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CSCI 101
Connecting with Computer Science
Lecture 1: Introduction to IT II

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2023 Fall Semester (S3)

Overview

- Focus: History of Computers
- Architecture: von Neumann
- Readings: 0
- Core Ideas:
    1. Information Representation in Computers
    2. Basic Constructions of Digital Computer: von Neumann Architecture

P1
Info. Rep.

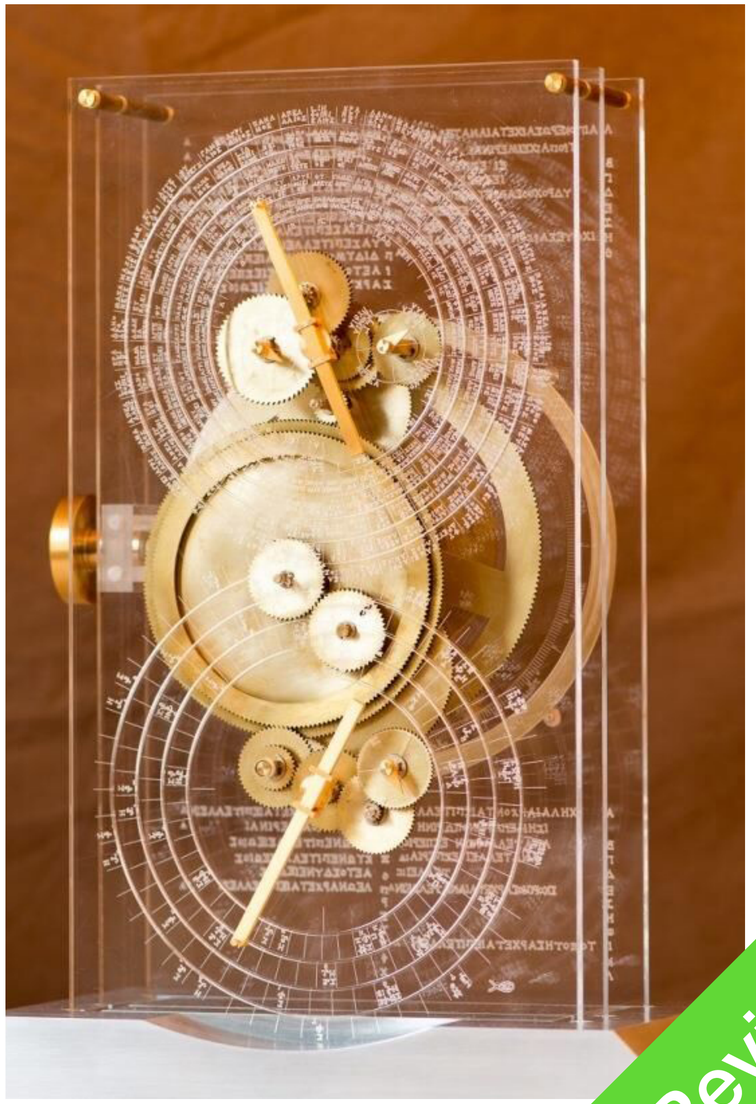
Information representation in computers

Summary

P1
Info. Rep.

The Example of Antikythera Mechanism

- In ancient computers, **information** are represented through **mechanical components**
  - **Positions of Components** such as gears
    e.g. rotation of input gear, position of output needles
  - Computation through **Mechanical Movements**
    e.g. input gear moves the output needle to the correct position through interlocking gears



Review

P1
Info. Rep.

What do all computing machinery share?

- Input/Output interface **Interaction**
  - Provide input to the machine, the machine presents output
- Mapping function **Computation**
  - The behaviour of the machine in response to given input

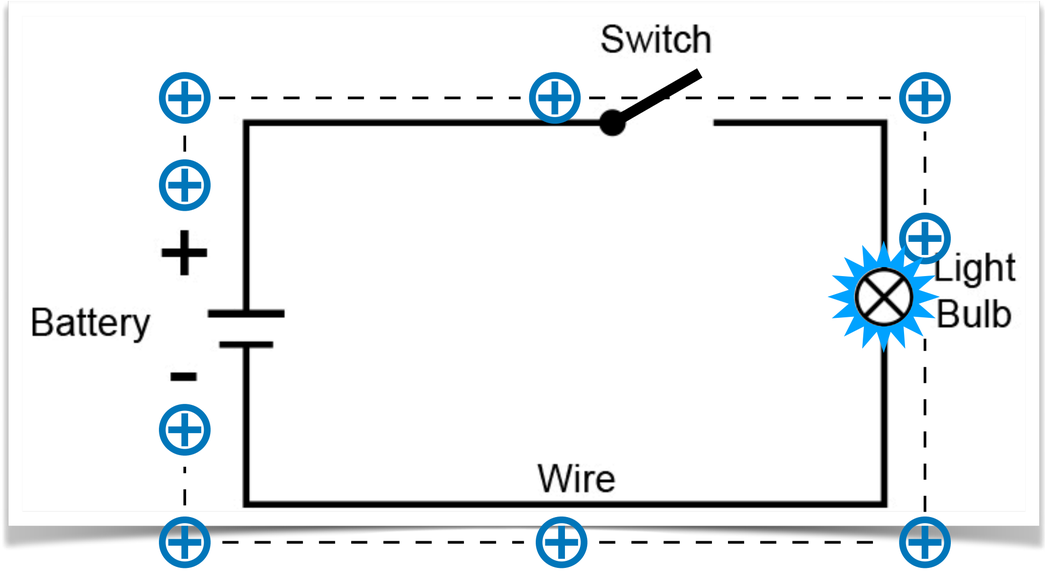
This is the essence of computers!

