# Lecture 24
# Wrapup

# Hardware

- logical/functional/architectural structure
  - bus connects processor, primary memory, disks, other devices
  - caching
  - CPU cycle: fetch-decode-execute; kinds of instructions
    - toy machine as an example
    - different processor families are incompatible at the instruction level
  - von Neumann: architecture;  Turing: equivalence of all machines
- physical implementation; sizes and capacities
  - chips; Moore's law, exponential growth
- analog vs digital
- representation of information
  - bits, bytes, numbers, characters, instructions
  - powers of 2;  binary and hexadecimal numbers
  - interpretation determined by context
- it's all bits at the bottom

# Software

- algorithms: sequence of defined steps that eventually stops
  - complexity: how number of steps is related to amount of data
    - linear: searching, counting, …
    - quadratic: simple sorting
    - logarithmic: binary search  (logarithm = number of bits needed to store)
    - n log n: quicksort
    - exponential:  towers of Hanoi, traveling salesman problem, …
- programs and programming languages:
  - evolution, language levels: machine, assembly, higher-level
  - translation/compilation; interpretation
  - a program can simulate a machine or another program
- basic programming, enough to figure out what some code is doing
  - variables, constants, expressions, statements, loops & branches (if-else, while), functions, libraries, components
- operating systems: run programs, manage file system & devices
  - file systems: logical: directories and files; physical: disk blocks
- application programs, interfaces to operating system, APIs

# Communications

- local area networks, Ethernet, wireless, broadcast media
- Internet: IP addresses, names & DNS, routing; packets
  - bandwidth
- protocols: IP, TCP, higher-level; layering
  - synthesis of reliable services out of unreliable ones

- Web: URLs, HTTP, HTML, browser
  - caching
- security & privacy: viruses, cookies, spyware, …
  - active content: Javascript, plugins, addons

- cryptography
  - secret key;  public key;  digital signatures;  secure hashes
- compression; error detection & correction

- wireless, cell phones, GPS, …

# Real world issues

- **legal**
  - intellectual property: trademarks, patents, copyrights, licenses
  - jurisdiction, especially international
- **social**
  - privacy, security
- **economic**
  - open source vs proprietary
  - who owns what
- **political**
  - policy issues
  - balancing individual, commercial and societal rights and concerns

# Things to take away

- **some skills, some specific technical knowledge**
  - how computers and communications work today
  - what's ephemeral, what's likely to still be true in the future
- **improved numeracy / quantitative reasoning**
  - what makes sense, what can't possibly make sense, and why
    - plausible estimates, engineering judgment, enlightened skepticism
- **another way of thinking**
  - how do things work?
  - how *might* something work?
  - you can often figure it out
- **some appreciation of tradeoffs & alternatives**
  - you never get something for nothing
- **some historical perspective**
  - everything derives from what came before

- **informed opinions about the role of technology**

# Final exam (watch the web page for updates)

- Exam will be emailed to you early on Wed Dec 9
  - must be returned by Sat Dec 12 9m EST
  - Q/A session 3:30 Dec 4 (Fri)
- similar to midterm but twice as long
- open book, as with midterm:

  open notes, book, problem sets, labs, old exams, …
- see instructions on web site

- I'm usually looking for something brief that shows that you understand or can reason
- if you're writing or calculating a lot, you're likely on the wrong track
- questions try to test understanding of basic ideas
  - meant to be simple and straightforward, if you understand
  - not meant to be tricky or rely on obscure facts
- think about plausibility and where I'm likely coming from
- if it still seems ambiguous, say "I'm assuming this..." and carry on

# What should be different next time?

- faster or slower?
- more topics or fewer?
- broader or deeper?
- different topics?
  - like what?

- how did the problem sets work out?
  - how would you improve them?
- how did the labs work out?
  - how would you improve them?

- what else would make it better next time?

# What lies ahead?

- 40 years ago we didn't have PCs
- 30 years ago we didn't have the Internet
- 20 years ago we didn't have Google, Facebook, ...
- 10 years ago we didn't have phone apps

- today everyone has smartphones, wireless, Internet
- Internet of Things things are everywhere
- machine learning, artificial intelligence are growing rapidly

- 10 years from now we may have self-driving cars, telemedicine, ...
- 10 years from now we may have zero privacy
- 10 years from now social networks may make us less social

- 20 years from now?