Building Courses Around MPI & Cuda with a LittleFe

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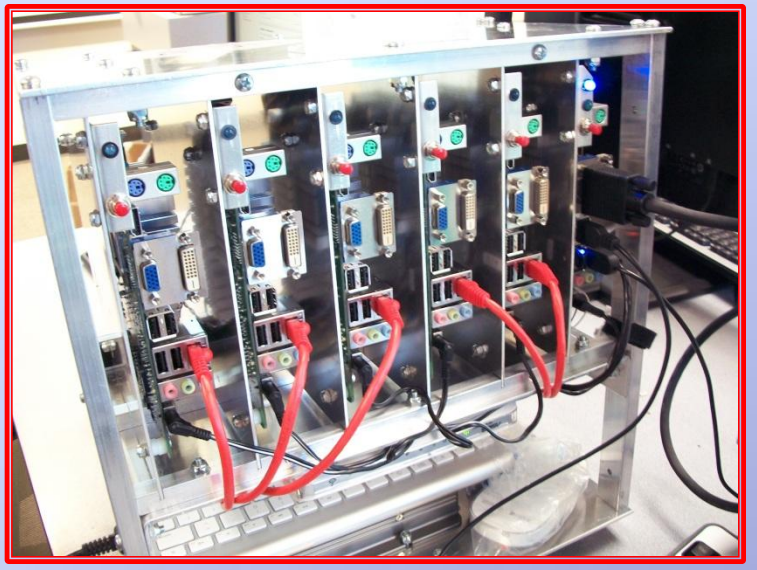
What is a LittleFe?

