CSC 252: Computer Organization
Spring 2020: Lecture 1

Instructor: Yuhao Zhu

Department of Computer Science
University of Rochester

Action Items:

- **Get CSUG account**
- **Sign up for Blackboard**

NOKIA
17:31
Freigabe

NOKIA
1
2 abc
def 3
4 ghi
5 jkl
mno 6
7 pqrs
8 tuv
wxyz 9
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#

Snake
circa **2000**

Snake
circa **2000**

Snake
circa **2020**

Computers are More Capable

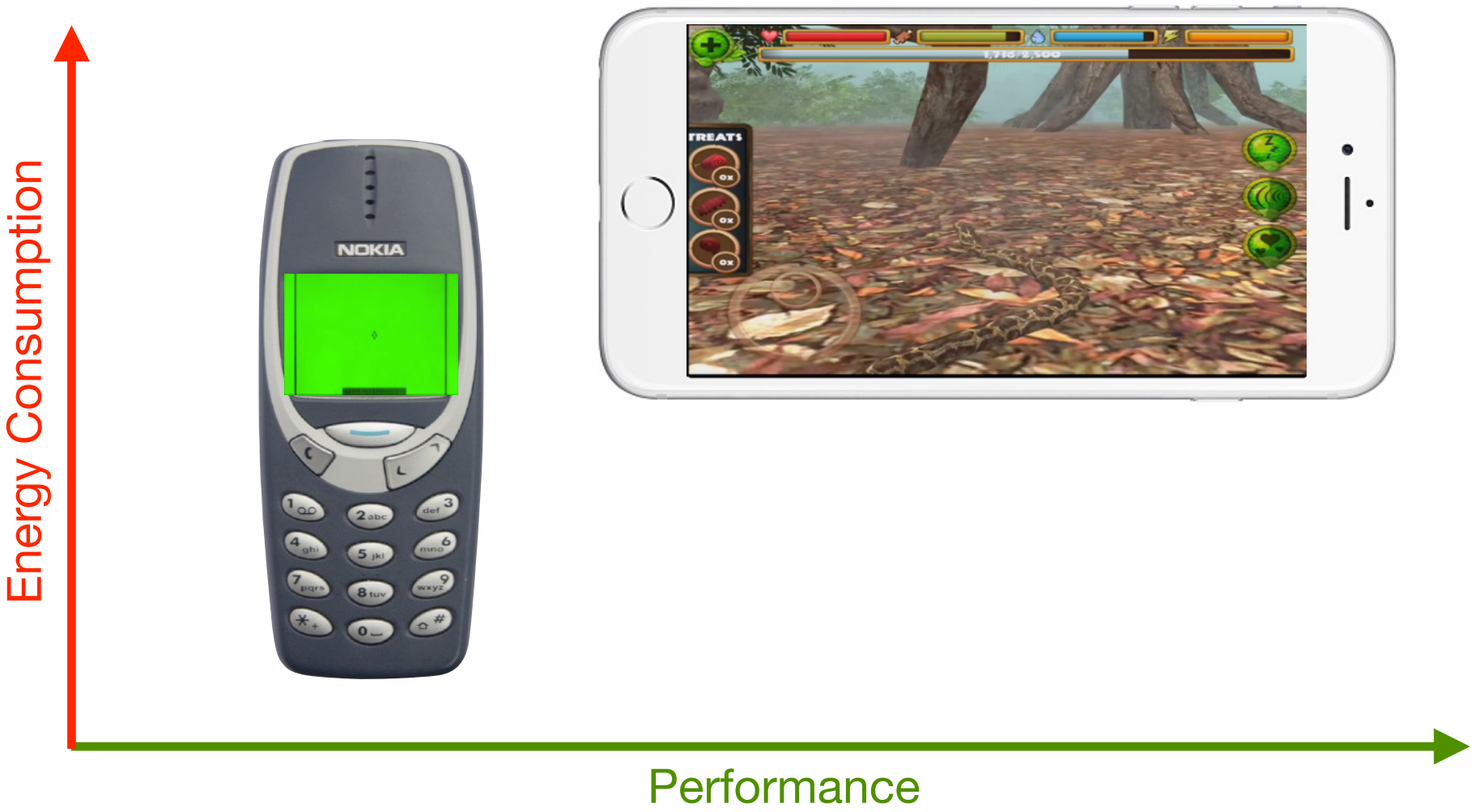
Snake
circa **2000**

Snake
circa **2020**

Computers are More Capable

Performance

Computers are More Capable



“Improving” Energy Capacity

600 smartphone from 2006 to 2014 on http://www.gsmarena.com/makers.php3

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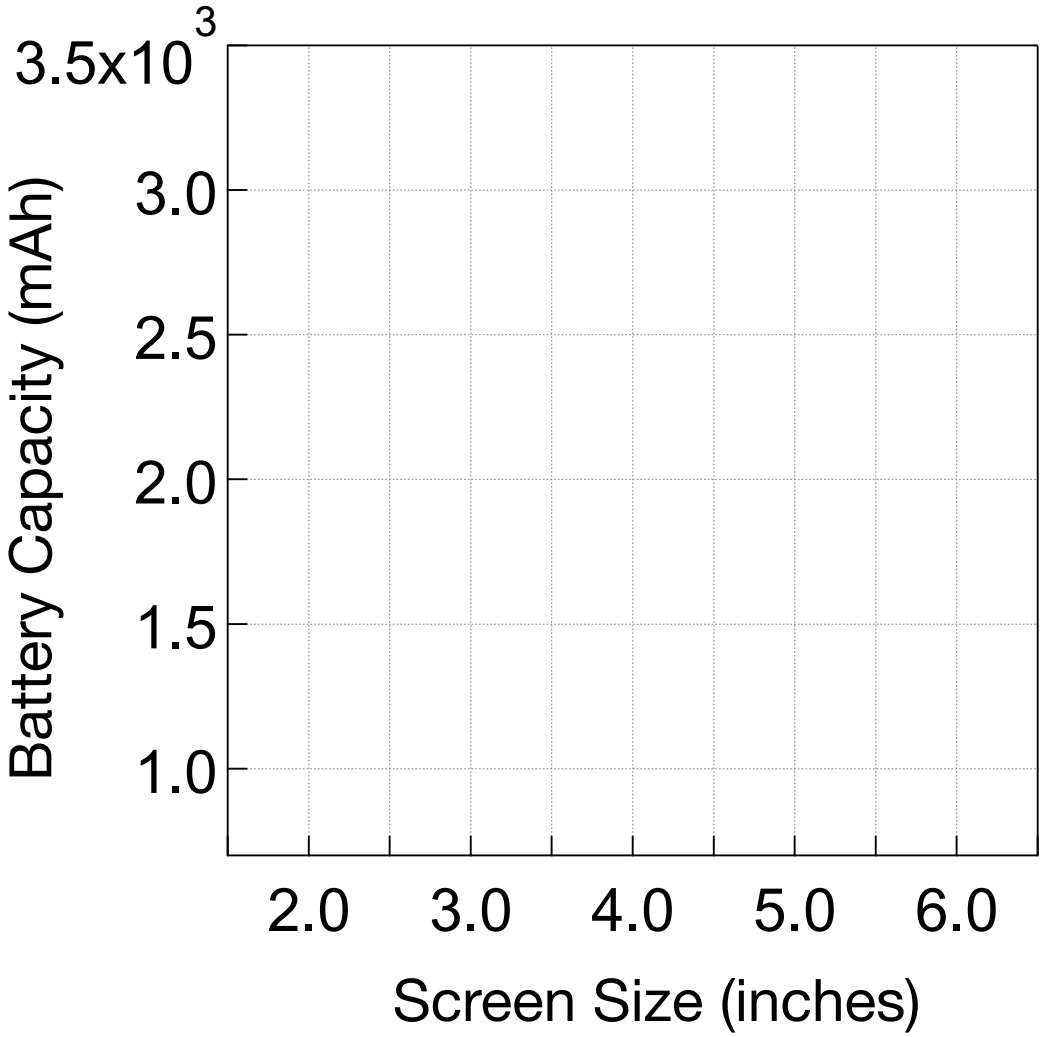

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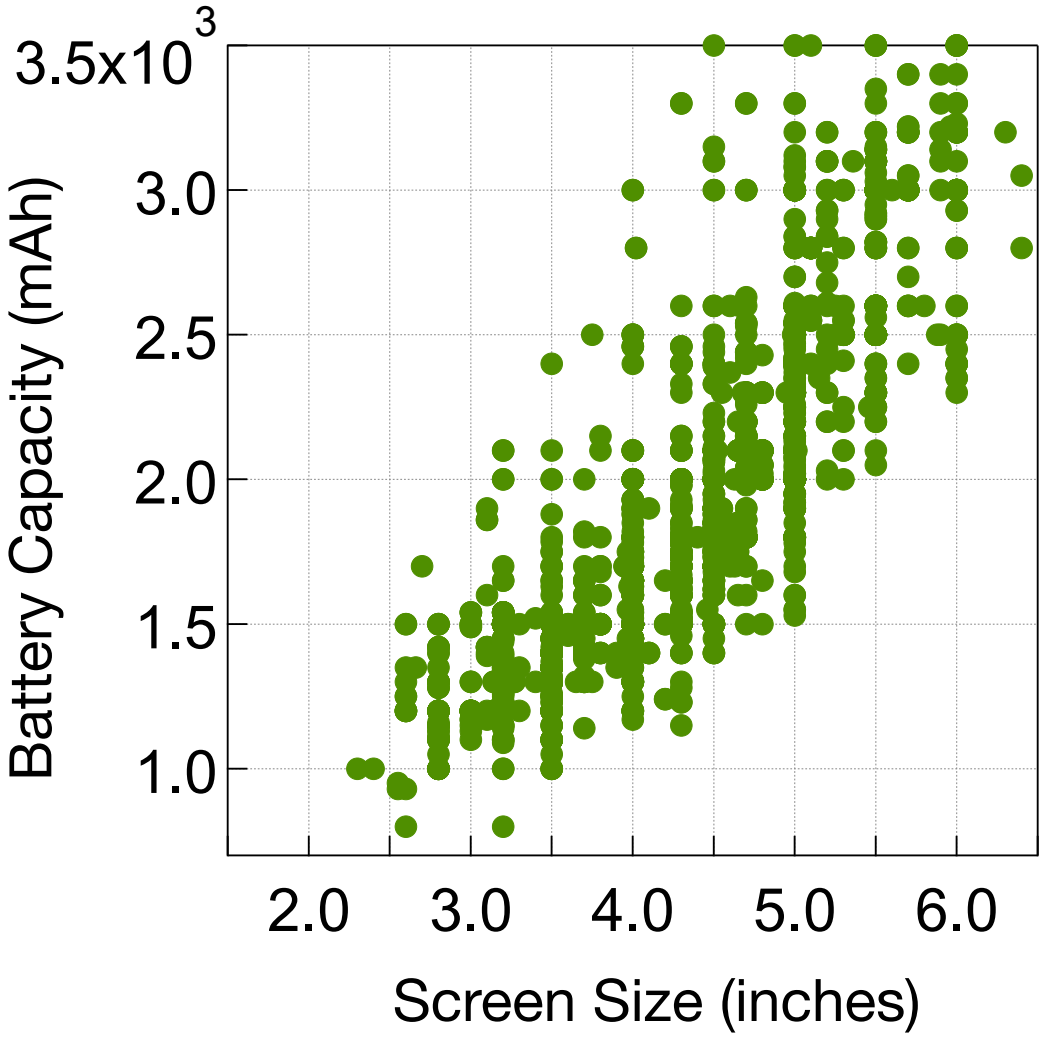

