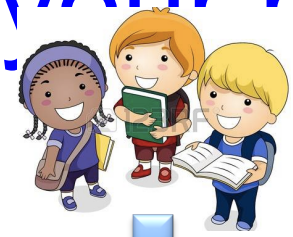
Computer Systems Organization

Instructor:
Zhaoguo Wang

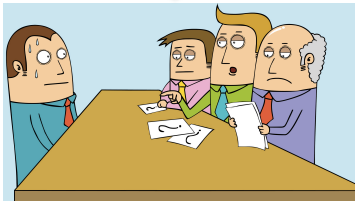
Why choose CSO?

The path of your next few years



graduation

interview

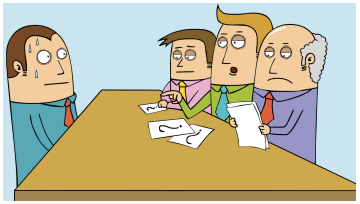


programmer

The path of your next few years

graduation

interview



apply for graduate school

programmer

programmer & researcher

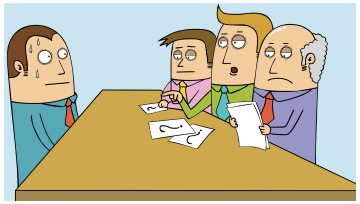
The pat[illegible]your next few years

graduation

interview

startup

graduate school



programmer & researcher

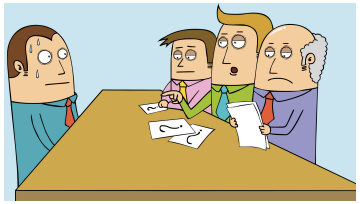
programmer

Hire / become

The path of our next few years

graduation

interview



graduate school

startup

lawyer

programmer & researcher

Hire / become

programmer

Be able to

The path of your next few years

graduation

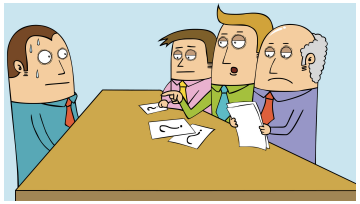
enjoy life

lawyer

startup

interview

graduate school



programmer & researcher

Hire / become

Be able to

programmer

~2M programmers in 2014 according to IDC

The path of our next few years

graduation

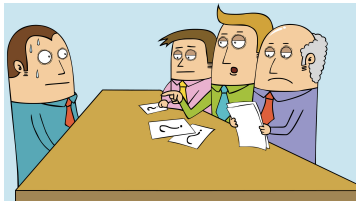
enjoy life

lawyer

interview

startup

graduate school



programmer & researcher

Hire / become

Be able to

programmer

be in a relationship with

Taking CSO will affect each step in the path!

For Graduation

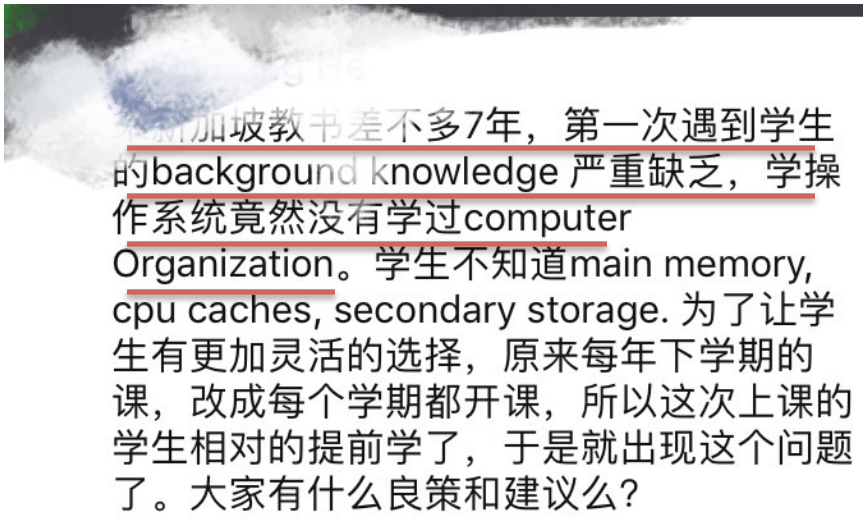
Required class

- For CS Major
- Also for CS minor ☹

Prepare for your later system classes

- Operating Systems, Compilers, Networks, Computer Architecture, Distributed Systems

Complaints from a professor teaching Operating System



After 7 years teaching OS class, this is the first time I meet some students who even do not have any basic background knowledge. **This is because they have never taken CSO before!!!**

For Interview

This class adds to your CV

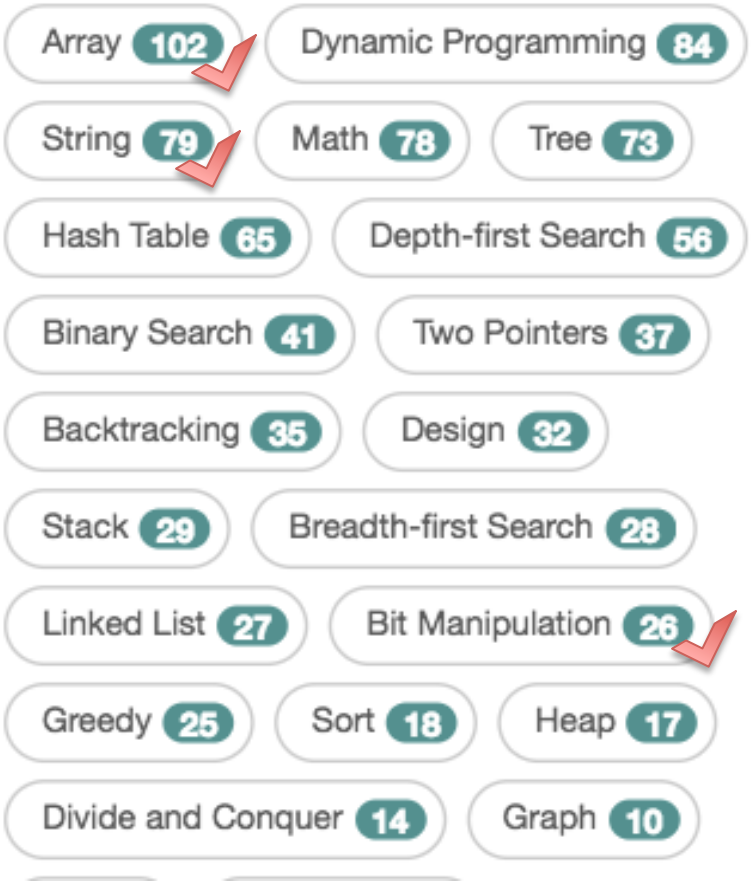
- C Programming, UNIX, X86 Assembly …

Interview related topics

- Basic knowledge of Array, String, Bit Manipulation

Topics Distribution From LeetCode

Topics ~30%



Some examples and exercises in this class are derived from the real interview questions !

