Operating System Concepts

## SunBeam Institute of Information & Technology, Hinjwadi, Pune & Karad.

Trainer: Akshita Chanchlani
Email: akshita.chanchlani@sunbeaminfo.com

Deadlock

- ***Deadlock*** is a situation where a set of processes are blocked because each process is holding a resource and waiting for another resource acquired by some other process.
- A set of processes is in a *deadlock state* when every process in the set is waiting for a resource that can only be released by another process in the set.
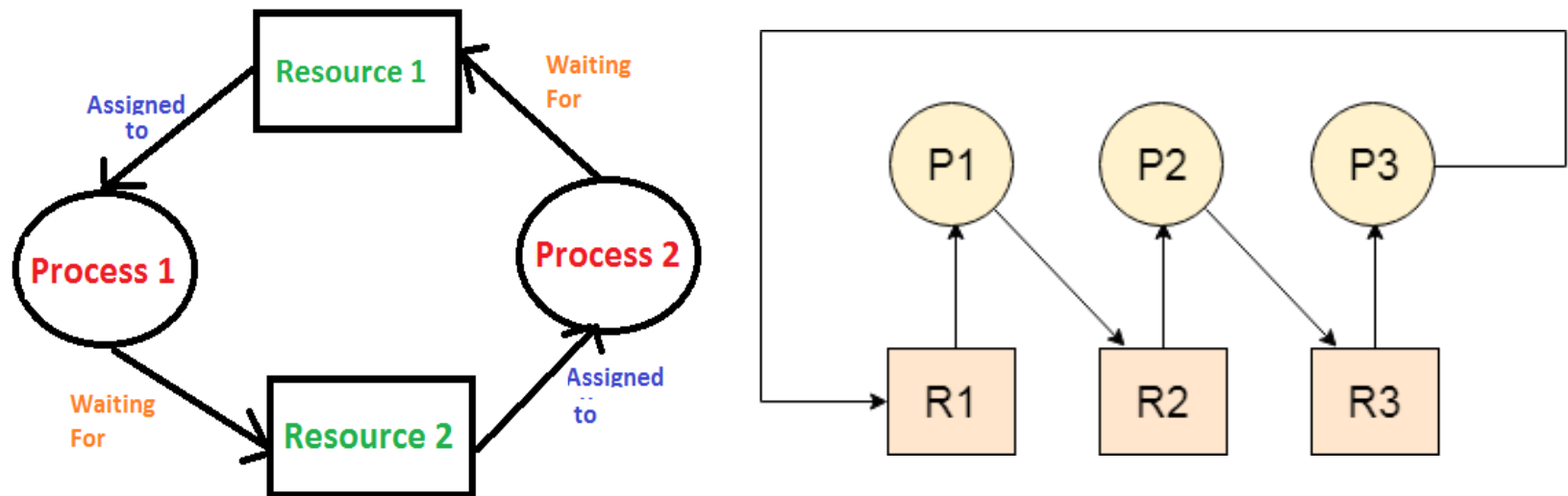
Process 1 is holding Resource 1 and waiting for resource 2 which is acquired by process 2, and process 2 is waiting for resource 1.

Conditions for Deadlock

Mutual exclusion

- At least one resource must be held in a non-sharable mode; that is, only one process at a time can use the resource.
- If another process requests that resource, the requesting process must be delayed until the resource has been released.

Hold and wait

- A process must be holding at least one resource and waiting to acquire additional resources that are currently being held by other processes.

No preemption.

- control of the resource cannot be taken away forcefully from any process.

Circular wait

- A set { P0 , Pl, ... , Pn } of waiting processes must exist such that
- Po is waiting for a resource held by P1,
- P1 is waiting for a resource held by P2, ... ,
- Pn-1 is waiting for a resource held by Pn,
- Pn is waiting for a resource held by Po.

Methods for handling deadlock

1. Deadlock Prevention
2. Deadlock Detection and Avoidance
3. Deadlock Recovery

Handling Deadlock

1. Deadlock Prevention: deadlock can be prevented by discarding any one condition out of four necessary and sufficient conditions.

2. Deadlock Detection & Avoidance: before allocating resources for processes all input can be given to deadlock detection algorithm in advanced and if there are chances to occur deadlock then it can be avoided by doing necessary changes.

There are two deadlock detection & avoidance algorithms:

1. Resource Allocation Graph Algorithm

2. Banker's Algorithm

Deadlock Prevention

Deadlock prevention ensures that deadlock is excluded from the beginning by invalidate at least one of the four necessary conditions, however deadlock prevention is often impossible to implement.

No Mutual Exclusion Condition

- Shared resources such as read-only files do not lead to deadlocks.
- Non-blocking synchronization algorithms can avoid mutual exclusion.

No Hold and Wait

- When a process ready to execute and requires some resources then all resources should be allocated at once that means there will not be wait for required resources. But sometime a process can be suffer from starvation and very low resource utilization.

No Preemption

- When a process is holding some resources and waiting for another resources that can not be allocated to it, then this process releases all resources so other process can complete their execution. But some resources like printer, tap drivers can not be preempted.

No Circular Wait

- To avoid circular wait, processes must request resources in increasing order only. But resource numbering may affects efficiency and a process may have to request a resource before it need.

Deadlock Detection

Deadlock can be detected by the resource scheduler as it keeps track of all the resources that are allocated to different processes.

After a deadlock is detected, it can be handed using the given methods:

1. All the processes that are involved in the deadlock are terminated. This approach is not that useful as all the progress made by the processes is destroyed.
2. Resources can be preempted from some processes and given to others until the deadlock situation is resolved.

Deadlock Recovery

In order to recover the system from deadlocks, either OS considers resources or processes.

For Resource

Preempt the resource

- Snatch one of the resources from the owner of the resource (process) and give it to the other process with the expectation that it will complete the execution and will release this resource sooner.

Rollback to a safe state

- System passes through various states to get into the deadlock state. The operating system can rollback the system to the previous safe state. For this purpose, OS needs to implement check pointing at every state.