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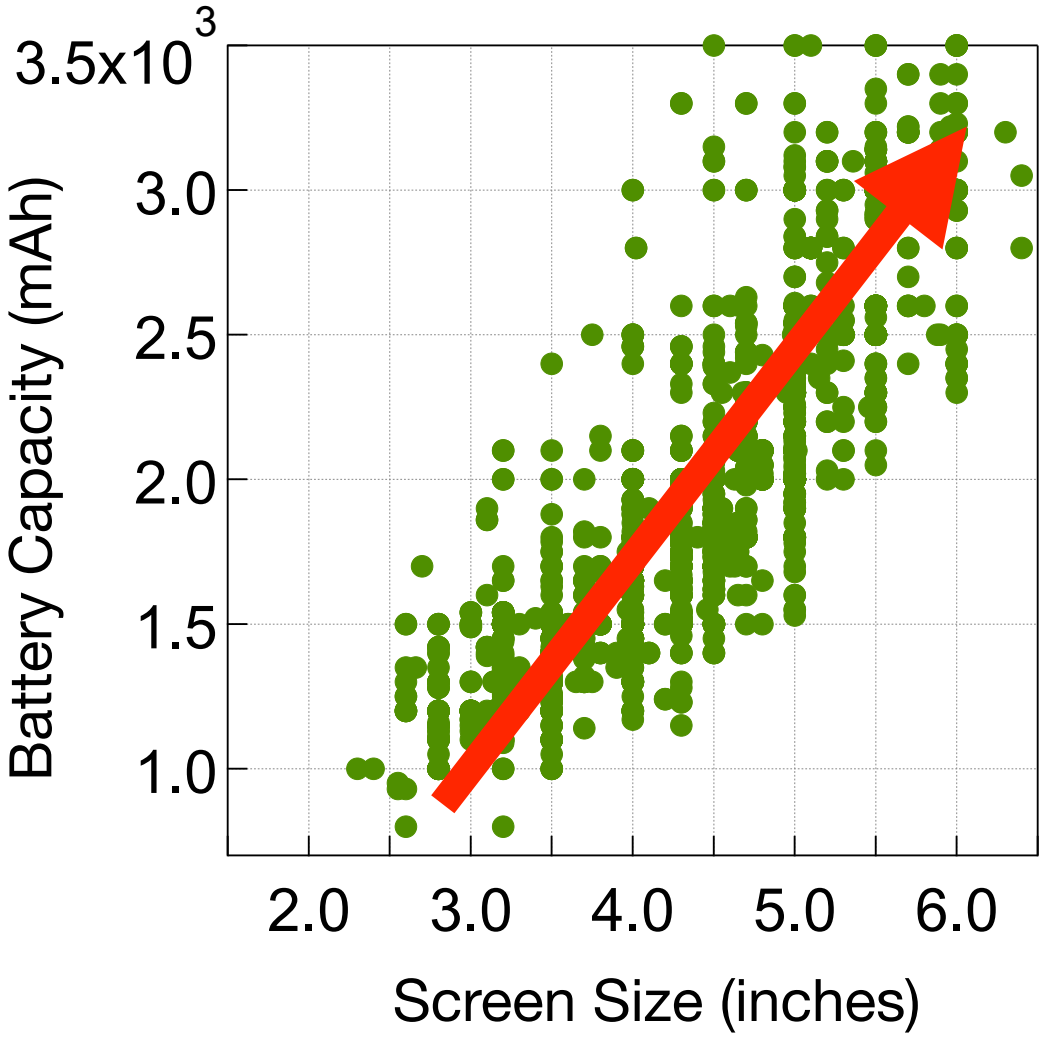

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Which Future Do You Want?

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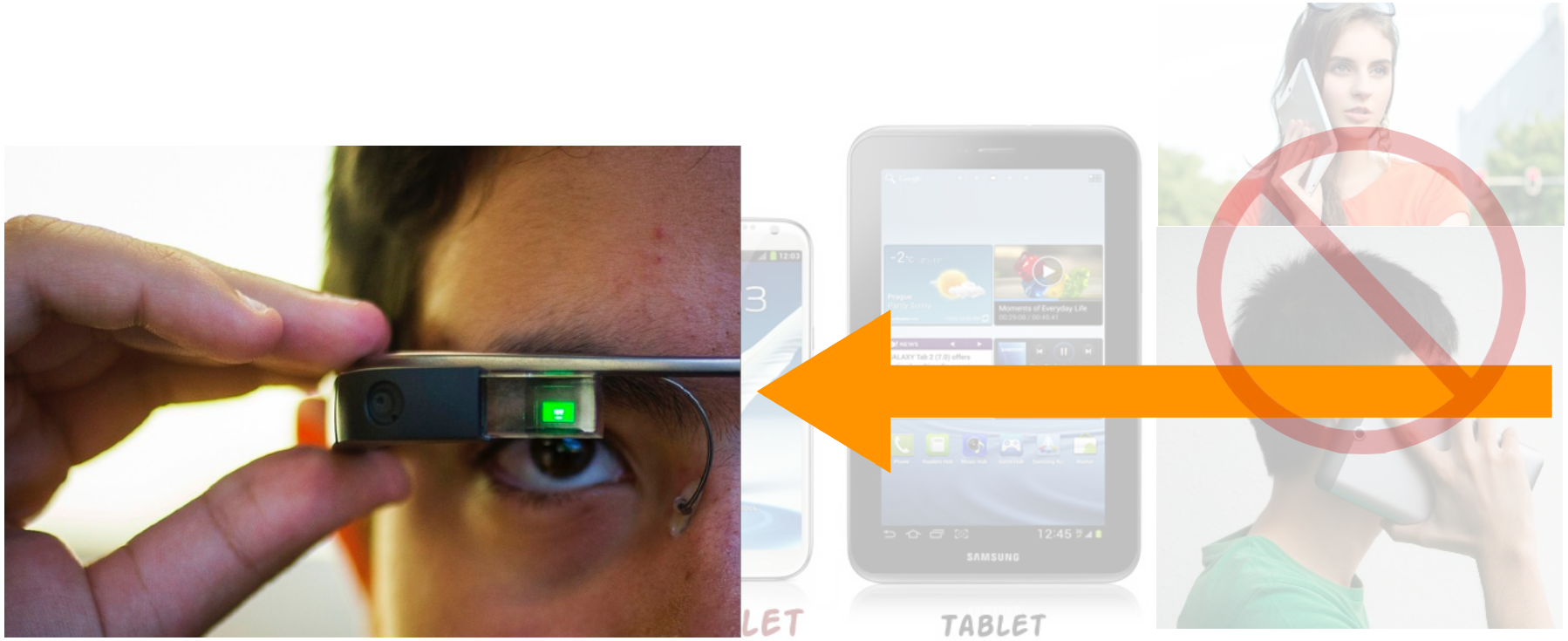
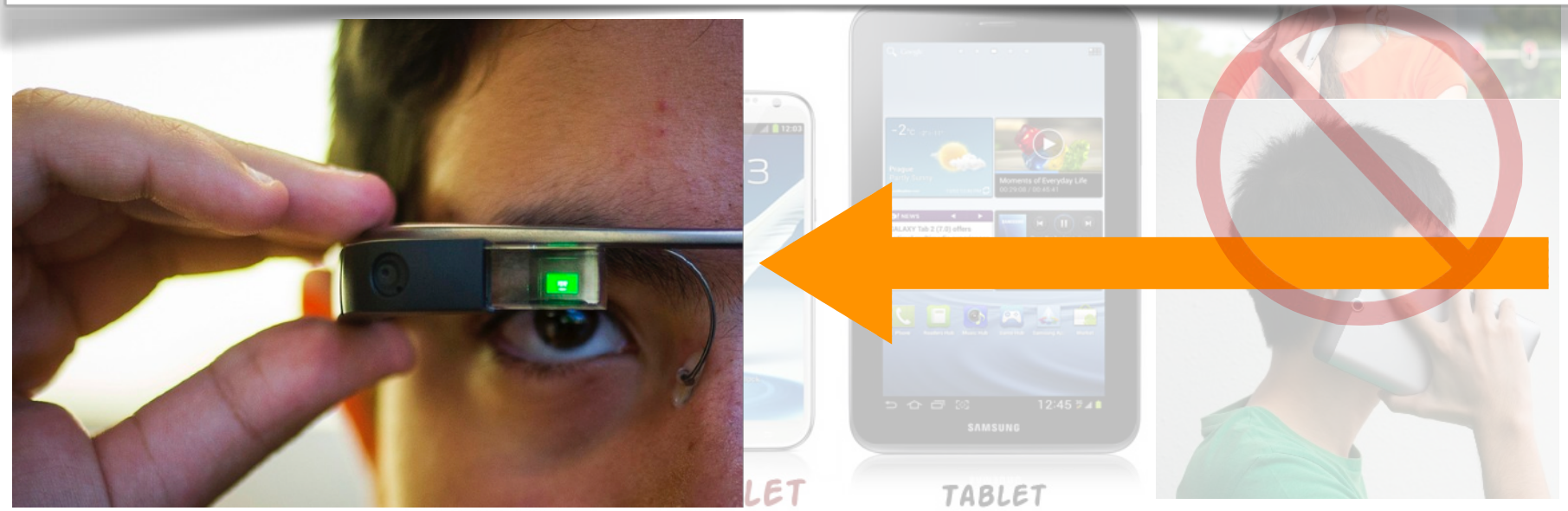


Which Future Do You Want?

How to build ever-more capable computers but with lower energy consumption and smaller form factor?



Outline: Class Introduction

- Introduction
  - What Are You Supposed to Learn in this Class?
    - What Is Computer Organization Anyways?
  - Instructor & TAs
  - What Do I Expect From You?
  - How am I Going to Teach?
  - Grading, Policies
- Action items:
  - **Get a CSUG account.**
    - cycle1.csug.rochester.edu (or cycle2, cycle3)
    - If you don't already have one, go to this link: **https://accounts.csug.rochester.edu/**
  - **Sign up for Blackboard** (https://learn.rochester.edu/)

Where to Find Stuff

- http://cs.rochester.edu/courses/252/spring2020/
  - General info
  - Programming assignments details
  - Slides
  - Practice problems, past exams

- CSUG machines for programming assignments submissions

What is Computer Systems?

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Problem

Who scores the highest on the exam?

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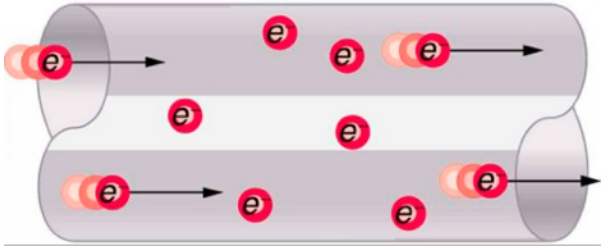

Circuit

Electrons, Resistors, Capacitors, etc.

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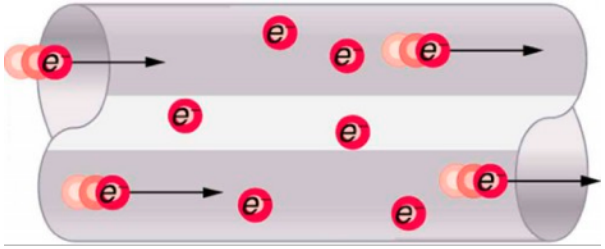

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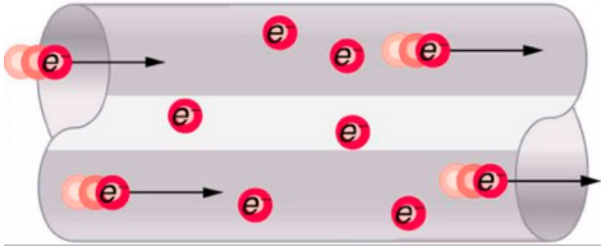

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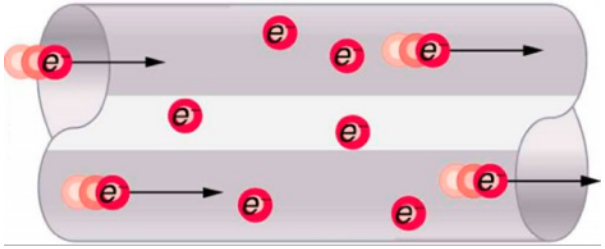

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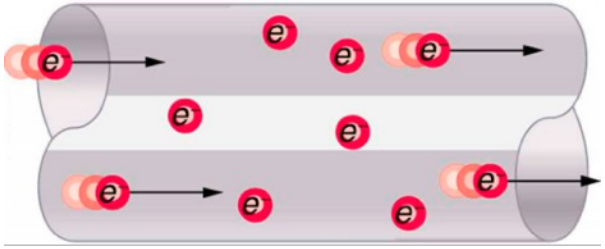

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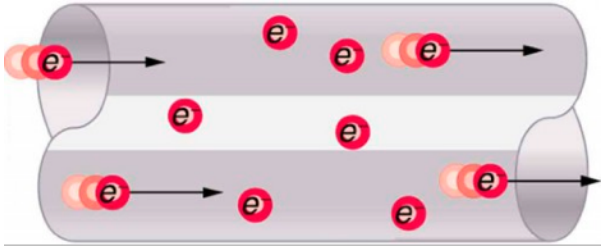

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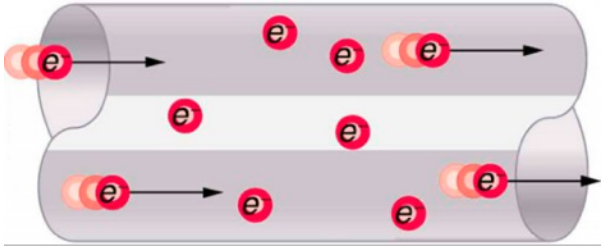

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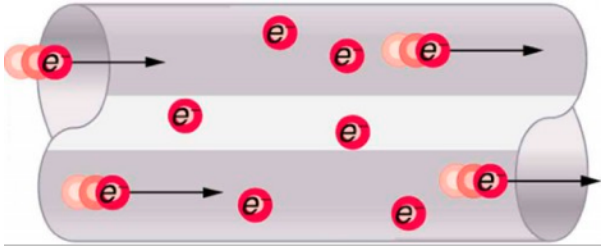

