

Oak Ridge National Laboratory

Computing and Computational Sciences

Measuring the Energy Efficiency of ORNL's Titan Supercomputer

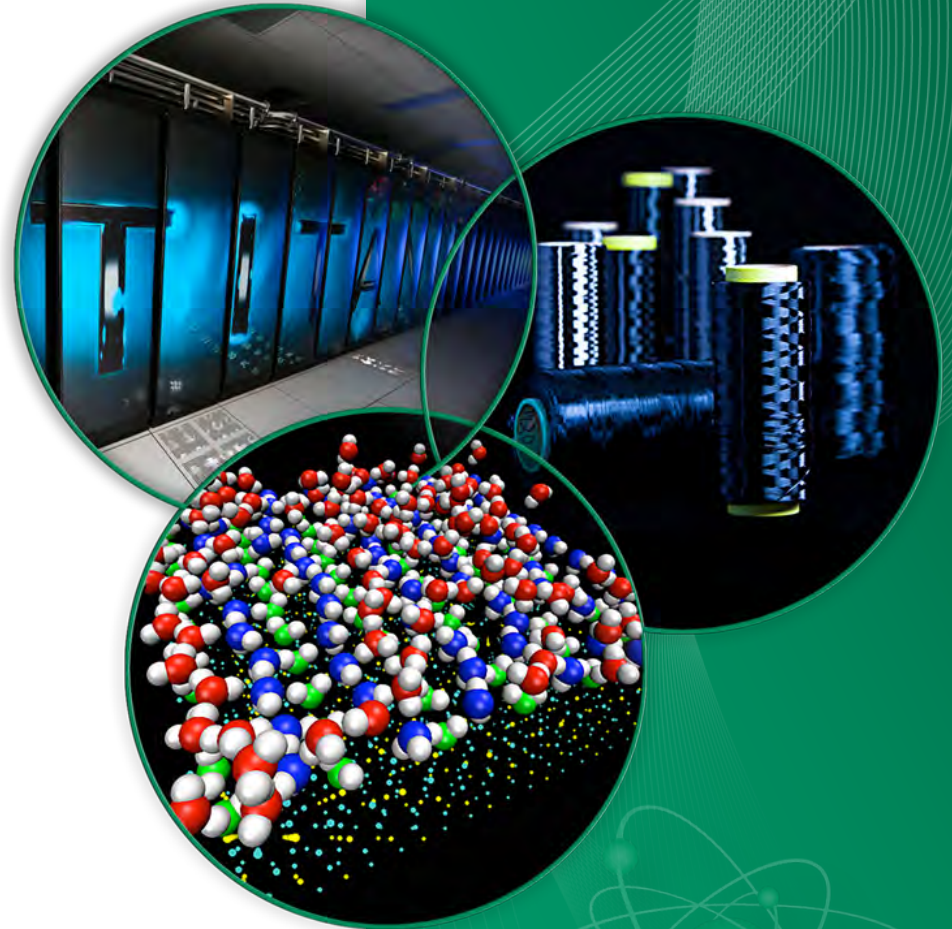
Chung-Hsing Hsu

Don Maxwell

Saeed Ghezawi

Joe Stephenson

Jim Rogers



5th Annual Energy Efficient HPC Working
Group Workshop
November 17, 2014

ORNL's Cray XK7 Titan



SYSTEM:

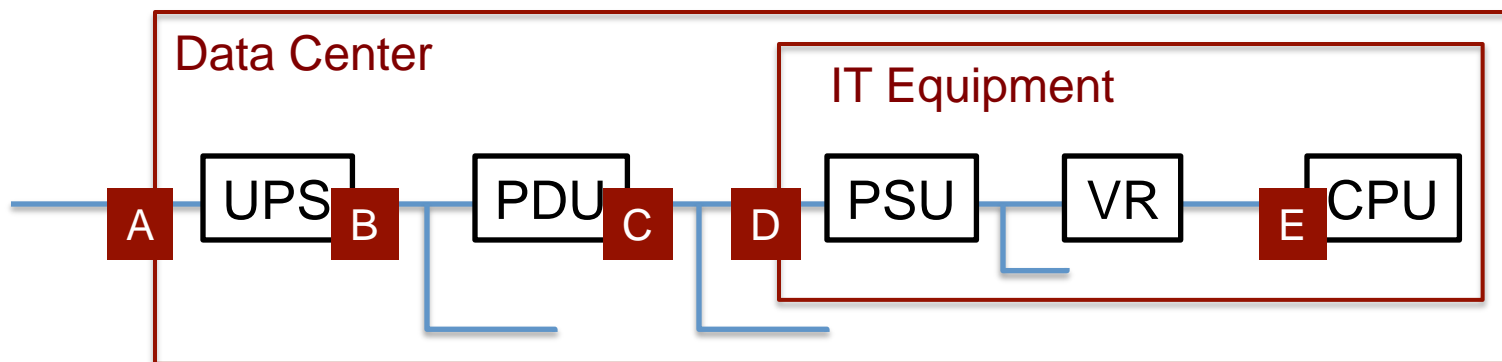
- A 27 PF Hybrid System
 - 17.59 PF on HPL
- 200 Cabinets
- 18,688 Compute Nodes
 - AMD Opteron CPUs
 - NVIDIA K20x GPUs
 - 32 + 6 GB memory
- Cray Gemini Interconnect

INFRASTRUCTURE:

- 4,352 ft² (404 m²)
- 8.2 MW on HPL
- (200) 480V/100A circuits
- (48) 480V/20A circuits
 - liquid cooling units
- (4) Transformers