Concept

P1
Info. Rep.

All machines are about information processing

- Circuits
  - Loop of conductive material
  - Charge carriers flow continuously within
- I/O: lightbulb, switch
- Information: user intention
- Behaviour: status changes according to information



Example

P1
Info. Rep.

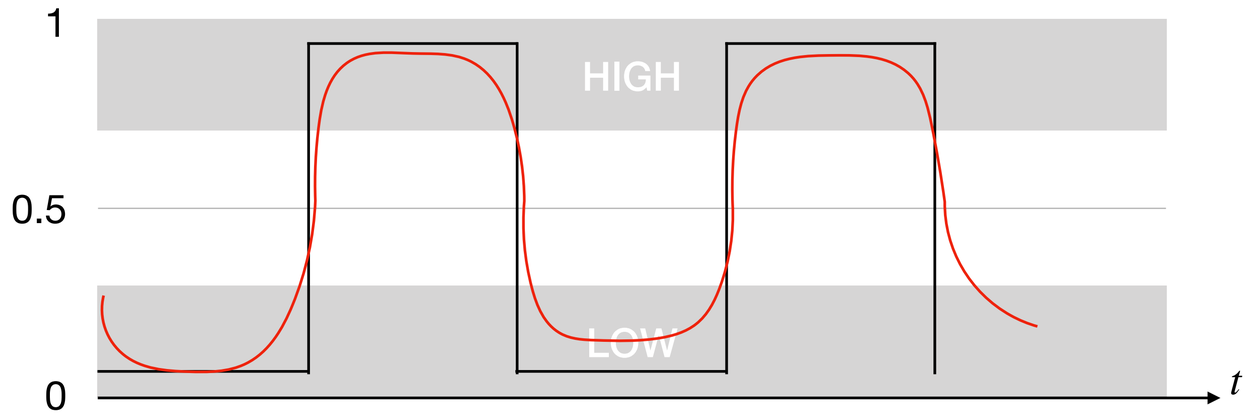
What makes a digital computer?

- The way information is represented in the system
  - Mechanical computers
    information represented through **mechanical** means
  - Digital computers
    information represented through **voltage/current** changes

Example

P1
Info. Rep.

What makes a digital computer?

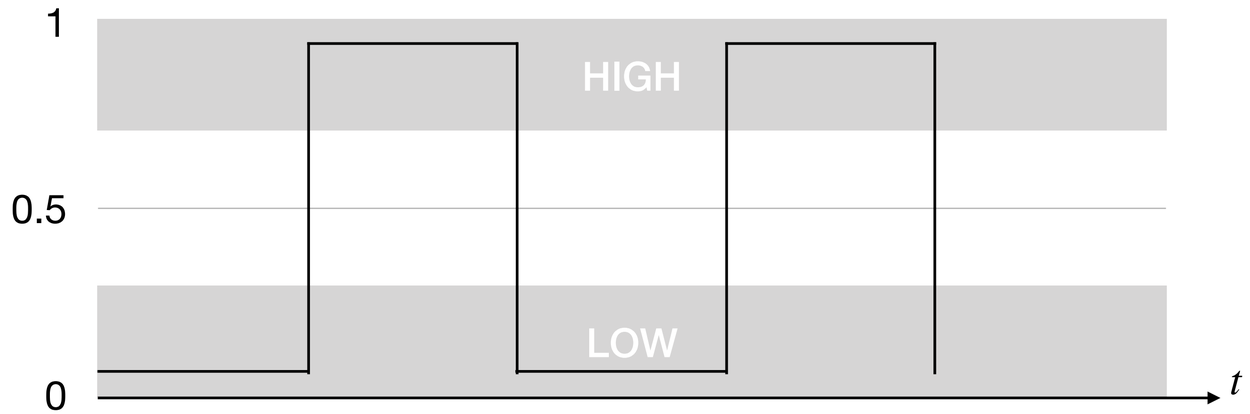


- This diagram represents the change of voltage throughout time t
- In digital computers, we define low/high voltage areas, representing information 0/1
- In reality, actual signals are not so rigid, the straight black lines are approximations of the actual voltage changes

Concept

P1
Info. Rep.

What makes a digital computer?