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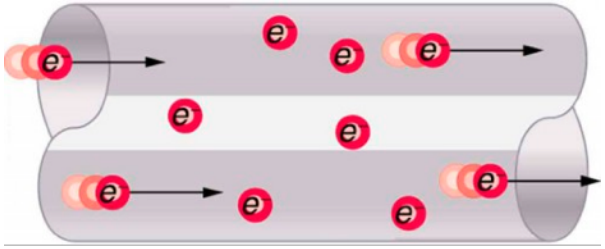

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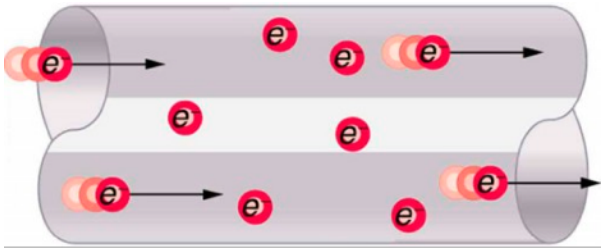

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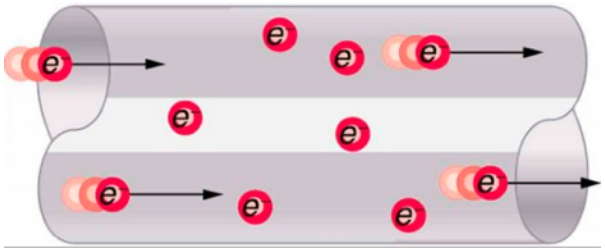

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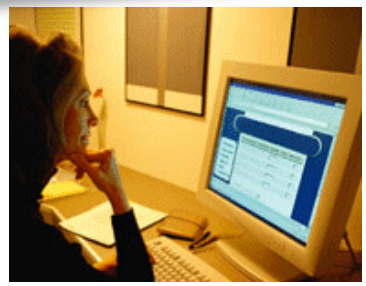
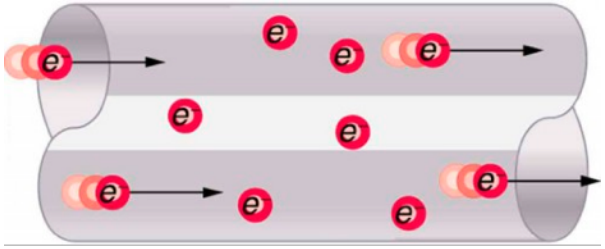
Computer Systems Match User Requirements to Hardware Technologies





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The “Translation” Process, a.k.a., Compilation

C Program

```
void add() {
  int a = 1;
  int b = 2;
  int c = a + b;
}
```

Pre-processor
Compiler

Assembly program

```
movl    $1, -4(%rbp)
movl    $2, -8(%rbp)
movl    -4(%rbp), %eax
addl    -8(%rbp), %eax
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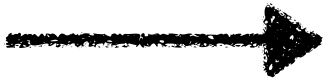
Assembler
Linker



Executable Binary

```
00011001   …
01101010   …
11010101   …
01110001   …
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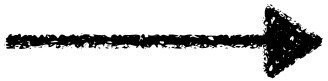

Executable Binary

```
00011001   …
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01110001   …
```

- It translates a text file to an executable binary file (a.k.a., executable) consisting of a sequence of instructions
- Why binary? Computers understand only 0s and 1s
  - The subject of next lecture

Back to Layers of Transformation…

How is a human-readable program translated to a representation that computers can understand?

How does a modern computer execute that program?

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The Single Most Important Idea of Computers

- Executables (i.e., instructions) are stored in “memory”
- Processors read instructions from memory and execute instructions one after another

Assembly program: add.s

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movl    $1, -4(%rbp)
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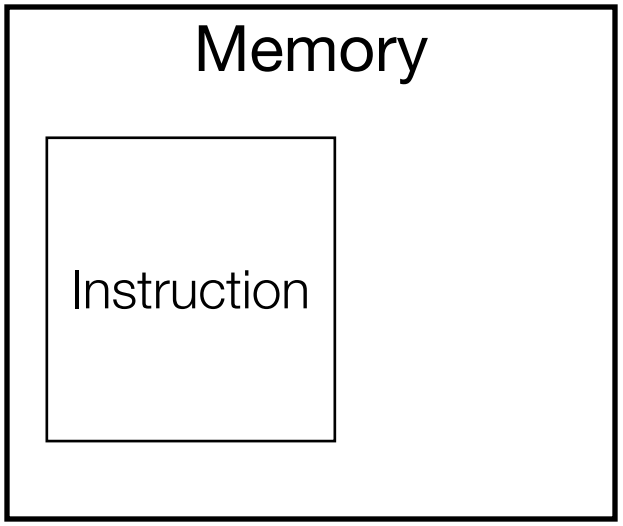

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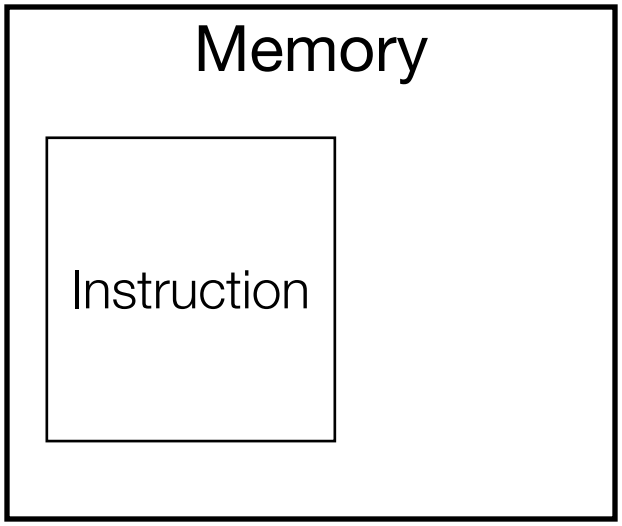

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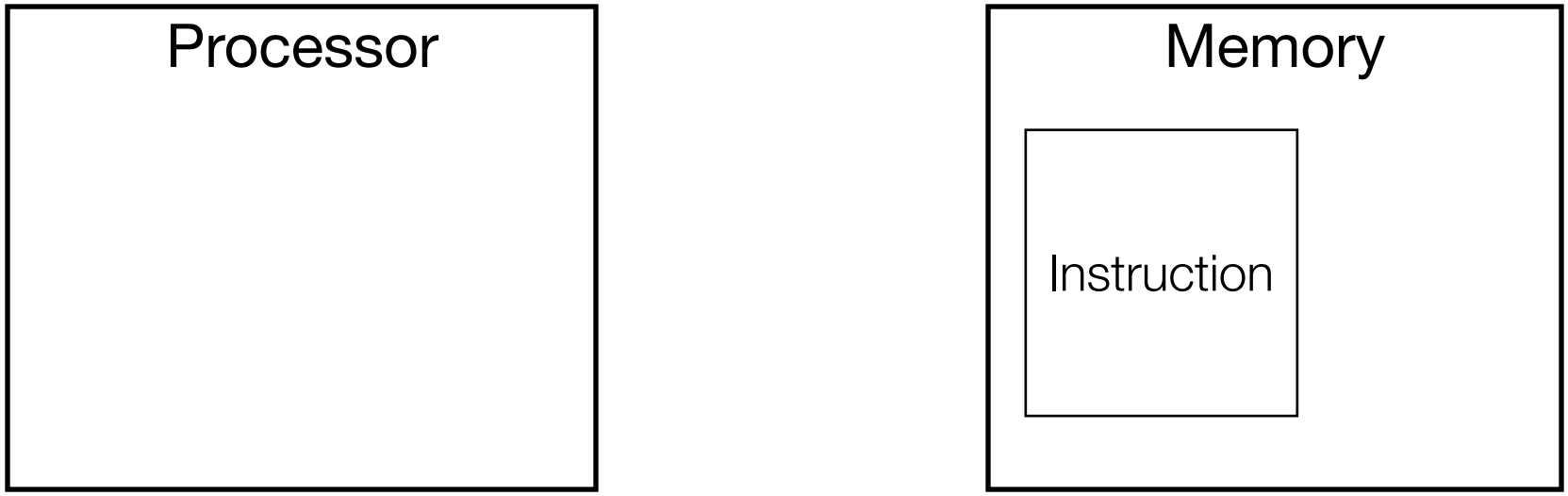

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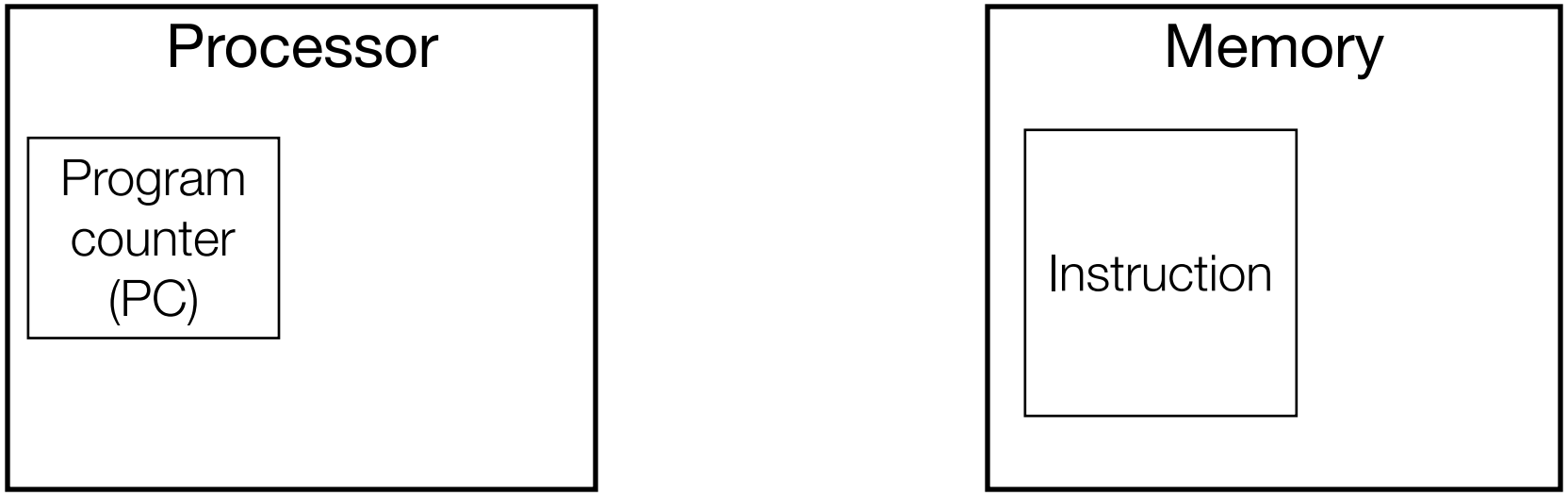
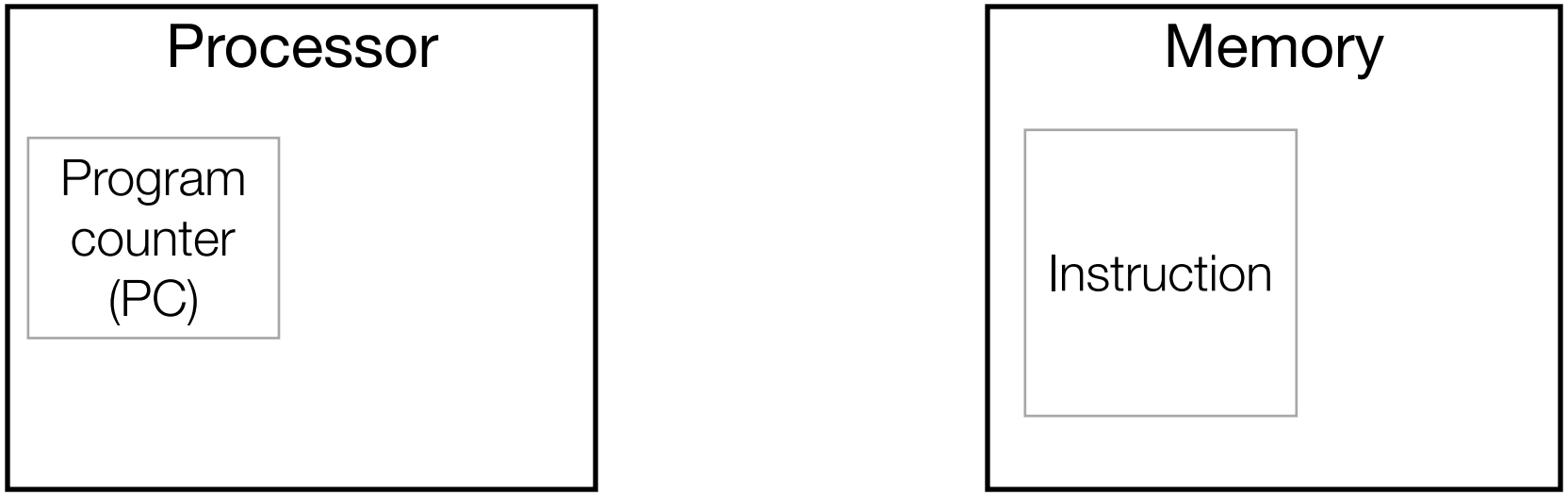


