LittleFe
The High Performance Computing Education Appliance

Authors:
Charles Peck (charliep@cs.earlham.edu), Ivan Babic, Kristin Mutterspaw (Earlham College), Skylar Thompson (University of Washington), Tom Murphy (Contra Costa College), Mobeen Ludin, Aaron Weeden, Jennifer Houschens (Shodor Education Foundation, Inc.)

Many institutions have little to no access to parallel computing platforms for in-class computational science or parallel and distributed computing education. Key concepts, motivated by science, are taught more effectively and memorably on an actual parallel platform. LittleFe is a complete six node portable cluster. The entire package weighs less than 50 pounds, travels easily, and sets up in five minutes. LittleFe hardware includes multi-core processors and GPGPU capability, which enables support for shared and distributed memory parallelism, GPGPU parallelism, and hybrid models. By leveraging the Bootable Cluster CD project, LittleFe is an affordable, powerful, and ready-to-run computational science, parallel programming and distributed computing educational appliance.

Keywords: computer science education, parallel programming, distributed computing, computational science education, outreach.

Technical Overview

The Hardware
LittleFe is a complete, multi-node, portable, computational cluster designed as an educational appliance for reducing the friction associated with teaching high performance computing (HPC) and computational science in a variety of settings. The entire package costs less than $3,000, weighs less than 50 pounds, travels easily, and sets up in five minutes.

On the road to creating our first professional system (v4), we received feedback from recipients of the previous models about their design and productivity. Our team used the feedback as a guide in considering improvements for the next model’s design, which was completed in 2011. Since 2006, over 100 LittleFe units, some of both models, have been distributed to a variety of colleges and universities.

The Software
The software stack of choice for LittleFe units is the Bootable Cluster CD (BCCD). The BCCD is a ready-to-run, custom, Debian GNU/Linux distribution that includes all of the software needed to teach HPC and computational science, e.g. MPI, OpenMP, CUDA, hybrid models etc. It comes in a live RAM-based flavor that can be booted from either a CD or USB, and can also be installed onto a hard drive.

The Curriculum
The BCCD comes loaded with computational science curriculum sufficient for many uses in the classroom. The BCCD modules include everything from “hello world” examples of CUDA and MPI to simulations of relevant computational science problems such as n-body, molecular dynamics, prime number generation, and many others. All of the simulations have been validated and verified through the Blue Waters Undergraduate Petascale Education Program (BW-UEP).

As a slimmed down version of a production cluster, LittleFe is an excellent teaching tool for getting students accustomed to a larger machine such as Blue Waters, Gordon, Kraken, or Blacklight, while still providing an environment where students can learn from their mistakes with few consequences.

Acknowledgments

We would like to acknowledge the help of many students at Contra Costa College and Earlham College, and many interns at the Shodor Education Foundation. Scott Lathrop, Craig Stewart, Bob Panoff, Henry Neeman, Steve Gordon, Almadena Chtcchelkanova, Jennifer Houschens, and Andrew Fitz Gibbon also provide our project with support and guidance.

More Information
For more information on LittleFe see http://LittleFe.net
For more information on the Bootable Cluster CD see http://BCCD.net

Parts List

<table>
<thead>
<tr>
<th>Component</th>
<th>Count</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atom 525 ION2 mainboard</td>
<td>6</td>
<td>$1,176</td>
</tr>
<tr>
<td>DDR2 800 memory 2GB</td>
<td>6</td>
<td>$234</td>
</tr>
<tr>
<td>Seagate SATA disk 320GB</td>
<td>1</td>
<td>$97</td>
</tr>
<tr>
<td>Netgear GS908 switch</td>
<td>1</td>
<td>$35</td>
</tr>
<tr>
<td>Ethernet adapter (USB)</td>
<td>1</td>
<td>$6</td>
</tr>
<tr>
<td>Wi-Fi adapter (mini PCI-E)</td>
<td>1</td>
<td>$19</td>
</tr>
<tr>
<td>Keyboard and mouse</td>
<td>1</td>
<td>$27</td>
</tr>
<tr>
<td>Network jumper</td>
<td>7</td>
<td>$6</td>
</tr>
<tr>
<td>MeanWell PB-150-12 power supply</td>
<td>1</td>
<td>$100</td>
</tr>
<tr>
<td>Frame assembly</td>
<td>1</td>
<td>$175</td>
</tr>
<tr>
<td>Mounting hardware</td>
<td>1</td>
<td>$25</td>
</tr>
<tr>
<td>Power cabling</td>
<td>1</td>
<td>$10</td>
</tr>
<tr>
<td>Pelican 16/30 case</td>
<td>1</td>
<td>$176</td>
</tr>
</tbody>
</table>

Total: $3,991

Figure 1: LittleFe v4b parts list

Programming Contests

We have used LittleFe as a tool to facilitate student programming contests at the XSEDE and Tapia conference series. These programming contests are a valuable way to excite students about practical applications for computational science and parallel programming. At each contest, students are grouped into teams and assigned a set of computational problems to work on over an eight-hour period. The students have to figure out their strengths and understand their available resources to solve as many problems as they can.

In comparison to personal laptops, which are not similar to production HPC clusters, or remote cluster resources, which are not hands-on and are susceptible to local infrastructure problems, LittleFe allows students to see and feel the physical structure of the cluster resource that they use to solve the computational science problems. This adds a hands-on element that piques the students’ interests in learning more about HPC beyond the contests.

Activities

Buildouts

Over the past two years, with support from Intel, the ACM, the EAPF, the XSEDE program, and the SC Conference HPC Educators program, we have distributed about 100 LittleFe units in five buildout events to nine pre-college schools, two community colleges, 21 undergraduate colleges, and 37 PhD-granting institutions, of which 20% are minority-serving institutions. Using these units, over 2000 students have learned about parallel, distributed, and high-performance computing.

The buildouts involve donated hardware, that a select group of science educators assemble onsite at the sponsoring conference. This creates a community of educators who are committed to the inclusion of high-performance computing in their coursework and in their institution as a whole. In exchange for a free LittleFe, the educators create curricula that they submit back to the community. These curricula are included in subsequent releases of the BCCD.

Outreach

LittleFe is an outstanding “people attractor,” which makes it a great tool for outreach activities. For the past few years, our group has participated in the Minority Engineering Advancement Program at IPUI. This is one of many events where LittleFe shines as a vehicle for building interest in STEM careers. In the picture to the right, high school students take apart a prototype v4 unit to see what makes up a computer.

Figure 2: LittleFe v4b unit

Figure 3: LittleFe in action, Tapia13
Figure 4: LittleFe buildout, SC12

Figure 5: Locations of the colleges and universities awarded LittleFe units