



# Operating System

## Day 4

PPT's Compiled by:

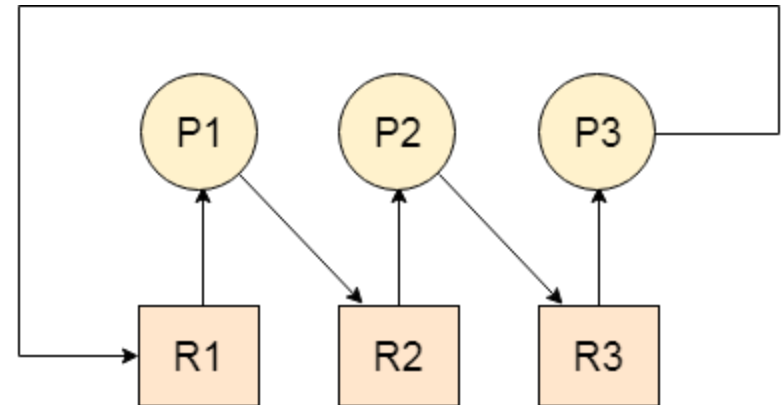
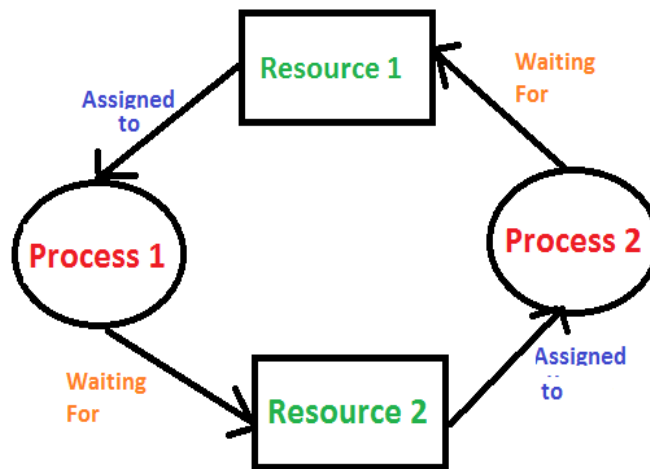
Mrs.Akshita.S.Chanchlani

SunBeam Infotech

[akshita.chanchlani@sunbeaminfo.com](mailto: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.

- only the process can release its held resource
- A resource can be released only voluntarily by the process holding it, after that process has completed its task.

## Circular wait

- A set  $\{ P_0, P_1, \dots, P_n \}$  of waiting processes must exist such that
- $P_0$  is waiting for a resource held by  $P_1$ ,
- $P_1$  is waiting for a resource held by  $P_2, \dots$ ,
- $P_{n-1}$  is waiting for a resource held by  $P_n$ ,
- $P_n$  is waiting for a resource held by  $P_0$ .

# Methods for handling deadlock

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

# 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 handled 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 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.

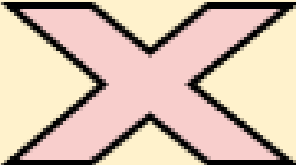
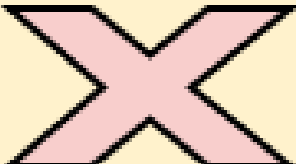
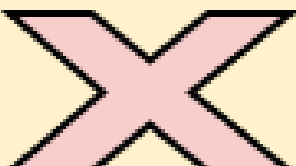
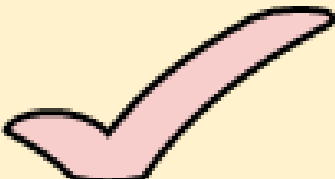
## No Preemption

- 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 Prevention

Condition	Approach	Is Practically Possible?
Mutual Exclusion	Spooling	
Hold and Wait	Request for all the resources initially	
No Preemption	Snatch all the resources	
Circular Wait	Assign priority to each resources and order resources numerically	