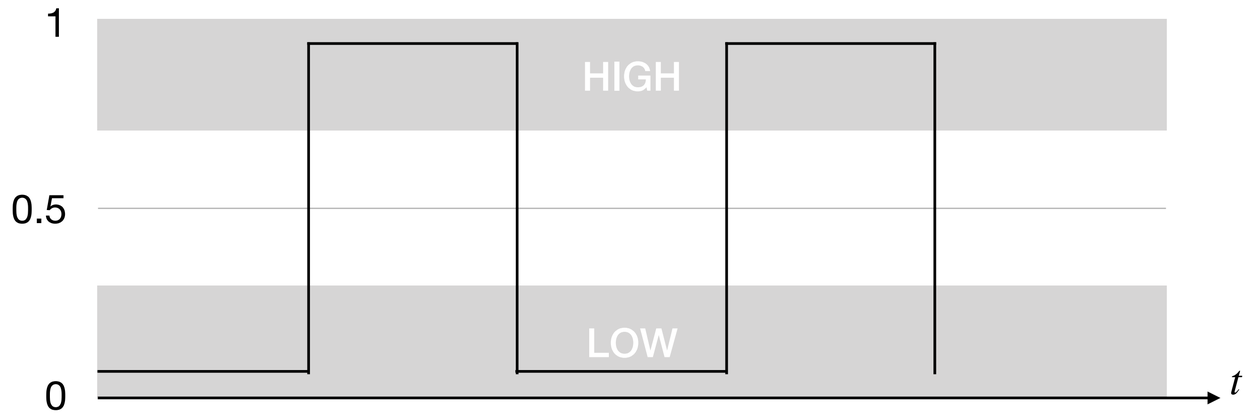
- How can we make sure, whether the information here is
  - 0101; or
  - 00110011

Bitrate

Concept

P1
Info. Rep.

Bitrate

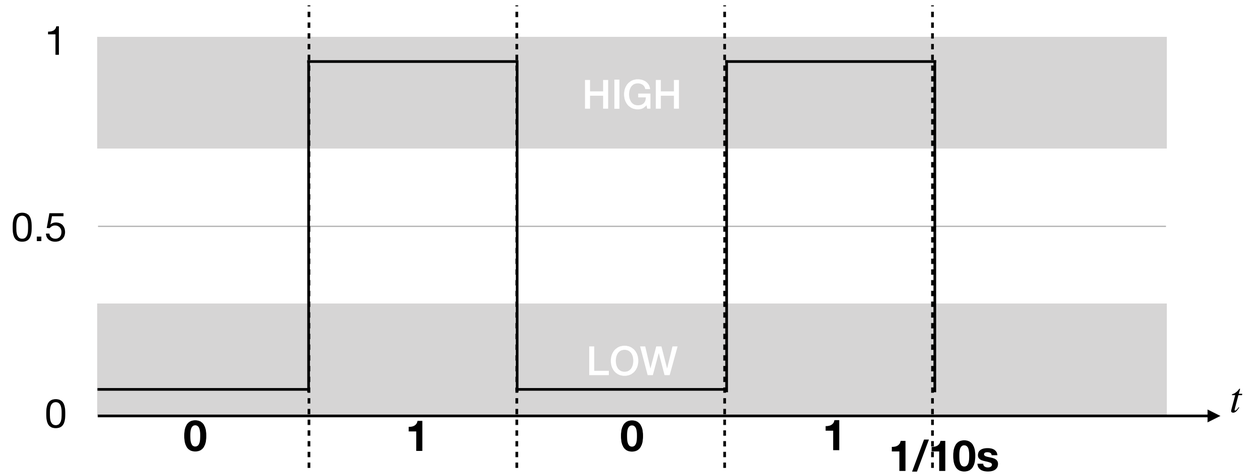


- Bitrate: number of bits per second, each bit is a single binary digit
  - e.g. 100bps: 100 bits per second
  - Each bit at 100bps takes 1/100sec on the diagram

Concept

P1
Info. Rep.

Bitrate

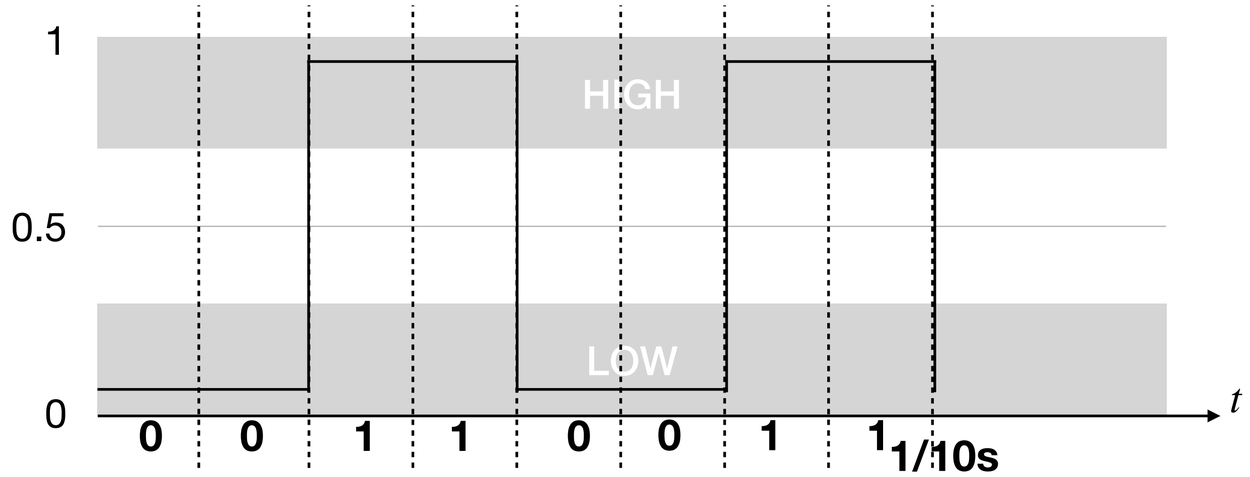


- E.g. bitrate = 40bps, 40 bits per second, divides a single second into 40 equal pieces
- In the above example, each divided spectrum is a single binary digit (bit)
- The information here is: 0101

Example

P1
Info. Rep.

