Lecture 1: Course overview

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601.229 Computer Systems Fundamentals

Welcome!

- Welcome to CSF!
- Today:
  - Administrative stuff
  - Course overview
  - Binary data representation

Administrative stuff

About the course

- Instructors
  - Xin Jin, `xinjin@cs.jhu.edu`, Malone 223
  - David Hovemeyer, `daveho@cs.jhu.edu`, Malone 337
- CAs
  - Coming soon, see course web page for details

Where to find stuff

- Course website: https://jhucsf.github.io/spring2020
  - Syllabus, schedule, lecture notes, assignments, etc.
  - All public course information will be here
- Piazza https://piazza.com/jhu/spring2020/601229
  - Non-public course information such as homework/exam solutions
  - Discussion forum, Q/A: please post questions here!

Syllabus highlights

- Please read the syllabus carefully:
  https://jhucsf.github.io/spring2020/syllabus.html
- Highlights:
  - Grades: 45% homework, 40% exams, 5% clicker quizzes
  - 6 or 7 assignments, mostly programming based, expect them to be challenging!
  - Late policy: you have 5 late days to use as needed (assignment submissions which exceed the late day limit receive no credit)
  - Two midterm exams, one comprehensive final exam

Academic integrity

- Please read the academic integrity policy in the syllabus carefully
- Highlights:
  - Follow the CS Academic Integrity Code: `https://www.cs.jhu.edu/academic-integrity-code/`
  - Homework assignments are done individually, code sharing is not allowed
  - Exams are (obviously) individual effort
  - Violations of academic integrity will be reported to the Student Conduct office
- Be careful about using web as a resource
  - Do *not* copy code
  - *Always* cite sources used

Class meetings

- Typical class meeting: lecture/discussion interspersed with peer instruction questions and occasional group activities
- *Do the reading in advance!*
- Come prepared to actively engage with the material!
  - Learning is not passive
  - More productive class time $\rightarrow$ better outcomes
  - Ask questions!

Peer instruction

- How peer instruction works:
  - Slide with a multiple choice question
  - Answer individually, discuss with peers, then answer again
  - Shown to improve outcomes!
  - Questions may be challenging
  - Graded for participation only
- You may have done this in other courses
- You will need an iClicker 2
  - Use the google form linked from the Piazza resources page to register your iClicker remote ID

Peer instruction etiquette

- During discussion phase, form a group of 2–4 with people sitting near you
- Be inclusive! (“Would you like to join our group?”)
- Be social! (“May I join your group?”)
- Be respectful:
  - Let everyone participate
  - Don’t put down anyone else’s ideas
- Work together and think carefully about the question!
- *No electronics use*

First clicker quiz!

Clicker quiz omitted from public slides

Computing requirements

- All assignments will be done using Linux
- Autograder will use Ubuntu 18.04
- Doing your development and testing on ugrad machines is generally fine (but note that compiler and other tools will likely be different than Gradescope)
- Development on Windows or MacOS is not recommended
  - Although Windows Subsystem for Linux is *probably* ok
- Running Linux in a VirtualBox VM highly recommended: see Resources page on course website
- *Get your development environment set up NOW*

Course overview

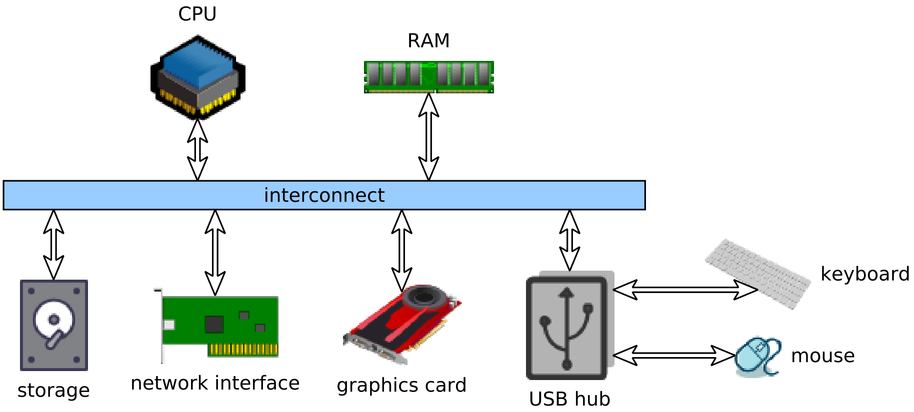
What the course is about

- Course is about *computer systems* from the *programmer's perspective*
- Computer system $=$ hardware $+$ software
  - Much of our concern is the interaction between hardware and software — how they work together