Our text books are considered as the bibles of job interview.

For Graduate School Application

This class adds to your CV

- A

Research related topics

- Performance optimization
  - Memory layout, code optimization, memory allocation, concurrent programming
- Security
  - Buffer Overflow

Startup

The life you imagine

CEO

CTO

CFO

COO

Startup

Your real life: full stack programmer

Server

Website

Phone's App

Optimizations

My lawyer friend

Take >10 hours each day to extract information from the documents

My lawyer friend

I want to study programming.

My lawyer friend

I want to study programming.

Ok, you need to study CSO first.

My lawyer friend

I want to study programming.

Ok, you need to study CSO first.

Hmm…, I want to have a programmer boyfriend.

My lawyer friend

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Ok, you need to study CSO first.

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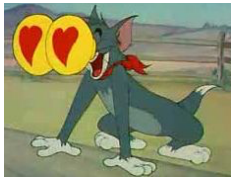
Ok, you need to study CSO first.

…The user is offline

Conversation with a programmer

Do you program?

I do not program a lot.
But I play with assembly sometime.



Let's date !!!

For Programming

Understand how your program runs on the hardware

- Why it fails
- Why it is slow

Why it fails?

What is the result of 1000,000 * 1000,000 ?

Why it fails?

What is the result of 1000,000 * 1000,000 ?

Expected answer: 1000,000,000,000 (1 trillion)

Why it fails?

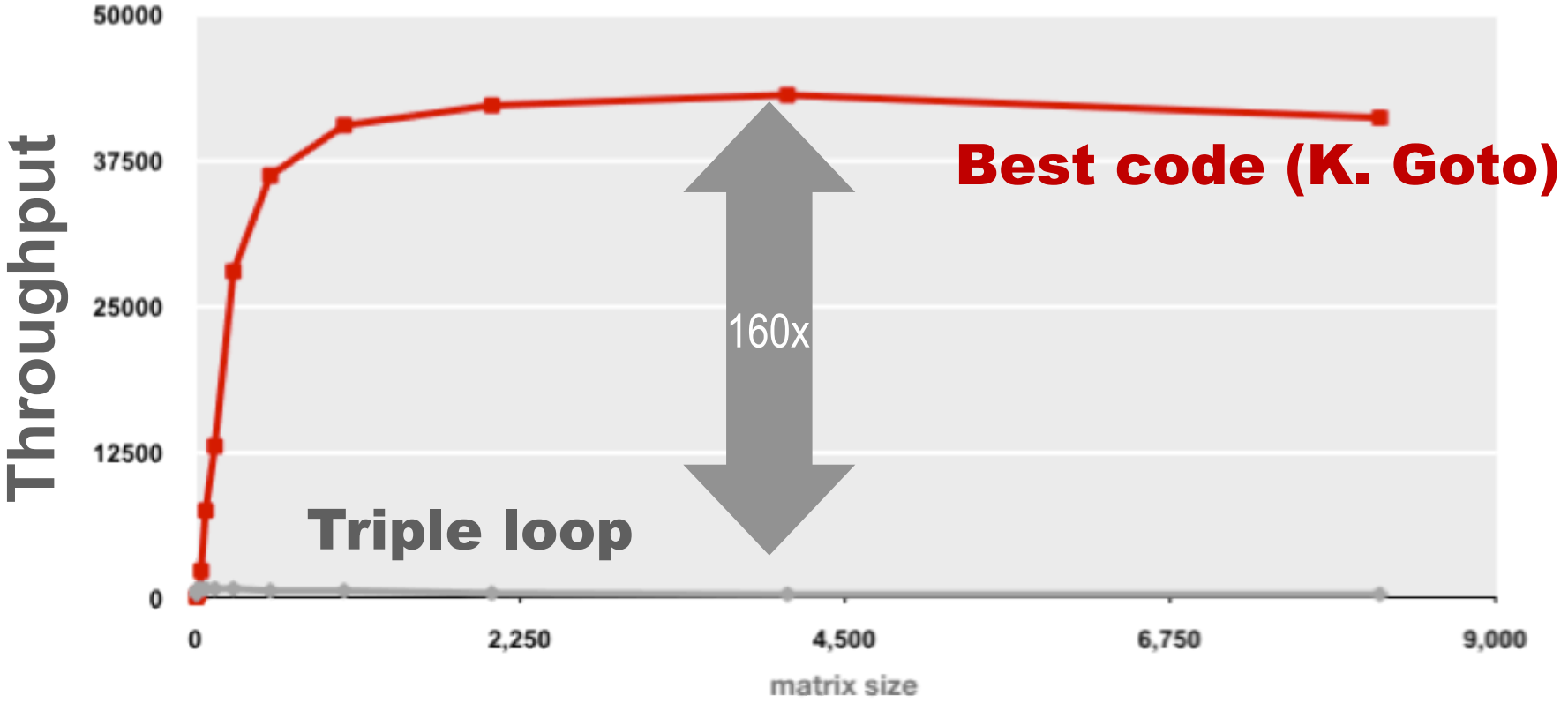
What is the result of 1000,000 * 1000,000 ?

Expected answer: 1000,000,000,000 (1 trillion)

```
int main()
{
    int a = 1000000;
    int b = 1000000;
    int r = a * b;
    printf("result is %d\n", r);
    return 0;
}
```

Why it is slow?

Example Matrix Multiplication

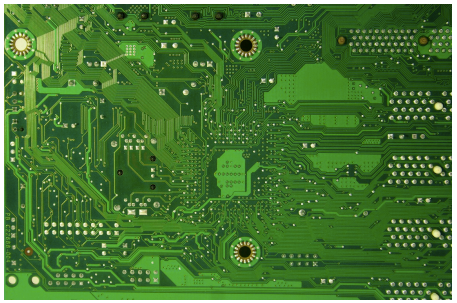


Both implementations have exactly the same operations count ($2n^3$)

What is CSO about?

