UNIT III MEMORY MANAGEMENT

Main Memory - Swapping - Contiguous Memory Allocation – Paging - Structure of the Page Table - Segmentation, Segmentation with paging; Virtual Memory - Demand Paging – Copy on Write - Page Replacement - Allocation of Frames –Thrashing.

I MAIN MEMORY

The main memory is the fundamental storage unit in a computer system. It is associatively large and quick memory and saves programs and information during computer operations. The technology that makes the main memory work is based on semiconductor integrated circuits.

RAM is the main memory. Integrated circuit Random Access Memory (RAM) chips are applicable in two possible operating modes are as follows −

- **Static** − It consists of internal flip-flops, which store the binary information. The stored data remains solid considering power is provided to the unit. The static RAM is simple to use and has smaller read and write cycles.
- **Dynamic** − It saves the binary data in the structure of electric charges that are used to capacitors. The capacitors are made available inside the chip by Metal Oxide Semiconductor (MOS) transistors. The stored value on the capacitors contributes to discharge with time and thus, the capacitors should be regularly recharged through stimulating the dynamic memory.

Random Access Memory

The term Random Access Memory or RAM is typically used to refer to memory that is easily read from and written to by the microprocessor. For a memory to be called random access, it should be possible to access any address at any time. This differentiates RAM from storage devices such as tapes or hard drives where the data is accessed sequentially.

RAM is the main memory of a computer. Its objective is to store data and applications that are currently in use. The operating system controls the usage of this memory. It gives instructions like when the items are to be loaded into RAM, where they are to be located in RAM, and when they need to be removed from RAM.

Read-Only Memory

In each computer system, there should be a segment of memory that is fixed and unaffected by power failure. This type of memory is known as Read-Only Memory or ROM.

SRAM

RAMs that are made up of circuits and can preserve the information as long as power is supplied are referred to as Static Random Access Memories (SRAM). Flip-flops form the basic memory elements in an SRAM device. An SRAM consists of an array of flip-flops, one for each bit. SRAM consists of an array of flip-flops, a large number of flip-flops are needed to provide higher capacity memory. Because of this, simpler flip-flop circuits, BJT, and MOS transistors are used for SRAM.

