Page No.
Date

Unit - III (Memory Management)

Logical Address Space

This address is generated by CPU while the program is running. The logical address is a virtual address as it not exist physically and it is also known as virtual address.

- This address is used as a refrence to access the physical memory location by CPU.
- Logical address space is set of all logical address generated by CPU.

Physical address Space

It identifies a physical location of required data in a memory. The user never directly interact with physical address but can be access by its corresponding logical address.

→ Difference between logical address and physical address

→ Logical Address

- It is generated by CPU
- It is a set of all logical addresses generated by CPU for a program
- It does not exist physically in memory
- User can view the logical address of a program
- Logical address can be change
- Also called virtual address

→ Physical Address

- It is a location that exist in the memory unit.
- The set of all physical address mapped to corresponding logical address is called physical address space
- It can be accessed physically.
- User can never view the physical address of a program.
- Physical address will not change
- Also called real address.

Swapping

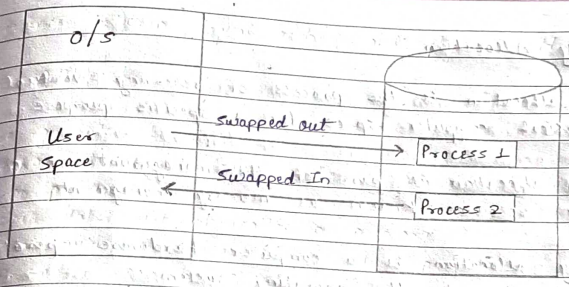
To increase CPU utilization the process of swapping is used. Swapping is the process of bringing a process into a memory than temporaly copy it to the secondary memory after it has run for a while.

The purpose of swapping in an operating system is to access data on secondary memory and move it to RAM so that application program can use it

Swapping is done only when the data is not available in the RAM.

Swapping has been subdivided into two concept :-

- Swap Out
  Swap out is a technique for moving a process from RAM to secondary memory.
- Swap In
  Swap in is a technique for moving a process from secondary memory to RAM.



→ Advantage

- Maximum CPU utilization
- Swapping helps avoid the problem of process starvation
- CPU perform various task simultaneously with the help of swapping
- Swapping ensure proper RAM (Main memory) utilization

→ Disadvantage

- If computer system loses power, the users may lose all information related to program
- The numbers of page faults increases.

Memory Allocation

- Memory allocation is the process of reserving virtual or physical computer space for a specific purpose.
- Memory allocation is part of the management of computer memory resource known as memory management.
- Memory allocation is a computer hardware operation managed through the operating system.

→ Contiguous Memory Allocation

Contiguous memory allocation is used to allocate the contiguous block of each process. In this process operating system allot a continuous segment from the entirely empty space to the process based on its size whenever a process request to enter the main memory.

Types

* fixed - Size Partitioning Method

This approach give the fixed size contiguous block in main memory this means that the entire memory will be partition into contiguous block of fixed size and each time the process enter the system it will be given one of the available block.

Advantages :-

- It is easy to implement and OS can easily allocate and manage memory.
- OS can easily determine how much memory is available and allocate it accordingly.
- Easy to free up memory when a process terminates.

Disadvantages :-

- Size of each partition is fixed such that process that require more memory than the size of partition cannot be accomodated.
- Internal fragmentation - This occur when a process does not use all of the memory allocated to it.
- Unequal partition size.

* flexible Partitioning Method / Variable - length

In this process no fixed block or memory partition are created in contiguous memory allocation instead according on its needs each process is given a variable - sized block. this approach also known as dynamic partitioning wher each block size is determine by the need of process.

Advantage :-

- OS can allocate memory block that are just the right size for each process.
- It can accomodate the process of different sizes.
- Reduced internal fragmentation.

Disadvantage :-

- External fragmentation - It occurs when there are small gaps between memory block, making it difficult to allocate memory for larger processes.
- It is difficult to free up memory when a process terminates.
- Difficult to maintain the record of processes.

- Technique for Contiguous Memory Allocation

① First fit

We start from the begining and allot the first hole, which is big enough as per the requirement of the process.

② Best fit

We allot that hole to the process, which is smallest hole that fits the requirement of the process. Hence we need to fix the hole according to their size.

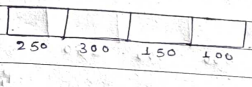
③ Worst fit

We sort the holes according to their sizes and choose the largest hole to be alloted to the incoming process.

