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 Beowulf style 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 Beowulf style 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.

The idea of LittleFe sprouted from our work building stationary clusters and our experience teaching workshops in a variety of places that lacked parallel computational facilities. After gathering more gear and experience, we worked through three different approaches and finally arriving at the first production system, v3, in 2006.

On the road to creating our first professional system, v4, the recipients of the v3 model provided us with feedback about the 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, 45 LittleFe units, some of both models, have been placed around different 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 Linux distribution that includes all of the software needed to teach HPC and computational science, *e.g.* MPI (MPICH2 and OpenMPI), OpenMP, CUDA, Hybrid Models *etc.* It comes in Live CD flavor that can be booted from either a CD or USB, and if one wished could later be installed onto the hard drive.

The Curriculum

The BCCD comes loaded with computational science curriculum sufficient for most classroom uses. The BCCD modules include N-Body problems, Molecular Dynamics, Area under a curve, Conway's Game of Life, Parameter Space, HPL-benchmarking, diseae modeling, prime number generation, tree sorting, and CUDA, MPICH2, and OpenMPI "hello-world" examples which have been updated through the Blue Waters Undergraduate Petascale Education Program.

One of the use cases of LittleFe/BCCD is an on-ramp to national computational resources such as XSEDE. By using the same compilers, parallel libraries and job submission tools as commonly found on e.g. XSEDE clusters, people can learn to use those tools in a simple and low-friction environment. This increases their productivity when they move to using machines such as SDSC's Gordon, UT's Kraken, and PSC's Blacklight.

For More Information

For more information on LittleFe see `http://LittleFe.net`

For more information on Bootable Cluster CD see `http://BCCD.net`

Acknowledgments

We'd like to acknowledge Charlie Peck, Tom Murphy, Jennifer Houchins, and Andrew Fitz Gibbon for their help, support, and mentorship.

Version 4a 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 v4a Parts Manifest

Figure 2: Build at SC12 (Salt Lake City)

Figure 3: LittleFe Works! (Tapia '13)

Figure 4: LittleFe in Action (Tapia '13)

Programming contests

We have used LittleFe as a tool to facilitate student programming contests at the XSEDE and Tapia conferences. 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.

Rather than depend on personal laptops (which are not similar to production HPC clusters) or remote cluster resources (which are not hands-on and susceptible to all sorts of local infrastructure problems), LittleFe provides a great way to have a cluster which the students can use locally and see the physical structure of the cluster resources they will be using.

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 distributed 93 LittleFe units in five buildout events between nine pre-college schools, two community colleges, 21 undergraduate colleges, and 37 PhD-granting institutions. Using these units, we've taught over 2000 students about parallel, distributed, and high-performance computing.

Figure 5: Locations of the colleges and universities awarded v4 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.