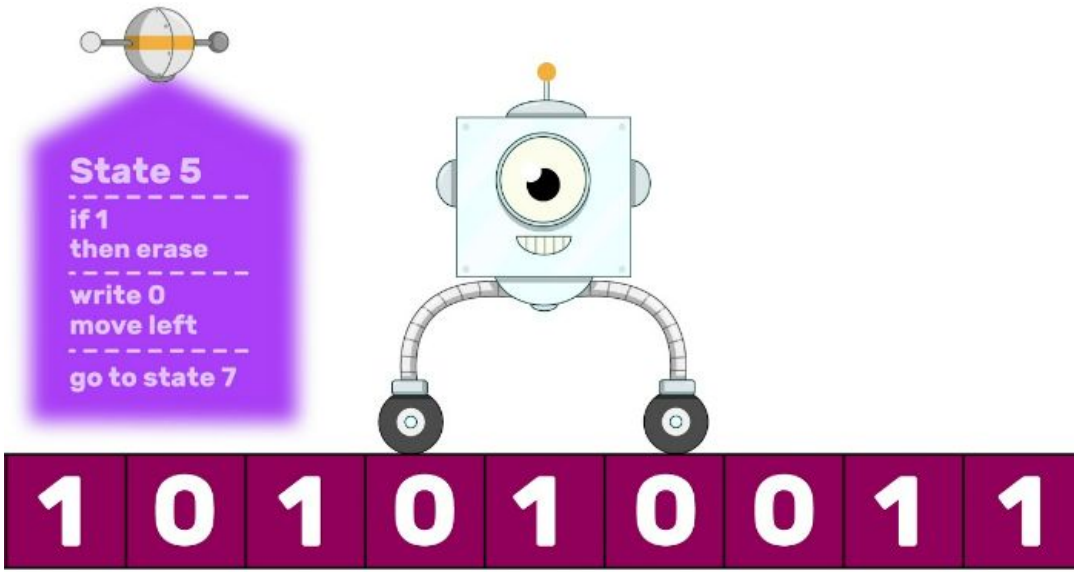
How Computers Work: Hardware

Turing Machine



- An infinitely long tape
  - Split into cells
  - Modern Computers: RAM
    - Capacitors and Transistors
- Head
  - Reads/Writes to the tape
  - Modern Computers: Central Processing Unit (CPU)
- Register
  - Stores state of program
  - Modern Computers: also CPU
- Set of Instructions
  - To be executed by the Head
  - Modern Computers: program/software
    - Logic gates at the CPU-level

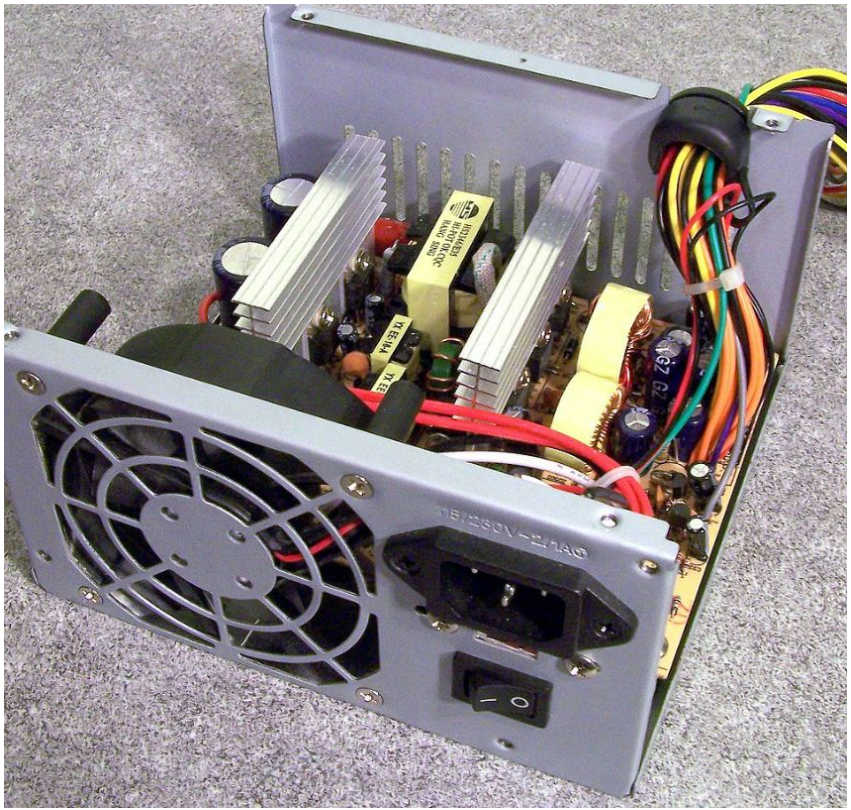
https://www.youtube.com/watch?v=E3keLeMwfHY