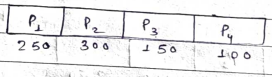
Page No.
Date

Ques Process Size, P_1 - 250 mb Mereory block - 250 MB
P_2 - 150 mb 300 MB
P_3 - 50 mb 150 MB
P_4 - 75 mb 100 MB

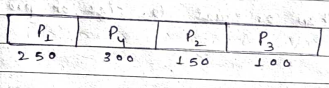
Sol°:- The main memory has been divided into fixed size partition as -



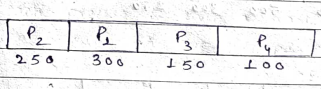
① First fit



② Best fit



③ Worst fit



Ques Memory block - 200 KB , 400 KB , 600 KB , 500 KB , 300 KB , 250 KB

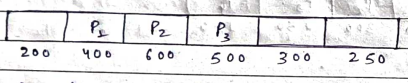
Process Size - 357 KB , 210 KB , 468 KB , 491 KB

Sol^{n}: The main memory has been divided into fixed size partition as -

Main Memory

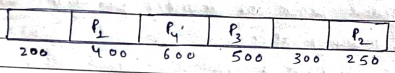
P_1 - 357 KB
P_2 - 210 KB
P_3 - 468 KB
P_4 - 491 KB

① First fit

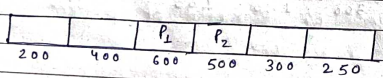


Process P_4 cannot be allocated the memory because no partition of size greater than or equal to size of process P_4

② Best fit



③ Worst fit



P_3 and P_4 cannot be allocated the memory because no partition of size greater than or equal to size of P_3 and P_4.

Page No.
Date

→ Non - Contiguous Memory Allocation

Non - Contiguous memory allocation divides the process into pages or segment that are allocated to different areas of memory space based on memory availability this method can decrease memory wastage but it also increase address translation overhead.

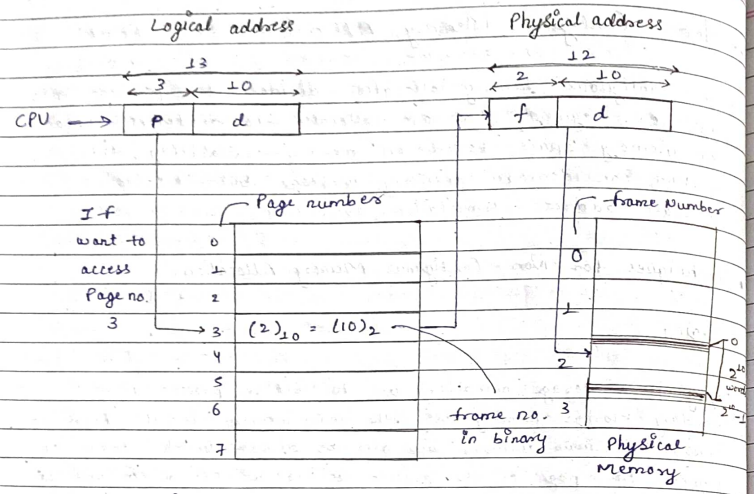
- Techniques for Non - Contiguous Memory Allocation

* Paging

Paging is a storage mechanism use to retrive process from secondary storage memory into the main memory in the form of pages. The main memory will also be divided in the form of frames one page of the process is to be stored in one of the frame of main memory.

The pages can be store at the different location of memory by the priority is always to find the contiguous frame page of the frame are taken into the main memory only when they are required otherwise they reside in secondary memory.

- The size of the frame is equal to the size of page



p - Page number
d - Page size / page offset
f - frame number

- Page number - Number of bits required to represent the page in logical address space.
- Page offset (d) - Number of bits required to represent the particular word in page or page size.

Paging is a memory management technique used in Operating system to manage memory and allocate memory to process. In paging, memory is divided into fixed size block called pages, and processes are allocated memory in terms of these pages. Each page is of the same size and the size is typically of a power 2, such as 4KB or 8KB.

* Important Points about Paging

→ Reduces Internal fragmentation :- Paging facilitates lessening internal fragmentation by using allocating memory in fixed-size block (pages).

→ Enables reminiscence to be allotted on call for :- Paging enable memory to be allocated on call for, this means that memory is most effectively allocated when it's far needed.

→ Protection and Sharing of memory :- Paging allows for the protection and sharing of reminiscence between method as each procedure has its own web page.

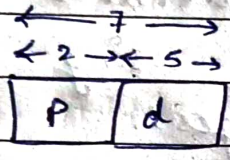
→ External fragmentation :- Paging can result in outside fragmentation, wherein memory turns fragmented into small, non-contiguous block.

→ Overhead :- Paging involves overhead because of the renovation of the web page table the translation of logical addresses to physical address.

