

Information Technology Essentials — Lecture 05

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Fall 2023

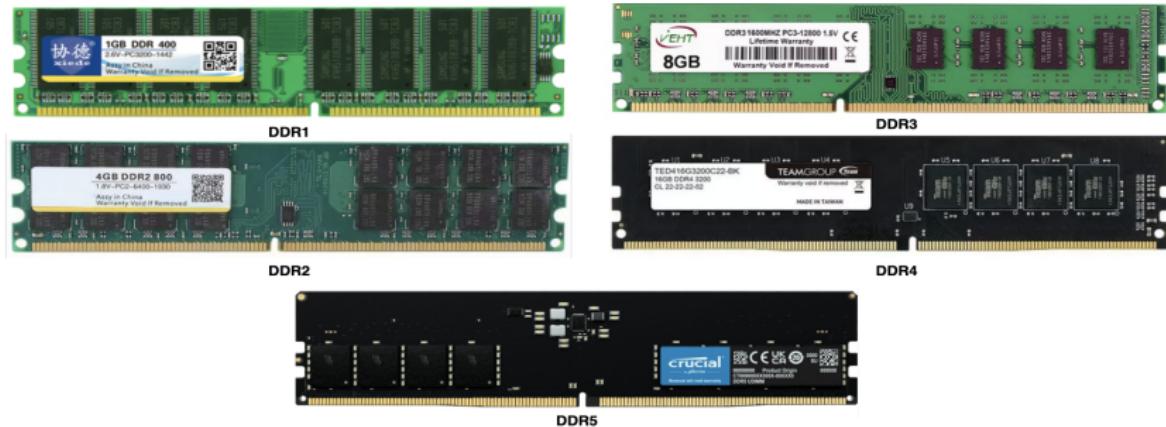


Computer Architecture (Con't)

II. Central Memeory — RAM

Central Memeory (RAM)

The **Central memory** or **RAM**, is a volatile type of memory circuit that is used to store information (e.g., text, programs, videos, images, etc).



RAMs r mainly featured by their: **frequency**, **storage capacity**, **data rate**, and **latency**. They r connected to the motherboard thru the **DIMM** slots.

There are various technologies: SDR SDRAM, DDR SDRAM, RDRAM, DDR2, DDR3, DDR4, and DDR5, LPDDR, and GDDR

Memories (RAM and Storage Devices)

Memories are hardware components used to store data.



They can be volatile or non-volatile.

Data is stored using different technologies: electrical (latches,), magnetic (disk,), and optical technology.

Memory Classification

RAM (Random Access Memory): Needs power to keep its content.

- **Static RAM:** or SRAM, uses latches components (flip-flops) to store data. Has smaller storage capacity but runs faster.

+ used in internal CPU memory +

- **Dynamic RAM:** or DRAM, uses capacitors to store data. Needs refreshment. Has larger storage-capacity, but runs slower.

+ used in central memory +

ROM (Read Only Memory): Does not need power to keep its content.

- **Programmable:** Can be erased and reprogrammed multiple times e.g., EPROM and EEPROM.

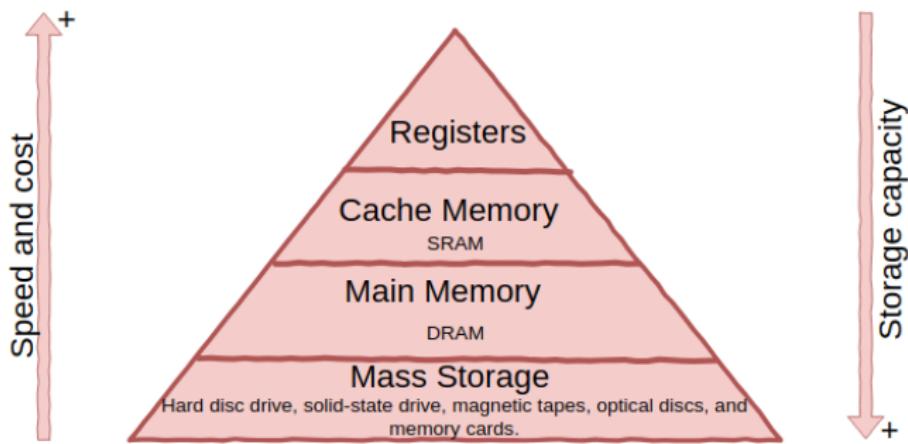
+ used in memory-sticks and pendrives +

- **Non-Programmable:** Cannot be programmed twice e.g., ROM and PROM (only once, after manufacturing).

