ECE 574 – Cluster Computing
Lecture 1

Vince Weaver

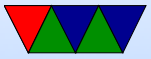
http://www.eece.maine.edu/~vweaver

vincent.weaver@maine.edu

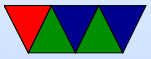
1 September 2015

Introduction

- Distribute and go over syllabus
- Talk about the class.
  - Homeworks, 50% – 11, lowest dropped.
    Generally will be due on Thursday by beginning of class. Will usually have at least a week to do them.
    Submission by e-mail, grades sent in response to that e-mail, if you don't like that let me know.
    Will send out e-mail when assignment posted on website.

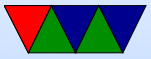


  - Midterm, 10%, usually week after fall break
  - Final, 15%
  - Class participation: 5%
  - Project, 20%. More details as we get closer.
- Late work penalty
- Class notes will be posted on the website.
- Will be handing out computer accounts, please use them



responsibly.

- Will involve C coding.

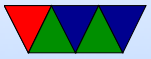


Cluster Computing

What is cluster computing?

Basically it's just a large number of computers working together.

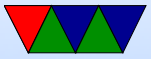
So why is that interesting?



Supercomputers/HPC

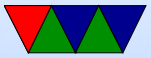
InsideHPC defines HPC: "High Performance Computing most generally refers to the practice of aggregating computing power in a way that delivers much higher performance than one could get out of a typical desktop computer or workstation in order to solve large problems in science, engineering, or business."

And a supercomputer is similarly vague, just a larger computer than the kind you'd normally use.

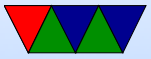


HPC Workloads

- Linear Algebra
- Modeling (weather, chemistry, biology, nuclear, aerospace)
- Business (high-speed trading)
- Simulation
- 3d rendering (movie studios, games)

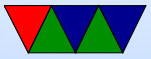


- Data crunching (geology exploring)



Related terms

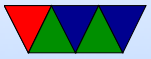
- Supercomputer – a large computer. No real definition, "I know one if I see one".
- High Performance Computing – a large computer
- Cluster – one way to make a large computer out of many small computers
- Grid computing – idea to make computing like the power grid, a utility you access to run your jobs. A large loosely coupled cluster.



- Cloud computing – more or less a newer and more buzzword-friendly term for grid computing. Often uses virtualization, not often used for high performance mostly because usually the network is not optimized in a cluster fashion.

- Datacenter – a large building with lots of network connected computers. Not a cluster unless they are working together. This gets complicated when things like google are involved.

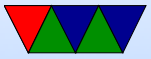
- Mainframe – a type of large computer. Usually



differentiated from a supercomputer because a mainframe concentrates on reliability and I/O performance rather than CPU performance.

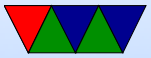
- Distributed systems – a system that is made out of many subnodes that communicate by passing messages to work on large problems. Sort of the old CS term for cluster computing.

- Parallel computing



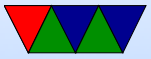
Cluster Definitions?

- Bunch of computers hooked together.
- Commodity Cluster – a large number of off-the-shelf machines hooked up via cheap off-the-shelf network (usually ethernet)
- as opposed to a custom cluster that will be custom hardware and custom fast network.



A little history

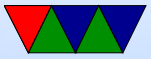
- 1960s Seymour Cray (interesting guy) CDC6600 (parallel) and 7600 (pipelined) and Cray 1 (vector) 1976.
- 1970s-1980s – clustered minicomputers, DEC, IBM, Tandem
- 1990s SGI = NUMA
- 1994 Beowulf clusters
  Beowulf was a 1994 NASA project to build a gigaflop



for less than $50k. Managed a 16-node 486 cluster for $40k. (comparison – raspberry pi 2 gives you a gigaflop for $35).

D.J. Becker and T. Sterling and D Savarese and J.E. Dorband and U.A. Ranawak and C.V. Packer "BEOWULF: A parallel workstation for scientific computation"

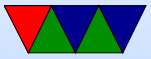
Usually cheap headless off-the-shelf computers connected by ethernet. Commodity cluster.



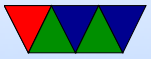
Are all supercomputers clusters?

Not necessarily, though trends have been taking things that way. *High Performance Computing: Crays, Clusters, and Centers. What Next?* by Bell and Gray, 2001. They propose that everything was converging to all clusters, all the time for all supercomputer needs.

In a fairly strongly worded rebuttal, Dongarra, Sterling, Simon and Strohmaier (*High performance computing: Clusters, constellations, MPPs, and future directions* (2003)) said that no, the world is more complex than

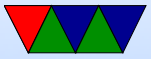


that and commodity clusters are not the end word.



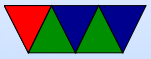
Supercomputer Features?

- From Dongarra et al.
- Is it clustered? meaning identical grouped together
  c for commodity, m monolithic
- How is the namespace organized?
  distributed means local variables on one node not visible on other
  d distributed, s shared, c cache coherent

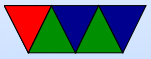


- How is the parallelism?
  t for multithreading, v for vector, c communicating sequential
  s systolic, w for VLIW, h for producer/consumer, p parallel process

- How does it handle latency/locality?
  c caches, v vectors, t multithreaded, m for processor in memory.
  f for prefetching, etc



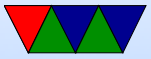
Top500 List



Top500 History

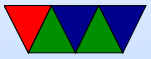
- In 1994, 20% single-cpu, 50% SMP, 24% MPP,7% SIMD
- In 1997, 0% single-cpu, 43% SMP, 0.5% cluster, 54% MPP, 0.5% SIMD
- in 2002, 40% Constellations, 18% cluster, 40% MPP
- in 2015, 90% cluster, 12% MPP

Definitions from Dongarra et al.

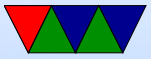


Cluster – system where inter-node communication is 10-1000 times slower than local memory access. (bell and gray)

- single-cpu = just one serial CPU
- simd = single instruction multiple data
- SMP = symmetric multiprocessing, more than one processor
- MPP = massive parallel programming, one machine with lots and lots of processors (see SGI)

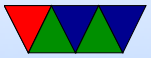


- cluster = number of nodes outnumbers number of CPUs per node (dominant programming style distributed, MPI)
- constellation = each node has more CPUs than total nodes (dominant programming style would be multithread, OpenMP)



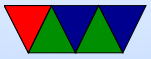
Software Concerns

- One OS image or multiple?
- single/smp/mpp = one image
- cluster = each node has own copy of operating system



Heterogeneous Computing

- Unequal nodes
- ARM big/little
- clusters with GPUs
- xeon-phi (almost like a cluster on a PCIe card)



Example Top500 Listing

- From the November 2002 list, entry #332
- Location: Orono, ME
- Proc Arch: x86
- Proc Type: Pentium III, 1GHz
- Total cores: 416
- RMax/RPeak: 225/416 GFLOPS
- Power: ???
- Accelerators: None