CSC 252: Computer Organization
Spring 2019: 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

Snake
circa **2000**

Snake
circa **2000**

Snake
circa **2019**

Computers are More Capable

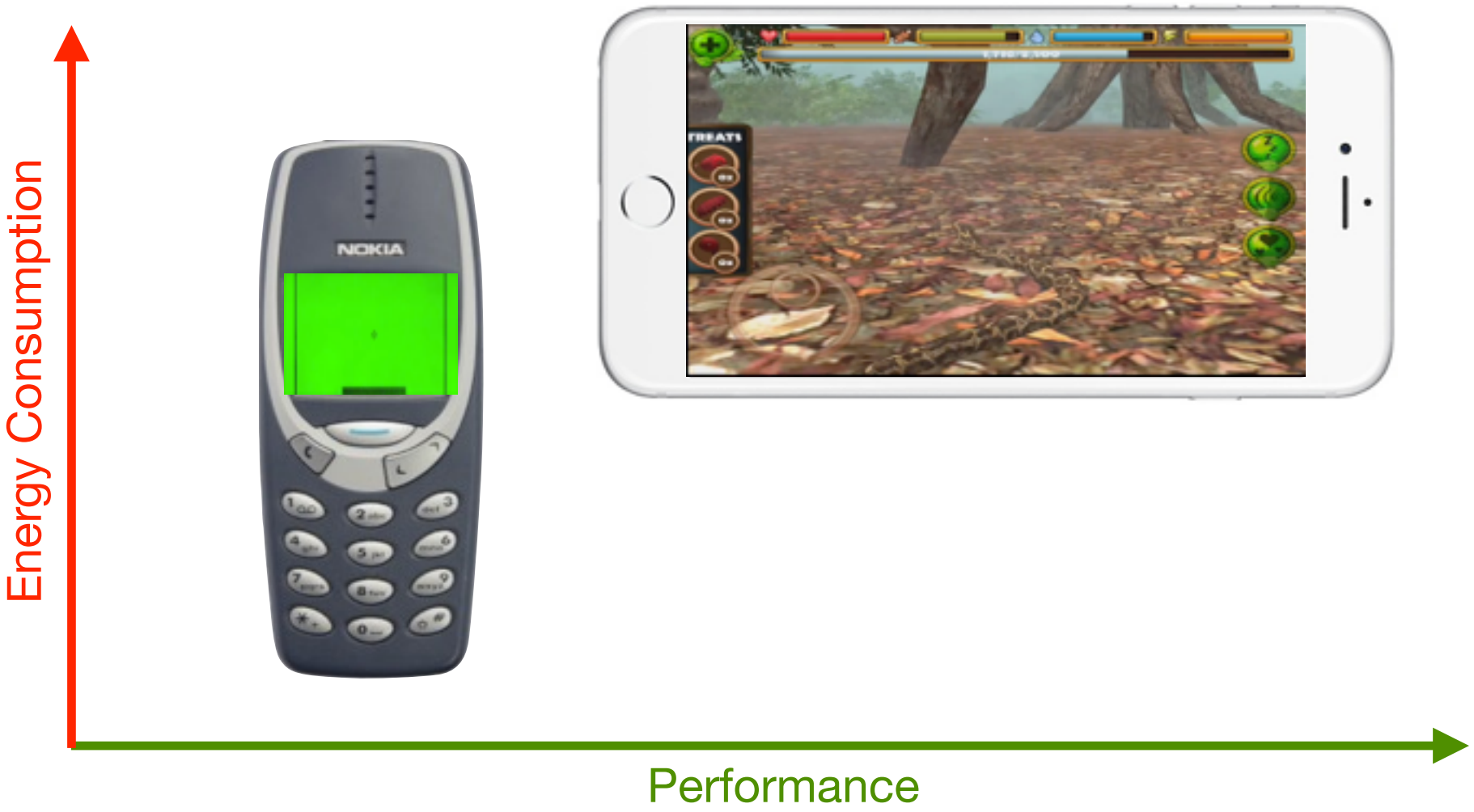
Snake
circa **2000**

Snake
circa **2019**

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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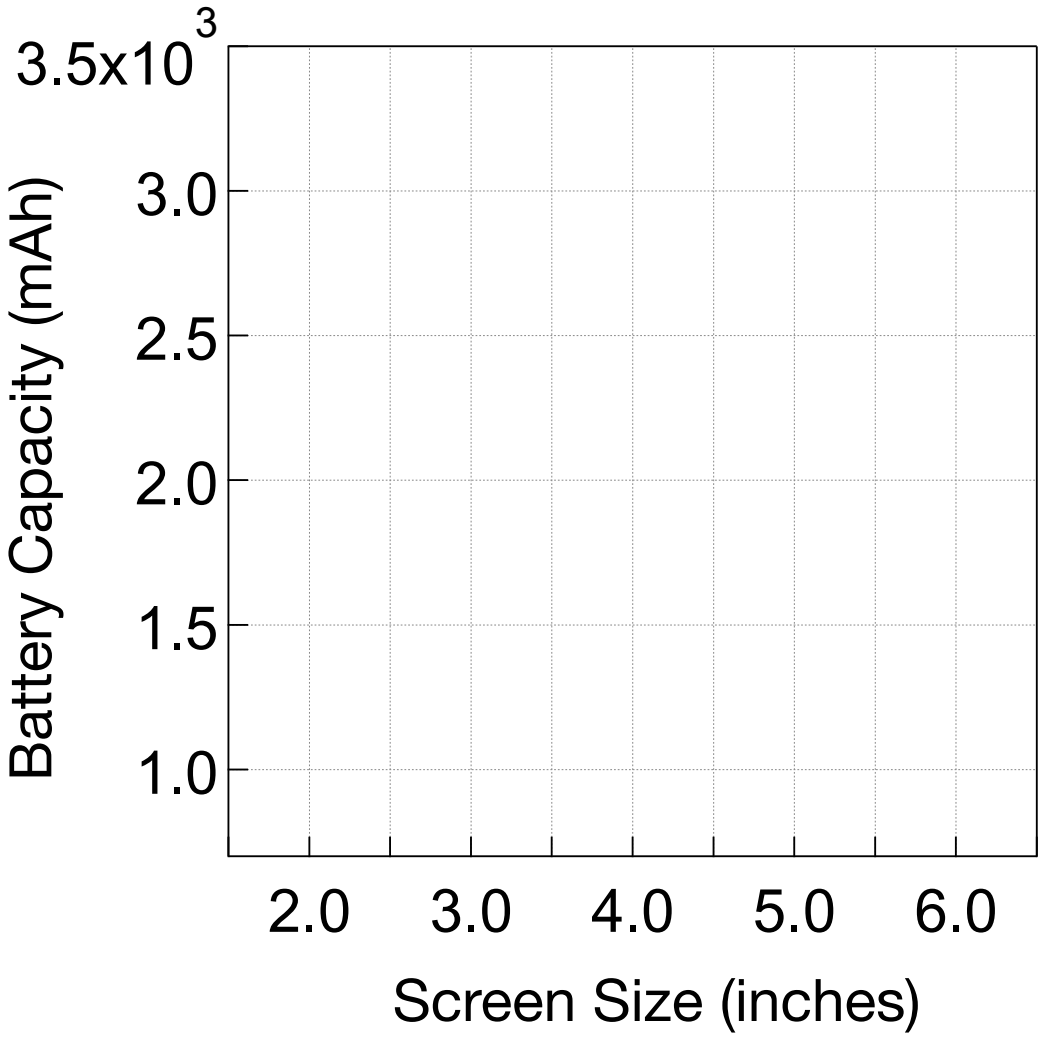

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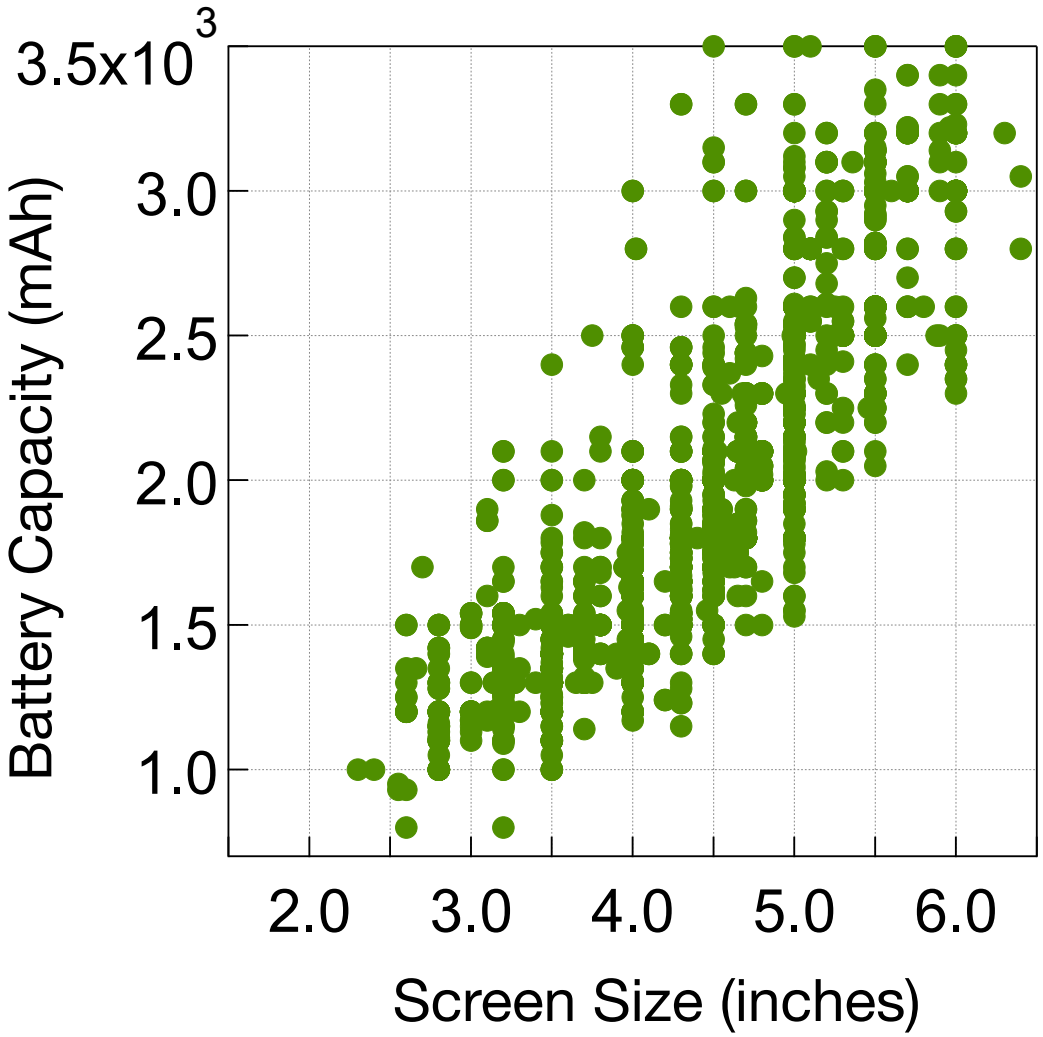

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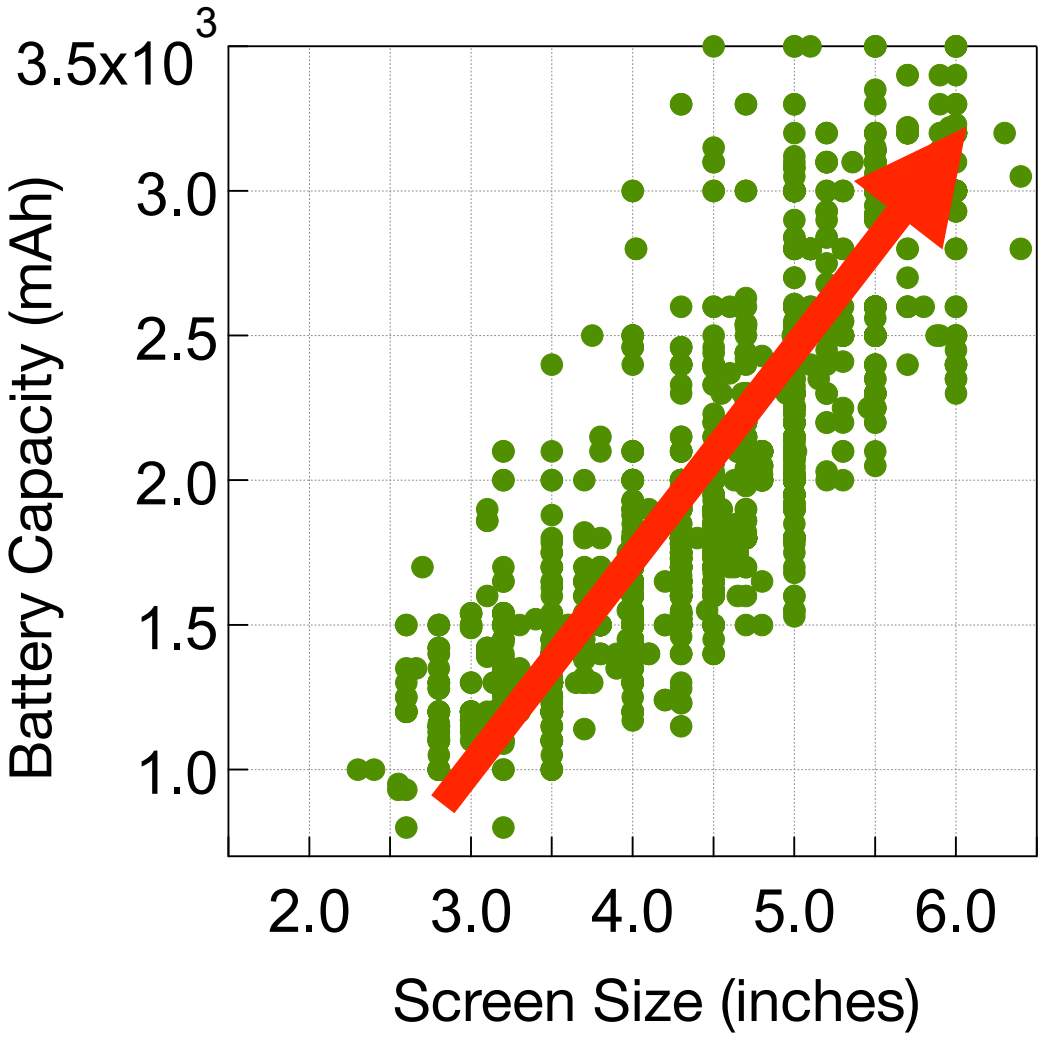

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Which Future Do You Want?

