

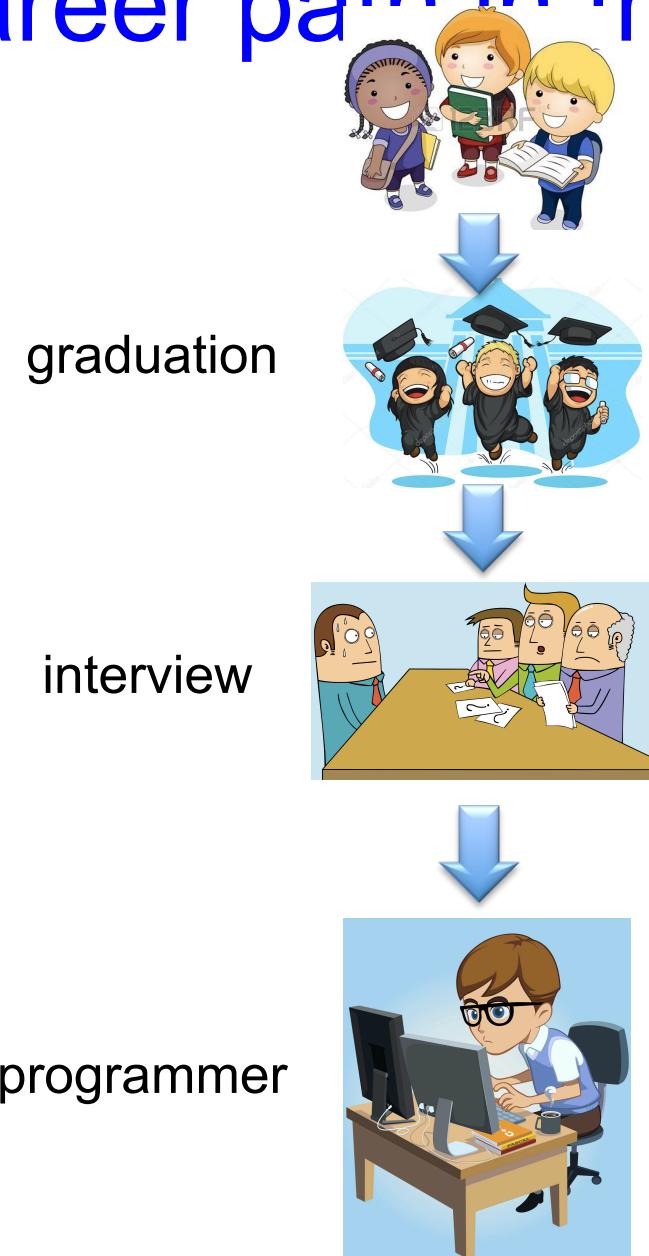
Computer Systems Organization

Jinyang Li

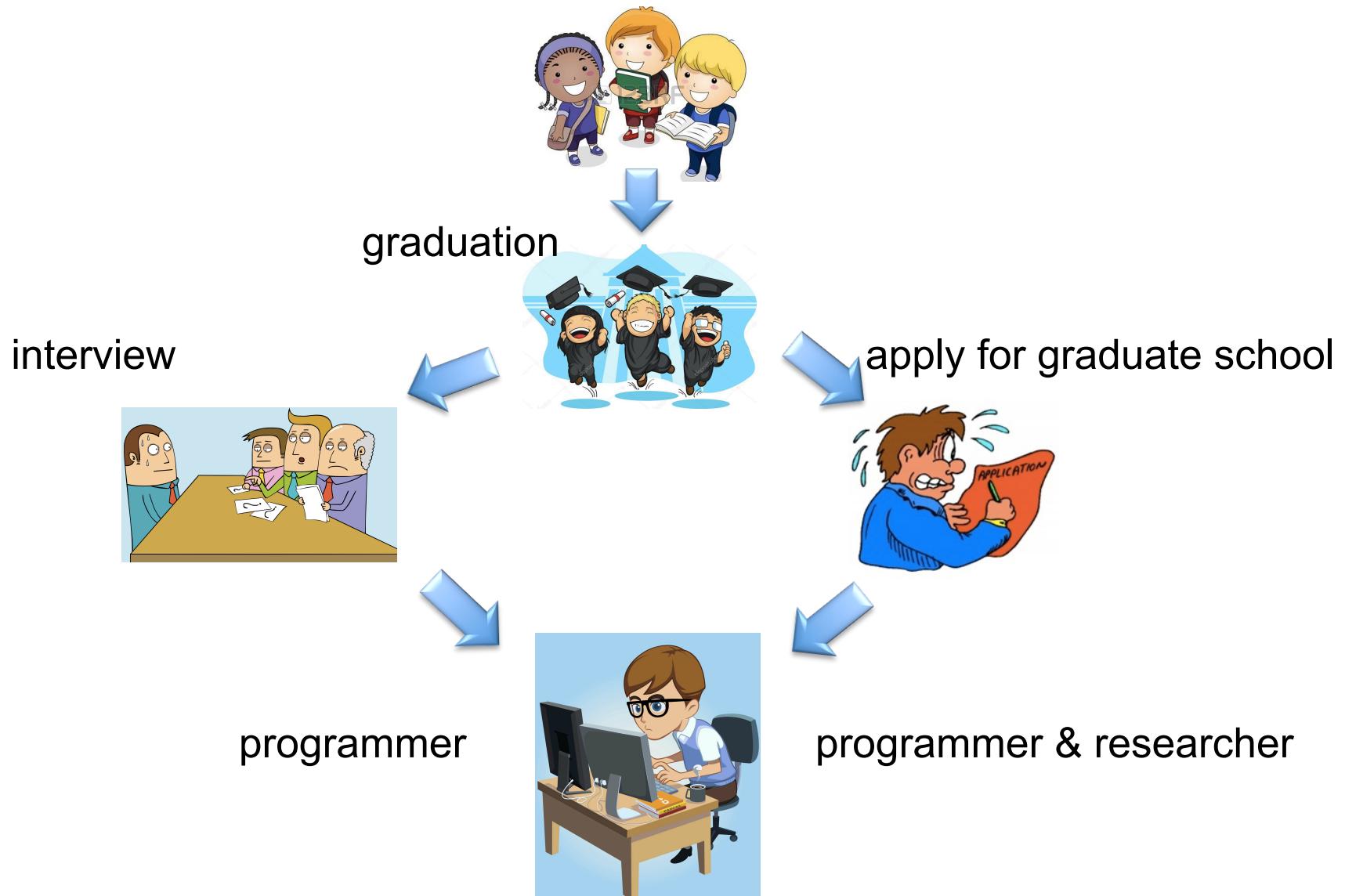
Slides are based on Tiger Wang's class

Why study CSO?