https://isaaccomputerscience.org/concepts/dsa_toc_turing_machines?examBoard=all&stage=all

Why 0s and 1s?

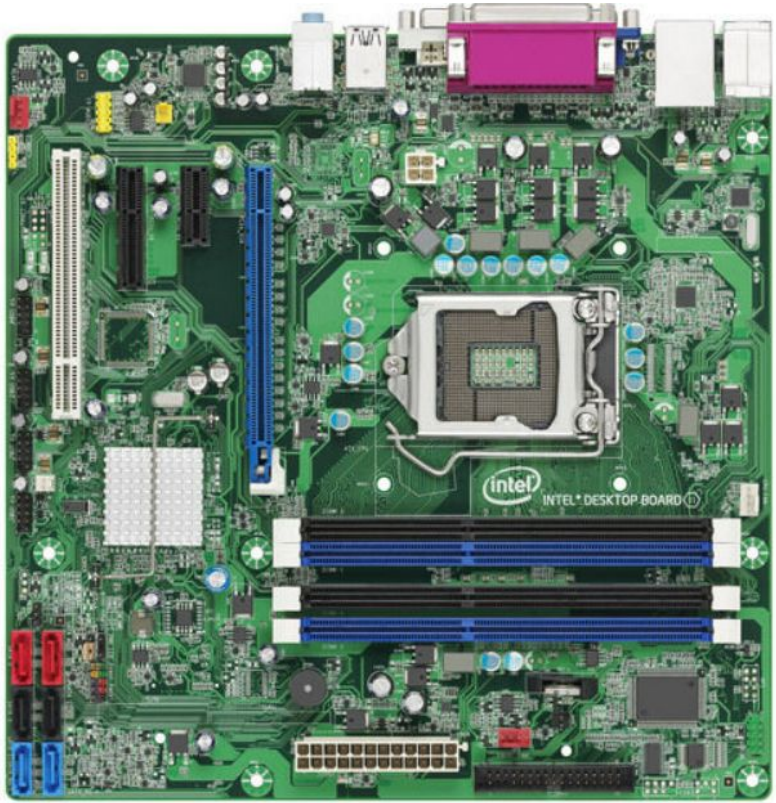
- 0s and 1s don’t actually exist (it’s all a LIE!!!), they simply represent electric charge
- We use electrical pulses/current to perform calculations
- Transistors are used to carry the pulses/current through the CPU and perform calculations
- Transistor can be in 2 states (low voltage and high voltage)
  - There are technically more states (no voltage, medium voltage, etc.), but it’s faster and more accurate to not use it
- Fun Fact: transistors are made of silicon because it carries electrical current REALLY well and it’s a cheap material to produce
  - Look up how solar panels work for some more interesting facts/knowledge