Bitrate



- E.g. bitrate = 80bps, 80 bits per second, divides a single second into 80 equal pieces
- In the above example, each divided spectrum is a single binary digit (bit)
- The information here is: 00110011

Example

Bitrate

- **Constant bitrate**
  - Bitrate is fixed during information transmission
- **Variable bitrate**
  - Bitrate is subject to changes during information transmission
- In either case, the bitrate is **agreed** between the sender and the receiver

Example

P1
Info. Rep.

All information in a computer are represented in binary

- Instructions
- Numbers: integers, float points
- Text strings: ASCII, UTF8
- Audio/Visual Codex: H264, H265
- etc.

Concept

P1
Info. Rep.

All information in a computer are represented in binary

- Computer programme (C, C++, Python)
  - Converts to machine code in binary (compiler, interpreter)
  - The computer sees the machine code, executes the desired programme to manipulate data

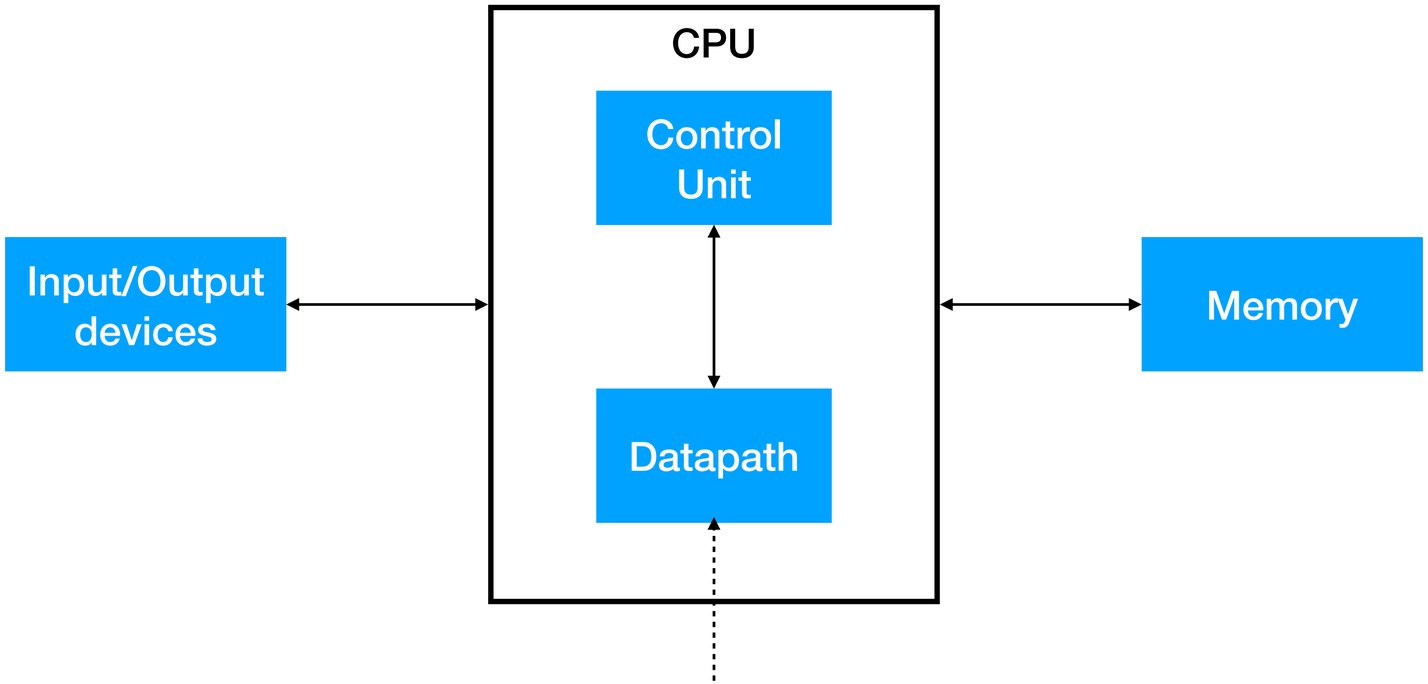
Concept

The von Neumann Architecture

Summary

P2
Architecture

von Neumann Architecture



also called arithmetic unit, logical unit, etc.

