A little bit about me …

• Ph.D. from the University of Illinois

• Spent eight years at Lawrence Livermore National Laboratory

• Started at the University of Maryland in August
Introductions

• Name
• MS or PhD / Department
• Area of research
• Why this course?
• Something interesting/ unique about yourself
This course is

• An introduction to parallel computing
  • Will cover programming models, architectures, tools, systems issues, algorithms and applications

• A qualifying course for MS/PhD

• Work expected:
  • Two programming assignments
  • Mid-term
  • Group project (3 students per group)
  • Classroom participation
The need for high performance computing

Drug discovery

https://www.nature.com/articles/nature21414
The need for high performance computing

Drug discovery

https://www.nature.com/articles/nature21414

Weather forecasting

https://www.ncl.ucar.edu/Applications/wrf.shtml
The need for high performance computing

Drug discovery

https://www.nature.com/articles/nature21414

Weather forecasting

2m Dewpoint Temperature

https://www.ncl.ucar.edu/Applications/wrf.shtml

Study of the universe

https://www.nas.nasa.gov/SC14/demos/demo27.html

https://www.nature.com/articles/nature21414
Why do we need parallelism

- Make some science simulations feasible in the lifetime of humans
  - Either due to speed or memory requirements
- Provide answers in realtime or near realtime
What is parallel computing?

- Does it include:
  - Grid computing
  - Distributed computing
  - Cloud computing

- Does it include:
  - Superscalar processors
  - Vector processors
  - Accelerators (GPUs, FPGAs)
Parallel Architecture

- A set of nodes or processing elements connected by a network.

https://computing.llnl.gov/tutorials/parallel_comp
Interconnection networks

- Different topologies for connecting nodes together
- Used in the past: torus, hypercube
- More popular currently: fat-tree, dragonfly
Memory and I/O sub-systems

- Similar issues for both memory and disks (storage):
  - Where is it located?
  - View to the programmer vs. reality
- Performance considerations: latency vs. throughput
System software: Programming models

- Shared memory/ address-space
  - Explicit: Pthreads
  - Implicit: OpenMP

- Distributed memory
  - Explicit: MPI
  - Implicit: Task-based models (Charm++)
Performance and debugging tools

- Debugging parallel programs is challenging
- Performance analysis and tuning is critical but hard


https://computing.llnl.gov/tutorials/totalview/

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Systems Issues

- Operating system noise
- Network congestion
  - Congestion-avoiding routing
  - Parallel I/O
- Job scheduling:
  - Interference from other jobs
Parallel algorithms and applications

• Parallel Matrix Multiplication
• Parallel Sorting
• N-body calculations
• Discrete event simulations
Parallel algorithms and applications

• Parallel Matrix Multiplication
• Parallel Sorting
• N-body calculations
• Discrete event simulations
• Molecular dynamics
• Computational cosmology
• Weather and climate modeling
• Discrete-event simulation
Questions?

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