Embedded Systems, Computer Architecture, & Finite State Machines

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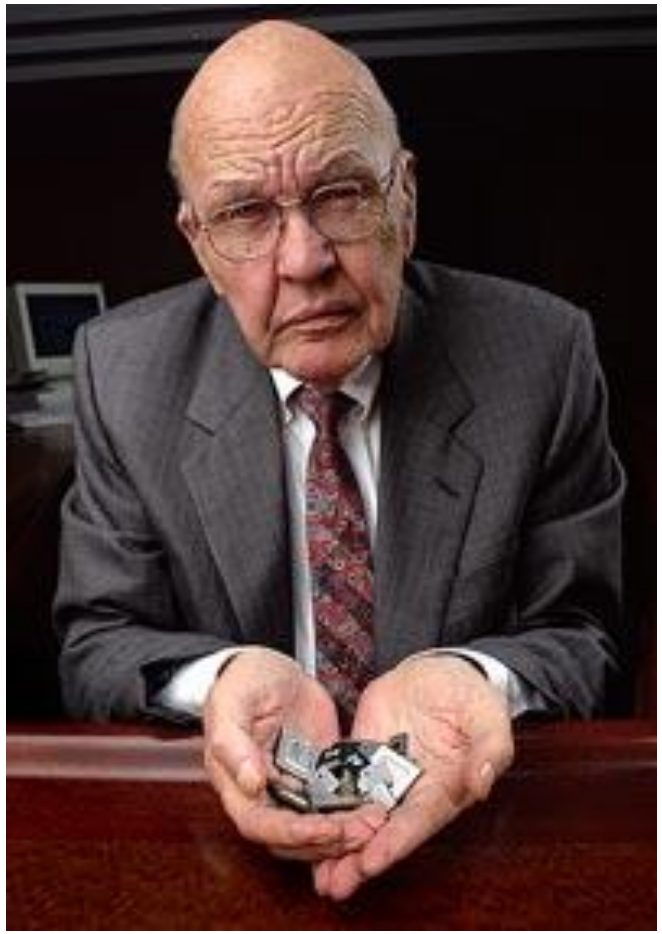
Tyranny of Numbers

For some time now, electronic man has known how 'in principle' to extend greatly his visual, tactile, and mental abilities through the digital transmission and processing of all kinds of information. However, all these functions suffer from what has been called 'the tyranny of numbers.' Such systems, because of their complex digital nature, require hundreds, thousands, and sometimes tens of thousands of electron devices.

-Jack Morton - 1957
VP of Bell Labs

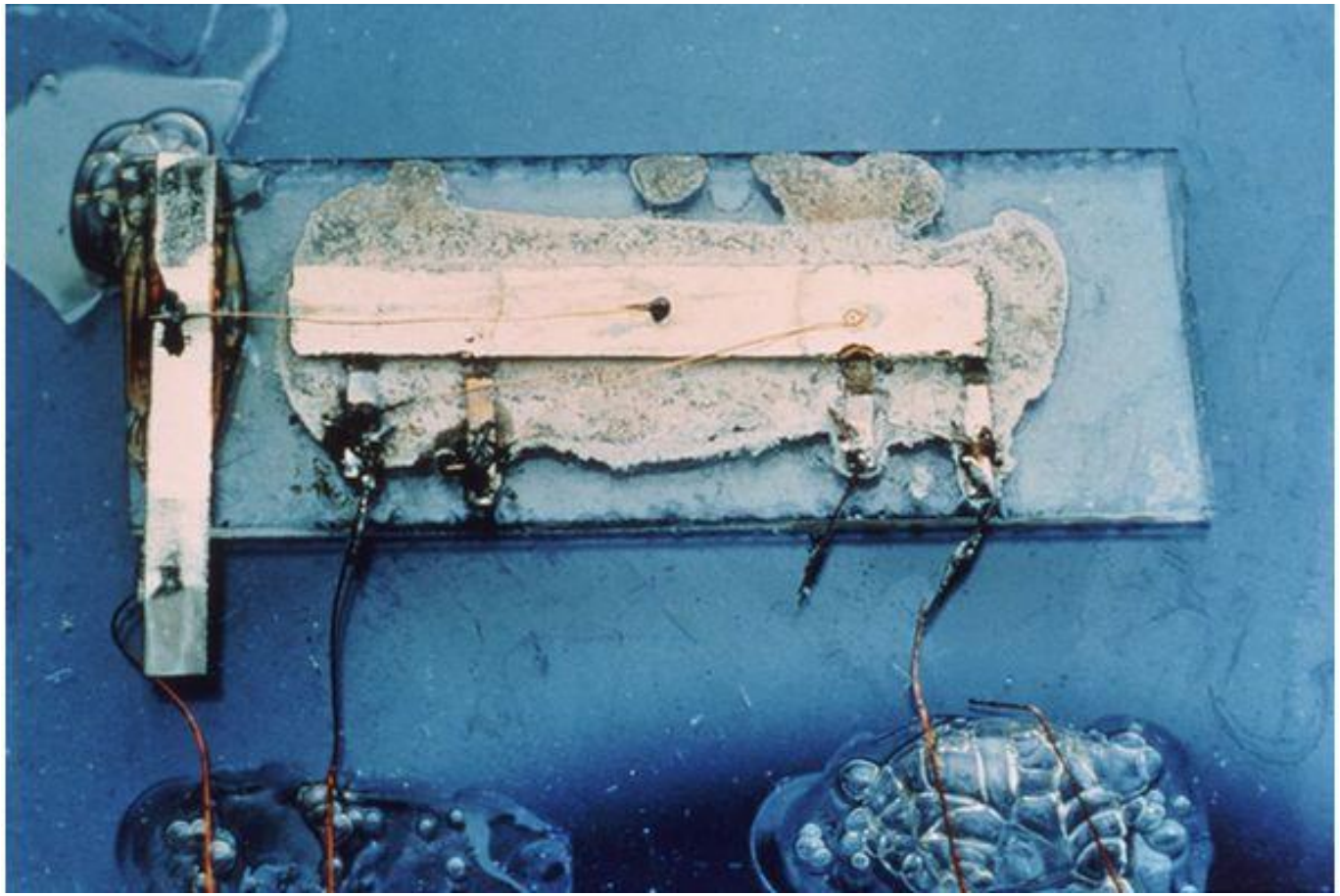
Jack Kilby

- Grew up in Great Bend, KS
- 1958 – Hired by Texas Instruments as an Electrical Engineer
- Worked to solve the “tyranny of numbers” problem
- Concluded components of a circuit could be made directly on a price of semiconductor material