For Process

Kill a process

- Killing a process can solve our problem but the bigger concern is to decide which process to kill. Generally, Operating system kills a process which has done least amount of work until now.

Kill all process

- This is not a suggestible approach but can be implemented if the problem becomes very serious. Killing all process will lead to inefficiency in the system because all the processes will execute again from starting.

Deadlock Avoidance

- Deadlock avoidance algorithm ensures that a processes will never enter into unsafe or deadlock.
- The system requires additional **prior information** regarding potential use of each resource for each process that means each process declare the maximum number of resources of each type that it may need, number of available resources, allocated resources, maximum demand of the processes.
- Processes inform operating system in advance that how many resources they will need.
- If we allocated resources in a order such that requirement can be satisfied for each process and deadlock can not be occur then this state is called as **safe state.**

Deadlock Avoidance algorithms

Resource allocation graph(RAG)

states resources is held by which process and which process is waiting for a resource of a particular type.

G(V,E)

V:

P = { P1, P2, P3 },

R = { R1, R2, R3 }

E:

request edge: { P1 -> R3, P2 -> R1, P3 -> R2 }

assignment edge: { R1 <- P1, R2 <- P2, R3 <- P3 }

process can be shown by using a "circle"

resources can be shown by using "rectangle", whereas one dot inside rectangle indicates only one instance of a resource is available, and two dots indicate two instances of the resource are available.

Bankers algorithm

tests for safety by simulating the allocation for predetermined maximum possible amounts of all resources, then makes an "s-state" check to test for possible activities, before deciding whether allocation should be allowed to continue.
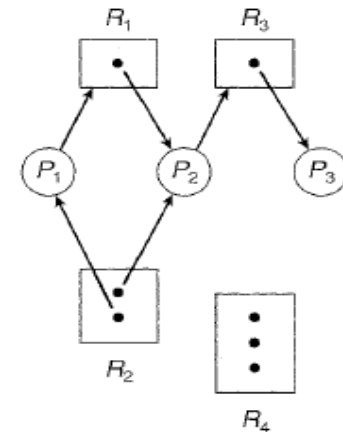
Memory Management

- Is the task carried out by the OS and hardware to accommodate multiple processes in main memory
- If only a few processes can be kept in main memory, then much of the time all processes will be waiting for I/O and the CPU will be idle
- Hence, memory needs to be allocated efficiently in order to pack as many processes into memory as possible

Memory Management Requirement

Relocation

- programmer cannot know where the program will be placed in memory when it is executed
- a process may be (often) relocated in main memory due to swapping
- swapping enables the OS to have a larger pool of ready-to-execute processes

Protection

- processes should not be able to reference memory locations in another process without permission
- impossible to check addresses at compile time in programs since the program could be relocated
- address references must be checked at run time by hardware

Sharing

- must allow several processes to access a common portion of main memory without compromising protection
  - cooperating processes may need to share access to the same data structure
  - better to allow each process to access the same copy of the program rather than have their own separate copy

# Swapping Memory Manager

SWAPPING: MEMORY MANAGER
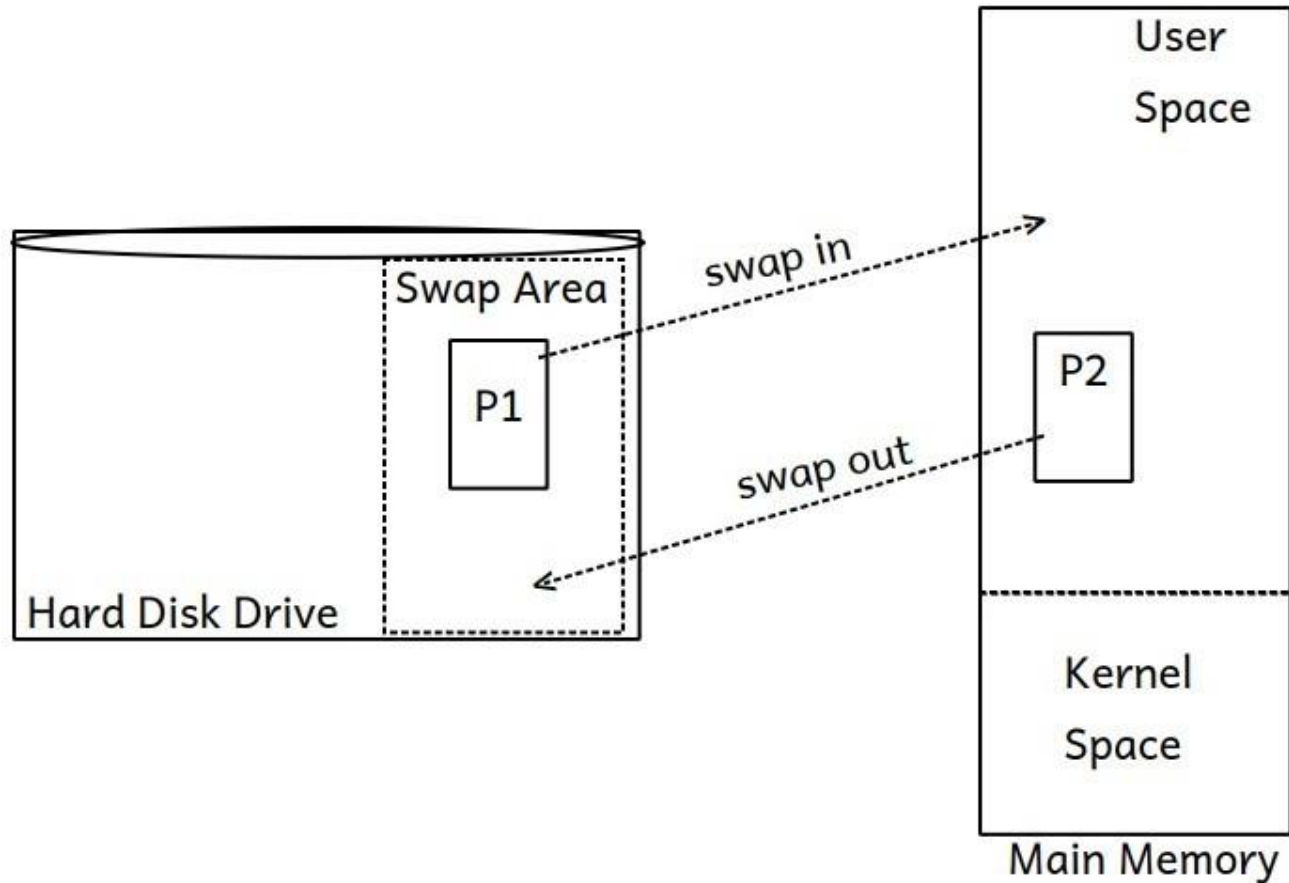
Loading Program

