Computer Systems are Different!

6.033 Spring 2008

Moore’s law

“Cramming More Components Onto Integrated Circuits”, Electronics, April 1965

Lithography: the driver behind transistor count

- Components/area $O(x^2)$ with feature size
- Total components $O(a)$ with die area
- Switching rate $O(x)$ with feature size

Static discipline

- Be tolerant of inputs and strict on outputs

Moore’s Law: # transistors/die doubles every ~18 months

CPU performance

Trends in CPU performance from minicomputers to supercomputers
ENIAC
- 1946
- Only one
- 5000 adds/sec
- 20 10-digit registers
- 18,000 vacuum tubes
- 124,500 watts
- Not really stored program

UNIVAC (Universal Automatic Computer)
- 1951
- 46 sold
- 2000 ops/sec
- 1,000 12-digit words (mercury)
- 5000 tubes
- $1.5 million

IBM System/360-40
- 1964
- 1.6 MHz
- 16-256 KB core
- $225,000
- Family of six
- 32-bit
- Time-sharing

Cray 1: supercomputer
- 1976
- 80 sold
- 80 MHz
- 8 Mbyte SRAM
- 230,000 gates
- $5 million
DEC PDP-8 (1964)
- 60,000 sold
- 330,000 adds/sec
- 4096 12-bit words
- $18,000

Apple II
- 1977
- 1 MHz
- 6502 microprocessor
- 4 to 48 Kilobytes
- $1300
- Basic, Visicalc

IBM’s wrist watch
- 2001
- Linux and X11
- 74 Mhz CPU
- 8 Megabyte flash
- 8 Megabyte DRAM
- Wireless

Software follows hardware

Cheap → Pervasive

Pervasive → qualitative change

Slide from David Culler, UC Berkeley
Latency improves slowly

Incommensurate doubling

Heat is a problem

Recent Intel CPU Clock Rates

The Future: will it be painful?

What went right?

- Unbounded composability
- General-purpose computers
  - Only need to make one thing fast
  - Simple interface, complex implementation
  - Decouple software from CPU
- Cumulative improvement over years