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 Progress will “Bump Into”
  - (Predicted many times but never seem to get there)
  - Limitations on Processing 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**
  - Run-time for 1 Processor / Run-time for K Processors
    - What is the best you would expect?
    - What is the worst?

- **Apparent Speedup for Small N**
  - Apparent for N <= # Processors
  - Still really t = A * 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
  - \( t = (A/k)*N \)

- 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