- Sometimes complete program is loaded into the memory, but some times a certain part or routine of the program is loaded into the main memory only when it is called by the program, this mechanism is called **Dynamic Loading**, this enhance the performance.
- Also, at times one program is dependent on some other program. In such a case, rather than loading all the dependent programs, CPU links the dependent programs to the main executing program when its required. This mechanism is known as **Dynamic Linking**.

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.

the system swaps back the process from the secondary storage to main memory.

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**.
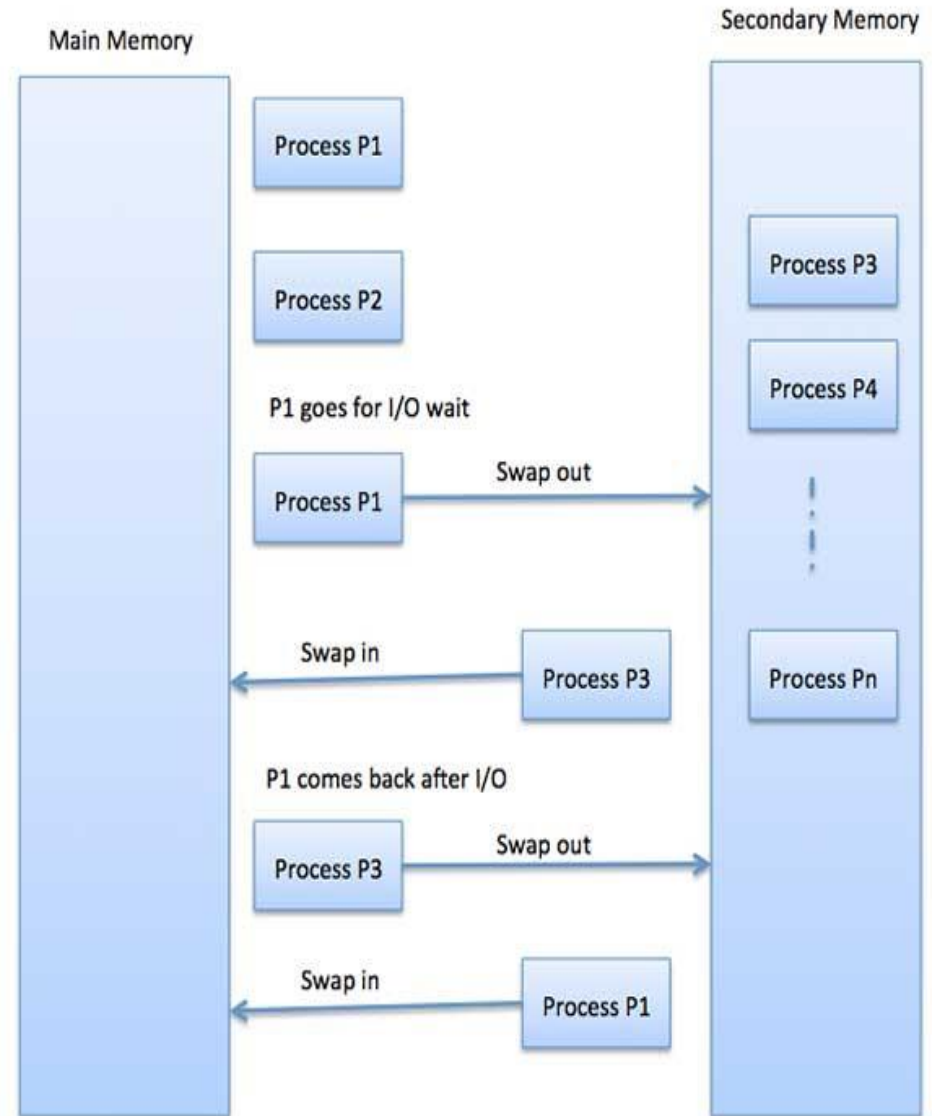
Swapping

- **Swap area:** it is a portion of the **hard disk drive** (keep reserved while installation of an OS) can be used by an OS as an extension of the main memory in which inactive running programs can be kept temporarily and as per request processes can be swapped in and swapped out between swap area and the main memory.

- In Linux swap area can be maintained in the form of **swap partition,** whereas in Windows swap area can be maintained in the form of **swap files.**

- **Conventionally size of the swap area should be doubles the size of the main memory,** i.e. if the size of main memory is 2 GB then size of swap area should be 4 GB, if the size of main memory is 4 GB then size of swap area should be 8 GB and so on.

  - Swapping done by the system program of an OS named as **Memory Manager**, it swap ins active running programs into the main memory from swap area and swap outs inactive running programs from the main memory and keep them temporarily into the swap area.

  there are two variants of **swapping: swap in & swap out.**

Swapping

Addresses generated by compiler (i.e. compiler + linker) are reffered as **logical addresses.**

Addresses which can be see by the process when it is in the main memory reffered as **physical addresses.**

-MMU (Memory Management Unit): wich is a hardware unit **converts logical address into physical address.**
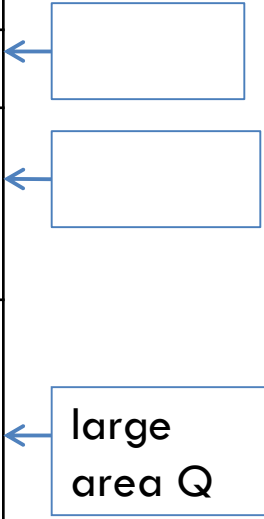
-MMU is a hardware contains **adder circuit, comparator circuit, base register and limit register.** Values of base register and limit registers gets change during context-switch, and memory space of one process gets protected from another process.