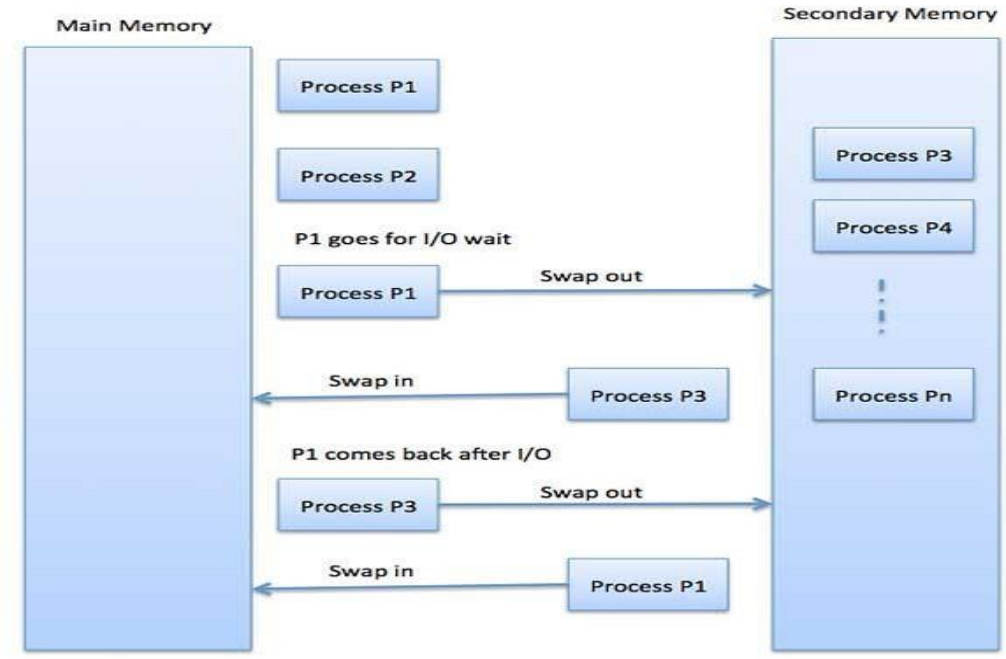
DRAM

SRAMs are faster but their cost is high because their cells require many transistors. RAMs can be obtained at a lower cost if simpler cells are used. A MOS storage cell based on capacitors can be used to replace the SRAM cells. Such a storage cell cannot preserve the charge (that is, data) indefinitely and must be recharged periodically. Therefore, these cells are called dynamic storage cells. RAMs using these cells are referred to as Dynamic RAMs or simply DRAMs.

2. SWAPPING:

Swapping is a mechanism in which a process can be swapped temporarily out of main memory (or move) to secondary storage (disk) and make that memory available to other processes. At some later time, the system swaps back the process from the secondary storage to main memory.

Though performance is usually affected by swapping process but it helps in running multiple and big processes in parallel and that's the reason **Swapping is also known as a technique for memory compaction**.



The total time taken by swapping process includes the time it takes to move the entire process to a secondary disk and then to copy the process back to memory, as well as the time the process takes to regain main memory.

Let us assume that the user process is of size 2048KB and on a standard hard disk where swapping will take place has a data transfer rate around 1 MB per second. The actual transfer of the 1000K process to or from memory will take

2048KB / 1024KB per second

= 2 seconds

= 2000 milliseconds

Now considering in and out time, it will take complete 4000 milliseconds plus other overhead where the process competes to regain main memory.

Memory Allocation

Main memory usually has two partitions −

- **Low Memory** − Operating system resides in this memory.
- **High Memory** − User processes are held in high memory. Operating system uses the following memory allocation mechanism.

	Memory Allocation & Description
	Single-partition allocation In this type of allocation, relocation-register scheme is used to protect user processes from each other, and from changing operating-system code and data. Relocation register contains value of smallest physical address whereas limit register contains range of logical addresses. Each logical address must be less than the limit register.
	Multiple-partition allocation In this type of allocation, main memory is divided into a number of fixed-sized partitions where each partition should contain only one process. When a partition is free, a process is selected from the input queue and is loaded into the free partition. When the process terminates, the partition becomes available for another process.

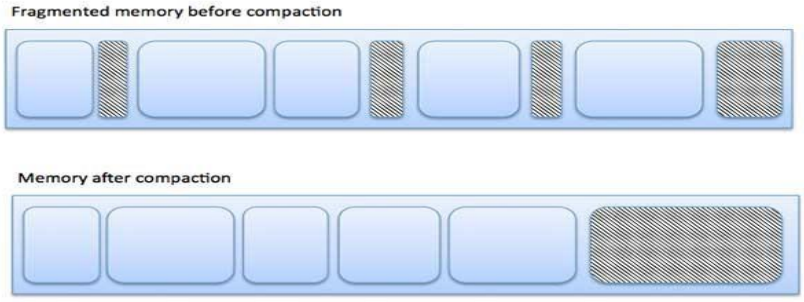
Fragmentation

As processes are loaded and removed from memory, the free memory space is broken into little pieces. It happens after sometimes that processes cannot be allocated to memory blocks considering their small size and memory blocks remains unused. This problem is known as Fragmentation.

Fragmentation is of two types −

	Fragmentation & Description
	External fragmentation Total memory space is enough to satisfy a request or to reside a process in it, but it is not contiguous, so it cannot be used.
	Internal fragmentation Memory block assigned to process is bigger. Some portion of memory is left unused, as it cannot be used by another process.

The following diagram shows how fragmentation can cause waste of memory and a compaction technique can be used to create more free memory out of fragmented memory .



External fragmentation can be reduced by compaction or shuffle memory contents to place all free memory together in one large block. To make compaction feasible, relocation should be dynamic.