+ used to store firmware +

Memory Classification

Memories can be classified following their storage capacity, speed (access time), and cost.



General fact. A computer has a small amount of fast memory and a large amount of slow memory.

Central Memory Interface

The interface of a memory is composed of three main components:

- **Address Size.** The size of one address is M bits (b_0, \dots, b_{M-1}).
- **Word Size.** The size of one location is W bits (d_0, \dots, d_W).
A Byte-addressable memory is a memory where W=8 bits.
- **Control Signal.** Read operation or write operation.

Example. A memory that has M=4 and W=8 is a 16 Byte memory.

There are 16 possible addresses ($2^M = 2^4 = 16$):

0000,0001,0010,0011, 0x0,0x1,0x2,0x3

0100,0101,0110,0111, 0x4,0x5,0x6,0x7

1000,1001,1010,1011, 0x8,0x9,0xA,0xB

1100,1101,1110,1111. 0xC,0xD,0xE,0xF

Central Memory Interface

When the value of M is greater than 10, multiples of the bytes (octets) are used:

- For W=8 and M=10, a memory has a size of 1 Kilobyte.

$$2^{10} \times 8 = 1024 \times 8 = K \cdot \text{Byte} = 1 \text{ KB}$$

- For W=8 and M=20, a memory has a size of 1 Megabyte.

$$2^{20} \times 8 = M \cdot \text{Byte} = 1 \text{ MB}$$

- For W=8 and M=30, a memory has a size of 1 Gigabyte.

$$2^{30} \times 8 = G \cdot \text{Byte} = 1 \text{ GB}$$

- For W=8 and M=40, a memory has a size of 1 Terabyte.

$$2^{40} \times 8 = T \cdot \text{Byte} = 1 \text{ TB}$$

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If W=8 and M=29 what is the size of the memory?

Permanent and backup storage memories

Permanent and backup storage memories

Permanent and Backup Storage Memories

There are different types of storage media for permanent storage, backup, and data archiving:

- **Magnetic tape:** Tapes are sequential access medium. Appeared in 1951-present. First time used (The UNISERVO) to record computer data in the UNIVAC I. The tapes were metallic and 1200 feet long, very heavy, the data is coded into magnetic substances.



Became practical after switching from metal tape to plastic tape. Nowadays magnetic tapes can hold 580 TB (2020).

Most organizations use magnetic tapes strictly for backup (cheap but very slow).

Permanent and Backup Storage Memories

There are different types of storage media for permanent storage, backup, and data archiving:

- **Hard Disk Drive:** Appeared in 1956-present. Faster than tape cartridge.



Nowadays HDD can hold up to 22 TB (2022).

Most computers have HDD as secondary storage.

Permanent and Backup Storage Memories

There are different types of storage media for permanent storage, backup, and data archiving:

- **Optical disk:** Stores data using pits/bumps and lands (to encode bit 0 and 1). A laser is used to read the data while the disk spins (if reflected means 1, else 0). Good for archives but are very slow.



Compact Disc (CD)
Capacity: 700 MB
Available from 1982

DVD
Capacity: 4.7 GB
Available from 1995

Blu-ray Disc
Capacity: 25 GB
Available from 2006

Permanent and Backup Storage Memories

There are different types of storage media for permanent storage, backup, and data archiving:

- **Solid state storage:** A.k.a, flash memory (thumb drive, secure digital cards, memory stick, etc).



Relatively costly for their low capacity, but offer excellent portability and ease of use.

Permanent and Backup Storage Memories

There are different types of storage media for permanent storage, backup, and data archiving:

- **Floppy disk:** Used in 1980s and early 1990s, it has low data rate and low storage capacity (less than 3MB).



No longer used.

III. I/O Devices — Peripherals

Peripherals (I/O Devices)

Peripherals or I/O Devices are electronic components used to input and/or output data into/out of a computer.



They are connected to the motherboard thru **expansion cards** and **device controller cards** using various ports, including **USB**, **VGA**, **HDMI**, etc.

Expansion cards and device controller cards are connected to the motherboard using **slots** and **connectors**.

