01 - Elicits the significant changes occurred in the computers from generation to generation with more emphasis on the evolution of processors.

Elicits the significant changes occurred in the computers from generation to generation with more emphasis on the evolution of processors.

Time from the first computer to present are divided into 4 periods
- Pre mechanical era
- Mechanical era
- Electro mechanical era
- Electronic era

1. Pre mechanical era (before 1450)
    1. Abacus
        - **World's first calculating device**
2. Mechanical era (1450-1840)
    1. Pascaline
        - by **French mathematician Blaise Pascal**
        - Only addition and subtraction of 2 numbers can be done
    2. Stepped Reckoner
        - by **German scientist Gottfried Wilhelm**
        - device carried out the operations addition, subtraction, multiplication and division too.
    3. Difference engine
        - **first mechanical computer**
        - by **Charles Babbage** (also made the Analytical Engine)
        - *the concept of input, process and output that is used* therefore, he is known as the Father of computing
3. Electromechanical era (1840 – 1940)
    1. Electronic valve (vacuum tube)
        - by **American inventor Lee De Forest**
    2. Automatic sequence controller (Mark 1)
        - **the first automatic computer**
        - by American physicist and computing Professor **Howard Aiken**
4. Electronic Era
    - Divided into 5 generations
    1. 1st Generation Computers
        - **vacuum tubes** are used as the basic component
        1. **ENIAC** (Electronic Numerical Integrator and Calculator)
            - by **John Mauchly and J. Presper Eckert**
            - **first electronic digital computer with stored program concept**
            - decimal related
        2. **EDSAC** (Electronic Delay Storage Automatic Calculator)

    - by **Maurice Wilkes**
    - built according to the *von Neumann machine principles* (by John von Neumann)
3. **EDVAC** (Electronic Discrete Variable Automatic Computer)
    - **first digital computer to with stored program concept**
    - binary related
    - by **John Mauchly and J. Presper Eckert**
4. **UNIVAC** (Universal Automatic Computer)
    - more vacuum tubes are used
    - utilized punch cards and switches to input data and punch cards to output
    - by **John Mauchly and J. Presper Eckert**

2. 2nd Generation Computers
    - **transistors** are used as the basic component
        - transistors were invented by **William Shockley, John Bardeen and Walter Brattain**
    - computers like IBM 1620, IBM 7094, CDC 1604, CDC 3600, UNIVAC 1108 were invented
3. 3rd Generation Computers (1964 – 1975)
    - **Integrated circuits** (IC) are used as the basic component
        - ICs are made by collection of transistors
        - 2 types of ICs were invented **by Jack Kilby** (with silicon) and **Robert Noyce** (with germanium) separately
    - IBM-360 series, PDP, TDC-316, PDP 11 were the computers of 3rd generation.
4. 4th Generation (1975 – 1989)
    - VLSI (Very Large Scale Integrated) are used as the basic component
    - single chip was made allowing to make micro computers
    - DEC 10, STAR 1000
5. 5th Generation Computers (1989 – present)
    - ULSI (Ultra Large Scale Integration) are used as the basic components

Generations	Major Hardware Technology	Software Used	Charateristics	Systems invented
Third Generation Computers (1964-1975)	• Integrated Circuits (IC) • High capacity disks for secondary storage • Keyboard and mouse for data input	• birth of Operating Systems (OS) • Well developed Programming languages • high level computer languages for coding	• Smaller in size • Less heat Generation • Comparatively faster than the second generation • Expensive • Low power consumption	• IBM-360/370 • PDP-8 • PDP-11 • CDC 6600
Fourth Generation Computers (1975-1989)	•LSIC (Large Scale Integrated Circuits) and VLSIC (Very Large Scale Integrated Circuits •Microprocessor •Palm Tops •High Capacity hard disks •Floppy disk •Optical disk •Personal computers (PC) •Faster computer networks	• OS with GUI (Graphical User Interface) • UNIX OS	• Very small in size • Portable • Upgradable	• IBM PC • Apple II

Generation	Major Hardware Technology	Software Used	Charateristics	Systems invented
Fifth Generation Computers (1989 to present)	• ULSI (Ultra Large Scale Integration) • Very High Capacity Hard disks and optical disks • Internet	• Operating Systems with GUI (Graphycal user Interface) • Internet and multi-media applications • Voice recognition based on AI (Artificial Intelligence) • Character recognition • Hand-writing recognition systems	• Portable • Less Expensive • Smaller in size • Easy operation • High reliability • High efficiency	• IBM notebooks • Pentium PCs • SUN workstations

Classification of Computers

- Computers
  - Purpose
    - General
    - Specific
  - Technology
    - Analog
    - Digital
    - Hybrid
  - Size
    - Super
    - Main frame

- Mini
- Micro
  - Desktop
  - Portable

Based on the Technology

1. Analog Computer
   - handles continuous values such as electrical, mechanical, or hydraulic quantities and environmental parameters (speed, pressure, and temperature).
   - Speedometers, road lamps with sensors and meteorological machines
2. Digital Computers
   - used by us in day-to-day life
3. Hybrid Computers
   - combination of analog and digital computers
   - ECG machine - machine identifies the function of the heart beat which is an analog signal. Then it is converted to a digital signal and these converted signals are printed by this machine