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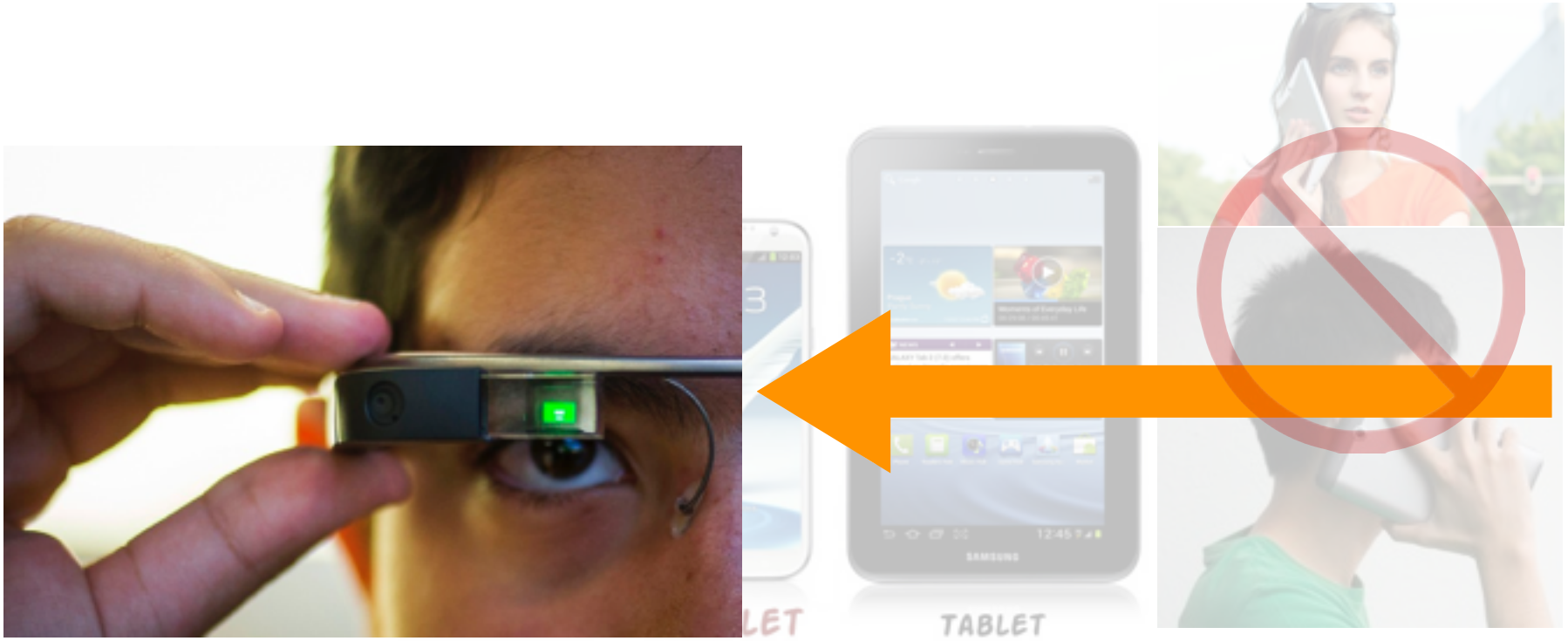

Which Future Do You Want?

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)
    - Talk to Brynn Wilkins (bwilkins@cs.rochester.edu) if you don't already have one
  - **Sign up for Blackboard** (https://learn.rochester.edu/)

Where to Find Stuff

- http://cs.rochester.edu/courses/252/spring2019/
  - 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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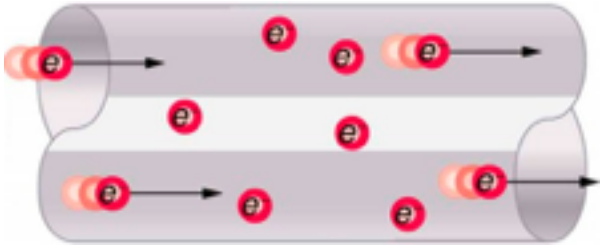

Circuit

Electrons, Resistors, Capacitors, etc.

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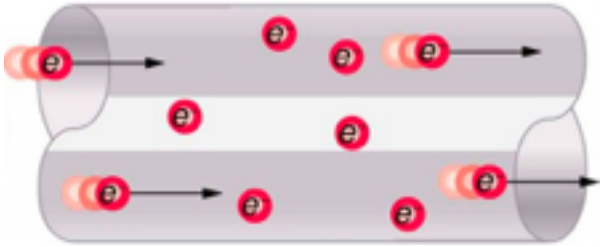

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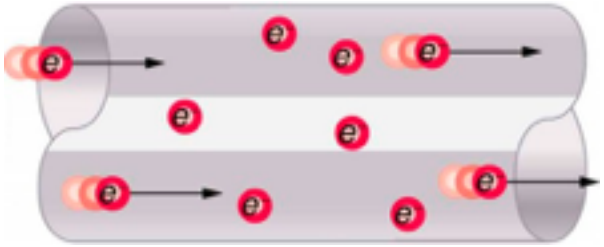

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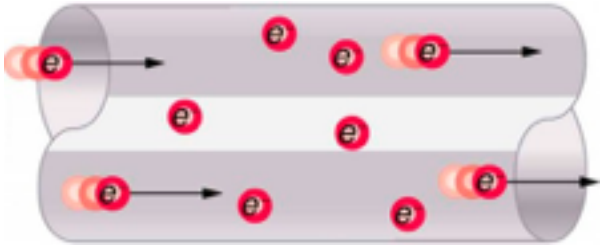

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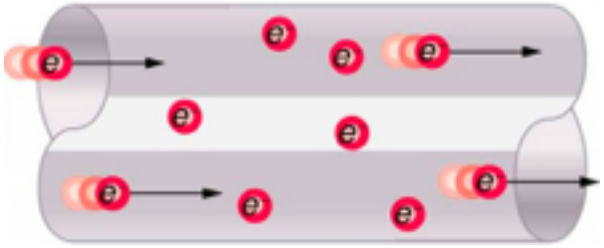
Human-readable language (Java, C)



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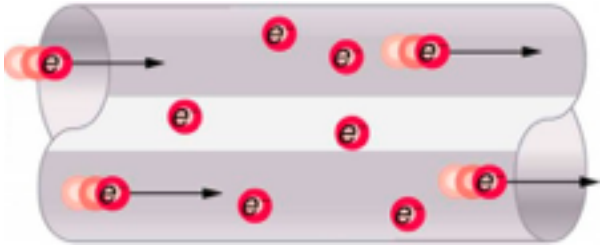

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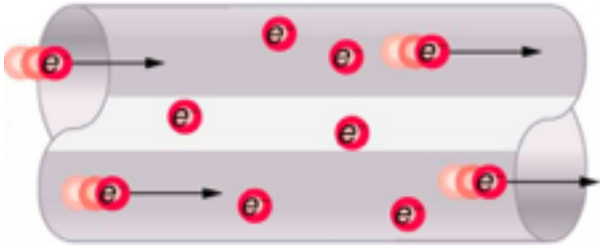
Machine Language



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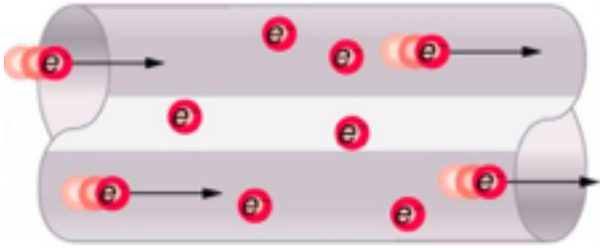
Instruction Set Architecture — Machine Language



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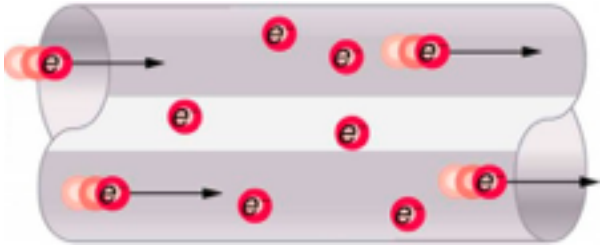

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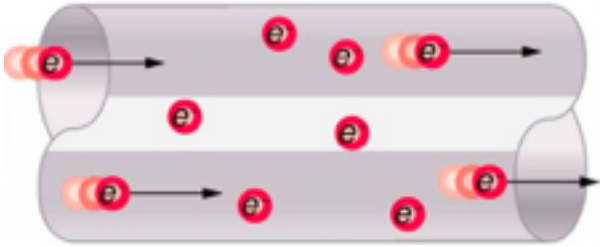

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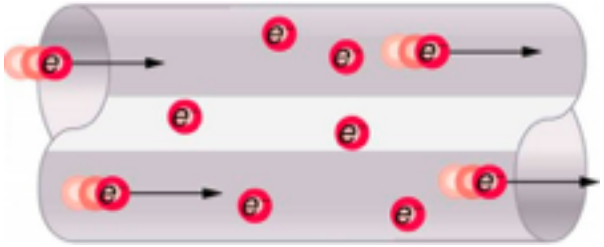

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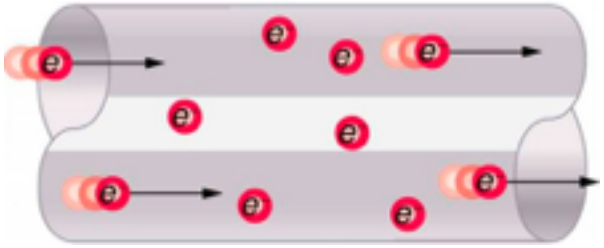
Computer Systems Match User Requirements to Hardware Technologies



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Two Fundamental Aspects of Computer Systems

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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
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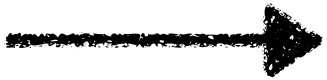
Assembler
Linker



Executable Binary

```
00011001   …
01101010   …
11010101   …
01110001   …
```

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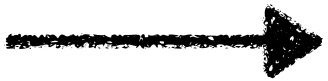