Computer System Organization

Computer System Organization



Printed Circuit

Computer System Organization

Layered Organization

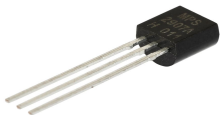
Software

Hardware

Layered Organization

Software

Hardware



Transistors

Diodes

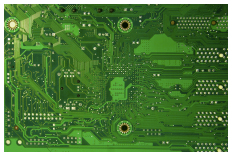
Resistors

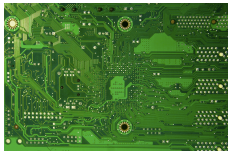
Layered Organization

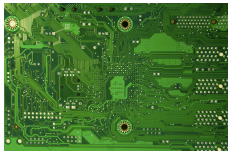
Software

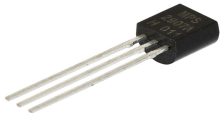
Hardware

Logical Circuits,
Flip-Flops, Gates









Transistors

Diodes

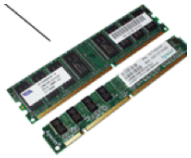
Resistors

Layered Organization

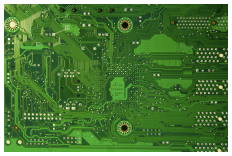
Software

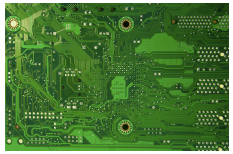
Hardware

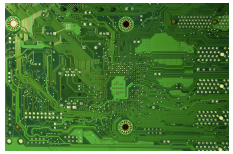
CPU, Memory, Disk

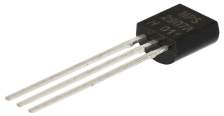


Logical Circuits,
Flip-Flops, Gates









Transistors

Diodes

Resistors

Layered Organization

Software

Hardware

CPU | Memory | I/O

Logical Circuits, Flip-Flops, Gates, …

Transistors, Diodes, Resistors, …

Layered Organization

System Software
(OS, compiler, VM···)

Software

Hardware

CPU | Memory | I/O

Logical Circuits, Flip-Flops, Gates, …

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Layered Organization

Layered Organization

Users

User Applications

System Software
(OS, compiler, VM···)