Based on Size

1. Super Computer
   - fastest and most powerful type of computers
   - are used for highly calculation intensive tasks such as weather forecasting, climate research, molecular modeling, physical simulation
2. Mainframe Computer
   - supporting hundreds, or even thousands, of users at the same times
   - very large and expensive computer
   - typical applications are the airline systems, central data banks
   - Univac 1100/10, Univac 1100/60, Honeywell
3. Mini Computer
   - mid-size computers
   - cheaper in cost, smaller and reliable than mainframe computers
   - does not require air conditioning
   - can be operated in room temperature
4. Micro Computer
   - Desktop, laptop, notebook

02 - Explores the functionality of a computer in relation to the hardware and their interfaces

Explores the functionality of a computer in relation to the hardware and their interfaces

Input devices

- Input devices
  - Direct entry input devices
    - Magnetic strip reader
    - Bar code reader
    - Smart card reader
  - Pointing devices
    - Mouse
    - Joy stick

Advantages of direct entry input device over keyboard

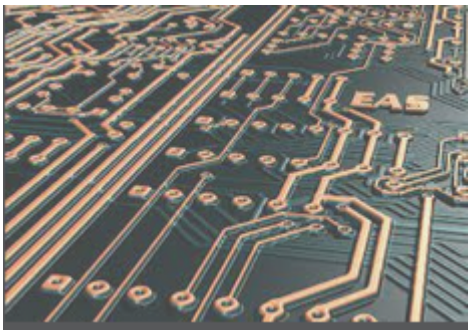
- Automatic capturing of data
- Accuracy - No human errors
- Less time is consumed
- No human involvement is needed

System Unit

The system unit, also known as the **system chassis** s a container that houses most of the electronic components that make up a computer system. This contain,
- System board / Mother board
- Bus
- Ports
- Memory

System board

- controls communications for the entire computer
- contains 3 main components as **sockets, slots, bus lines**
  - Sockets
    - provide a connection point for small specialized electronic parts called **chips** made of silicon
    - used to connect the system board to a variety of different types of chips, including microprocessor and memory chips
  - Slots
    - provide a connection point for specialized **cards** or **circuit boards**
    - I.e wireless networking card
  - Bus lines
    - provide pathways that support communication among the various electronic component



Microprocessor/CPU

CPU is contained on a single chip called the **microprocessor**

- It has 3 basic components.
  1. Memory unit (Registers)
  2. Control unit
     - tells the rest of the computer system how to carry out a program's instructions
     - directs the movement of electronic signals between memory(RAM) and ALU and between input-output devices and CPU
  3. ALU
     - 2 main operations
     - Arithmetic operations (+. -, *, /)
     - Logical operations (>. <, =)
- **Chip processing capacities are often expressed in word sizes** (the number of bits processed by the CPU of a computer in a single action) A word is the number of bits (such as 16, 32, or 64) that can be accessed at one time by the CPU
  - 32 bit → 4 bytes at a time
  - 64 bit → 8 bytes at a time
- The processing speed of a microprocessor is typically represented by its **clock speed**. **Clock speed is number of times the CPU can fetch data in a second.** Unit used it **Hertz** (Hz)

Unit	Speed
Microsecond	Millionth of a second
Nanosecond	Billionth of a second
Picosecond	Trillionth of a second
Femtosecond	Quadrillionth of a second

- Microprocessors can run only one program at a time. Multicore processors can run multiple processors at a time.
  - 2 core → 2 programs at a time. 1 core for Excel. 1 core for word
  - parallel processing is used to divide the tasks in to parts to process it faster

Specialty Processors

- Different specialized chips used instead of CPU are specialty processors
  - Coprocessors - specialty chips designed to improve specific computing operations.
  - GPU - Used to process graphics
  - Crypto processors - used in encrypting and decrypting (ATM cards)
- When it comes to CPU compatibility with its motherboard, we need to consider 4 things.
  1. Socket support
  2. Chipset support
  3. Motherboard Wattage support
  4. BIOS support

Memory

```
Memory is a holding area for data, instructions, and information
```

There are 3 types of memory
1. RAM
2. ROM
3. Flash

Unit used to measure is **Gigabytes**

RAM

- Volatile
- Temporary memory are stored
- Fastest memory out of 3 main memory types

Cache memory

- Second fastest memory from all (1st is registry memory)
- Act as a mediator between CPU and RAM
- Store most often accessed data temporarily
- 3 types of cache memory
  - Level 1 - always inside the processor
  - Level 2
  - Level 3 - always outside the processor
- Level 2 cache are brought inside the microprocessor, BUT they are **not components of the processor**
- RAM can be expanded by inserting an expansion module called **DIMM (dual in-line memory module)**
- If still memory is not enough virtual memory is used. (Virtual memory = RAM + HDD)
- Virtual memory is given by the HDD when RAM is not enough

ROM

- Non-volatile
- Booting instructions are stored
- 4 types of ROM chip
  - Mask ROM - Can't be programmed or erased, instructions set by the manufacturer are stored
  - PROM - programmable ROM
  - EPROM - Erasable ROM using UV rays
  - EEPROM - Electronic Erasable ROM
- Flash memory chips have replaced ROM chips for many applications.