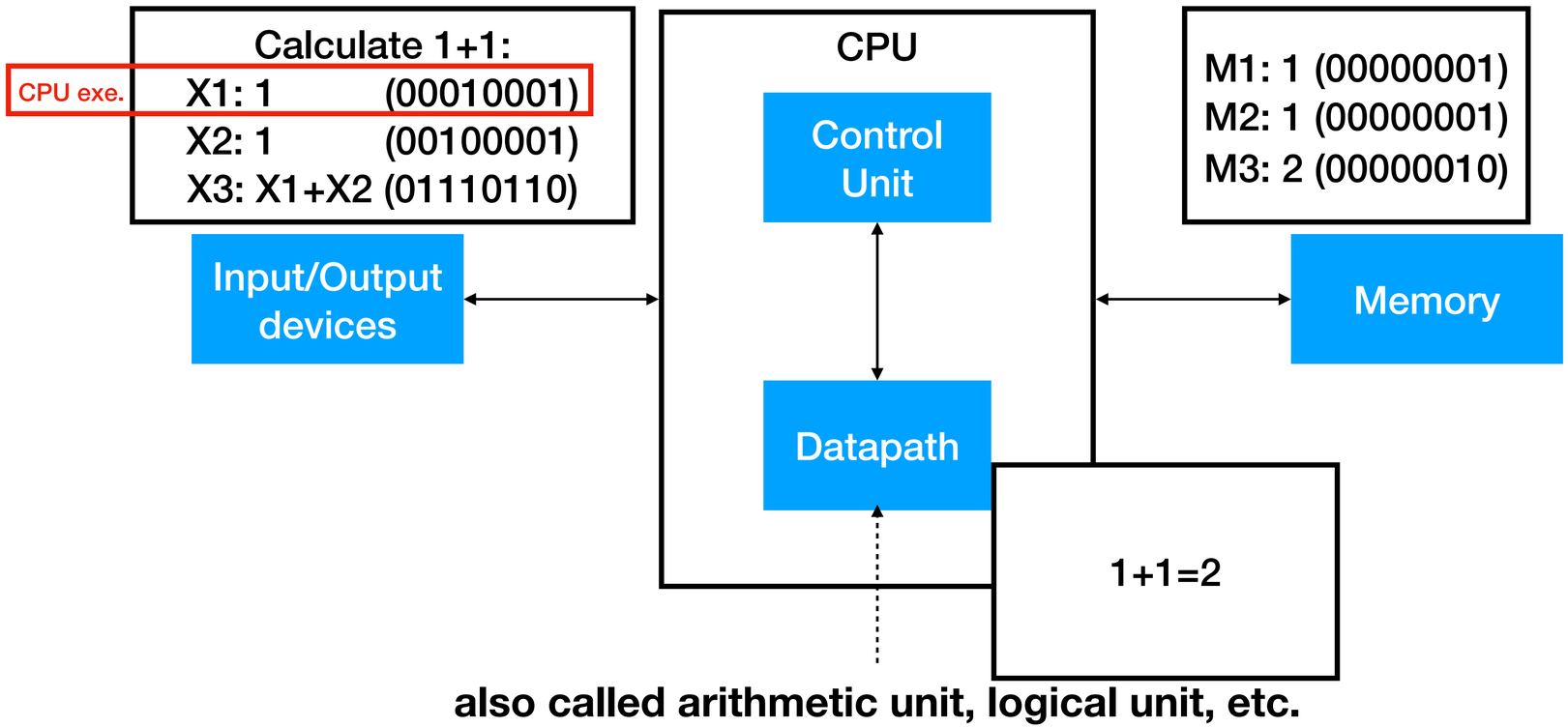
Concept

1. https://www.youtube.com/watch?v=Ml3-kVYLNr8

P2
Architecture

von Neumann Architecture

A very rough example



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Demo

Computer

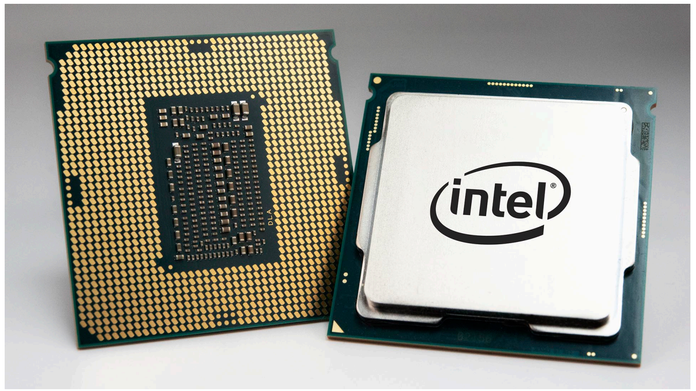
What's it like compared to a human?

- Input/Output devices
  - Interaction (Mouth, hands and feet, eyes, etc.)
- CPU + Memory
  - Processing information, thinking (Brain, short-term memory)
- Storage?
  - Part of I/O devices (Books, long-term memory)

Concept

CPU

- Central Processing Unit
  - Consists of millions of transistors on a single chip
  - Control Unit
    - Processing controlling instructions (CSCI250)
  - Data Path
    - Executing arithmetic operations (CSCI150)



Concept

CPU

- Cores
  - Intel: number of independent processors (CPUs)
  - AMD: number of independent datapaths (part of the control unit is shared)