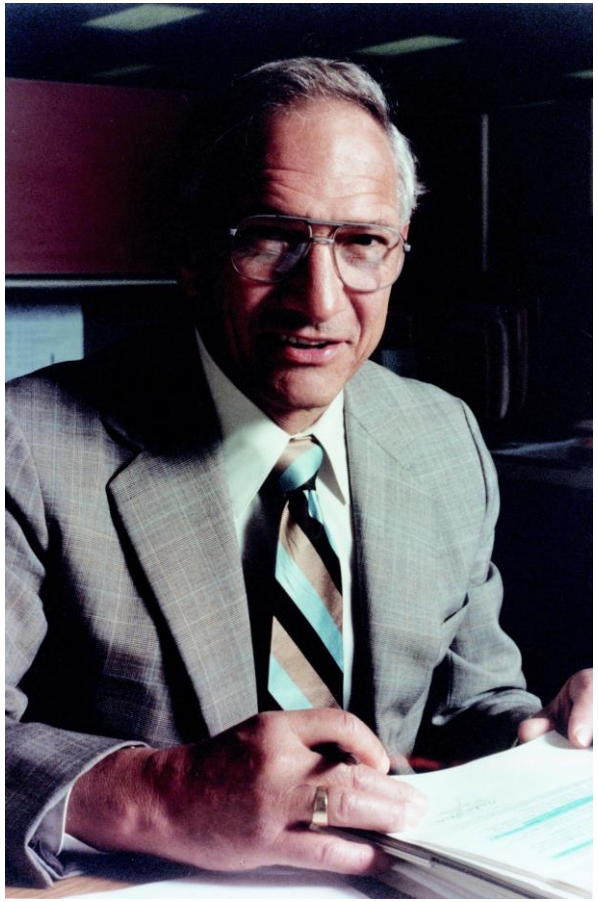
https://www.youtube.com/watch?time_continue=6&v=62JMBnT2HUc

First Integrated Circuit



Robert Noyce

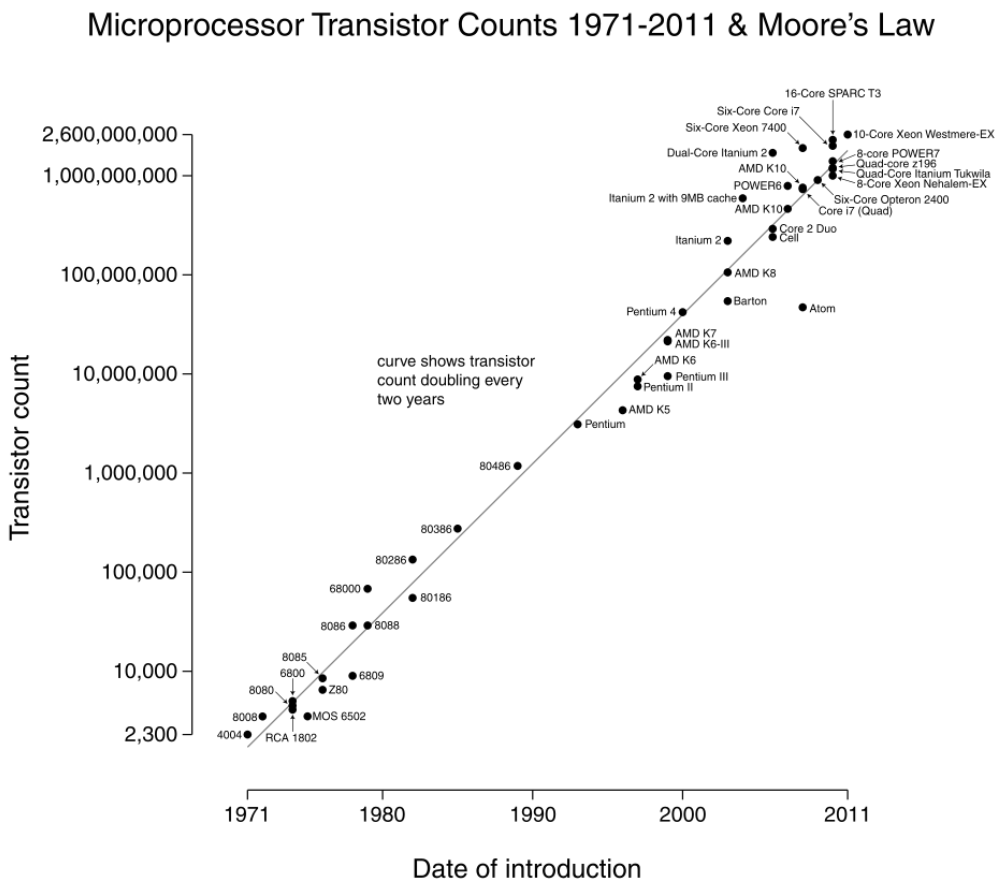
- Worked at Fairchild Semiconductor
- Made an integrated circuit made of silicon
- Overcame some of the flaws of Kilby's design independently
- Left Fairchild Semi conductor with Gordon Moore to create a new company



