[1] Utilization

of a resource : percentage of time a resource is busy.

e.g. CPU is at 80% utilization

cannot exceed 100%.

[2] Throughput : measures the output of a system (rate).

3 process / min.

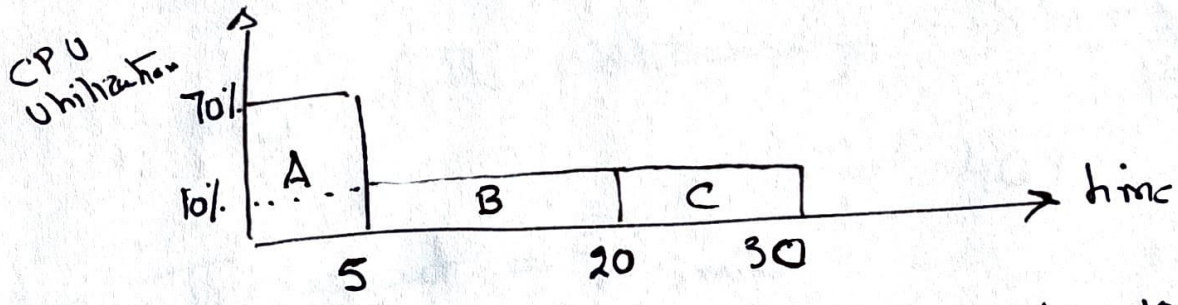
[3] Turnaround time : Time taken from a process arrival until completion. (time).

Process	duration	CPU	Memory	Disk	Terminal	Printer
A	5 min	70%	50MB	N	N	N
B	15 min	10%	100MB	N	Y	N
C	10 min	10%	75MB	Y	N	Y

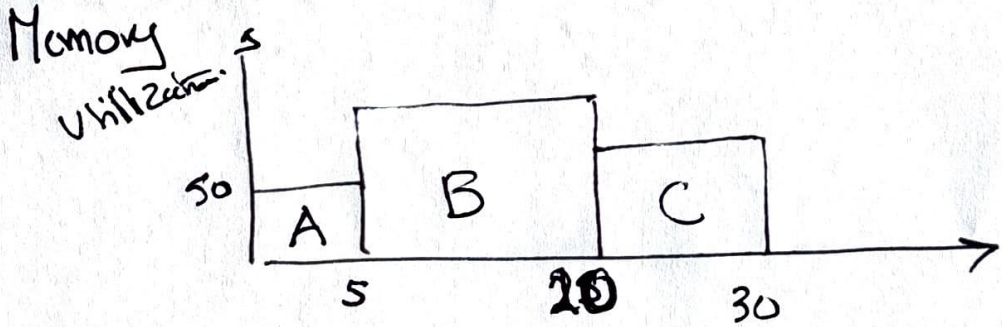
Total Memory is 250MB.

[1] Serial processing (uniprogramming)

CPU : what is average CPU utilization?



$$\text{Avg. CPU utilization} = \frac{5*70 + 15*10 + 10*10}{30} = 20\%$$



$$\text{avg. mem utilization} = \frac{50*5 + 100*15 + 75*10}{30 * 250}$$

Throughput = 3 process/30 mins = 1 process/10 mins

6 procs/hr.

Avg. Turnaround Time $= \frac{5_A + 20_B + 30_C}{3} = 18$ mins. [3]

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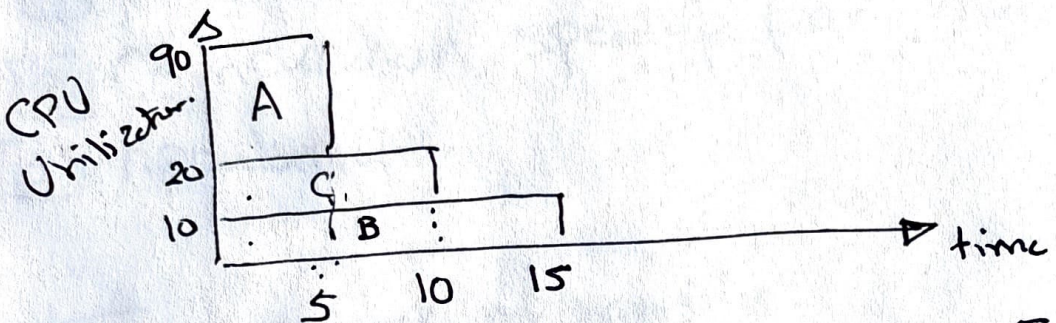
[b] Multiprogramming

CPU Utilization



Avg. CPU utilization $= \frac{5*90 + 5*20 + 5*10}{15}$

$= 40\%$.

Avg. Throughput $= 3/15$ mins

Avg Turnaround time $= \frac{5+10+15}{3} = 10$ mins

Avg utilization of the printer $= \frac{10 \text{ mins}}{15 \text{ mi}} = 66\%$.

