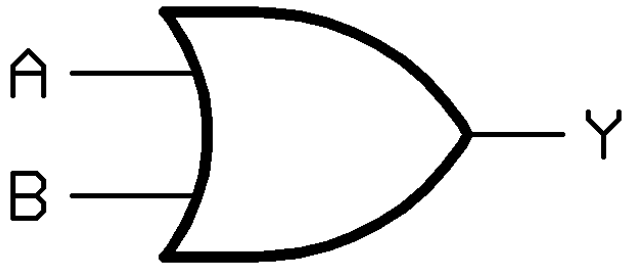
Input, Output and Hardware

CS105

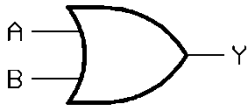
Electrical Signals

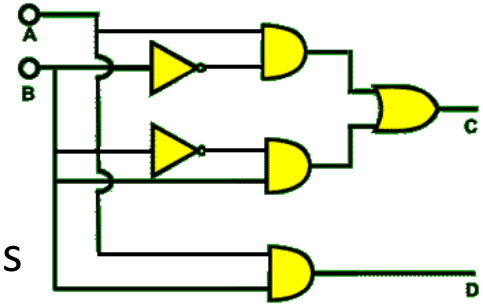
- Transmission of data
- Any electrical signal has a level of voltage
  - Interpretation of 1s and 0s
- Generally speaking:
  - range of 0 to 2 volts – 'low' – 0
  - Range of 2 to 5 volts – 'high' – 1
- Control signals by a gate
  - A device that performs a basic operation on electrical signals
  - Input one or more signals producing an output



Electrical Signals

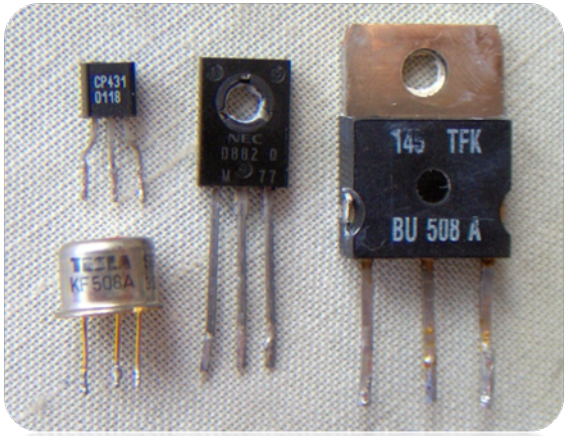
- Gates are combined to form circuits
  - Circuits for a logical function such as arithmetic, store values
  - Three equally powerful notational methods for describing behavior of gates and circuits
    - Boolean expressions
      - Expressions in algebraic notation
    - Logic diagrams
      - Graphical representation of a circuit
    - Truth tables
      - Function of a gate by listing input combinations

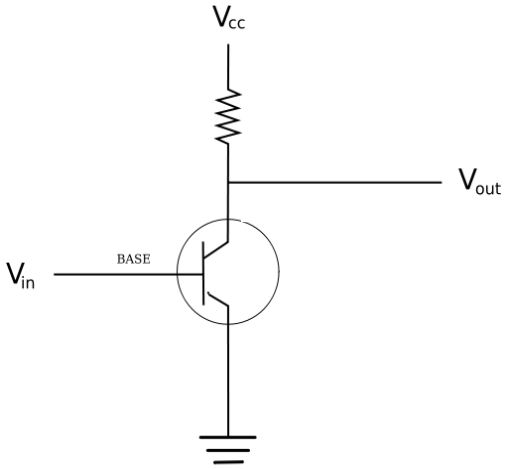




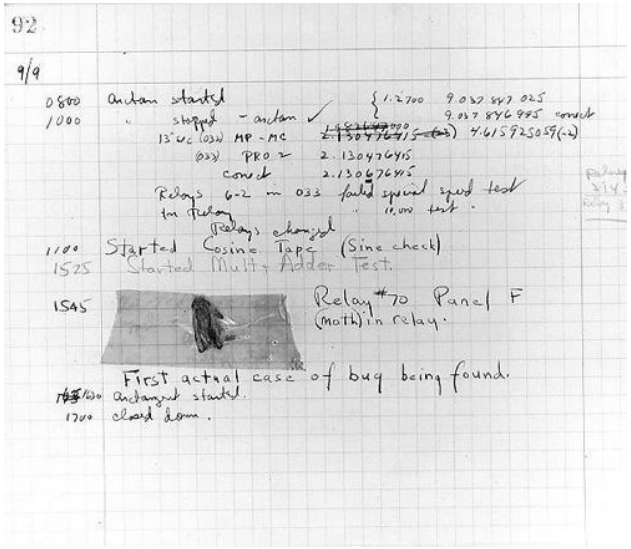
Transistors

- A transistor is a device that acts depending on the voltage level of the input signal, either as a conductor or as a resistor of the flow of electricity
  - Great for logic circuits





