EAGER
Power Aware Data Driven Distributed Simulation on Micro-Cluster Platforms

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Project Team

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Motivation: Micro-Clusters and Energy

- Increasing computational capability of mobile computing devices
- Explosion in mobile devices
- Proliferation of low cost battery-powered drones and sensors
- Suggests trend: push more computing closer to data

- Micro-cluster: High performance cluster computer constructed from power efficient components operating in energy constrained environments
- Power and energy consumption are major concerns
A DDDAS Application: Adaptive Sensor Networks

Autonomous team of mobile sensors monitoring an evolving physical system
- Spreading forest fire
- Dispersing cloud plume
- Traffic in a city

Each mobile device includes
- Sensors
- Ability to participate in P2P wireless communication
- Predictive data driven simulation

Processing Loop
1. Sense: construct current system state
2. Predict: distributed simulation to estimate future state
3. Adapt: relocate sensors
Research Goals

- Evaluate energy, time tradeoffs in data driven distributed simulation middleware
  - Synchronization algorithms
- Evaluate accuracy, energy, time tradeoffs for data-driven transportation analytics
  - Simulation, destination prediction, route computation
  - Data tradeoffs
- Develop approaches for efficient energy use
- Evaluate approaches experimentally via benchmarks and prototypes
# Micro-cluster Testbed System

<table>
<thead>
<tr>
<th></th>
<th>Jetson TK1</th>
<th>Jetson TX1</th>
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</thead>
<tbody>
<tr>
<td><strong>CPU</strong></td>
<td>ARM A15</td>
<td>ARM A57</td>
</tr>
<tr>
<td></td>
<td>(32-bit, 2.3 GHz, 4+1 cores)</td>
<td>(64-bit, 1.9 GHz, 4 cores)</td>
</tr>
<tr>
<td><strong>GPU</strong></td>
<td>192 core Kepler, 326 GF/s <em>(peak)</em></td>
<td>256 core Maxwell, 1 TF/s</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>2 GB LPDDR3</td>
<td>4 GB LPDDR4</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>16 GB eMMC</td>
<td>16 GB eMMC</td>
</tr>
<tr>
<td><strong>Networking</strong></td>
<td>Ethernet</td>
<td>802.11ac / BT</td>
</tr>
<tr>
<td><strong>Form Factor</strong></td>
<td>Dev board</td>
<td>Module with 400 pin connector</td>
</tr>
<tr>
<td><strong>I/O</strong></td>
<td>USB, HDMI, Serial</td>
<td>Provided separately</td>
</tr>
<tr>
<td><strong>Release Date</strong></td>
<td>2014</td>
<td>2015</td>
</tr>
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**Micro-Cluster Server Hardware**
- Jetson TK1 Boards (TX1 under evaluation)
- Tunable core (10x), memory (3x) frequencies
- PowerMon2 measurement system

**Client Hardware**
- Quadcore Qualcomm MSM8974 Snapdragon Processor (LG Nexus 5 cellular phone)
Transportation System Monitoring

- Portable bluetooth detectors
- Record ID of passing vehicles
- Extract vehicle route information
Distributed Simulation Middleware

Creating Energy Profiles*
- Techniques developed to measure energy profiles of distributed simulations
- CMB synchronization algorithm
- Queueing network benchmark

Synchronization Algorithms**
- Chandy/Misra/Bryant null message algorithm
- YAWNS: algorithm based on barrier synchronizations
- Different behaviors observed
- Energy for synchronization algorithms not studied before

* submitted for publication
** IEEE Conference on Distributed Simulation & Real-Time Applications
Modified Algorithm
• 45% better performance
• 20% lower peak power
Route Prediction Analytics

- GPS trajectories of 10,357 taxis (Beijing)
- 15M data points: Feb. 2 to Feb. 8, 2008
- Average sampling interval 177s (623m on avg)
- Trips are not marked within taxi tours

Source: T-Drive User Guide (Yu Zheng, Microsoft)

Route Prediction Accuracy improved using dynamic data

- Original approach (Krumm) based on past trajectory of single vehicle
- Modified approach uses dynamic traffic data
Status & Research Plans

• Testbeds
  – Micro-cluster, power measurement set up
  – Validated power measurements
  – Bluetooth vehicle detection operational; Next: WiFi
• Distributed simulation middleware
  – Energy profiling techniques developed, validated
  – Preliminary synchronization algorithm measurement
  – Next: Application benchmark suite; predictive models
• Transportation analytics
  – Benchmarked graph algorithms, simulations, destination prediction algorithms
  – Next: Data-driven tradeoffs, automated energy tuning
• Workshop on Research Challenges in Modeling & Simulation for Engineering Complex Systems
  – Arlington, Virginia, January 13-14, 2016
• DDDAS Workshop in connection with ACM-SIGSIM PADS conference (Jin, Fujimoto)
  – Banff, Canada, May 16, 2016
  – Paper deadline: February 1, 2016
• Winter Simulation Conference
  – Crystal City, Virginia, December 12-14, 2016
  – Paper deadline: April 1, 2016