Concept

P2
Architecture

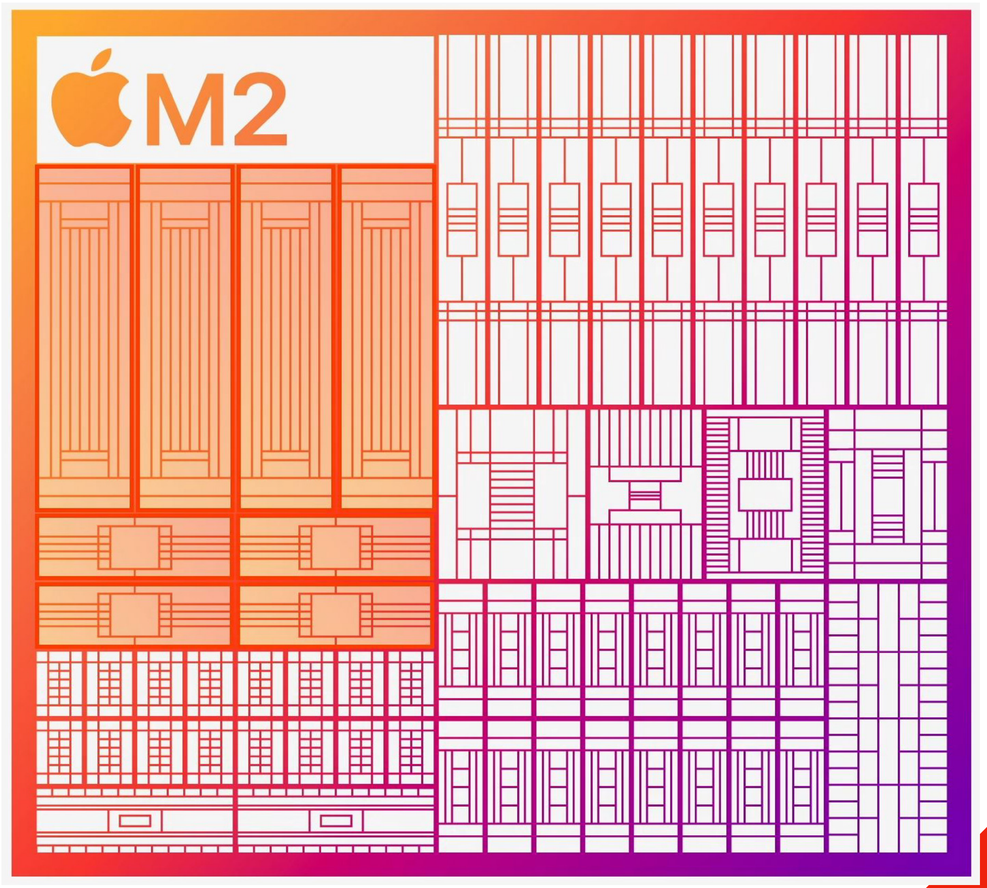
CPU

- Clock-speed
  - Maximum number of instructions it can execute per second
  - Clock-speed can be dynamic
  - e.g. 2.8 GHz: upper-limit for clock-speed (box speed)
  - Over-clocking: going over the box speed

Concept

CPU

- Modern CPUs you buy from Intel and AMD also contain **coprocessors**
  - Integrated GPU
  - Multimedia Codex
  - Encryption modules
  - Virtualisation modules
  - Neural Engines
  - etc.



Concept

Memory

- Your iPhone does not have 64GB memory
  - That is storage
- Memory refers to RAM (Random Access Memory) and ROM (Read-Only Memory)

Concept

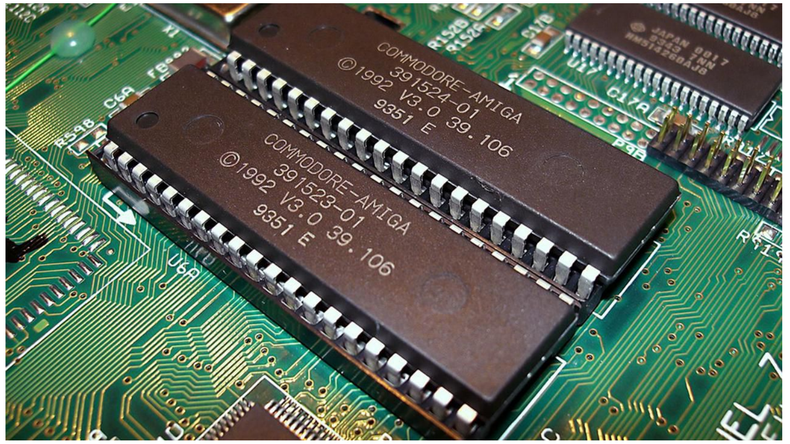
RAM

- Also my fav daft punk album
- Volatile memory
  - When the power goes off, the data disappears
- RAM holds data and program instructions
- Sorta like short-term memory

Concept

ROM

- Comes with your motherboard
- Contains firmware and hardware data
- Exceptions
  - CD-ROM
  - DVD-ROM