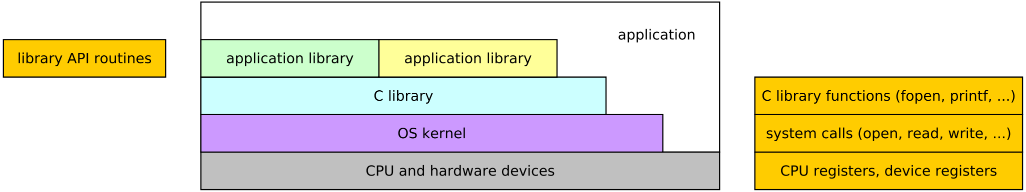
Goals of course

- “Deep” understanding of how computers work (down to hardware)
  - OS and runtime library interfaces
  - Machine-level ISA / assembly language
  - Processor features
  - Operating system features
- Apply this understanding to...
  - Optimize application performance
  - Avoid pitfalls such as security vulnerabilities
  - Take full advantage of the computer’s and operating system’s capabilities

A computer system (hardware)

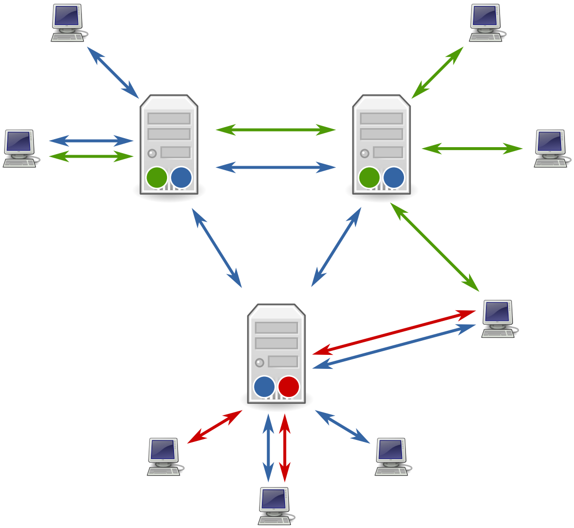


A computer system (software)



- Your application program is supported by lower layers of software and hardware
- Each layer provides an interface to the layer above

A computer network



Computer networks allow your program to communicate with peer systems.

Thanks to the global Internet, the peer systems could be anywhere on earth!

Binary data representation

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- Consider a representation of a number:
  - A *continuous* representation would allow the number to have *any* value
    - We think of physical phenomena (mass, velocity, etc.) as being continuous
  - A *discrete* representation would allow the number to have one of a set of possible values, where the set of possible values is *enumerable*
    - Often we think of discrete values as corresponding to a range of integers

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- OK, let's think about what discrete data representations will look like...
  - Starting with *integers* (if you can represent integers, you can represent anything)

Decimal numbers

- We're all familiar with decimal (base 10) numbers
- E.g.,

$$42 = 4 \cdot 10^1 + 2 \cdot 10^0$$

  - Digits are 0–9
  - Places are powers of 10

Other bases

- Base 10 is arbitrary!
- Representing decimal 42 using base 5:

$$42_{10} = 132_5 = 1 \cdot 5^2 + 3 \cdot 5^1 + 2 \cdot 5^0$$

  - "Digits" are 0–4
  - Places are powers of 5

Try it!

How to express decimal 42 using base 6?

$$\_\_\_\_ \cdot 6^2 + \_\_\_\_ \cdot 6^1 + \_\_\_\_ \cdot 6^0$$

How to express decimal 79 using base 6?

$$\_\_\_\_ \cdot 6^2 + \_\_\_\_ \cdot 6^1 + \_\_\_\_ \cdot 6^0$$

Reference:

$$6^2 = 36$$
$$6^1 = 6$$
$$6^0 = 1$$

Binary

- Binary = base 2
- Representing decimal 42 using base 5:

$$
\begin{aligned}
42_{10} &= 101010_2 \\
&= 1 \cdot 2^5 + 0 \cdot 2^4 + 1 \cdot 2^3 + 0 \cdot 2^2 + 1 \cdot 2^1 + 0 \cdot 2^0
\end{aligned}
$$

  - "Digits" are 0 and 1
  - Places are powers of 2
- Computers use binary representations for all data, because
  - *Digital circuits* use two voltage levels, high and low
  - By convention, 1=high voltage, 0=low voltage
  - So, computer hardware fundamentally operates on binary data

Try it!

How to express decimal 29 using base 2?

$$\underline{\hspace{2em}} \cdot 2^5 + \underline{\hspace{2em}} \cdot 2^4 + \underline{\hspace{2em}} \cdot 2^3 \ \underline{\hspace{2em}} \cdot 2^2 + \underline{\hspace{2em}} \cdot 2^1 + \underline{\hspace{2em}} \cdot 2^0$$

Reference:

$$2^5 = 32$$
$$2^4 = 16$$
$$2^3 = 8$$
$$2^2 = 4$$
$$2^1 = 2$$
$$2^0 = 1$$