Transistors: History



First computer bug

- Harvard Mark 1 : First programmable computer in the US built in 1944
  - Switches, rotating shafts, relays, clutches..not purely electrical machine
  - 5 tons, 500 miles of wires

Gates

AND

OR

NOT

A	B	A & B
0	0	0
0	1	0
1	0	0
1	1	1

A	B	A | B
0	0	0
0	1	1
1	0	1
1	1	1

A	-A
0	1
1	0

Gates

NAND

NOR

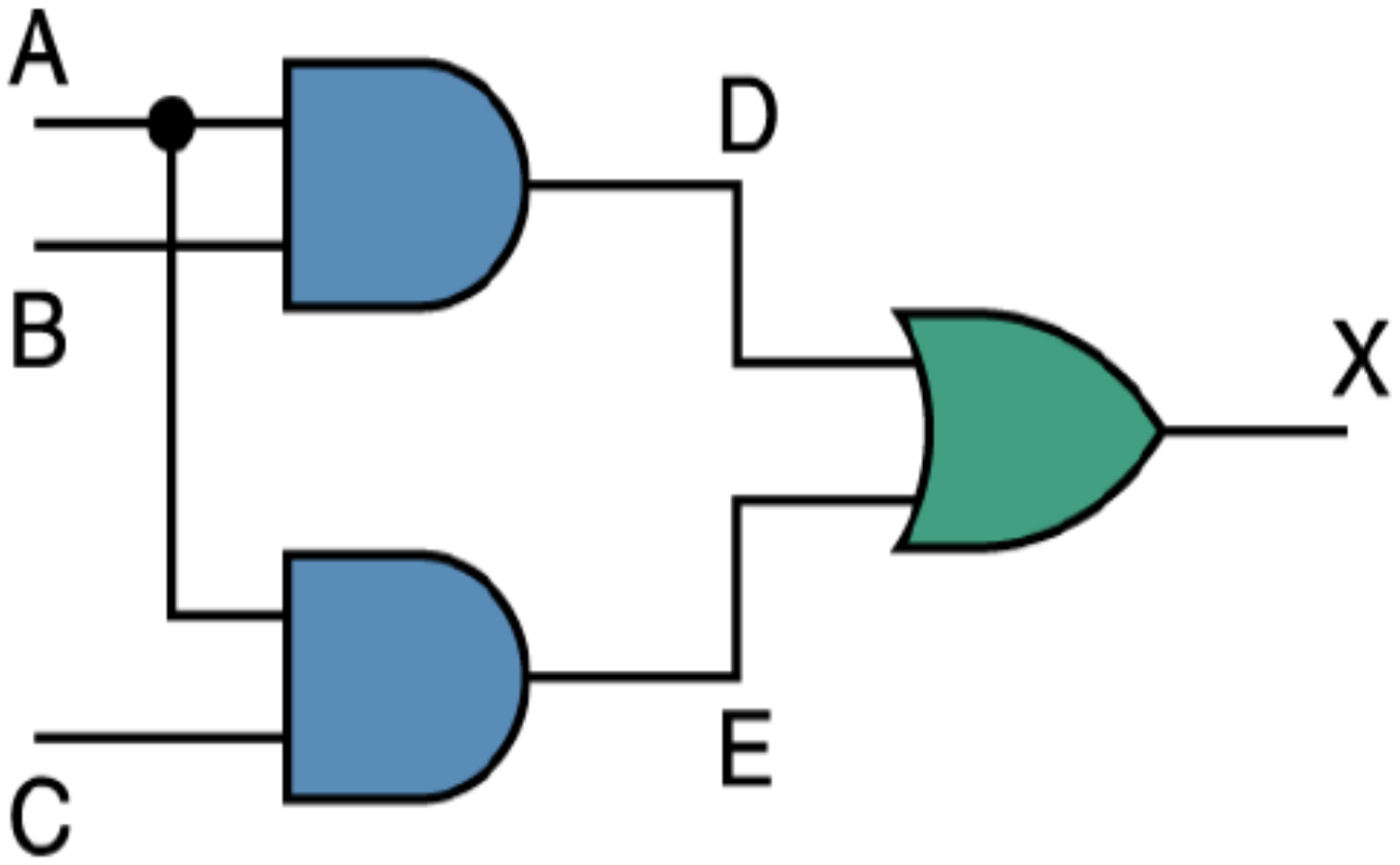
XOR

A	B	-(A & B)
0	0	1
0	1	1
1	0	1
1	1	0

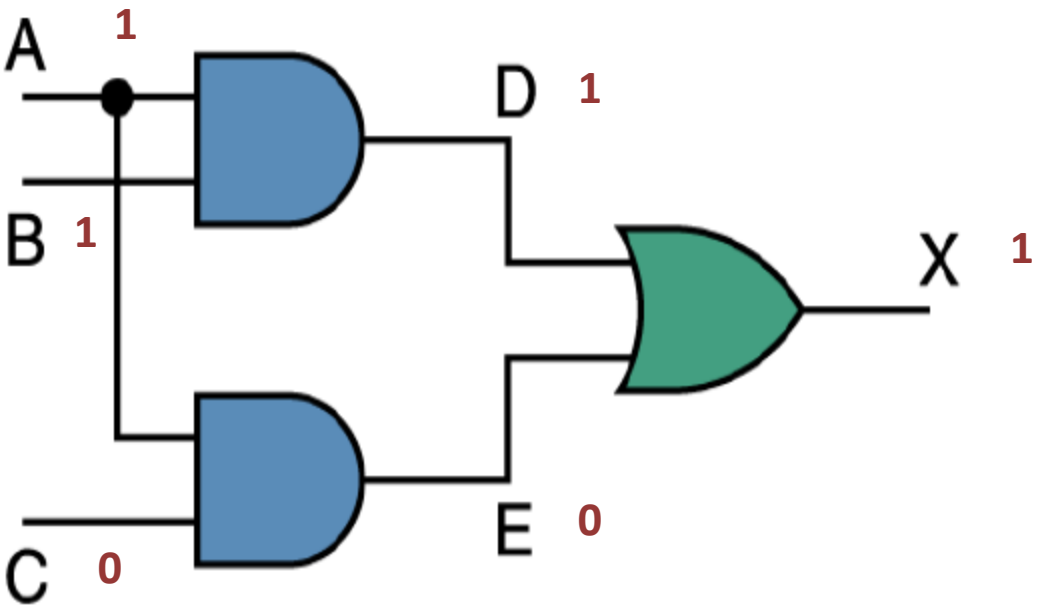