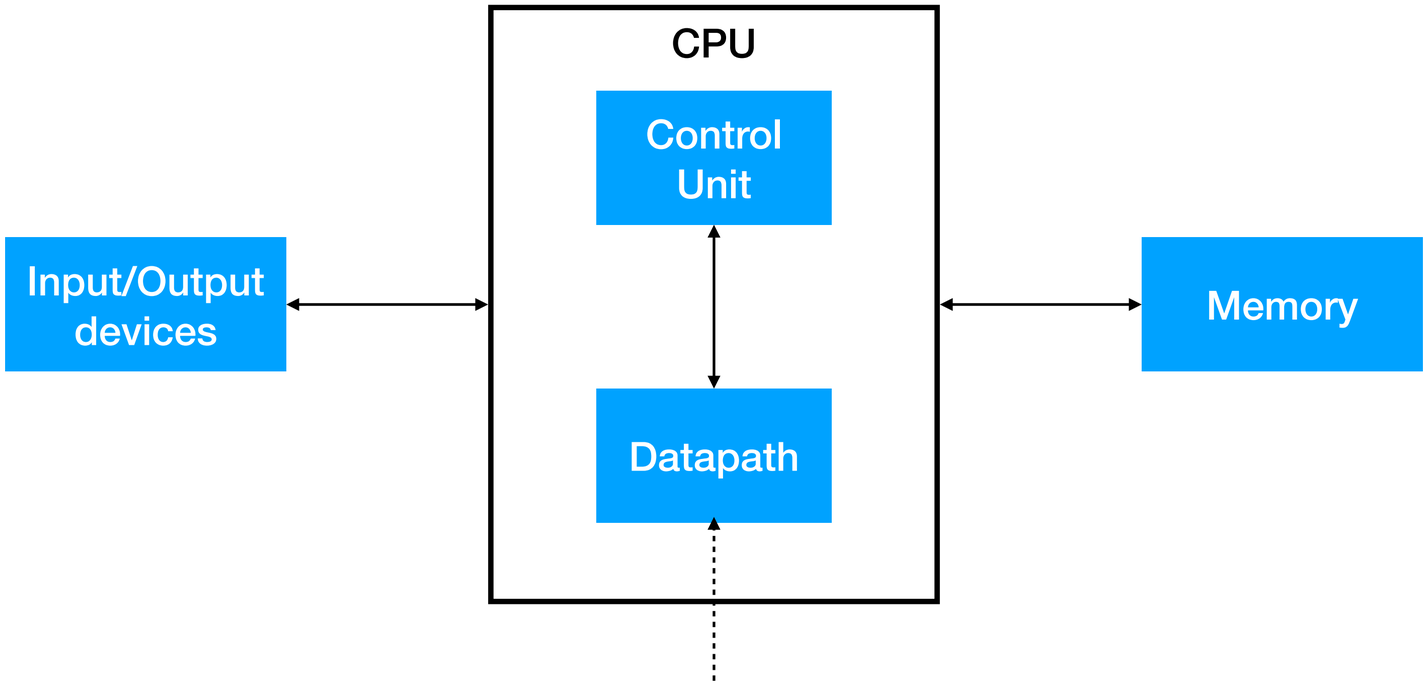


I/O Devices

- Disk storage
  - SSD/Flash storage (sometimes called memory)
    The tech was inspired by RAM technology
  - Not volatile
  - Read/Write much much slower than RAM
- Mouse, Keyboard, Monitor, etc.

Concept

von Neumann Architecture



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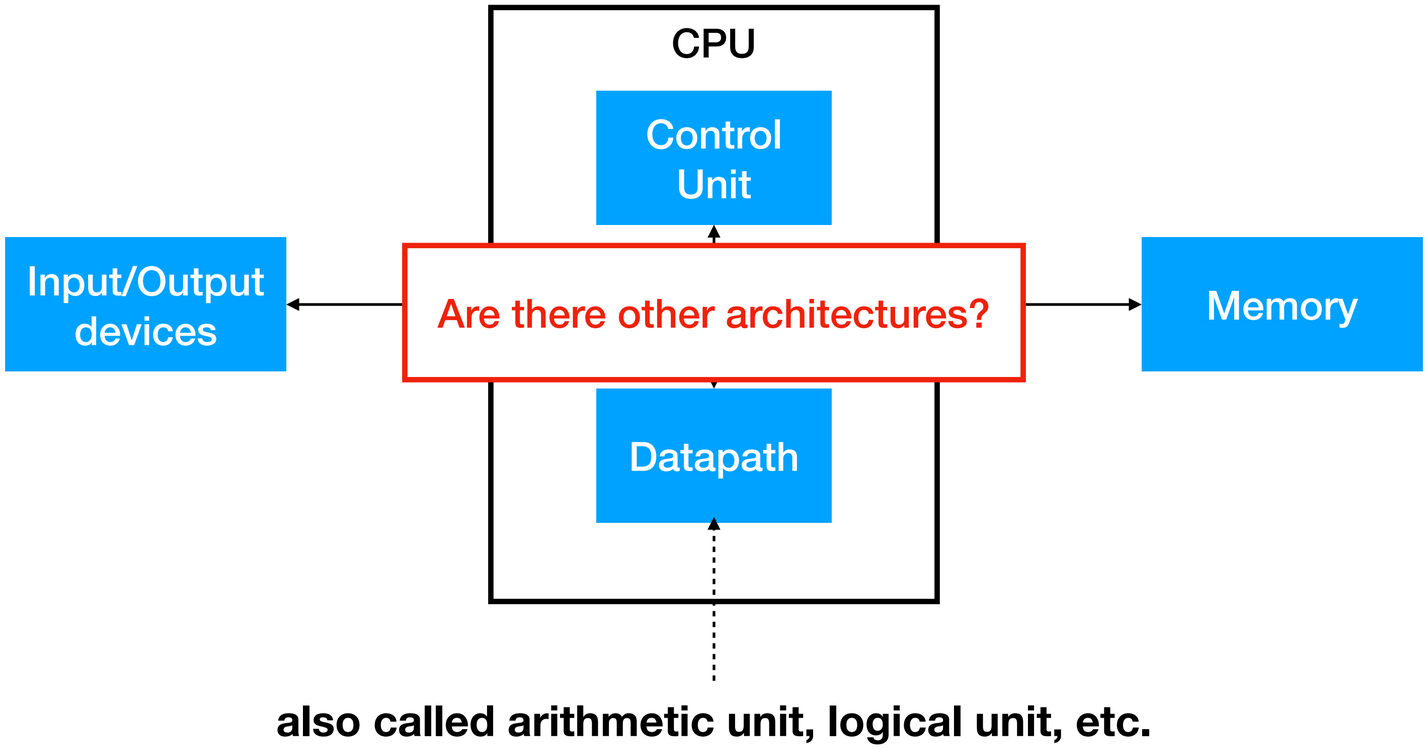
von Neumann Architecture