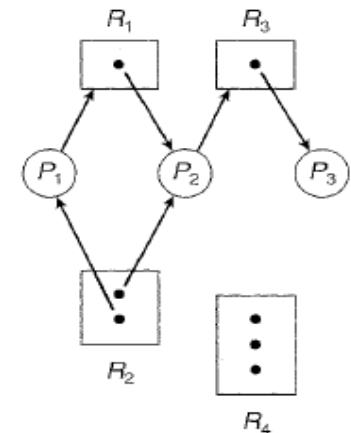
# Deadlock Avoidance

- 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.
  - $G(V,E)$
  - $V$ :
  - $P = \{ P_1, P_2, P_3 \}$ ,
  - $R = \{ R_1, R_2, R_3 \}$
  - $E$ :
- request edge:  $\{ P_1 \rightarrow R_3, P_2 \rightarrow R_1, P_3 \rightarrow R_2 \}$
- assignment edge:  $\{ R_1 \leftarrow P_1, R_2 \leftarrow P_2, R_3 \leftarrow P_3 \}$
- 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

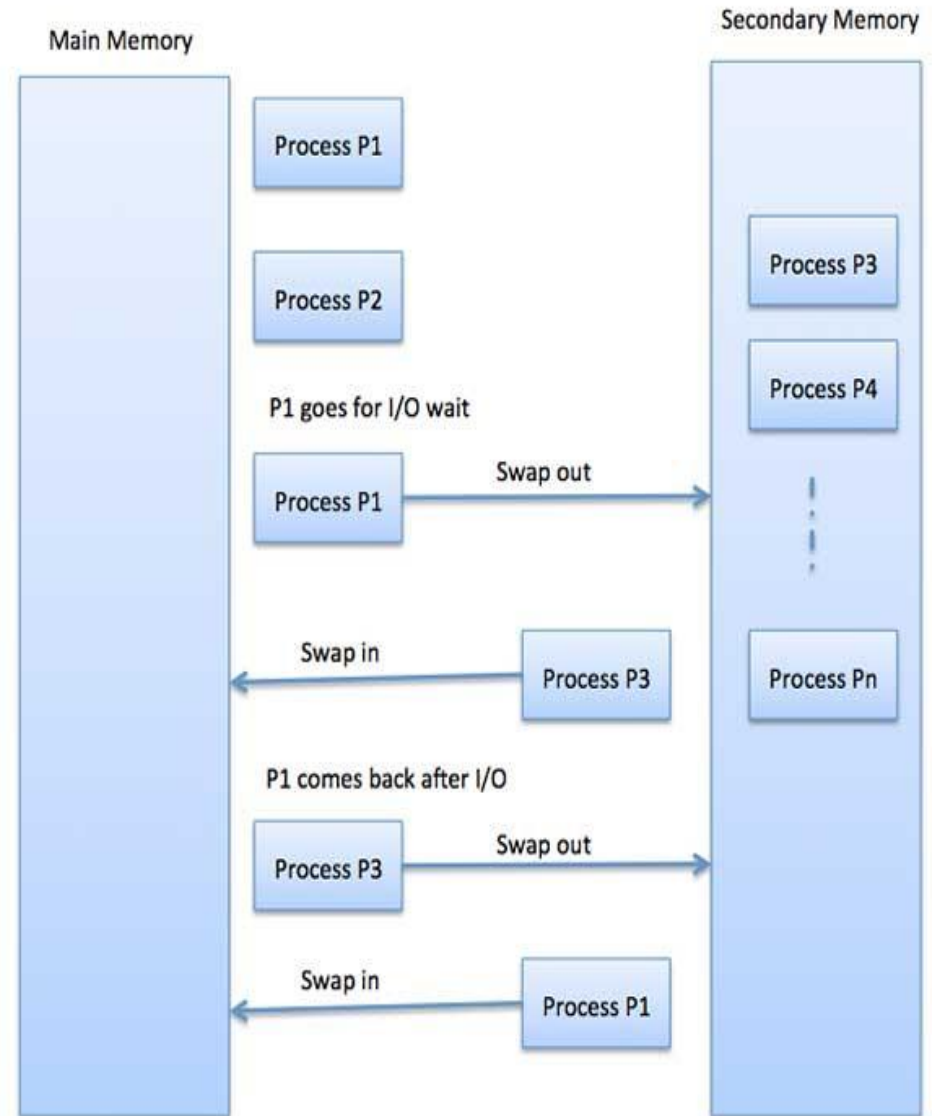
- must allow several processes to access a common portion of main memory without compromising protection
  - cooperating processes may need to share access to the same data structure
  - better to allow each process to access the same copy of the program rather than have their own separate copy

# 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**.

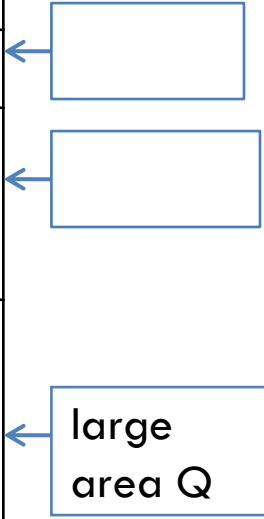
# Swapping

- 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.**



# Fixed Partition

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



- 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.

