### 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** 

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# **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 ft<sup>2</sup> (404 m<sup>2</sup>)
- 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 * IT (ref. ISC'13 pa



# **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**



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# **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 × 84%)
  - C drops by 4%
  - Z drops by 14%
  - The cause is **unequal** reduction!
  - Watch for **bias** in any ratio form!





# **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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