<http://www.olcf.ornl.gov>

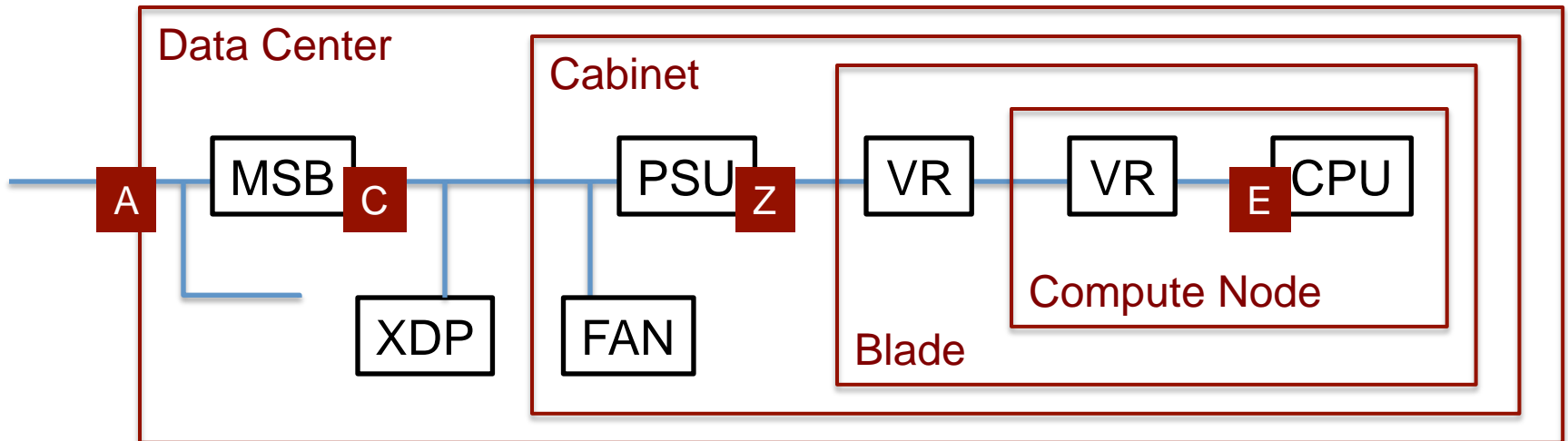
Energy Efficiency Metrics



	PUE1	PUE2	PUE3	TUE
Facility Energy	Utility Inputs	Utility Inputs	Utility Inputs	Utility Input
IT Energy	UPS Outputs	PDU Outputs	IT equip. Inputs	Compute nodes
Formula	A/B	A/C	A/D	A/E
Frequency	Monthly/ Weekly	Daily/Hourly	15min or less	Continuous
Human Efforts	Some	Less	None	

TUE = PUE * ITUE
(ref. ISC'13 paper)

Calculating Efficiency for Titan



FACTS:

- Can measure A and C
 - in kW and kWh
 - at 1min frequency
- Can measure Z
 - in kW
 - at 1min frequency
- Cannot measure E
 - estimation is needed
 - assume 84% efficiency

METHOD:

- $PUE2 = A/C$
- $ITUE = C/(Z \times 84\%)$
- $TUE = PUE2 * ITUE$

Titan's Energy Efficiency



PUE = 1.24
ITUE = 1.71
TUE = 2.11

The graph shows daily efficiency for August 2014

Discussions

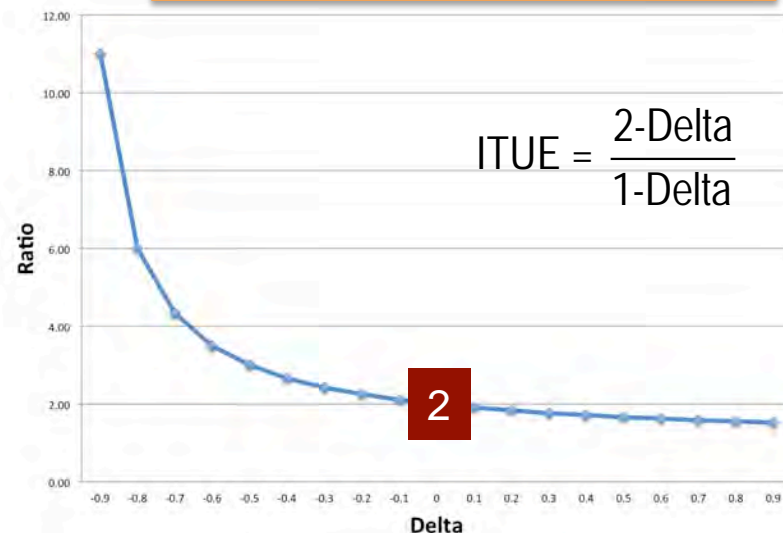
- In comparison to ORNL's Jaguar (August 2011)

	PUE	ITUE	TUE
Titan XK7	1.24	1.71	2.11
Jaguar XT5	1.25	1.54	1.92

- Why does Titan's ITUE increase?

- Recall $ITUE = C / (Z \times 84\%)$
- C drops by 4%
- Z drops by 14%
- The cause is **unequal** reduction!
- Watch for **bias** in any ratio form!

$$ITUE = \frac{1.54}{1} \times \frac{1-4\%}{1-14\%} = 1.71$$



Discussions (cont.)

- Opposite trends of two energy efficiency metrics

	ITUE	GLFOPS/W
Titan XK7	1.71	2.14
Jaguar XT5	1.54	0.25

- BoF:
 - Panel discussion on HPC system and data center energy efficiency metrics and workloads.
 - Tuesday 12:15 PM – 1:15 PM in Room 294.

Acknowledgements

Thank You!



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