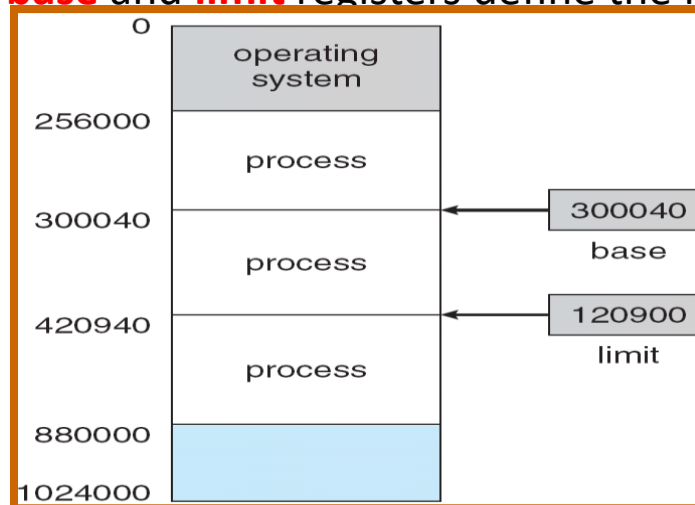
•The main problem with the fixed partitioning method is how to determine the number of partitions, and how to determine their sizes.

# 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

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

# first fit

P4 of 3KB  
arrives

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

# first fit

P4 of 3KB  
loaded here  
by  
FIRST FIT

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 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

<b>OS</b>
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

P4 of 3KB  
loaded here by  
BEST FIT

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

# 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

P5 of 15 KB  
loaded here by  
BEST FIT

OS
P1 12 KB
<FREE> 10 KB
P2 20 KB
P5 15 KB
<FREE> 1 KB
P3 6 KB
P4 3 KB
<FREE> 1 KB

# worst fit

- Worst Fit : 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

Initial memory  
mapping

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



# 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

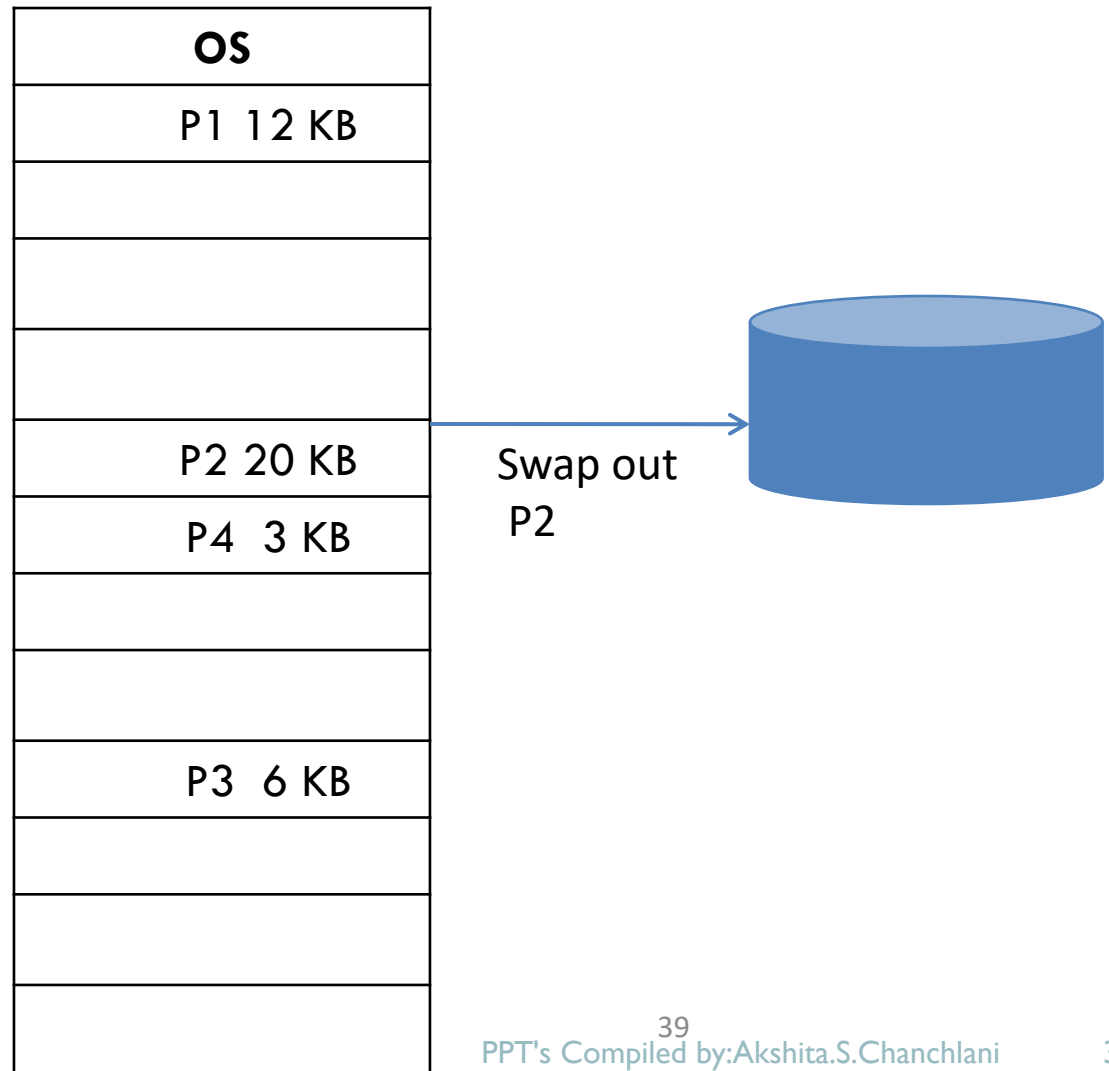
- Compaction is a method to overcome the external fragmentation problem.
- All free blocks are brought together as one large block of free space.
- Compaction requires dynamic relocation.
- One method for compaction is swapping out those processes that are to be moved within the memory, and swapping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

