ASSIGNMENT - 1

Study of processor

1.Introduction

A processor is an integrated electronic circuit that performs the calculations that run the computer. It is often referred to as the “Brain of a PC” because all the computations and processing are carried out directly or indirectly by the processor containing millions of transistors. It is a single chip that is capable of processing data. In fact, the performance, capability, and pricing of a computer system are largely determined by the processor to present in it. It controls all the components in a PC. The modern CPU is an intricate piece of technology that integrates numerous features such as multiple cores, large cache memory, hyper-threading, and advanced instruction sets to deliver high performance across a wide range of applications.

The primary functions of processor are –

1. Fetch
2. Decode
3. Execute
4. Write back

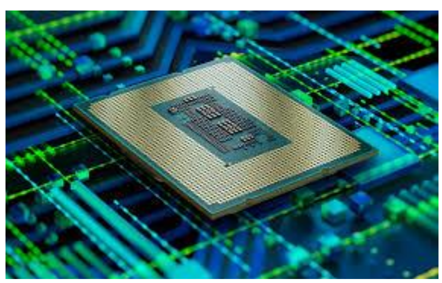

Figure.1.1 Processor

2. History

The development of processors has been a significant driver of technological progress, impacting various industries from personal computing to scientific research. Below is an in-depth timeline showcasing the key milestones in the history of processors:

Year	Processor	Developer	Key Features
1971	Intel 4004	Intel	First commercial microprocessor, 4-bit, 740 kHz
1972	Intel 8008	Intel	8-bit, 200 kHz
1974	Intel 8080	Intel	8-bit, 2 MHz
1975	MOS Technology 6502	MOS Technology	8-bit, used in Apple II and Commodore 64
1976	Zilog Z80	Zilog	8-bit, widely used in embedded systems
1978	Intel 8086	Intel	16-bit, 5-10 MHz
1982	Intel 80286	Intel	16-bit, 6-25 MHz, protected mode
1985	Intel 80386	Intel	32-bit, 12-40 MHz, multitasking
1989	Intel 80486	Intel	32-bit, 20-100 MHz, integrated FPU

Year	Processor	Developer	Key Features
1993	Intel Pentium	Intel	32-bit, 60-300 MHz, superscalar architecture
1997	AMD K6	AMD	32-bit, 166-300 MHz, competitive with Intel Pentium
1999	Intel Pentium III	Intel	32-bit, 450-1400 MHz, SSE instructions
2000	AMD Athlon	AMD	32-bit, 500-1400 MHz, high performance
2003	AMD Athlon 64	AMD	64-bit, 1.8-2.4 GHz, first consumer 64-bit processor
2006	Intel Core 2 Duo	Intel	64-bit, 1.86-3.33 GHz, dual-core
2008	Intel Core i7	Intel	64-bit, 1.6-3.33 GHz, quad-core
2011	AMD FX	AMD	64-bit, 3.1-4.2 GHz, up to 8 cores
2017	AMD Ryzen	AMD	64-bit, 3.0-4.0 GHz, up to 16 cores

Year	Processor	Developer	Key Features
2019	Intel Core i9	Intel	64-bit, 3.6-5.0 GHz, up to 18 cores
2020	Apple M1	Apple	64-bit, 3.2 GHz, ARM architecture, high efficiency

Table 1.1 :- History of processor

3. Available Technologies in the field

Processor technologies have diversified to meet the demands of various computing environments, from mobile devices to supercomputers. Here's a detailed look at the primary technologies available:

1. Multi-Core Processors: There are often several cores in modern CPUs allowing them handle many tasks at the same time. This results in better speed and effectiveness especially when doing many things at once and also multi grand process.

2. Quantum Computing: Unlike other types of processors that operate using bits, Quantum processors make use of qubits which enables them to run complex computations much faster than their predecessors. Even though this technology is still in its early stages, there is a lot of promise for its future.

3. AI Integration: More and more chips come with built-in AI capabilities, like Neural Processing Units (NPUs). With these types of processors, AI jobs can be done easily thus enhancing the performance of applications such as machine vision and natural language processing.

4. Neuromorphic Computing: The goal is to create computer systems that can learn and change by imitating how neurons work in the human brain. For instance, neuromorphic systems have been developed to emulate human brain activities including learning and pattern recognition.

