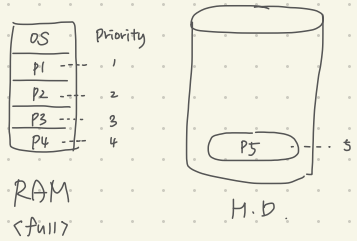
Types of scheduler, Context switching

every process has a process control block & attributes

= Context of a process

1. which & how many processors in hard disk should be moved into the RAM? by **Long term scheduler**
2. which processor in RAM should access the CPU first? by **Short term scheduler** (= scheduler)
3. which & how many processors in RAM should be moved back into the H.D? by **Medium term scheduler**



: P5가 priority가 높아 RAM에 들어가면 먼저 실행되겠지만 RAM에 남은 공간이 없는 상황.

⇒ 기존의 RAM에 있던 process 中

low priority를 가진 process를 H.D에 옮기고

H.D에 있는 higher priority process를 RAM에 옮김

swapping: swap-out / swap-in

- **Context switching**

CPU에서 실행되던 process보다 높은 priority의 process가 RAM에 있을 때

CPU에서 처리되던 process의 context를 남긴 채 higher priority process를 실행하는 것

(2 두 해당 작업이 끝나면 이전 process를 실행하던 지점 (context 정보를 가지고) 부터 다시 실행하도록)

Context switching

: 멀티프로세스 환경에서 CPU가 어떤하나의 프로세스를 실행하고 있는 상태에서 인터럽트 (interrupt) 요청에 의해 다음 우선순위의 프로세스가 실행되어야 할 때, 기존 프로세스의 상태 혹은 레지스터값 (context)을 저장하고 CPU가 다음 프로세스를 실행하도록 새로운 프로세스의 상태 혹은 context를 교체하는 작업

Various times of a process

1. **Arrival time** : time when process has arrived RAM
2. **Burst time** (= execution time) :
3. **Completion time** : time when process has completed execution & can be removed from RAM
4. **Turn-around time** : time between arrival time to completion time
5. **Waiting time** : waiting time for execution or I/O (process is idle at this moment)

TAT
- ① Completion time - arrival time
- ② burst time + waiting time + I/O time

6. **Response time** : 서로의 다른 값
7. **I/O time** : amount of time spent in reading & writing I/O

(cf)

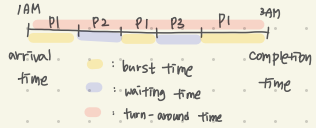
point in time

arrival time, completion time

duration in time

burst time, turn-around time, waiting time, response time

ex) Various times for process 1



Types of scheduling algorithms

목적 : CPU의 efficiency를 높이기 위함

CPU scheduling algorithms

- **Preemptive scheduling algorithms** : preempt the process
- **Non-preemptive scheduling algorithms** : CPU에서 process를 execute하는 중일 때, RAM의 higher priority process가 방해로 execution을 멈추지 않는 방식

· CPU scheduling algorithms are applied only to processes which are in ready state.

Process which are in I/O state will be "blocked" and will not be considered by scheduling algorithms

I/O state = block state

: P1 - running state / P2, P3 - ready state / P4 - I/O state 일 경우

P4의 priority가 P2, P3보다 높다라도 P1 방해이 끝난 뒤 P2, P3 중에 priority가 높은 process가 실행된다.

SJF scheduling algorithm

Shortest Job First scheduling algorithm

is optimal in terms of average waiting time among SJF, SRTF, FCFS

: Among the arrived process, process with the least burst time will be given preference (higher priority)

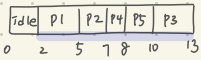
non-preemptive scheduling & priority based algorithm

ex1)

process Id	1	2	3	4	5
arrival time	2	3	4	6	8
burst time	3	2	3	1	2

Q) Find the average TAT, WT, Throughput and schedule length

S)



A)

CT	5	7	13	8	10
TAT (CT-AT)	3	4	9	2	2
WT (TAT-BT)	0	2	6	1	0

→ avg = 4

이 시간이전에 arrive 한 process들 中 burst time이 짧은 것이 먼저 실행됨

└ in this case we don't assume I/O time

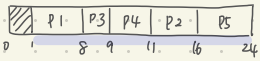
- Schedule length = CT of last process - AT of first process = 11
- Throughput : number of processes executed in unit time = Number of processes / schedule length = 5/11 = Processes / unit time

ex2)

process Id	1	2	3	4	5
arrival time	1	2	3	4	5
burst time	7	5	1	2	8

Q) Find the average TAT, WT, Throughput and schedule length

S)