Inside a Modern Computer: Power Supply Unit



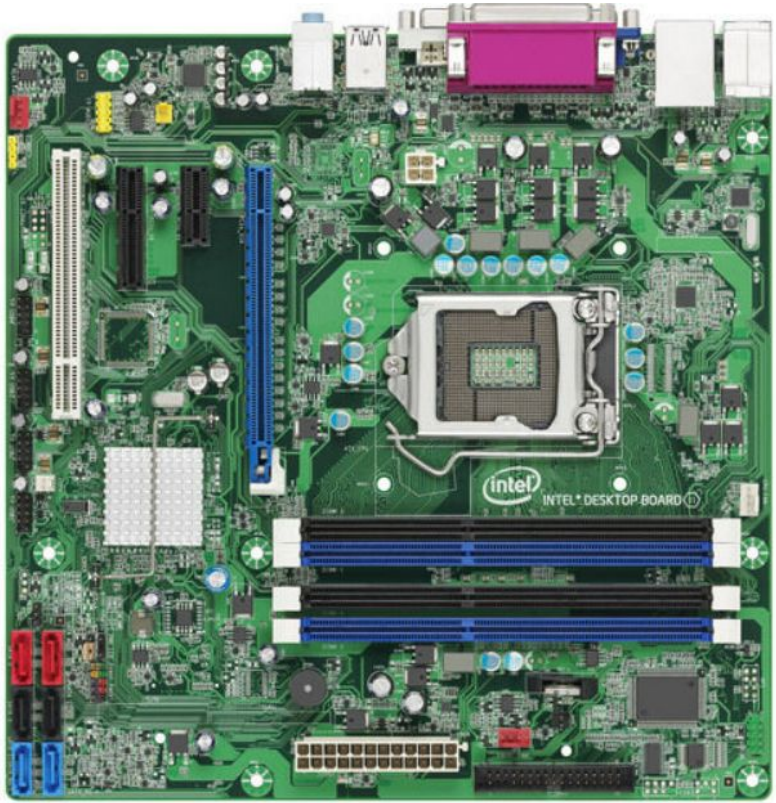
- Power Cord
  - Power input
- Heat Sink
- Fan
- Transistor (normal-sized)

Inside a Modern Computer: Motherboard



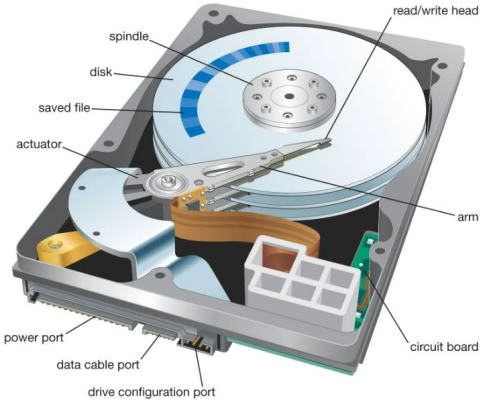
- Power
  - Main Power
  - Capacitors and Inductors
- Central Processing Unit (CPU)
- Chipset; Platform Controller Hub (PCH)
  - Communication between CPU and other (mostly storage) devices
  - System Clock
- Random Access Memory (RAM
- Data Bus