Executable Binary

```
00011001   …
01101010   …
11010101   …
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…

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The Fundamental 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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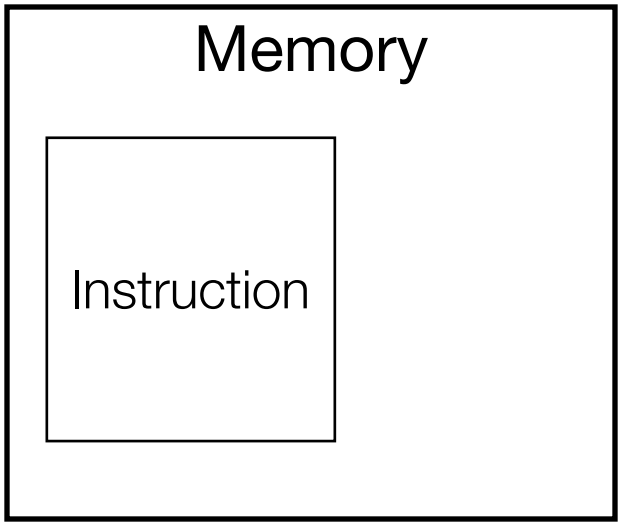

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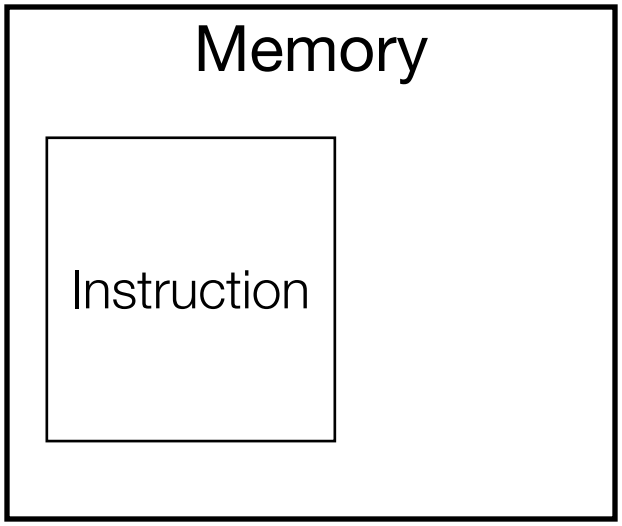

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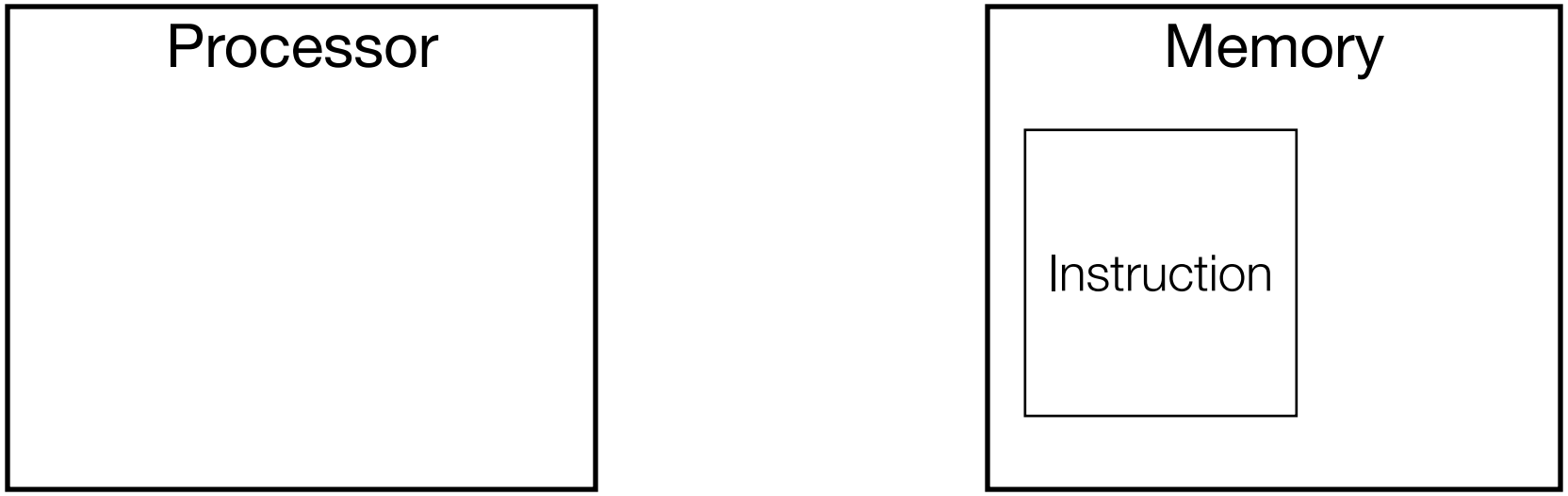

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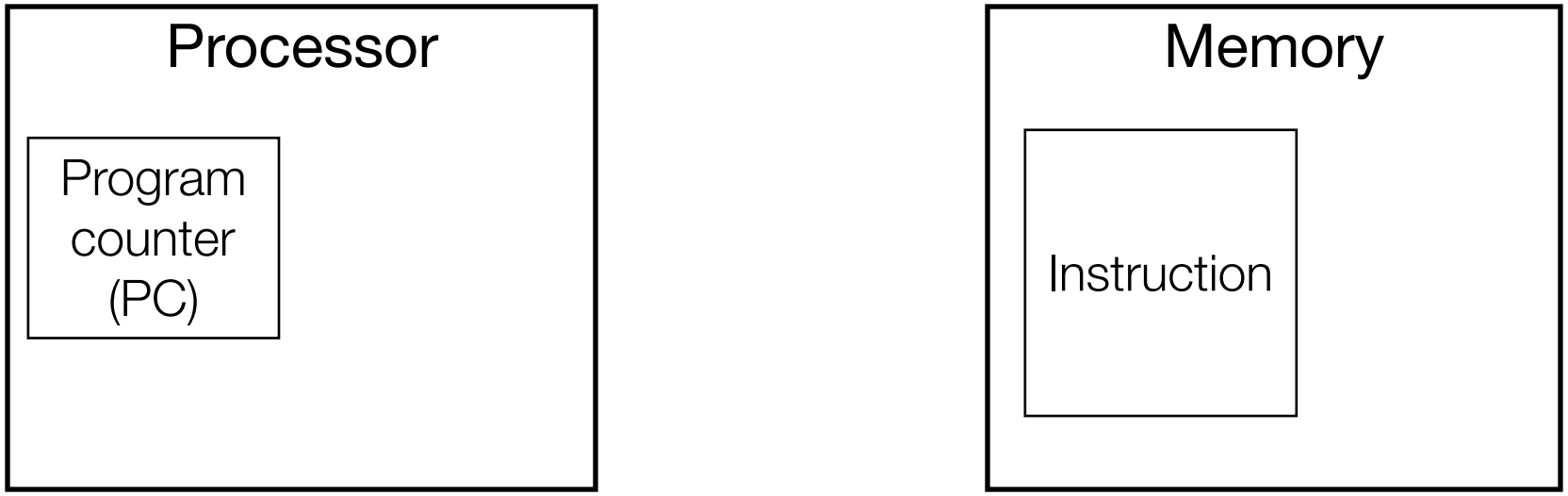
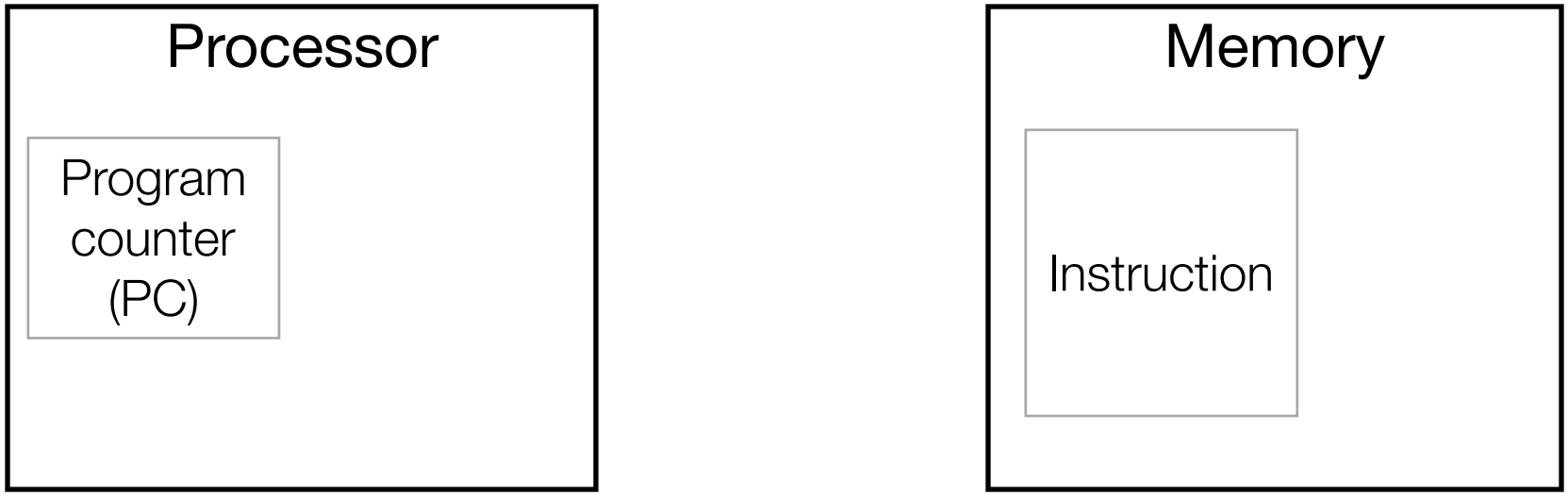


High-level Organization of Computer Hardware a.k.a., The Von Neumann Model