CPU always executes program in its logical memory space.

Fixed Partition

	memory
	OS
n KB	small
3n KB	Medium
6n KB	Large

small area Q ←

medium area Q ←

large area Q ←

- Processes are classified on entry to the system according to their memory requirements.
- We need one *Process Queue (PQ)* for each class of process.
- If a process is selected to allocate memory, then it goes into memory and competes for the processor.
- The number of fixed partition gives the degree of multiprogramming.
- Since each queue has its own memory region, there is no competition between queues for the memory.

- The main problem with the fixed partitioning method is how to determine the number of partitions, and how to determine their sizes.

Variable Partition

•Initially, the whole memory is free and it is considered as one large block.

•When a new process arrives, the OS searches for a block of free memory large enough for that process.

• We keep the rest available (free) for the future processes.

• If a block becomes free, then the OS tries to merge it with its neighbors if they are also free.

Base and Limit Register

•A pair of **base** and **limit** registers define the logical address space
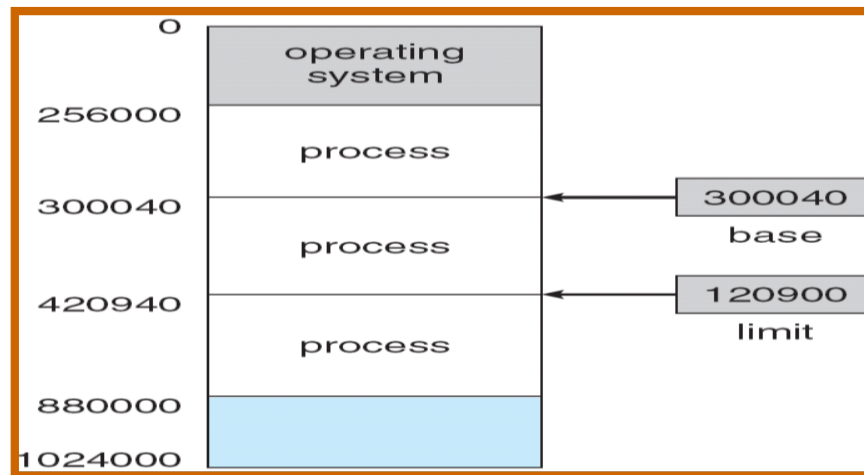
Logical versus Physical Address Space

- An address generated by the CPU is commonly referred to as a logical address.
- an address seen by the memory unit-that is, the one loaded into the memory address register of the memory is physical address.
- **Logical address** – generated by the CPU; also referred to as **virtual address**
- **Physical address** – address seen by the memory unit
- Logical and physical addresses are the same in compile-time and load-time address-binding schemes; logical (virtual) and physical addresses differ in execution-time address-binding scheme

Dynamic Storage-Allocation Problem

How to satisfy a request of size *n* from a list of free holes

- **First-fit**: Allocate the *first* hole that is big enough
- **Best-fit**: Allocate the *smallest* hole that is big enough; must search entire list, unless ordered by size
    – Produces the smallest leftover hole
- **Worst-fit**: Allocate the *largest* hole; must also search entire list
    – Produces the largest leftover hole

First-fit and best-fit better than worst-fit in terms of speed and storage utilization

first fit

□First Fit : Allocate the first free block that is large enough for the new process.

■This is a fast algorithm.

first fit

Initial memory mapping

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

first fit

P4 of 3KB arrives

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

first fit

first fit

P5 of 15KB arrives

OS
P1 12 KB
P4   3 KB
<FREE> 7 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

first fit

P5 of 15 KB
loaded here
by
FIRST FIT

OS
P1 12 KB
P4   3 KB
<FREE> 7 KB
P2 20 KB
P5 15 KB
<FREE> 1 KB
P3 6 KB
<FREE> 4 KB

Best fit

☐Best Fit : Allocate the smallest block among those that are large enough for the new process.

■In this method, the OS has to search the entire list, or it can keep it sorted and stop when it hits an entry which has a size larger than the size of new process.

■ This algorithm produces the smallest left over block.

■However, it requires more time for searching all the list or sorting it

■If sorting is used, merging the area released when a process terminates to neighboring free blocks, becomes complicated.

best fit

Initial memory mapping

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

best fit

P4 of 3KB arrives

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

best fit

best fit

P5 of 15KB arrives

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
P4 3 KB
<FREE> 1 KB

best fit

worst fit

❑<u>Worst Fit :</u> Allocate the largest block among those that are large enough for the new process.

■Again a search of the entire list or sorting it is needed.

■This algorithm produces the largest over block.

worst fit

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

Initial memory mapping

worst fit

P4 of 3KB arrives

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
<FREE> 16 KB
P3 6 KB
<FREE> 4 KB

worst fit

P4 of 3KB
Loaded here
by
WORST FIT

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
P4 3 KB
<FREE> 13 KB
P3 6 KB
<FREE> 4 KB

worst fit

No place to load
P5 of 15K

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
P4 3 KB
<FREE> 13 KB
P3 6 KB
<FREE> 4 KB

worst fit

No place to load
P5 of 15K

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
P4 3 KB
<FREE> 13 KB
P3 6 KB
<FREE> 4 KB

Compaction is needed !!

