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 multicore 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.

Backgrounds and Technical Overview

LittleFe Background

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.

Bootable Cluster CD Background

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.

BCCD comes with different teaching curriculum modules in the areas of computational sciences. These module include, the N-Body problems, Molecular dynamic, Area under curve, Convey Game of Life, Parameter Space, HPL-benchmarking, Pandemic, Sieve, Tree-sort, CUDA, and MPI hello-world. Our project goal was to make BCCD evolve into a more useful and user friendly tool for petascale education. This was done by the following two sub projects: (**1**) Updating all of the existing teaching modules that are currently being shipped with BCCD and develop new modules. This would include instrumenting, documenting and improving all the software packages that are part of the BCCD with the PetaKit benchmarking software we developed previously. (**2**) These would be used for individuals teaching themselves about hybrid models or by faculty teaching a class with a unit on one or more hybrid models.

LittleFe/BCCD serves as 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 Kraken and Black Light.

For More Information

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

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

Version 4a Compared to Version 3

Many of the frustrations with the v3 design revolved around the frame: the power supply mounting was poorly located, and the strength of the frame was not enough to withstand the excessive force applied by airline baggage handlers. While technically very sound, our choice of using wood for the mainboard plates also came under a certain amount of scrutiny, as people regularly commented that it didn't look "professional".

The major changes in v4a include: New all aluminum frame design; encased power supply mount; Dual core mainboards with on–board CUDA–capable chipsets, 2GB RAM per node rather than 1GB; no CD/DVD drive; no on–board daughter board power supplies; and gigabit ethernet networking.

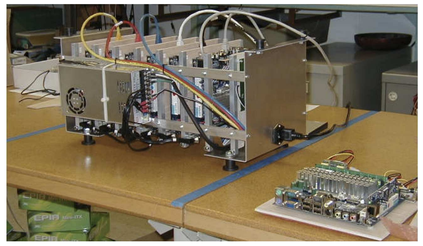


Figure 1: An early v3 unit.

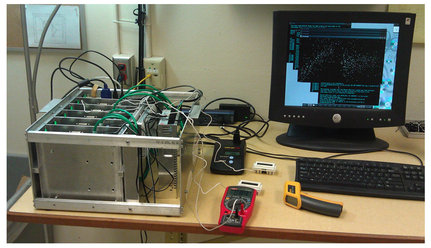


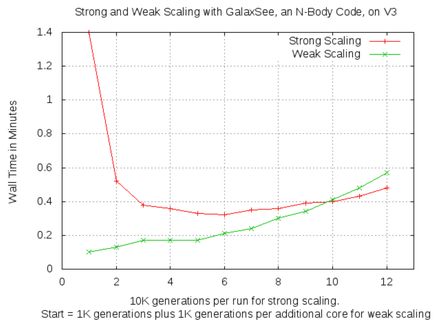
Figure 2: A v4a prototype during thermal testing.

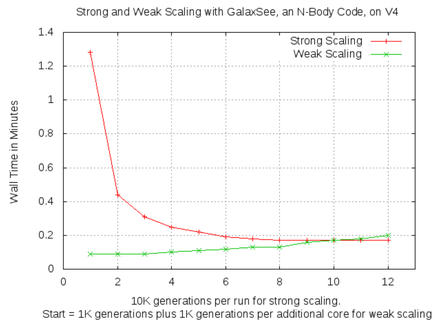
Component	Count	Cost
VIA CN10000 mainboard	6	$1,038
DDR2 533 memory 1GB	6	$732
Hitachi Travelstar disk 80GB	1	$100
Panasonic CW-8124-B CD/DVD	1	$77
Pico PSU 120W	6	$294
PCI 10/100Mb NIC	1	$13
D-Link DSS-8+ 10/100Mb switch	1	$17
Network jumpers	7	$14
MeanWell SP-320-12 power supply	1	$90
Frame assembly	1	$50
Mounting hardware	1	$20
Power cabling	1	$25
Pelican 1610 case	1	$173
Total		**$2643**

Table 1: LittleFe v3 Parts Manifest

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**

Table 2: LittleFe v4a Parts Manifest





Activities

2011 & 2012 Buildout

With support from Intel, the ACM, the EAPF, the XSEDE program, and the SC Conference series we managed to build 25 LittleFe v4 kits during the summer of 2011 for distribution to colleges and universities across the United States. Teams from each of these institutions attended buildout events at either the NCSI/SC Intermediate Parallel Programming and Cluster Computing workshop or as a part of the Education Program at SC11.

At the buildouts, the teams assembled their kits into fully functional LittleFes, including installing the Bootable Cluster CD distro. We are planning to add 30 more LittleFe units to the existing fleet during 2012 buildouts, making the current total number of units close to about 80. These teams in return will develop curriculum modules for teaching some aspect of parallel programming or distributed computing using the LittleFe/BCCD platform.

Figure 3: 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.