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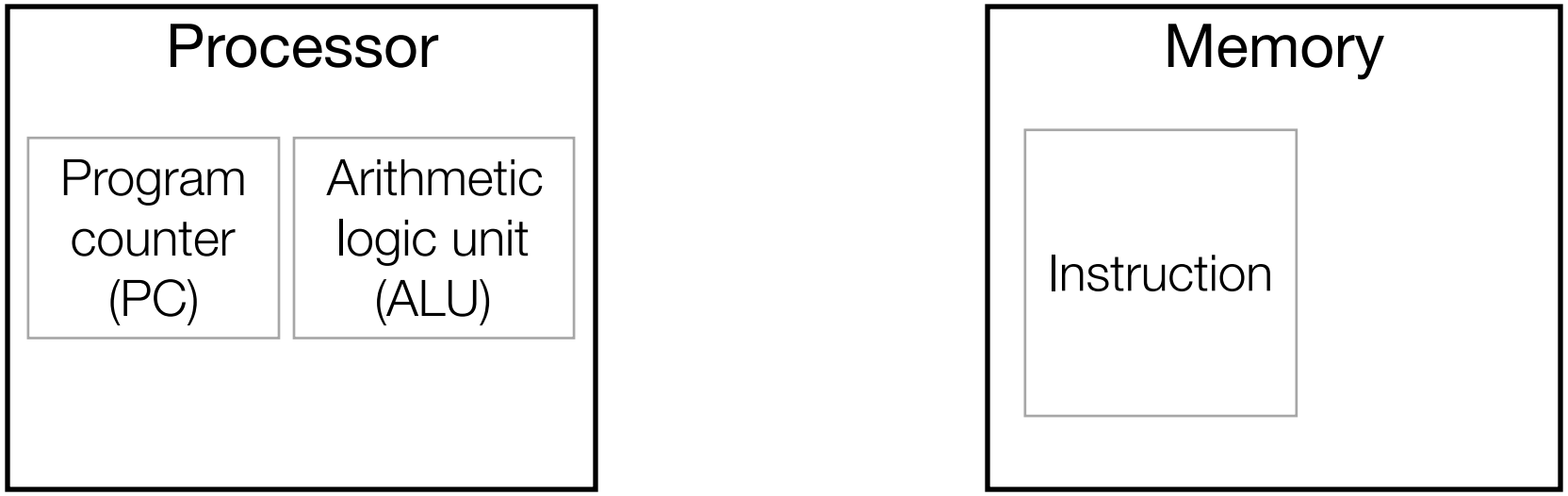

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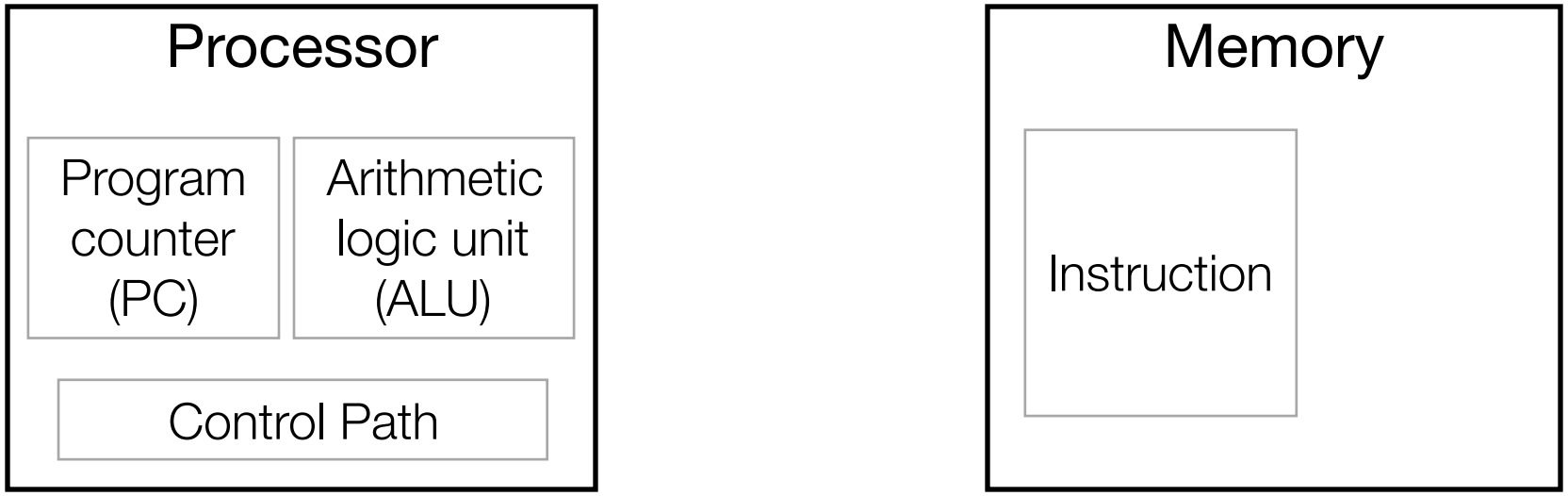

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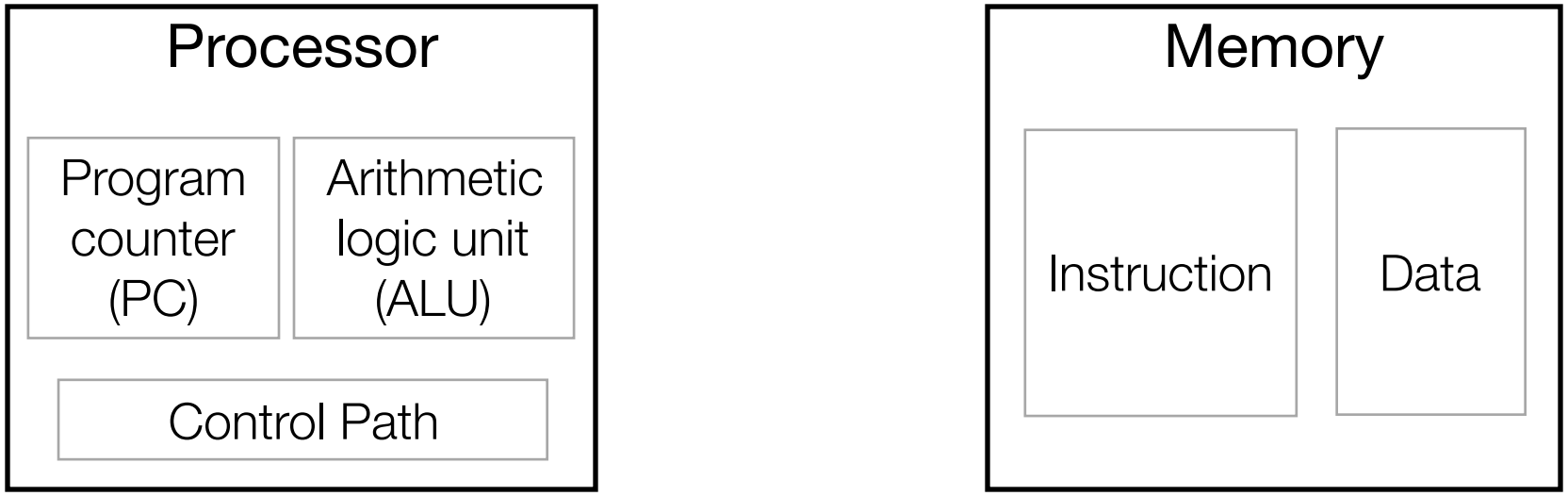

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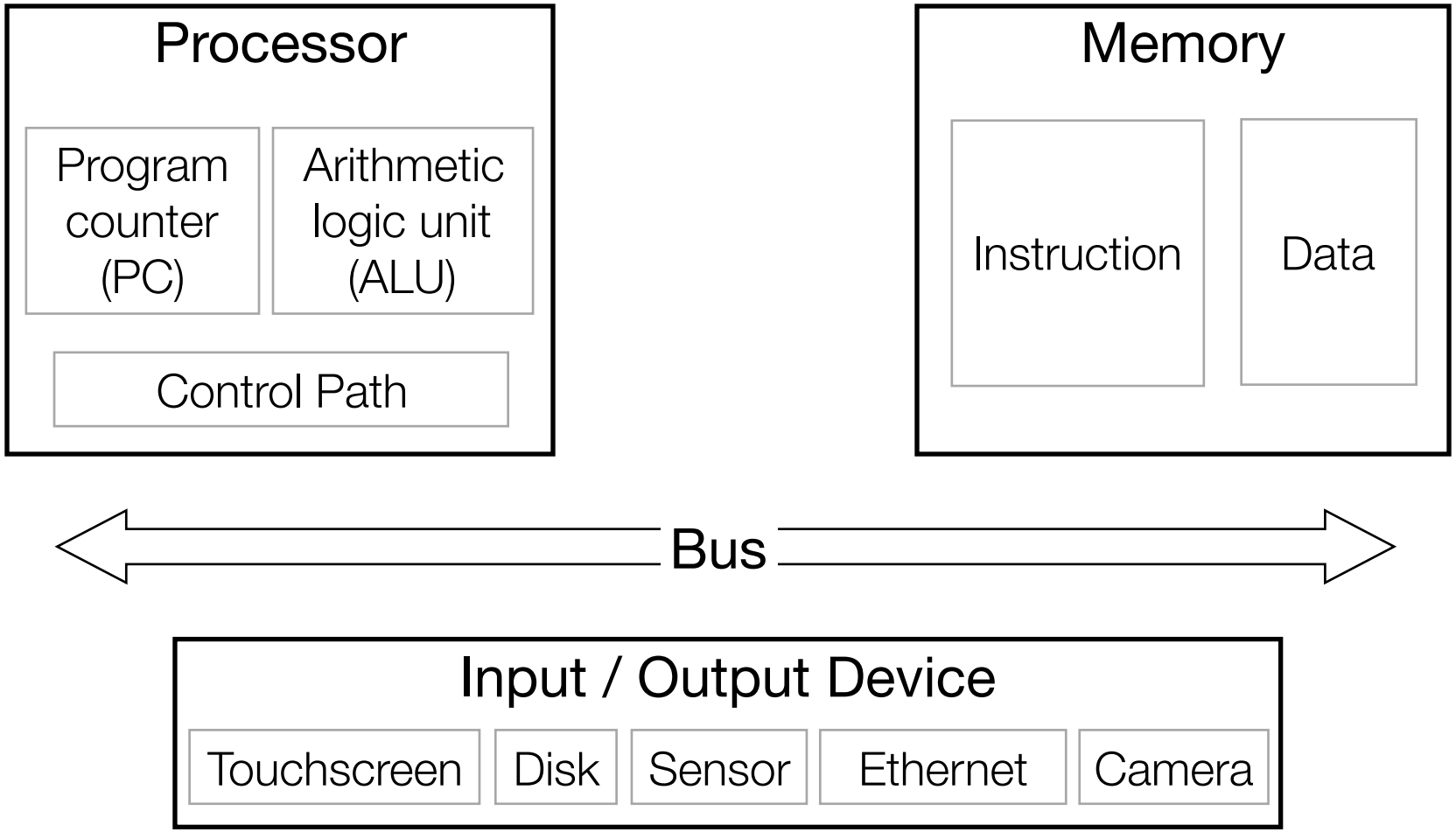

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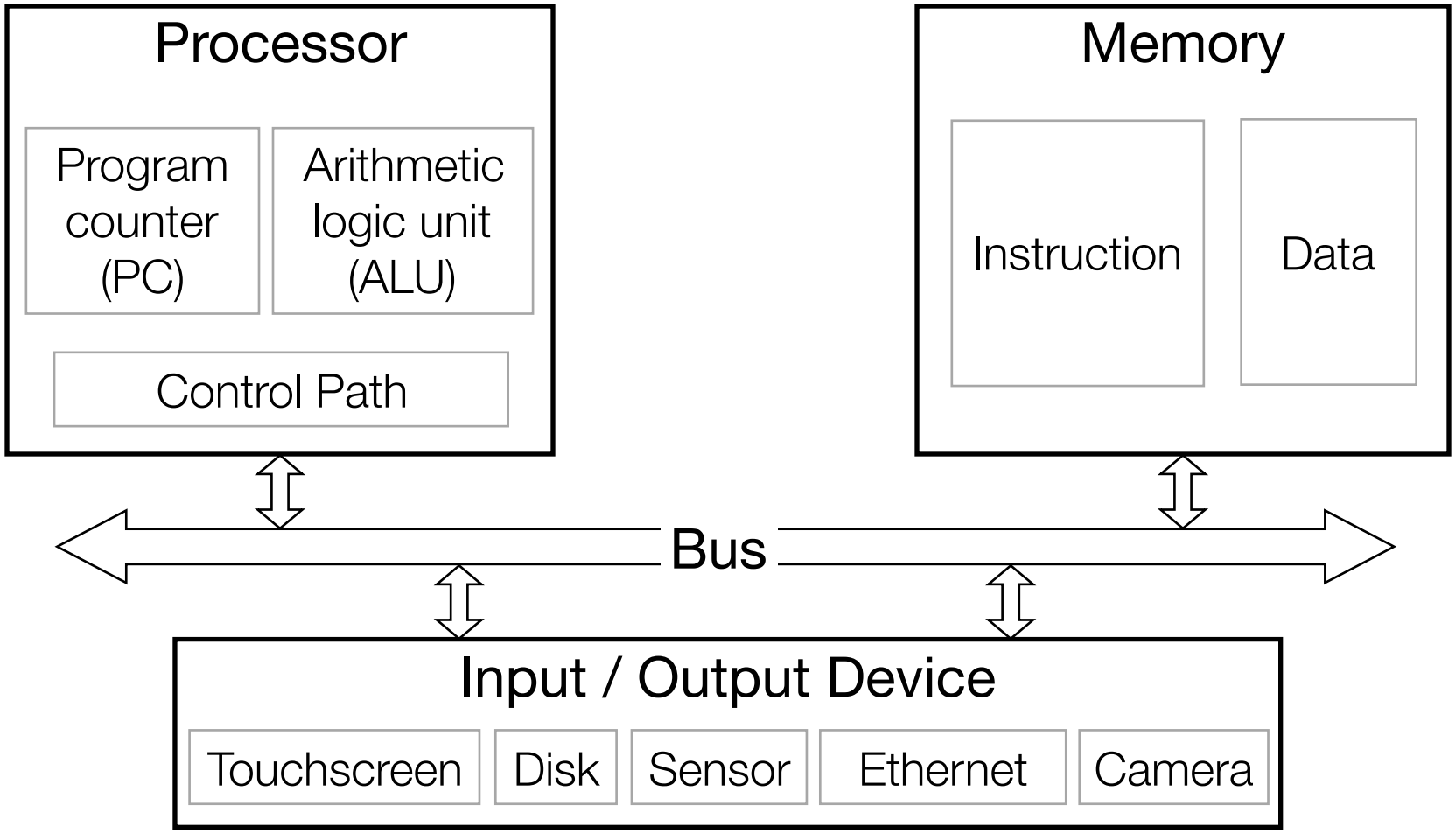

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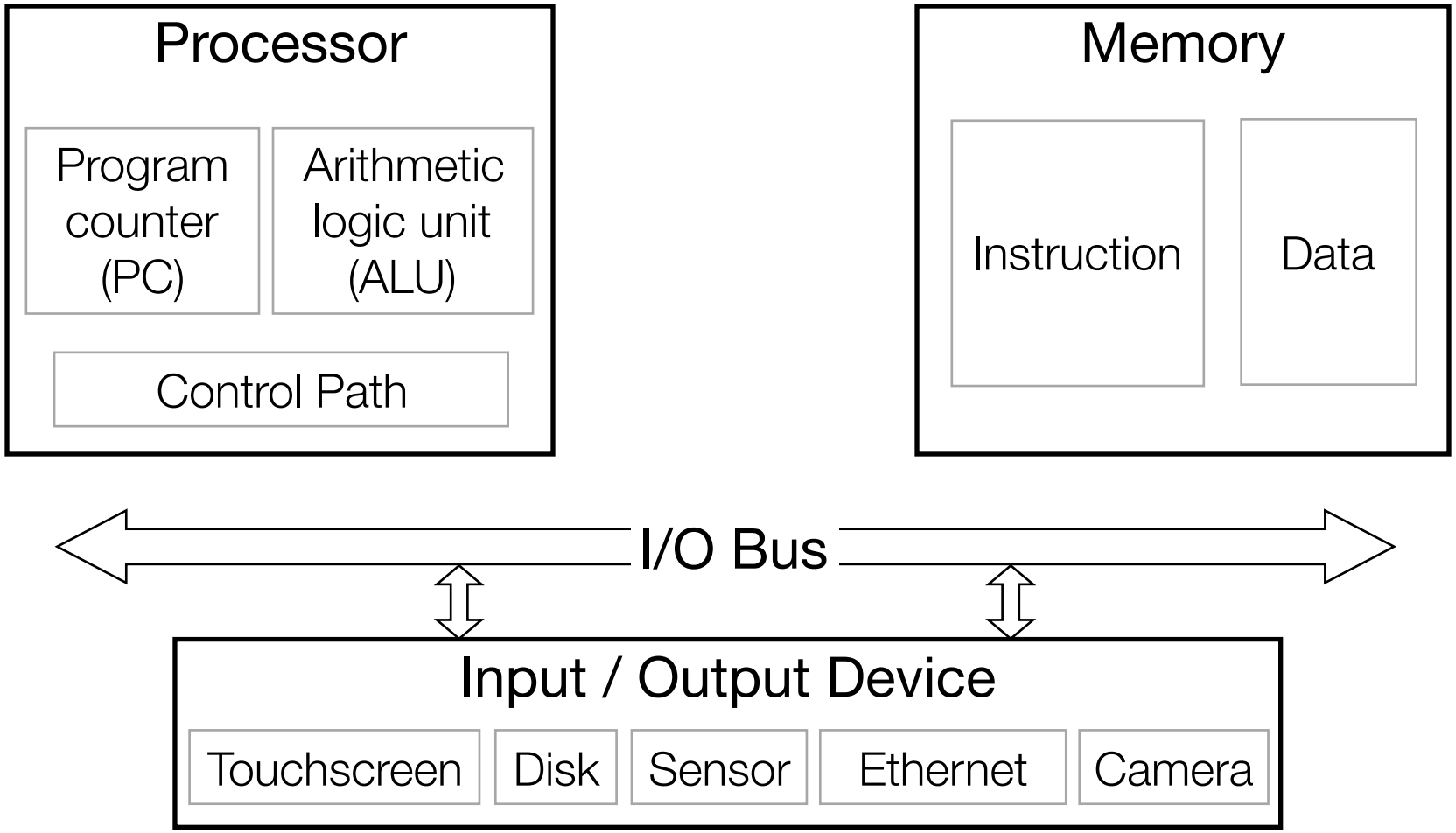

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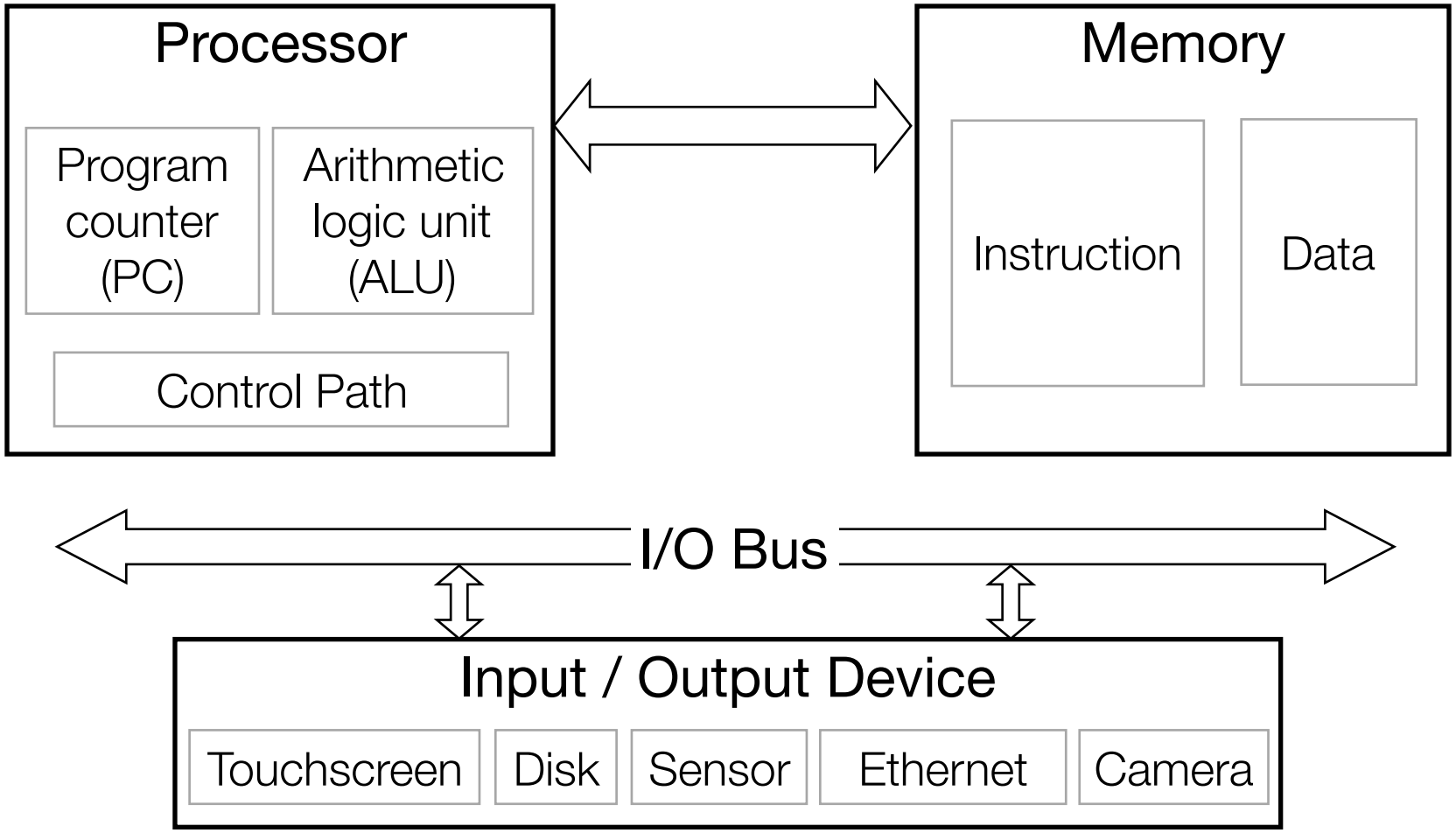

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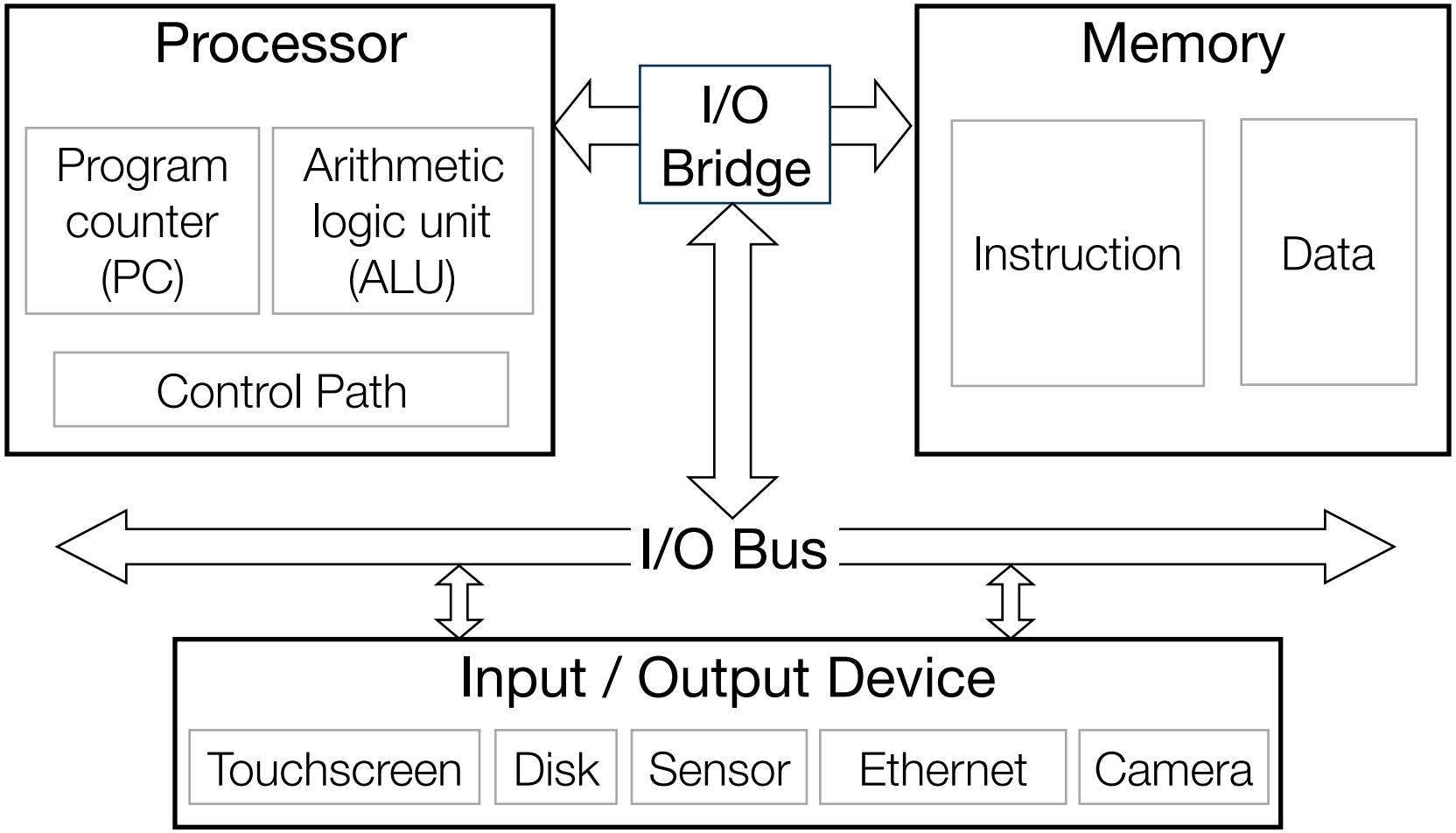