Your career path in the next few years

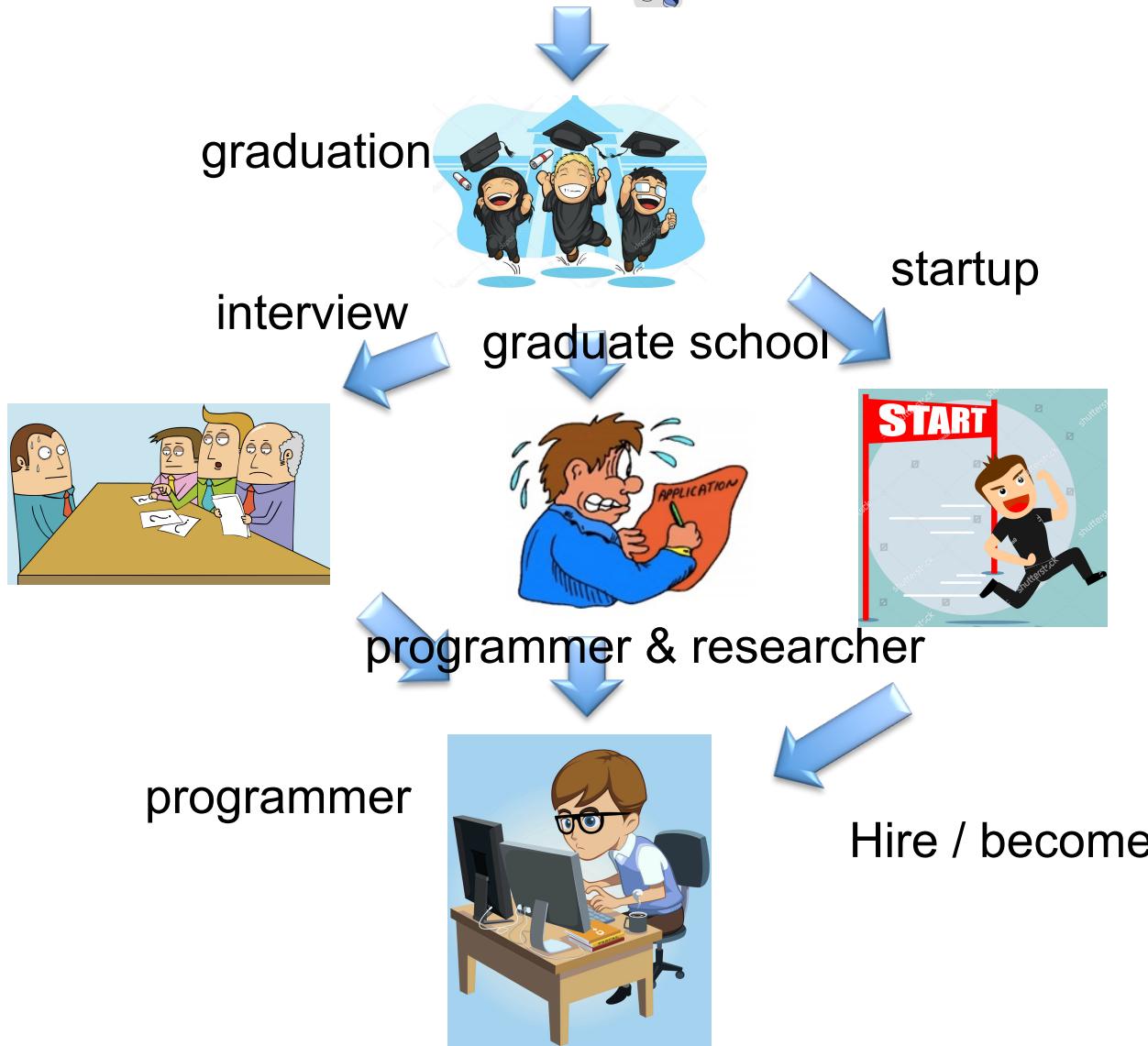


Your career path in the next few years





Your career path in the next few years



Your career path in the next few years



Your career path in the next few years



Your career path in the next few years



**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

For Interview

This class adds to your CV

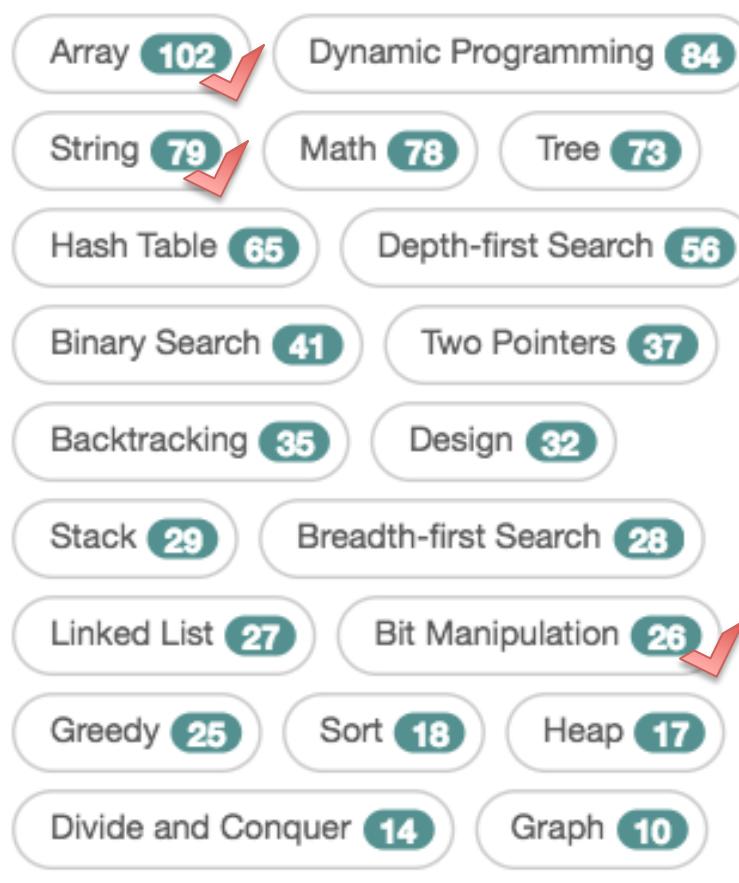
- C Programming, UNIX, X86 Assembly ...

