Today’s Topics

Computer Science
Parallel Computing

Upcoming
Noncomputability
*Great Ideas,* Chapter 15

Reading
*Great Ideas,* Chapter 14
On the Limits of Computing

- The “Wall” that Limits Progress
  - (Predicted many times but never seem to get there)
  - Limitations on Processor Speed
  - Speed of Light
    - 1 foot = 1 nano-second
    - Make Smaller
    - Heat Dissipation
  - Memory Size
- More Limitations on Processor Speed
  - Manufacturing Problems with Small Sizes
    - Feature size < wavelength of light
    - UV, X-ray
  - Got to lower voltages
- Ultimately Parallelism is Only Hope
Thinking Parallel

- Forms of Parallelism
  - Word Size
    - Addition with short words
    - Example
  - Pipe Line
    - Assembly Line for Instructions
    - Laundry Example
    - Stalls
  - Superscalar
  - Multiprocessors
  - Networks of Processors
  - Internet
Multiprocessing

- What can we do with 100 processors in a row?
  - Search: "Is name x in the list of 100 names?"
    - Can get constant time algorithms
    - E.g. do you have a match?
    - Curve?
  - What about 200 names?
  - 500 names?

- Speedup
  - Speed for K Processor / Speed for 1 Processor
    - What is the best you would expect?
    - What is the worst?

- Apparent Speedup for Small N
  - Apparent for $N \leq \# \text{ Processors}$
  - Still really $t = A \times N$, but $N$ is up to 100 times smaller
Multiprocessing

- Even with optimal speedup
  - No huge help for exponential programs
  - Either impossibly large number of processors or just cut A by some factor
  - \( t = (A/k) \times N \)

- Communicating Processes
  - Imagine Sorting of 100 Items
  - Synchronization Problems
    - Assembly Line for Instructions
    - Shared resources: Deadlocks
    - Shared information: Race Conditions

- Sort Speed Up
  - From \( N \log N \)
  - To \( N \)
Multiprocessing

- Work by Committee !!!
- Variations on Architecture
  - Bus
  - Ring
  - Grid
  - Hypercube
  - Complete Connection
  - Tightly Coupled
  - Loosely Coupled
  - Length of path between nodes
Back to Earth

- Parallel Processing a Very Difficult Area
  - Lots of promise
  - Limited results
- Special Applications Work Quite Well
  - Array Processing
- General Results Hard to Come By
  - Mostly, tackle problems one-at-a-time
  - Several companies that specialized in this are now gone
- Speedup Disappointing
- Most successful form of Parallelism
  - COMPUTERS IN EVERYTHING