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

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**Computer Organisation & Assembly Language**

## 3rd Semester

## Assignment 1

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**Question 1:**

Explain the stored-program concept introduced in the IAS computer. Why was it a groundbreaking development in computer history?

**Answer:**

A fundamental design approach first implemented in the IAS(Institute for Advanced Study) computer is known as the stored-program concept. This stored-program concept was given by John von Neumann and his colleagues in the 1940s. This concept allowed the computer to store both instructions and data in a single memory location, enabling it to execute instructions by fetching them from memory one at a time and processing them in a sequence.

* **Why it was Groundbreaking:**

The stored-program concept was groundbreaking because it allowed computers to store instructions and data together, making them flexible and easy to reprogram. Before this, changing a program required manual rewiring, which was slow and limited. This concept laid the foundation for modern computers, enabling them to perform many tasks by simply loading new instructions into memory.

**Question 2:**

Compare and contrast the characteristics of vacuum tubes and transistors. How did the invention of transistors improve computer design?

**Answer:**

|  |  |
| --- | --- |
| **Vacuum Tube** | **Transistors** |
| * 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. * Vacuum tubes are large and bulky, requiring a lot of space in computers. * They consume a lot of power, making computers inefficient and costly to operate. * They generate a lot of heat, which can lead to overheating and frequent breakdowns. * They are less reliable and more prone to failure, requiring regular maintenance. * The devices that use vacuum tube are less portable. * Vacuum tubes cannot be integrated with other elements to form ICs. | * A three terminal semiconductor electronic device used for regulation of electronic signals is called a transistor. * Transistors are small and compact, allowing for much smaller computer designs. * They Use very little power, making computers more energy-efficient. * They produce minimal heat, allowing computers to run cooler and more reliably. * They are highly reliable with a longer lifespan, reducing the need for repairs. * The devices that use transistor are easily portable. * Transistors can be integrated to form ICs. |

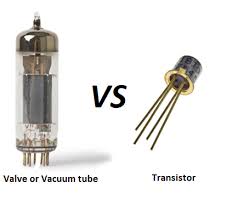
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Figure: Vaccum Tube vs Transistor

**Invention of Transistors:**

The invention of transistors changed computer design by making computers smaller, faster, and more reliable. Transistors used less power and produced less heat, allowing computers to be built in smaller sizes and with better performance. This progress led to today’s powerful computers and made them more useful and accessible for many different purposes. Now-a-days we have computers that are completely based on integrated circuits (ICs), which is manufactured using transistors. Thus the invention of transistor can be classified as the most crucial invention in the history of computer engineering.

**Question 3:**

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

**Answer:**

Microelectronics is the branch of electronics that focuses on designing and manufacturing extremely small electronic components, such as transistors, resistors, and capacitors, often at the microscopic level. These components are integrated into microchips, which are used to build compact and efficient electronic circuits.

**Role:**

Microelectronics played a crucial role in the third generation of computers (1960s–1970s) by enabling the use of integrated circuits (ICs), where multiple transistors and other components were placed on a single silicon chip. This advancement allowed computers to become much smaller, faster, more reliable, and energy-efficient compared to the earlier generations that used individual transistors or vacuum tubes. With microelectronics, computers could perform complex tasks at higher speeds, and the reduced size and cost made them more accessible for businesses, organizations, and eventually, personal use.

**Question 4:**

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

**Answer:**

* **Moore’s Law:**

While popularly referred to as a “law,” Moore’s Law is better understood as an empirical observation regarding advancements in computing. In a 1965 Electronics Magazine article, the cofounder of Fairchild Semiconductor International, Inc. and Intel, Gordon Moore, projected that the ideal number of transistors per square inch on a microchip would double each year while the manufacturing cost per component would halve. Ten years later, Moore revised his original projection and said chip density would, instead, double every two years for at least the next decade.

More transistors and components, in layman’s terms, means more computing power, higher efficiency, and more complex functions. A corollary of Moore’s Law is that the cost of computing has fallen dramatically, enabling adoption of semiconductors across a wide span of technologies. Today, semiconductors are the technology platform underpinning how the world works, communicates, and consumes.

* **Is it still viable?**

Moore’s Law has largely held true into the twenty-first century, though it has begun to slow down as engineers reach the limits of shrinking circuits within the laws of physics. Even so, the computing power of a single integrated circuit today is roughly 2 billion times what it was in 1960.

