Cooling System Overview: Summit Supercomputer

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Today’s Presentation

- System Description
- Cooling System Components
- Cooling System Performance

<table>
<thead>
<tr>
<th></th>
<th>NOVEMBER 2018 #1</th>
<th></th>
<th>JUNE 2018 #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cores</td>
<td></td>
<td>2,397,824</td>
<td>2,282,544</td>
</tr>
<tr>
<td>Rmax</td>
<td>143,500.0</td>
<td>122,300.0</td>
<td></td>
</tr>
<tr>
<td>Rpeak</td>
<td>200,794.9</td>
<td>187,659.3</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>9.783</td>
<td>8.806</td>
<td></td>
</tr>
</tbody>
</table>
### Summit Node Overview

#### Feature

<table>
<thead>
<tr>
<th>Feature</th>
<th>Titan</th>
<th>Summit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Performance</td>
<td>Baseline</td>
<td>5-10x Titan</td>
</tr>
<tr>
<td>Number of Nodes</td>
<td>18,688</td>
<td>4,608</td>
</tr>
<tr>
<td>Node performance</td>
<td>1.4 TF</td>
<td>42 TF</td>
</tr>
<tr>
<td>Memory per Node</td>
<td>32 GB DDR3 + 6 GB GDDR5</td>
<td>512 GB DDR4 + 96 GB HBM2</td>
</tr>
<tr>
<td>NV memory per Node</td>
<td>0</td>
<td>1600 GB</td>
</tr>
<tr>
<td>Total System Memory</td>
<td>710 TB</td>
<td>&gt;10 PB DDR4 + HBM2 + Non-volatile</td>
</tr>
<tr>
<td>Interconnect</td>
<td>Gemini (6.4 GB/s)</td>
<td>Dual Rail EDR-IB (25 GB/s)</td>
</tr>
<tr>
<td>Interconnect Topology</td>
<td>3D Torus</td>
<td>Non-blocking Fat Tree</td>
</tr>
<tr>
<td>Bi-Section Bandwidth</td>
<td>15.6 TB/s</td>
<td>115.2 TB/s</td>
</tr>
<tr>
<td>Processors</td>
<td>1 AMD Opteron™</td>
<td>2 IBM POWER9™</td>
</tr>
<tr>
<td></td>
<td>1 NVIDIA Kepler™</td>
<td>6 NVIDIA Volta™</td>
</tr>
<tr>
<td>File System</td>
<td>32 PB, 1 TB/s, Lustre®</td>
<td>250 PB, 2.5 TB/s, GPFS™</td>
</tr>
<tr>
<td>Peak Power Consumption</td>
<td>9 MW</td>
<td>13 MW</td>
</tr>
</tbody>
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**Oak Ridge National Laboratory**
System Description – How do we cool it?

• >100,000 liquid connections
System Description – What’s in the data center?

- **Passive RDHXs** - 215,150ft$^2$ (19,988m$^2$) of total heat exchange surface (>20X the area of the data center)
  - With a 70°F (21.1 °C) entering water temperature, the room averages ~73°F (22.8°C) with ~3.5MW load and ~75.5°F (23.9°C) with ~10MW load. Note that only ~25% of compute rack load is on the RDHXs.
  - The racks turn over the data center’s air volume 2-3 times each minute when under load.

- **CPU cold plates** – 4,105ft$^2$ (381m$^2$) of total heat exchange surface

- **GPU cold plates** – 4,448ft$^2$ (413m$^2$) of total heat exchange surface

- **Other** - electrical transmission losses, lights, return water piping losses, building envelope, rack radiant, back of rack air exfiltration, VRF AHU fans
System Description – What does the cooling system see in the data center?
System Components – Facility Improvements
PUE – ORNL’s Measurement Overview

\[
PUE = \text{MSBs}(x5) + \text{ATS} + \text{UPSs}(x2) + \text{MSBs}(x2) + \text{Chilled Water Cooling Load} \times \text{Chiller Plant Efficiency}
\]

- \text{MSBs}(x5)
- \text{ATS}
- \text{UPSs}(x2)

\[
\text{MSBs}(x5) + \text{ATS} + \text{UPSs}(x2)
\]
Cooling System Performance - PUE

MARCH-OCTOBER 2018 5600 K100 PUE- 15min Data
Average IT Load over period- 3900kW    Projected Annual PUE - 1.10

- 8 Month’s of Data –
- Average PUE = 1.14 (overall light usage)
Cooling System Performance – HPL Runs

Summit MTW Cooling Loads and Temperatures
HPL Run 10/25/18 03:31:48 - 09:32:00

PUE during HPL Run = 1.024
Cooling System Performance – Cooling Source

MARCH-OCTOBER 2018 5600 K100 COOLING SOURCE - 15min Data
Average IT Load over period - 3900 kW  Peak IT Load - 11200 kW

DATE

CHW kWcm  CTW kWcm  1wk PUE (kW)
Cooling System Performance – Chilled Water Use

Efficiencies

- Chilled Water – ~0.8kW/ton
- Cooling Tower – ~0.2kW/ton

kWh of cooling from March to October:
22% Chilled Water
78% Cooling Towers
Cooling System Performance – Within the Data Center
Cooling System Performance – Within the Data Center
Thank You

https://www.olcf.ornl.gov/summit/