Flash memory

- Combination of RAM and ROM
- Like RAM, it can be updated to store new information

- Like ROM, it does not lose that information when power to the computer system is turned off.
- Bootup instructions are called BIOS (Basic Input Output System)

Type	Use
RAM	Programs and data
ROM	Fixed start-up instructions
Flash	Flexible start-up instructions

- Memory from fastest to slowest

```
Registers
Cache
RAM
HDD
Flash drive
Optical media
Magnetic tape
```

Expansion Slots and Cards

- allow users to expand their systems by providing expansion slots on the system board
  - Graphics cards
  - Network Interface cards

Bus lines

- connects the parts of the CPU to each other
- Instructions are transfused within bus as bits (0 and 1)
- **The number of bits that can travel simultaneously down a bus is known as the bus width**
- 64-bit bus lines should be with x64 processor, same goes with 32-bit (compatibility of the buses with the processor)
- 2 types of bus lines
  - System bus - connects the CPU to memory
  - Expansion bus - connects the CPU to other expansion slots and components

Expansion Buses

- USB
  - The current USB standard is USB 3.1
- FireWire buses
- PCI Express (PCIe)
  - used in many of today's most powerful computers
  - unlike USB, this provides a single path, paths are not shared

Ports

> A port is a socket for external devices to connect to the system unit.

Storage Devices

There are 2 main types of storage devices

1. Magnetic
2. Optical
3. Solid State

Also, they are divided as follows

1. Fixed internal magnetic HDD
2. External HDD
3. Magnetic tape
4. Optical discs

Type	Capacity
CD-ROM	650-900 MB
CD-R	
CD-RW	
DVD-ROM	4.7-9.4 GB
DVD-R	
DVD-RW	
DVD-RAM	
Blu-Ray	25-128 GB

DVD-RAM is like an ordinary RAM (but aren't volatile) which can be repeatedly read, written and erased. These are way faster than DVD-RW

6. Flash drive

Developed using electrically erasable programming read only memory (EEPROM)

Parallel computing

> Parallel computing is a type of computation in which many programs or processes are done simultaneously

> Parallel processing is breaking down a large process in to smaller pieces and executing them in the same time.

On a single processor, the steps needed to calculate a value for Y might look like:

- Step 1: Y = 20 + (1 x 6) + (5 x 3)
- Step 2: Y = 20 + 6 + (5 x 3)
- Step 3: Y = 20 + 6 + 15
- Step 4: Y = 41

In a parallel computing scenario, with three processors or computers, the steps look something like:

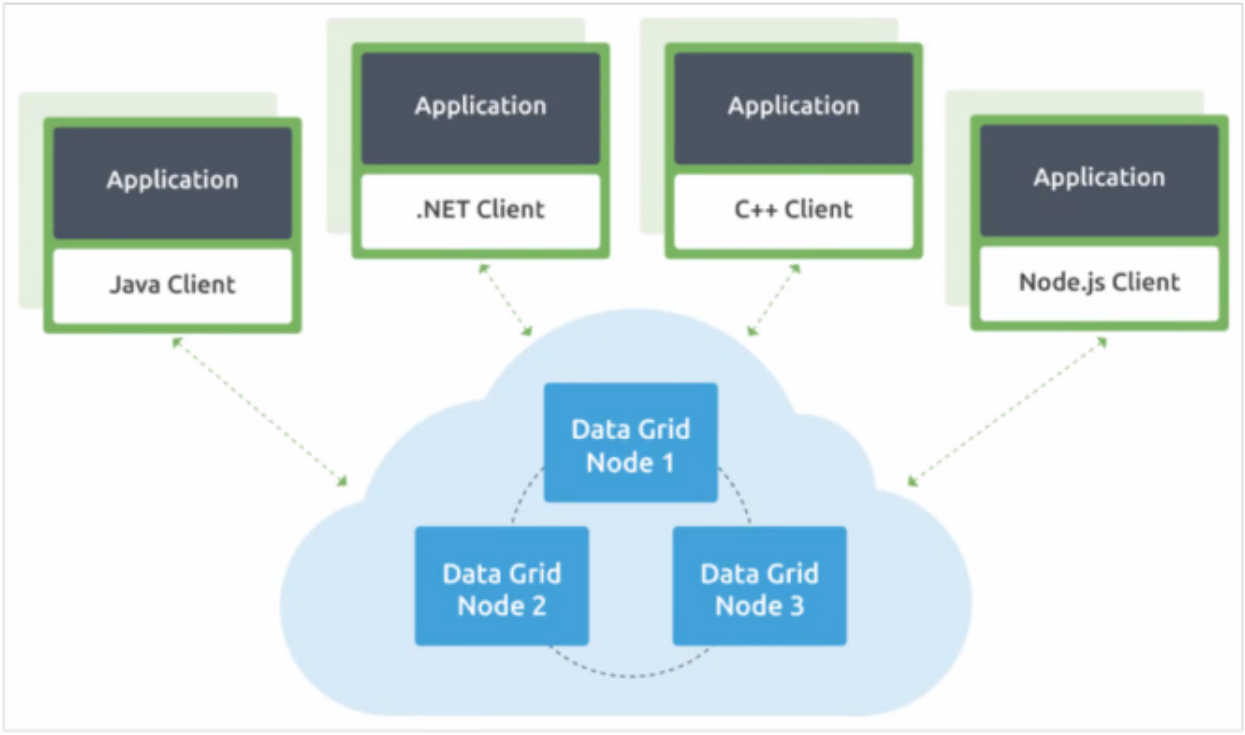
- Step 1: Y = 20 + 6 + 15
- Step 2: Y = 41

Practical issues / scenarios in parallel computing.
- Some task might not be divisible
- Some task may not be able to divide equally.
- It is necessary to take overhead associated with splitting the task up also into account.