BigFe



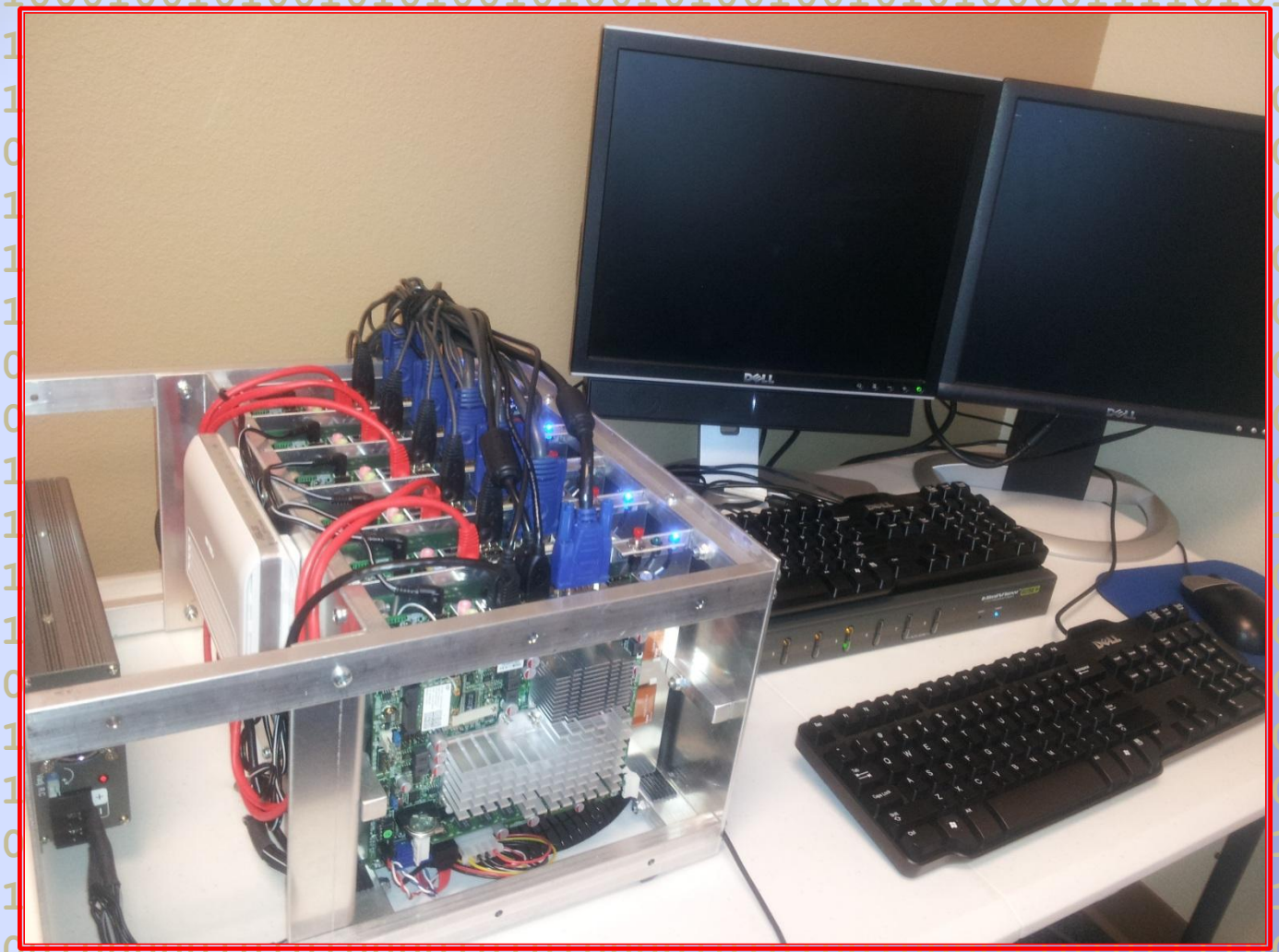
LittleFe

Remember, Fe = Iron

Our first cluster – made from junk – but it worked!

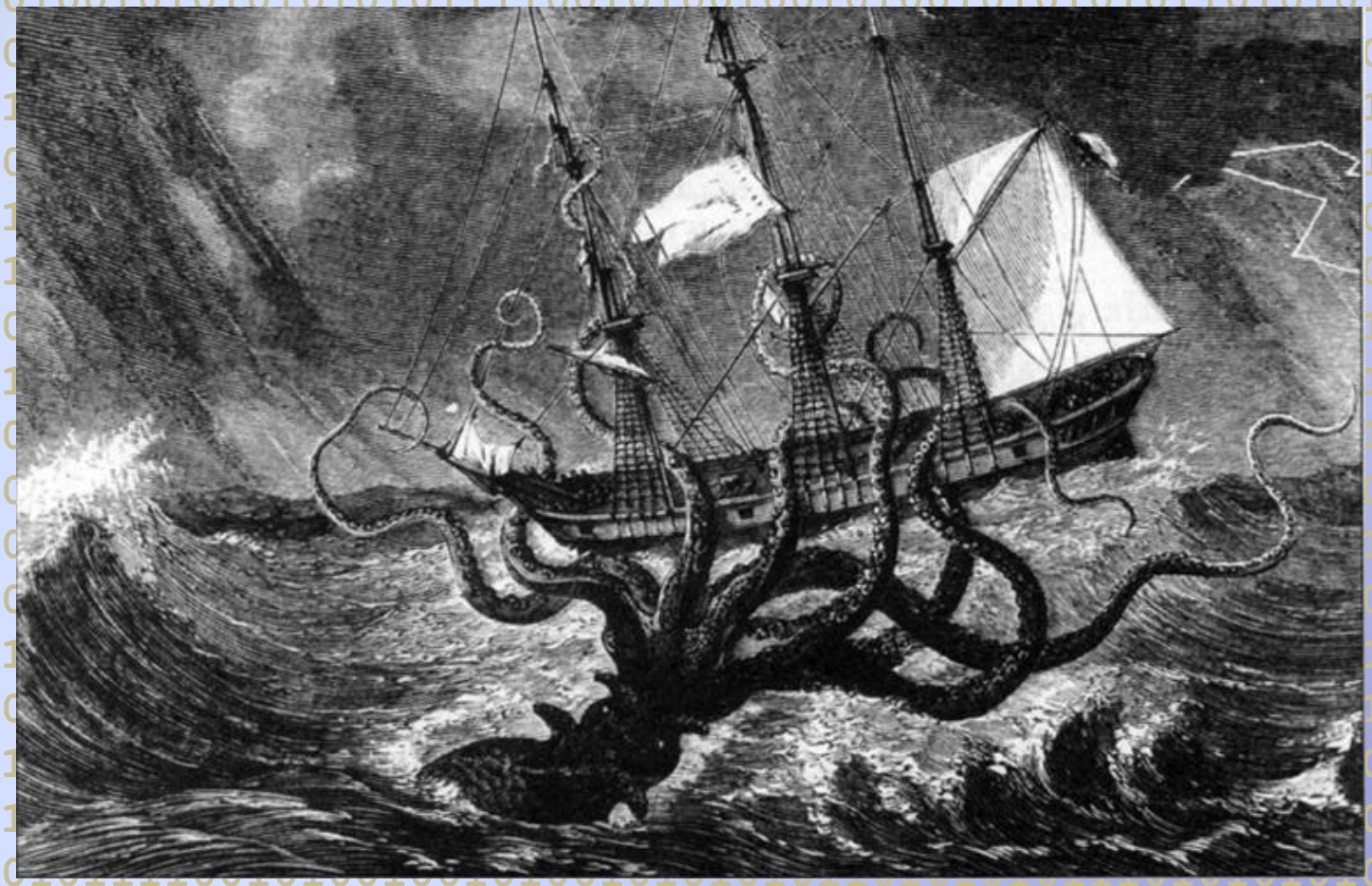
This was a “SluggishFe”