Software

Hardware

CPU | Memory | I/O

Logical Circuits, Flip-Flops, Gates, …

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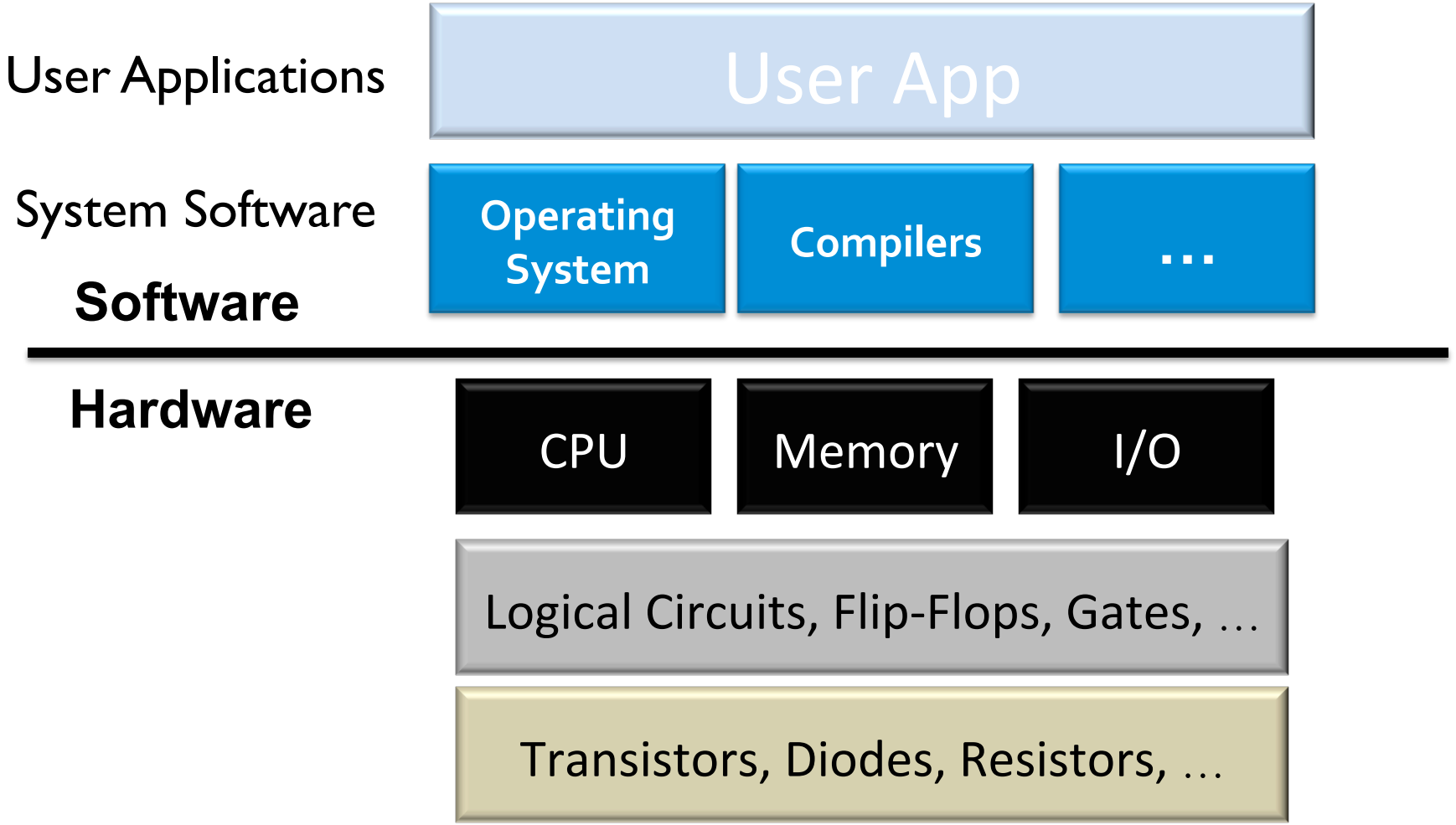
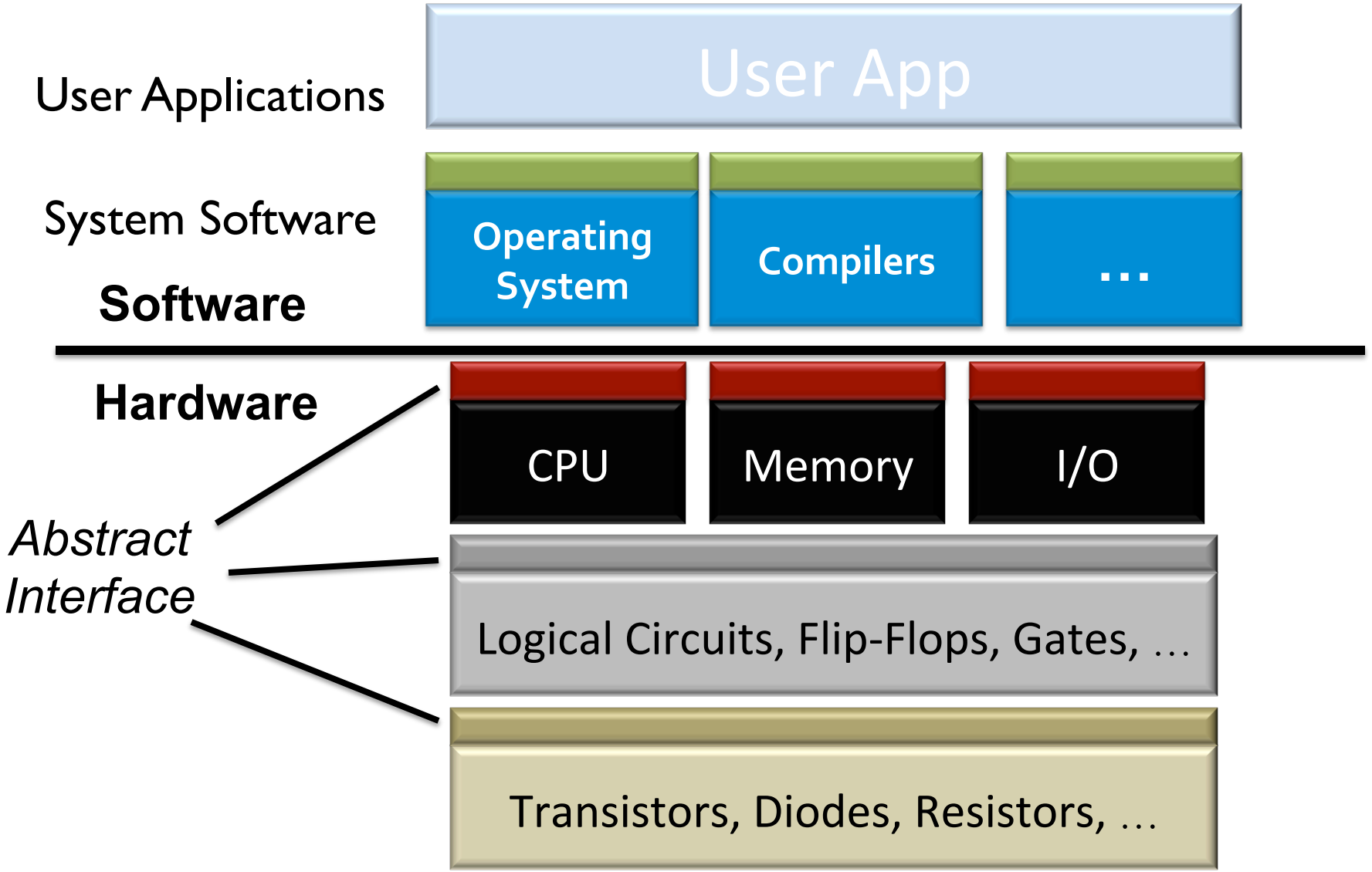
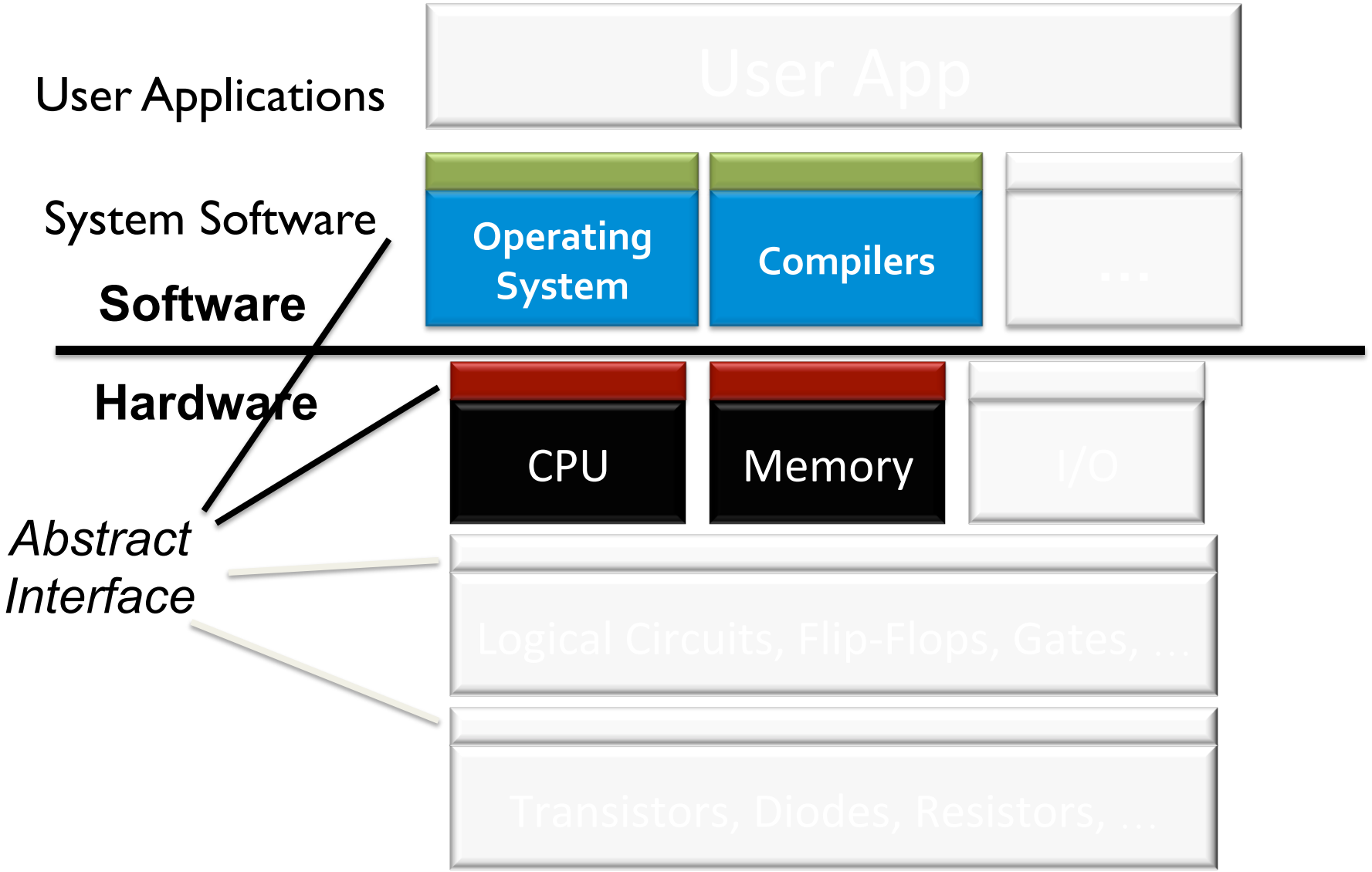
Layered Organization