Interview related topics

- Basic knowledge of Array, String, Bit Manipulation

Topics Distribution From LeetCode

↳ Topics ~30%



Some 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

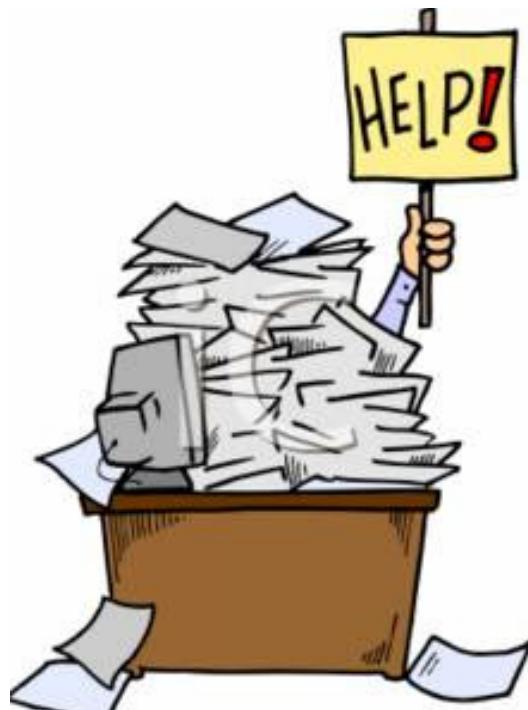
Website

Phone's App

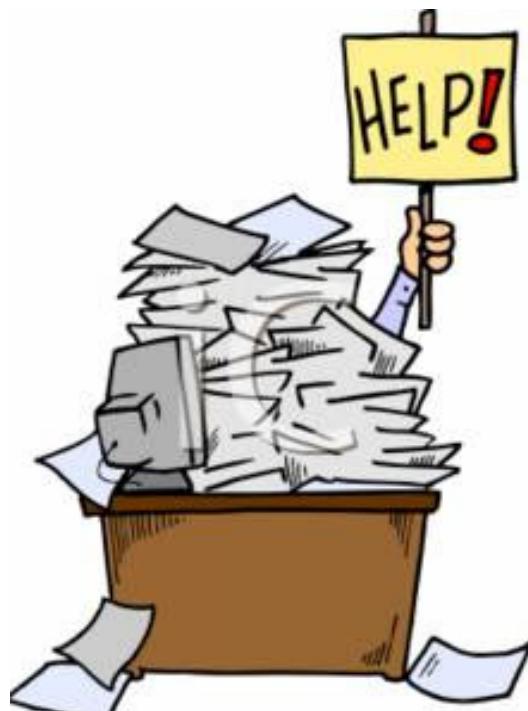
Optimizations

My lawyer friend

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

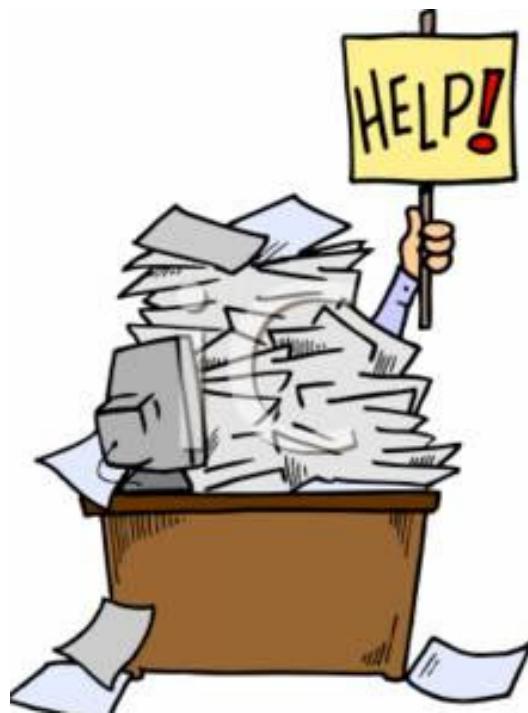


My lawyer friend



I want to study programming.

My lawyer friend



I want to study programming.

Ok, you need to study CSO first.

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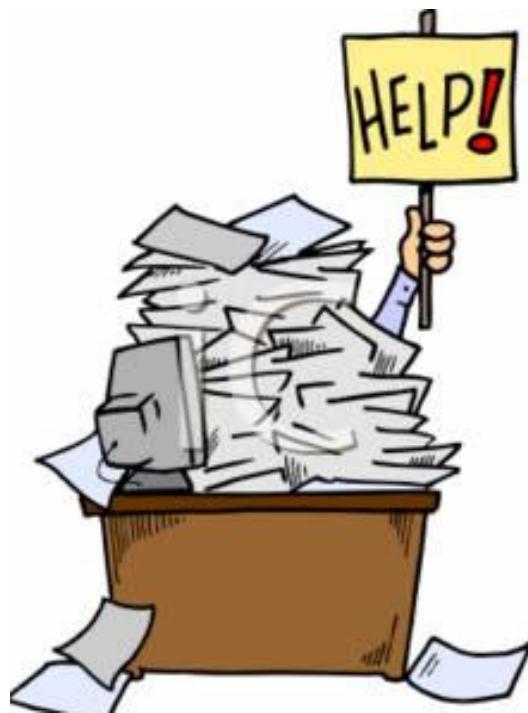


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Hmm..., I want to marry a
programmer.

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I want to study programming.

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Hmm..., I want to marry a
programmer.

Ok, you need to study CSO first.

...The user is offline

Conversation between programmers



Have you heard of the Meltdown attack?



No. Is it bad?

Meltdown lets an attacker read another process' address space!

What is an address space?

He does not know anything about computers...

Sorry I have to run now, bye!

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?

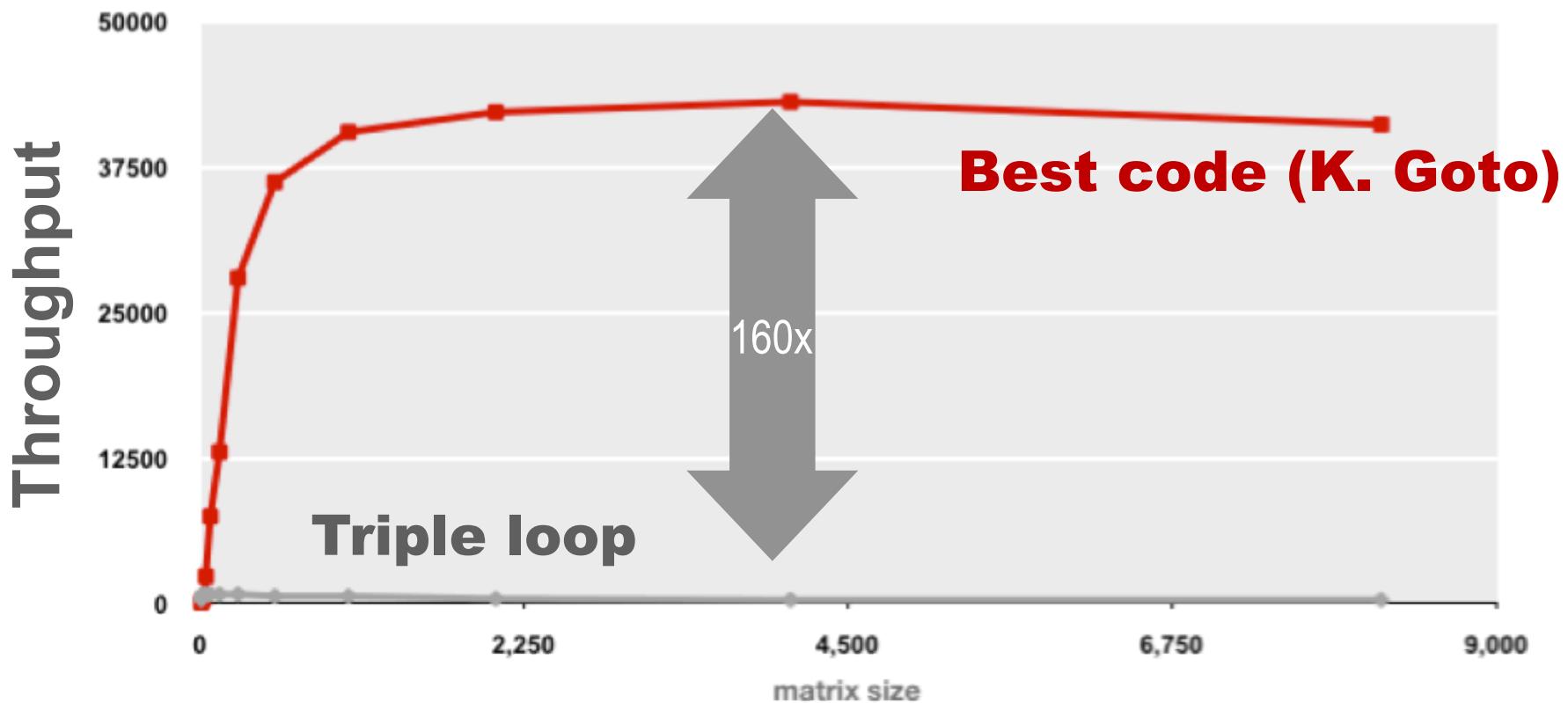
What is the result of $1000,000 * 1000,000$?

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



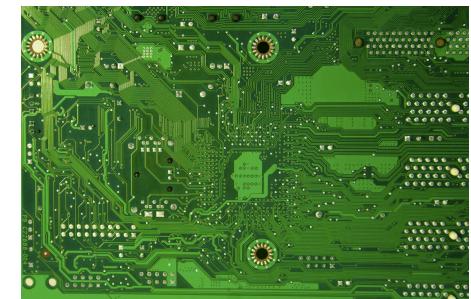
Both implementations have **exactly** the same operations count ($2n^3$)

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..)



Visual Studio

The Microsoft .NET logo consists of the word "Microsoft" above ".NET". The ".NET" part is written in a bold, lowercase sans-serif font. The "N" has a blue gradient, the "E" has a green gradient, the "T" has an orange gradient, and the ".NET" suffix has a white gradient.