Grid computing

```
Grid computing is a distributed network of large numbers of computers located in different geographical area connected to solve a complex problem
```

Grid computing is the practice of leveraging multiple computers, often geographically distributed but connected by networks, to work together to accomplish joint tasks.



> With grid computing, specialized software runs on every computer that participates in the data grid. This controller software acts as the manager of the entire system and coordinates various tasks across the grid.

I.e a research team may analyze the weather in Gamapaha and another team would analyze in Colombo and Kaluthara, then the results are combined to deliver the full weather report for the western province.

03 - Explores the Von-Neumann Architecture

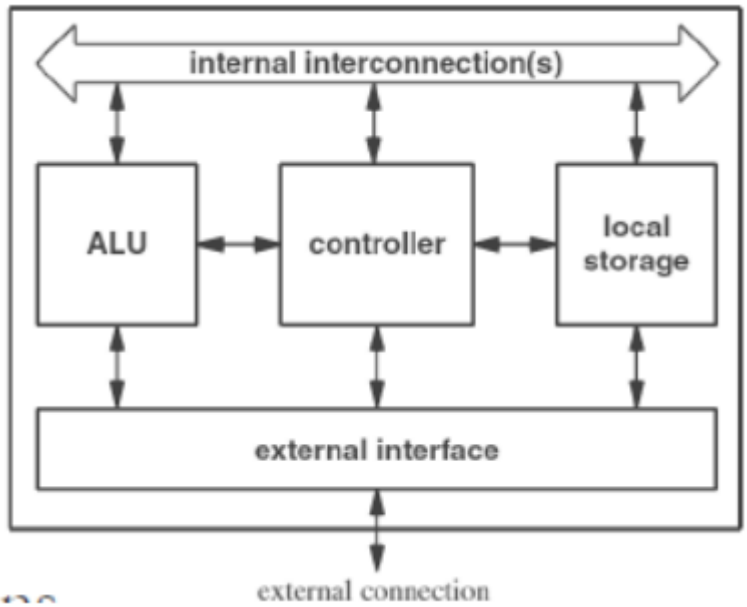
Explores the Von-Neumann Architecture

Processor

```
A processor is a digital device that can perform one or more computations
involving multiple steps
```

Components of the processor

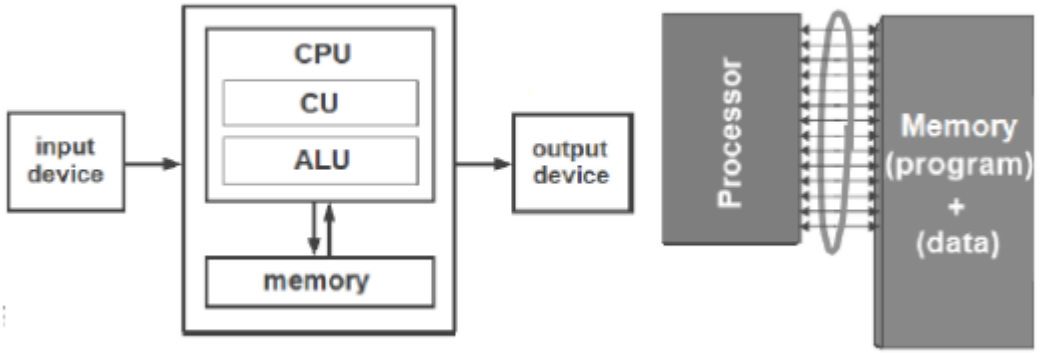
- Control Unit
- Storage Unit
- ALU
- Internal interconnection - move data and instructions among other internal components
- External interface - connect external device (devices in the mother board I.e RAM, cache memory)



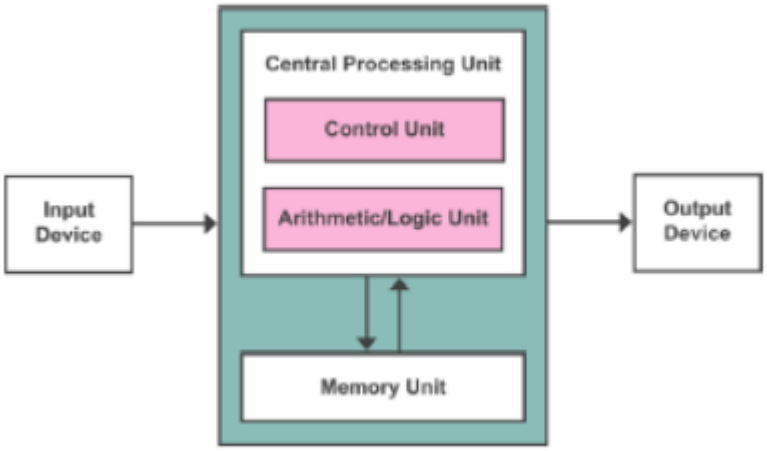
Computer Architectures

Von Neamann Architecture

- by **John Von Neumann**
- **Stored program concept** is introduced by him
- Bus line is **shared to access both instructions and data** (both instructions and data cannot be accessed at the same time)
- Therefore, bus becomes a bottleneck (von Neumann bottleneck)
- Even this **results in performance lack**, **present day computers uses this** as it's **simple and inexpensive**



Major components of Von-Neumann architecture



The programs are stored in RAM, CPU fetches memory from RAM at a time and executes them.