High-level Organization of Computer Hardware a.k.a., The Von Neumann Model



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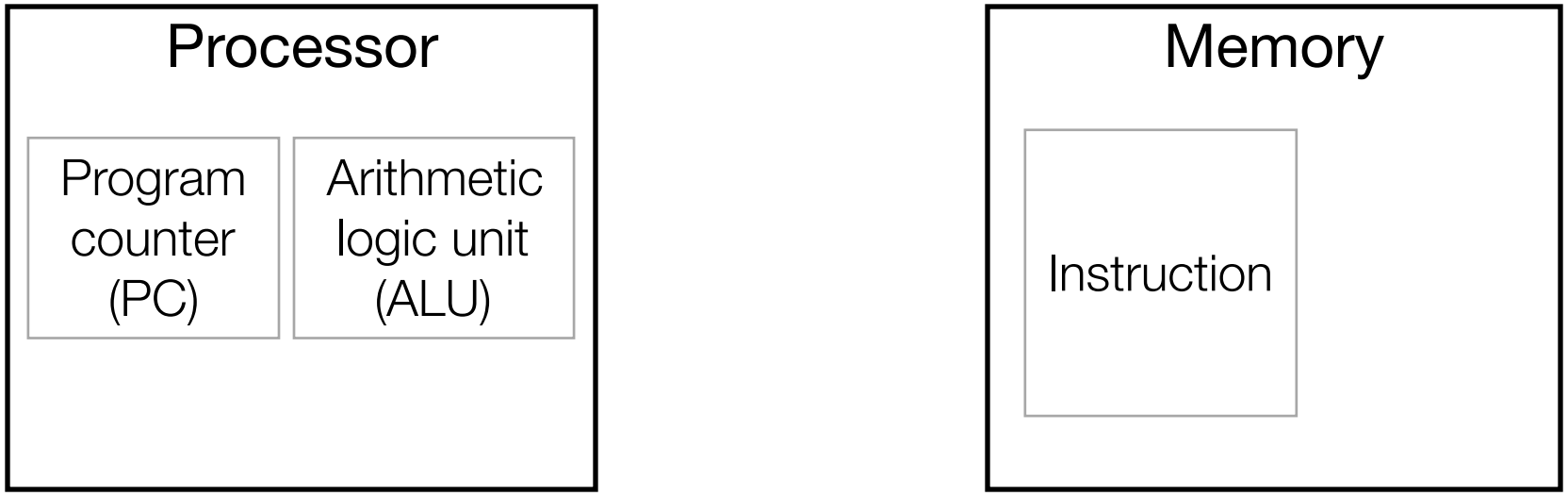

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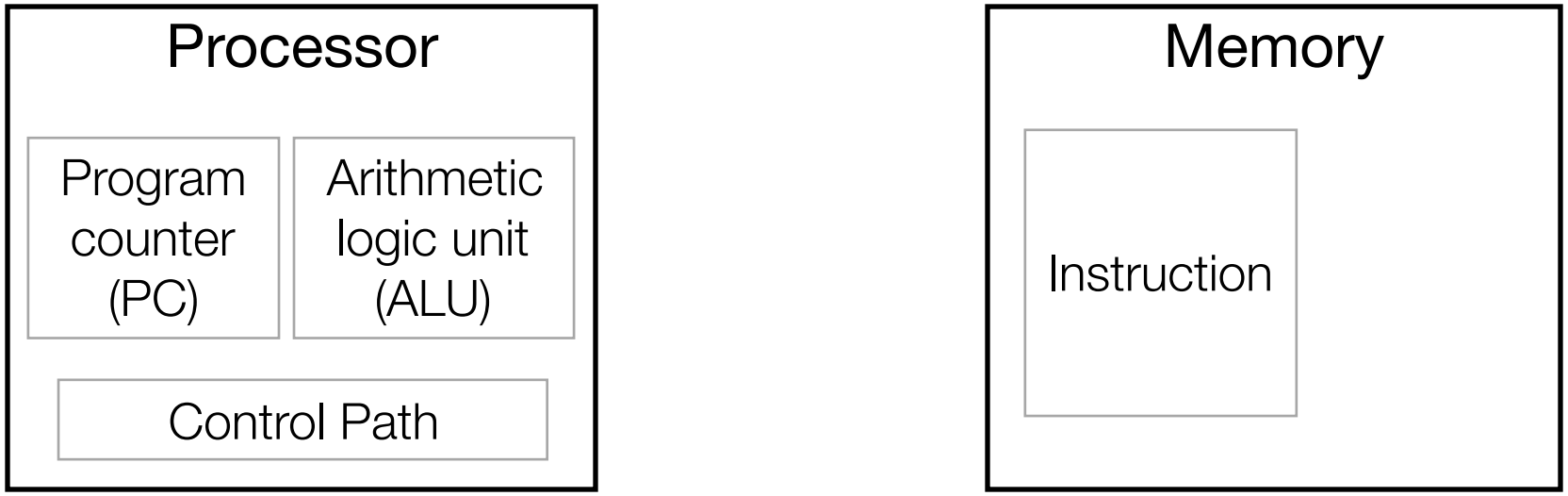

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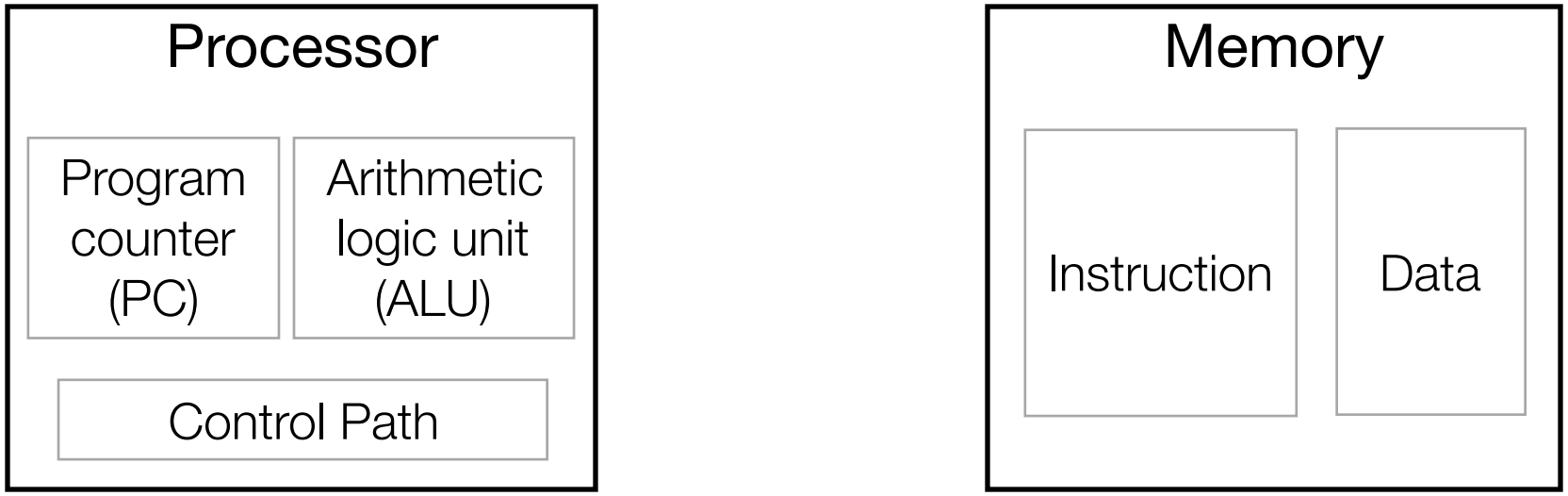

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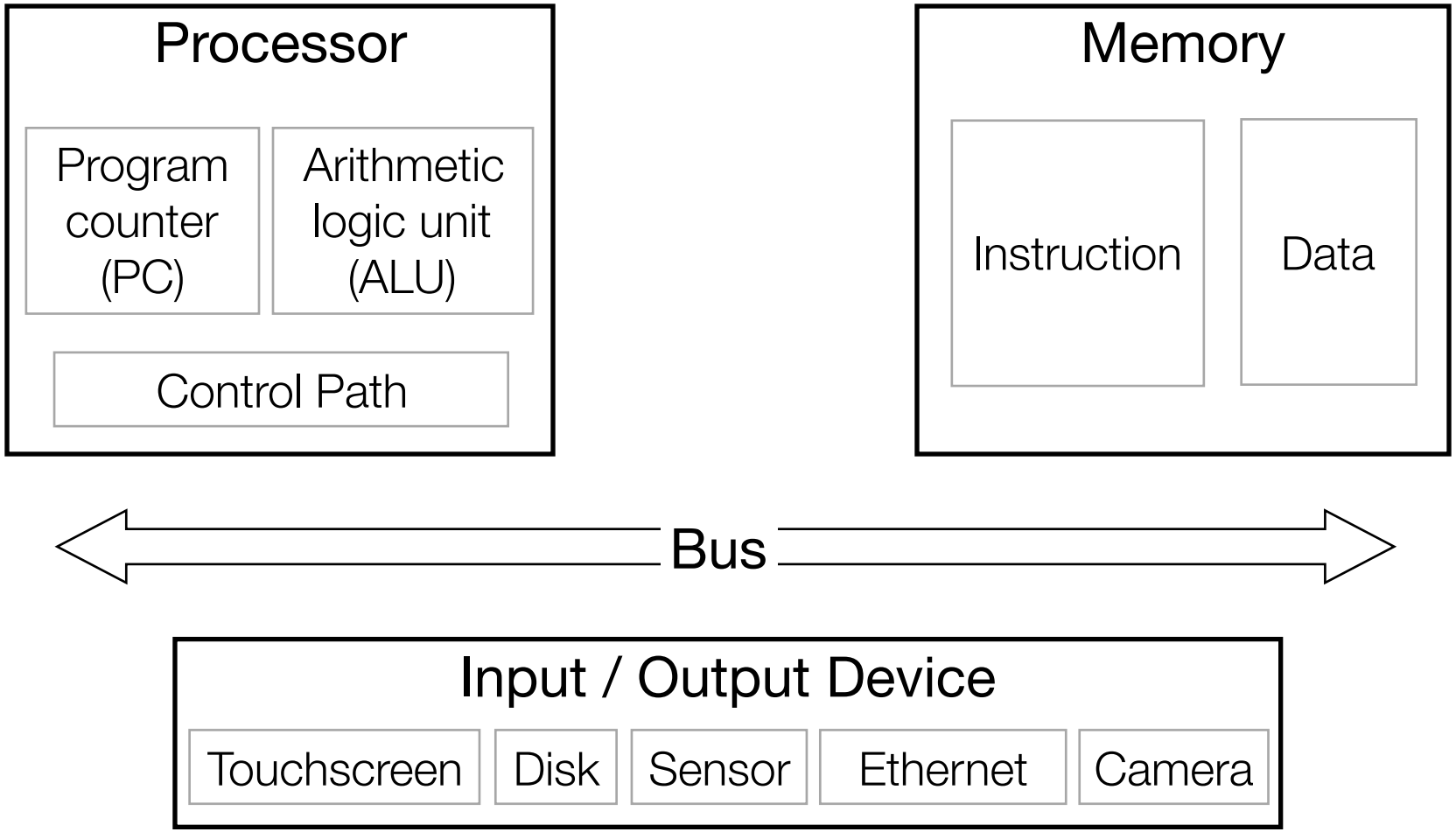