compaction

- Compaction is a method to overcome the external fragmentation problem.
- All free blocks are brought together as one large block of free space.
- Compaction requires dynamic relocation.
- One method for compaction is swapping out those processes that are to be moved within the memory, and swapping them into different memory locations
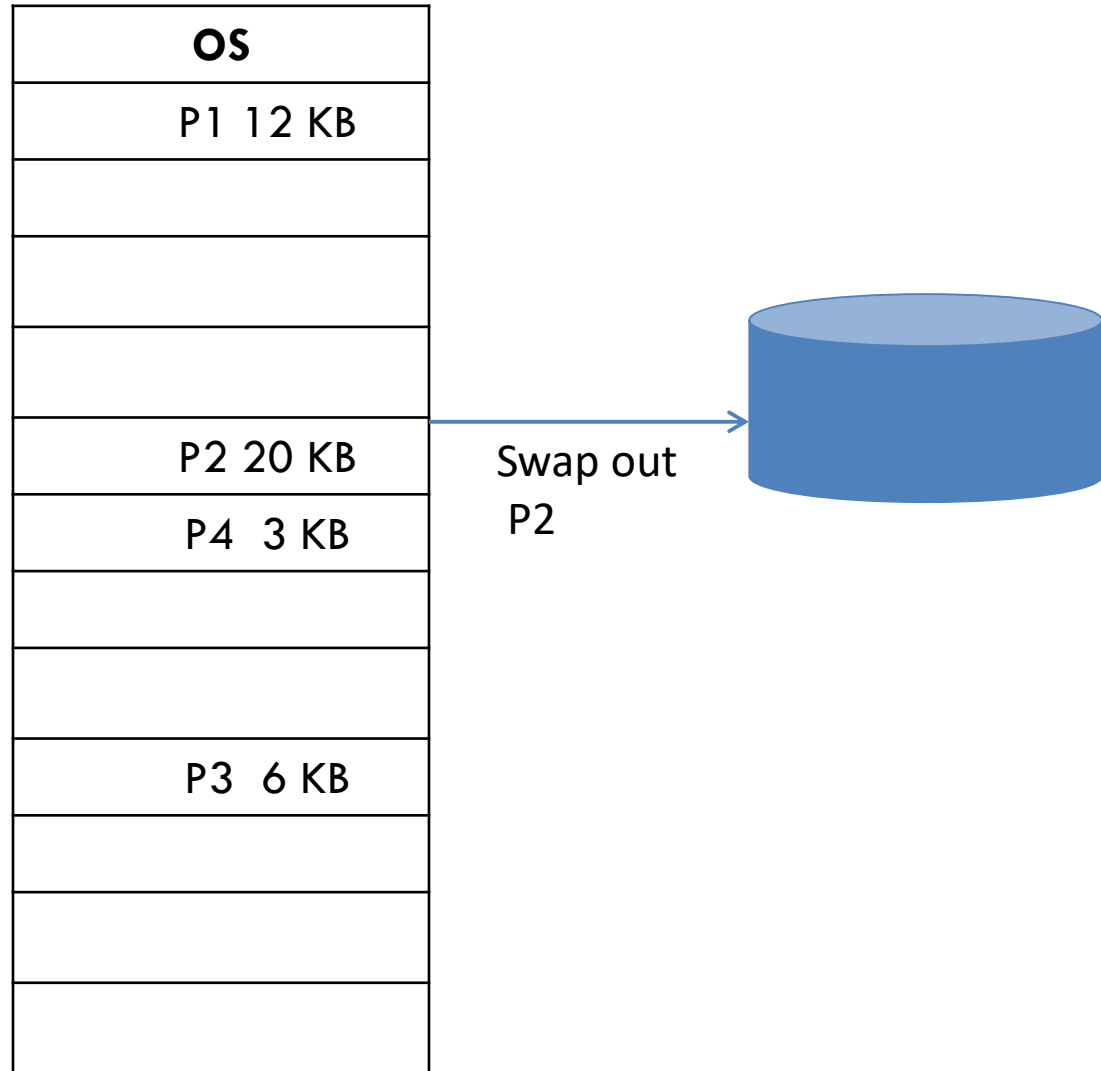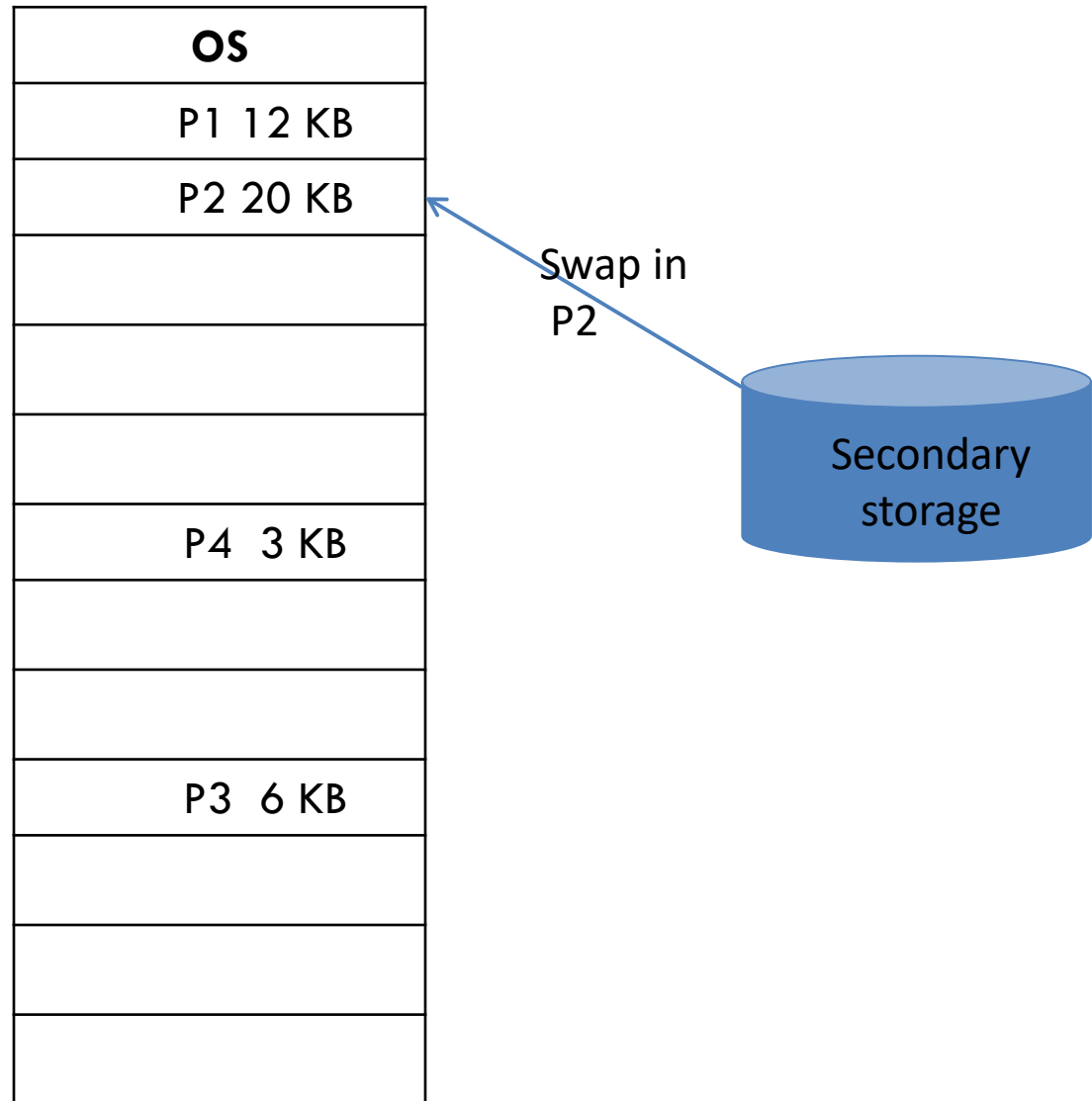
compaction