Intel Founders

- Noyce and Moore founded Intel in 1968
- Focus on creation and manufacture of new integrated circuits and semi conductors

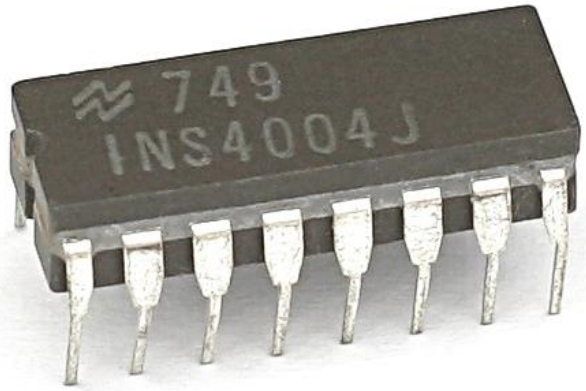
Moore's Law



- *"Cramming More Circuits onto Integrated Components"* – 1965
- Circuits on chips double every year for another 10 years

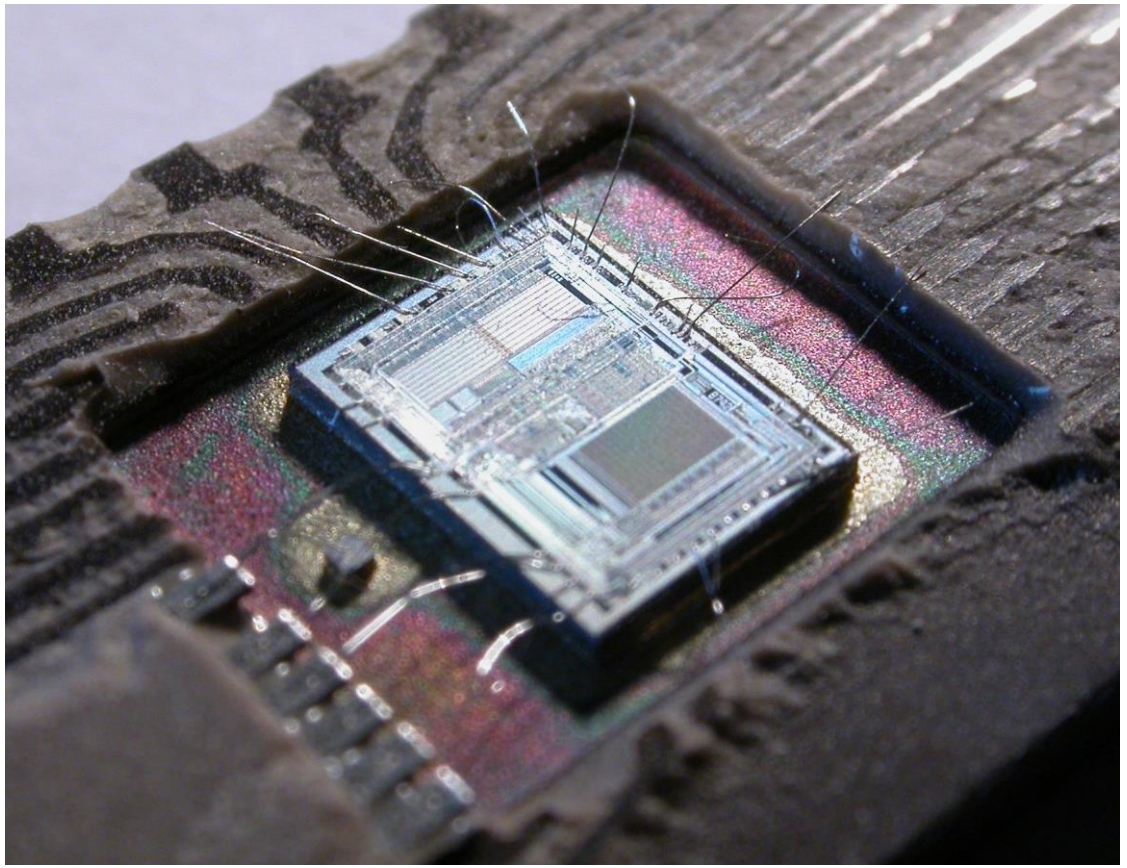
Intel 4004

- First ever Central Processing Unit (CPU)
- Had 2,300 transistors, but it was the size of a small finger
- Circuits were 10 times smaller than human hair