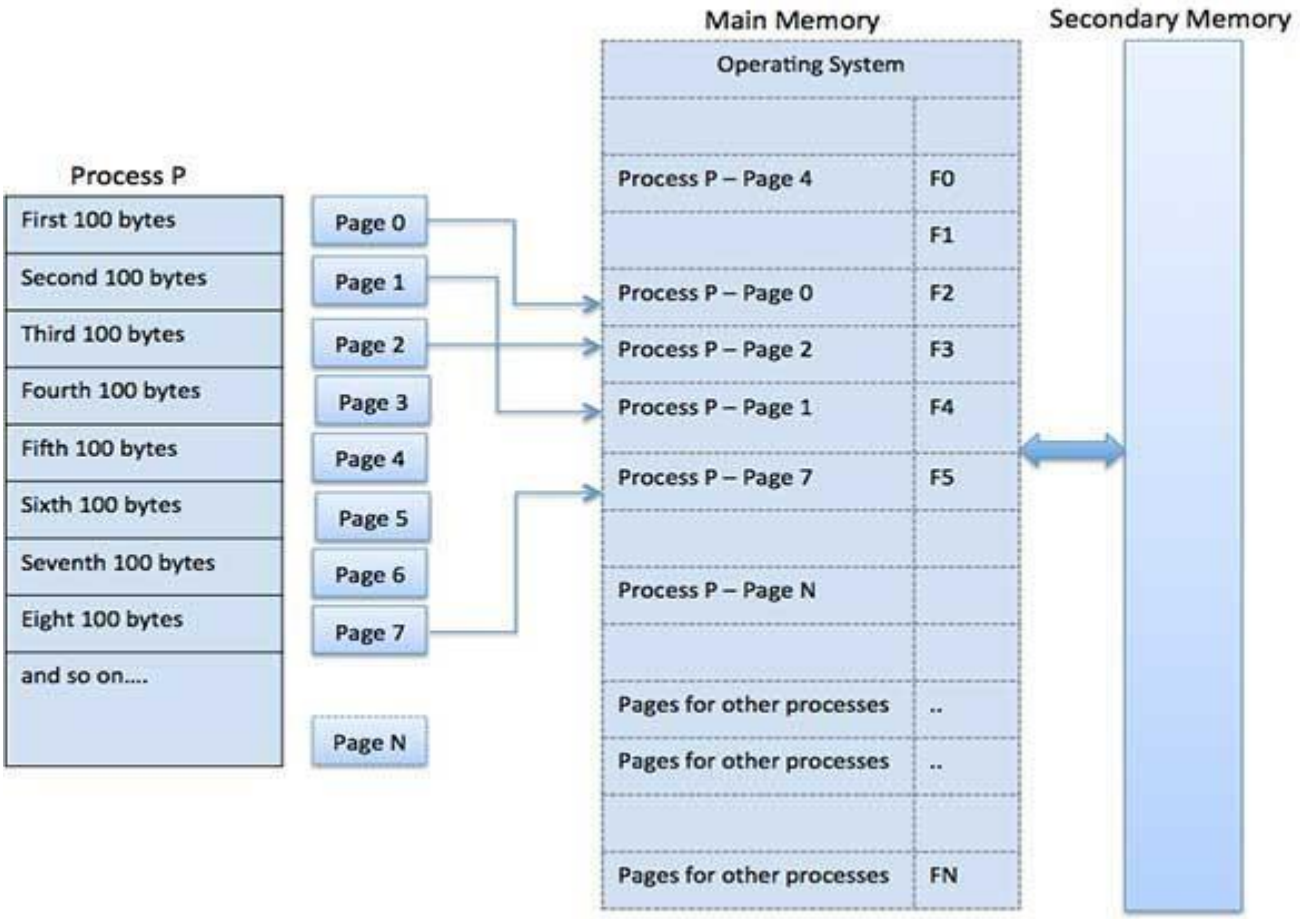
The internal fragmentation can be reduced by effectively assigning the smallest partition but large enough for the process.