# compaction

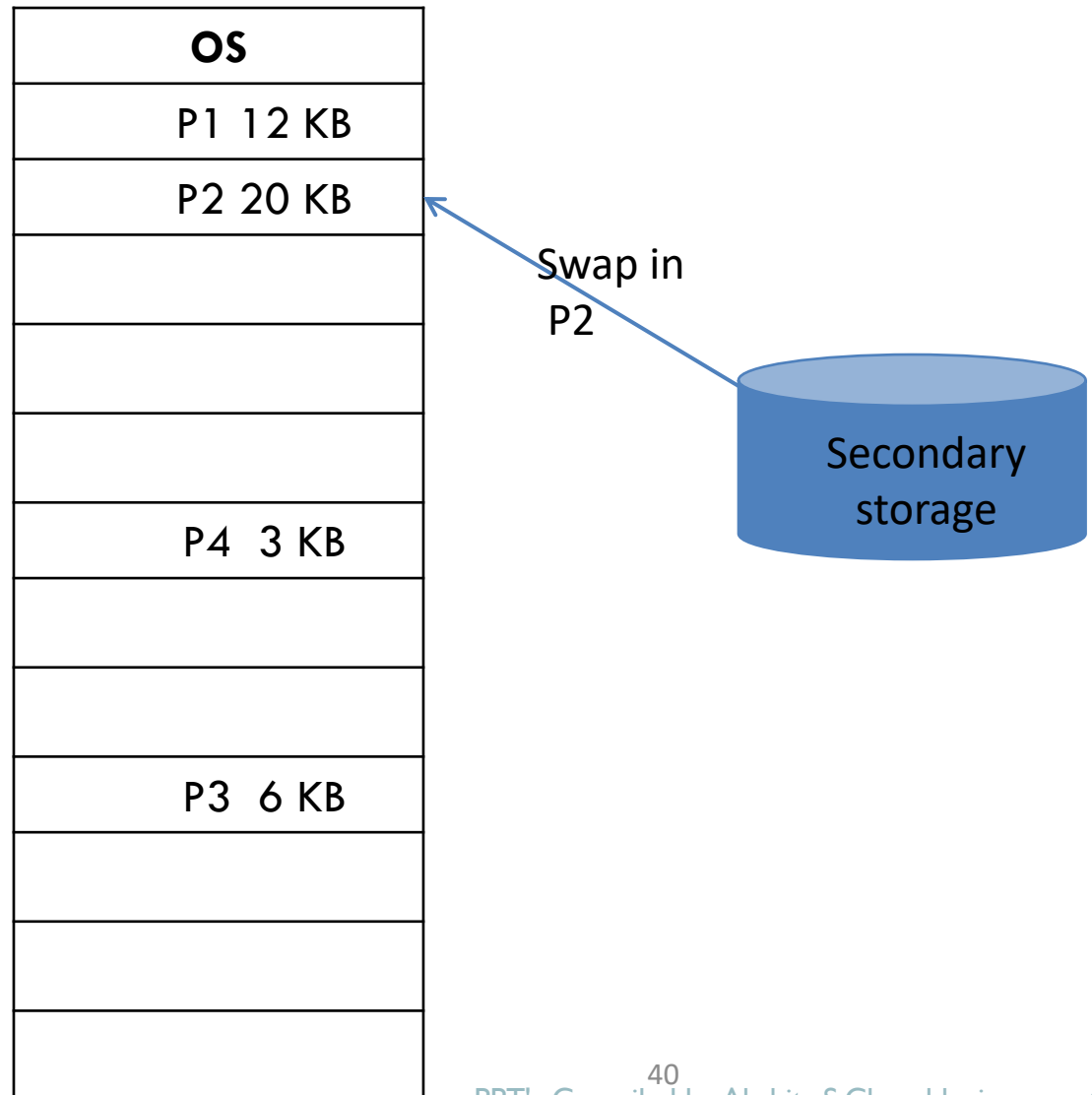
Memory mapping  
before  
compaction