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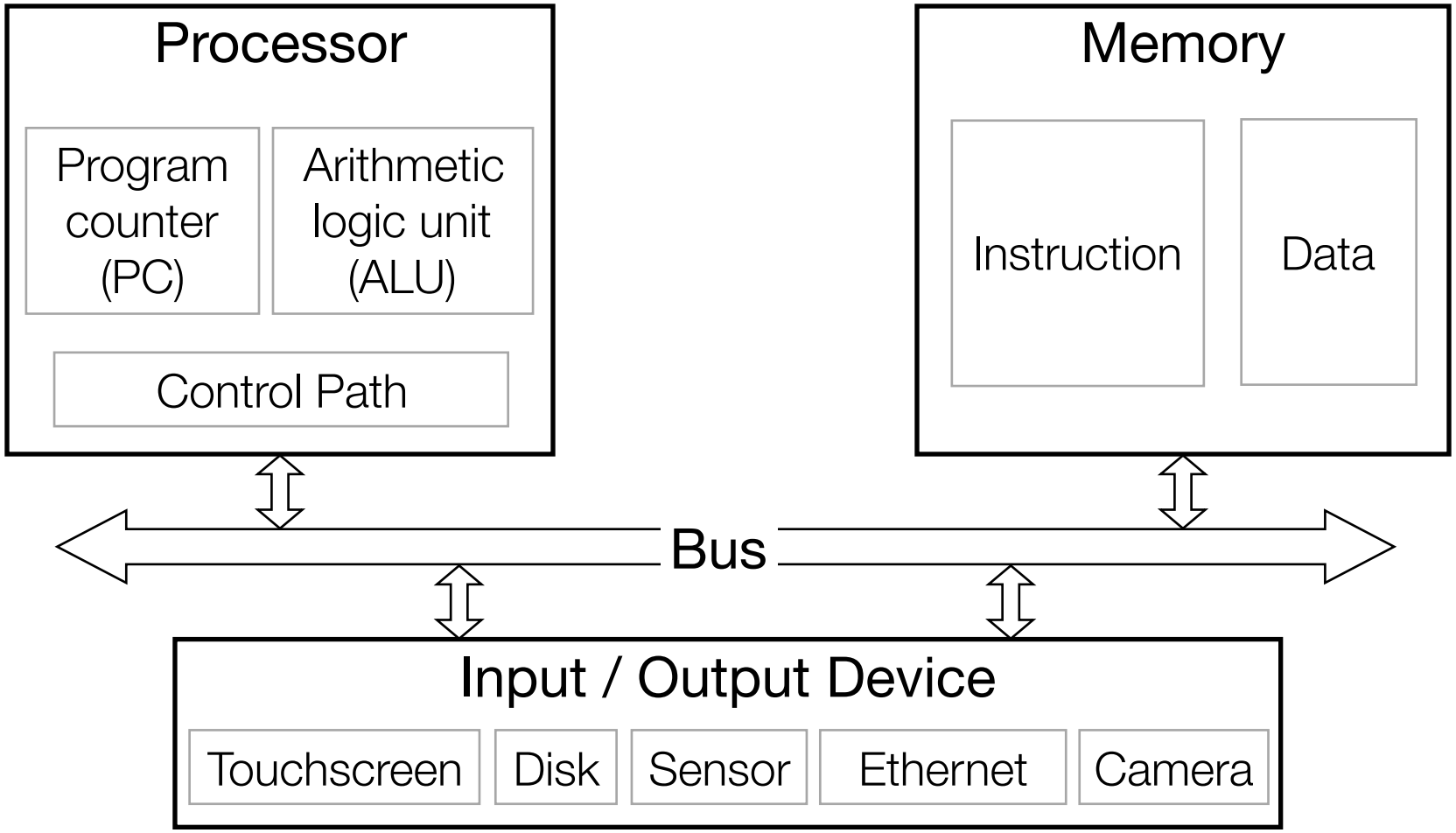

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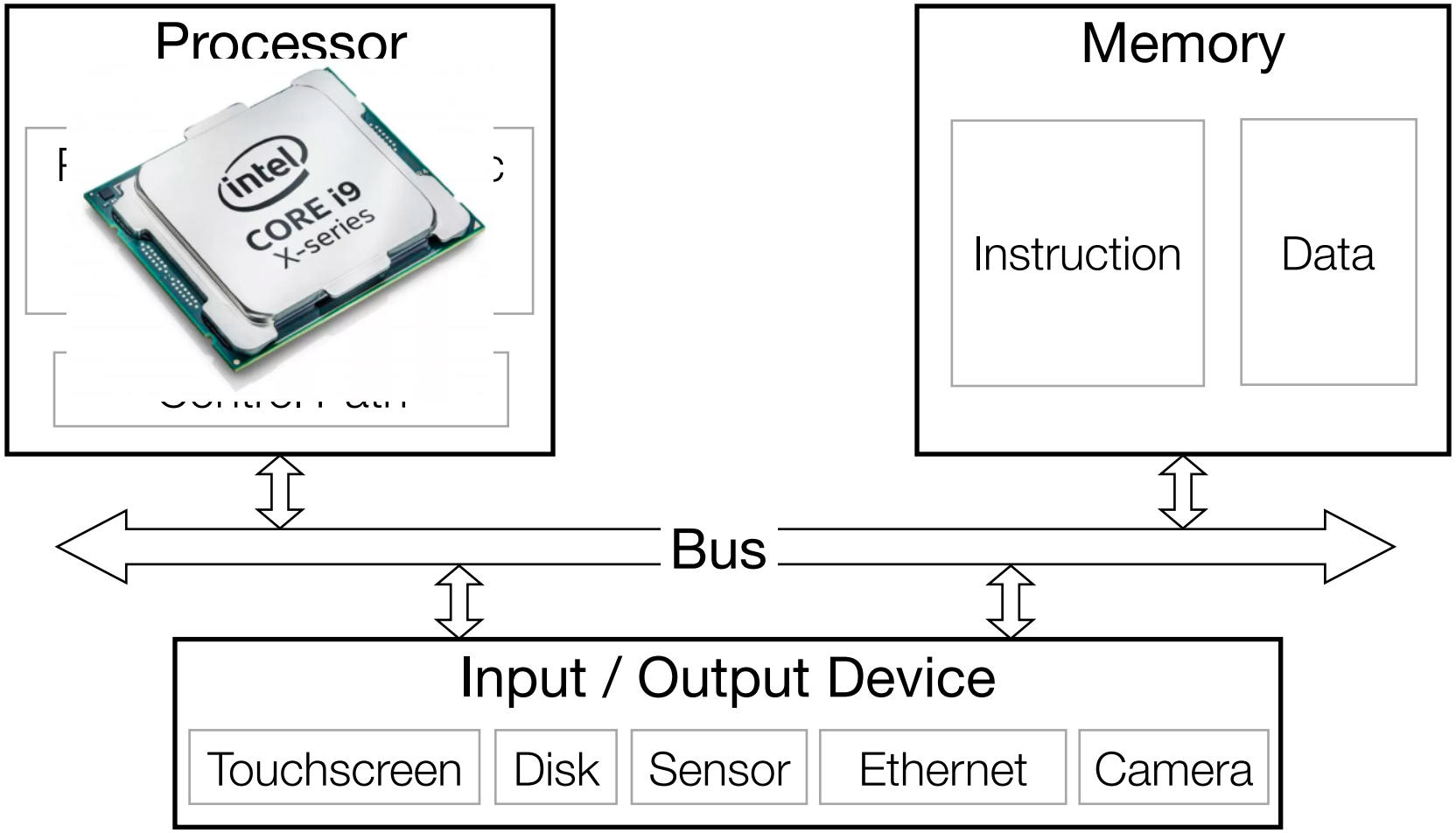

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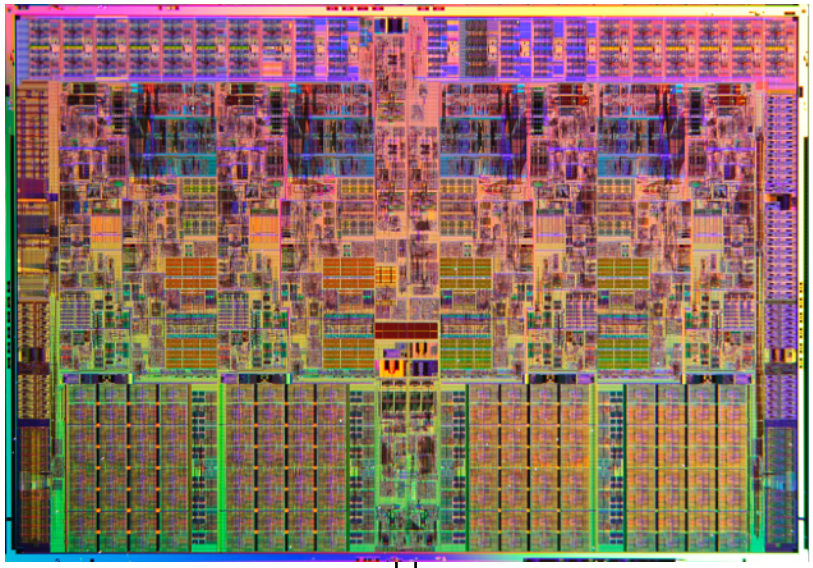

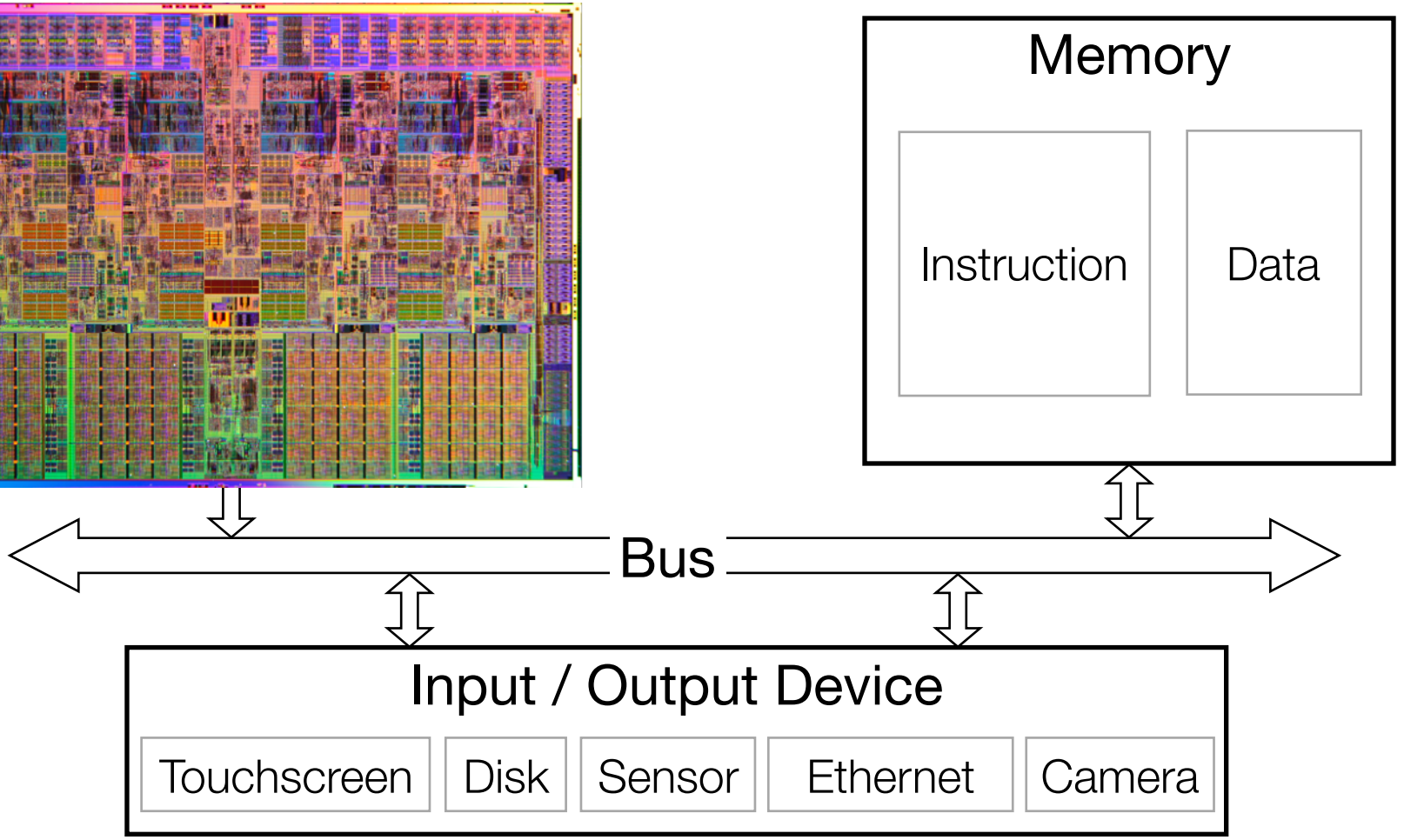

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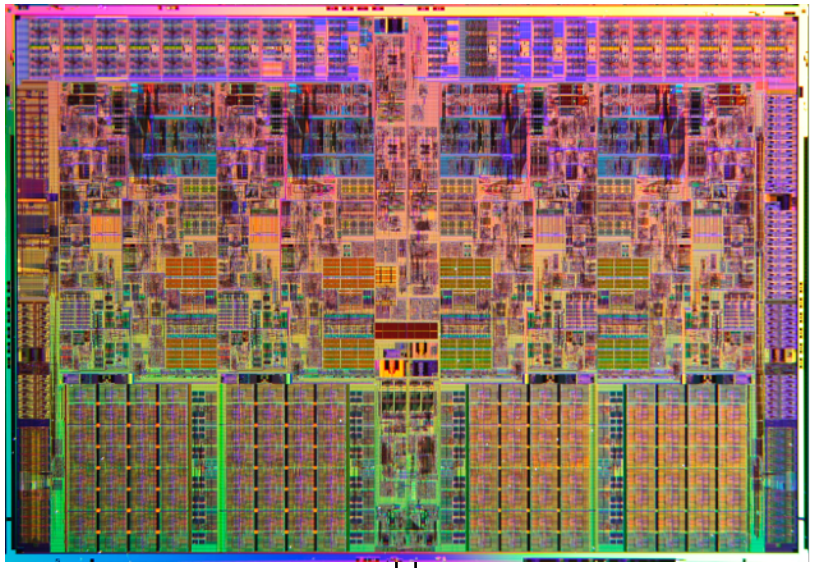