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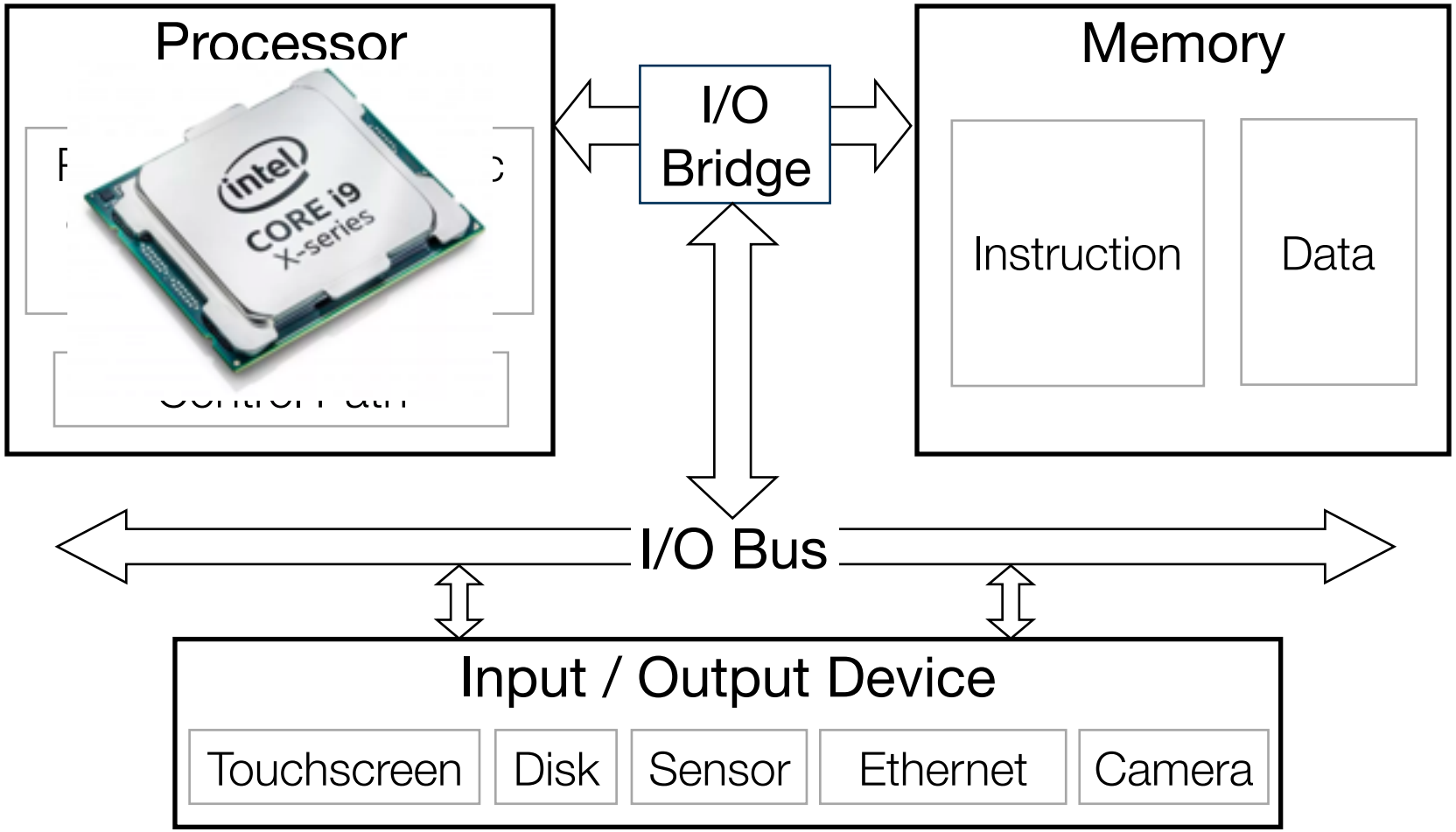

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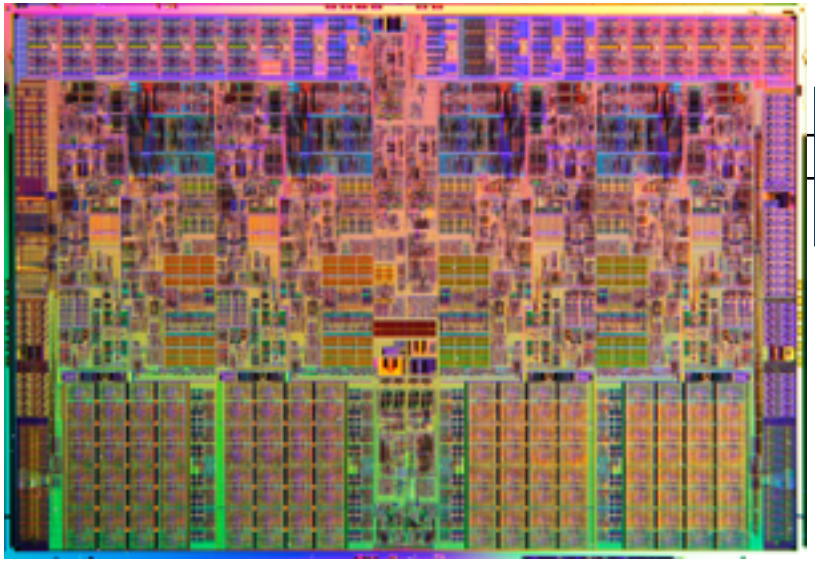

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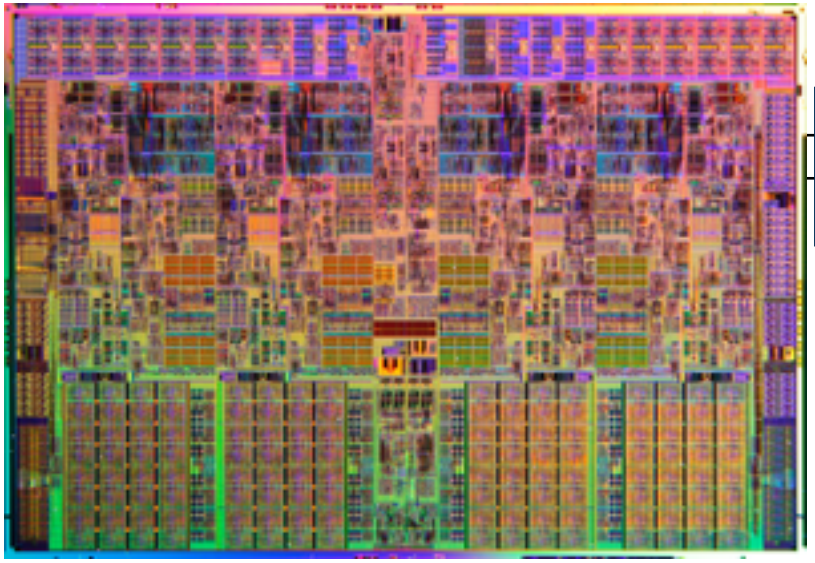
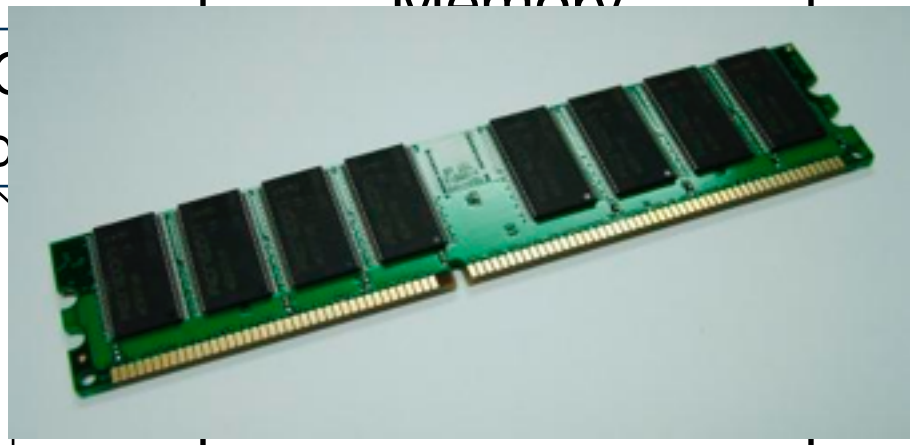


Memory

I/O Bridge



I/O Bus

Input / Output Device

Touchscreen | Disk | Sensor | Ethernet | Camera

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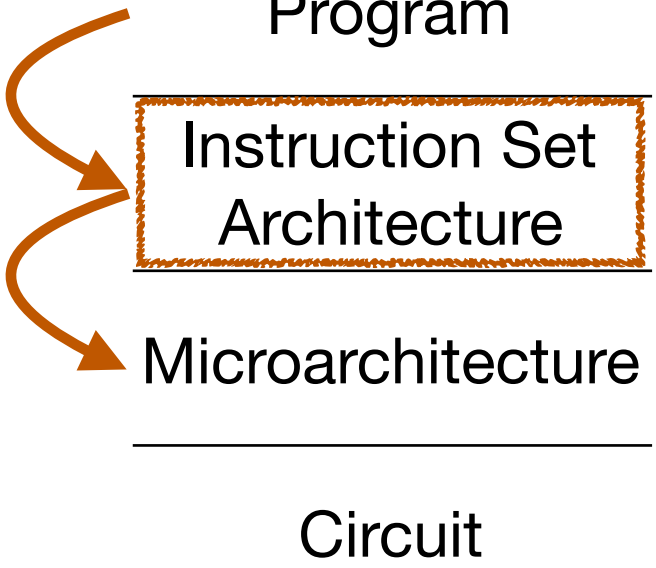

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Quicksort

Human-readable language (Java, C)

Machine Language

Hardware Design

Electrons, Resistors, Capacitors, etc.

Instruction Set Architecture

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