Abstraction



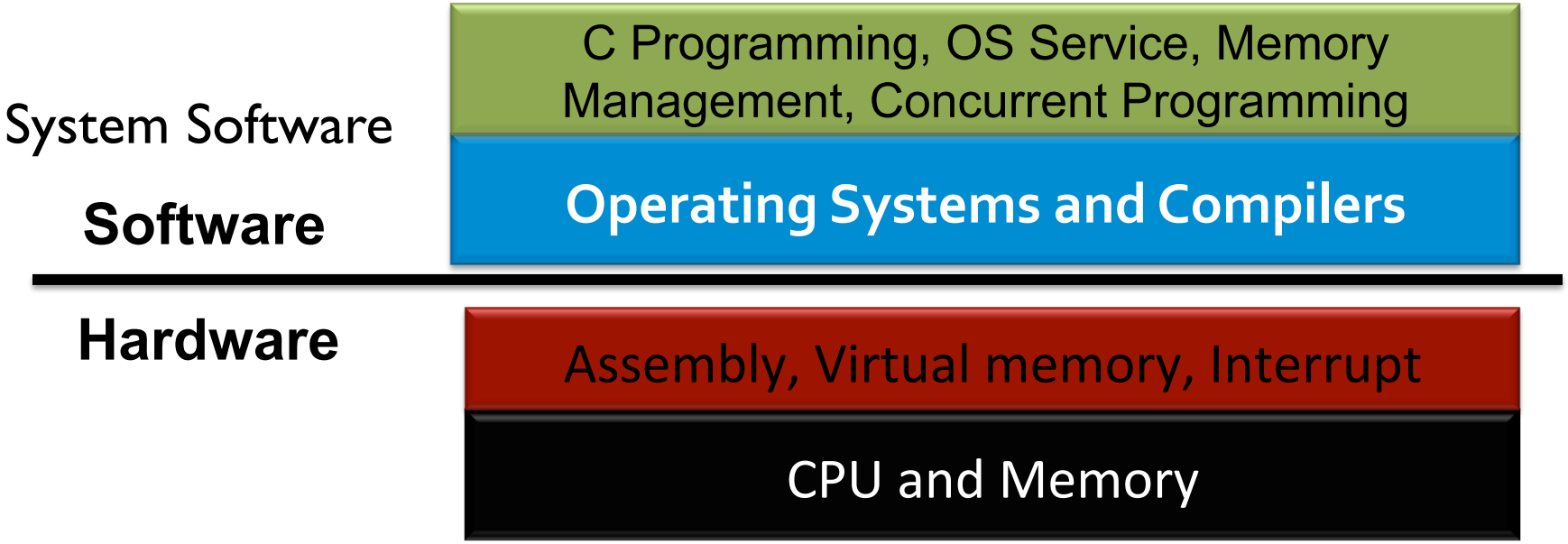
The Scope of This Class



The Scope of This class

Focus on abstract interfaces exposed by

- CPU and Memory
- Operating System, Compilers



Schedule of Our Class

http://news.cs.nyu.edu/~zhaoguo/fa17-cso/schedule.html

overview
bit, byte and int
float point
[C] basics, bitwise operator, control flow
[C] scopes rules, pointers, arrays
[C] structs, mallocs
[C] large program (linked list)

C Programming

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Machine Prog: ISA, Compile, movq
Machine Prog: Control Code (condition, jump instruction)
Machine Prog: Array allocation and access
Machine Prog: Procedure calls
Machine Prog: Structure, Memory Layout
Machine Prog: Buffer Overflow
Code optimizations

C Programming

Assembly (X86)

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Code optimizations
Virtual memory: Address Spaces/ Translation, Goal
Virtual memory: Page table/physcial to virtual
Process

C Programming

Assembly (X86)

Virtual Memory

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Virtual memory: Address Spaces/ Translation, Goal
Virtual memory: Page table/physcial to virtual
Process
Dynamic Memory Allocation I: malloc, free
Dynamic Memory Allocation II: design allocator
Dynamic Memory Allocation III: futher optimization

C Programming

↓

Assembly (X86)

↓

Virtual Memory

↓

Memory Management

Schedule of Our Class

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Machine Prog: Buffer Overflow
Code optimizations

Virtual memory: Address Spaces/ Translation, Goal
Virtual memory: Page table/physcial to virtual
Process

Dynamic Memory Allocation I: malloc, free
Dynamic Memory Allocation II: design allocator
Dynamic Memory Allocation III: futher optimization

Concurrent Programming I: thread, race
Concurrent Programming II: lock
Concurrent Programming III: conditional variable
Concurrent Programming IV: Other primitives

C Programming

Assembly (X86)