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

# compaction

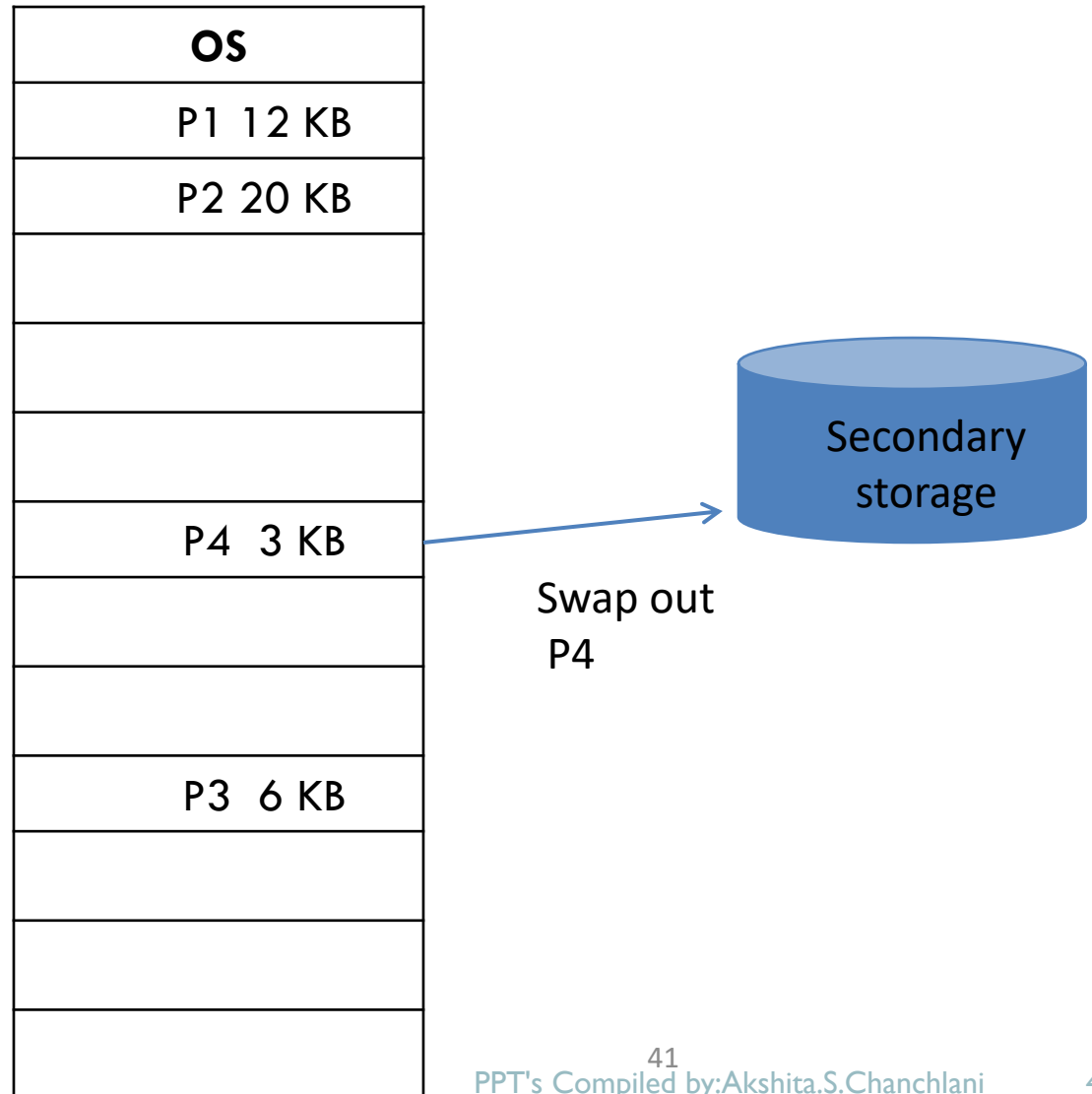