Inside a Modern Computer: Motherboard

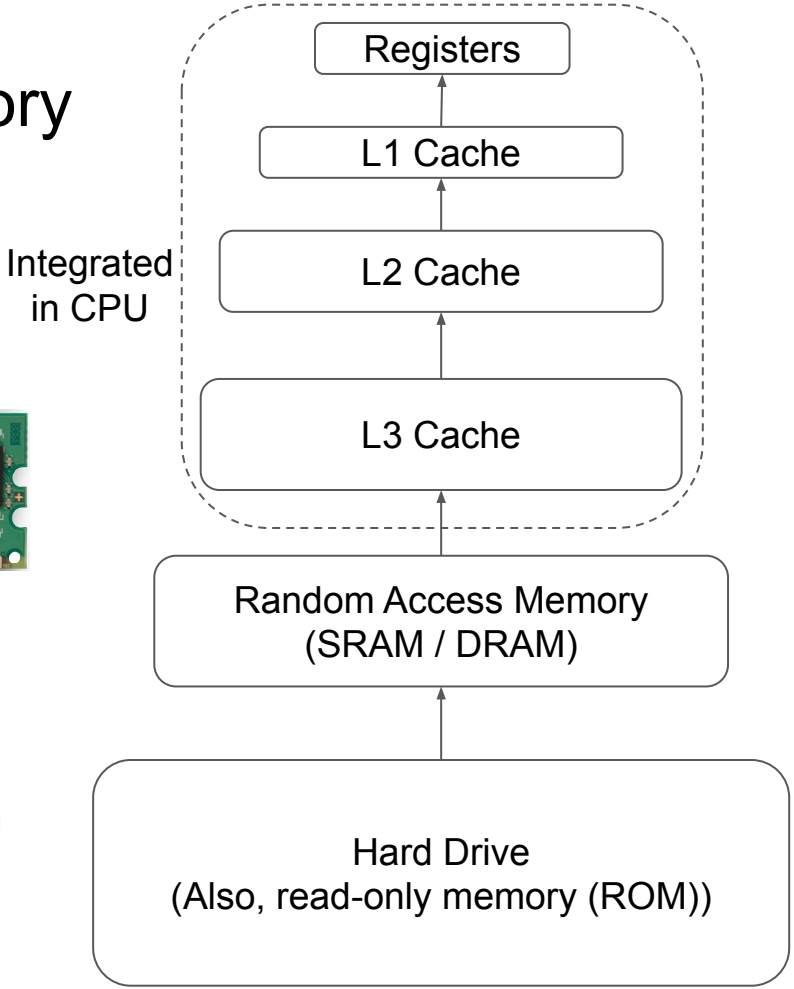


- Serial Advanced Technology Attachment (SATA)
- Super I/O
- Peripheral Component Interconnect (PCI)
  - Graphics Card

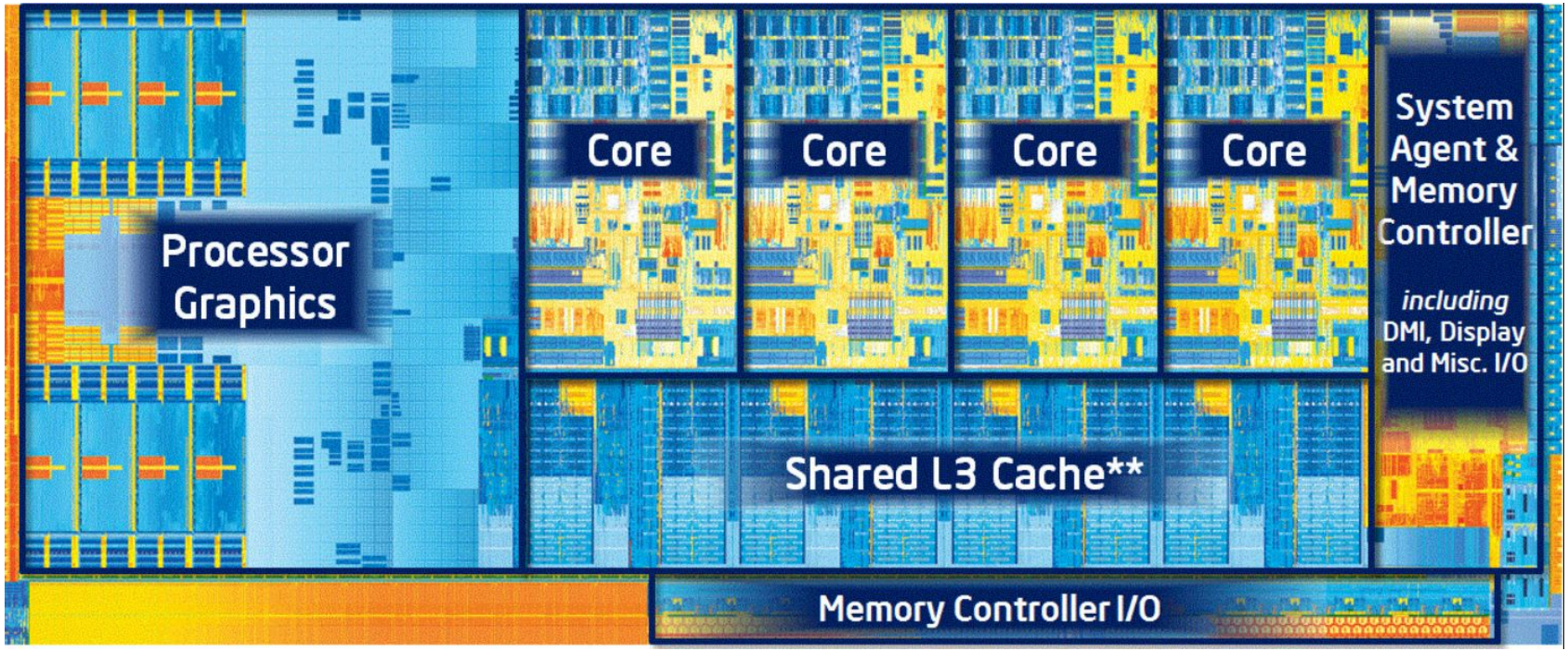
Inside a Modern Computer: Memory



- Speed of moving memory
  - About 90% the speed of light
  - About 6cm-7cm per clock cycle
- To speed up, get closer to the CPU