Future

P2
Architecture

von Neumann Architecture

- Potential presentation topics:
  - How does 5G work with Autonomous Vehicles 
  - Compare between the Harvard and von Neumann Architecture 
  - Embedded Systems and IofT 

Concept

P3
Booooooooot

Booting: How does a computer start?

Summary

P3
Booooooooot

Starting a Modern Computer is Complex

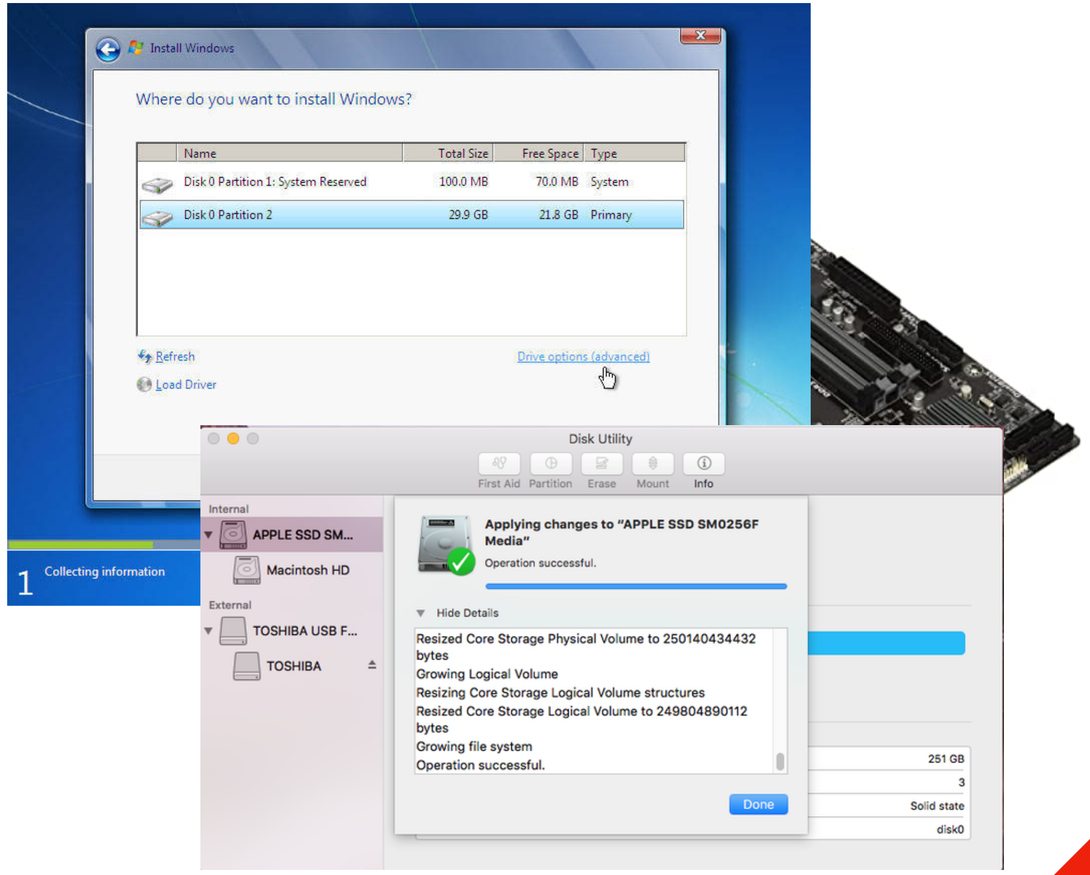
- Before everything else: Motherboard self-checking
  - Loads up firmware from ROM
    e.g. BIOS, EFI, UEFI systems
  - Perform system check
    e.g. Where's my CPU?
  - Detects attached storage devices

Concept

P3
Booooooooot

Starting a Modern Computer is Complex

- Still motherboard
  - Look for partitions on storage devices, look for bootable volumes
  - Load the booting code for the OS into the memory, now your computer is ready to be booted!



Concept

P3
Booooooooot

Starting a Modern Computer is Complex

- Loading the OS...
  - Detect attached devices...
  - Loading drivers for different devices...
- Loading graphics interface...
- You can login now!

Concept

P3
Booooooooot

Scheduling

- Multitasking is hard
  - A given computer core can only do one thing at a time
  - At any given time, there are hundreds of processes (programmes) running, some of which user processes, some system
  - The OS needs to schedule tasks for each core! This is called CPU scheduling (very complex issue)
    - Scheduler

Concept

Summary

- Information Representation in Digital Computers
- Modern Computer Architecture: von Neumann
- Starting a Modern Computer

Review