Memory

Bus

Input / Output Device

Touchscreen | Disk | Sensor | Ethernet | Camera

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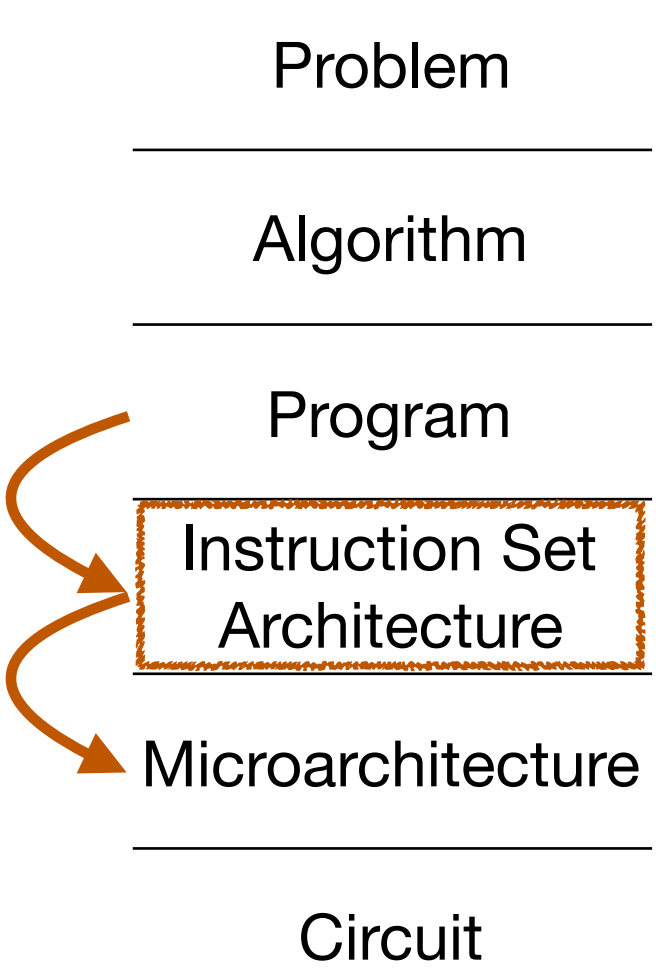

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Quicksort

Human-readable language (Java, C)

Machine Language

Hardware Design

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Instruction Set Architecture

- The assembly language's view of the computer is called the "instruction set architecture" (*ISA*)

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Instruction Set Architecture

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- No need to care how the instructions are implemented as long as they are somehow implemented
- Implementation of an ISA is called *microarchitecture*

Assembly program: add.s

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movl    -4(%rbp), %eax
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…
callq   _printf
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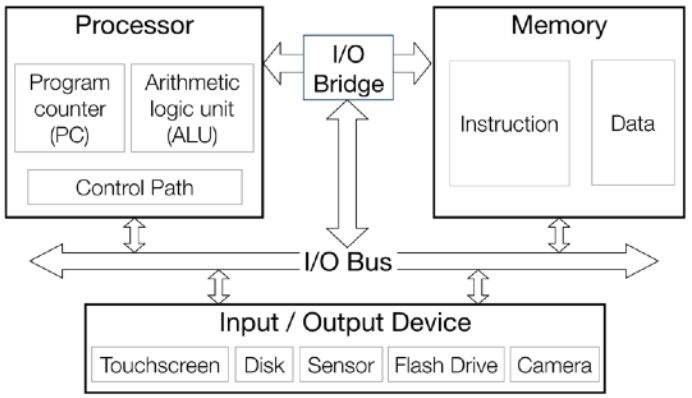

Instruction Set Architecture

- The assembly language's view of the computer is called the "instruction set architecture" (*ISA*)
- No need to care how the instructions are implemented as long as they are somehow implemented
- Implementation of an ISA is called *microarchitecture*
- ISAs *abstract* away details of microarchitecture

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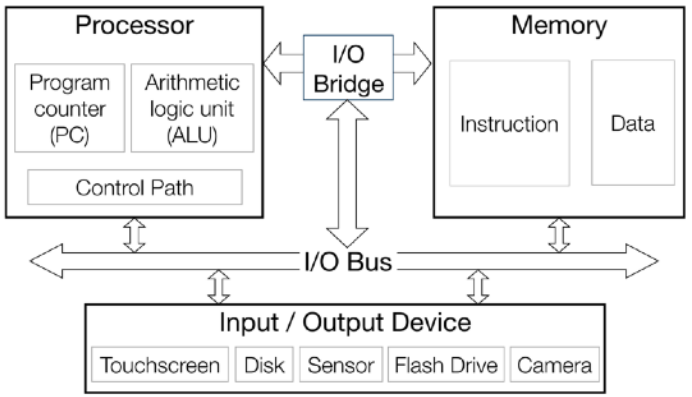

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  - ISA leaves out *how* “ADD” is implemented
  - ISA also leaves our *how long* an “ADD” instruction takes
- Bad abstractions throw away essential features of problem
  - Topologist is someone who does not know the difference between a doughnut and coffee-cup
  - Bad ISAs don’t tell you the hardware can do multiplication

Every Layer in CS is an Abstraction

Problem	Who scores the highest on the exam?
Algorithm	Quicksort
Program	Human-readable language (Java, C)
Instruction Set Architecture	Machine Language
Microarchitecture	Hardware Design
Circuit	Electrons, Resistors, Capacitors, etc.

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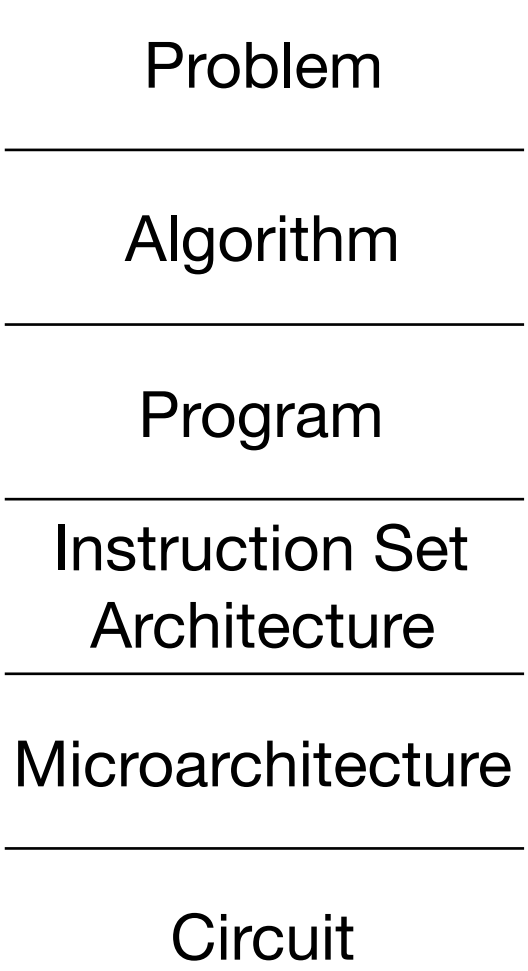
- Depend on which layer you want to live at, you have different views of the computer



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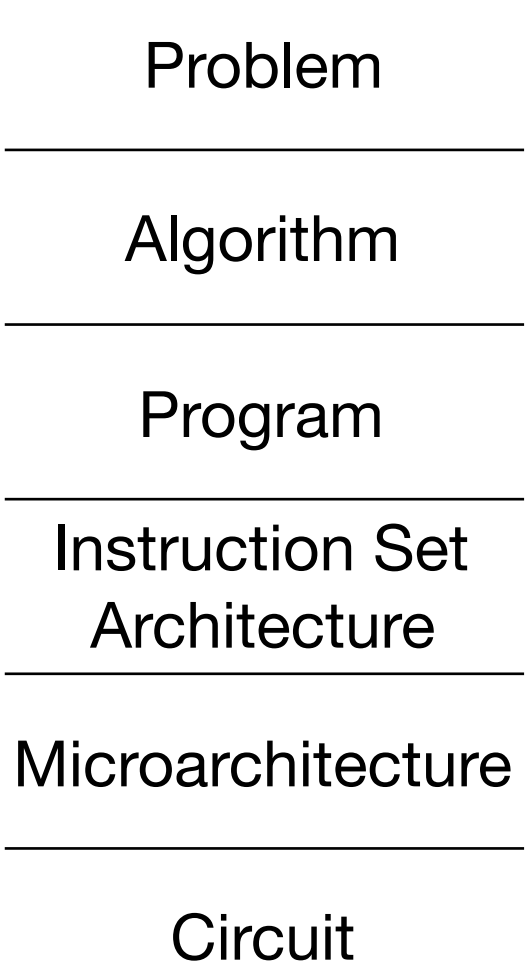
- This course expands your layers of abstractions



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- ISA is lucrative business: ARM's Business Model
  - Patent the ISA, and then license the ISA
  - Every implementer pays a royalty to ARM
  - Apple/Samsung pays ARM whenever they sell a smartphone

Instruction Set Architecture

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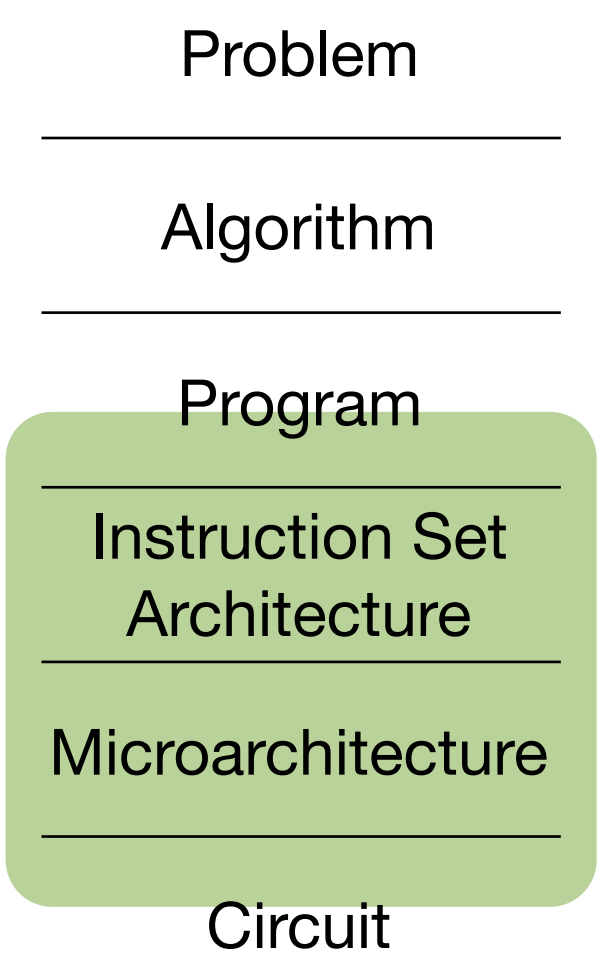
  - E.g., Transmeta executes x86 ISA programs on their own ISA

The Role of a Computer System Designer



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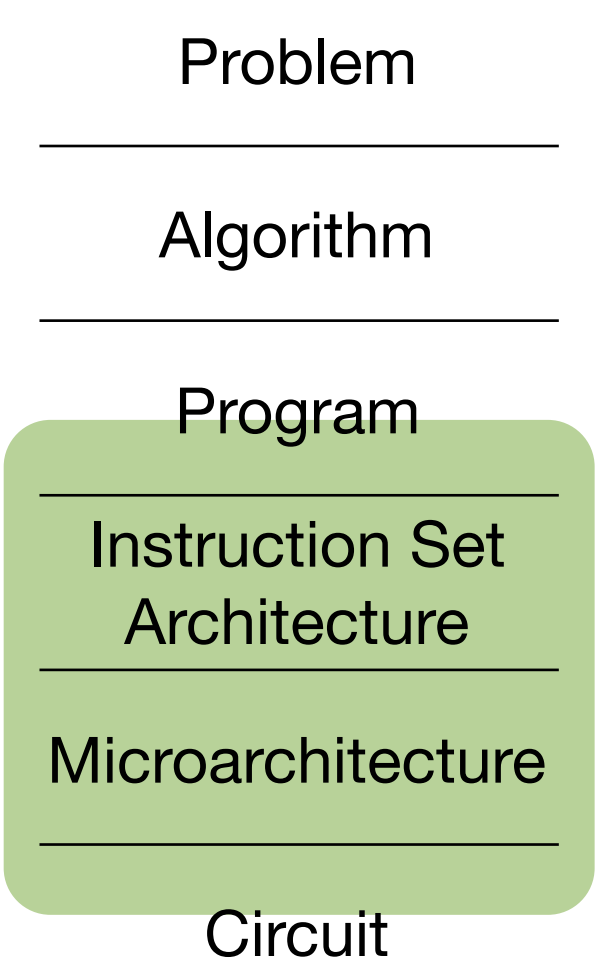

