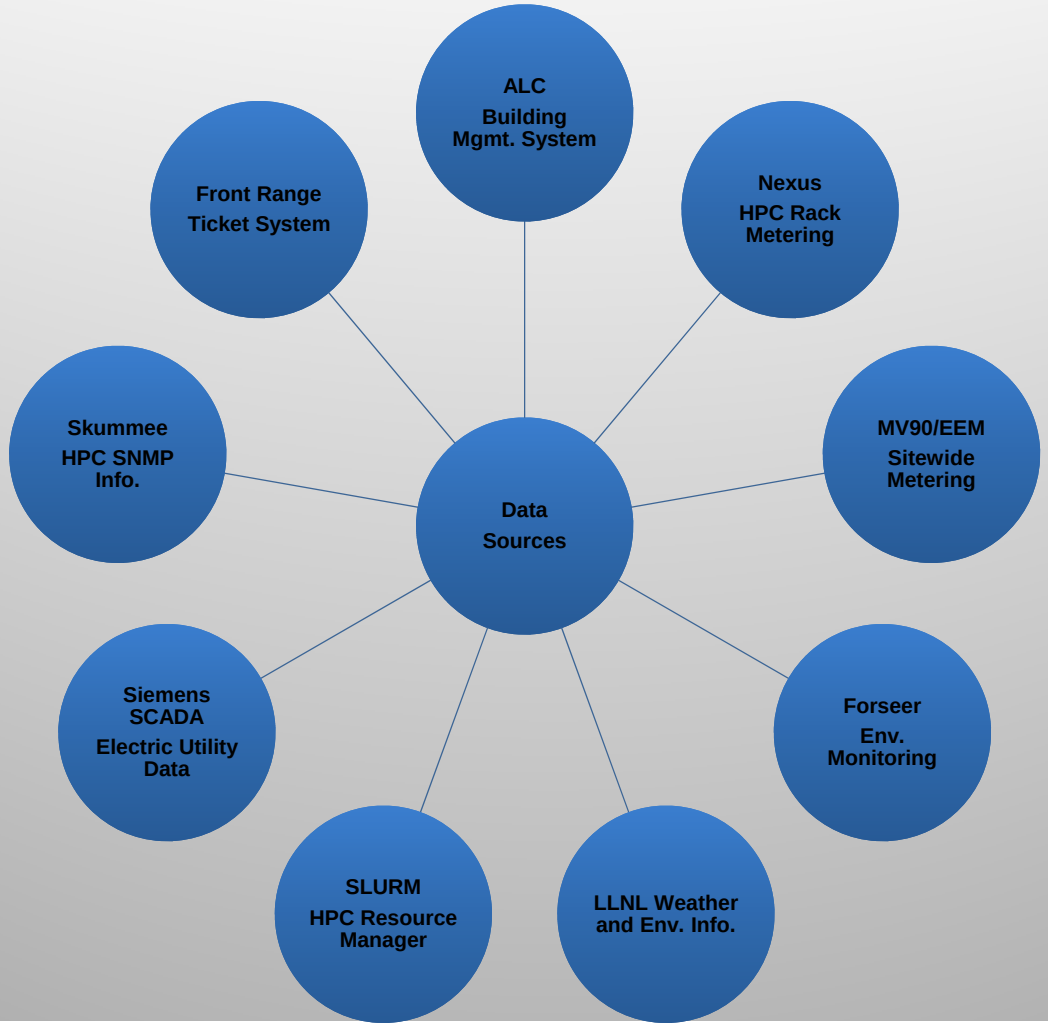
Implement Centralized System

Created an operational, event, and real-time data management infrastructure of all external and internal data sources



Goal = Lower power utilization without sacrificing Mission

Current data sources spread across LLNL

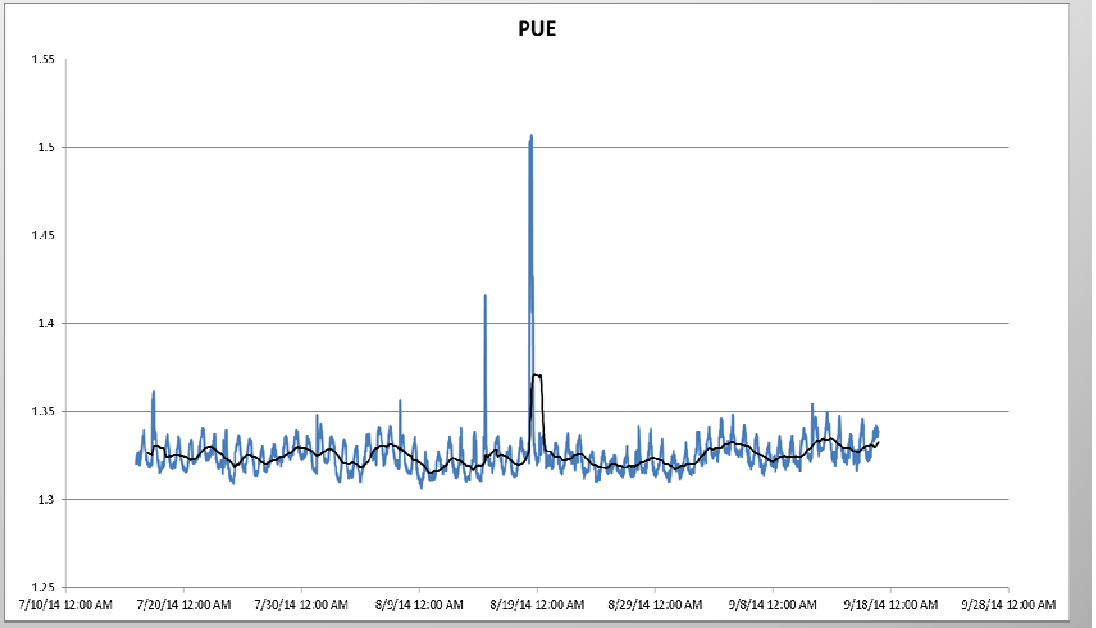


Data collection and Validation

- Data is collected using the MV-90 meters
  - Power to Sequoia and other HPC machines
  - Mechanical load (chillers, cooling tower, etc.)
- Sequoia power can be collected from the racks meters
  - Verified power from the rack level collection
  - One of the meters was not reporting correctly

PUE Dashboard

- PUE calculated using the metered data (not sequoia rack power)
  - PUE is now a tag in the DB
- High spikes are when Sequoia is down for maintenance
  - Regular maintenance schedule with one major outage
- Daily and weekly cycles



TUE graph for Sequoia