

ECE 574 – Cluster Computing

Lecture 2

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11:00am, Barrows 133

2 September 2026

Announcements

- Special HW#1, assigned today, due Friday in class
- Submit via e-mail, but also bring the info to class
- Will hand out slips saying which computer from Top500 you will be reporting on
- Also watch part of a video about top500

A note on Models

- “It’s tough to make predictions, especially about the future.” — Yogi Berra
- “All models are wrong, but some are useful” — George E. P. Box
- Wasted lots of time on computer architecture simulations at a PhD student. Validating models important.
- GIGO

A little history – Old Stuff

- 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

A little history – 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 pi2 gives 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.

Commodity Cluster Notes

- 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.

Are all supercomputers clusters?

- Back in early 2000s was much debate
- *High Performance Computing: Crays, Clusters, and Centers. What Next?* by Gordon Bell (DEC/MS) and Jim Gray (MS), 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.

Current HPC Status

- Currently (2026) the top list is mostly commodity clusters
- Although maybe you would not consider a \$50,000 GPU to be commodity

Supercomputer Features (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

Top500 Cluster Definition

Definitions from Dongarra et al.

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

Historical Categories – Shared Memory

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

Historical Categories – Distributed Memory

- 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)

Top500 Historical Makeup

- 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
- in 2025: ?

Software Concerns

- One OS image or multiple?
- single/smp/mpp = one image
- cluster = each node has own copy of operating system
- Shared memory (just write to memory and all cores can see it, hard work in hardware) vs Message Passing (have to explicitly send data before others see it, hard work in software)

Heterogeneous Computing

- Unequal nodes
- ARM big/little (Intel Power/Efficiency)
- 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

UMaine Supercomputer Details

- Located at Target Tech Center (Orono Business Park)
- 208 desktop PIIIs, 100Mb eth admin, 1G Myrinet
- Originally single socket. With that they got #501 on list (briefly on before getting kicked off)
- Populated rest of the sockets, made the list



Homework 1

- A brief homework for next class!
- Look up the info on the Top500 super computer I assigned to you
- E-mail your results, but also bring the info to class for discussion
- Also watch the Top500 BoF if you have the chance