VirtualBox



Software

Hardware

CPU

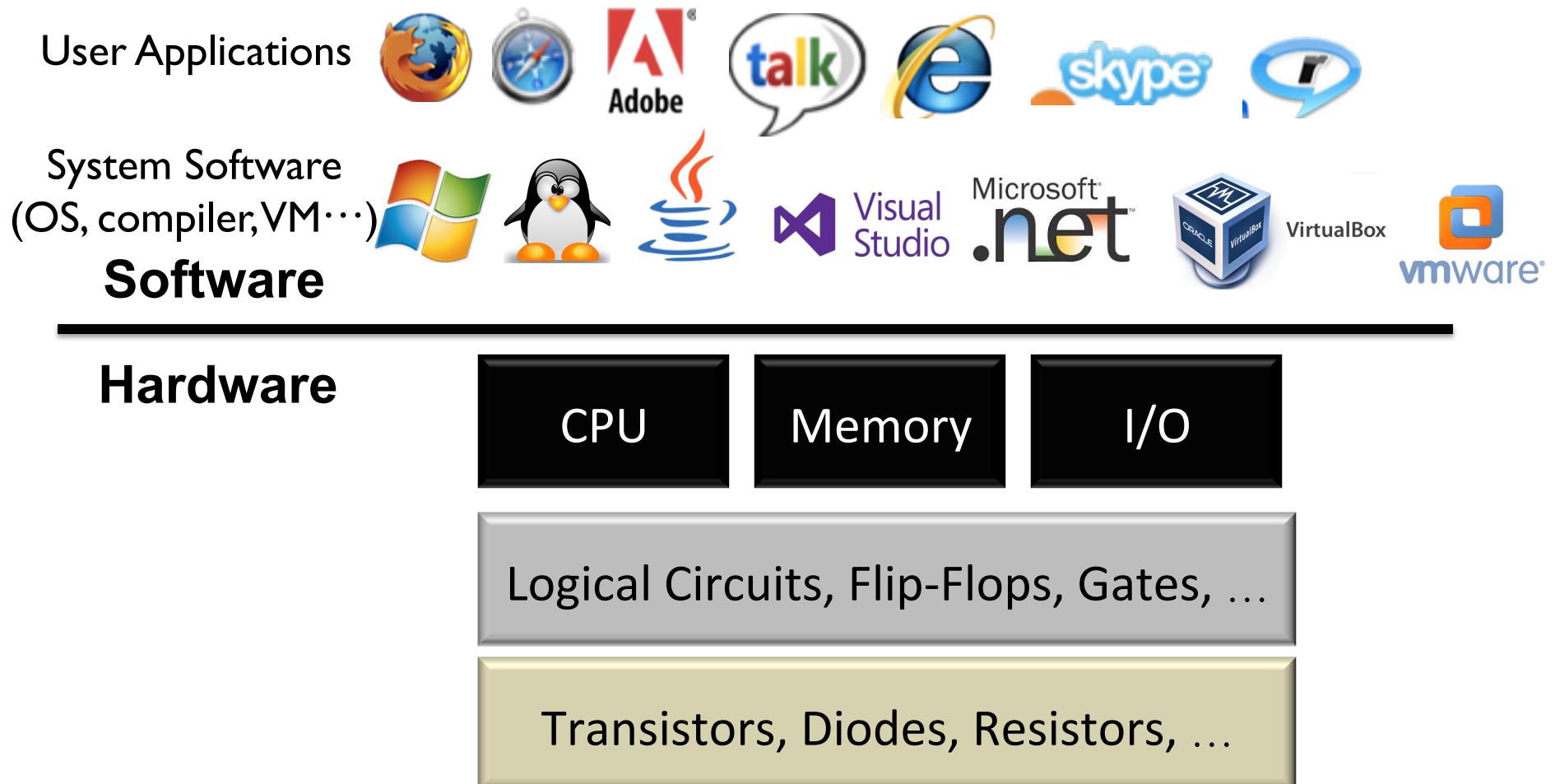
Memory

I/O

Logical Circuits, Flip-Flops, Gates, ...

Transistors, Diodes, Resistors, ...

Layered Organization



Layered Organization

Users



User Applications



System Software (OS, compiler, VM..)