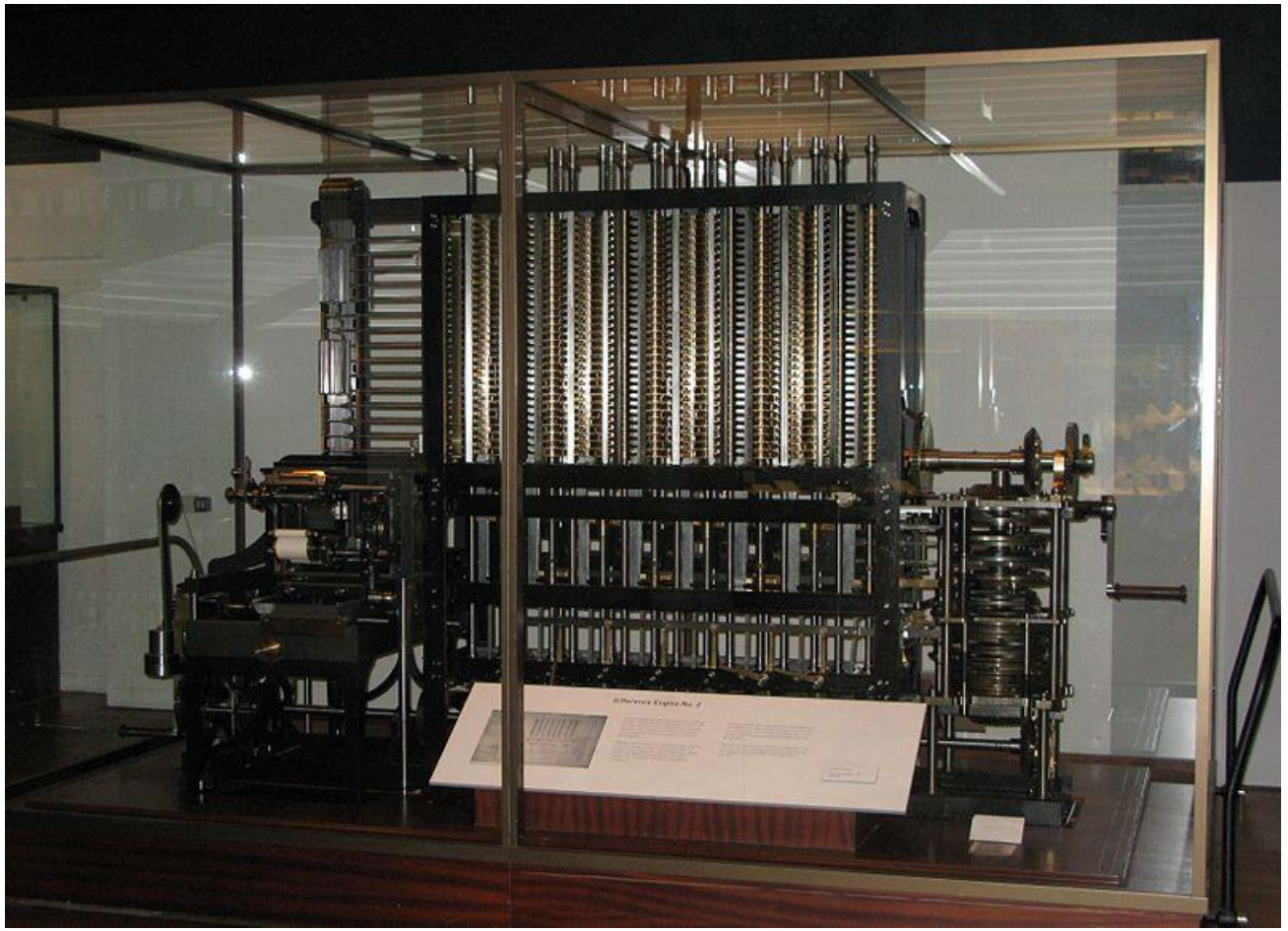


Microcontrollers

- Include everything a device needs to think and function
- How do we make electronic machines that react to input from the real world?



