Four Main Elements of a Computer

Central Processing Unit (CPU): The brain of the computer that performs instructions defined by software, executing arithmetic, logic, control, and input/output (I/O) operations.

Memory: The component that stores data temporarily (RAM) or permanently (ROM or secondary storage like hard drives) for quick access by the CPU.

Input/Output (I/O) Devices: Devices that allow communication between the computer and the outside world, including peripherals like a keyboard, mouse, and display monitor.

Storage: Secondary storage devices like hard drives and SSDs that store data persistently, allowing data retention even when the computer is turned off.

Characteristics of Memory Hierarchy Elements

Speed: Faster access times are found in elements closer to the CPU, such as registers and cache, while slower times are found in main memory and secondary storage.

Size: Higher-level memory elements (like registers and cache) are smaller in size compared to lower levels like main memory and disk storage.

Cost: The cost per bit of storage generally decreases as you move down the hierarchy, with cache being the most expensive and disk storage being the least expensive.

Volatility: Elements like cache and RAM are volatile (lose data when power is off), while secondary storage is non-volatile.

DMA (Direct Memory Access) is given higher priority than processor access to the main memory because DMA allows data transfer directly between I/O devices and memory without CPU involvement, which is more efficient for large data transfers. Granting DMA priority ensures that these transfers are fast and do not stall, improving the overall system performance

Average Access Time Calculation

To calculate the average time required to access a referenced word, consider the three possible scenarios:

Cache Hit: 20 ns (occurs 90% of the time).

Main Memory Hit: 60 ns + 20 ns = 80 ns (occurs 6% of the time, since 10% of references miss the cache and 60% of those hit main memory).

Disk Access: 12,000,000 ns (12 ms) + 60 ns + 20 ns = 12,000,080 ns (occurs 4% of the time, since 10% of references miss the cache and 40% of those miss main memory).

The average access time:

Average Time=(0.9×20)+(0.06×80)+(0.04×12,000,080)

Calculating each term:

Cache hit: 0.9×20=18 ns

Main memory hit: 0.06×80=4.8 ns

Disk space: 0.04×12,000,080=480,003.2 ns

Adding them up:

Average Time=18+4.8+480,003.2=480,026 ns

So, the average time required to access a referenced word is 480,026 ns.