Highlights of the 53rd TOP500 List

ISC 2019, Frankfurt, June 17, 2019

Erich Strohmaier
ISC 2019 TOP500 TOPICS

• Petaflops are everywhere!
• “New” TOP10
• Dennard scaling and the TOP500
• China: Top consumer and producer? A closer look
• Green500, HPCG
• Future of TOP500
## List: The Top 10

<table>
<thead>
<tr>
<th>#</th>
<th>Site</th>
<th>Manufacturer</th>
<th>Computer</th>
<th>Country</th>
<th>Cores</th>
<th>Rmax [Pflops]</th>
<th>Power [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oak Ridge National Laboratory</td>
<td>IBM</td>
<td>Summit IBM Power System, P9 22C 3.07GHz, Mellanox EDR, NVIDIA GV100</td>
<td>USA</td>
<td>2,414,592</td>
<td>148.6</td>
<td>10.1</td>
</tr>
<tr>
<td>2</td>
<td>Lawrence Livermore National Laboratory</td>
<td>IBM</td>
<td>Sierra IBM Power System, P9 22C 3.1GHz, Mellanox EDR, NVIDIA GV100</td>
<td>USA</td>
<td>1,572,480</td>
<td>94.6</td>
<td>7.4</td>
</tr>
<tr>
<td>3</td>
<td>National Supercomputing Center in Wuxi</td>
<td>NRCPC</td>
<td>Sunway TaihuLight NRCPC Sunway SW26010, 260C 1.45GHz</td>
<td>China</td>
<td>10,649,600</td>
<td>93.0</td>
<td>15.4</td>
</tr>
<tr>
<td>4</td>
<td>National University of Defense Technology</td>
<td>NUDT</td>
<td>Tianhe-2A ANUDT TH-IVB-FEP, Xeon 12C 2.2GHz, Matrix-2000</td>
<td>China</td>
<td>4,981,760</td>
<td>61.4</td>
<td>18.5</td>
</tr>
<tr>
<td>5</td>
<td>Texas Advanced Computing Center / Univ. of Texas</td>
<td>Dell</td>
<td>Frontera Dell C6420, Xeon Platinum 8280 28C 2.7GHz, Mellanox HDR</td>
<td>USA</td>
<td>448,448</td>
<td>23.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Swiss National Supercomputing Centre (CSCS)</td>
<td>Cray</td>
<td>Piz Daint Cray XC50, Xeon E5 12C 2.6GHz, Aries, NVIDIA Tesla P100</td>
<td>Switzerland</td>
<td>387,872</td>
<td>21.2</td>
<td>2.38</td>
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<tr>
<td>7</td>
<td>Los Alamos NL / Sandia NL</td>
<td>Cray</td>
<td>Trinity Cray XC40, Intel Xeon Phi 7250 68C 1.4GHz, Aries</td>
<td>USA</td>
<td>979,072</td>
<td>20.2</td>
<td>7.58</td>
</tr>
<tr>
<td>8</td>
<td>National Institute of Advanced Industrial Science and Technology</td>
<td>Fujitsu</td>
<td>AI Bridging Cloud Infrastructure (ABCI) PRIMERGY CX2550 M4, Xeon Gold 20C 2.4GHz, IB-EDR, NVIDIA V100</td>
<td>Japan</td>
<td>391,680</td>
<td>19.9</td>
<td>1.65</td>
</tr>
<tr>
<td>9</td>
<td>Leibniz Rechenzentrum</td>
<td>Lenovo</td>
<td>SuperMUC-NG ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path</td>
<td>Germany</td>
<td>305,856</td>
<td>19.5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Lawrence Livermore National Laboratory</td>
<td>IBM</td>
<td>Lassen IBM Power System, P9 22C 3.1GHz, Mellanox EDR, NVIDIA Tesla V100</td>
<td>USA</td>
<td>288,288</td>
<td>18.2</td>
<td></td>
</tr>
</tbody>
</table>
REPLACEMENT RATE
PERFORMANCE DEVELOPMENT

June 2008
Slowdown of Dennard Scaling

N=1

N=500

SUM
Less incentives to upgrade systems leads to older systems.