1. CPU
    1. CU
    2. ALU
2. Memory register
    - Hold instructions and data, storage locations
    - Registers help to access memory faster making the processor efficient.
    1. **Program Counter** (RIP)
        - address of the next **instruction** to run is stored in this register
    2. **Instruction Register**
        - holds the instruction currently being executed
        - located in Control Unit in CPU
    3. **Memory Address Register**
        - stores the **address of the data** which is fetched by the CU and sent from the ALU
    4. **Memory Data Register** (MDR)
        - stores the **data** being transferred to and from the immediate access storage (cache)
        - also know as memory buffer register
    5. **General purpose registers**

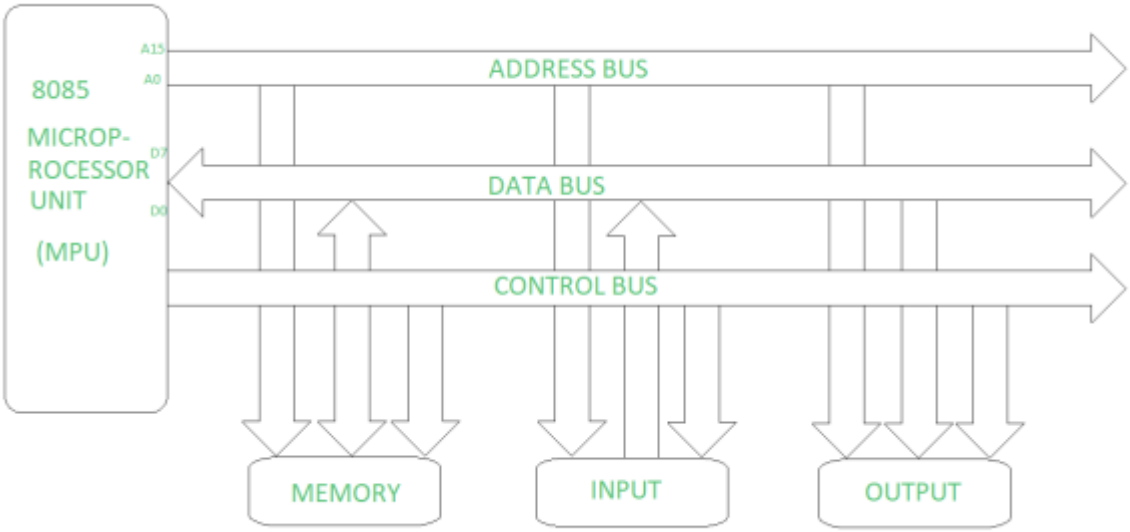
- used to store temporary data
- Supports two operations such as fetch and store
- used either by programmer or by a user

6. **Floating point registers**
    - large enough to store floating point value

Programming with registers

Bus

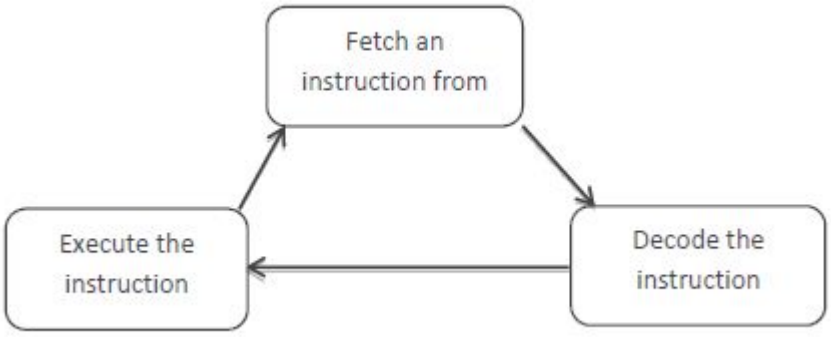
> Bus is a group of conducting wires which carries information which connects all the peripherals to the microprocessor.

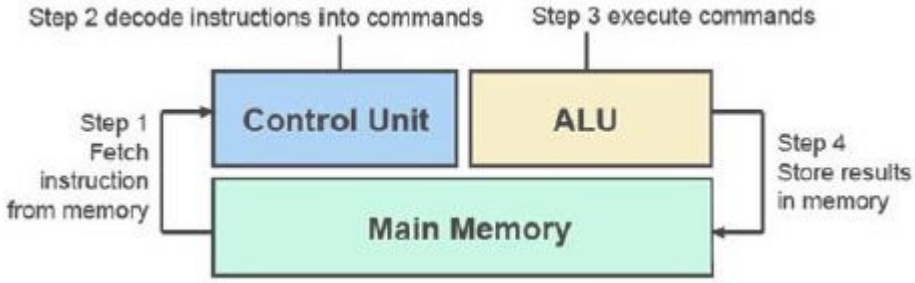


There are 3 types of busses.
1. Address bus - carries addresses
2. Data bus - carries data and instructions
3. Control bus - carries control signals (writing, reading, storing instructions, Opcode fetch)

Fetch-Decode-Execution Cycle

- Basis of programmable processors
- Allows processor to move through program instructions automatically
- Implemented in processor hardware
- Run by the operating system
- If no further instructions are there, endless loop automatically runs to keep the cycle going.
- Its never stopped unless the computer is powered off