# compaction

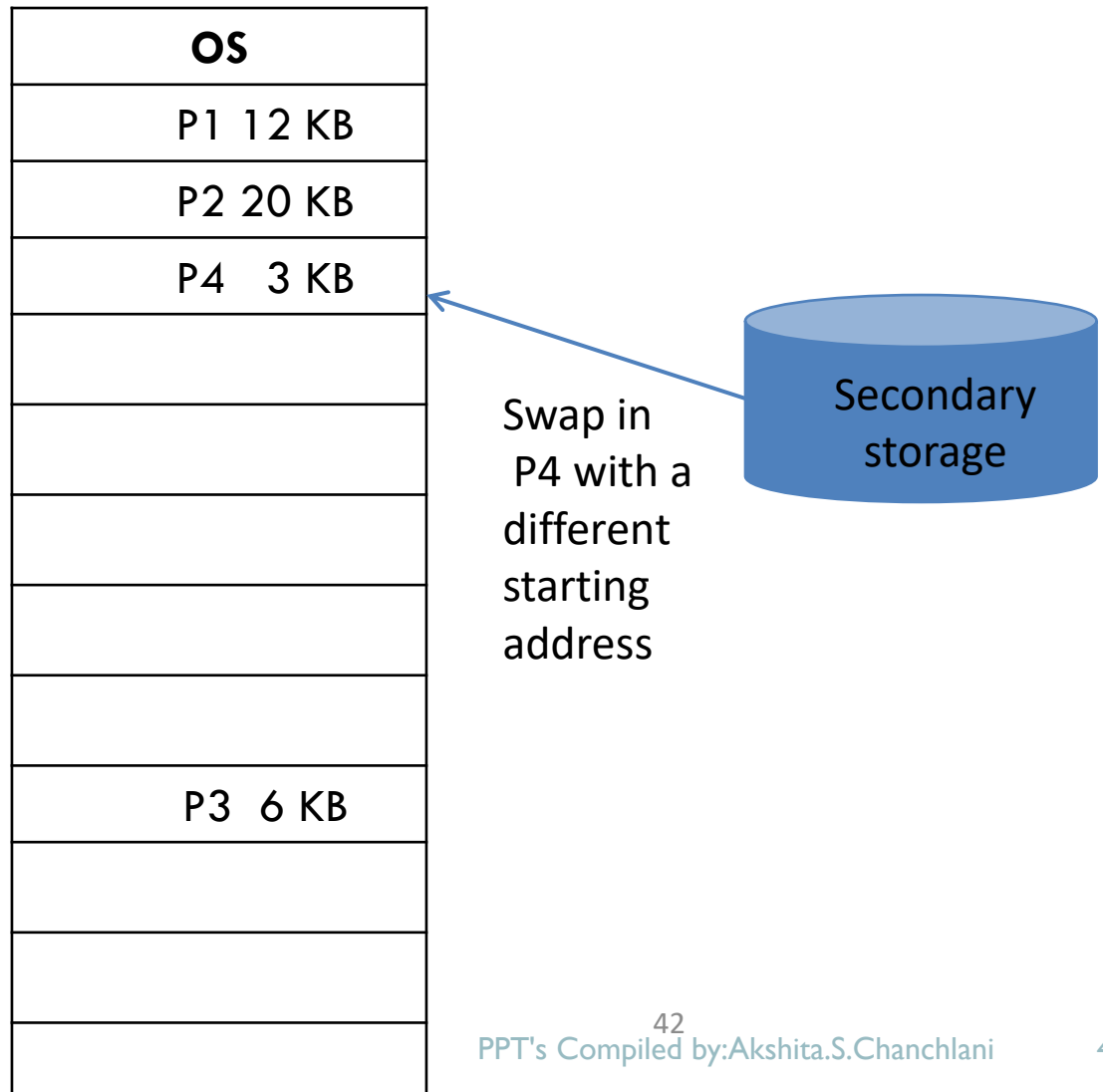




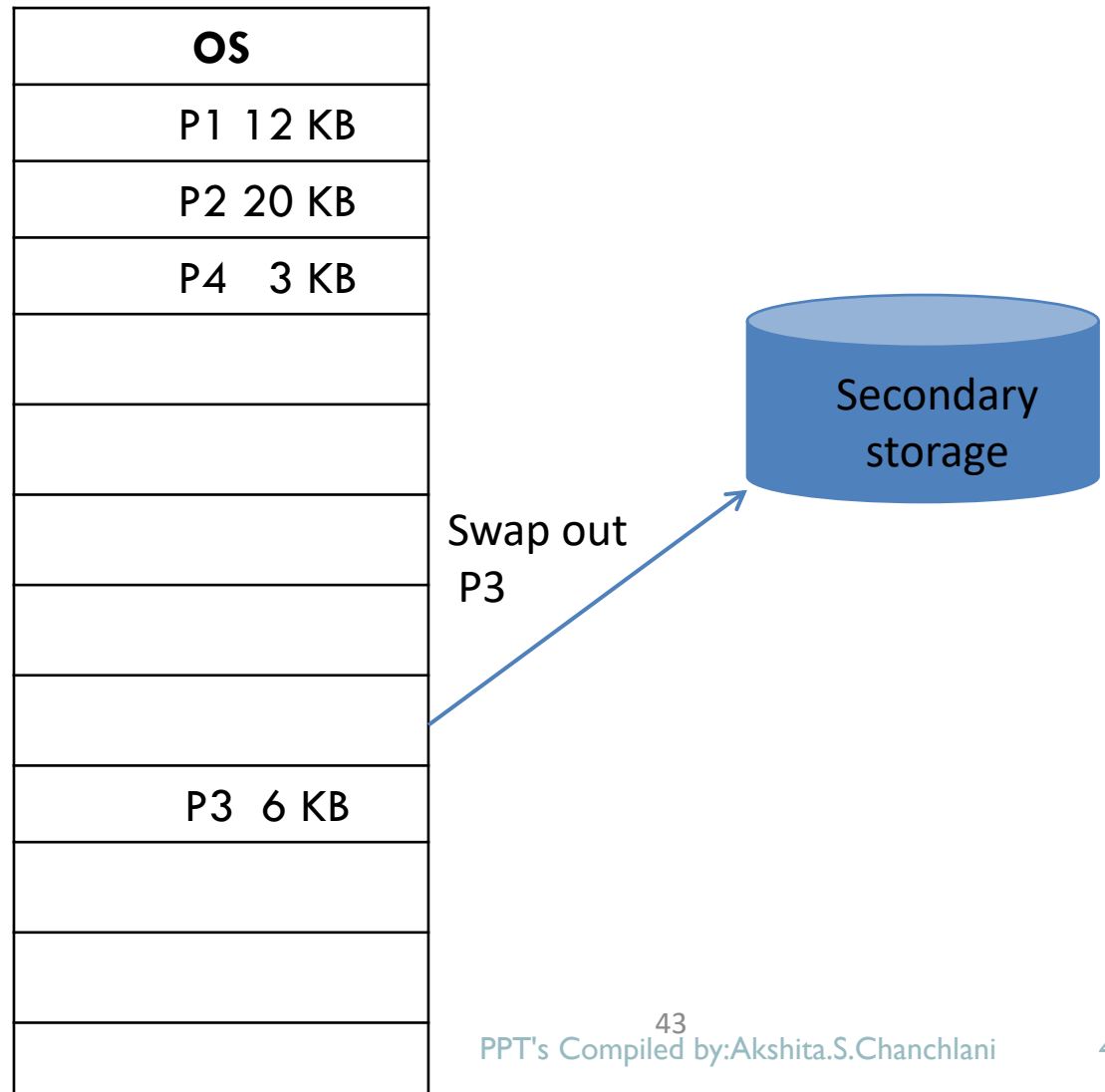