A	B	-(A | B)
0	0	1
0	1	0
1	0	0
1	1	0

A	B	A ⊕ B
0	0	0
0	1	1
1	0	1
1	1	0

Combinational Circuits



Combinational Circuits

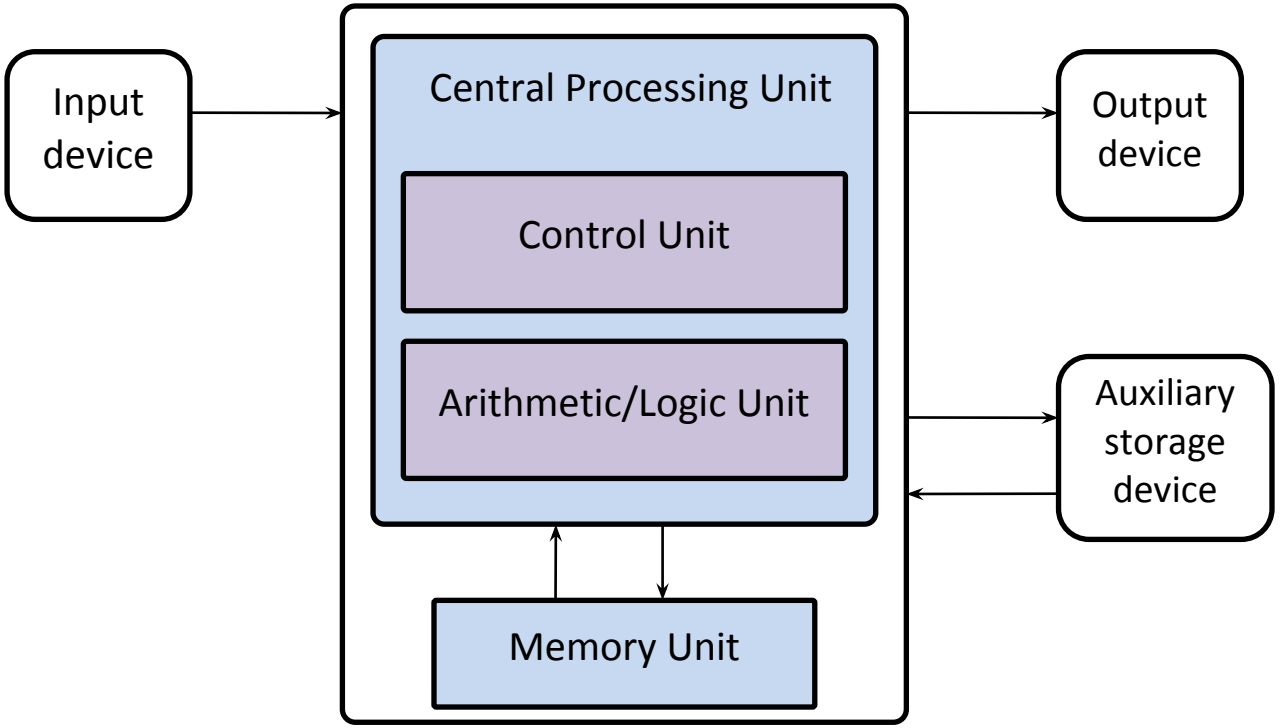


A	B	C	D	E	X
0	0	0	0	0	0
0	0	1	0	0	0
0	1	0	0	0	0
0	1	1	0	0	0
1	0	0	0	0	0
1	0	1	0	1	1
1	1	0	1	0	1
1	1	1	1	1	1

Stored program concept

- Early design:
  - Unique set of instructions for central processor (Example: Calculator)
  - Physical separate storage and pathways for data and instructions (Example: Harvard Mark 1)