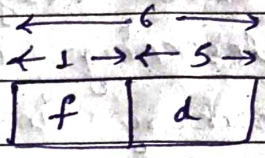
Page No.
Date

Ques Logical address = 128 byte, address space - 2^7 = 7 bit
Physical address = 64 byte, address space - 2^6 = 6 bit
page size - 32 byte - 2^5 : 5 bit
find • frame no. • No. of frame • Page no. • No. of page

Sol^n:- Page No. - 2
No. of page - 2^2
= 4

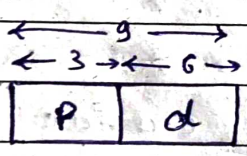


frame no. - 1
No. of frame - 2^1
= 2

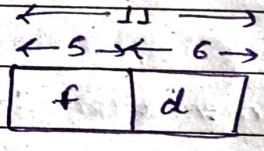


Ques L.A.S - 512 byte
- 2^9 : 9 bit
P.A.S = ?
Page size - 64 byte
= 2^6 : 6 bit
frame NO. - 32 byte
= 2^5 : 5 bit
find • Page no. • NO. of page • frame size • NO. of frame
• P.A.S

Sol^n:- Page NO. - 3
NO. of page - 2^3
= 8



frame size = 2^5 = 32 byte
No. of frame - 5 bit



* Segmentation

Segmentation is a memory management technique in which non-contiguous memory divided into variable size segment. The detail about each segment are stored in a table called a segment table.

Segment table contains two information about segment :-

- Base Address - It contain starting physical address.
- Limit - It is the length of segment

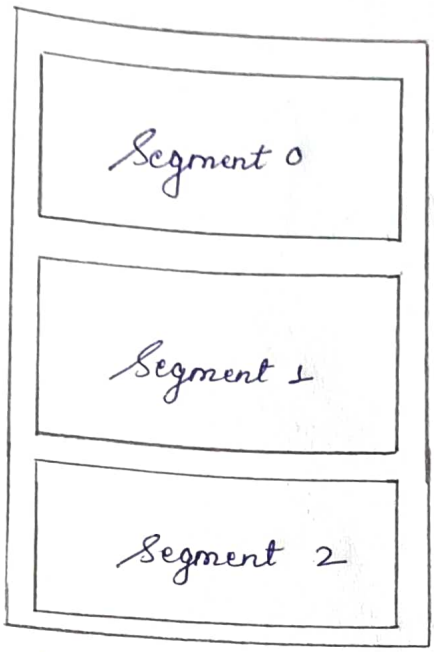
Segmentation gives the user view of process which paging does not provide.

Types of Segmentation

- Virtual memory Segmentation
  Each process is divided into a number of segment, but the segmentation is not done all at once. This segmentation may or may not take place at run time.

- Simple Segmentation
  Each process is divided into number of segment, all of which are loaded into main memory at run time.

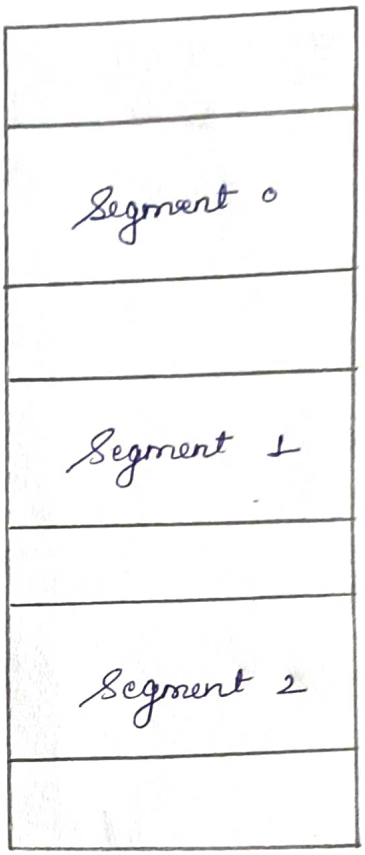
- Segmentation is a memory management technique that is used to improve the performance of an operating System.



Logical Address Space

Limit	Base Address	Access

Segment Table



Physical Address Space

- The address generated by CPU is divided into :-

→ Segment number :- No. of bits required to represent segment

→ Segment offset :- No. of bits required to represent size of segment.

* Advantages of Segmentation
- No internal fragmentation
- Segment table consume less space
- Segmentation improve CPU utilization
- Segment size is specified by user.

* Disadvantages of Segmentation
- Causes External fragmentation
- time to retrive instruction increases.
- Segmentation can be complex to implement and manage.
- Increases overhead and reduce performance.