Software

Hardware

CPU

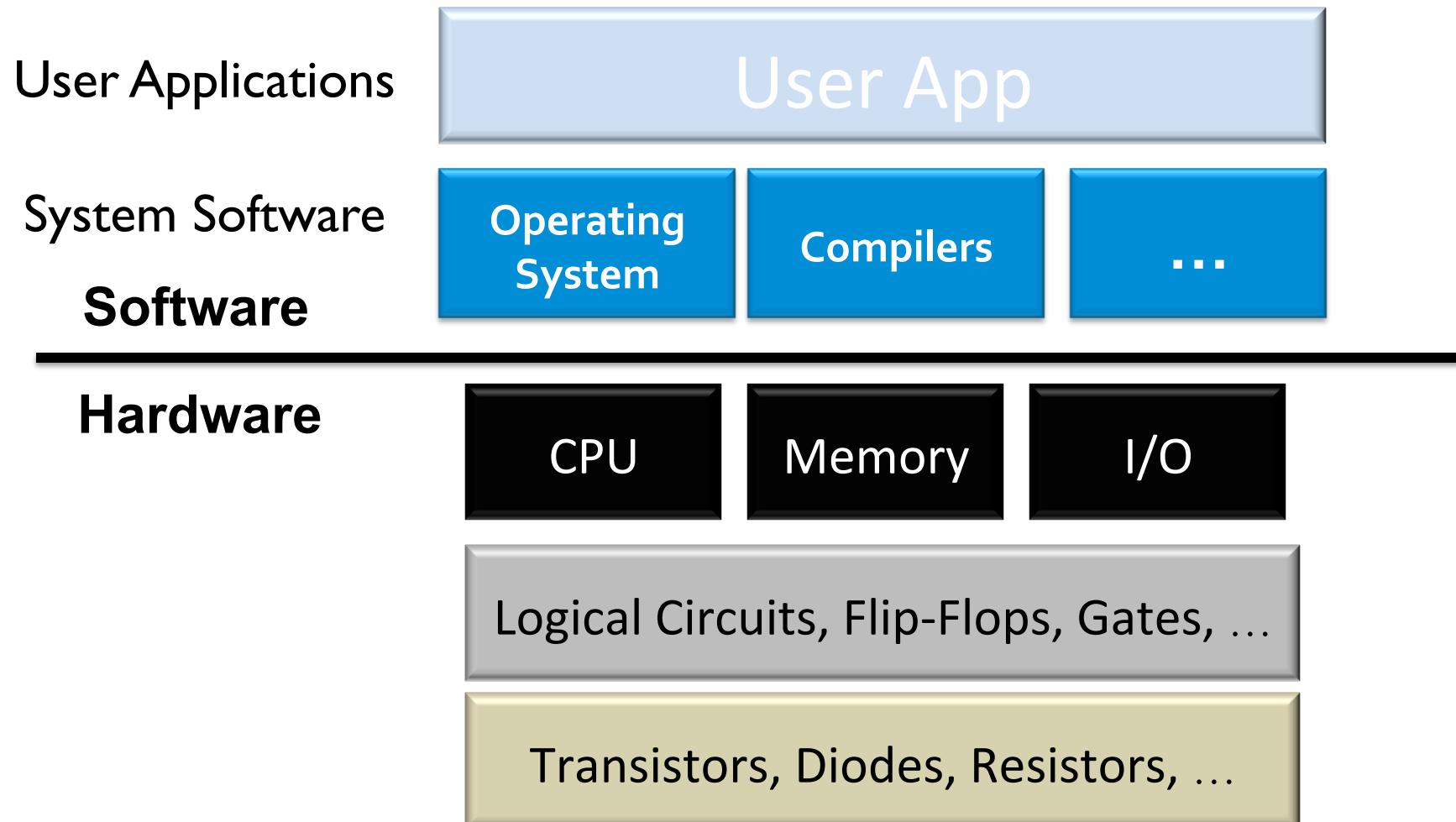
Memory

I/O

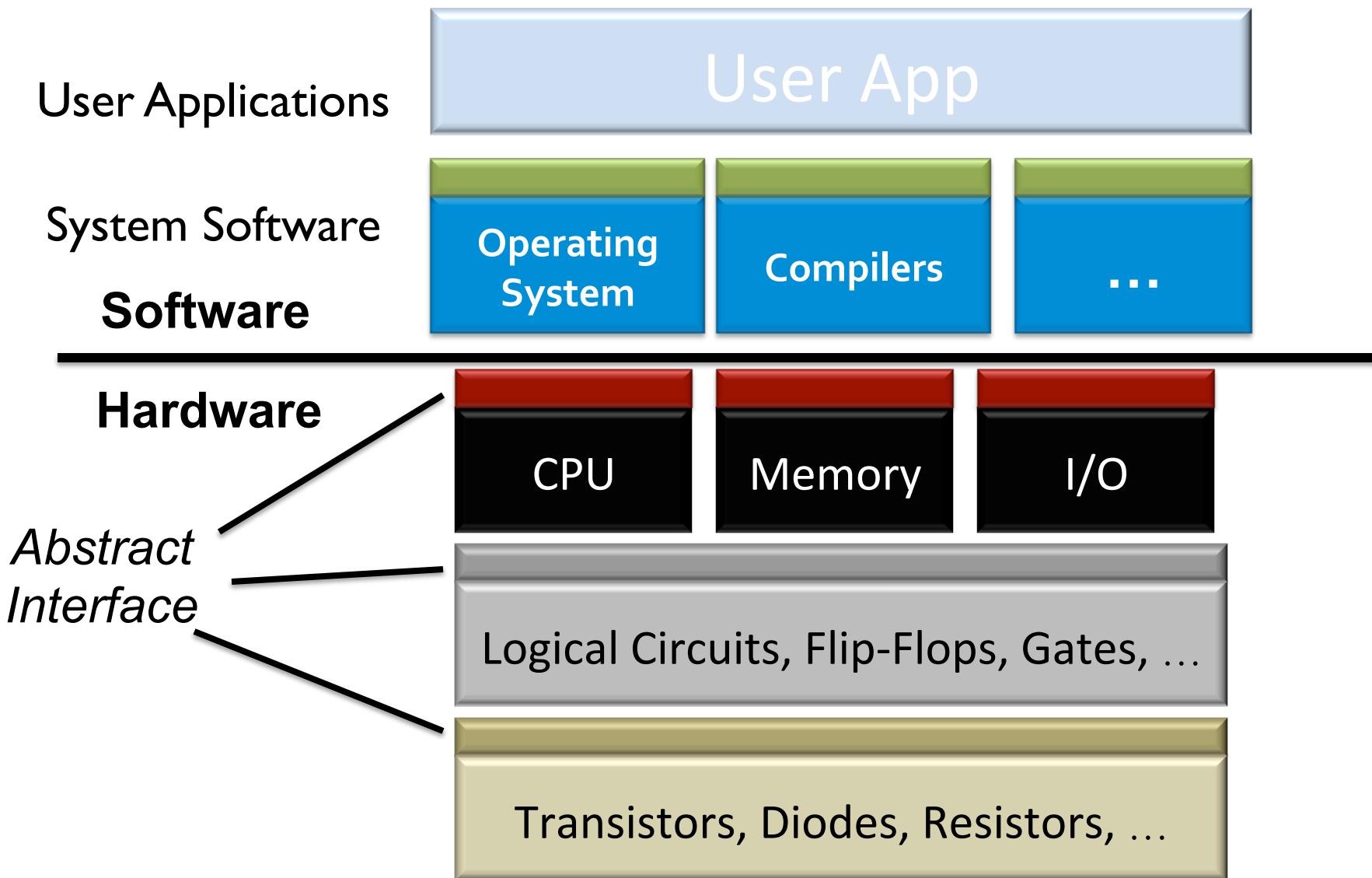
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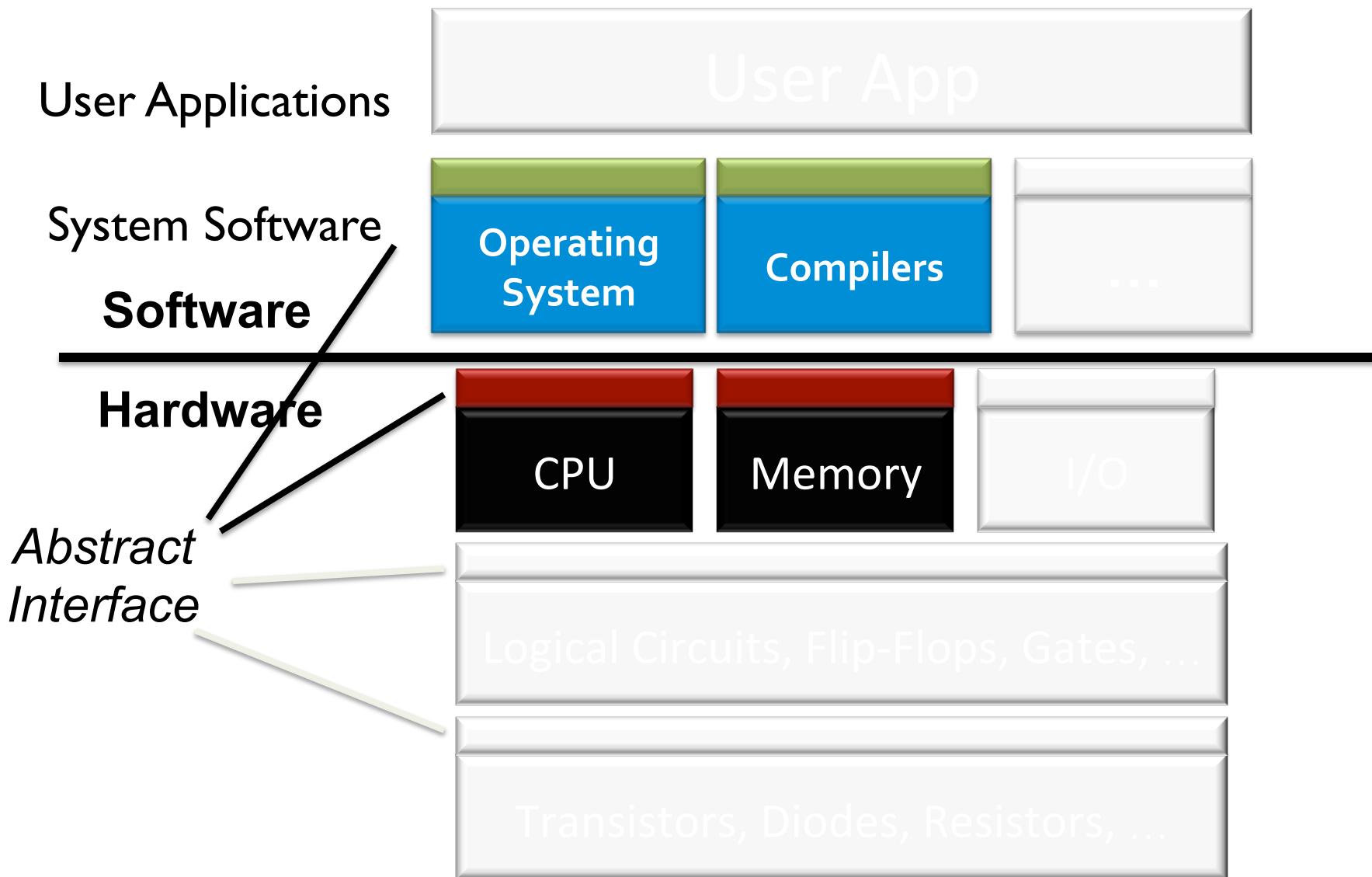
Layered Organization



