Basic Computer Hardware Concepts

https://onlinequestions.org/

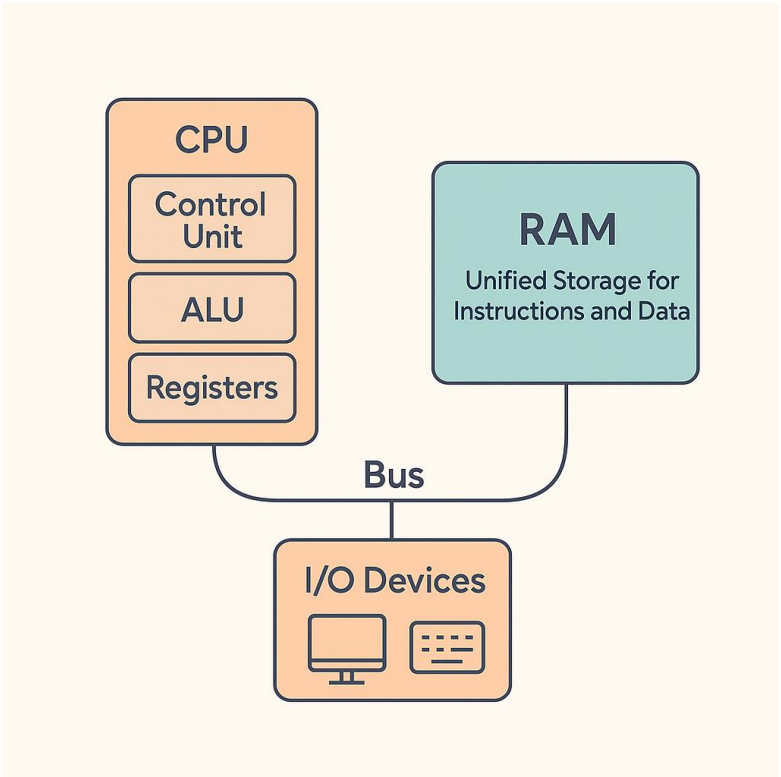
Event code: 16279

Learning goals

- Understand the basic idea behind the von Neuman architecture.
- Know the following components: RAM, ROM(firmware/BIOS), CPU, GPU, Data bus, I/O Peripherals (e.g. Disk, USB, Network adapter).
- Understand – at a high level - their roles and how they interact in data transfer and processing.

Von Neuman architecture - basics

- Basic architecture of a computer https://www.youtube.com/watch?v=Z5JC9Ve1sfI&ab_channel=TomScott
- CPU
  - Contains Control Unit, ALU, Registers (Program Counter PC, Instruction Register IR, Accumulator)
  - Fetch – decode – execute cycle
  - **Fetch**: PC to bus -> data to IR
  - **Decode**: Interprets data in the Instruction register
  - **Execute**: Control Unit + ALU perform operations and bus read/write instructions
- Memory
  - Stores data and instructions; byte addressable through address bus
  - Maps digital address to memory locations
  - Volatile, wiped when power off.
- Bus
  - Address bus: selects memory/IO address
  - Data bus: carries data/instruction
  - Control lines: e.g. for read/write distinction
- I/O
  - Devices interface via bus.
  - Special memory-mapped "registers" that map to certain addresses
  - CPU performs read/write to these addresses