Virtual Memory

Memory Management

Concurrent Programming

Course Perspective

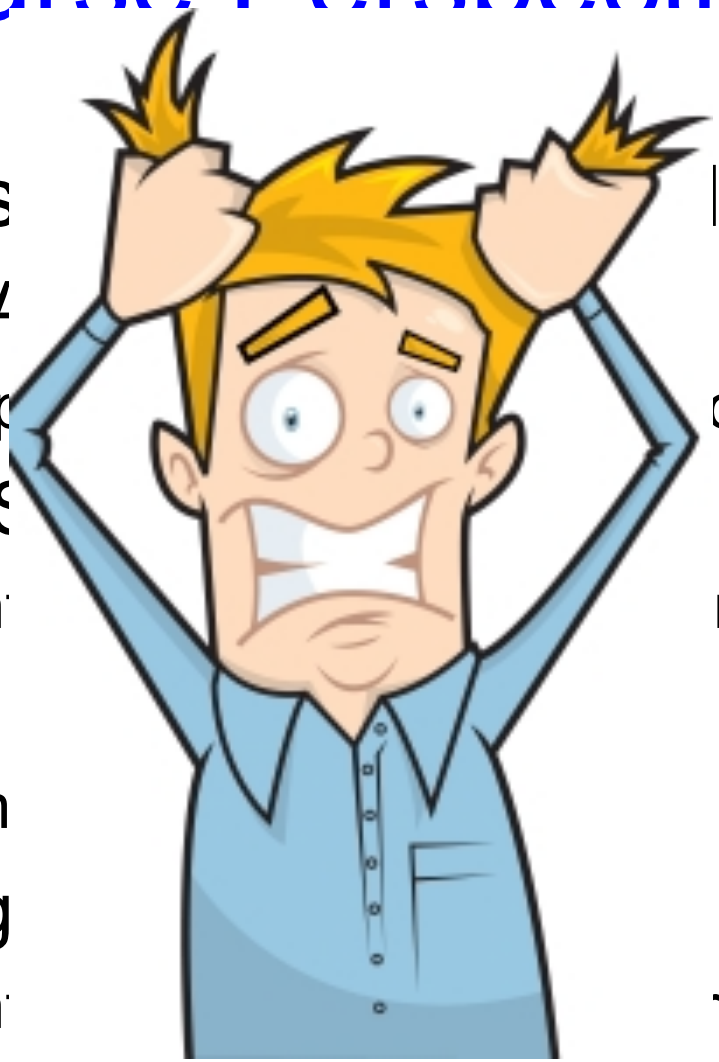
Most Systems Courses are Builder-Centric

- Computer Architecture
  - Design pipelined processor in Verilog
- Operating Systems
  - Implement large portions of operating system
- Compilers
  - Write compiler for simple language
- Networking
  - Implement and simulate network protocols

Course Perspective

Most Systems ler-Centric

- Computer A
  - Design pip og
- Operating S
  - Implemen ng system
- Compilers
  - Write com
- Networking
  - Implemen otocols



Course Perspective (Cont.)

This course is programmer-centric

- Understanding of underlying system makes a more effective programmer
- Bring out the hidden hacker in everyone

Course Perspective (Cont.)

This c grammer-centric

– Ul of underlying system makes a m rogrammer

– Br lden hacker in everyone

Course Perspective (Cont.)

This c gram

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m rogra

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Course Perspective (Cont.)

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– Br lden ne

Course Perspective (Cont.)

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m rogram

– Br lden ha

To be a happy programmer, you need to

Take

- Lectures (M/W 3:30-4:45pm)
- Recitation (Thu 12:30-1:45 pm)
  - In-class exercises provide hands-on instruction
  - Please make sure you will attend tomorrow's recitation

