Big Data and Extreme Computing: Updates about China

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Outline

HPC and Big Data Projects in China

Recent Efforts on Tianhe-2

Recent Efforts on Sunway TaihuLight
MOST HPC Projects 2016

- Exa-scale pilot system (three systems in parallel)
  - Sunway successor
  - Tianhe successor
  - Sugon
- Computational physics model and numerical methods for exa-scale systems
- Programming framework
- HPC environment service and supporting system
- HPC numerical simulator
  - aircraft simulator
  - earth simulator
- Other typical HPC applications
  - complex EM environment simulation
  - ocean and wave modeling
  - mechanical engineering
  - material science

deep learning benchmark

310 Million, 19 Projects
MOST Cloud Computing and Big Data Projects 2016

- Software defined cloud computing: basic theory and methods
- Big data storage technology and platform
- Dataflow oriented big data analytic system
- Network operating system for cloud computing
- Scientific big data management system
- Big data management system for advanced manufacturing
- Big data based intelligent software development method and environment
- Big data knowledge engineering: basic theory and applications
- Human-computer interaction
- VR, AR

389 Million, 15 Projects
Outline

- HPC and Big Data Projects in China
- Recent Efforts on Tianhe-2
- Recent Efforts on Sunway TaihuLight
Big Data Science Research Center

- **NSFC-GuangDong Joint Project based on Tianhe-2**
  - 2016-2020, ¥300 Million, steering by NSCC-GZ

- **Big data projects focus on Smart City**
  - Transportation 智能交通
  - Medical & Health 智慧医疗与健康
  - Disaster prevention 智慧防灾
  - Finance 智慧金融
  - Education 智慧教育
  - Social Management 智慧管理

- **Convergence of talent and technology resources, jointly solve key problems of big data science**
BigData Science Research Center

- Bigdata + HPC
- Pearl River Delta National Bigdata Integration Test Zone

### Bigdata Applications

- video processing
- Medical & Health
- Intelligent transport
- Finance
- Gov. Admin
- Disaster Prevention

### Domain Specific Parallel Support Framework

### Bigdata Analysis and Parallel Processing Platform

### Basic Model & Algorithm oriented to Bigdata

- Tianhe-2
- Extending Storage System
Outline

- HPC and Big Data Projects in China
- Recent Efforts on Tianhe-2
- Recent Efforts on Sunway TaihuLight
2016 Highlights

Over 60 large-scale applications from over 100 research institutes covering 19 application domains, 6 full-scale applications, 18 half-scale, 22 million-core-scale, 3 Gordon Bell Finals, and 1 Gordon Bell Prize.
## Sunway TaihuLight: Overview

<table>
<thead>
<tr>
<th>System</th>
<th>TaihuLight</th>
<th>Tianhe-2</th>
<th>Titan</th>
<th>Sequoia</th>
<th>Cori</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Performance (PFlops)</td>
<td>125.4</td>
<td>54.9</td>
<td>27.1</td>
<td>20.1</td>
<td>27.9</td>
</tr>
<tr>
<td>Total Memory (TB)</td>
<td>1310</td>
<td>1024</td>
<td>710</td>
<td>1572</td>
<td>879</td>
</tr>
<tr>
<td>Linpack Performance (PFlops)</td>
<td>93.0(74%)</td>
<td>33.9(62%)</td>
<td>17.6(65%)</td>
<td>17.2(85.3)</td>
<td>14.0(50%)</td>
</tr>
<tr>
<td>Performance/Power (Mflops/W)</td>
<td>6051.3</td>
<td>1901.5</td>
<td>2142.8</td>
<td>2176.6</td>
<td>3266.8</td>
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<tr>
<td>GTEPS</td>
<td>23755.7</td>
<td>2061.48</td>
<td>###</td>
<td>23751</td>
<td>###</td>
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<tr>
<td>HPCG (Pflops)</td>
<td>0.3712</td>
<td>0.5801</td>
<td>0.3223</td>
<td>0.3304</td>
<td>0.3554</td>
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<tr>
<td>Rank of Top500</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Rank of Green500</td>
<td>4</td>
<td>135</td>
<td>100</td>
<td>90</td>
<td>26</td>
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<tr>
<td>Rank of Graph500</td>
<td>2</td>
<td>8</td>
<td>###</td>
<td>3</td>
<td>###</td>
</tr>
<tr>
<td>Rank of HPCG</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>
10-million-core scalable full implicit solver for non-hydrostatic atmospheric dynamics

- support up to 500m resolution
- sustained performance of 7.95 Pflops
- 2016 Gordon Bell Prize winner
MASNUM (Key laboratory of MArine Science and NUmerical Modeling) wave model

- sustained performance 45.43 Pflops
- global 1km wave simulation
- 2016 Gordon Bell Prize finalist
Large Scale Phase Field Simulation for Coarsening Dynamics Based on Cahn-Hilliard Equation with Degenerated Mobility
- over 50 Pflops sustained performance
- highly scalable, large time-step integrating algorithm
The CESM Project on Sunway TaihuLight

- Four component models, millions lines of code

- Large-scale run on Sunway TaihuLight
  - 24,000 MPI processes
  - Over one million cores
  - 10-20x speedup for kernels
  - 2-3x speedup for the entire model

Tsinghua + BNU
30+ Professors and Students
The CESM Project on Sunway TaihuLight

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"Refactoring and Optimizing the Community Atmosphere Model (CAM) on the Sunway TaihuLight Supercomputer", in Proceedings of SC 2016.
Library for Deep Learning (swDNN)

- swDNN: Provide interface for optimized basic operators
  - Fully-connected layer (BLAS); Pooling layer
  - Activation function; Batch Normalization
  - *Convolutional Layer (90% time for CNN)

### Related Works on other architectures

<table>
<thead>
<tr>
<th>Work</th>
<th>Platform</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>cuDNN(2014)</td>
<td>GPU</td>
<td>GEMM</td>
</tr>
<tr>
<td>fbtfft(2014)</td>
<td>GPU</td>
<td>FFT</td>
</tr>
<tr>
<td>Andrew Lavin (2015)</td>
<td>GPU</td>
<td>Winograd</td>
</tr>
<tr>
<td>Chen Zhang (2015)</td>
<td>FPGA</td>
<td>Direct Conv</td>
</tr>
<tr>
<td>swDNN</td>
<td>SW26010</td>
<td>Blocking GEMM</td>
</tr>
</tbody>
</table>
Library for Deep Learning (swDNN)

- **Performance**
  - Convolutional performance above **1.6 Tflops** with double-precision
  - Speedup ranging from **1.91x to 9.75x** compared with cudnnv5.1.
Framework for Deep Learning (under development)

- **Distributed framework**
  - Customized from *Caffe* with less dependencies
  - Two-level Parameter Server Based-on MPI
swDNN Supported Project: Sunway-Lingo

collaborated with Prof. Zhiqing Liu, BUPT

- Original go board to be processed
- Converted to a 48-channel image fed to deep CNN with essential go features such as liberties
- Order of probabilities of plausible moves as outputted by policy network
Long Term Plan

- Traditional HPC Applications
  - weather / climate service
  - seismic data processing service
  - CFD simulation framework for Advanced Manufacturing

- Deep Learning Related Applications
  - the swDNN framework
  - collaborating with face++ for face recognition applications
  - collaborating with Sogou for voice recognition and translation
  - customized DNN Sunway chip?

- Big Data Center
  - National Health and Medical Big Data Center at Nanjing