Building an Exotic HPC Ecosystem at The University of Tulsa

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Tandy School of Computer Science
Changing Our CS Culture

• Platforms
  – Desktop, workstations, mobile

• Programming
  – Java, python
  – Serial
Changing Our CS Culture

• Platforms
  – Desktop, workstations, mobile += Big iron and HPC

• Programming
  – Java, python += C, etc.
  – Serial += parallel and multi-threaded
Changing Our CS Culture

- Platforms
  - Desktop, workstations, mobile += Big iron and HPC

- Programming
  - Java, python += C and HPC toolchains/APIs.
  - Serial += parallel and multi-threaded

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Friends in HPC Places

• OU – Oklahoma Supercomputing Center for Education and Research (OSCER)
  – Wisdom, guidance and models
• OneOklahoma Cyberinfrastructure Initiative (ONEOCII)
  – Community and relationships
• Tandy SuperComputing Center
  – Resources, access and expertise
• Researchers at TU and OU-Tulsa
  – Problem spaces and commiseration
TU HPC Ecosystem Overview

• Facilities
  – Anvi1, Hamm3r, Furn4ce

• Classes
  – High Performance Computing
  – HPC Competition

• Research
  – Security analytics, Bioinformatics, Geosciences

• Philosophy
  – Leverage resources; add value; be different
Bootstrapping

• Re: Friends in HPC Places
  – Sage advice
  – Generous donations of equipment and service

• Instrumentation grants
  – DoD DURIP
  – NSF MRI

• Finding a niche
  – Be different; add value...Heterogeneous computing
Heterogeneous Computing

• Definition: systems using more than one kind of processor, exploiting specialized capabilities in problem solving

• Common heterogeneous compute elements
  – CPU, GPU, MiC, FPGA

• Problem Domains
  – Systems biology, computer vision, image processing
Our First Cluster - Anvil

• Two Alums of our research group went to work at Wikipedia

• Wikimedia/Wikipedia was retiring a large number of servers and giving them to another non profit made the paperwork easy

• We thought we were going to get about five servers, we ended up with forty-five.

• I drove a U-Haul full of servers from Tampa, Florida back to Tulsa, OK

• We decided to build a cluster with the majority of the machines
Anvil – Duct Tape and Bailing Wire

• 32 compute node CPU-only Linux cluster using Dell PowerEdge 1950 III servers

• Dual Xeon L5420 (Quad-Core each), 2.5GHz “Harpertown” CPUs

• 32GB (Upgraded from 8GB) of Fully Buffered DDR2

• Each machine has three Ethernet networks – Compute/Management, Storage, and Lights out management

• Cluster-wide shared storage (3TB), VMware machine for management and services, Dedicated Login and Head node
Software

- Nodes run CentOS 6 for RHEL compatibility (for “science” software)
- Runs SLURM scheduler, single job queue
- Simple shared storage using NFS from NAS
- Machines are configured using puppet and pxe boot using razor
- Paths and environment variables are managed with lmod (lua)
New Machines - HAMM3R and FURN4CE

- 12/16 Nodes, each with Dual Xeon E5-2630 v3 “Haswell” CPUs @ 2.4GHz
- Each node has 64GB of RAM, 240GB SSD, 56Gb/s FDR Infiniband
- HAMM3R - Dual Xeon Phi 31S1P w/ 57 cores @ 1.1GHz, 8GB RAM
- FURN4CE – Single AMD FirePro S9050 GPU, 12GB RAM, 1792 SPs
- Each node will have a Nallatech OpenCL accelerator with either Altera Stratix-V (HAMM3R) FPGA or Arria-10 FPGA (FURN4CE)
- Built using SuperMicro servers assembled by Colfax

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### HAMM3R Node

<table>
<thead>
<tr>
<th>Memory</th>
<th>Processor</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>8GB DDR3</td>
<td>Stratix V FPGA</td>
<td>240GB SSD</td>
</tr>
<tr>
<td>32GB DDR4</td>
<td>Xeon 8C E5-2630v3</td>
<td>32GB DDR4</td>
</tr>
<tr>
<td>8GB GDDR5</td>
<td>Xeon Phi 31S1P</td>
<td>8GB GDDR5</td>
</tr>
</tbody>
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### FURN4CE Node

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<td>FirePro S9050</td>
<td>32GB DDR4</td>
</tr>
<tr>
<td>8GB DDR3</td>
<td>Arria 10 FPGA</td>
<td>8GB DDR3</td>
</tr>
</tbody>
</table>

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Command and Control Interface

• Called – “Blacksmith”

• Web interface for monitoring and managing the cluster

• Tightly integrated with SLURM, Puppet, and Razor

• Planned to visual and simplify the using the machine greatly

• VAPORWARE
Computing Environment

1. Fixed Purpose Units
   - CPU
   - MiC
   - FPGA

2. Fixed Purpose Units
   - CPU
   - GPU
   - FPGA

User-Defined Hardware

Node

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FPGA Benefits

• Customizable
  – “Blank Slate” for hardware
  – Custom pipelines
  – New architectures

• Reconfigurable between jobs
  – Optimally balance resources

• Soft-Core Processor
  – More control over internal components
FPGA Hardware

• Altera Stratix V
  – General purpose logic
• Customizable
• Connectivity
  – InfiniBand
  – Ethernet
Education and Outreach

• New 1-credit course
  – Basic HPC knowledge
  – Train to participate in HPC competition
  – Freshman to Senior Undergraduates

• HPC Competition
  – ISC 2016 Student Cluster Competition
  – Build a local HPC Competition?
Conclusions

• New Research Capabilities
  – HPC
  – Novel HPC Architecture
  – Software/Hardware Co-Development
  – HPC and Software/Hardware Tool Development

• New Education Capabilities
  – HPC Courses

• New Outreach Capabilities
  – HPC Competition – Internal and External