Abstraction



The Scope of This Class



The Scope of This class

Focus on abstract interfaces exposed by

- CPU and Memory
- Operating System, Compilers

System Software

Software

Hardware

C Programming, OS Service, Memory Management, Concurrent Programming

Operating Systems and Compilers

Assembly, Virtual memory, Interrupt

CPU and Memory

Schedule

<http://news.cs.nyu.edu/~jinyang/fa18-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/physical to virtual
Process

C Programming

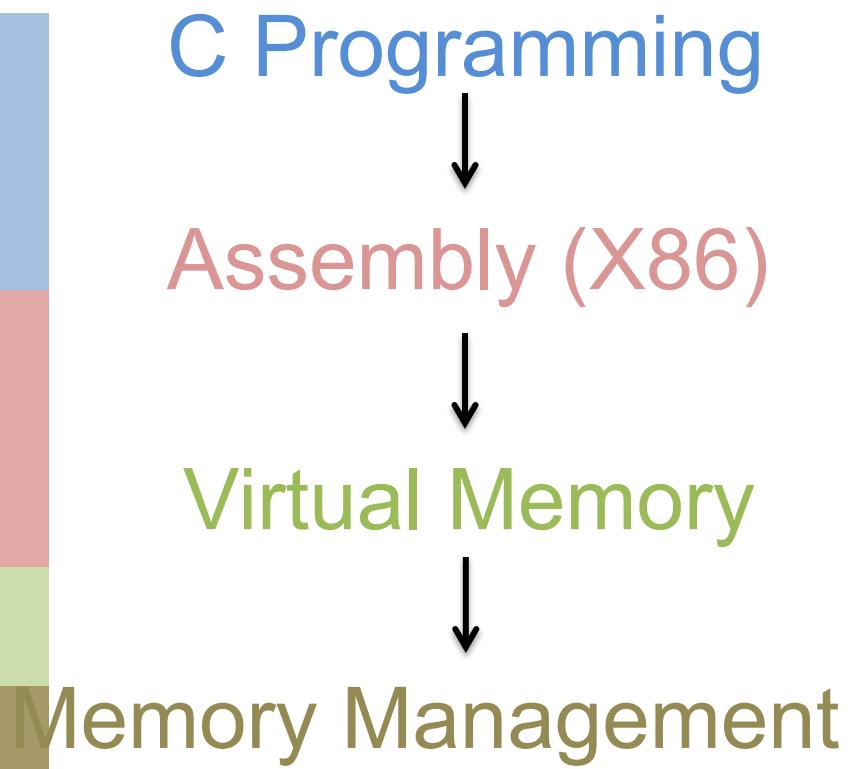
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Virtual Memory

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



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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

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Course Perspective (Cont.)

This course is **programmer-centric**

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



To be a happy programmer, you should

Attend

- Lectures (M/W 3:30-4:45pm) Wav 366
- Recitation (Th 12:30-1:45 pm) CIWW 312
 - In-class exercises provide hands-on instruction

Do

- 5 Programming labs
- Recitation exercises

Pass

- Quiz 1 (10/3)
- Quiz 2 (10/31)
- Final exam

Starts tomorrow!
Bring Laptop to
class

Due on Thu 11pm.

