# Riphah School of Computing and Innovation (RSCI), Lahore

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## 3rd Semester

## Assignment 1

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**Computer Organization & Assembly Language (Theory)**

**QNo1. Explain the stored-program concept introduced in the IAS computer. Why was it a ground breaking development in computer history?**

**Ans: Stored-Program:**

* The stored-program concept enables both program instructions and data to reside in the same memory space.
* Instructions are accessed and executed directly from memory in a sequential manner.
* This design was a groundbreaking innovation in computing, first implemented in the IAS (Institute for Advanced Study) computer.

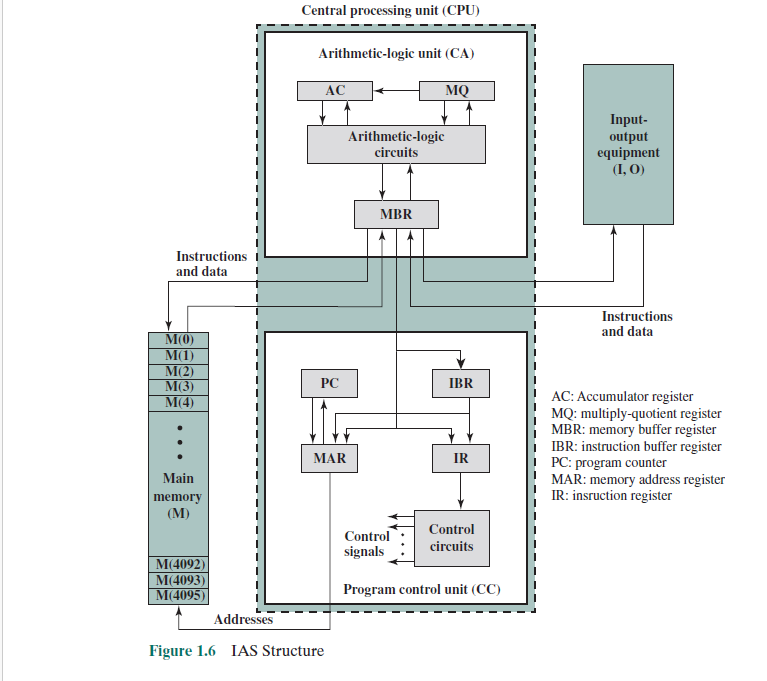


Figure 1: IAS Structure

**Groundbreaking:**

* Previously, computers needed manual rewiring for each task, but the stored-program concept allowed users to load instructions directly into memory, eliminating this hassle.
* This concept introduced the von Neumann architecture, providing flexibility in software development and supporting complex operating systems.
* Storing instructions in memory enabled techniques like loops and conditionals, essential for modern programming languages.

**Importance:**

* Eliminated the need for manual hardware reconfiguration, allowing automated and flexible computing through dynamic program execution.
* Established the widely adopted von Neumann architecture, forming the foundation for modern computers and complex operating systems.
* Enabled technological advancements, driving the rise of personal computing and the digital age.

**QNo2: Compare and contrast the characteristics of vacuum tubes and transistors. How did the invention of transistors improve computer design? {Write in table}**