Computer Ports, Sockets, and Connectors

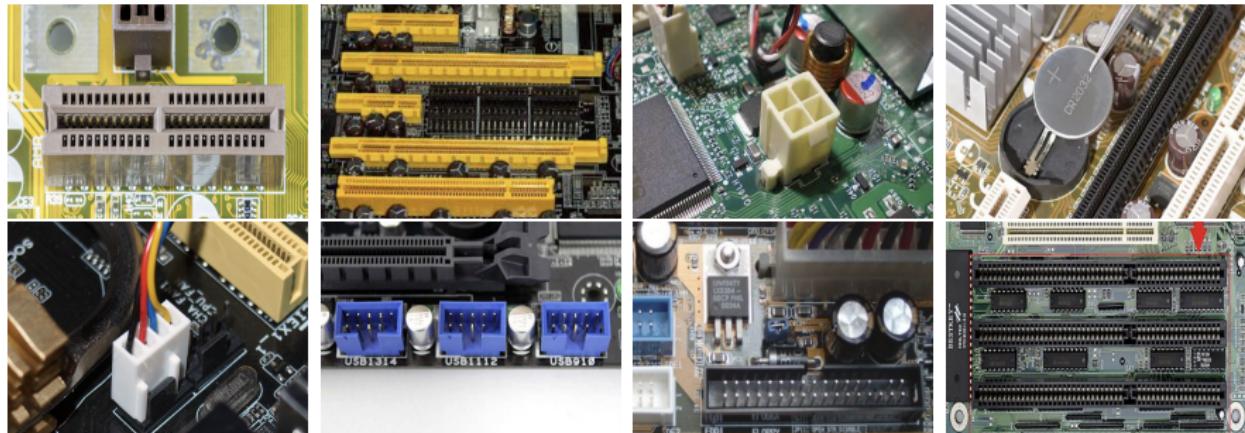
Hardware components (e.g., CPU, RAM, expansion cards, etc) are connected to the motherboard through either a socket, a connector, or a slot:



From left to right, top to down: (1) AGP slot, (2) PCI slots, (3) Memory DIMM slots, (4) CPU socket, (5) SATA connectors, (6) IDE connectors, (7) ATX 24-pin power connector, and (8) M.2 slot for SSD.

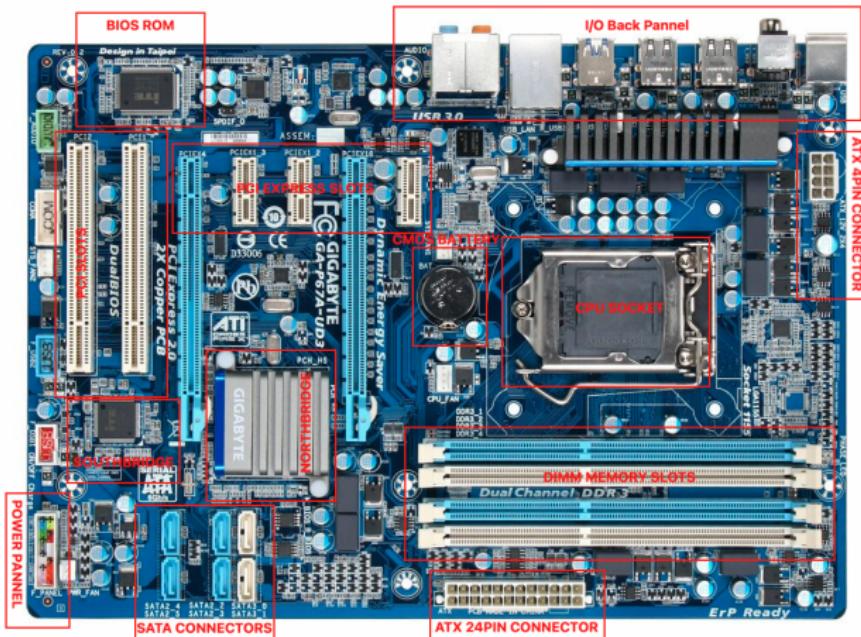
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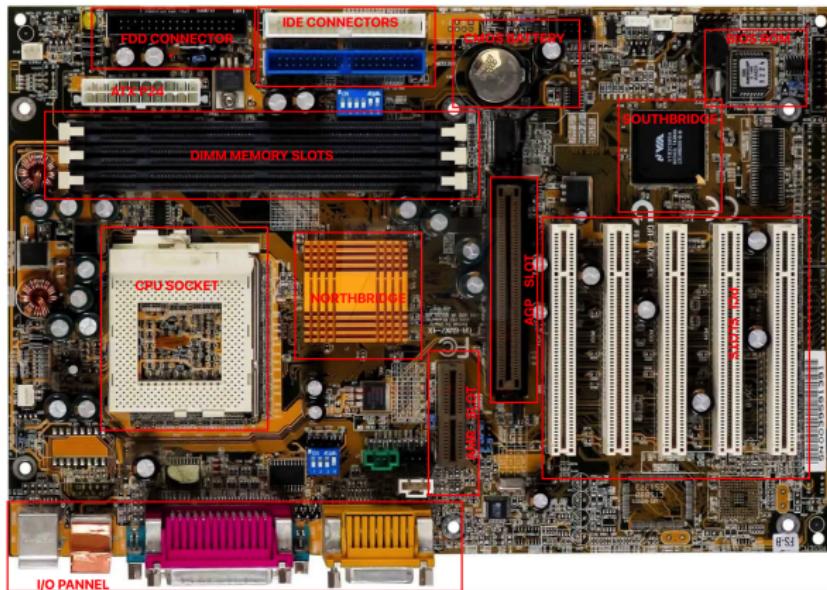
From left to right, T2D: (1) AMR slot, (2) PCI Express slots, (3) ATX P4 power connector, (4) CMOS Battery connector, (5) CPU Fan connector, (6) USB External connectors, (7) FDD connector, and (8) ISA slots.