Page No. _____
Date

- Difference between Contiguous and Non - Contiguous Memory Allocation

→ Contiguous Memory Allocation

- Contiguous M.A allocates consecutive block of memory to file/process.
- Faster in execution.
- It is easier for OS to control.
- Both Internal fragmentation and external fragmentation occur.
- Degree of multiprogramming is fixed.
- Wastage of memory is there.
- It include single partition allocation and multi-partition allocation.

→ Non - Contiguous Memory Allocation

- Non - Contiguous M.A allocates separate block of memory to file/process.
- Slower in execution
- It is difficult for OS to control.
- Only External fragmentation occur.
- Degree of multiprogramming is not fixed.
- No memory wastage is there.
- It includes paging and segmentation.

Page No.
Date

Virtual Memory

- If any process is larger than the size of memory, then the concept of virtual memory comes into play to store such process in memory.
- Virtual memory is a storage allocation scheme in which secondary memory can be addressed as though it were part of the main memory. The addresses a program may use to refrence a memory are different from address.
- The memory system uses to identify physical storage and program generated addresses are translated automatically to the corresponding machine address.
- It is a technique that can be implemented using hardware and software. It maps memory addresses used by program called virtual address into physical addresses.

Advantages

- More process may be maintained in the main memory.
- A process may be larger than all of the main memory.

Disadvantage

- It can slow down the system performance.
- Increase the risk of data loss or corruption.

Demand Paging

- The process of loading the page into memory on demand (whenever page fault occur) is known as demand paging.
- Virtual memory is implemented using demand paging.

* Page fault

- The term 'page miss' or 'page fault' refers to a situation where a referenced page is not found in the main memory.
- The missed page must be accessed by the CPU from the secondary memory.

→ Advantage of Demand Paging

- Support for larger programs
- faster program start
- Reduce memory usage
-

→ Disadvantage of Demand Paging

- Page fault overload
- Degraded performance
- fragmentation.

* If the page to be searched is found among the frames then this process is known as Page Hit.

Page Replacement Algorithms

① First In first Out (FIFO)

This is the simplest page replacement algorithm. The OS keeps track of all pages in the memory in a queue, the oldest page is in the front of the queue. When a page needs to be replaced page in the front of the queue is selected for removal.

Ques Consider page reference string 6, 1, 1, 2, 0, 3, 3, 4, 6, 0, 2, 1 for a memory with 3 page frame. Calculate the number of page fault

Sol": Page Refrence string - M M H M M M M M M M M M

2	0	3	4	6	0	2	1				
1	2	0	3	4	6	0	2				
6	1	2	0	3	4	6	0				

Page frame = 3

No. of page miss = No. of page fault

- Page fault - 10
- Page Hit - 1
- Hit Ratio - $\frac{\text{No. of Hit}}{\text{No. of Hit + No. of Miss}} = \frac{1}{11} = 0.09$
- Miss Ratio - $\frac{\text{No. of Miss}}{\text{No. of Hit + No. of Miss}} = \frac{10}{11} = 0.90$

Page No.
Date

Ques Consider Page refrence string 3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3 for a memory with 3 page frame Calculate the no. of page fault.

Sol°: Page refrence string - Page frame - 5

M M M H M M M M H H H M H H
3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3

1	6	3	8	2
9	1	6	3	8
2	9	1	6	3
8	2	9	1	6
3	8	2	9	1

Miss - 9
Hit - 6

- Page fault - 9
- Page Hit - 6
- Hit Ratio - $\frac{\text{No. of Hit}}{\text{No. of Hit + No. of Miss}} = \frac{6}{15} = \frac{2}{5} = 0.4$
- Miss Ratio - $\frac{\text{No. of Miss}}{\text{No. of Hit + No. of Miss}} = \frac{9}{15} = \frac{3}{5} = 0.6$

Ques Consider Page Refrence String 4, 7, 6, 1, 7, 6, 1, 2, 7, 2 for a memory with 3 page frame calculate the no. of page fault.

Sol°: Page Refrence String - Page frame - 3

M M M M H H H M M H
4, 7, 6, 1, 7, 6, 1, 2, 7, 2

6	1	2	7						
7	6	1	2						
4	7	6	1						

Miss - 6
Hit - 4

- Page fault - 6
- Page Hit - 4
- Hit Ratio - $\frac{4}{4+6} = \frac{4}{10} = \frac{2}{5} = 0.4$
- Miss Ratio - $\frac{6}{6+4} = \frac{6}{10} = \frac{3}{5} = 0.6$

② Least Recently Used

In this algorithm, page will be replaced which is least Recently used

Ques Consider the page refrence string 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 3 with 4 page frames. Calculate the number of page fault.