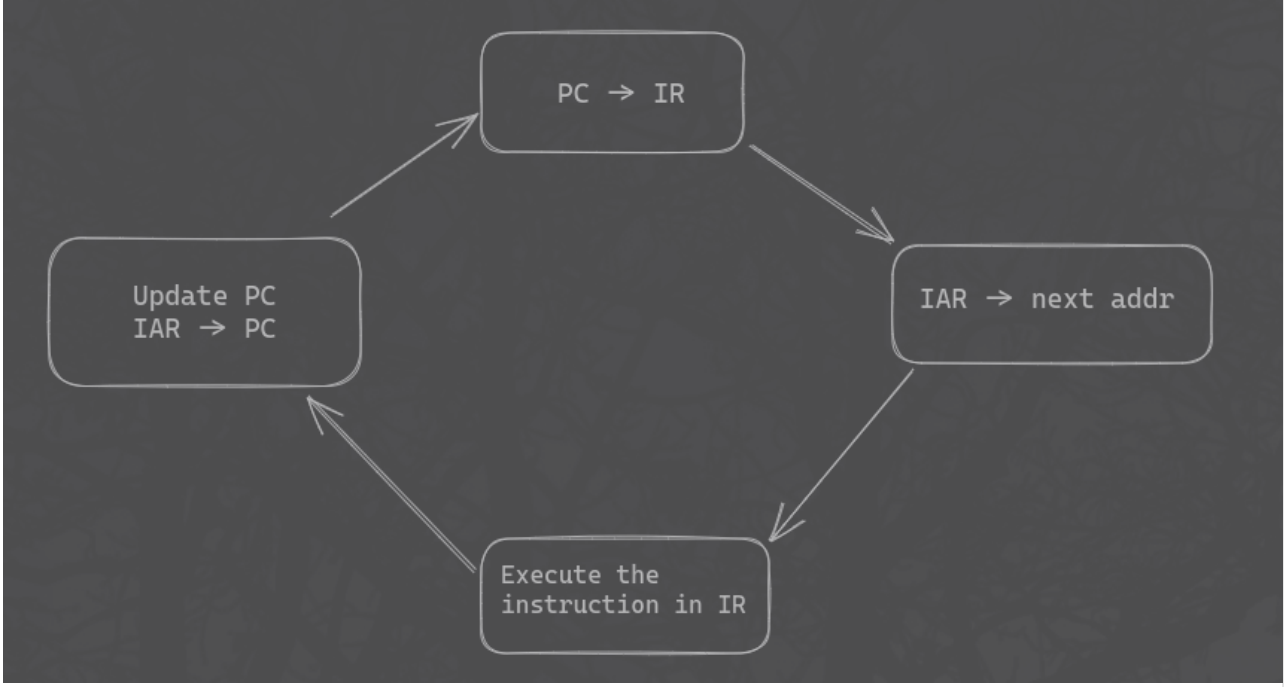
1. Control unit fetches instructions from memory
2. Control unit converts instructions to command and feeds to ALU
3. ALU executes the commands (not instructions) and sends data to Main memory
4. Main memory stores the given data from ALU for future use.

Fetch-Execute Algorithm

```
PC ← memory address of first instruction
repeat forever
{
   fetch : read the next instruction
           into IR using address in PC
   IAR ← address beyond the instruction
           that was just fetched
   execute : execute the instruction
           in IR
   PC ← IAR
}
```

```
                memory
  address          value
0x00000000   instruction 1
0x00000004   instruction 2
0x00000008   instruction 3
0x0000000C   instruction 4
0x00000010   instruction 5
0x00000014   instruction 6
0x00000018   instruction 7
                 :
                 :
```

```
          ← 32 bits →
PC   | 0x00000008 |
IR   | instruction 3 |
IAR  | 0x0000000C |
```



Multi-core processors

Need of multi-core processor
- Can run a program by dividing some parts. So it gets executed fast
- It enables parallel programming
- To get the high performance from a single machine

04 - Examines PC memory system to identify different types of memory and their main characteristics

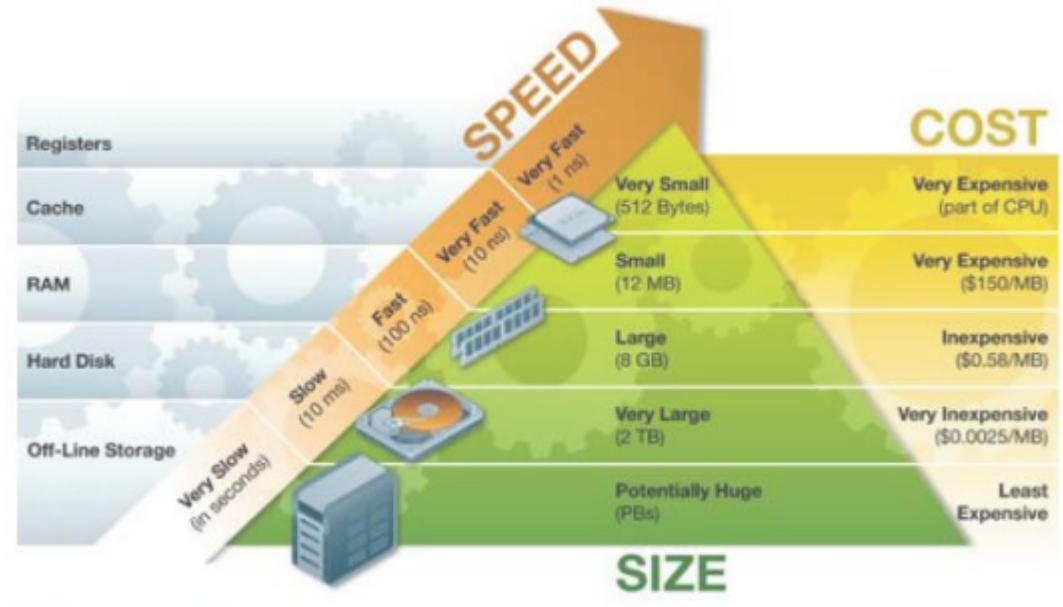
Examines PC memory system to identify different types of memory and their main characteristics.