Fixed Program Computers

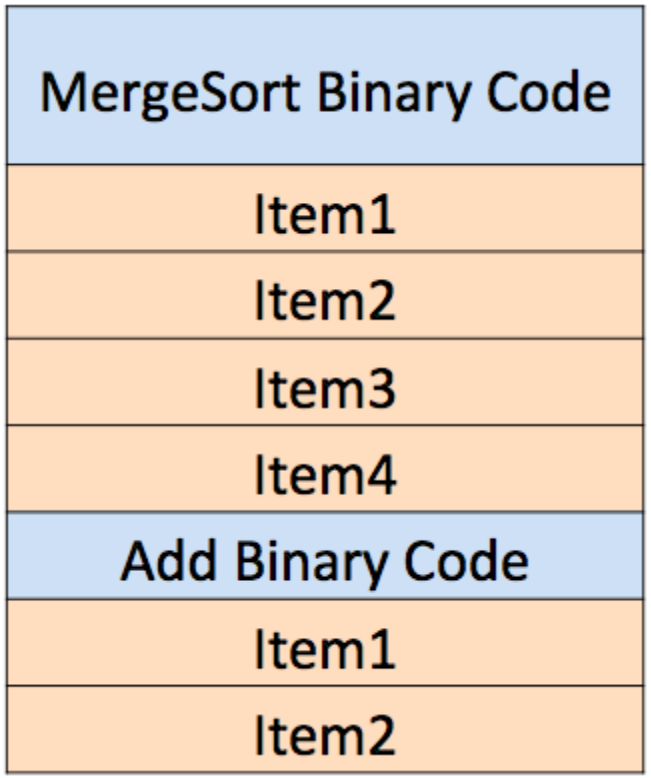


John Von Neumann

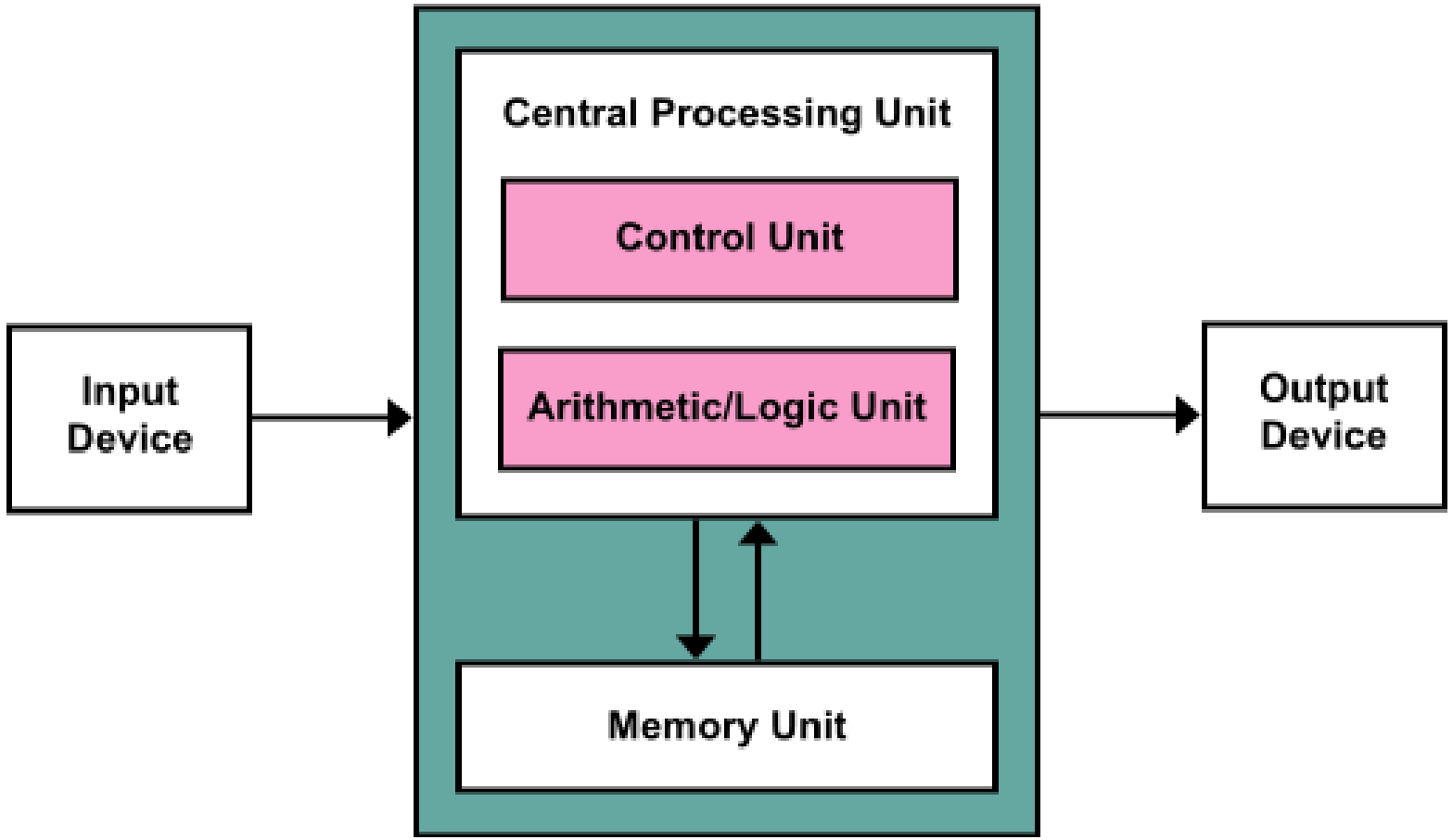
- Research involved in the Manhattan project
- Inspired by Alan Turing
  - As well as the EDVAC