Memory mapping before compaction

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
P4 3 KB
<FREE> 13 KB
P3 6 KB
<FREE> 4 KB

compaction

OS
P1 12 KB
P2 20 KB
P4 3 KB
P3   6 KB

Swap out
P2

compaction

OS
P1 12 KB
P2 20 KB
P4 3 KB
P3 6 KB

Swap in
P2

Secondary
storage

compaction

OS
P1 12 KB
P2 20 KB
P4   3 KB
P3   6 KB

Secondary storage

Swap out
P4

compaction

OS
P1 12 KB
P2 20 KB
P4   3 KB
P3   6 KB

Swap in
P4 with a
different
starting
address

Secondary
storage

compaction

compaction

OS
P1 12 KB
P2 20 KB
P4   3 KB
P3   6 KB

Swap in
P3

Secondary
storage
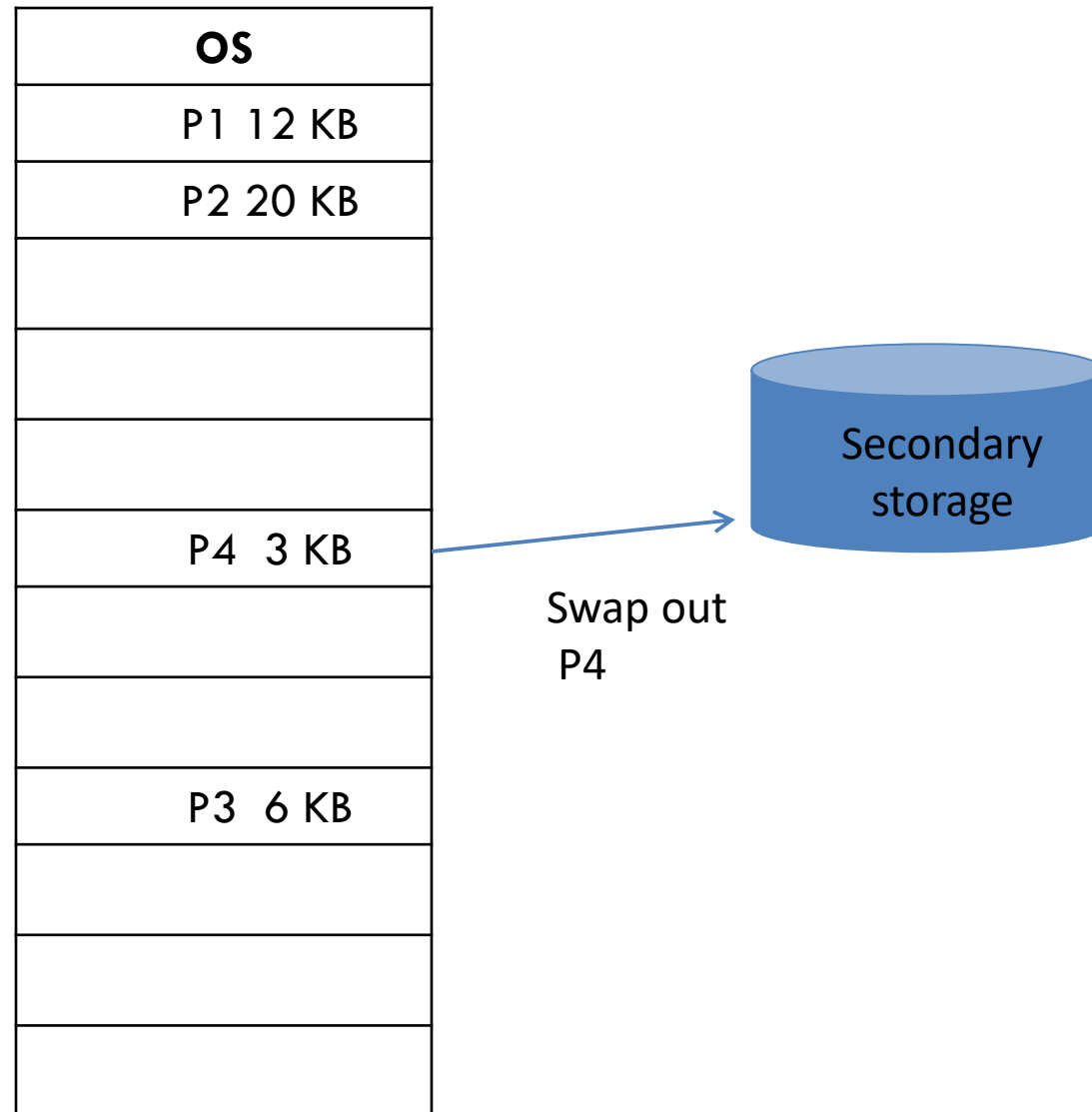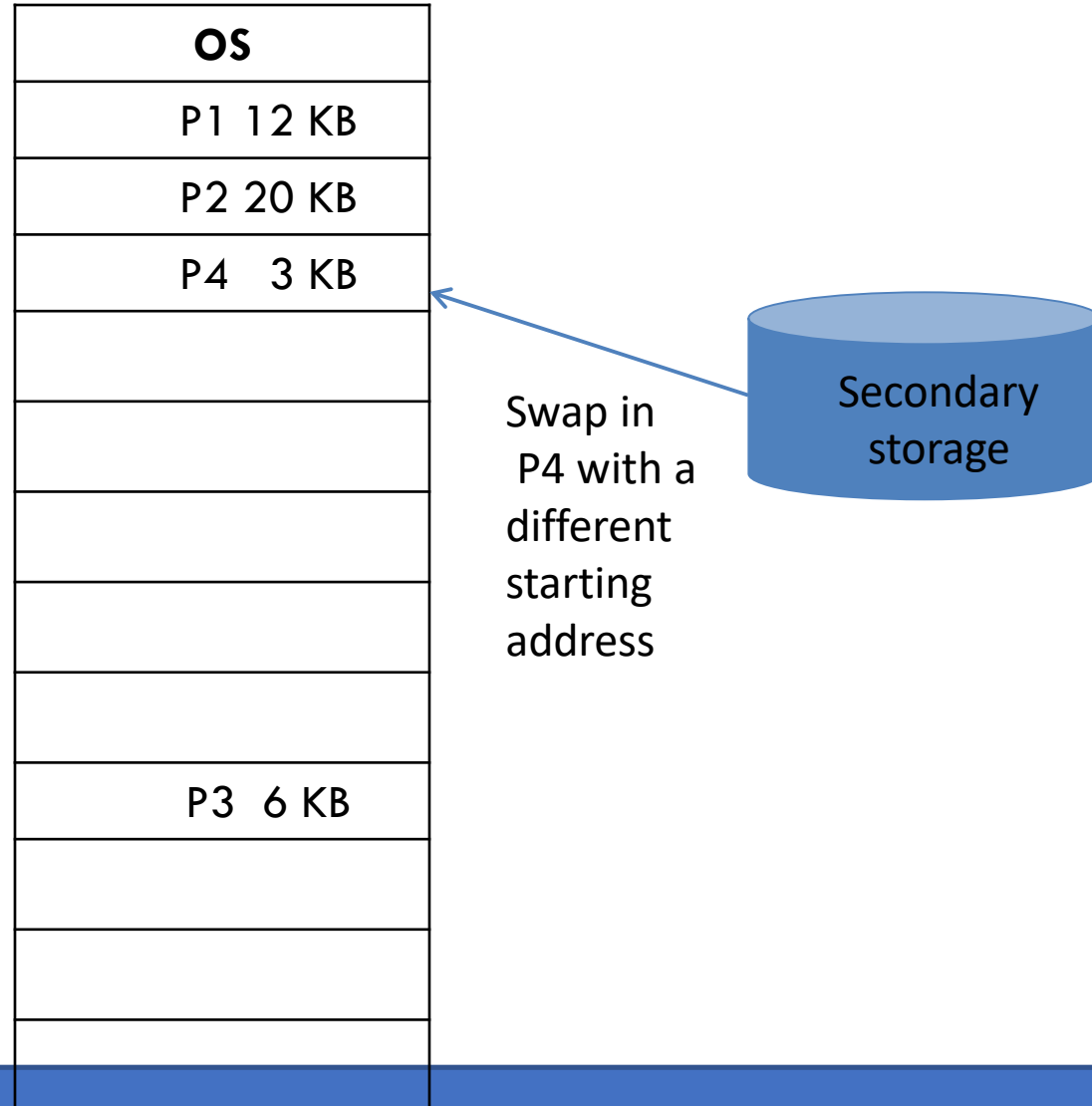