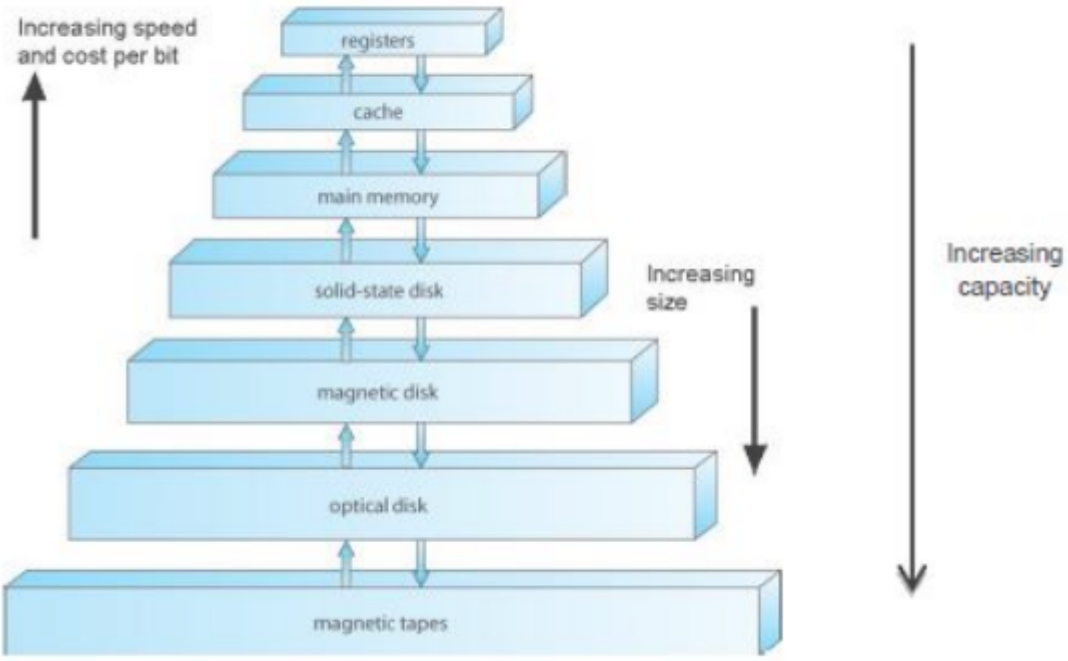
Memory hierarchy

This memory hierarchy mainly divides into 2
1. External Memory/ Secondary memory
- Memories which **aren't accessible directly** by the CPU are called secondary memory
2. Internal memory / Primary memory
- Memories which **are accessible directly** by the CPU are called primary memory

Characteristics of Memory Hierarchy Design

- Capacity
- Access Time
- Performance
- Cost per bit





Different types of memory and their characteristics

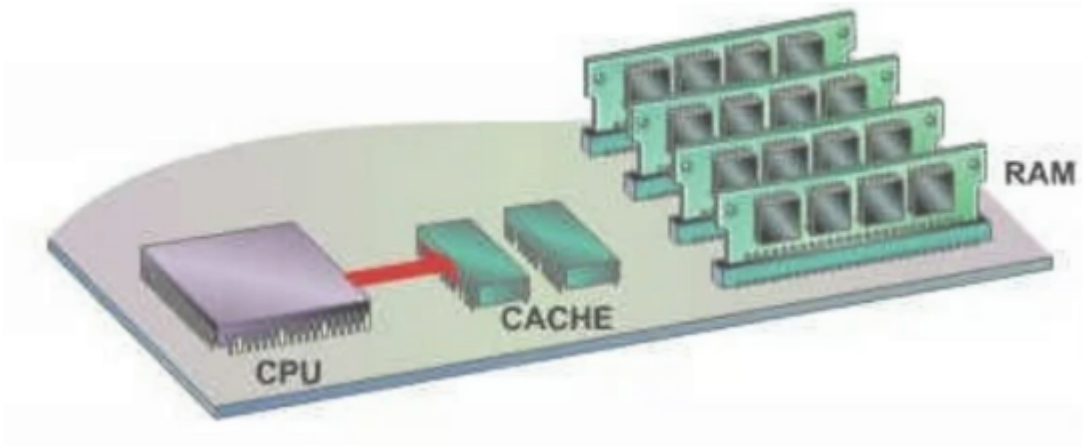
Another way to group memory is:
1. Volatile memory - Memory is not permanent
2. Non-volatile memory - Memory is permanent