Computer Components



In this Gigabyte GA-P67A-UD3 motherboard, we can identify the various components, connectors, slots, and port on a motherboard.

Computer Components



In this Gigabyte GA-6VX7-4X motherboard, we can identify the various components, connectors, slots, and port on a motherboard.

Computer I/O Devices Ports

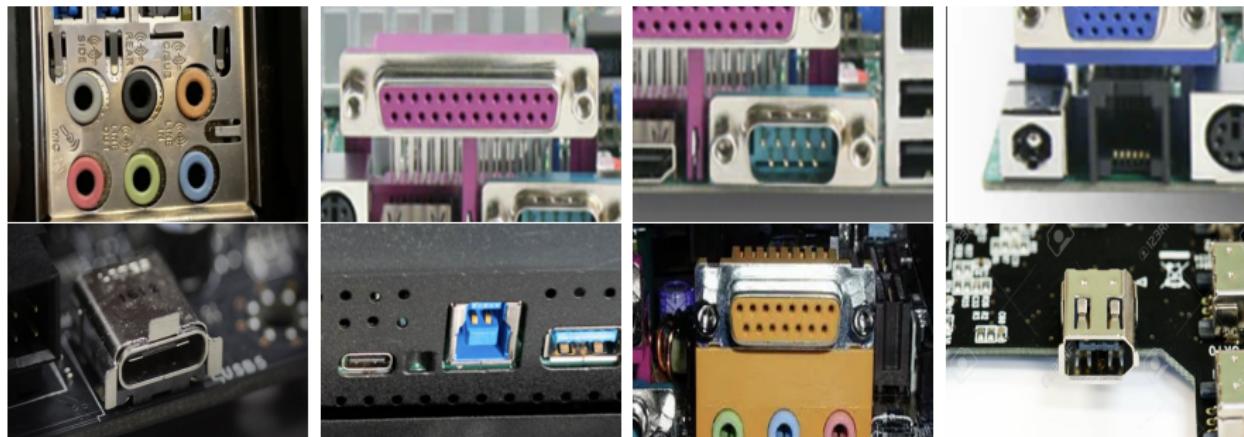
Peripherals are plugged into the motherboard through various port:



From left to right, top to down: (1) VGA, (2) DVI, (3) HDMI, (4) RJ45-Ethernet, (5) PS/2, (6) USB-A 2.0/3.0, (7) DisplayPort, and (8) BNC.

Computer I/O Devices Ports

Peripherals are plugged into the motherboard through various port:



From left to right, top to down: (1) Audio jacks, (2) DB25, (3) DB9 for printers, scanners, serial mice, and modems, (4) RJ11 for telephones, (5) USB-type C, (6) USB-Type B, (7), Game port, and (8) Firewire.

How to Choose a Computer?

You may have been to an IT store to purchase a personal computer. But, how did you choose a computer? It was based on which features?



How to Choose a Computer?

You may have been to an IT store to purchase a personal computer. But, how did you choose a computer? It was based on what?

- The color.
- The guy who sells you the computer.
- The serial number of the computer.
- How many people have bought the same computer.
- How many people will crack jokes on you if you bought the computer.
- ...
- Whether Youtube will run on it.
- Whether you can play GTA5 on it.
- Whether you can make the computer blast if stolen.

How to Choose a Computer?