**Ans:**

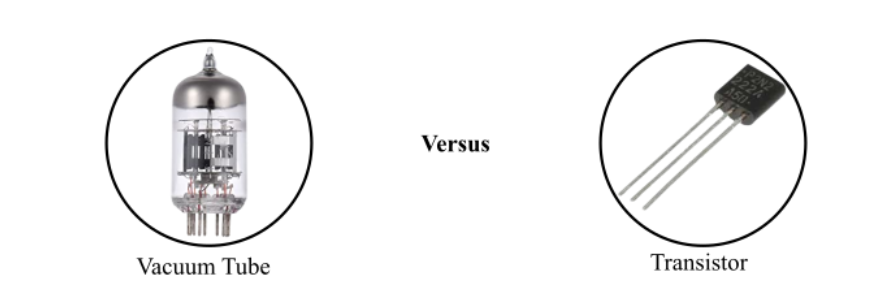
|  |  |  |
| --- | --- | --- |
| **Basis of Difference** | **Vacuum Tube** | **Transistor** |
| Definition | An electronic device that uses a sealed glass tube and vacuum inside it to control the flow of current in a circuit is called vacuum tube. | A three terminal semiconductor electronic device used for regulation of electronic signals is called a transistor. |
| Construction | A vacuum tube consists of a cathode, an anode, sealed in an air tight glass tube. Inside the tube, vacuum is created. | A transistor consists of three layers of semiconductor materials that are sandwiched to form two PN junctions. Each layer has a connection wire called terminal, hence there are three terminals namely emitter, base and collector. |
| Charge carriers | In vacuum tube, electrons are the only charge carriers that are responsible for conduction. | In transistor, two type of charge carriers exist namely electrons and holes. |
| Emission and flow of charge carriers | In vacuum tube, the electrons are emitted by the heating of cathode and flow towards the anode. | In transistor, the charge carrier are emitted by emitter and flows towards the collector. |
| Principle | Vacuum tube works on the principle of thermionic emission, i.e. a heated metal cathode produces the charge carriers, i.e. electrons. | Transistor works on the principle of solid state physics, i.e. charge carriers are produced by the semiconductor effects. |
| Power consumption | Vacuum tubes consume large amount power. | The power consumption for transistors is less. |
| Wastage of power | In vacuum tube, a lot power is wasted in the form of heat. | In transistors, the wastage of power in the form of heat is less. |
| Physical size | Vacuum tubes are large in size. | The size of transistors is comparatively smaller. |
| Portability | The devices that use vacuum tube are less portable. | The devices that use transistor are easily portable. |
| Voltage | Vacuum tubes require high voltage power supplies. | Transistors require low voltage power supplies. |
| Mechanical strength | As vacuum tubes use glass tube, hence their mechanical strength is less. | Transistors are mechanically stronger than vacuum tubes. |
| Efficiency | Vacuum tubes are comparatively less efficient. | Transistors have very high efficiency compared to vacuum tubes. |
| Voltage gain | For vacuum tubes, the voltage gain is low. | Transistors have high voltage gain. |
| Input impedance | Vacuum tubes have high input impedance. | Transistors have low input impedance. |
| Effect of temperature | The change in temperature slightly affects the performance of a vacuum tube. | The change in the temperature greatly affects the performance of the transistor. |
| Suitability for small signal circuits | Vacuum tubes are not much suitable for small signal circuits due to high power loss. | Transistors are greatly suitable for small signal circuit as they are highly efficient than vacuum tubes. |
| Life span | Vacuum tubes have shorter life span upto thousand hours. | Transistors have relatively longer life span, of many years. |
| Fabrication in ICs | Vacuum tubes cannot be integrated with other elements to form ICs. | Transistors can be integrated to form ICs. |
| Switching time | The switching time of vacuum tube is more, i.e. a vacuum tube does not work instantly when the switched ON because it requires some time for the cathode to get hot. | The switching time of transistor is less, it starts working instantly when switched ON. |
| Replacement | A user of the device can easily replace the vacuum tube. | The replacement of transistor is relatively more difficult as it is soldered at the circuit board. |
| Cost | The cost of vacuum tube is high | Transistors are low cost device. |

**Impact:**

 Transistors launched the second generation of computers, making machines smaller, faster, and more efficient.

 They enabled integrated circuits, which further reduced size and cost while boosting performance.

 Transistors transformed the computer industry, driving advancements in telecommunications and consumer electronics.