5. 3D Stacking: Dense multi-layered chips that contain both processor and memory parts are produced by 3D stacking technology. Therefore, it helps surpass the limitations of the regular two-dimensional chips.

6. High-Bandwidth Memory (HBM): This is memory with extremely high data transfer rates enabled by the use of multiple stacked DRAMs on a single chip design.

4. Working and Basic Concepts

To understand how processors work, it's essential to dive into the core components and operations:

- **Instruction Cycle**: The basic operation of a CPU consists of fetching an instruction from memory, decoding it to understand the required action, executing the instruction, and then storing the result. This cycle is repeated continuously.
- **ALU (Arithmetic Logic Unit)**: The ALU is responsible for performing all arithmetic and logical operations, such as addition, subtraction, and comparisons. It is a crucial component for the processor's ability to handle mathematical computations.
- **Control Unit**: The control unit orchestrates the operations of the CPU, directing how data moves between the ALU, registers, and memory. It also interprets the instructions fetched from memory and signals the other components on how to proceed.
- **Registers**: Registers are small, fast storage locations within the CPU used to hold data that is being processed. Common types include the accumulator, instruction register, and program counter.
- **Cache Memory**: Cache is a small amount of very fast memory located close to the CPU cores. It stores copies of frequently accessed data from the main memory, reducing the time needed for the CPU to access this data and significantly speeding up processing.
- **Pipelining**: Pipelining is a technique where multiple instruction phases (fetch, decode, execute, etc.) are overlapped. This allows the CPU to work on multiple instructions simultaneously, increasing throughput.
- **Clock Speed**: The clock speed of a processor, measured in GHz, indicates how many cycles per second the CPU can perform. Higher clock speeds generally mean faster performance, although other factors like architecture and core count also play crucial roles.

5. Study on Various Parameters Like Cost, Speed, and Performance

1. Price

Budget Processors: Usually used in the entry-level devices, these processors are cost-effective examples Intel's Celeron and AMD's Athlon series.

Mid-Range Processors: They provide a balance between cost and performance for most users. Some examples include Intel Core i5 or AMD Ryzen 5 series.

High-End Processors: This category is for enthusiasts or professionals who want maximum power under their hood like Intel Core i9 or AMD Ryzen 9 series.

2. Speed

Clock Speed: Measured in GHz, this shows how many cycles a processor can run per second i.e., more cycles faster output speed.

Cores and Threads: The more cores and threads there are the more tasks that may be done at the same time. For instance, a quad-core processor can cater to four workloads at one time.

Cache Size: In an easy way larger caches can accommodate more data near CPU thereby decreasing the frequency of accessing them.

3. Performance

Single-Core Performance: Important for tasks that rely on a single core, basic applications and even some games belong here as well.

Multi-Core Performance: This is because multi-tasking tasks like video editing or 3D rendering rely heavily on this (using several cores). In addition to this, it is a critical attribute for multi-tasking applications that use multiple cores such as video editing software or 3D rendering ones.

Thermal Design Power (TDP): Indicates heat output and energy consumption rates respectively. However, lower TDP may imply better energy efficiency but could also indicate lower performance.

Elements Affecting Performance

Architecture: Different architectures (e.g. Intel's x86 vs. ARM) provide different levels of efficiency and performance.

Manufacturing Process: Smaller nanometer processes (e.g. 7nm vs 14nm) usually lead to better performance and efficiency.

Software Optimization: A processor's performance can be greatly improved through proper software optimization.

6. Market Study

The processor market is highly competitive, with several key players dominating different segments:

- **Global Market Size**: The global CPU market is projected to reach over $90 billion by 2026, driven by demand for high-performance computing, data centers, and mobile devices.
- **Key Players**:
    - **Intel**: The dominant player in the desktop, laptop, and server CPU markets. Known for its Core and Xeon series, Intel has a long-standing reputation for delivering high-performance processors.
    - **AMD**: Intel’s primary competitor, especially in the desktop and server markets. AMD’s Ryzen and EPYC series have challenged Intel’s dominance, particularly in multi-core performance and value.
    - **ARM Holdings**: ARM licenses its processor designs to manufacturers like Qualcomm, Apple, and Samsung. ARM-based processors are prevalent in mobile devices, tablets, and embedded systems due to their power efficiency.
    - **Apple**: With the introduction of its M1 and M2 chips, Apple has moved away from Intel processors, developing its own ARM-based CPUs that offer high performance and energy efficiency, particularly in their Mac product line.
- **Consumer Segments**:
    - **Desktop PCs**: Intel and AMD dominate, with products ranging from budget to high-end gaming and workstation CPUs.
    - **Laptops**: Intel leads in this segment, but AMD has made significant inroads with its Ryzen Mobile processors.
    - **Servers**: Intel’s Xeon processors are widely used in data centers, though AMD’s EPYC processors have gained significant market share due to their core density and performance per watt.

7. Future advancement that are under progress

The processor industry is continuously evolving, with several exciting advancements on the horizon:

I. Quantum Computing

In place of ordinary bits, quantum processors utilize qubits enabling them to rapidly handle huge volumes of information at once. Such technology is expected to transform complicated calculations' fields including material science and cryptography.

II. Heterogeneous Computing

Heterogeneous computing refers to a strategy whereby CPUs, GPUs, FPGAs and other specialized processors' different types are combined in one package that future processors will increasingly adopt. AI tools like data analytics benefit from this approach optimized for specific tasks.

III. Chiplets and Advanced Packaging

Chiplet technology involves processing units that consist of greater numbers of smaller chips (chiplets), which can be assembled together on demand or used alone. This makes it possible for more flexible and efficient designs and manufacturing processes in processors.

IV. AI-Specific Processors

There is a growing trend towards creating processors that are exclusively created with AI in mind. These chips perform better than traditional ones when it comes to machine learning algorithms or neural network inference while consuming less electricity.

V. High-tech Lithography

Modern lithography techniques including Extreme Ultraviolet (EUV) lithography are facilitating the creation of smaller and more effective transistors which is essential for ensuring transistors density and efficiency continue to increase as per Moore's Law.

VI. Neuromorphic Computing

Neuromorphic processors seek to emulate human brain architecture in order to boost efficiency in tasks like pattern recognition or sensory processing. Such advancements would be beneficial for the development of robotics and autonomous systems.

VII. Photonic Computing

Seeing that photonic processors employ light instead of electrical signals in order to make computations, effort put into it would result in greater data transfer speeds with minimal power consumption thus making them fit for high performance computing uses.

8. Conclusions

The evolution of processors is a testament to the relentless pursuit of innovation in computing technology. From the early days of the Intel 4004 to the latest developments in quantum computing, processors have become increasingly powerful, efficient, and versatile. As the demand for high-performance computing continues to grow, particularly in areas like AI, big data, and gaming, the competition between companies like Intel, AMD, ARM, and Apple will drive further advancements. Understanding these technologies and their implications is crucial for anyone involved in computer science or engineering.

9. Indian contributions to the field

India has been a major player in the development of processors both in the past and presently. Some major highlights are:

Historical Contributions

Vinod Dham: The "Father of Pentium," Vinod Dham was pivotal to Intel's Pentium microprocessor development which transformed personal computing in the 1990s1.

PARAM Supercomputers: In response to technological embargoes, India produced its first homegrown supercomputer – PARAM 8000 – in 1991. This marked an important milestone for the Centre for Development of Advanced Computing (C-DAC)2.

Modern Contributions

Intel Xeon Processors: Intel's Xeon processors were designed and validated by Indian engineers among others. For instance, most parts of the Xeon 7400 series, which is the world's first processor with six computing cores were designed here in India3.

Startups and Innovations: A lot of new Indian firms have been making way for themselves in processor technology mainly centered on AI, machine learning and IoT. A good illustration could be InCore Semiconductors or Saankhya Labs.

Future Prospects

In pursuance of the semiconductor research and development, India continues pouring millions of dollars in order to become a leading global centre for chip designing and manufacturing. The "Make in India" campaign and alliances with multinational technological businesses are among their future possibilities.

10. References

Books: - Hennessy, J. L., & Patterson, D. A. (2019), Stallings, W. (2020),

Intel Corporation. (2021).

Website :- GeeksforGeeks, Shiksha