LittleFe
The High Performance Computing Education Appliance

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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 includes 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-UPEP).

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.

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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

Component	Count	Cost
Atom 525 ION2 mainboard	6	$1,176
DDR2 800 memory 2GB	6	$234
Seagate SATA disk 320GB	1	$97
Asus GX-D108 gigabit switch	1	$33
Ethernet adapter (USB)	1	$6
WiFi adapter (mini PCI-E)	1	$19
Keyboard and mouse	1	$27
Network jumpers	7	$8
MeanWell PB-360P-12 power supply	1	$90
Frame assembly	1	$175
Mounting hardware	1	$25
Power cabling	1	$10
Pelican 1610 case	1	$176
Total		**$2076**

Figure 1: LittleFe v4b parts list

Figure 2: LittleFe v4b unit

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.

Figure 3: LittleFe in action, Tapia13

Figure 4: LittleFe buildout, SC12

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.

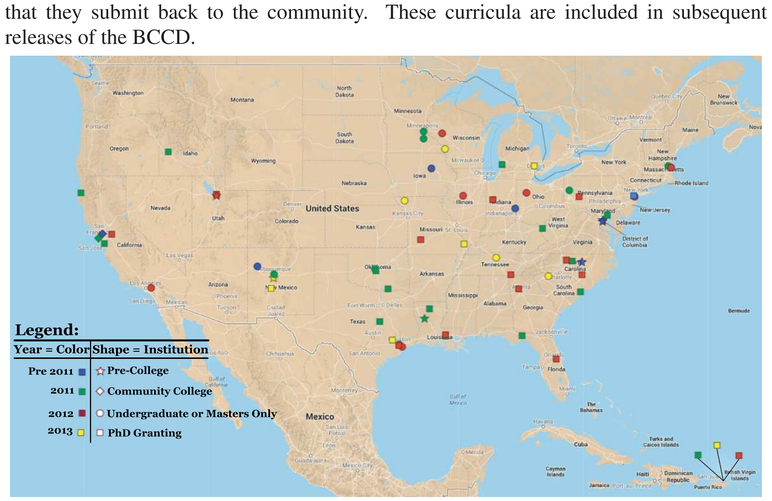

Figure 5: Locations of the colleges and universities awarded LittleFe units

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 IUPUI. 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.