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**Source :** [**https://www.tutorialspoint.com/difference-between-vacuum-tube-and-transistor**](https://www.tutorialspoint.com/difference-between-vacuum-tube-and-transistor)

**QNo3: Define microelectronics and explain its role in the development of the third generation of computers.**

**Ans:**

**Microelectronics:**

* Microelectronics is one of the subcategories of electronics which focuses on the design and manufacture of very few electronic devices like transistors, capacitors, integrated circuits, etc, on a very small scale on semiconductor materials, usually silicon chips.
* Microelectronics Technology is a technology that allows design of electronic components of smaller sizes thereby helping in designing smaller devices more efficiency.

**Role in 3rd Gen Computer development:**

1. The invention of microelectronics made it possible to fit a large number of transistors on a single silicon chip which led to faster and more capable microprocessors able to handle more complicated tasks.
2. Thanks to increased performance, computers had become quicker and more dependable, handling demanding tasks such as scientific computations and analysis of large amounts of data.
3. The widespread use of microelectronic devices shrank their production costs, consequently making computers cheaper and accessible to organizations and households.
4. Microelectronics also allows the increase of energy efficiency by designing low-power components thus allowing the build of sma ller and portable devices as well as reducing energy consumption.

**QNo4: Discuss** **Moore’s Law and its implications for computer performance and cost.**

**Ans:**

**Moore’s Law:**

1. In 1965, Intel co-founder Gordon Moore observed that technological advancements allowed more transistors to be incorporated into a chip with each generation.
2. This increase in transistor density led to smaller chips from one generation to the next.
3. Moore noted that this progression occurs approximately every two years.
4. This trend has continued for several decades, highlighting the competitive nature of microchip development.

**Implications:**

* A denser cluster of transistors facilitates more computing power, which in turn allows for the faster manipulation of processors for more intricate processes.
* A smaller form factor of transistors allows for cheap mass production of complex hardware, and hence, makes high- end computing technology within everyone’s reach.
* There is a direct result of Moore's Law on the rate of advancement of hardware and software leading to more complexity in applications.
* The tenets of Moore’s Law influence as well the telecommunications, medicine and automobile industries by encouraging processing and usage of data, artificial and machine intelligences.

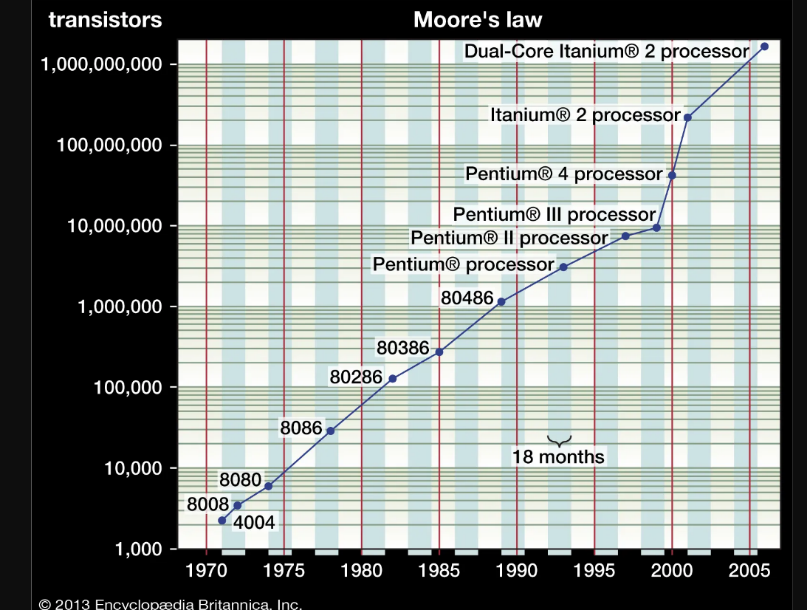
Following is an illustration by Britannica Encyclopedia that shows us how the transistors used in computers increased over the years according to Moore’s law.