Grade Breakdown

Recitation and Exercises 15%

Labs 40%

Quiz-1 10%

Quiz-2 15%

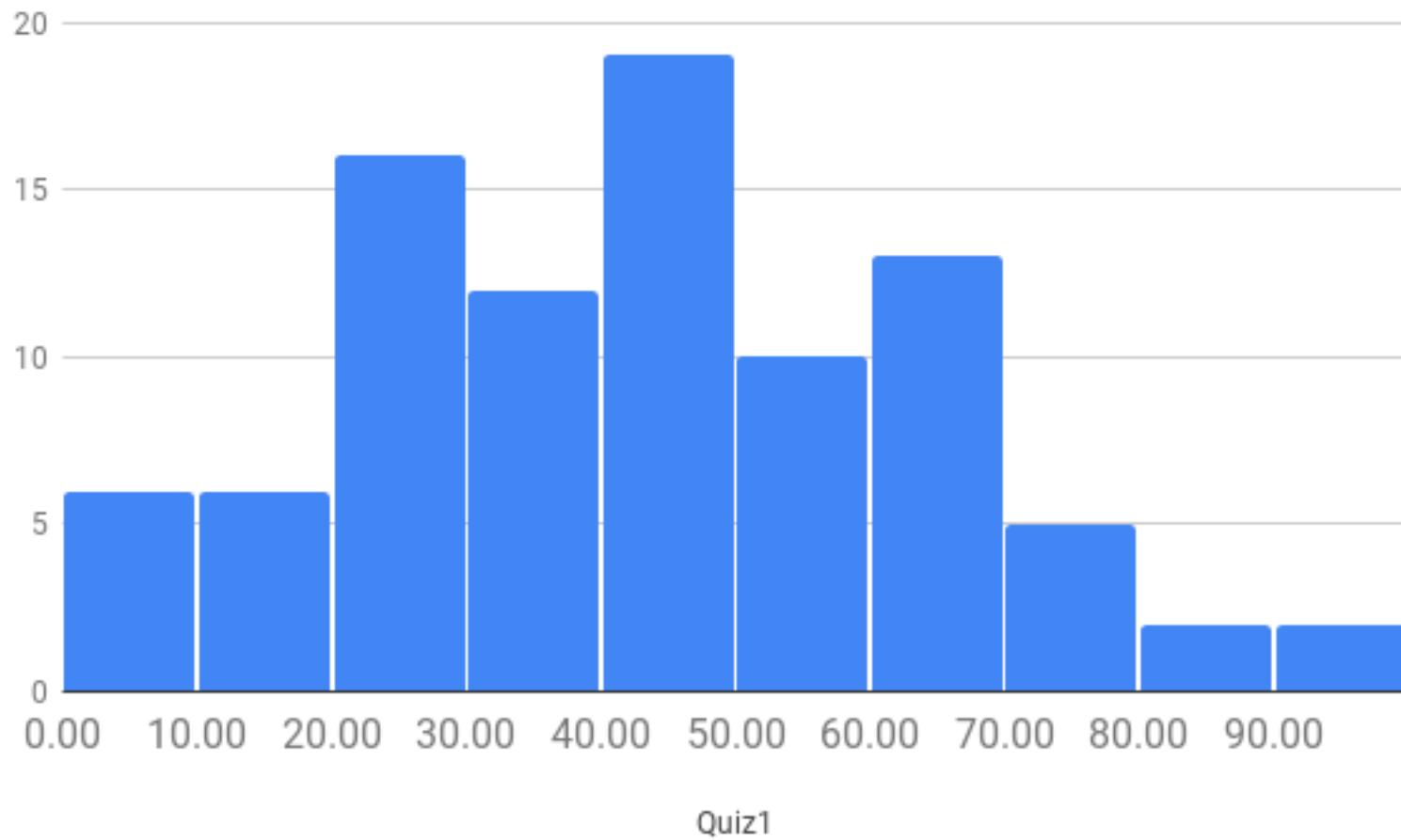
Final 20%

Bonus I: lecture and piazza participation 5%

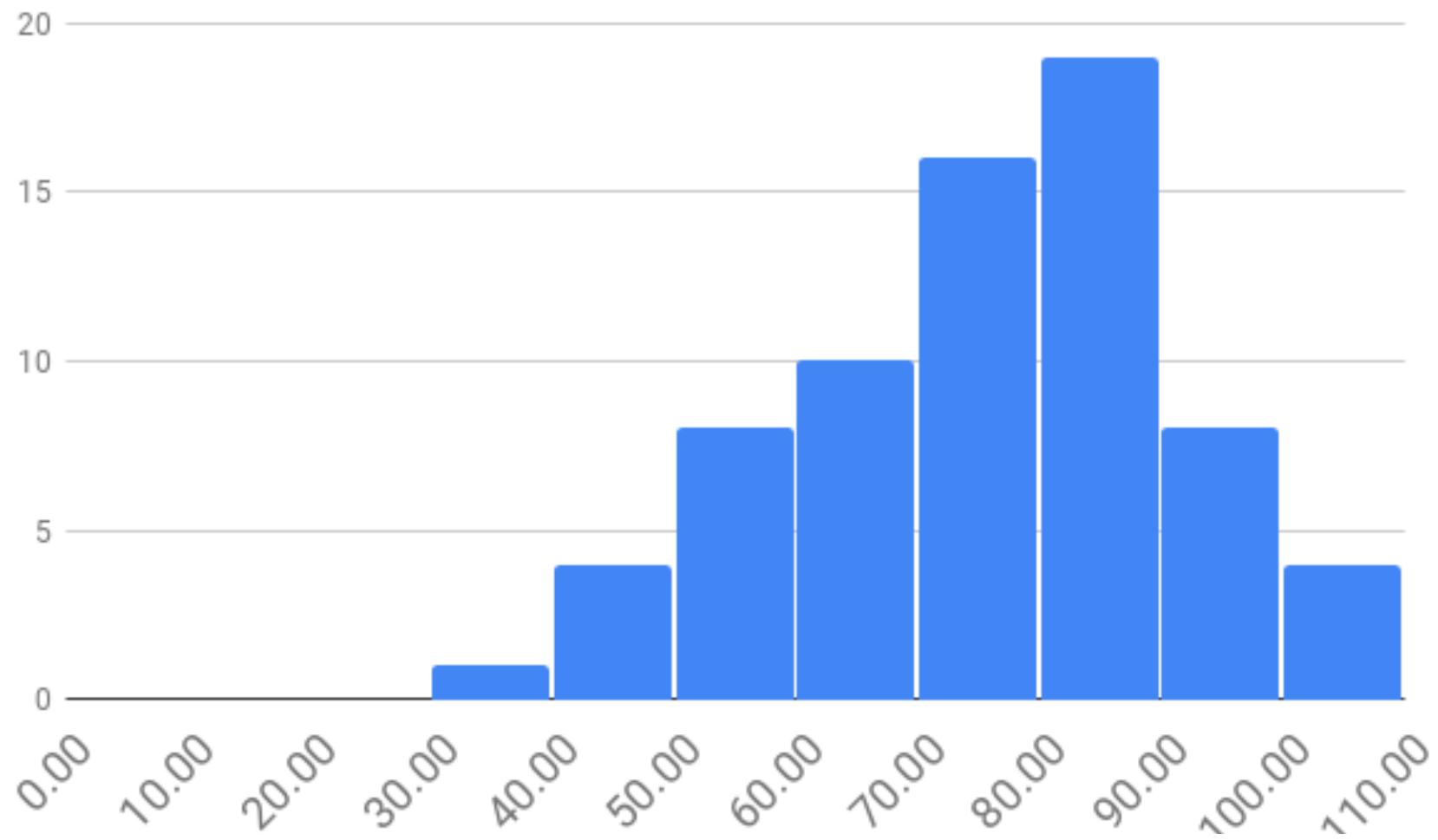
Bonus II: extra-credit lab questions (points vary)

Is CSO going to be hard?