Interprocess Communication

Need to allow processes to communicate

Why?

1. Data Sharing
2. Computation speedup (on multiprocessor System).
3. Modularity.

Two general mechanisms

1. Shared Memory
2. Message Passing

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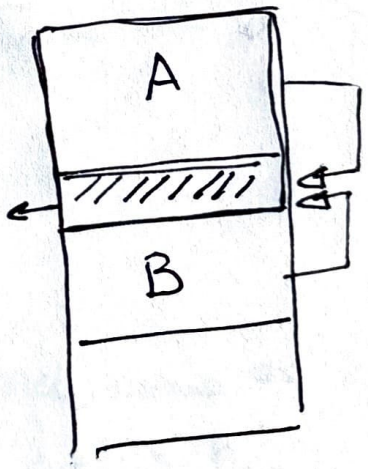
1. Shared Memory

→ Establish a shared region in memory

→ process can read/write.

→ Resides in the address space of the process creating the shared memory.

→ other processes attach to this region



Issues

[1] Need to coordinate writing to the same location at the same time.

[2] Processes need permissions to access this shared memory (Need to remove OS restrictions for protection).

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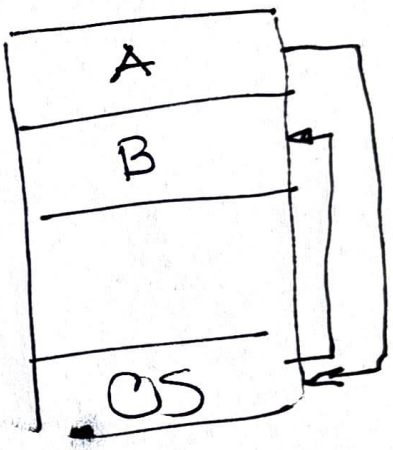
[2] Message Passing

Allow processes to exchange messages



Direct Communication

Each process refers explicitly to other process.

Send (P, msg) Send message msg to process P.

receive (Q, msg) receive a message from process Q.

"link between processes"

Indirect Communication

Messages Sent/received through mailboxes or port.

Owner of a mailbox: receiver who creates the mailbox.

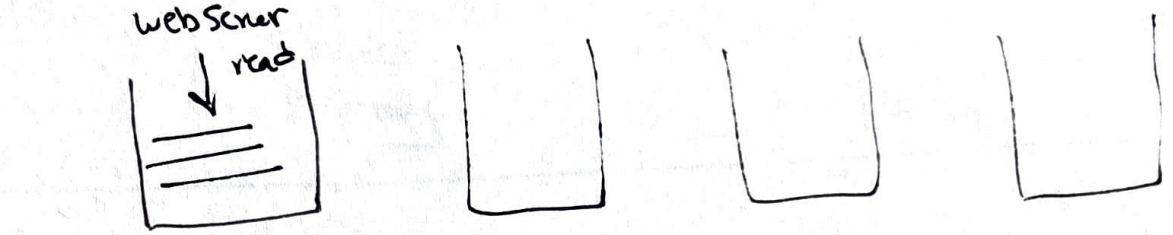
User: sender.

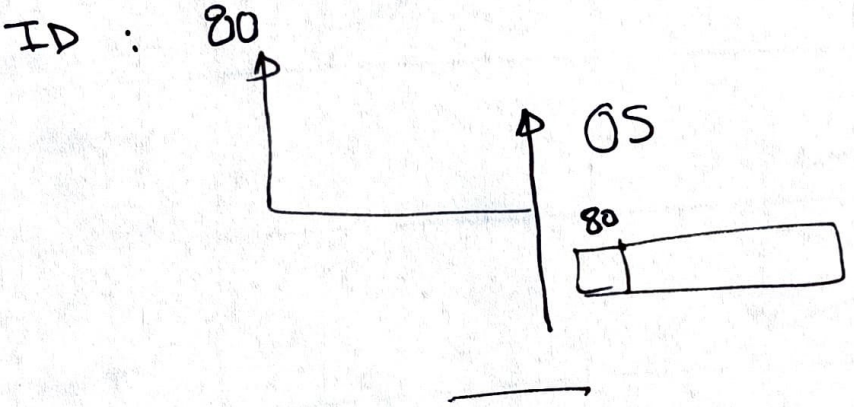
OS provides services to

Create / delete mailboxes

send / receive messages

Each mail box has an ID.





Synchronization Issues

Blocking Send : Sending process waits until the msg is received.

Non Blocking Send : Send a msg and resume execution.

Blocking receive : waits for a msg to arrive

Non blocking receive : receive a msg or null.

Buffering

Each mailbox has a capacity.

	Shared Memory	Message Passing
Speed (faster)	✓	
Small amount of data to be shared		✓
Easier to implement		✓