- Work was leading the direction to storing logic alongside data

Stored Program Computers

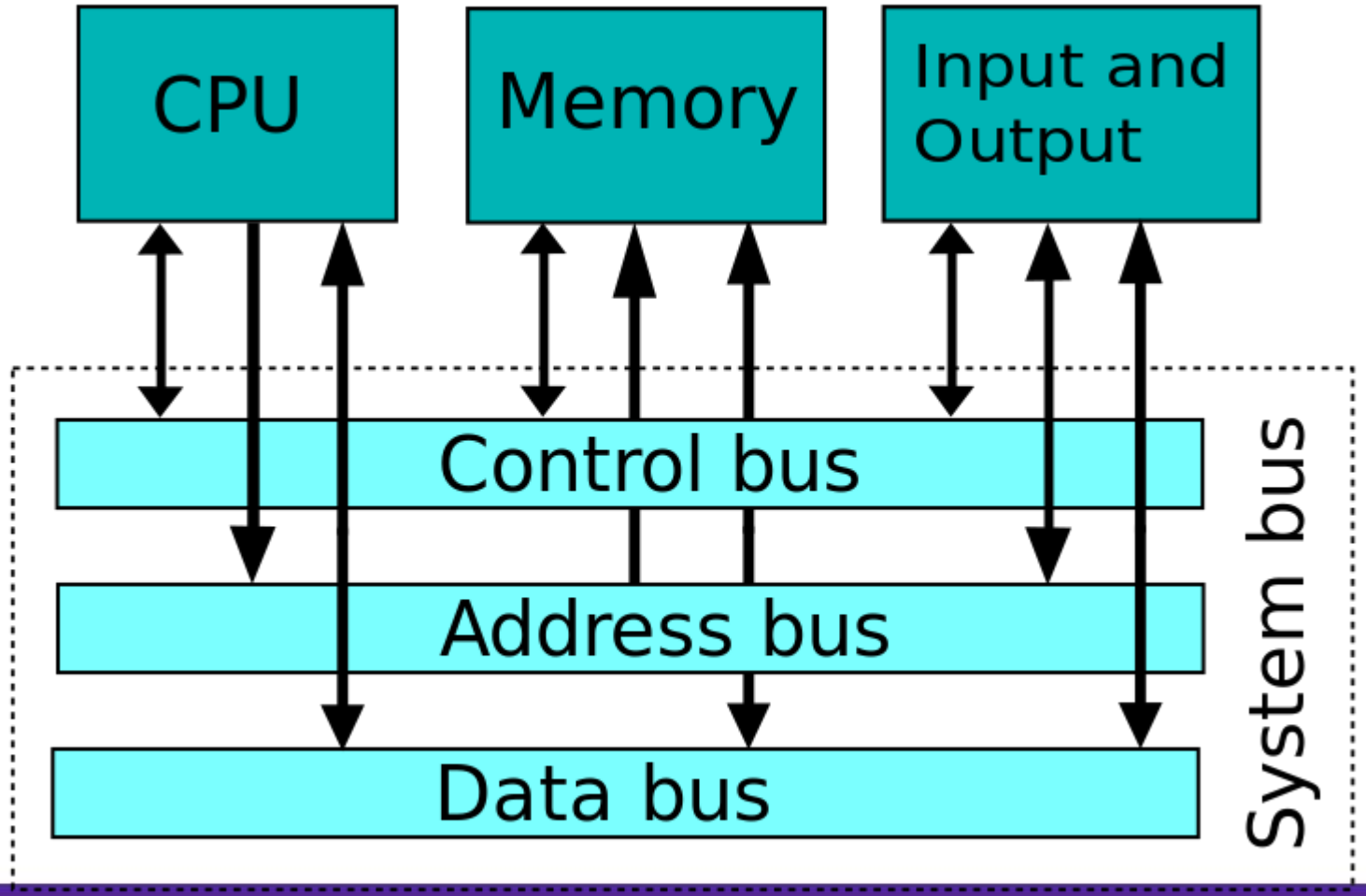
- Computer program can be stored in the same memory as the program data
- No need to have separate parts for each
- Treats programs as data