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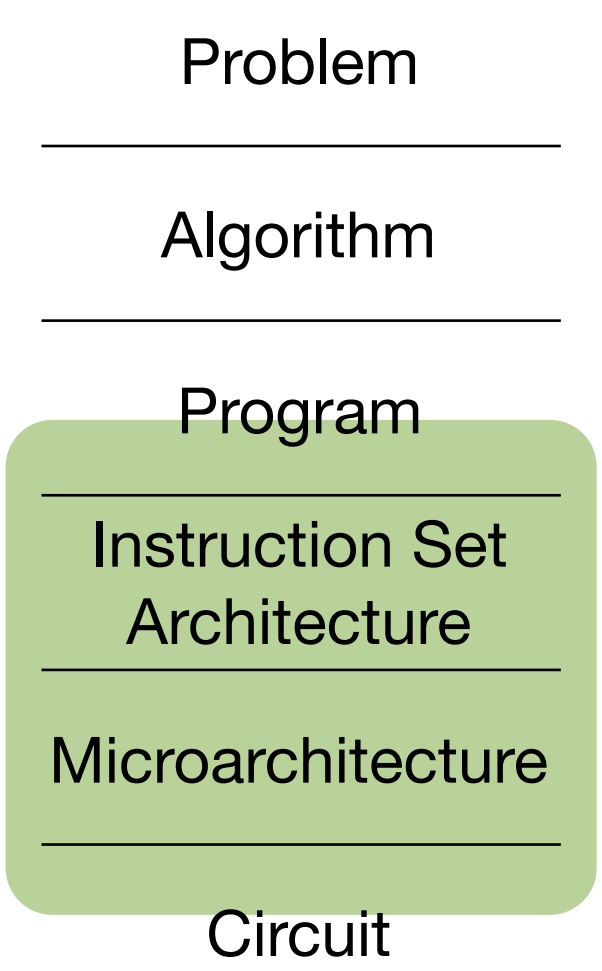

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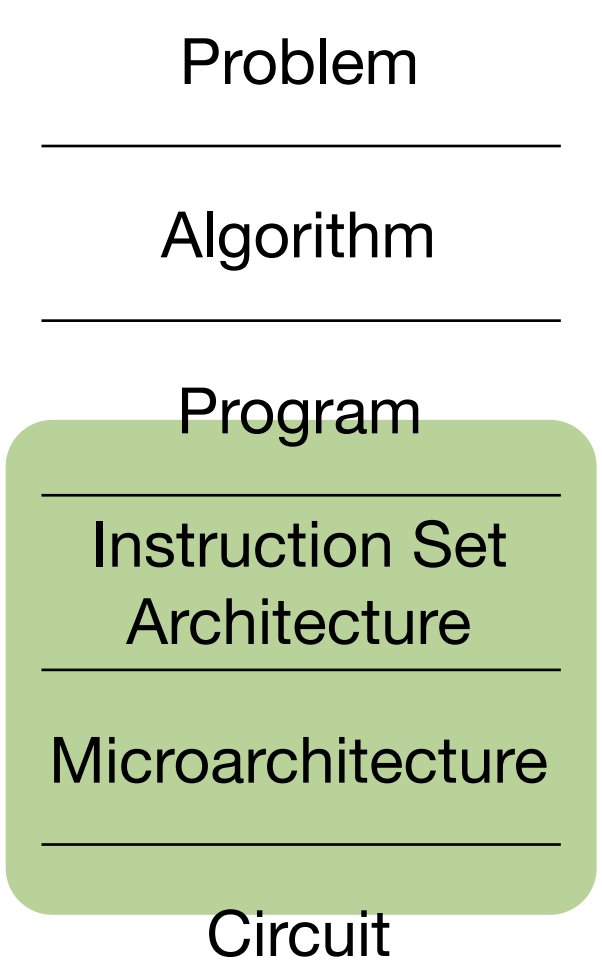

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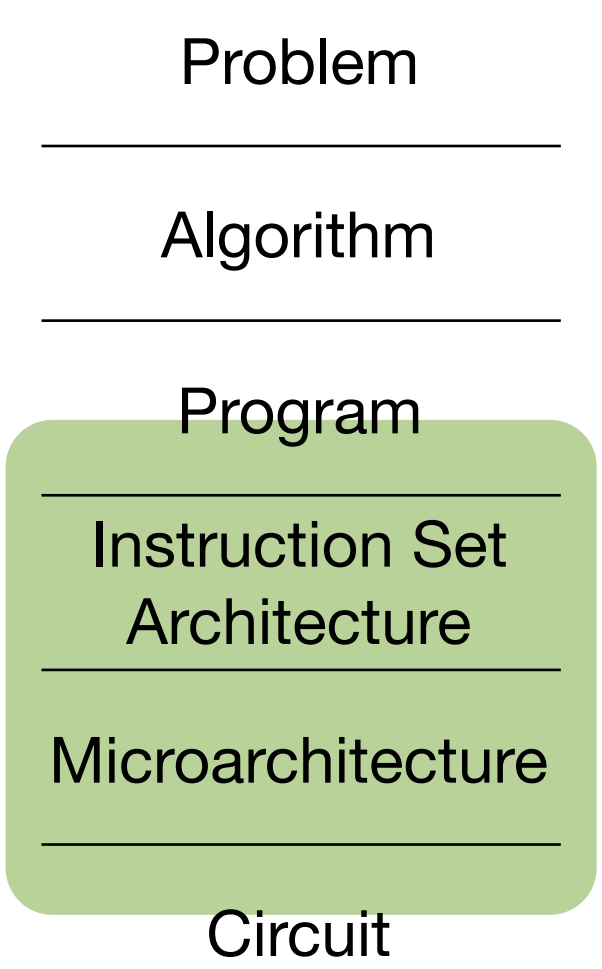

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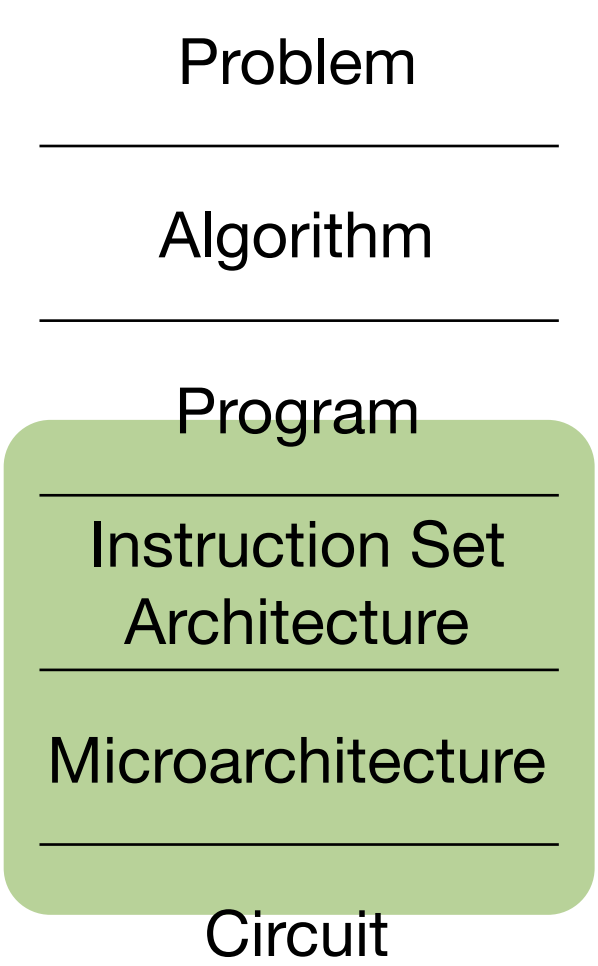

Questions?

Who Are We?

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  - WH 3501, yzhu@rochester.edu
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- **Coming to office hours does NOT mean you are weak!**

A Word about Lectures and Medieval Times

- Lecture: It's a large part of what you pay for

- But why do we have the "lecture" format?
  - Why does someone stand at the front and tell you things?
  - Why do you take "notes" on what they say?

All The Way Back to Medieval Times..

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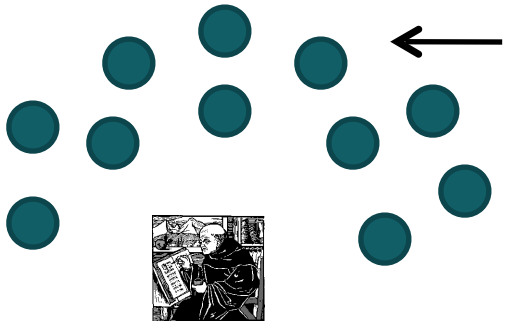

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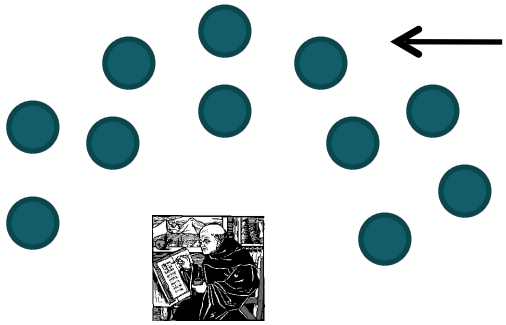
Lecture Halls



people

Modern Times

- You don’t have to trust the monk!
  - The printing press: a revolutionizing development
  - The web: order your knowledge up for yourself on Amazon!
- Read books and analyze for YOURSELF!
  - If I rephrase it for you, what purpose does that serve?

amazon.com

FAQ: "But, wouldn't it be more efficient if you just taught us with the right answer to begin with?"

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- Have you ever heard of a workout class where the instructor did all the exercises while everyone else just watched attentively?
- To learn, you must do the work with your own muscle (brain)!

Textbook

- Required textbook
  - Bryant and O'Hallaron's *Computer Systems: A Programmer's Perspective* (3rd edition)
  - In the past, students got As without owning the textbook

- Some recommended (but not required) textbooks
  - *Introduction to Computing Systems: From Bits and Gates to C and Beyond*, 2/e. This is where I learnt Computer Systems.
  - *Structured Computer Organization*, 6/e. More emphasis on SW.
  - *Computer Organization and Design: The Hardware Software Interface*, ARM Edition. More emphasis on hardware.

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- 1 comprehensive final exam, 30%

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- Share ideas but not artifacts (e.g., code, sketch)

Programming Environment

- Develop code (or at least test it) on the CSUG Linux boxes (csug.rochester.edu)
  - Microsoft Visual Studio could be nice, but it's not what we use
  - The lack of Unix knowledge is a major problem according to our industry contacts
- Projects will be mostly in C and x86 assembly.
- We only accept ANSI-C that can be compiled by the default GCC on the CSUG Linux boxes

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Loved how the final exam was set up. Actually made me THINK.

Programming Assignments and Exams

The assignments were often very different from what we were learning in the course, causing a lot of frustration in the beginning. People had to rely on outside sources to get a grounding of how to do an assignment.

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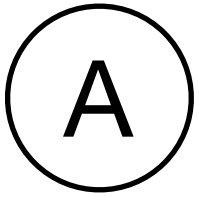

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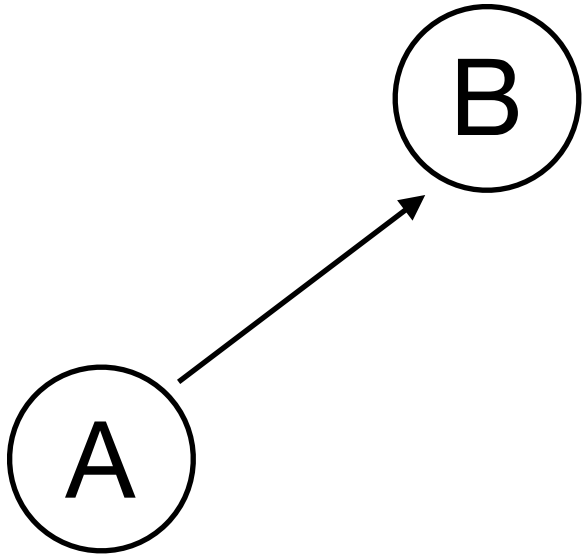

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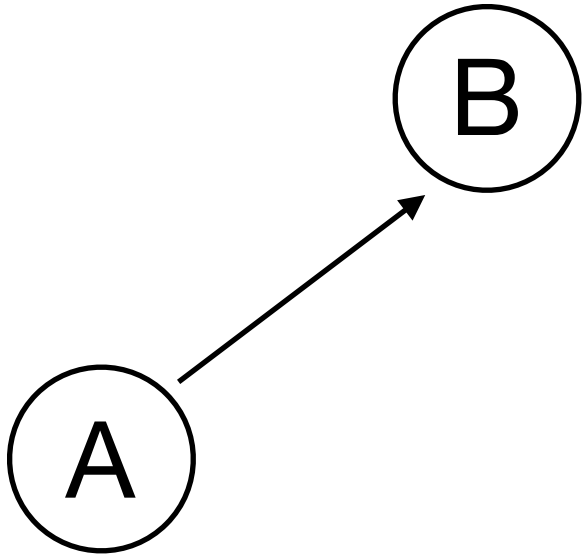