You may have been to an IT store to purchase a personal computer. But, how did you choose a computer? It was based on what?

- The brand.
- The power of the CPUs.
- The size of the memory.
- The available communication ports.
- The keyboards.
- The graphical card (or GPU).
- The limitations of its hardware.
- The storage capacity.
- The available budget.
- The review of experienced people.

Computer Architecture (Exercise)

Answer the following questions:

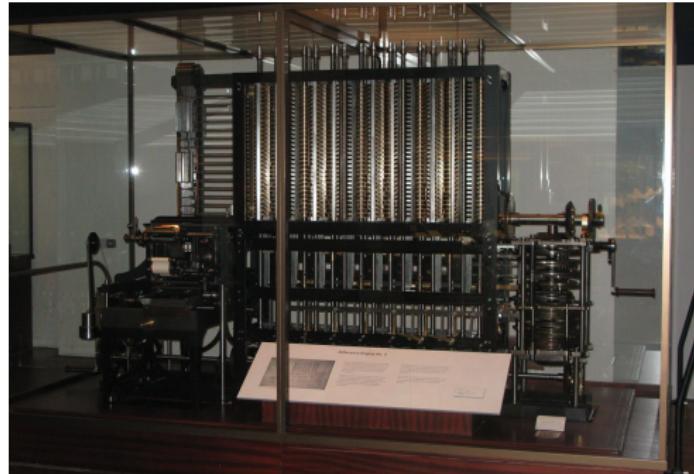
- ① What are the three main hardware components of a computer?
- ② Which type of RAM do we use for the central memory, CPU cache, and pendrives?
- ③ What is CISC and RISC?
- ④ What is the maximum addressable size for a byte-addressable memory connected to a 32 bits address line?
- ⑤ Which type of backup and storage memory requires rewinding to access previous data?
- ⑥ Why don't we build a computer with a huge memory (room size) instead of clustering group of computers?

A Brief History of Computers

A Brief History of Computers

Computer. It is an electronic machine that is designed to automatically compute problems at a very high velocity.

- The first computers were mechanical machines that performed simple calculations. E.g., The Babbage Difference Engine (1822, by Charles Babbage — UK) was used to tabulate polynomial functions.



A Brief History of Computers

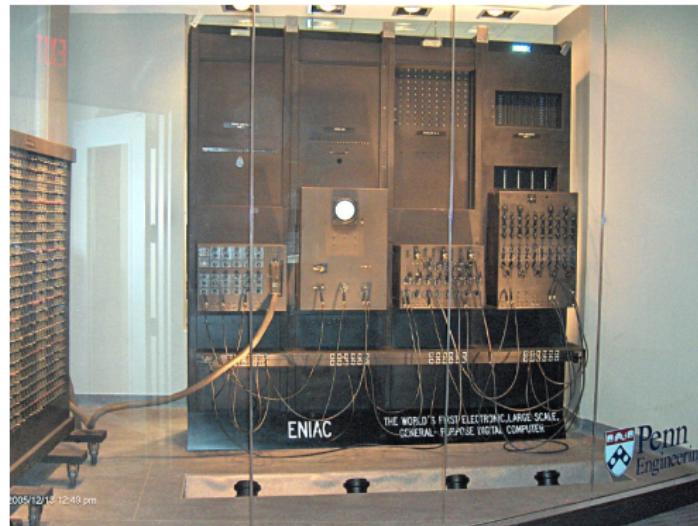
- **Atanasoff–Berry Computer.** The ABC (by John V. Atanasoff and his graduate student, Clifford Berry, in 1942 — USA) was the first electronic computer. It was designed to solve problems with up to 29 different variables (one operation per 15 seconds).



Before ABC, some other computers were designed, but were electro-mechanical machines. E.g., The Torpedo Data Computer (1938) — USA, the Z2 (1940), Z3 (1941), and Z4 (1950) — DE.

A Brief History of Computers

- **Electronic Numerical Integrator And Computer.** The ENIAC (by the University of Pennsylvania, in 1945 — USA) was the first turing-complete (general-purpose) computer. It used IBM's punchcards to input and output data.



The ENIAC patent (claim 1st EC, 47') was thrown out by a judge in 1973.

A Brief History of Computers

Punchcards are pieces of stiff papers that contain digital information represented by the presence or absence of holes in predefined positions. These holes were made by a keypunch machine.



The pattern of holes represented data or instructions that could be read by a computer or data processing machine.