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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

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- Implementation of an ISA is called *microarchitecture*

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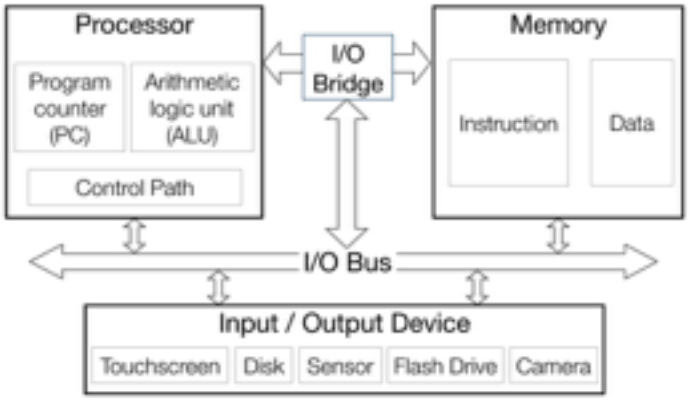

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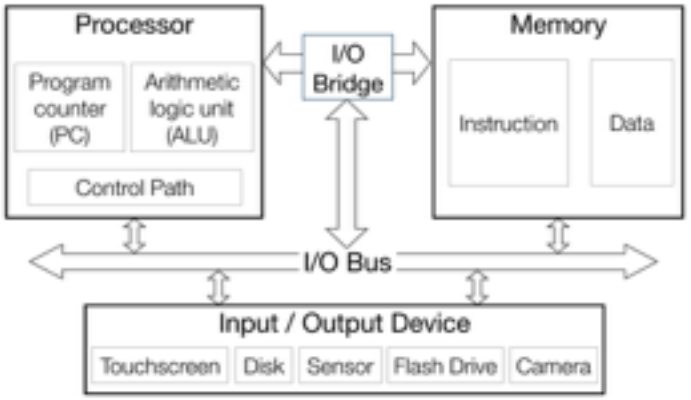
- The assembly language's view of the computer is called the "instruction set architecture" (*ISA*)
- No need to care how the instructions are implemented as long as they are somehow implemented
- Implementation of an ISA is called *microarchitecture*
- ISAs *abstract* away details of microarchitecture

Assembly program: add.s