Do

- 5 (or 6) Programming labs
- Exercises

Pass

- 1 Quiz (before the mid-term)
- 1 Mid-term
- 1 Final exam

Grade Breakdown

Lecture 10%

Recitation and Exercises 15%

Labs 30%

Quiz before midterm 10%

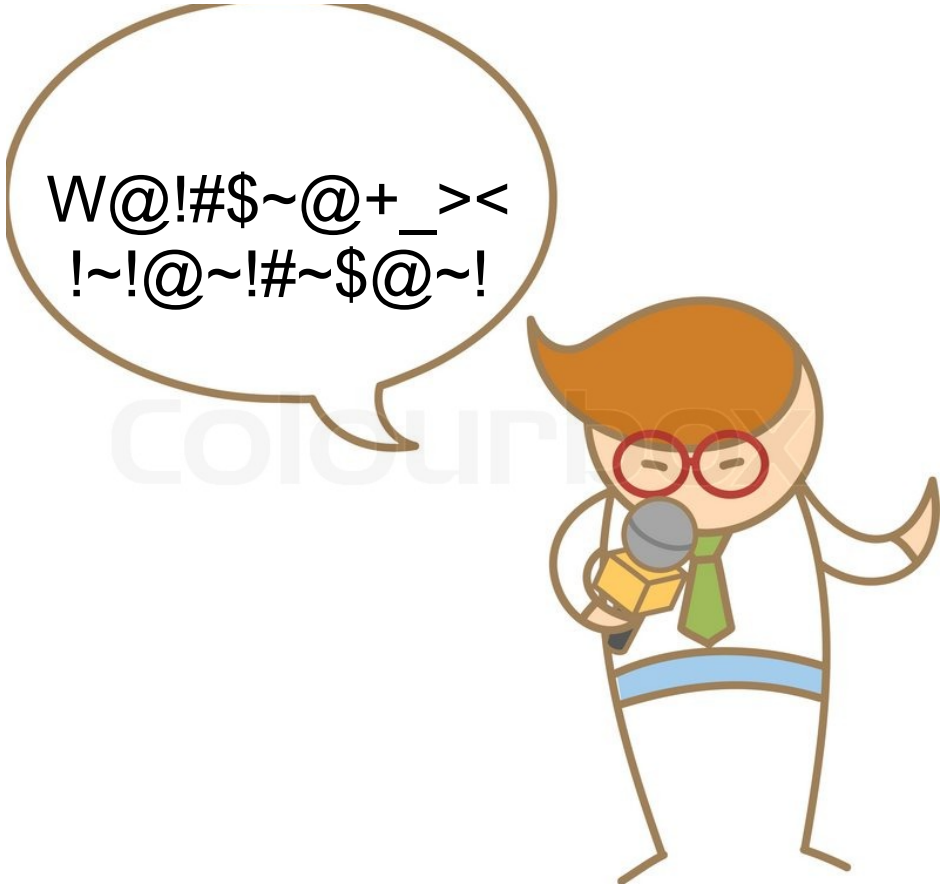
Midterm 15%

Final 20%

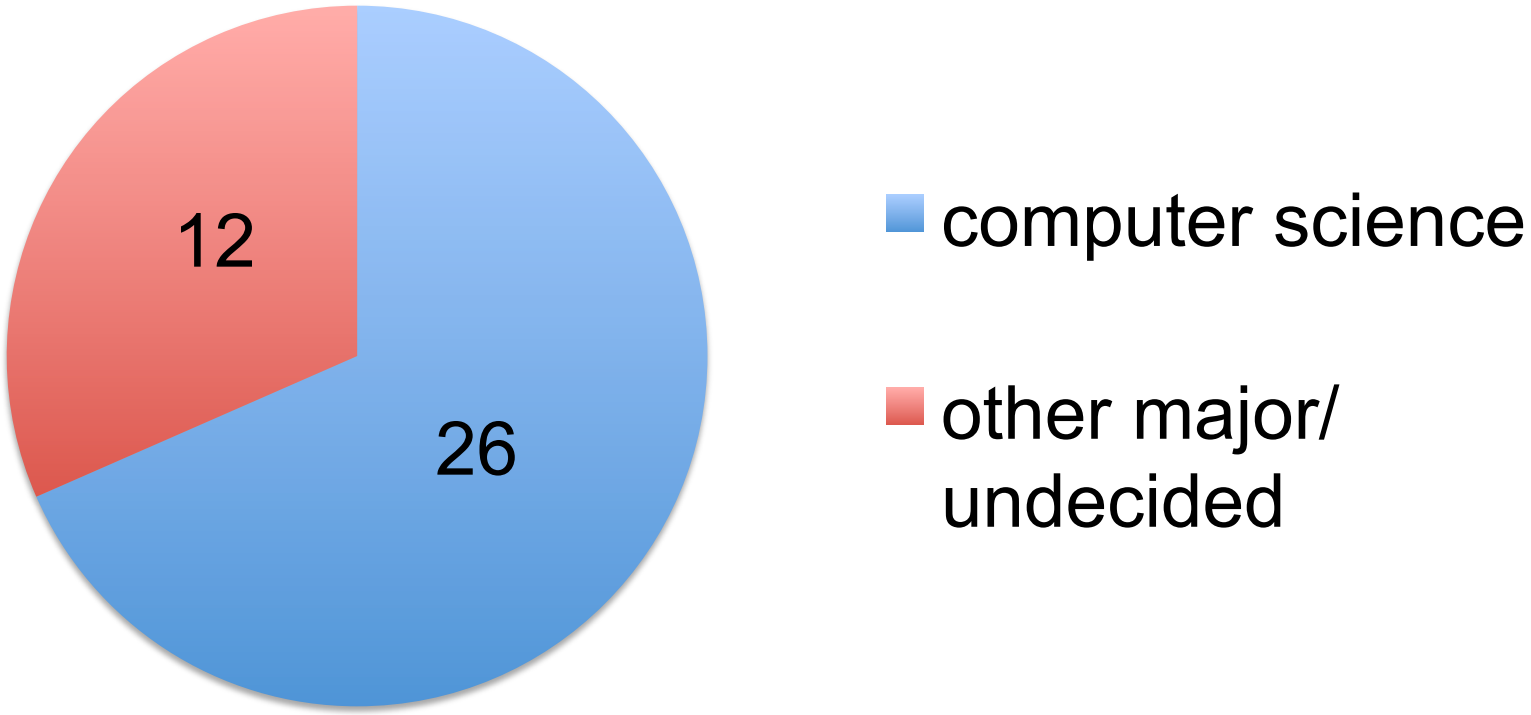
Please make sure you will attend tomorrow's recitation!

What are the challenges?

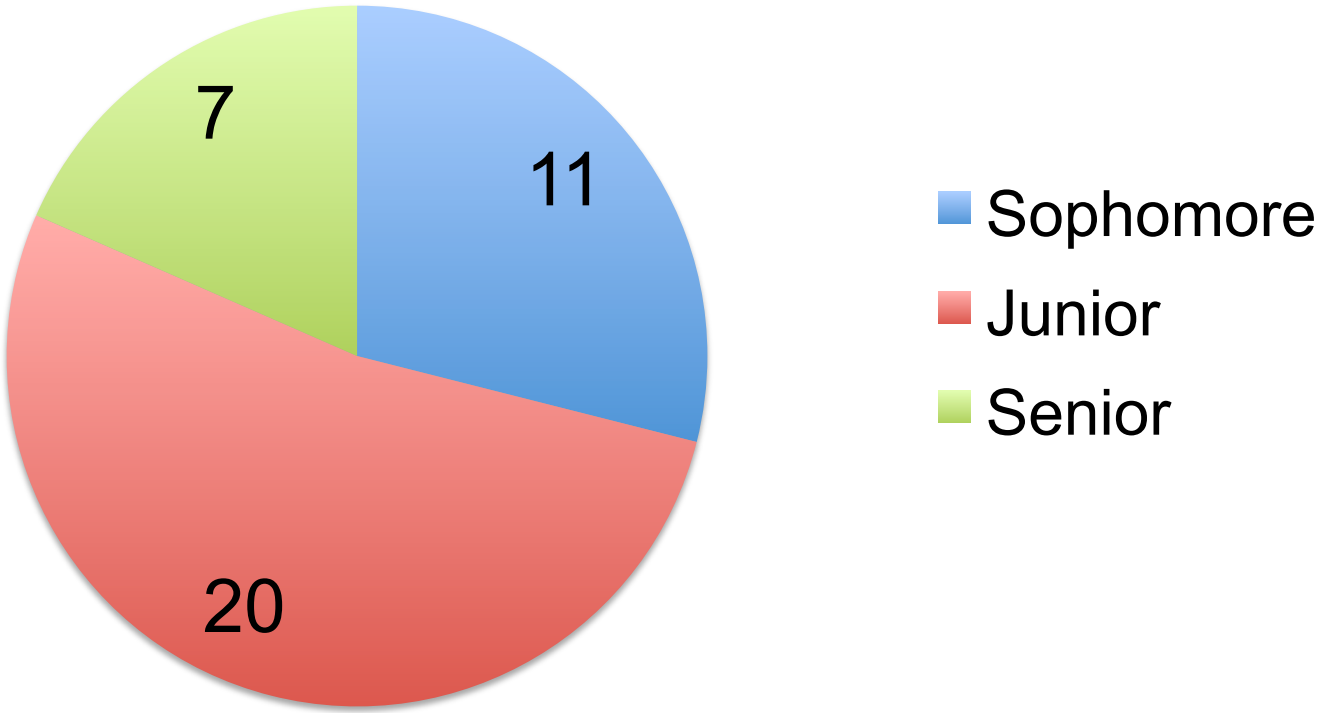
Challenges



Challenges



Challenges



Don’t Worry

We are here to help

Who are we?