Figure 2: Transistor usage Over the Years

**QNo5: Explain the transition from magnetic-core memory to semiconductor memory. What advantages did semiconductor memory offer?**

**Ans:**

**Magnetic Core Memory:**

Employed in early computing systems (from the 1950s to the 1970s), the technology comprised of a number of small magnetizable round rings (cores) with each core capable of holding a bit of a data based on its magnetization. It had many cores, so it was heavy and inefficient, and slow and demanding in power.

**Move to Semiconductor Memory:**

With the advancement in technology from the late 1960s through the 1970s, there came up the use of semiconductors memory which comprised of integrated circuit chips made of silicon. It contains also types of Dynamic RAM (DRAM) which is cheaper than the other but has to be refreshed after a certain period and Static RAM (SRAM) which is more expensive and takes a larger space but is faster.

**Advantages of Semi-Conductor Memory:**

1. Modern data access equipment eliminates bottlenecks in the processing units hence enhances the efficiency of the system especially in real time applications where the access of information is done quickly.
2. The use of small chips aids in the increase of data density and also miniaturization which is very important for gadget portability.
3. Does not use up a lot of energy, which is helpful in increasing the life span of the battery and also lowering the running costs of operations.
4. Less expensive as far as manufacturing is concerned bringing down the overall cost of hard erections.
5. Less prone to failures as there are no moving components and therefore less challenge from external elements.
6. Allows making chips with greater capacity and performance as well as complex configurations of those systems support.

In a recent issue published on IEEE with the name of [Semiconductor Memory Technologies: State-of-the-Art and Future Trends](https://www.computer.org/csdl/magazine/co/2024/04/10488872/1VORpSFSQuc) written by Shimeng Yu and Tae-Hyeon Kim from Georgia Institute of Technology, Atalanta, GA, USA have shown some infographics of recent memory purchases and usages along the world. One of those is given in the following figure which is for trends of memory capacity for various technologies.

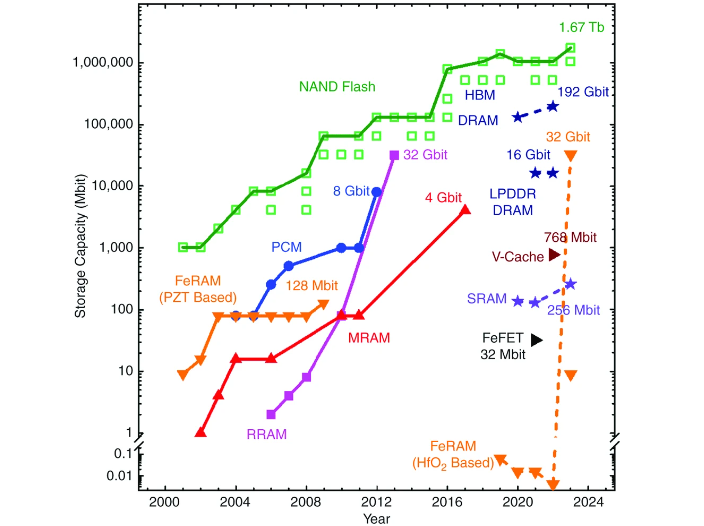


Figure 3: Memory Capacity Trends for Various Technologies

**QNo6: Explain the importance of bus width, clock speeds, and feature size in microprocessor evolution. How do these factors influence computer performance?**

**Ans:**

**Bus Width**: It is the number of bits transferred between the CPU and memory in one cycle.

**Clock Speed:** It is measured in hertz and simply indicates the number of cycles that a CPU can complete in a second.

**Feature Size:** It is referred to as the size of transistors on an integrated circuit and is taken in nanometers. In other words, the smaller the siz3e, the more the processors and hence an increase in the operational capabilities of the chip which is crucial for handheld gadgets.

**Performance Impact**

1. A wider bus coupled with increased clock speeds results to more data being moved and processed in record time.
2. Smaller transistors makes it possible to fit more cores and threads hence improving multitasking capabilities and overall responsiveness.
3. Such improvements also help in making devices more energy efficient therefore allowing the users to enjoy longer battery life and allowing data centers to be cheaper to operate.