Inside a Modern Computer: CPU



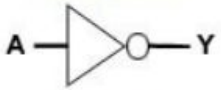
https://www.youtube.com/watch?v=Fxv3JoS1uY8

Inside a Modern Computer: How a CPU Calculates

Logic Gate Examples

KEY: Input = A and B -- Output = Y

Not gate



If A = 0 then Y = 1
If A = 1 then Y = 0

Or gate

If A = 0 and B = 0 then Y = 0
If A = 1 and B = 0 then Y = 1
If A = 0 and B = 1 then Y = 1
If A = 1 and B = 1 then Y = 1

And gate

If A = 0 and B = 0 then Y = 0
If A = 0 and B = 1 then Y = 0
If A = 1 and B = 0 then Y = 0
If A = 1 and B = 1 then Y = 1

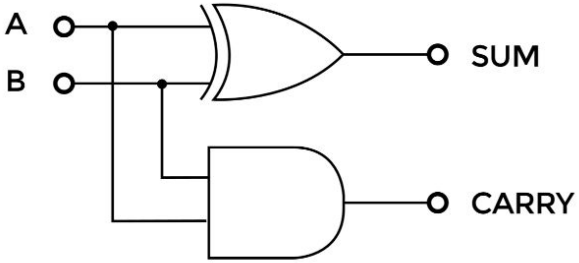
Nand gate

If A = 0 and B = 0 then Y = 1
If A = 0 and B = 1 then Y = 1
If A = 1 and B = 0 then Y = 1
If A = 1 and B = 1 then Y = 0

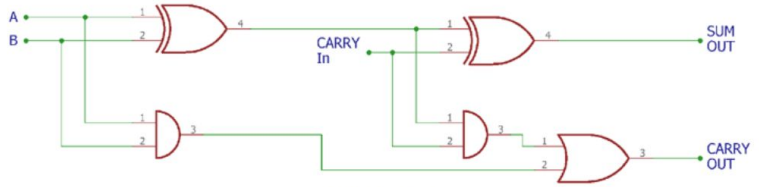
Nor gate

If A = 0 and B = 0 then Y = 1
If A = 0 and B = 1 then Y = 0
If A = 1 and B = 0 then Y = 0
If A = 1 and B = 1 then Y = 0

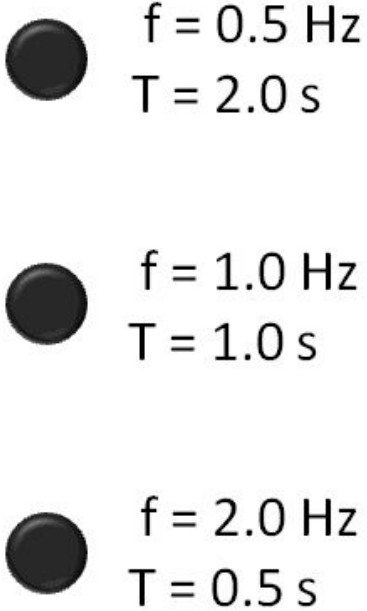
half-Adder



A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



Inside a Modern Computer: The Clock



- The clock ensures calculations are synced
  - Different thicknesses and lengths of transistor may move electric current/pulse quicker or slower
- Measured in hertz (1 event/pulse/cycle per second)
  - Uses a quartz-based crystal to produce a cycle/pulse
  - Common for computers to have 3.5-4.0 Gigahertz (a billion hertz per second)
  - 3.5-4.0 needed for intensive tasks such as video, sound, etc.; only need about 2.0-2.5 for normal tasks