Our present LittleFe



It’s called “The Kraken”

Our present LittleFe



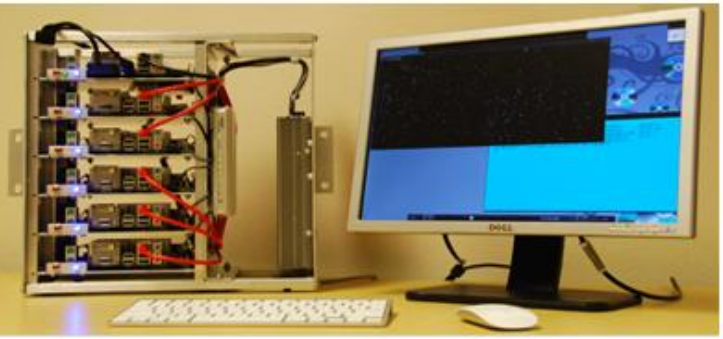
It’s called “The Kraken”

http://littlefe.net

Home | About | SC12 Buildout | History | Resources | Curriculum | News | Gallery | On The Road | Events

LITTLEFE

Parallel and Cluster Computing Education On The Move



Welcome to LittleFe.net

SC12 HPC Educators Program Buildout application is available, apply now for a free LittleFe!

Many institutions and teaching environments do not have access to parallel platforms for parallel and distributed computing education. Teaching key concepts such as speedup, efficiency, and load balancing are much more effectively done on a parallel platform. LittleFe is a complete 6 node Beowulf style portable computational cluster which supports shared memory parallelism (OpenMP), distributed memory parallelism (MPI), and GPGPU parallelism (CUDA).

LittleFe weighs less than 50 pounds, easily and safely travels via checked baggage on the airlines, and sets-up in 10 minutes wherever there is a 110/220 VAC outlet and a wall to project an image on. By leveraging the Bootable Cluster CD project, and its associated curriculum modules, LittleFe makes it possible to have a powerful ready-to-run computational science and HPC educational platform for less than $3,000. The parts list and illustrated assembly instructions are available under the "Resources" tab above.

CONNECT WITH US

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SITE SETTINGS

Select Language

What is MPI?

Message
Passing
Interface

MPI was designed for distributed memory systems, such as clusters.

As a side note, **OpenMP** is more suited to shared memory systems, such as p-threads on a single computer.

What is CUDA?

Compute
Unified
Device
Architecture

CUDA is the computing engine developed by Nvidia for high speed graphics rendering and physics calculations.

CUDA allows languages such as C/C++ to take advantage of high-speed GPUs in computationally intensive programs.

Building Courses Around MPI & Cuda with a LittleFe

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others

Henry Neeman

Director, OSCER

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others
    a. You're here!
    b. Attend a summer workshop
        http://www.shodor.org/
http://www.computationalscience.org/workshops/

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others

II. Buy or build a cluster

    a. Try your school's discard stash

    b. Apply for a FREE LittleFe

    c. Purchase a LittleFe (< $3,000)

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others
II. Buy or build a cluster
III. Get your chair/admin to OK a course
    a. It doesn't have to be permanent
    b. Use a "Special Seminar"
    c. Be sure to make it upper level
    d. Be prepared to teach it for free
    e. Advertise & promote the course

(Advertise & Promote the Course)

i. Exhaust the CS crowd
ii. Court the CIS/MIS/MATH students
iii. Contact other disciplines (even artsy ones)
iv. Waive most CS pre-reqs – you'll be pleasantly surprised how quickly students adapt
v. Use your (and others') imaginations!