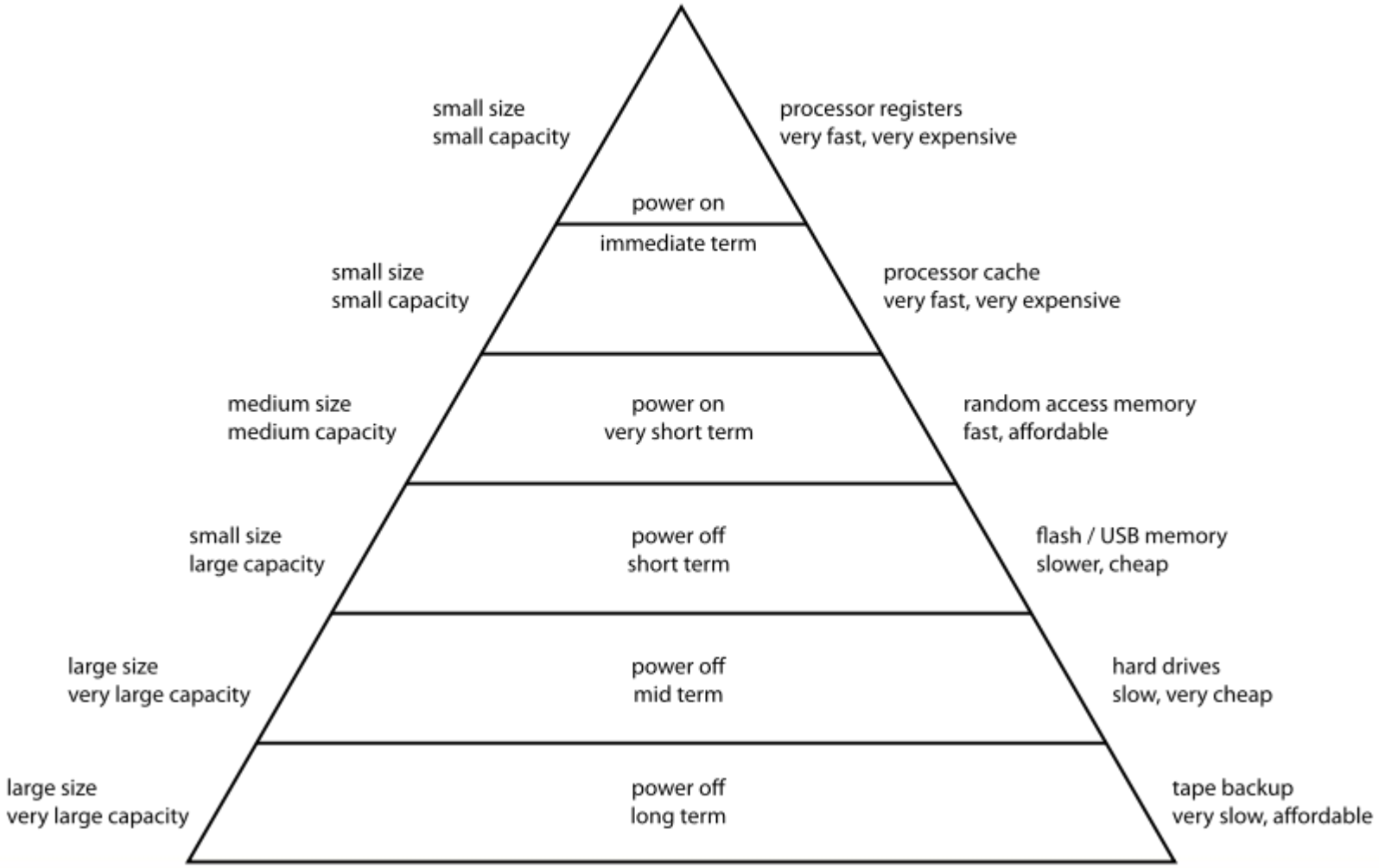
Von Neumann Architecture



System Bus


CPU
Memory
Input and Output
Control bus
Address bus
Data bus
System bus

Computer Memory Hierarchy

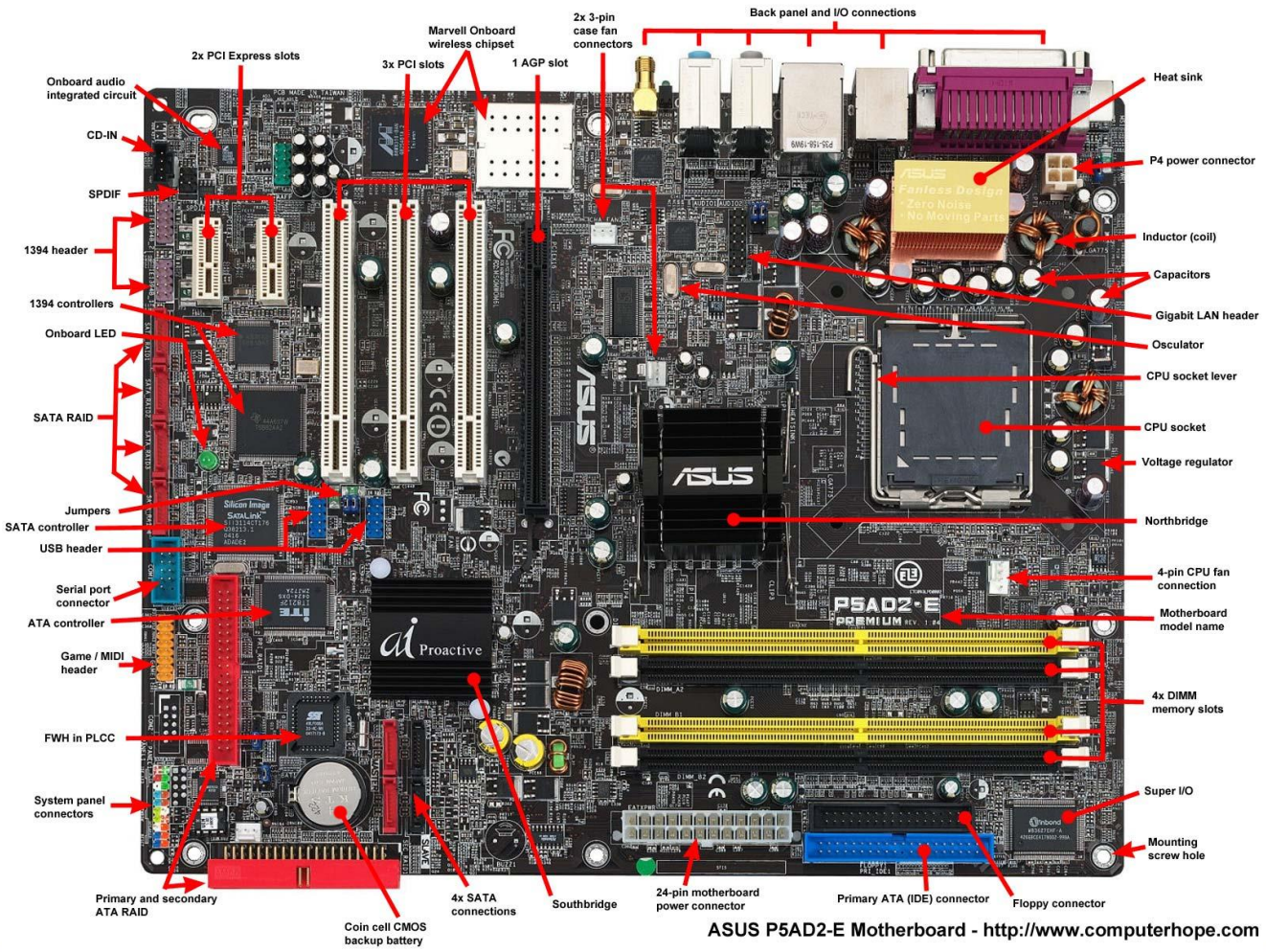


Instruction Set Architecture (ISA)

- x86
- x86-64
- IA64 (Itanium)
- ARM
- PowerPC
- MIPS

Motherboard

- CPU Socket
- Memory Slots
- Northbridge
- Southbridge
- Onboard GPU and Sound
- Expansion slots



Central Processing Unit (CPU)