```
movl    $1, -4(%rbp)
movl    $2, -8(%rbp)
movl    -4(%rbp), %eax
addl    -8(%rbp), %eax
…
callq   _printf
```



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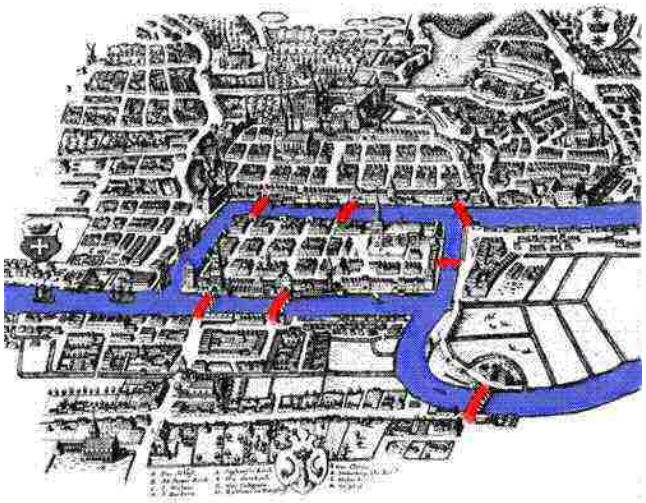
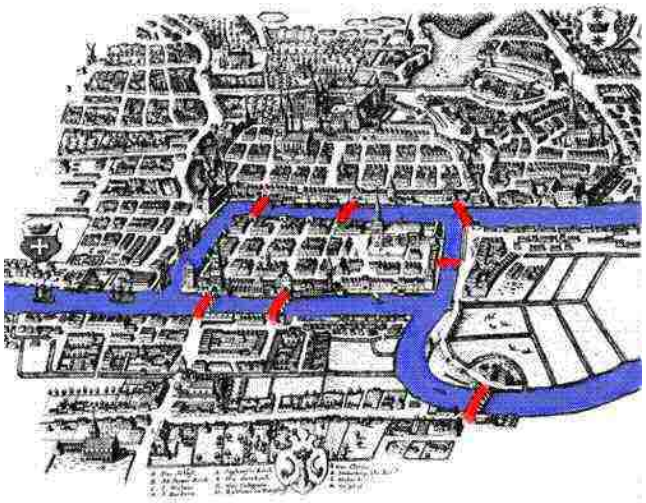
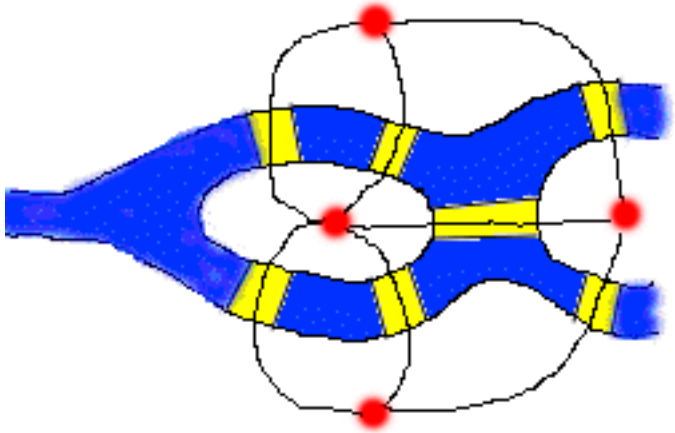


Abstraction

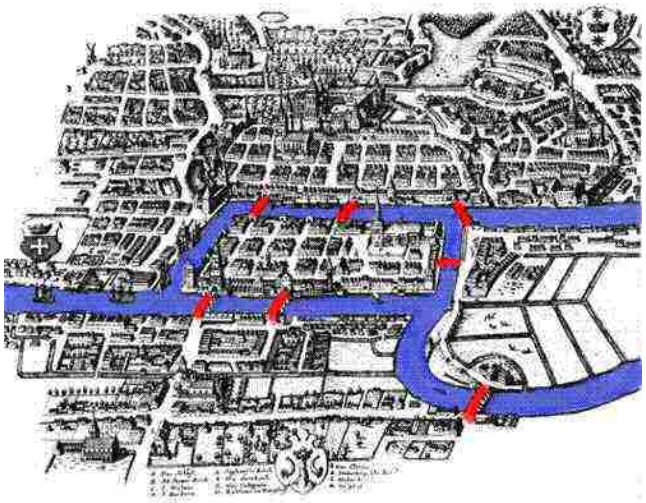
- Think of car versus engine, transmission, brakes, …
- Bridges of Konigsberg
  - Is there a walk that crosses each bridge exactly once?
- Solution by Euler
  - Key insight: connectivity between land masses is what is important, not the actual distances or the orientations of the bridges

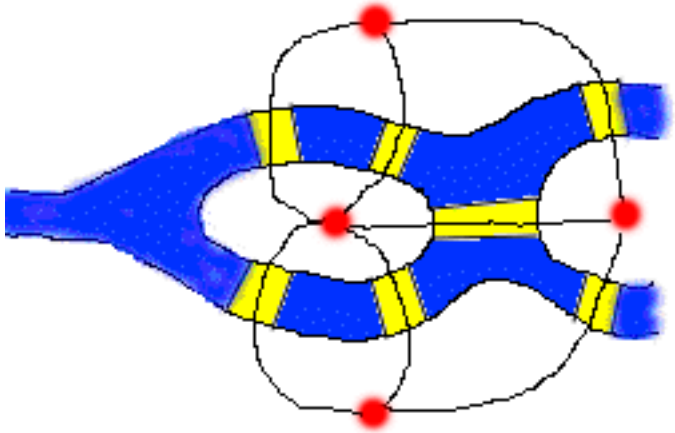




Abstraction

- Create an abstraction
  - One node for each land mass
  - Edge between two nodes if there is a bridge connecting the two land masses
- Graph has nodes of odd degree, so there is no walk with desired property.
- Led to field we now call topology.





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- The act or process of leaving out of consideration one or more properties of a complex object so as to focus on others
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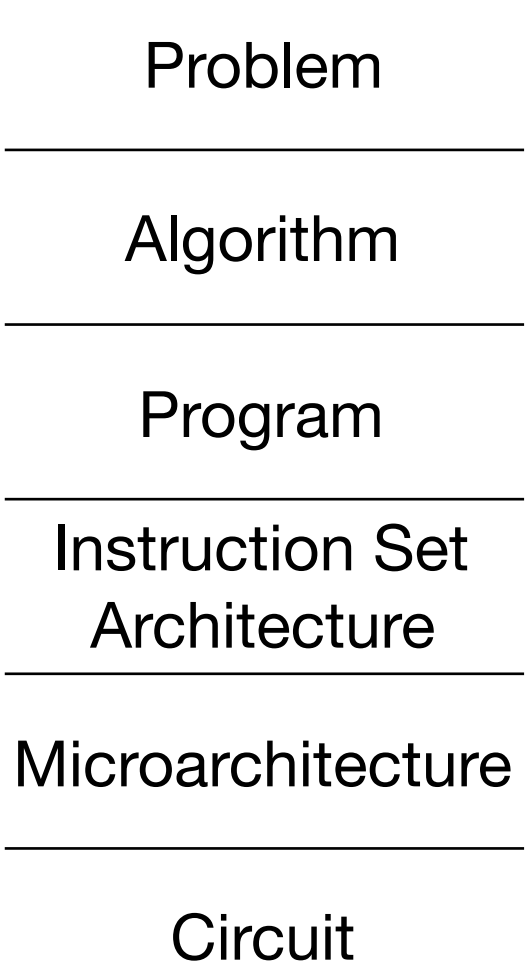
  - ISA leaves out *how* “ADD” is implemented
  - ISA also leaves our *how long* an “ADD” instruction takes
- Bad abstractions throw away essential features of problem
  - Topologist is someone who does not know the difference between a doughnut and coffee-cup
  - Bad ISAs don’t tell you the hardware can 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.

Every Layer in CS is an Abstraction

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



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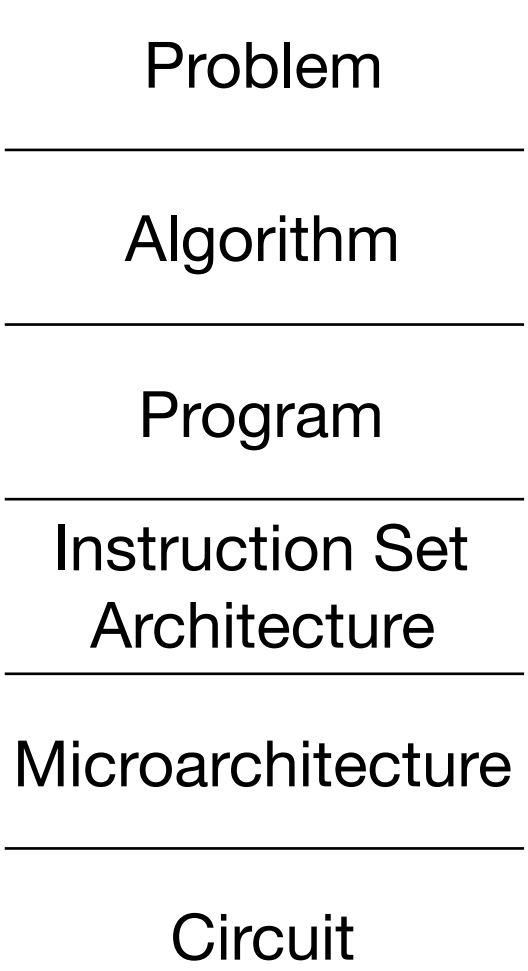
Every Layer in CS is an Abstraction

- Depend on which layer you want to live at, you have different views of the computer
- This course expands your layers of abstractions



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  - Intel and AMD have different microarchitectures for x86
- 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

- Little research on ISA, much more microarch. research
  - ISA is stable now. “One ISA rules them all.”
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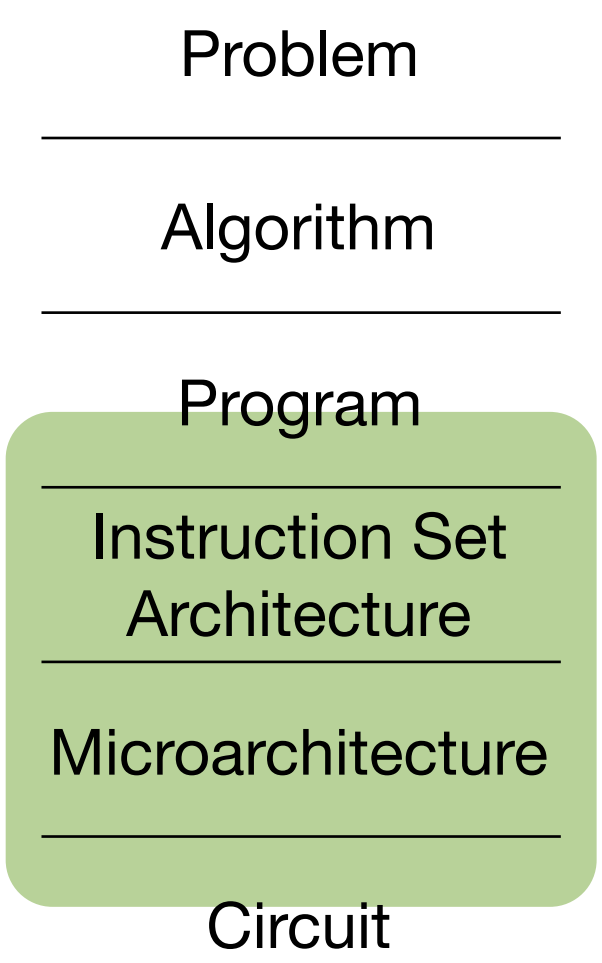
  - E.g., Transmeta executes x86 ISA programs on their own ISA

The Role of a Computer System Designer



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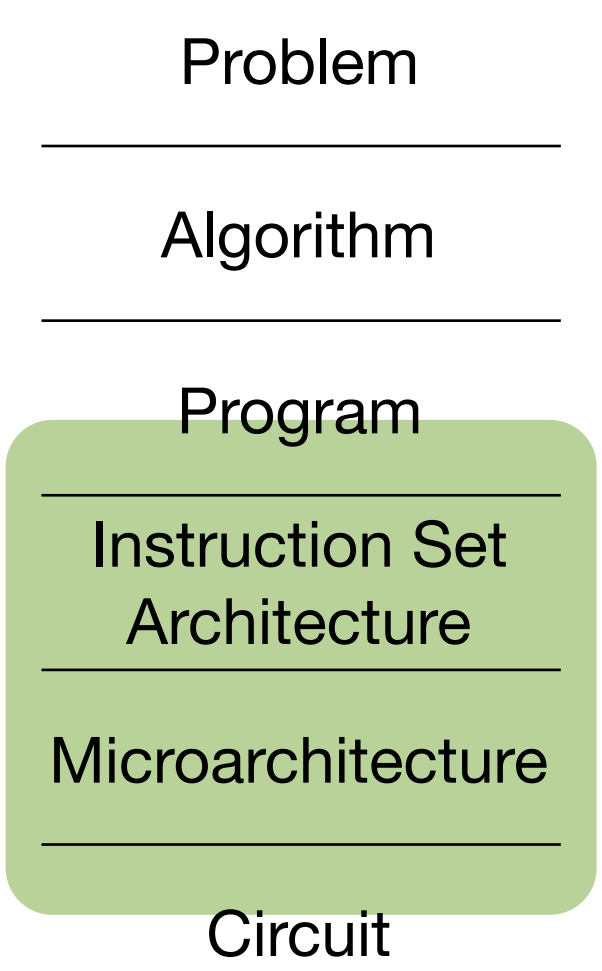

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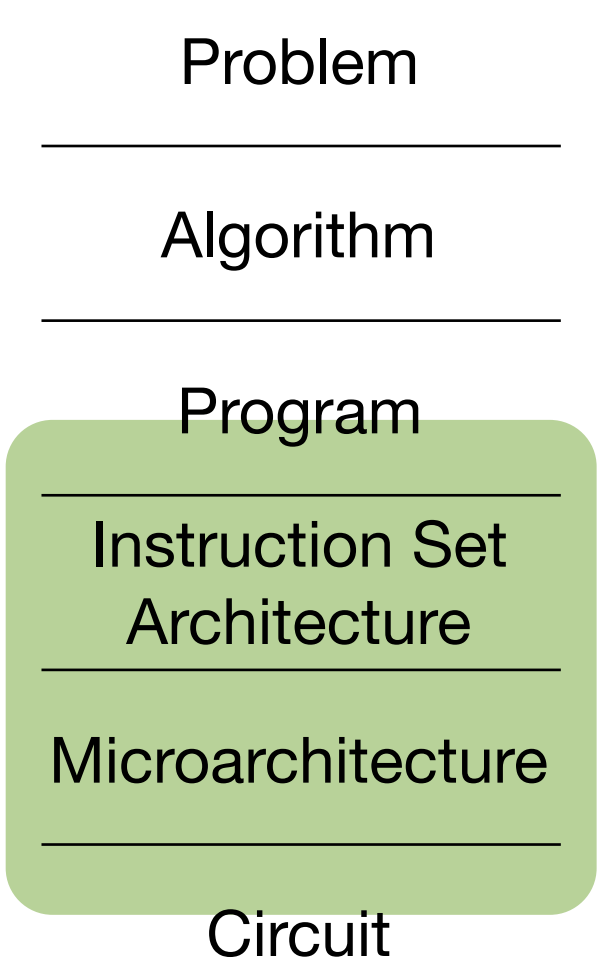

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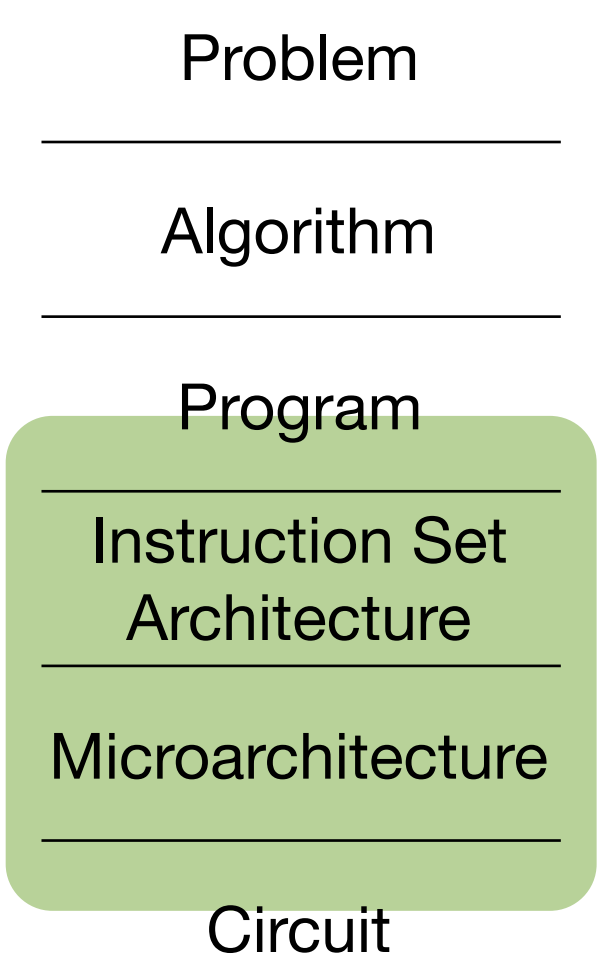
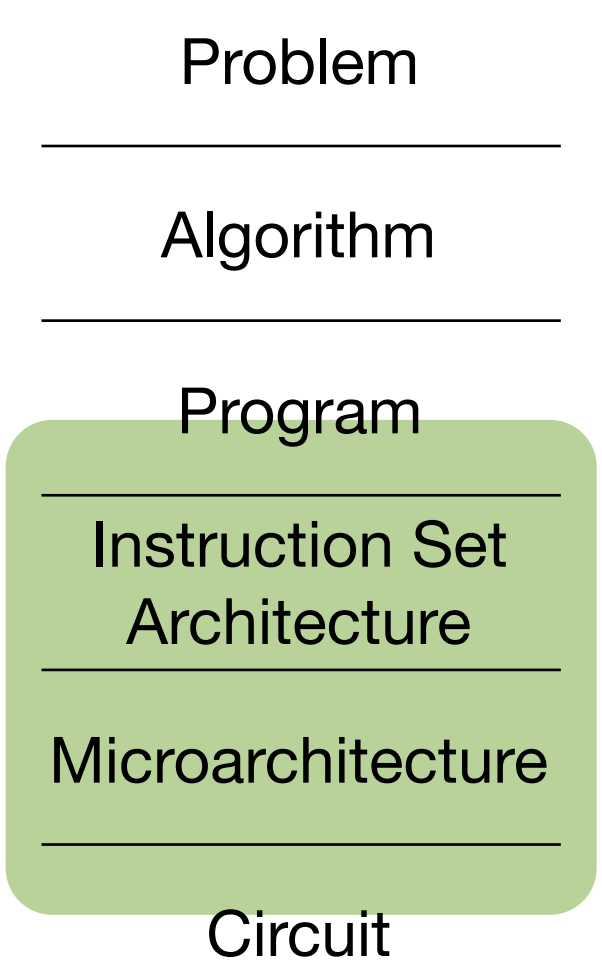


The Role of a Computer System Designer

- Look Up (Nature of the problems)
- Look Down (Nature of the circuit technology and physics)
- Look Backward (Evaluating old ideas in light of new technologies)