As the exponential increase in the density of transistors per square inch on a chip decelerates, some observers have proclaimed Moore’s Law demise. However, advances in chip packaging and design may allow a form of Moore’s Law to “survive” into the 2020s. In 1995, Moore himself admitted that “the definition of ‘Moore’s Law’ has broadened to refer to anything related to the semiconductor industry that, when plotted on semi-log paper, approximates a straight line.” A reconceptualization of Moore’s Law—sometimes dubbed “more than Moore” or MtM—prioritizes system complexity over chip density as a more accurate path for progress in computing technology and has extended the continued viability of Moore’s Law.

As of 2022, advancements along the lines of MtM, including the advent of the so-called three-dimensional integrated circuit (3DIC), heterogenous integration, and “chip stacking,” as well as the potential for quantum-enabled semiconductors, may hold the key to the persistence or even acceleration of Moore’s Law—albeit in different form—well into the twenty-first century.

* **Practical Implications:**

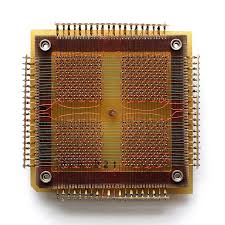
The implications of Moore’s Law for cost and performance have been transformative. As transistor counts doubled, computer performance increased exponentially, enabling faster processing speeds, enhanced multitasking with multi-core processors, and complex real-time applications like AI and data analytics. At the same time, the cost per transistor dropped significantly, making powerful computing accessible and affordable for a wide range of industries and consumers. This decline in costs has democratized technology, allowing widespread access to powerful devices in education, healthcare, and business. However, as transistors approach physical and quantum limits, production costs for advanced manufacturing have risen, challenging further cost reductions. To sustain performance gains, the industry is increasingly exploring specialized hardware like GPUs and FPGAs, as well as alternative computing paradigms.

**Question 5:**

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

**Answer:**

Magnetic-core memory, a form of random-access memory, dominated the computer industry for roughly two decades from the mid-1950s to the mid-1970s. It consisted of tiny ferrite rings strung on wires, where the direction of a magnetic field within each ring determined the stored bit of data. While reliable, it was bulky, expensive, and slow.



**Magnetic Memory**

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**Semi-Conductor Memory**

The transition from magnetic-core memory to semiconductor memory marked a significant milestone in the evolution of computer memory. Magnetic-core memory, developed in the 1950s, used tiny magnetic rings (cores) through which wires were threaded to store data as a magnetic field, with each core representing a single bit (0 or 1).

In the late 1960s and early 1970s, semiconductor memory began to emerge, using transistors to store bits of data electronically. This shift was driven by the advent of the integrated circuit (IC), which allowed multiple transistors to be fabricated on a single silicon chip. Semiconductor memory, particularly dynamic random-access memory (DRAM), quickly became the preferred memory technology.

**Advantages:**

1. **Speed:** Semiconductor memory offered significantly faster access times compared to magnetic-core memory. This improvement in speed was crucial for accelerating computer operations.
2. **Size and Weight:** Semiconductor memory chips were much smaller and lighter than magnetic-core memory modules, enabling the development of smaller and more portable computer systems.
3. **Power Consumption:** Semiconductor memory consumed less power, leading to lower operating costs and reduced heat dissipation.
4. **Scalability:** Semiconductor technology allowed for rapid increases in memory capacity, enabling the development of increasingly powerful computers.
5. **Reliability:** Semiconductor memory was more reliable than magnetic-core memory, as it had fewer mechanical components prone to failure.

**Question 5:**

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

**Answer:**

The performance of a microprocessor is significantly influenced by three key factors: bus width, clock speed, and feature size.

**1. Bus Width:**

The bus width refers to the number of bits that can be transferred simultaneously over a data bus. A wider bus allows for more data to be transferred in a single clock cycle, increasing the overall data transfer (input/output). This translates to faster data transfer between the CPU and other components like memory and peripherals.

**2.** **Clock Speed:**

The clock speed, measured in Hertz (Hz), determines the number of cycles a processor can execute per second. A higher clock speed means the processor can execute instructions more rapidly, leading to faster overall performance. However, increasing clock speed also increases power consumption and heat generation, which can limit the maximum achievable speed.

**3. Feature Size:**

Feature size is measured in nanometers (nm) and is defined as the minimum size of a transistor that can be manufactured on a chip. Smaller feature sizes allow for more transistors to be packed into a chip, leading to increased complexity and higher performance. Smaller transistors also consume less power and generate less heat, enabling higher clock speeds and lower power consumption.