- Architecture
- Clock speed
- Cache memory
- Processing cores

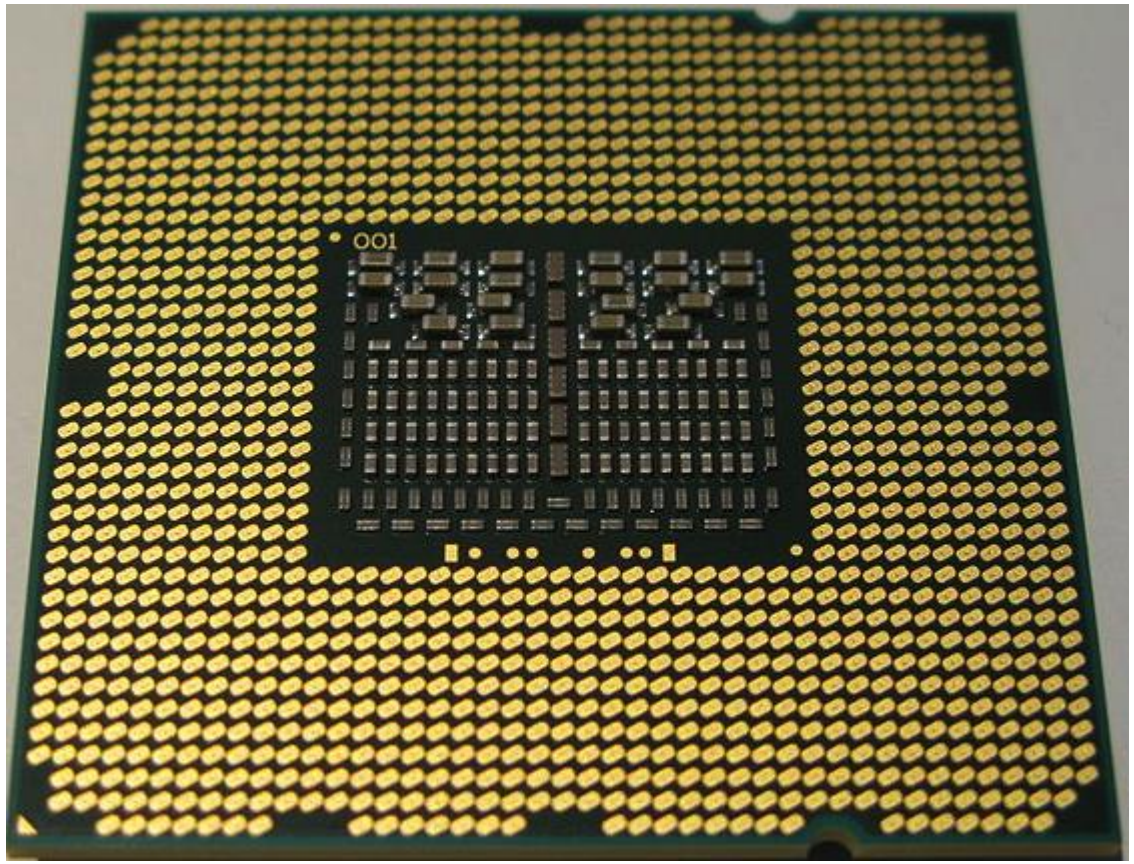
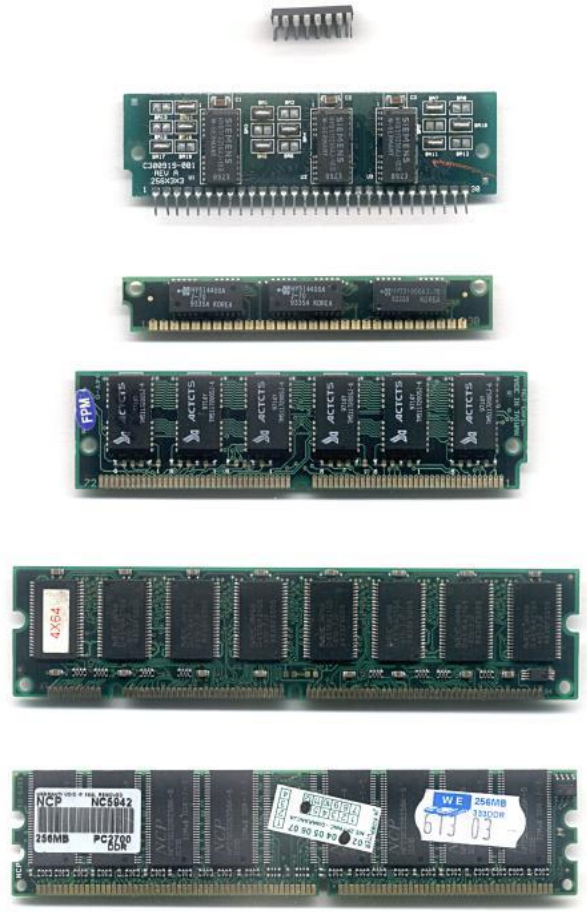


Image Credit: Wikipedia

Memory

- Size
- Speed
- Type/class
- ECC
- Registered



Storage

- Capacity
- Interface
- Spindle Speed (HDD)
- Read speed
- Write speed
- Latency
- Raid
  - 0: striping, 1: mirroring, 5: striping + parity, 10: mirror + striping

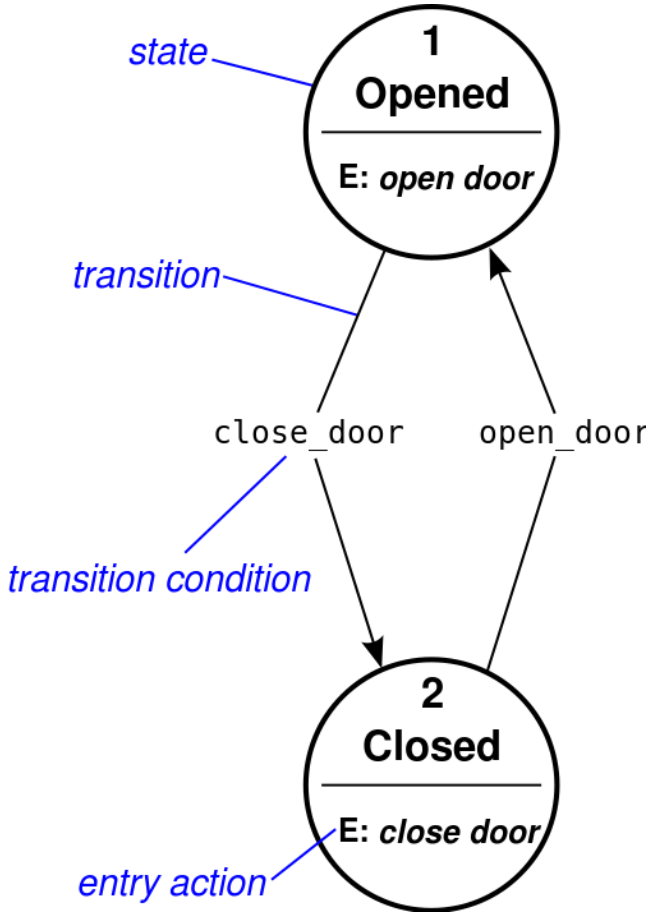
And More!

- Optical Disk Drive (ODD)
- Graphics Card
- Sound Card
- Wireless Card
- Network Card
- Power Supply (PSU)
- …….

How can we represent the way real-world systems operate using a computer?

Finite State Machine

- Device that has a limited number of states
- Can change based on inputs
- Used in many real world applications



1. Elevator Control System
2. Stoplight
3. Baseball At-bat
4. Starting a Car
5. Pinball Machine
6. Store Self-Checkout
7. ATM Withdrawal
8. Keypad Security Lock
9. Paper-Rock-Scissors Game
10. Changing a Tire
11. 2 Player Texas Hold-em Poker
12. A DVD Player

Let's make a Finite State Machine (FSM)