7.6 month
Less frequent purchases allow to increase system sizes and lead to a more top-heavy TOP500
Less frequent purchases on steady budget leads to increases in system sizes, which temporarily keeps overall performance increase up.
PROJECTED PERFORMANCE DEVELOPMENT

100 Eflop/s
10 Eflop/s
1 Eflop/s
100 Pflop/s
10 Pflop/s
1 Pflop/s
100 Tflop/s
10 Tflop/s
1 Tflop/s
100 Gflop/s
10 Gflop/s
1 Gflop/s
100 Mflop/s

SUM
N=1
N=500

COUNTRIES / SYSTEM SHARE

- United States; 23%
- China; 44%
- Japan; 6%
- France; 4%
- United Kingdom; 3%
- Germany; 3%
- Netherlands; 2%
- Ireland; 3%
- Canada; 2%
- Others; 10%

- United States
- China
- Japan
- France
- United Kingdom
- Germany
- Netherlands
- Ireland
- Canada
COUNTRIES / PERFORMANCE SHARE

- United States: 38%
- China: 30%
- Japan: 8%
- France: 4%
- Germany: 4%
- United Kingdom: 3%
- Switzerland: 4%
- Ireland: 1%
- Others: 77%
VENDORS / SYSTEM SHARE

- Lenovo: 175; 35%
- Inspur: 71; 14%
- Sugon: 63; 13%
- HPE: 40; 8%
- Cray Inc.: 42; 9%
- Bull: 21; 4%
- Fujitsu: 14; 3%
- Dell EMC: 17; 3%
- IBM: 16; 3%
- Others: 41; 8%

# of systems, % of 500
Lenovo; 306; 20%
Inspur; 87; 6%
Sugon; 96; 6%
HPE; 120; 8%
Cray Inc.; 195; 12%
IBM; 324; 21%
Fujitsu; 71; 4%
Dell EMC; 58; 4%
Bull; 54; 3%
NUDT; 66; 4%
others; 90; 6%

Sum of Pflop/s, % of whole list
VENDORS (TOP50) / SYSTEM SHARE

- Cray Inc.; 14; 28%
- HPE; 10; 20%
- IBM; 7; 14%
- Fujitsu; 5; 10%
- Lenovo; 3; 6%
- Bull; 3; 6%
- Others; 8; 16%
LENOVO*/SYSTEM SHARE 2018+2019

China; 69; 42%
United States; 38; 23%
Ireland; 13; 8%
Netherlands; 12; 7%
United Kingdom; 6; 4%
Singapore; 5; 3%
Canada; 4; 2%
Australia; 3; 2%
Others; 14; 9%

* Inspur, Sugon, Huawei have not sold outside of China yet.
ACCELERATORS (TOP50) / SYSTEM SHARE

- Nvidia Kepler: 1
- Nvidia Pascal: 3
- Nvidia Volta: 9
- Matrix-2000: 1
- Deep Computing P.: 1
- Xeon Phi Main: 8
- ShenWei: 1
- Power BQC: 3
- None: 23
## MOST ENERGY EFFICIENT ARCHITECTURES

* Efficiency based on Power optimized HPL runs of equal size to TOP500 run.

<table>
<thead>
<tr>
<th>Computer</th>
<th>Processor</th>
<th>Memory</th>
<th>Accelerator</th>
<th>Rmax/Power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shoubou system B, ZettaScaler-2.2</strong></td>
<td>Xeon 16C 1.3GHz</td>
<td>Infiniband EDR</td>
<td>PEZY-SC2</td>
<td>17.6</td>
</tr>
<tr>
<td><strong>DGX Saturn V, NVIDIA DGX-1 Volta36</strong></td>
<td>Xeon 20C 2.2GHz</td>
<td>Infiniband EDR</td>
<td>Tesla V100</td>
<td>*15.1</td>
</tr>
<tr>
<td><strong>Summit, IBM Power System</strong></td>
<td>Power9 22C 3.07GHz</td>
<td>Infiniband EDR</td>
<td>Volta GV100</td>
<td>14.7</td>
</tr>
<tr>
<td><strong>AI Bridging Cloud Infrastructure (ABCI), Fujitsu PRIMERGY, NVIDIA Tesla V100</strong></td>
<td>Xeon Gold 20C 2.4GHz</td>
<td>Infiniband EDR</td>
<td>Tesla V100 SXM2</td>
<td>*14.4</td>
</tr>
<tr>
<td><strong>MareNostrum P9 CTE, IBM Power System</strong></td>
<td>Power9 22C 3.1GHz</td>
<td>Infiniband EDR</td>
<td>Tesla V100</td>
<td>14.1</td>
</tr>
<tr>
<td><strong>Tsubame 3.0, SGI ICE XA</strong></td>
<td>Xeon 14C 2.4GHz</td>
<td>Intel Omni-Path</td>
<td>Tesla P100 SXM2</td>
<td>*13.7</td>
</tr>
<tr>
<td><strong>PANGEA III, IBM Power System</strong></td>
<td>Power9 18C 3.45GHz</td>
<td>Infiniband EDR</td>
<td>Volta GV100</td>
<td>13.1</td>
</tr>
<tr>
<td><strong>Sierra, IBM Power System</strong></td>
<td>Power9 22C 3.1GHz</td>
<td>Infiniband EDR</td>
<td>Volta GV100</td>
<td>12.7</td>
</tr>
<tr>
<td><strong>ACS (PreE), Sugon TC8600</strong></td>
<td>Hygon Dhyana (Epyc 7501) 32C 2GHz</td>
<td>200Gb 6D Torus</td>
<td>Deep Computing</td>
<td>11.4</td>
</tr>
<tr>
<td><strong>Tawania 2, QCT QuantaGrid D52G-4U/LC</strong></td>
<td>Xeon Gold 6154 18C 3GHz</td>
<td>InfiniBand EDR</td>
<td>Tesla V100 SXM2</td>
<td>11.3</td>
</tr>
</tbody>
</table>