- Look Forward (Listen to dreamers and predict the future)



Why This Course Matters to You

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makes you think about computer science in a more complete way

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Questions?

Who Are We?

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- Myself: Yuhao Zhu
  - WH 3501, yzhu@rochester.edu
  - Office hours Thursday 5-6pm or by appointment
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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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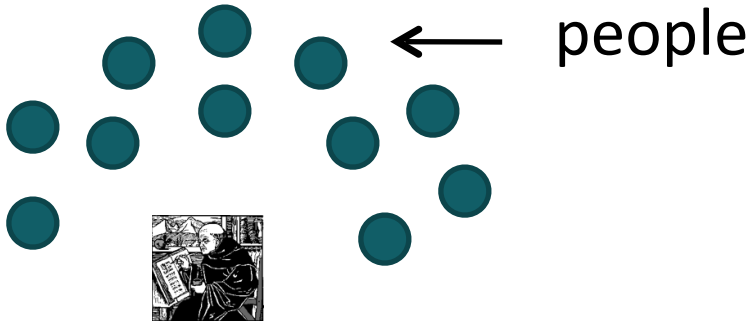
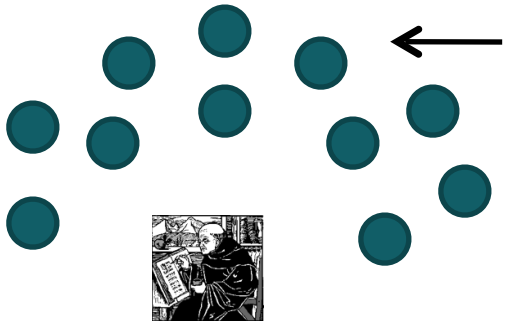


All The Way Back to Medieval Times..

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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- To learn, you must do the work with your own muscle (brain)!

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There are a lot of stupidly funny questions asked, and he handles them so professionally, I'm genuinely impressed.

[redacted] we can ask however many questions we want in class and not seem dumb based on his response to our questions.

What Should You Expect From Us?

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  - Be your guide in inducing you to explore concepts
  - Create situations and post problems that set the scene for your exploration
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- *Think of us as your friends, not enemies*
  - The last thing I care about is your grades
  - I'd love to give you an A, but give me a reason to do that
  - After all, do you want to climb the mountain with your friends or your enemies?

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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- Programming Assignments: 54%
  - 6 assignments, 9% each
  - Each assignment has two deadlines
  - One for the “pre-assignment” (a.k.a. trivia), whose point is to get you start thinking about the assignment (**1.5%**)
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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 assembler.
- 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.

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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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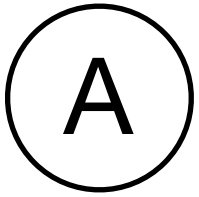

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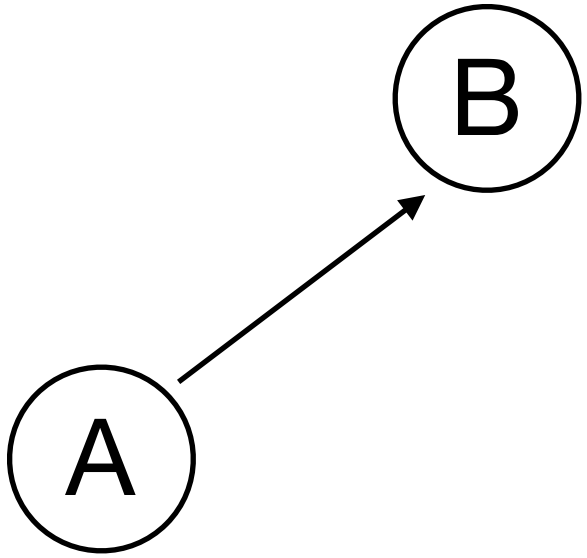

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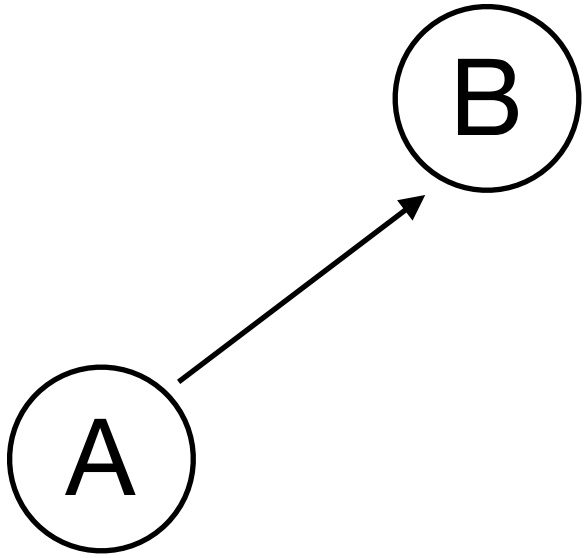
- Projects ask you to go from **B** to **C**



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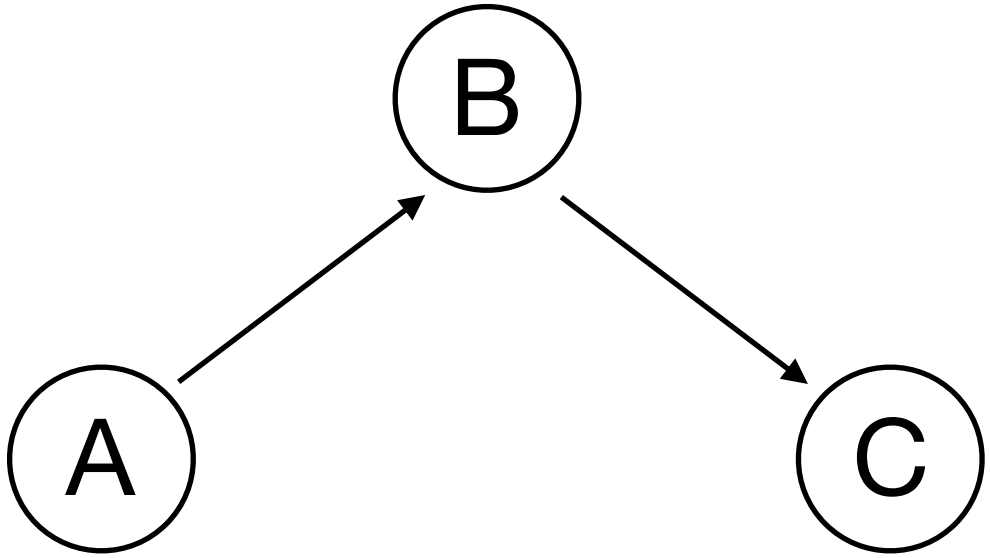

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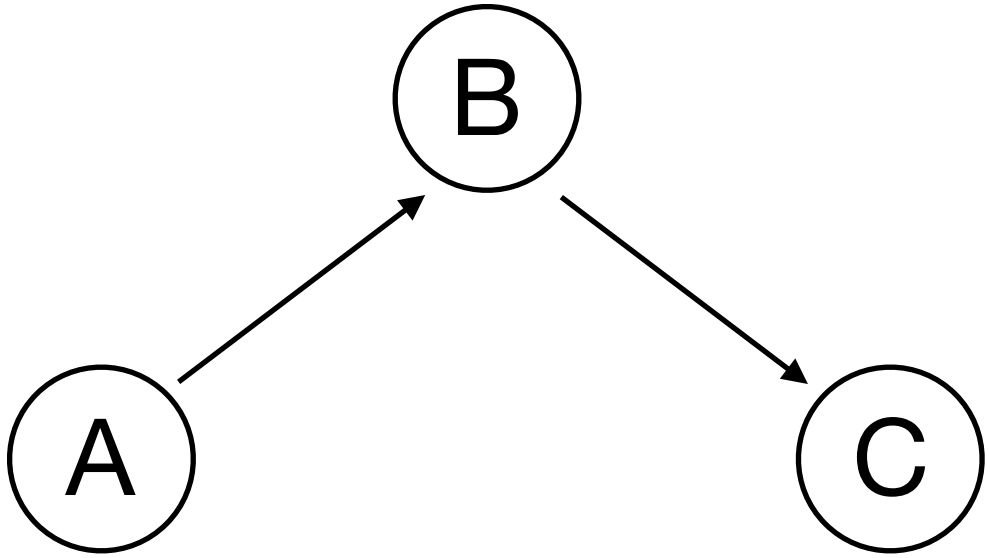

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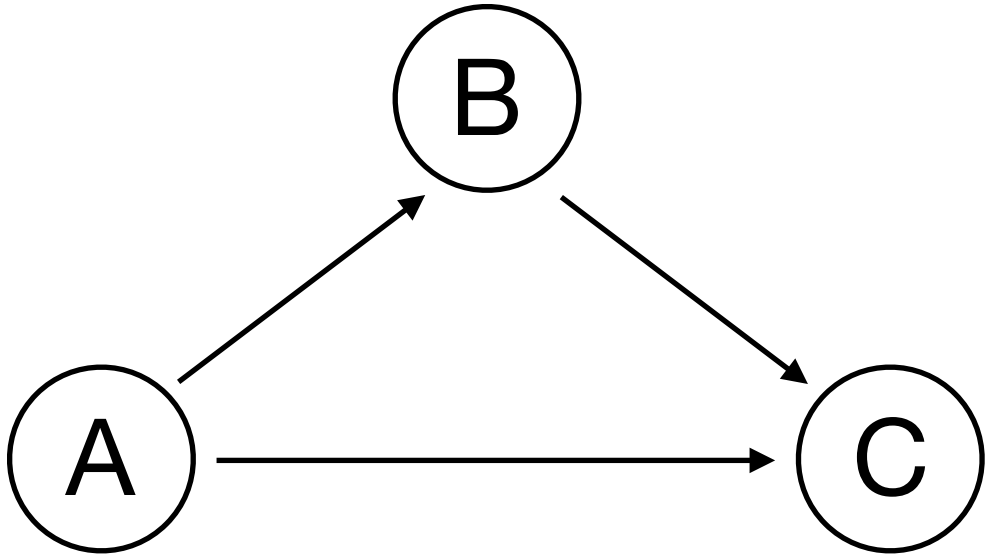

Final Grades Spring 2018