Zhaoguo Wang

Lecturer

zhaoguo@nyu.edu

Chien-chin Huang

Recitation Leader / Grader

huang@cs.nyu.edu

HungWei Chen

Grader

hc2264@nyu.edu

Gossip Time

Chien-chin Huang

- 5^{th} years PH.D, a perfect husband and father

Gossip Time

Chien-chin Huang

- 5th years PH.D, a perfect husband and father

HungWei Chen

- GPA: 4.0/4.0
- 8 years working experience
  - 4 years staff software engineer

Gossip Time

Chien-Chin Huang

- 5th years PH.D, a perfect husband and father

HungWei Chen

- GPA: 4.0/4.0
- 8 years working experience
  - 4 years staff software engineer

Zhaoguo Wang

- no gossip… ☺

Office Hours

Zhaoguo Wang

- Monday 5:00 PM – 6:00 PM, 60 FA, Room 406

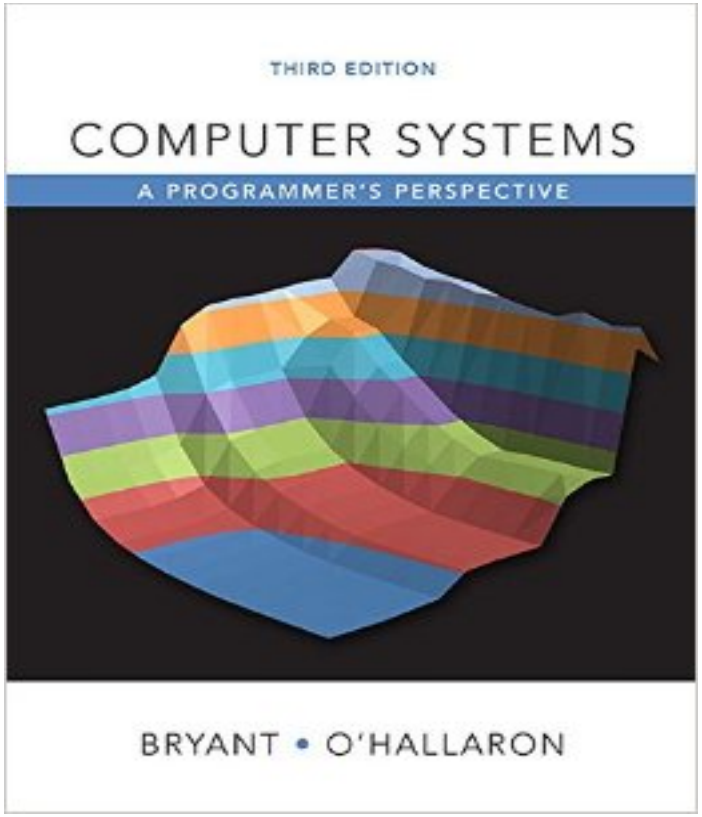
Chien-Chin Huang and HungWei Chen

- Thursday 3:00 PM – 4:00 PM, 60 FA, Room 406

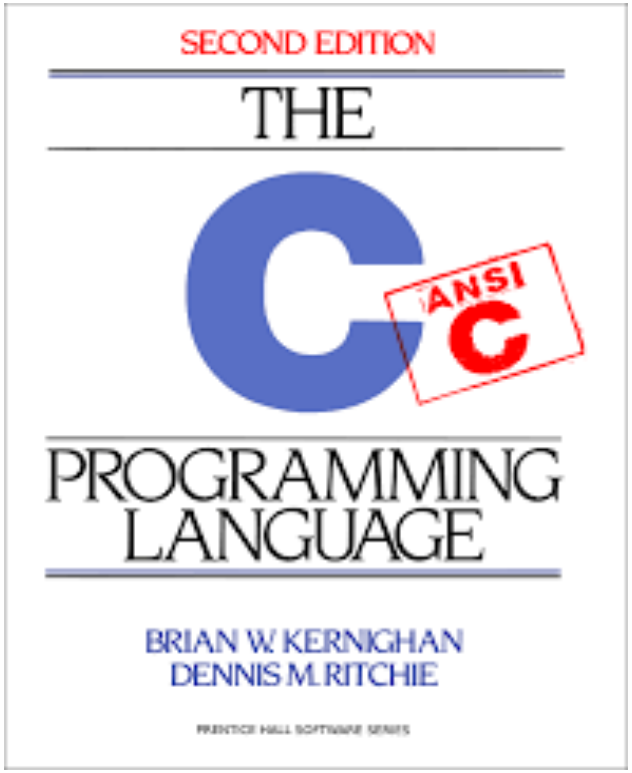
Who are we?

Before Class

Read the related sections in the text books



"Computer Systems: A Programmer's Perspective, 3nd Edition", http://csapp.cs.cmu.edu



"The C Programming Language, 2nd Edition", Prentice Hall, 1988, Reserved at NYU library

Be Active In Class

Raise your hand at any time

- Ask me to repeat, repeat and repeat
- Ask questions
- Answer questions from me or others

Have discussion and make friends with each others

After Class

Finish all labs / exercises

- By yourself

Attend the recitations

- Any issue of doing labs or exercises

Getting help

- Office hour, Piazza

Policies

You must work alone on all assignments

- You may post questions on Piazza,
- You are encouraged to answer others' questions, but refrain from explicitly giving away solutions.

Labs & Exercises

- Assignments due at 11:59pm on the due date
- Everybody has 5 grace days
- Zero score after the due

Class Info

http://news.cs.nyu.edu/~zhaoguo/fa17-cso/

Reminder: please attend tomorrow's recitation!

Integrity and Collaboration Policy

We will enforce the policy strictly.

1. The work that you turn in must be yours
2. You must acknowledge your influences
3. You must not look at, or use, solutions from prior years or the Web, or seek assistance from the Internet
4. You must take reasonable steps to protect your work
   - You must not publish your solutions
5. If there are inexplicable discrepancies between exam and lab performance, we will over-weight the exam and interview you.

Integrity and Collaboration Policy

We will enforce this policy strictly and report violators to the department and Dean.