[GFlops/Watt]
POWER EFFICIENCY
ENERGY EFFICIENCY

Max-Efficiency

ZettaScaler-2.2
Tsubame 3.0
DGX SaturnV
ZettaScaler-1.6 c
Tsubame KFC
NVIDIA K20x – K80
DGX SaturnV
Tsubame KFC
NVIDIA K20x – K80
ZettaScaler-1.6 c
Tsubame 3.0
DGX SaturnV
ZettaScaler-2.2

Linpack/Power [Gflops/W]


The GREEN 500
<table>
<thead>
<tr>
<th>#</th>
<th>T</th>
<th>Site (Manufacturer)</th>
<th>Computer (Country)</th>
<th>HPCG</th>
<th>Rmax</th>
<th>HPCG/ Peak</th>
<th>HPCG/ HPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Oak Ridge National Laboratory (IBM)</td>
<td>Summit IBM Power System, P9 22C 3.07 GHz, Volta GV100, EDR</td>
<td>USA</td>
<td>2.9258</td>
<td>148.6</td>
<td>1.6%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Lawrence Livermore National Laboratory (IBM)</td>
<td>Sierra IBM Power System, P9 22C 3.1 GHz, Volta GV100, EDR</td>
<td>USA</td>
<td>1.7957</td>
<td>94.6</td>
<td>1.5%</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>RIKEN Advanced Institute for Computational Science (Fujitsu)</td>
<td>K Computer SPARC64 VIII fx 2.0GHz, Tofu Interconnect</td>
<td>Japan</td>
<td>0.6027</td>
<td>10.5</td>
<td>5.3%</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>Los Alamos NL / Sandia NL (Cray)</td>
<td>Trinity Cray XC40, Intel Xeon Phi 7250 68C 1.4GHz, Aries</td>
<td>USA</td>
<td>0.5461</td>
<td>20.2</td>
<td>1.2%</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>National Institute of Advanced Industrial Science and Technology (Fujitsu)</td>
<td>Al Bridging Cloud Infrastructure (ABCI) PRIMERGY CX2550 M4, Xeon Gold 20C 2.4GHz, IB-EDR, NVIDIA V100</td>
<td>Japan</td>
<td>0.5089</td>
<td>19.9</td>
<td>1.6%</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>Swiss National Supercomputing Centre (CSCS) (Cray)</td>
<td>Piz Daint Cray XC50, Xeon E5 12C 2.6GHz, Aries, NVIDIA Tesla P100</td>
<td>Switzerland</td>
<td>0.4970</td>
<td>21.2</td>
<td>1.8%</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>National Supercomputing Center in Wuxi (NRCPC)</td>
<td>Sunway TaihuLight NRCPC Sunway SW26010, 260C 1.45GHz</td>
<td>China</td>
<td>0.4808</td>
<td>93.0</td>
<td>0.4%</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>Korea Institute of Science and Technology Information (Cray)</td>
<td>Nurion Cray CS500, Intel Xeons Phi 7250 68C 1.4 GHz, OmniPath</td>
<td>South Korea</td>
<td>0.3915</td>
<td>13.9</td>
<td>1.5%</td>
</tr>
<tr>
<td>9</td>
<td>14</td>
<td>Joint Center for Advanced HPC (Fujitsu)</td>
<td>Oakforest-PACS Cray CX1640 M1, Intel Xeons Phi 7250 68C 1.4 GHz, OmniPath</td>
<td>Japan</td>
<td>0.3855</td>
<td>13.6</td>
<td>1.5%</td>
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<tr>
<td>10</td>
<td>12</td>
<td>Lawrence Berkeley National Laboratory (Cray)</td>
<td>Cori Cray XC40, Intel Xeons Phi 7250 68C 1.4 GHz, Aries</td>
<td>USA</td>
<td>0.3554</td>
<td>14.0</td>
<td>1.3%</td>
</tr>
</tbody>
</table>
ISC 2019 TOP500 HIGHLIGHTS

• Petaflops are everywhere!
• Slow-down of Dennard’s scaling lead to longer procurement cycles which provided a 5 year delay from slowing down at the very TOP (2008-2013)
  – Don’t expect this for Moore’s Law!
• China: Top consumer and producer overall but not in the TOP50 (yet)
• Future increase in architectural diversity will necessitate a flexible approach to benchmarking