  - Rewiring required
- Conceptually programs and data seem very different
  - But not to a computer – both instructions and data can be represented as numbers
- John von Neumann's idea:
  - *Store programs, together with data in the memory of the computer*
  - Memory contains: (a) data (b) instructions
  - Random access to different memory addresses and hence instructions

Von Neumann Architecture



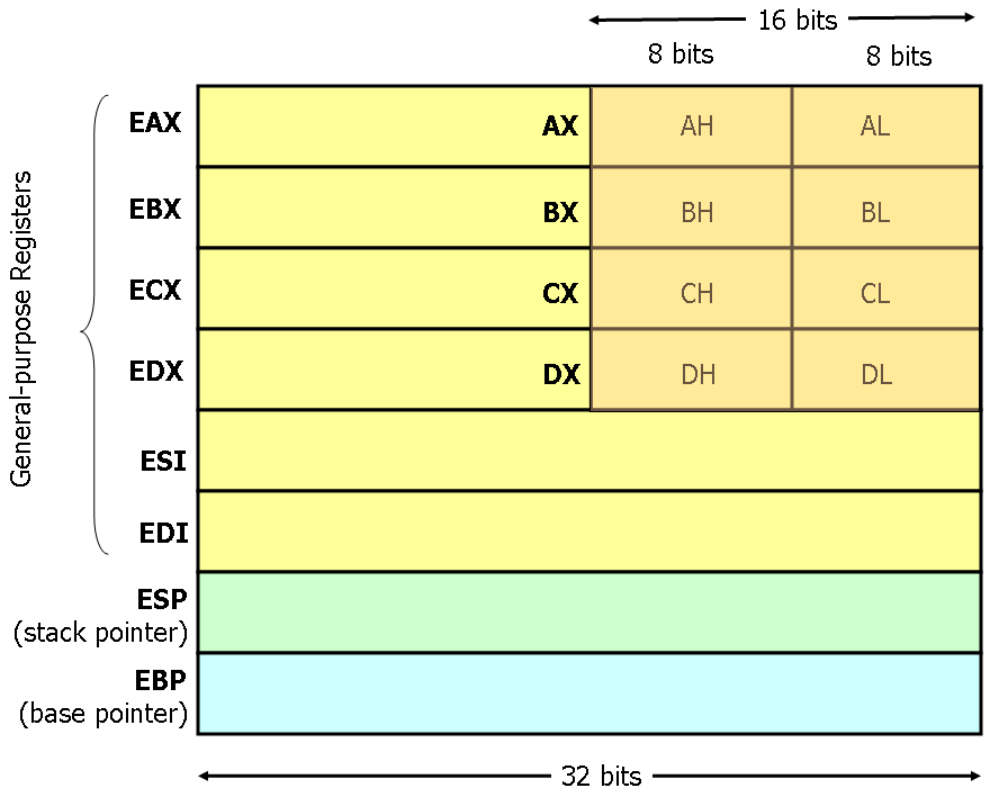
Five components:

- Memory unit holds both data and instructions
- ALU is capable of performing arithmetic and logic operations on data
- Input unit moves data from user to computer
- Output unit displays or prints results
- Control unit acts as manager of different components

Current Computer Architectures

- x86 (Intel)
- SPARC (sun)
- PowerPC (Motorola)
- ARM

Registers



Registers:

General registers
eax ebx ecx edx

Index and pointers
esi edi ebp eip esp

Indicator
eflags

Registers represent the state of a computer similar to ram of hard drives. Registers are stored closer to the CPU so their access speed is faster

x86 From the CPUs Point of View

fetch-and-execute cycle:

while (true){

Fetch instruction pointed to by eip register

Increment eip

Execute instruction

}

Registers:

General registers
eax ebx ecx edx

Index and pointers
esi edi ebp eip esp

Indicator
eflags

x86 From the CPUs Point of View

Example of opcodes being executed

iadd %eax, %edx // adds eax to edx registers

cmp %edx, $0x04 // if edx > 4 set flag in eflags

jmp $0xa432f53 // set eip to 0xa432f53

mov $0x6ee1e0, %edx
// put memory at 0x6ee1e0 into edx

Registers:

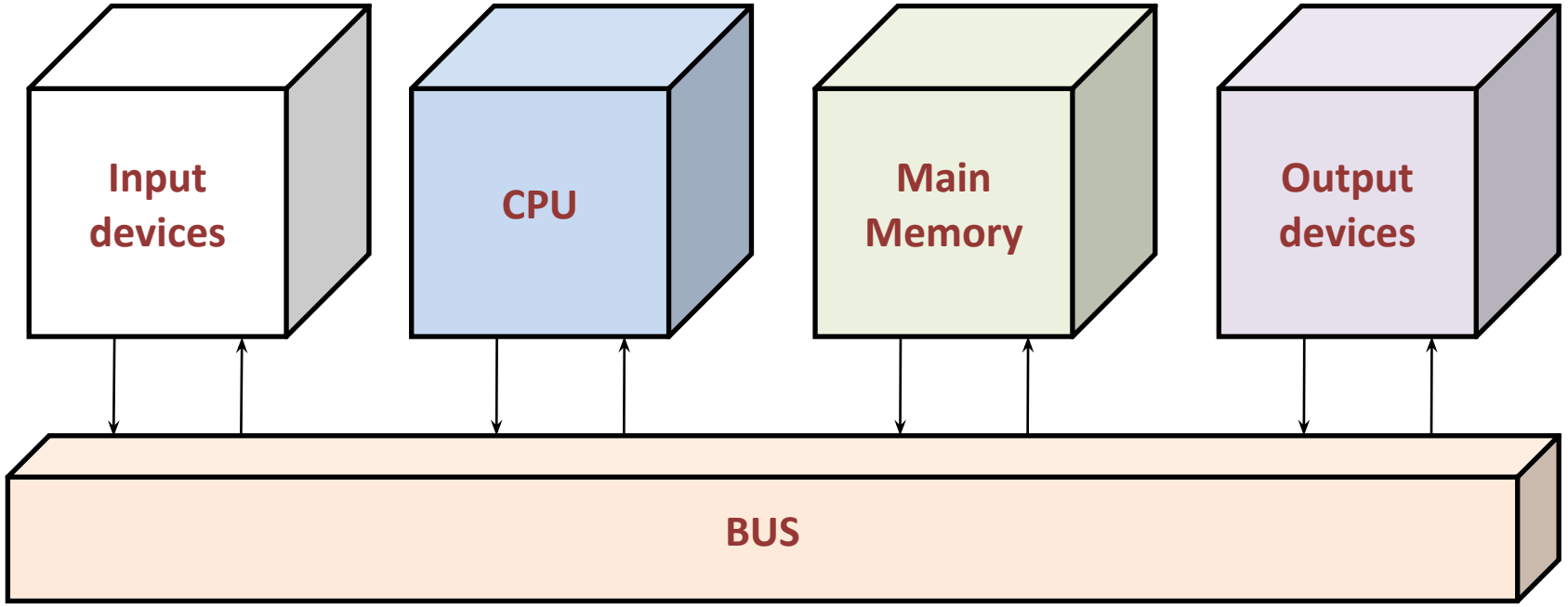