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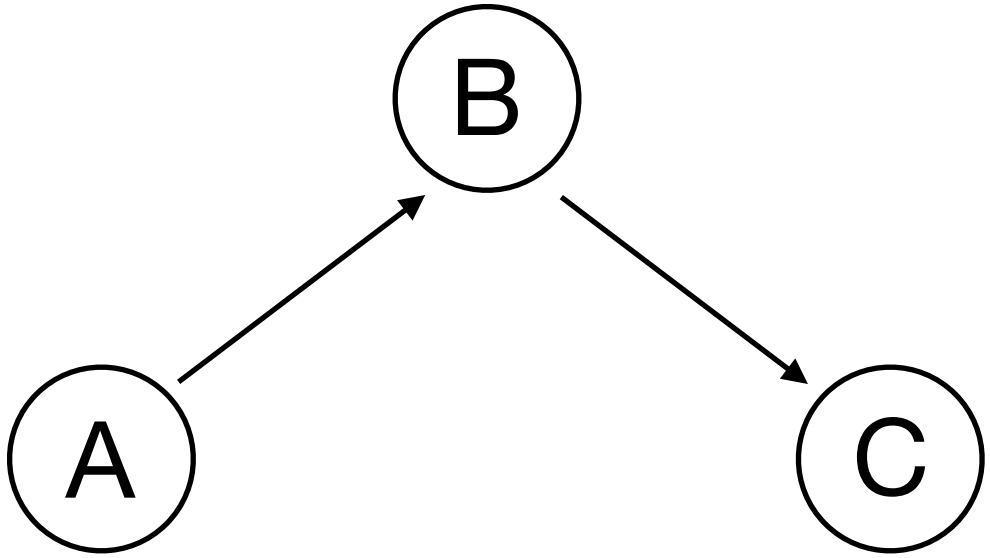

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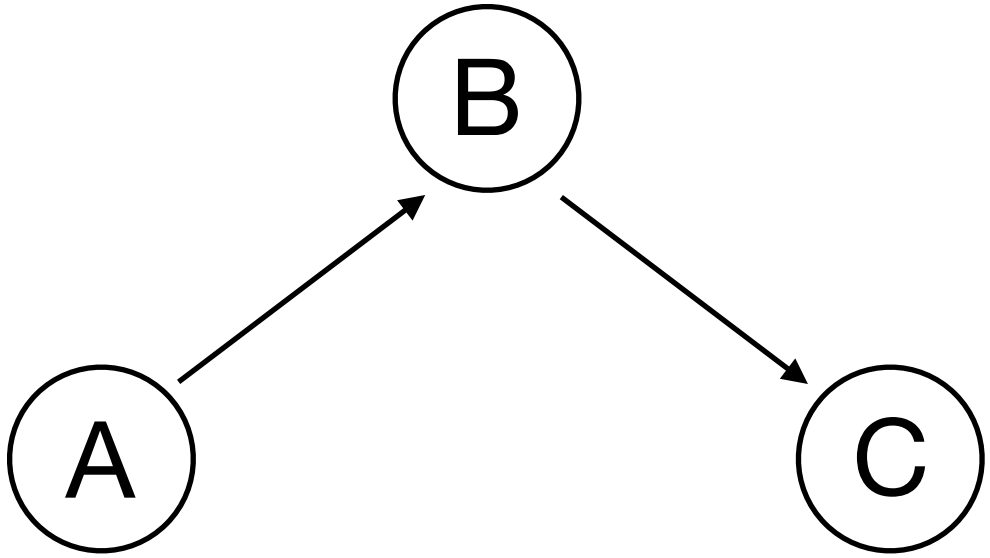

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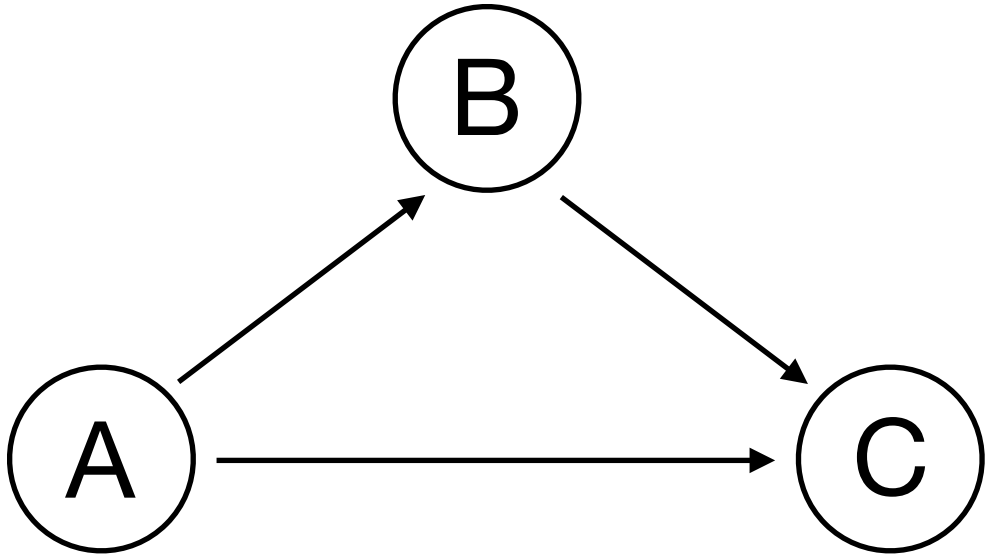

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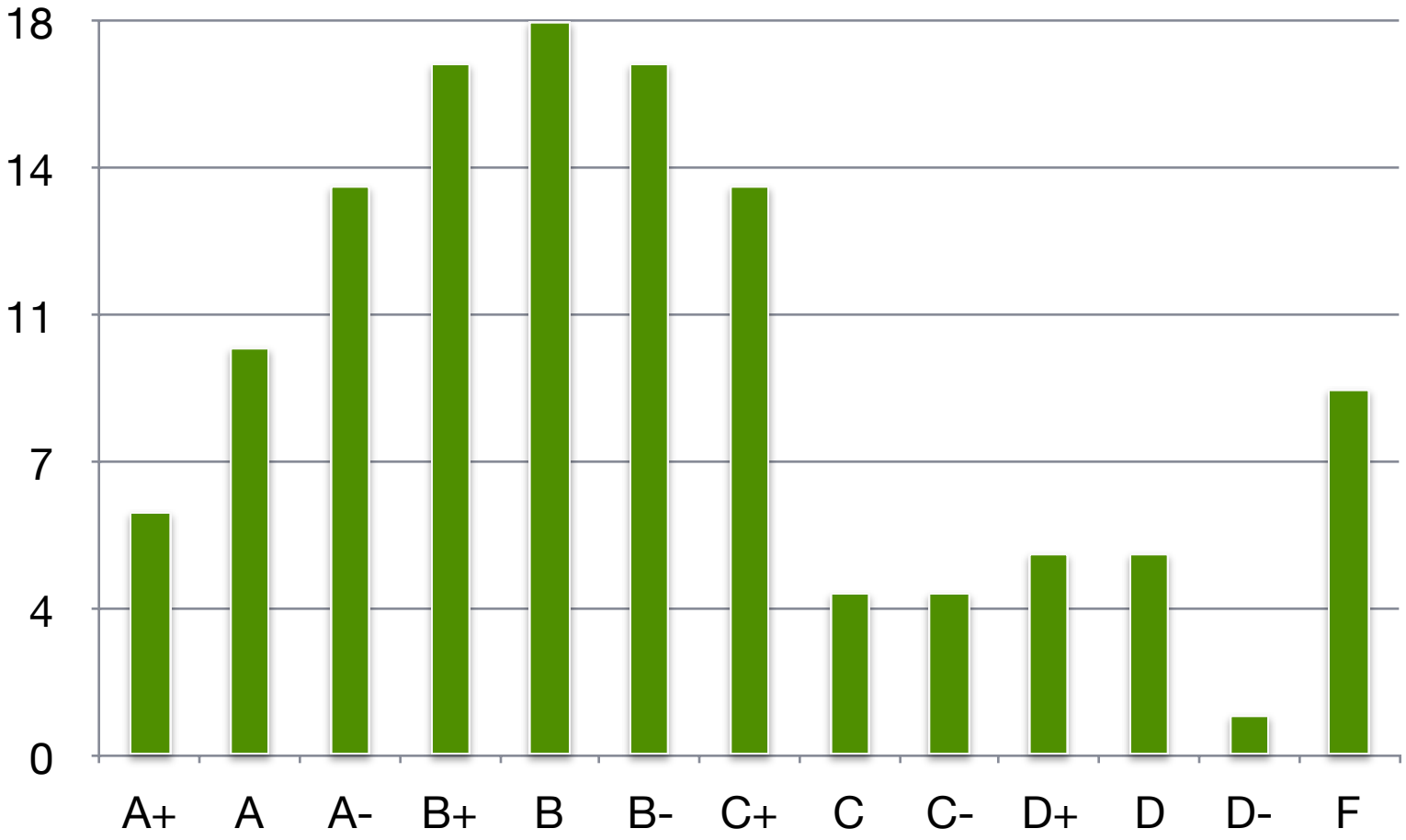
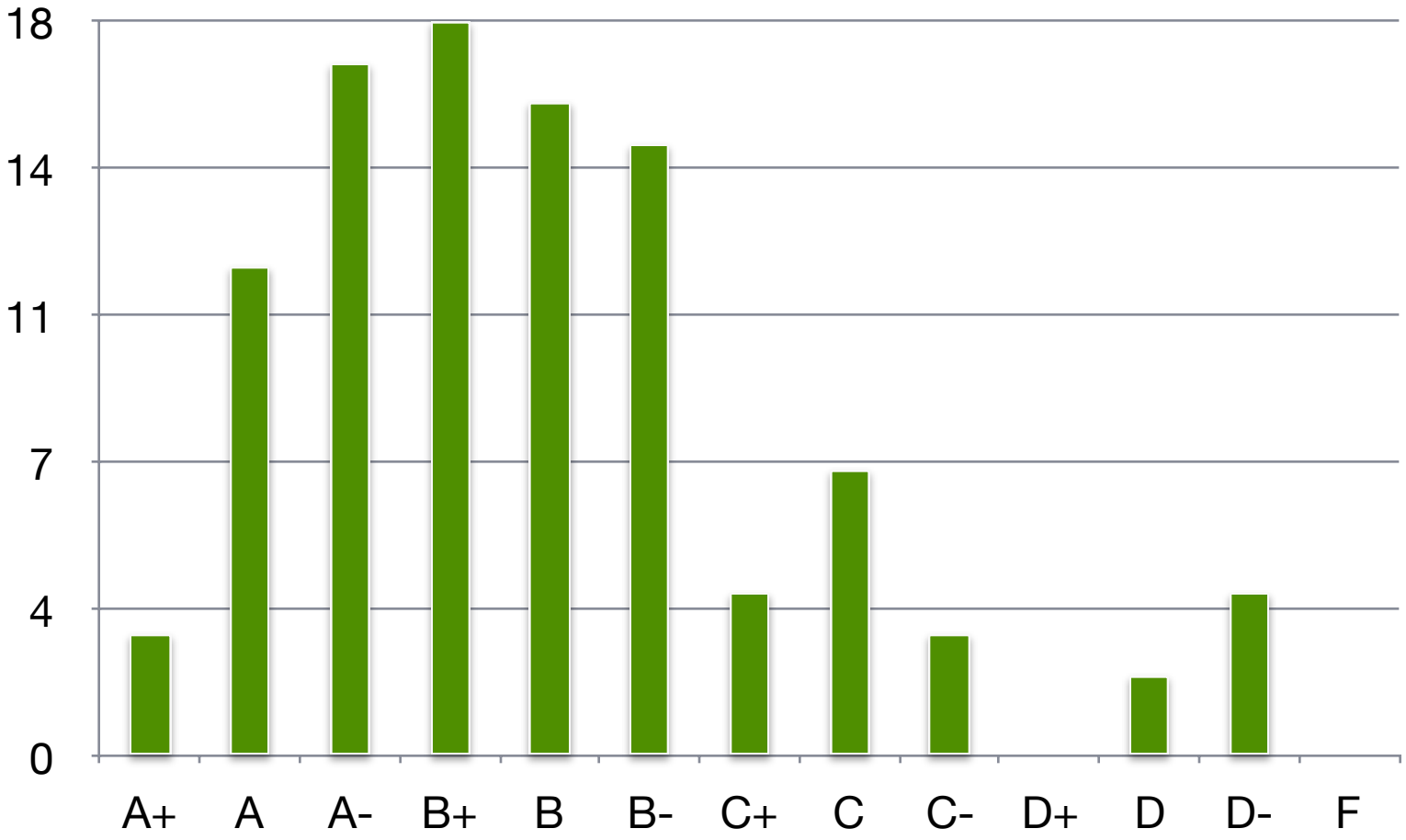
  - Think of me and TAs as your friends, not enemies

Final Grades Spring 2018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