LittleFe - The HPC Education Appliance

Ivan Babic (Earlham College), Andrew Fitz Gibbon (Shodor Foundation), Mobeen Ludin (Earlham College), Tom Murphy (Contra Costa College), Charles Peck (Earlham College), Skylar Thompson (University of Washington), Aaron Weeden (Earlham College)
ibabic09@earlham.edu, fitz@shodor.org, mobeen.ludin@gmail.com, tmurphy@contracosta,edu, charliep@cs.earlham.edu, skylar@cs.earlham.edu, amweeden.earlham@gmail.com

Many institutions have little or no access to parallel computing platforms for in-class computational science or parallel programming and distributed computing education. Key concepts, motivated by science, are taught more effectively and memorably on an actual parallel platform. LittleFe is a complete 6 node Beowulf style portable HPC cluster. The entire package weighs less than 50 pounds, easily travels, and sets up in 5 minutes. Current generation LittleFe hardware includes multicore processors and GPGPU capability, enabling support for shared memory parallelism, distributed memory parallelism, GPGPU parallelism, and hybrid models. By leveraging the Bootable Cluster CD project LittleFe is an affordable, powerful, ready-to-run, computational science, parallel programming, and distributed computing educational appliance.

This work is supported by the Educational Alliance for a Parallel Future (EAPF), Intel Lab's University Program Office, the SC Conference Series, TeraGrid, the Shodor Education Foundation, and Earlham College.

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

Background and Technical Overview

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, easily travels, and sets–up in 5 minutes.

LittleFe's design grew out of our work building stationary clusters and our experience teaching workshops in a variety of places that lacked parallel computational facilities. Once we had some gear and some experience moving it around we worked through three different approaches before arriving at the first production system, v3, in 2006.

Since 2006 about 15 v3 LittleFe units have been placed at colleges and universities around the United States. We have received lots of feedback about the design and utility of the units, most of it good and some that indicated that we needed to revisit certain aspects of the v3 design as we moved forward with v4.

What's New in v4

Many of the frustrations with the v3 design centered around the frame. It wasn't strong enough to withstand the excessive force applied by airline baggage handlers without deforming the end plates a bit and the power supply mounting was poorly located. While technically very sound our choice of using wood for the mainboard plates also came under a certain amount of scrutiny, people regularly commented that it didn't look "professional".

Moore's Law has delivered significant improvements in commodity hardware since 2006 as well: inexpensive multi–core processors, cheaper disks, cheaper memory, and inexpensive on–board CUDA–capable chipsets. All of these have contributed to the reduced cost and increased performance found in LittleFe v4.

The major changes in v4 include:

- New frame design, all aluminum, 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
- Gigabit ethernet network fabric
- Integrated power supply

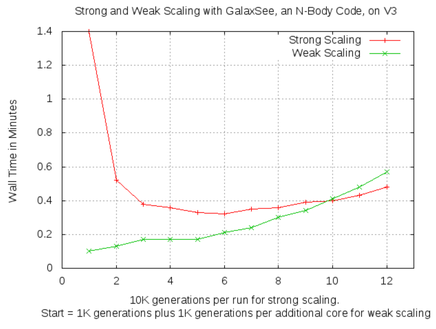
Version 3 Compared to Version 4

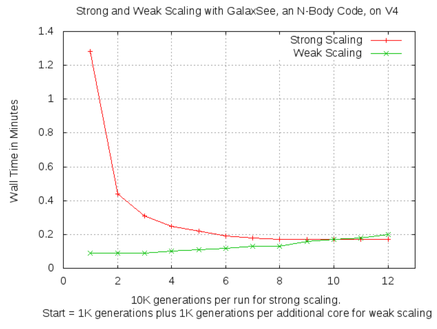
Component	Count	Cost
VIA CN10000 mainboard	6	$1,038
DDR2 533 memory 1GB	6	$732
Hitachi Travelstar disk 80GB	1	$100
Panasonic CW-8124-B CD/DVD	1	$77
Pico PSU 120W	6	$294
PCI 10/100Mb NIC	1	$13
D-Link DSS-8+ 10/100Mb switch	1	$17
Network jumpers	7	$14
MeanWell SP-320-12 power supply	1	$90
Frame assembly	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	$1,014
DDR2 800 memory 2GB	6	$282
Seagate SATA disk 160GB	1	$45
Asus GX-D108 gigabit switch	1	$35
Bluetooth adapter (USB)	1	$12
WiFi adapter (mini PCI-E)	1	$24
Apple keyboard and mouse	1	$140
Network jumpers	7	$8
MeanWell PB-360P-12 power supply	1	$100
Frame assembly	1	$75
Mounting hardware	1	$25
Power cabling	1	$10
Pelican 1610 case	1	$167
Total		**$1937**

Table 2: LittleFe v4 Parts Manifest





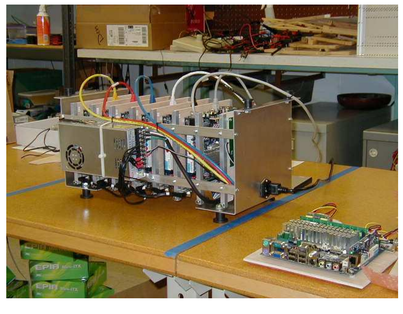


Figure 1: An early v3 unit.

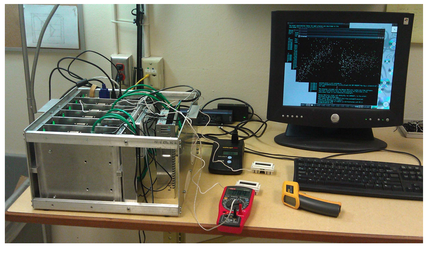


Figure 2: A v4 prototype during thermal testing.

Activities

2011 Buildout

Thanks to the generous support of Intel Lab's University Program Office and the SC Conference Series our group will be building 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 will be attending buildout events at either the NCSI/SC Intermediate Parallel Programming and Cluster Computing workshop in August or as part of the Education Program at SC11. At the buildouts the teams will assemble their kits into a fully functional LittleFe, including liberating the Bootable Cluster CD distro and running their first parallel programs on it.

Outreach

One of LittleFe's strengths is as a people attractor, which makes it a great tool for outreach activities. For the past couple of years our group has participated in the Minority Engineering Advancement Program at IUPUI in Indianapolis. This is one of many events where LittleFe shines as a vehicle for building interest in STEM careers.

Figure 3: Students take apart a prototype v4 unit to see what makes-up a computer.

For More Information

Complete design documents and parts lists for LittleFe v3 and v4 can be found at `http://LittleFe.net`

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, *etc.* See `http://BCCD.net` for more information.