Sol°: Page Refrence string - Page frame - 4

M M M M H M H M H H H H M H
7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 3

2	2	2	2 →	2	2	2	2 →	2	2 ↳	2	2		
1	1	1 →	4	4	4	4 →	3		3	3			
0	0 →	0	0	0	0 →	0	0		0	0			
7 →	3	3	3	3 →	3	3	3		3	3 →	3		

- Page fault - 6
- Page Hit - 8
- Hit Ratio - $\frac{8}{6+8} = \frac{8}{14} = 0.55$
- Miss Ratio - $\frac{6}{6+8} = \frac{6}{14} = 0.42$

Miss - 6
Hit - 8

Ques Consider Page Refrence string 3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3 for a memory with 5 page frame. Calculate the number of Page fault.

Sol^n:- Page Refrence string - Page frame - 5

	3	8	2	3	9	1	6	3	8	9	3	6	2	1	3
	M	M	M	H	M	M	M	H	M	H	H	H	M	H	H

3	8	2	3	9	1
8	2	3	9	1	6
2	3	9	1	6	3
3	9	1	6	3	8
9	1	6	3	8	9

Miss - 9
Hit - 6

- Page fault - 9
- Page Hit - 6
- Hit Ratio - $\frac{6}{15} = 0.4$
- Miss Ratio - $\frac{9}{15} = 0.6$

③ Most Recently Used

In this algorithm, Page will be replaced which has been used recently.

Ques Consider Page Refrence string 6, 1, 1, 2, 0, 3, 4, 6, 0, 2, 1 for a memory with 3 page frame. Calculate the number of Page fault.

Sol^n:- Page Refrence string - Page frame - 3

6	1	1	2	0	3	4	6	0	2	1
M	M	H	M	M	M	M	H	M	M	H

6	6	6	6	4	4
1	1	1	1	1	1
	0	3	4	0	2

Miss - 8
Hit - 3

- Page fault - 8
- Page Hit - 3
- Hit Ratio - $\frac{3}{11} = 0.27$
- Miss Ratio - $\frac{8}{11} = 0.72$

Ques Consider Page Refrence string 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 3 for a memory with 4 Page frame Calculate the number of Page fault.

Sol°:- Page Refrence string - Page frame - 4

M M M M H M M M H M M M M M
7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 3

Miss - 12
Hit - 2

- Page fault - 12
- Page Hit - 2
- Hit Ratio - $\frac{2}{17} = 0.14$
- Miss Ratio - $\frac{12}{17} = 0.85$

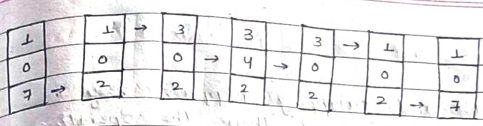
(4) Optimal Page Replacement

In this algorithm, pages are replaced which would not be used for the longest duration of time in the future.

Ques Consider Page refrence string 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1 of memory with 3 page frame. Calculate the no. of page fault.

Sol°:- Page Refrence string - Page frame - 3

M M M M H M H M H H M H H M H H H M H H
7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1



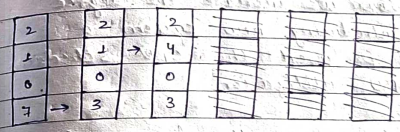
Miss - 9
Hit - 11

- Page fault - 9
- Page Hit - 11
- Hit Ratio - $\frac{11}{20} = 0.55$
- Miss Ratio - $\frac{9}{20} = 0.45$

Ques Consider a Refrence string 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 3 of memory with 4 page frame. Calculate the no. of page fault.

Sol°:- Page Refrence string - Page frame - 4

M M M M H M H M H H H H M H H
7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 3

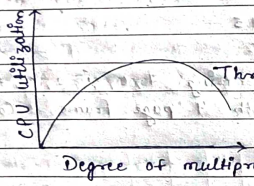


Miss - 6
Hit - 8

- Page fault - 6
- Page Hit - 8
- Hit Ratio - $\frac{8}{14} = 0.57$
- Miss Ratio - $\frac{6}{14} = 0.42$

(#) Thrashing

when the page fault and swapping happens very frequently at a higher rate and then the operating system has to spend more time on swapping this process, this state in the Operating system is known as thrashing.



→ Causes of Thrasing

- If CPU utlization is too low we increase the degree of multiprogramming by introducing new system a global page replacement is used the CPU scheduler seize the decrease CPU utilization.
- CPU utilization is plotted against the degree of multi- if the degree of multiprogramming is increase the possibility of thrashing will increase.

Solution :-

How to Eliminate thrasing

- Adjust the swap file size.
- Increase the amount of Ram
- Decrease the no. of application running on Computer.
- Replace Programs.