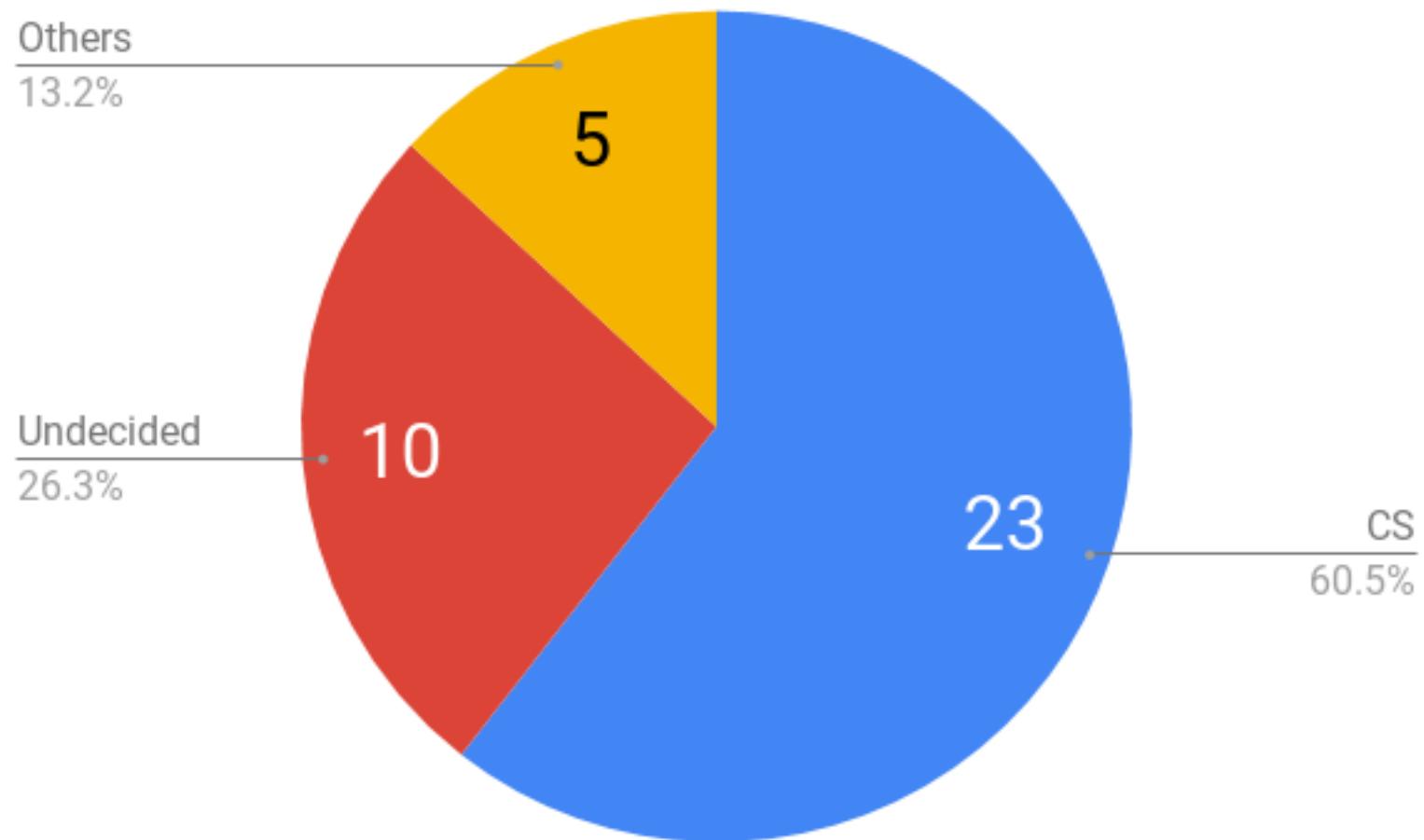
Statistics from last term: quiz 1



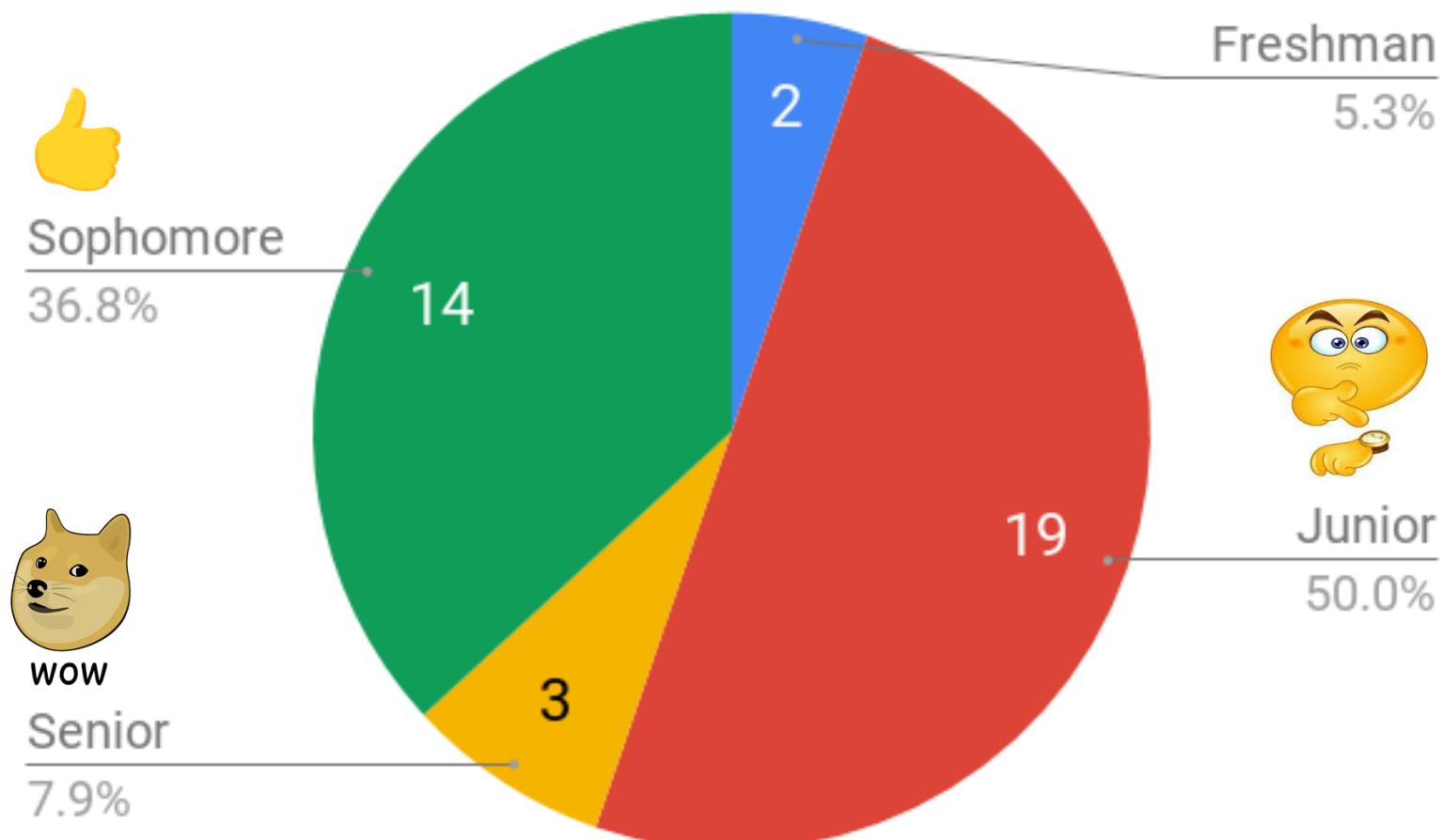
Statistics from last term: final



Statistics from this term: major vs. minor



Statistics from this term: student level



Time to work hard



We (the course staff) are here to help

We are here to help

Jinyang Li

Lecturer

Lingfan Yu

Recitation Leader
Head grader

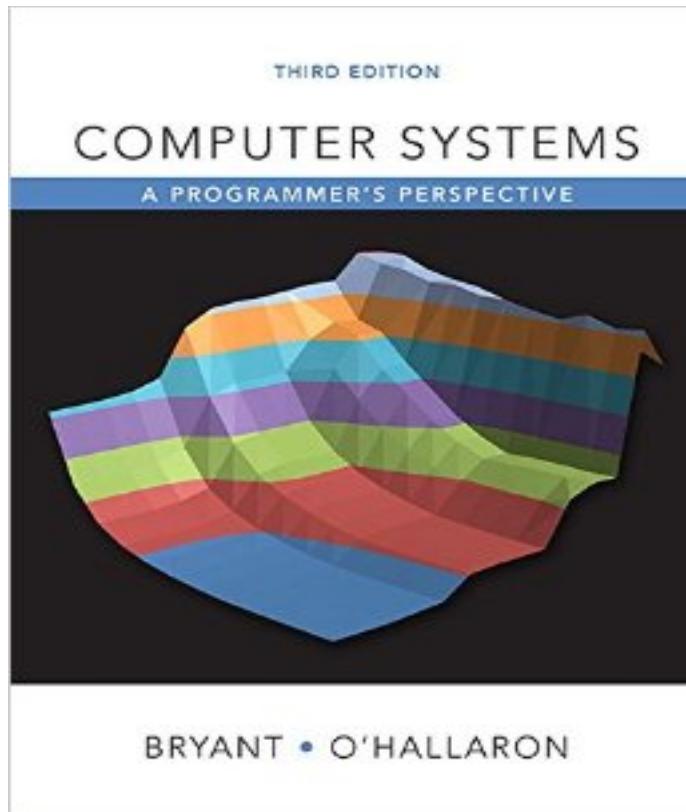
Jingyu Liu

Grader

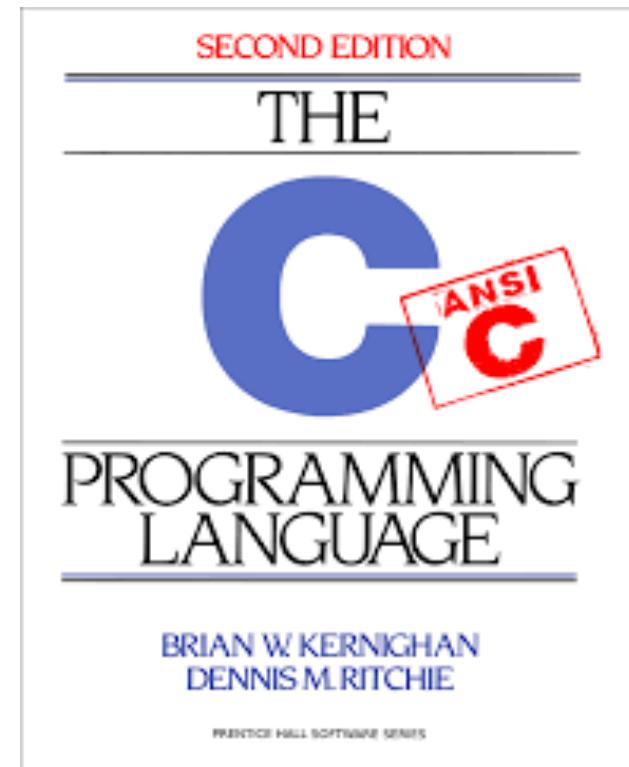
cso-staff@cs.nyu.edu

Before Class

Read the related sections in the text books



“Computer Systems: A Programmer’s Perspective, 3rd 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 11:00pm on the due date
- Everybody has 5 grace days (incremented at half day granularity)
- Zero score after the due

Class Info

<http://news.cs.nyu.edu/~jinyang/fa18-cso/>

Recitation starts tomorrow,
bring your laptop to class

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.

**Do not turn in labs/exercises that are not yours
You won't fail because of one missing lab**

Integrity and Collaboration Policy

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