General registers
eax ebx ecx edx

Index and pointers
esi edi ebp eip esp

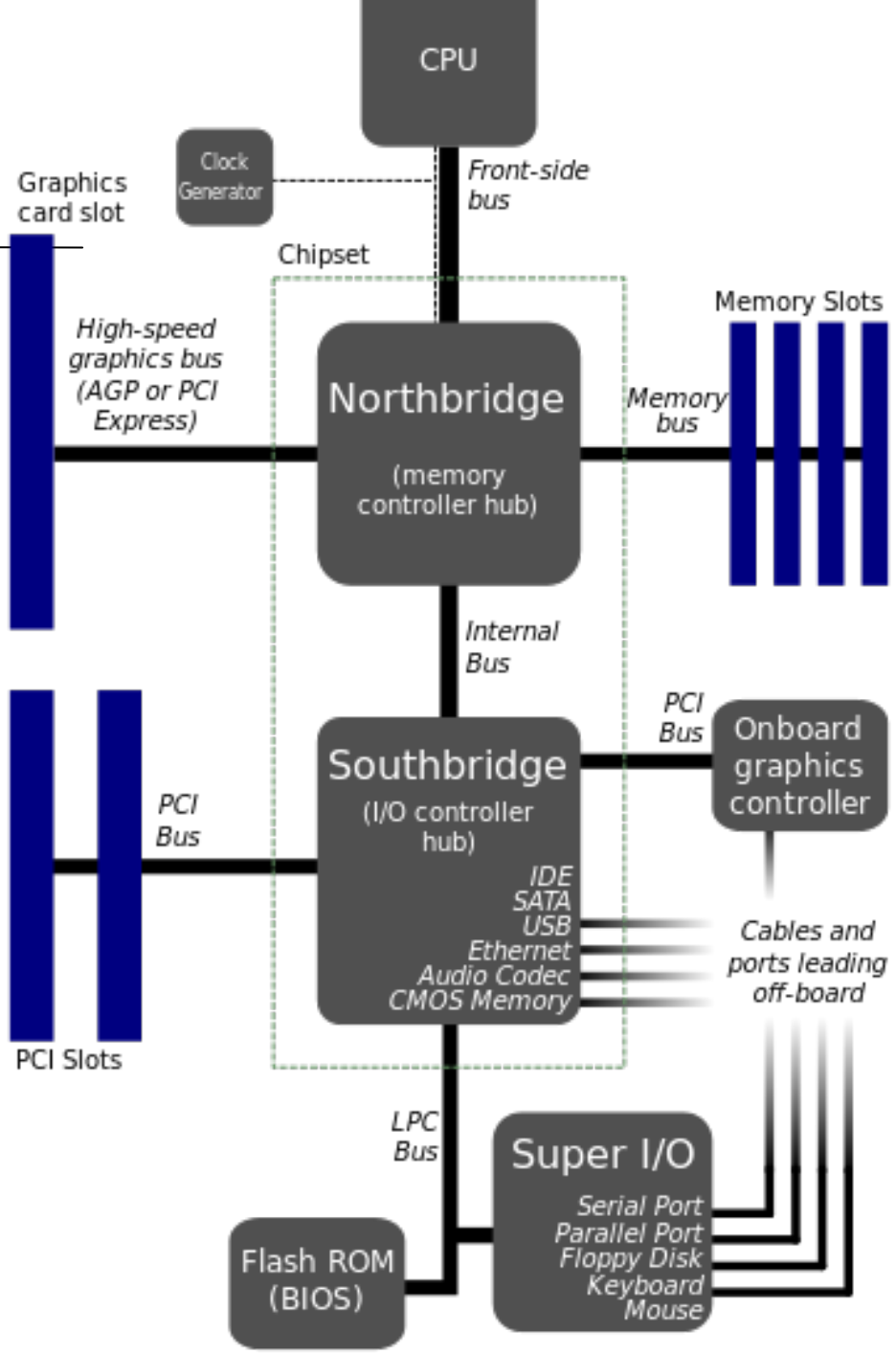
Indicator
eflags

Computer BUS

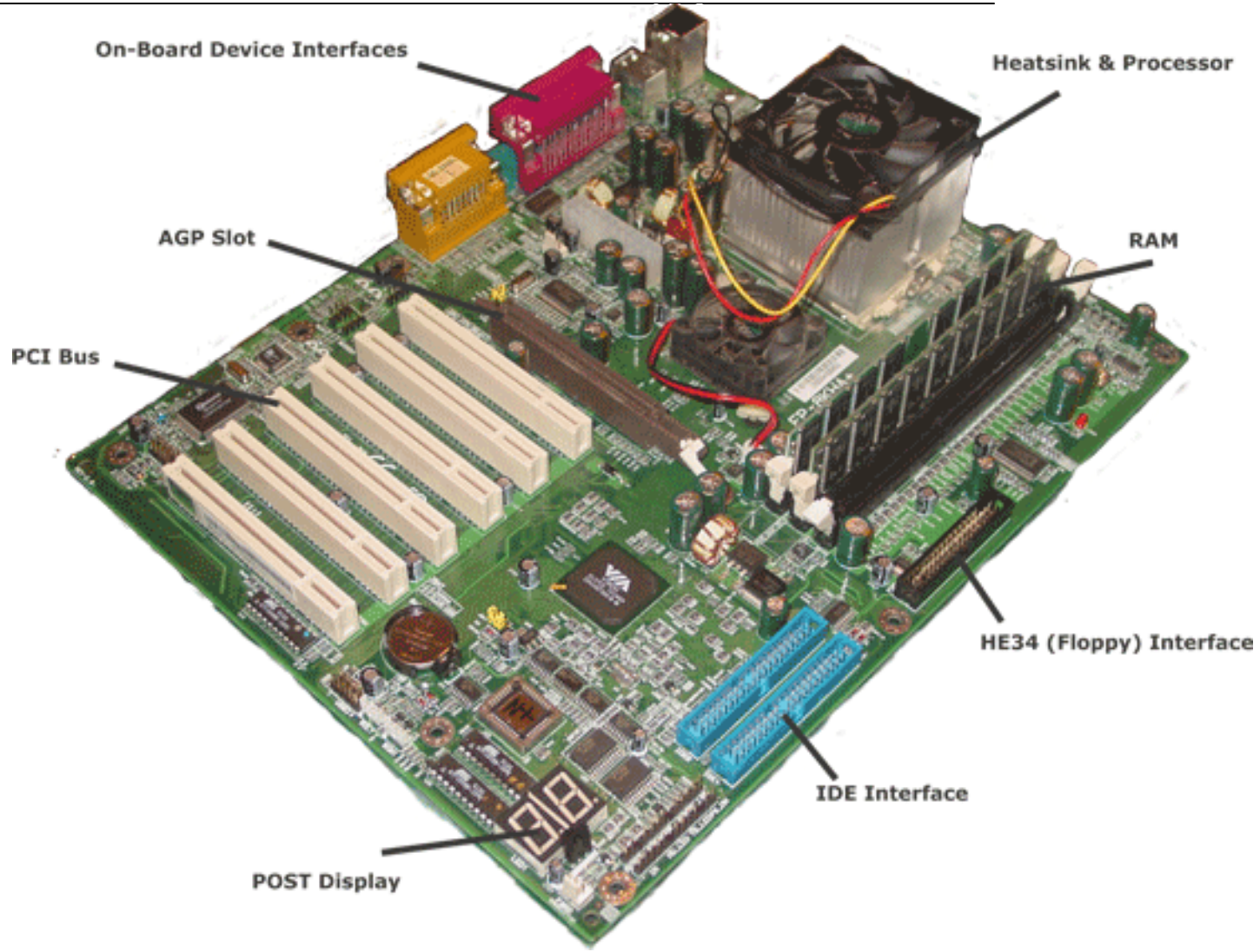
- Communication in the von Neumann System
  - Bus: A set of wires that connects major components of a machine through which data flows



Computer BUS



Motherboard



Processors nomenclature

- Clock speed
  - faster might mean more power
- Number of bits the processor can deal with per clock cycle
  - 32, 64, 128
- *Cores*: Number of instruction processors in a CPU
  - unrelated computations may be parallelized