A Brief History of Computers



The largest punchcard computer program (1950s) was the SAGE air defense system with 62,500 punchcards (4.5 megabyte).

A Brief History of Computers (1964 IBM 029 Keypunch)

A Brief History of Computers

Need for a program that makes things much easier?

- Computers in the '40s and early '50s ran one program at a time. The manual process of punching cards and feeding them to the machine worked Okay, as the computers were slow. Yet, when computers became faster, that manual process was taking longer.
- In the era of one-off computers, programmers only had to write code for that single machine. With the proliferation and diversification of computers, their configurations were not always identical. This created a huge pain for programmers.
- When faster computers came in, the need to run multiple programs simultaneously on the same CPU has been raised. There was a need for a **program** to schedule the execution of concurrent programs as well to manage shared resources among various programs.

The first instance of such a program was the **GM-NAA I/O**, produced in **1956** by General Motors' Research division for its **IBM 704**.

A Brief History of Computers

- **Other Computers.** Things have evolved and improved over the years.

Computers in the '60s:



PDP-11 (L) and VAX-11 (R) by Digital Equipment Corporation (DEC).

A Brief History of Computers

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Computers in the '70s:



DEC's '70s computer (L) and IBM's '70s computer (R).

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Computers in the '80s (RGB era):

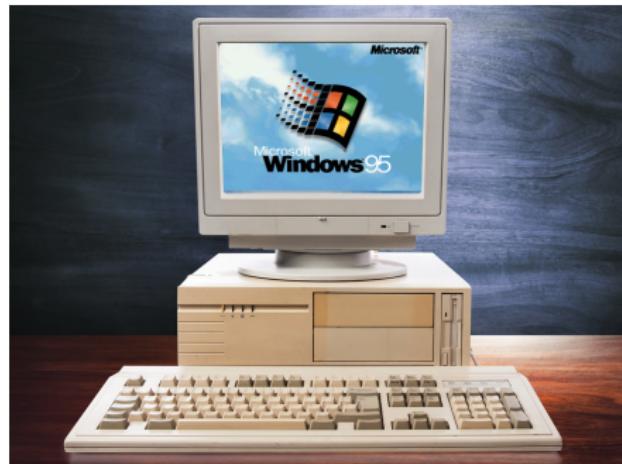


IBM 1981 PC (Left) and Macintosh 1984 computer (Right).

A Brief History of Computers

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Computers in the '90s (RGB era):



IBM's PC (Left) and Apple's iMac (Right).

A Brief History of Computers

- **Other Computers.** Things have evolved and improved over the years.

Computers these days:



A Gamer PC (Left) and a Laptop (Right).

Type of Computers

Type of Computers

- **Supercomputer.** Are computers with high performance. The performance is commonly measured in floating-point operations per second (FLOPS) instead of million instructions per second (MIPS).



Control Data Corporation's CDC 6600 supercomputer 1964 (R) and IBM's Blue Gene/P supercomputer 2007 (L).

These computers are used for data-intensive and computation-heavy scientific and engineering purposes such as oil and gas exploration, molecular modeling, physical simulations, aerodynamics, nuclear fusion research, and cryptoanalysis.

Type of Computers

- **Mainframes.** Are powerful and large computers but not as large as supercomputers.



IBM's 1401 mainframe '60s (R) and IBM's Z15 mainframe 2019 (L).

These computers are used primarily by large organizations for critical applications like bulk data processing for tasks such as censuses, industry and consumer statistics, enterprise resource planning, and large-scale transaction processing.

Type of Computers

- **Server.** Is a computer that runs a service. It does not necessarily have to be a powerful computer. It could be your PC or a Raspberry Pi.



- **Laptop.** You know this one! Just a portable small-sized personal computer. E.g., HP's ProBooks, Apple's MacBooks, etc.
- **Desktop computer.** Sometimes — workstation. Is actually any computer that can fit on top of a table.

Type of Computers

- **Things.** Any object that can perform computation.



Computer Vs Single-board computer Vs Microcontroller

It is also fundamental to differentiate between a computer, single-board computer, and a microcontroller.



A Brief History of Computers

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Any idea of what that magical program is?

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Computers Systems (Exercise)

Answer the following questions:

- ① In a refrigerator, do we find a modern computer, a single-board computer, or a microcontroller?
- ② What is a server?
- ③ What is MIPS and FLOPS in computing?
- ④ What are punchcards and what were they used for?
- ⑤ What is RGB in computing?
- ⑥ Why there was a need for an Operating System?

- End.