**Impact:**

These three factors work together to determine a microprocessor's overall performance:

Increased bus width allows for faster data transfer, reducing bottlenecks and improving overall system responsiveness. Higher clock speed enables the processor to execute instructions more quickly, leading to faster application execution. Smaller feature size enables higher transistor density, allowing for more complex designs and higher clock speeds.

However, it is important to note that increasing one factor without considering the others can lead to diminishing returns or even performance degradation. For instance, increasing the clock speed without improving the cooling system can lead to thermal heating, reducing performance. Similarly, increasing the bus width without sufficient memory bandwidth can create another bottleneck. In conclusion, changing one characteristic of microprocessor can heavily affect it’s performance speed and cost.

**Question 7:**

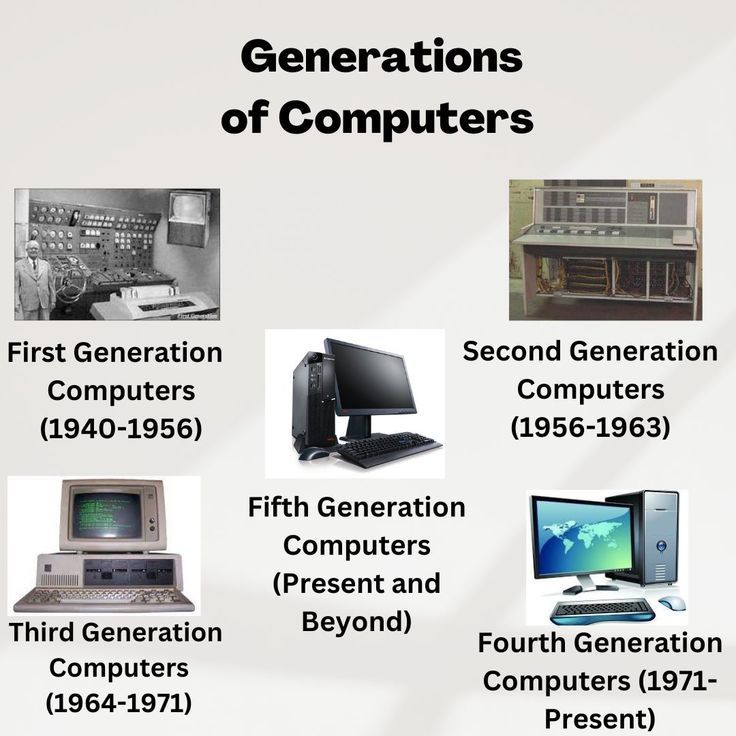
Discuss the pros and cons of classifying computers into generations. Why might this classification become less meaningful over time?

**Answer:**

It has been almost a century that computing machines are being manufactured and we’ve seen computers that were very huge based on vacuum tubes to now-a-days computer which is relatively smaller and a lot faster. This evolution of computer is also classified as the generation of computers. Following is a table showing generation of computers.

|  |  |  |  |
| --- | --- | --- | --- |
| **Generation** | **Approximate Dates** | **Technology** | **Typical Speed (Operations per second)** |
| 1 | 1946-1957 | Vacuum Tube | 40,000 |
| 2 | 1957-1964 | Transistor | 200,000 |
| 3 | 1965-1971 | Small- and medium-scale integration. | 1,000,000 |
| 4 | 1972-1977 | Large scale integration. | 10,000,000 |
| 5 | 1978-1991 | Very large scale integration. | 100,000,000 |
| 6 | 1991- | Ultra large scale integration | >1,000,000,000 |

**Table: Generation of Computers**

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**Figure: Generation of Computers**

**Pros and Cons:**

**Pros:**

* It provides a clear historical framework for understanding the evolution of computing technology.
* It highlights significant advancements in hardware and software, such as the transition from vacuum tubes to transistors and integrated circuits.
* It's a useful tool for teaching computer science and history, simplifying complex technological advancements into digestible chunks.

**Cons:**

* It can oversimplify the complex and continuous nature of technological development, as advancements often overlap and blur the lines between generations.
* It often emphasizes hardware advancements, while neglecting significant software developments and paradigm shifts that have shaped computing.
* As technology evolves rapidly, the traditional generational model may become less useful in describing the latest advancements.

**Why the Classification Might Become Less Meaningful Over Time**

The traditional generational model is increasingly challenged by several factors. The pace of technological innovation has accelerated significantly, making it difficult to clearly define distinct generations. The lines between hardware and software, as well as between different computing platforms, are becoming increasingly blurred. The rise of specialized hardware, such as GPUs and AI accelerators, challenges the traditional focus on general-purpose processors. Modern computing is characterized by continuous improvement and iteration, rather than distinct generational leaps.