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others
II. Buy or build a cluster
III. Get your chair/admin to OK a course
IV. Ask your network techs to help you . . .
    a. Connect your cluster to the internet
    b. Get your cluster to a status where you can SSH into it from off-site
    c. Get MPI & CUDA running properly on your machine

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others
II. Buy or build a cluster
III. Get your chair/admin to OK a course
IV. Ask your network techs to help you . . .
V. Work "Hello World" to death
    a. Start with the MPI version
    b. Make students modify it (Karl will show us)
    c. Consider waiting on CUDA until you get some MPI stuff running well

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others
II. Buy or build a cluster
III. Get your chair/admin to OK a course
IV. Ask your network techs to help you . . .
V. Work "Hello World" to death
VI. Come up with a single project
    a. We used the ol' reliable matrix multiplication
    b. Scorn us if you wish – there's enough material there for a whole semester

Recipe for Course Development

I. Get involved with Henry Neeman, OSCER & others
II. Buy or build a cluster
III. Get your chair/admin to OK a course
IV. Ask your network techs to help you . . .
V. Work “Hello World” to death
VI. Come up with a single project
VII. Turn the students loose! (but watch over them)

. . . and now, we'll let Karl take over and. . .

. . . and now, we'll let Karl take over and. . .

Release The Kraken!

Our first course:
CS4973
Special Studies – Parallel Programming

. . . from Hello World to . . .

. . . memory management . . .

. . . matrix multiplication . . .

. . . etc.

The Matrix: Evolution

Teach necessities as you go

Phase I: You gotta start somewhere!

(1) Matrix stored in ASCII text file with rows/columns

(2) Program is on one node, and in C only

(3) You learn File I/O here

The Matrix: Evolution

Teach necessities as you go

Phase 2: A little better?

(1) Matrix stored in ASCII text file with no rows/columns

(2) Program is on one node, and in C only

(3) You learn a little mathematical indexing here

The Matrix: Evolution

Teach necessities as you go

Phase 3: Even Distribution over MPI?

(1) Matrix stored in binary file
(2) Program is simply distributed
(3) Learn about
  (a) MPI file I/O structure
  (b) Binary files (read, write)
  (c) Validation process to ensure working code
  (d) Computer architecture breakdown

The Matrix: Evolution

Teach necessities as you go

Phase 4: Uneven workload

(1) Design programs that deal with architecture
(2) Program requires more sophisticated MPI code
(3) Learn about
    (a) coding to the architecture
    (b) performing tasks in the classroom with people!
    (c) program analysis

The Matrix: Evolution

Teach necessities as you go

Phase 5: Tweaking time

(1) Learning new MPI commands to cut down on runtime
(2) Streamlining code, how fast can your code run a problem?
(3) Continue streamlining, a good program is never complete.

Runtimes

Program	# Nodes	Dimension	Real Runtime	User Runtime	System Runtime
Even Distribution	12	100X100	12m48.744s	0m56.396s	4m31.217s
	12	1000X1000	>24 hours	>24 hours	>24 hours
	1	1000X1000	77m33.990s	23m3.086s	53m26.540s
Head Node Distribute	12	100X100	0m3.604s	0m0.504s	0m1.744s
	12	1000X1000	3m32.956s	0m0.504s	0m1.744s
Head Node Double Distribute	12	100X100	0m4.134s	0m0.436s	0m1.244s
	12	1000X1000	2m7.069s	0m26.554s	3m25.397s

Our second course:
CS4973
Special Studies – CUDA Parallel Programming

. . . from Hello World in CUDA to . . .

. . . new team projects . . .

. . . C + MPI + CUDA . . .

Our second course:
CS4973
Special Studies – CUDA Parallel Programming

(1) Large number multiplication
(2) Prime number checking
(3) password cracking

Our third course:
CS4973
Special Studies – whatever we want

. . . pondering content at this time . . .

Thank You!

We especially thank Henry Neeman, Charlie Peck, Tom Murphy, Bob Panoff and everyone else associated with OU IT, the LittleFe project and all of our colleagues and friends in the educational community involved with HPC, for all the help we have received.

Karl Frinkle – Mike Morris