# compaction



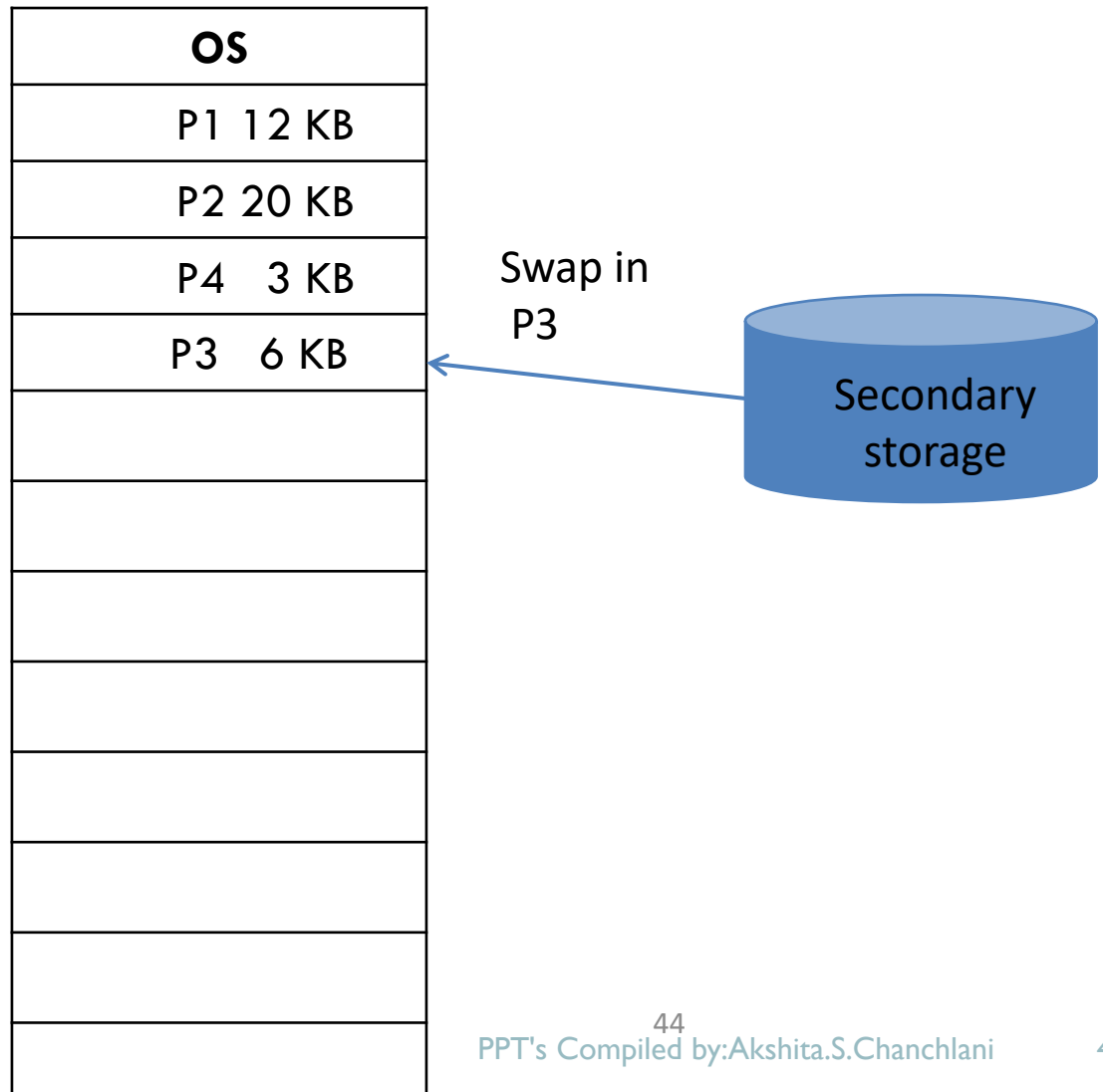
# compaction



# compaction



# compaction



# 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

THANNK YOU