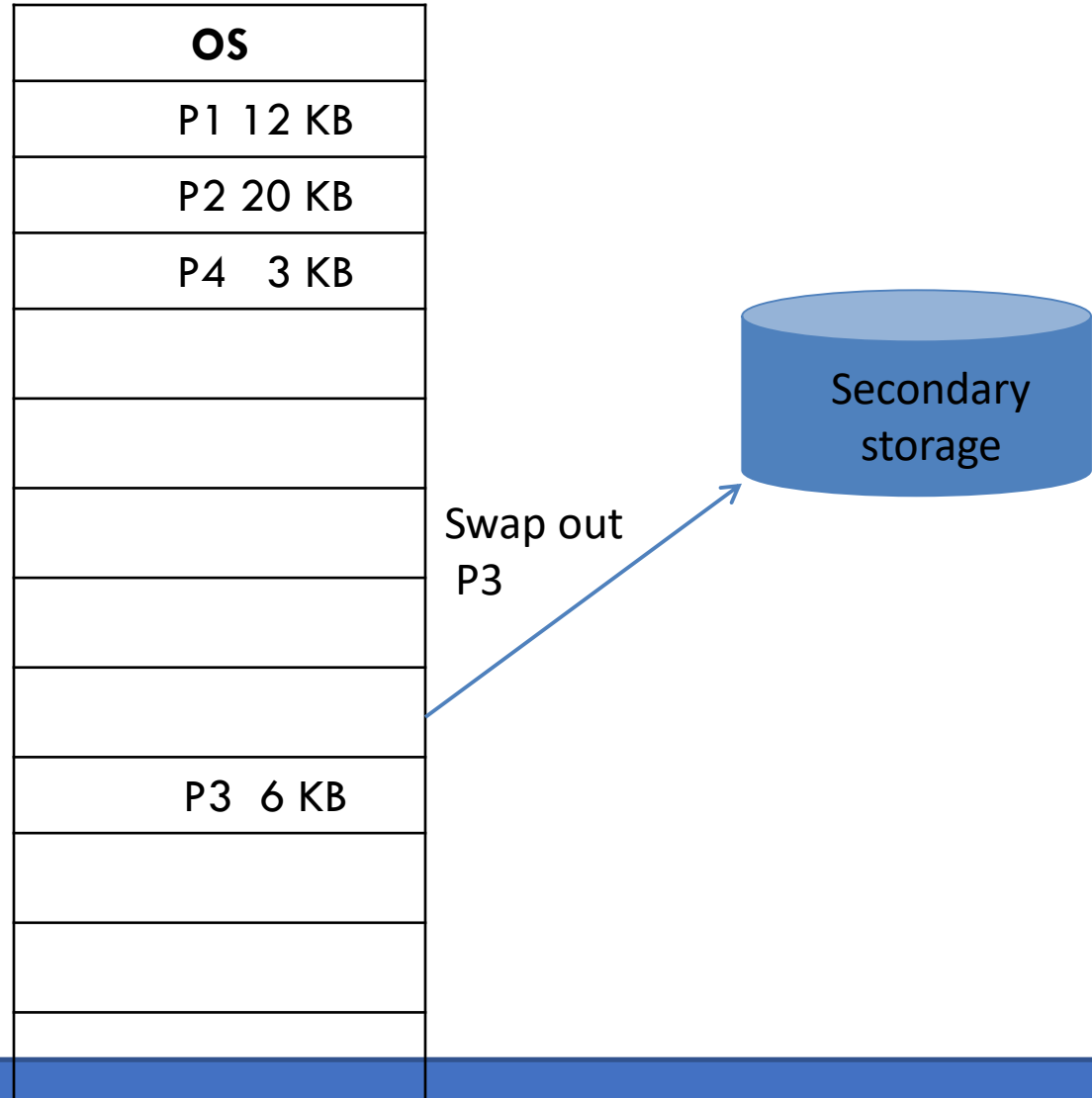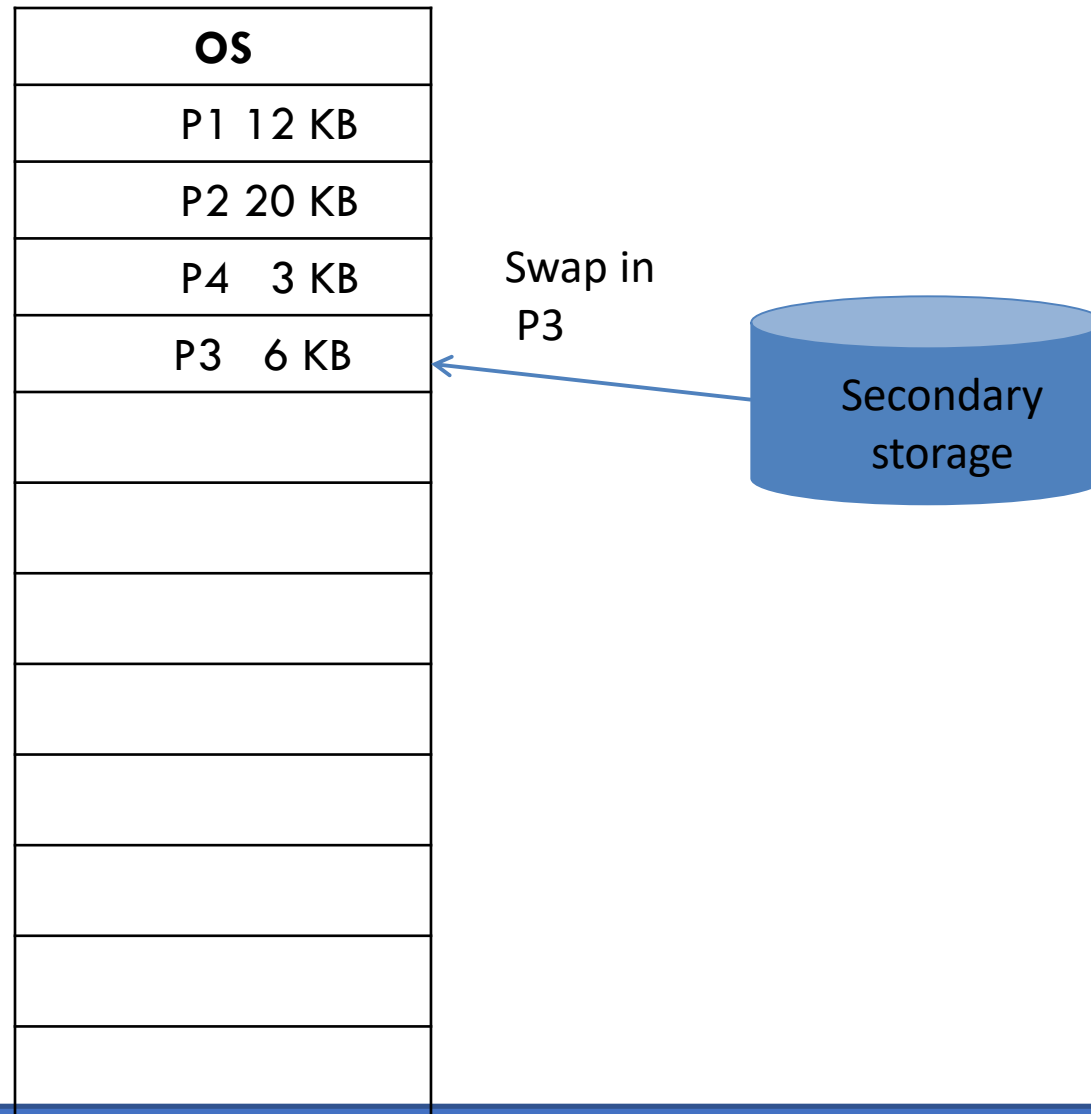
compaction

Memory mapping after compaction

OS
P1 12 KB
P2 20 KB
P4 3 KB
P3 6 KB
<FREE> 27 KB

Now P5 of 15KB can be loaded here

compaction

OS
P1 12 KB
P2 20 KB
P4   3 KB
P3   6 KB
P5 12 KB
<FREE> 12 KB

P5 of 15KB is loaded