Paging

A computer can address more memory than the amount physically installed on the system. This extra memory is actually called virtual memory and it is a section of a hard that's set up to emulate the computer's RAM. Paging technique plays an important role in implementing virtual memory.

Paging is a memory management technique in which process address space is broken into blocks of the same size called **pages** (size is power of 2, between 512 bytes and 8192 bytes). The size of the process is measured in the number of pages.

Similarly, main memory is divided into small fixed-sized blocks of (physical) memory called **frames** and the size of a frame is kept the same as that of a page to have optimum utilization of the main memory and to avoid external fragmentation.



Address Translation

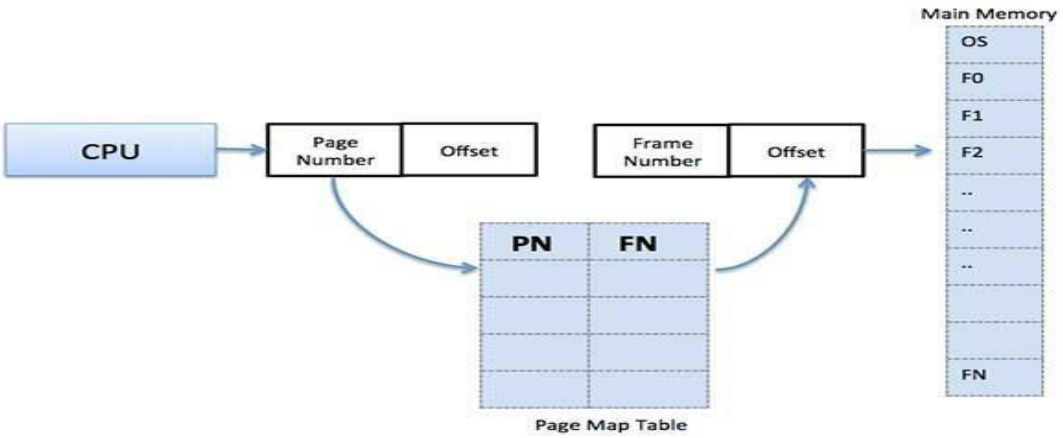
Page address is called **logical address** and represented by **page number** and the **offset**.

Logical Address = Page number + page offset

Frame address is called **physical address** and represented by a **frame number** and the **offset**.

Physical Address = Frame number + page offset

A data structure called **page map table** is used to keep track of the relation between a page of a process to a frame in physical memory.



When the system allocates a frame to any page, it translates this logical address into a physical address and create entry into the page table to be used throughout execution of the program.

When a process is to be executed, its corresponding pages are loaded into any available memory frames. Suppose you have a program of 8Kb but your memory can accommodate only 5Kb at a given point in time, then the paging concept will come into picture. When a computer runs out of RAM, the operating system (OS) will move idle or unwanted pages of memory to secondary memory to free up RAM for other processes and brings them back when needed by the program.

This process continues during the whole execution of the program where the OS keeps removing idle pages from the main memory and write them onto the secondary memory and bring them back when required by the program.

Advantages and Disadvantages of Paging

Here is a list of advantages and disadvantages of paging −

- Paging reduces external fragmentation, but still suffer from internal fragmentation.
- Paging is simple to implement and assumed as an efficient memory management technique.
- Due to equal size of the pages and frames, swapping becomes very easy.
- Page table requires extra memory space, so may not be good for a system having small RAM.

Segmentation

Segmentation is a memory management technique in which each job is divided into several segments of different sizes, one for each module that contains pieces that perform related functions. Each segment is actually a different logical address space of the program.

When a process is to be executed, its corresponding segmentation are loaded into non-contiguous memory

though every segment is loaded into a contiguous block of available memory.

Segmentation memory management works very similar to paging but here segments are of variable-length where as in paging pages are of fixed size.

A program segment contains the program's main function, utility functions, data structures, and so on. The operating system maintains a **segment map table** for every process and a list of free memory blocks along with segment numbers, their size and corresponding memory locations in main memory. For each segment, the table stores the starting address of the segment and the length of the segment. A reference to a memory location includes a value that identifies a segment and an offset.