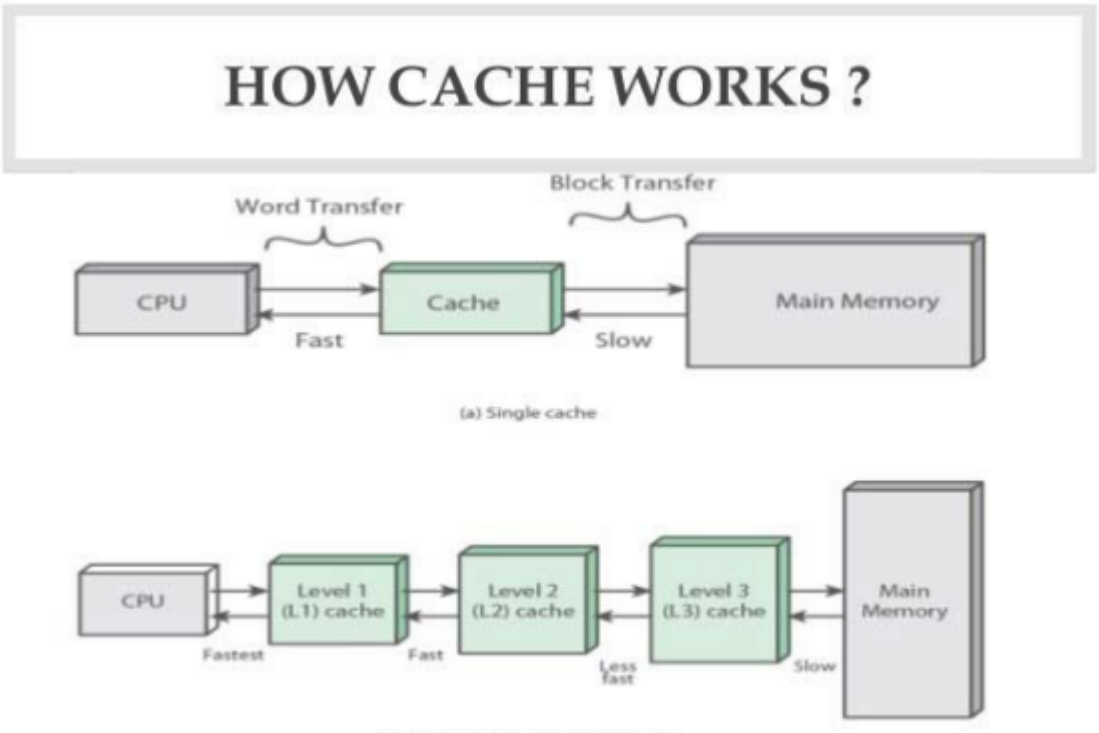
Basis	Volatile Memory	Non Volatile Memory
Definition	Data is not stored in memory as soon as power is gone.	Data remains stored in the memory even if power is done
Temporary	Temporary memory	Not temporary memory but is permanent memory
Performance	Fast	Slow that Volatile memory
Example	RAM	ROM
Storage	Primary	Secondary

Cache memory

There are 3 types of cache memory

1. Level 1
   - extremely fast, but relatively small
   - usually embedded in the processor chip
2. Level 2
   - often more capacity than L1
   - located on the CPU or on a separate
3. Level 3
   - works to improve the performance of L1 and L2
   - significantly slower than L1 or L2
   - but usually double the speed of RAM



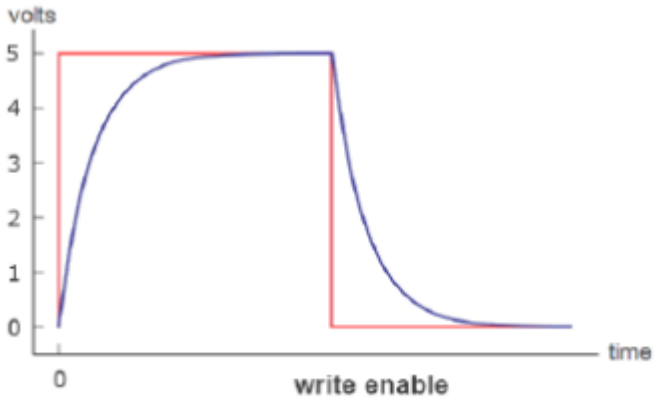


RAM

- Main memory
- Directly accessible by the CPU and so called Volatile
- s fast and expensive
- Two technologies are used in RAM
    1. Static RAM
        - memory cell is implemented with a **flip-flop**
        - Very fast
        - Low density
        - used in cache and register memory
        - Expensive
        - Consumes more power and generates more heat
        - Sometimes used to create main memory (in embedded devices) but not often as DRAM
        - Use charge to store memory
    2. Dynamic RAM
        - memory cell is implemented with a **transistor and a capacitor**
        - Cheap
        - High density
        - Not as fast as SRAM
        - Consumes less power
        - One problem with DRAM is that it looses the charge in capacity
        - Commonly used to create Main memory
        - Use voltage to store memory

Criteria	SRAM	DRAM
Main Component	Flip Flops	Transistors and Capacitors
Speed	Faster	Slower
Density	Less dense	High dense
Cost	Expensive	Cheap

Criteria	SRAM	DRAM
Power Consumption	High	Low
Method of storing memory	as charge	as voltage
Places found	cache and registry	Main memory
Need periodic refreshment	No	Yes
Capacity	Low	High



- Solution is to refresh the charge periodically (While refreshing, cannot read/write)

ROM

- Non-volatile
- Bootup instructions are stored
- Types of ROM
  - MROM
  - PROM
  - EPROM
  - EEPROM

Synchronous dynamic random access memory (SDRAM)

- An interface synchronous with the system bus carrying data between the CPU and the memory controller hub
- rapidly responding synchronous interface
- **synchronizes with the computer's system clock**

Questions

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- Q&A Competency 2