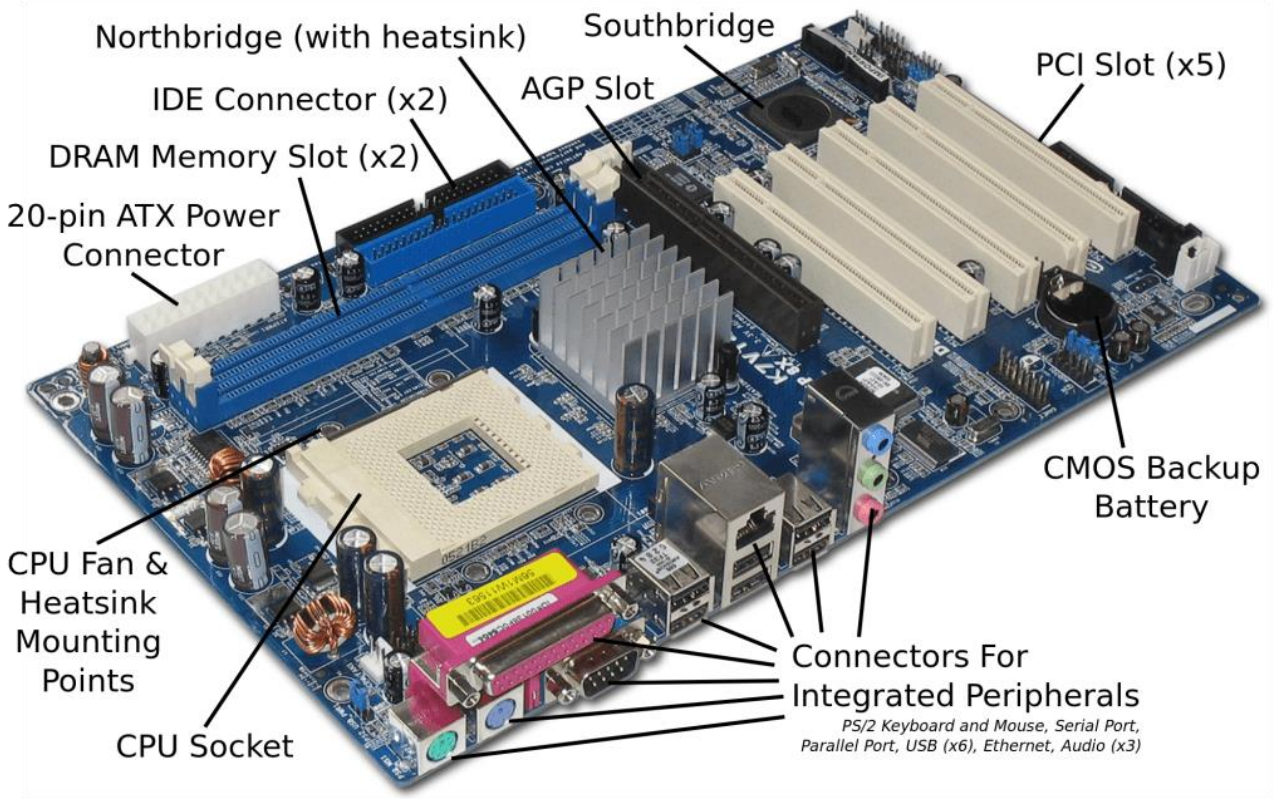


Hardware overview

- Motherboard
- CPU
- RAM
- Firmware/bios (not shown)
- Display adapter (GPU)
- Peripherals
  - USB/Network connectors
  - Hard disk (HDD)
  - Solid State Disk (SSD)
- Power supply

Motherboard

- Connects everything and provides the BIOS and IO
  - BUS
    - Set of parallel wires that connect components
    - Data transport between components
  - CPU connector
    - Central processor (the actual computer)
    - Fast bus connection
  - DRAM memory slots
    - Volatile working memory
    - Fast bus connection
  - AGP/PCI slots
    - Extra hardware extension (e.g. GPU)
    - Fast bus connection or
    - Shared memory
  - Peripheral connectors (ATX IDE USB)
    - Slow bus connection
    - To and from devices

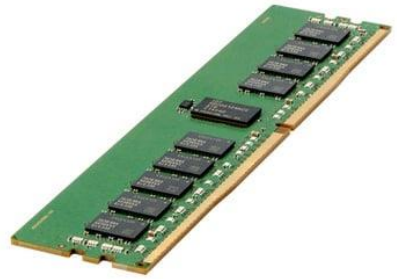


CPU – central processing unit

- The actual "computer"
- Performs the instructions of your program
- Reads and writes data to RAM, and IO ports, using the BUS
- Fetches (reads) instructions from RAM
- Modern CPUs in fact contain multiple CPUs in one:
  - Cores

RAM – random access memory

- Working memory of your computer
- Volatile, when power goes off, memory is wiped
- Stores application data to work with
- Stores instructions for CPU (programs)
- Connected with high speed parallel (64 bit) databus to CPU



Display adapter - GPU

- The display adapter (or GPU: graphics processing unit) is a piece of specialized peripheral hardware

- Provides a graphics memory for display
  - A **frame buffer** containing pixels in R(ed)G(reen)B(lue) color format
  - Usually 8 bits per color, e.g., Full HD = 1920x1280 pixels =7200kB ~ 7mb
  - This is shown on your screen and is send through the HDMI cable
- Provides memory for fast retrieval of data
  - Stores textures: bitmap images
  - Stores data: neural networks, matrices
- Provides parallel processing for fast pixel operations
  - Many simple processors (e.g. Tensor Cores) that perform fast linear algebra
  - Used for 3D rendering in e.g. game
  - Used for Neural network training and calculations

Other Peripherals – Input – Output

- Most other hardware is for input – output
- I/O bus types
  - Serial (bit-stream line): USB and PCI Express
  - old Parallel (8 bit line) busses (lots of hardware sync problems at high speeds)
  - PIC Express using multiple bit-stream lanes
- Disks
  - Hard disks: spinning magnetic disks on which a file system is stored
  - Solid state disks: non-volatile memory on which a file system is stored
  - USB disks: nonvolatile removable memory on which a file system is stored
- Network controllers
  - Wired LAN: hardware for sending and receiving digital signals over a wire
  - Wireless LAN: hardware for sending and receiving digital signals over the air
  - Bluetooth: low-power point to point hardware for sending and receiving digital signals over the air
- Mouse and keyboard
  - The usual ☺

Firmware and booting

- Non volatile memory containing code and data to configure and start up the computer.
- The firmware's job is to initialize hardware to a usable state and then find, load and run your OS from a drive.

- 1. Power-on
  - CPU fetches it's first instruction from a fixed address, the **reset vector** (0xFFFFFFF0 on x86 hardware)
  - The motherboard bus controller chip (hardware) maps the Firmware to this address
- 2. Firmware hardware initialization
  - Initializes the minimal hardware: RAM, CPU state and disk IO
- 3. Execution of bootloader
  - Looks for a bootloader in the Master Boot Record (executable file on the disk at a predestinate place on the disk)
  - Load the bootloader in memory
  - BIOS executes a CPU jump to bootloader code and executes it.
- 4. Loading and execution of OS
  - Bootloader prepares CPU for OS
  - Bootloader finds the OS kernel file on the disk
  - Loads the kernel file
  - Jumps to OS kernel code

- Your operating system starts! (next Lecture)