1. Cache Memory

Cache memory is a high speed memory, which is placed between the CPU and main memory. It is very small in size but very fast in operation. It is used to store the data and instructions that are frequently used by the CPU.

Advantages of Cache memory:

- It reduces the average access time for data and instructions.
- It reduces the bandwidth required for the main memory.
- It increases the processor speed.

Disadvantages of Cache memory:

- It is very expensive.
- It has limited capacity.

2. Virtual Memory

Virtual memory is a memory management technique that allows the operating system to use more memory than the physical RAM installed on the computer. It creates the illusion of a large memory by using a combination of RAM and disk space.

Advantages of Virtual Memory:

- It allows multiple programs to run simultaneously.
- It allows programs larger than the physical memory to run.
- It provides memory protection.

Disadvantages of Virtual Memory:

- It slows down the system performance.
- It requires additional hardware and software.

3. Interrupt

An interrupt is a signal from a hardware device or software to the CPU, which temporarily halts the current execution and transfers control to an interrupt handler routine. After the interrupt is handled, the CPU resumes the interrupted task.

Types of Interrupts:

- Hardware interrupts: Generated by hardware devices (e.g., keyboard, mouse, timer).
- Software interrupts: Generated by software instructions (e.g., system calls).

4. Pipelining

Pipelining is a technique that allows multiple instructions to be processed simultaneously by dividing the execution process into stages. Each stage performs a specific task on an instruction, and multiple instructions can be in different stages at the same time.

Advantages of Pipelining:

- It increases the throughput of the processor.
- It reduces the overall execution time.

Disadvantages of Pipelining:

- It requires complex hardware.
- It may cause pipeline hazards (data, control, structural).

5. Cache Mapping

Cache mapping is the process of determining which memory blocks are stored in which cache lines. There are three mapping techniques:

- Direct Mapping: Each memory block maps to a specific cache line.
- Fully Associative Mapping: Any memory block can be stored in any cache line.
- Set Associative Mapping: Combination of direct and fully associative mapping.

6. Cache Coherence

Cache coherence refers to the consistency of data stored in multiple caches. When multiple processors have copies of the same data in their caches, cache coherence ensures that all copies are updated consistently.

Cache coherence protocols:

- Snoop based protocols: Caches monitor the bus for updates.
- Directory based protocols: A centralized directory keeps track of cache lines.

7. Deadlock

Deadlock is a situation where two or more processes are blocked indefinitely, waiting for resources held by each other.

Conditions for deadlock:

- Mutual exclusion: Resources can be held by only one process at a time.
- Hold and wait: Processes hold resources while waiting for others.
- No preemption: Resources cannot be forcibly taken from processes.
- Circular wait: A circular chain of processes waiting for resources.

Deadlock prevention:

- Avoid mutual exclusion: Make resources shareable.
- Avoid hold and wait: Request all resources at once.
- Allow preemption: Take resources from processes.
- Avoid circular wait: Impose a resource ordering.

Deadlock avoidance:

- Banker's algorithm: Check if granting a request will lead to a safe state.

Deadlock detection:

- Resource allocation graph: Detect cycles in the graph.

Deadlock recovery:

- Process termination: Kill processes to break the deadlock.
- Resource preemption: Take resources from processes.

8. Scheduling

Scheduling is the process of deciding which processes should be executed by the CPU. The operating system uses various scheduling algorithms to manage the execution of processes.

Scheduling algorithms:

- First Come First Serve (FCFS): Processes are executed in the order they arrive.
- Shortest Job First (SJF): The process with the shortest burst time is executed first.
- Round Robin: Each process gets a fixed time slice (quantum) to execute.
- Priority Scheduling: Processes are executed based on their priority.

9. Paging

Paging is a memory management technique that divides the physical memory into fixed-size blocks called frames and the logical memory into fixed-size blocks called pages. The operating system maps pages to frames using a page table.

Advantages of Paging:

- It eliminates external fragmentation.
- It allows efficient memory allocation.

Disadvantages of Paging:

- It may cause internal fragmentation.
- It requires additional hardware support.

10. Segmentation

Segmentation is a memory management technique that divides the logical memory into variable-size segments based on the logical units of a program (e.g., code, data, stack). The operating system maps segments to physical memory using a segment table.

Advantages of Segmentation:

- It provides logical protection and sharing.
- It allows efficient memory allocation.

Disadvantages of Segmentation:

- It may cause external fragmentation.
- It requires complex hardware support.