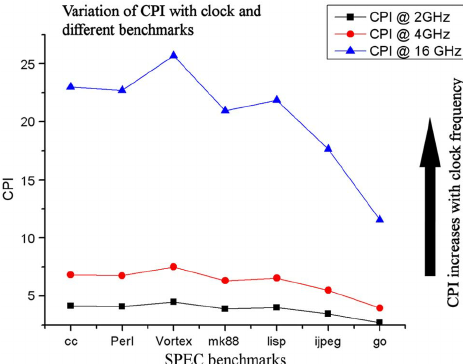
Following is an infographic from a research paper published on ResearchGate showing throughput and latency using CPI.

Figure 4: CPI by Latency and Througput

**QNo7: Discuss the pros and cons of classifying computers into generations. Why might this classification become less meaningful over time?**

**Ans:**

**Pros:**

* It enables understanding the evolution of technology, especially in computing, with ease.
* Spotlights fundamental inventions (for instance, transistors, and microprocessors) that influence the dramatic increase in performance and design.
* Aids in understanding computing power, volume, and costs through time.

**Cons:**

* Makes a generalized approach to progress in invention as any technology overlaps with another in one way or another.
* Omits to provide details on the enhancements made within a single generation.
* The wear and tear due to extreme alterations in technology tend to spoil that structure almost rendering it useless.

**Meaningless Over Time:**

1. Where almost all things changes on a continuous basis over time, the source of this challenge lies in the fact that there are no proper demarcation lines of generations.
2. The likes of AI and quantum, and also nanotechnology do not fit the traditional scope of technologies.
3. Because there are hybrid systems and varying architectures, improvements cannot be classified under one generation’s progress.

**QNo8: Describe the impact of each generation of computers on society and industry. How did each generation change the way computers were used? {Should be well-written, graphical way}**

**Ans:**

**1. The First Generation (1940s-1950s)**

* **Societal Influence:** The conception of computing was basically born for the sake of doing complex arrays of calculations mostly for government, military and research oriented purposes.
* **Industry Transformations:** Devices of this age were mainly devoted to scientific computations, cryptography and primitive forms of data entry processing; these were huge expensive devices found mainly in big companies.

**2. The Second Generation (1950s-1960s)**

* **Societal Influence**: Broadened the scope of computation in organizations to include corporate entities and universities and not rendered only to governments.
* **Industry Transformations:** The reliance on transistors improved the reliability and reduced the sizes enabling faster processing power and the introduction of business processes the first of which was accounting systems.

**3. The Third Generation (1960s-1970s)**

* **Societal Influence:** The scope of computing was also broadening as it began to be used in diverse applications, with smaller and more efficient machines being used by more industries.
* **Industry Transformations:** because of the application of integrated circuits (ICs), the cost and volume of produced hardware decreased considerably, and the software business and its interactive applications began to develop rapidly in commercial and educational services.

**4. The Fourth Generation (1970s-1990s)**

* **Societal Influence:** Those development cycles led to usage of personal computers (PCs) in households and offices, allowing for personal work and changing day-to-day activities.
* **Industry transformations:** Microprocessors made it possible to produce cheap and affordable personal computer systems, leading to a boom of the software market, the automation of offices, and a paradigm shift from distributed computing systems in enterprises to computing in the home and small enterprises.

**5. The Fifth Generation (1990s-Present)**

* **Societal Impact:** Pervaded every aspect of life with the internet and mobile devices as well as artificial intelligence laced into the fabric of everyday life.
* **Industry Changes:** Enhanced processing power paved the way for cloud computing technology along with advancements in artificial intelligence, processing of big data as well as the introduction of the internet of things which changed the way industries such as health care, finance, and communication are conducte. And also made globalization possible to the extent of real time coordination.

I found an infographic from visual capitalist on history of computer. [Click here to view](https://www.visualcapitalist.com/history-computer-science-one-infographic/)