CT	8	16	9	11	24
TAT (CT-AT)	7	14	6	7	19
WT (TAT-BT)	0	9	5	5	11

→ avg = 10.6

- Scheduling length = 23
- Throughput = 5/23

SRTF Scheduling algorithm

SJF & SRTF may cause Starvation when the long process is in ready state and shorter processes keeps coming

Shortest Remaining time first scheduling algorithm : preemptive version of SJF

: 이미 process가 실행 중이더라도 새로운 (RAM에 있는) process의 실행에 필요한 총 시간이 현재 process에서 남은 시간보다 짧다면, 먼저 실행
단, 모든 process가 ready queue에 있다면 SJF와 같은 방식으로 실행

ex1)

process Id	1	2	3	4	5	6
arrival time	0	1	2	3	4	5
burst time	~~7~~ ~~6~~ 0	~~5~~ ~~4~~ 0	~~3~~ ~~2~~ ~~1~~ 0	~~1~~ 0	~~2~~ 0	~~1~~ 0

Q) Find the average TAT, WT, Throughput and schedule length.
(같은 시간이 존재할 경우 먼저 arrive한것 먼저 실행할 것)

S)

P1	P2	P3	P4	P3	P3	P6	P5	P2	P1
0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–9	9–13	13–19

A)

CT	19	13	6	4	9	7
TAT (CT-AT)	19	12	4	1	5	2
WT (TAT-BT)	12	7	1	0	3	1

← last completed process부터 계산하는 것이 좋다.

TAT → avg = 43/6

L in this case we don't assume I/O time

- Schedule length = CT of last process − AT of first process = 19
- Throughput : number of processed executed in unit time = Number of processes / schedule length = 6/19 = Processes / unit time

*** Response time** : waiting time of certain process until it gets to the CPU for the first time

process Id	1	2	3	4
arrival time	0	15	30	45
burst time	20	25	10	15

SJF

P1	P2	P3	P4
0–20	20–45	45–55	55–70

SRTF

P1	P1	P2	P3	P2	P2	P4
0–15	15–20	20–30	30–40	40–45	45–55	55–70

SJF RT	0	5	15	10
SRTF RT	0	5	0	10

⇨ In any non-preemptive scheduling algorithm, Response time = waiting time, but it may not be true in preemptive scheduling algorithm.

ex2)

Problem :

Consider the following CPU processes with arrival times (in milliseconds) and length of CPU bursts (in milliseconds) as given below:

Process	Arrival Time	Burst Time	CT	TAT	WT	RT
P1	0	~~7~~ ~~4~~ 0	12	12	5	0
P2	3	~~3~~ ~~1~~ 0	6	3	0	0
P3	5	~~5~~ 0	17	12	7	7
P4	6	~~2~~ 0	8	2	0	0

P1	P2	P2	P4	P1	P3
0–3	3–5	5–6	6–8	8–12	12–17

If the pre-emptive shortest remaining time first scheduling algorithm is used to schedule the processes, then the average waiting time across all processes is __3__ milliseconds.

An operating system uses shortest remaining time first scheduling algorithm for pre-emptive scheduling of processes. Consider the following set of processes with their arrival times and CPU burst times (in milliseconds):

Process	Arrival Time	Burst Time	CT	TAT	WT	RT
P1	0	~~12~~ ~~10~~ 0	27	27	15	0
P2	2	~~4~~ ~~3~~ 0	6	4	0	0
P3	3	~~6~~ ~~4~~ 0	12	9	3	3
P4	8	~~5~~ 0	17	9	4	4

P1	P2	P2	P3	P3	P4	P1
0–2	2–3	3–6	6–8	8–12	12–17	17–27

The average waiting time (in milliseconds) of the processes is __5.5__.

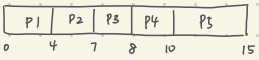
FCFS scheduling algorithm

First Come First Served Scheduling Algorithm : Cause long waiting times, especially when the first job takes too much CPU time.

The process which has the least arrival time will be scheduled first

non-preemptive # not priority based (not depending on a property of a process ex. burst time)

process Id	1	2	3	4	3
arrival time	0	1	2	3	4
burst time	4	3	1	2	5



CT	4	7	8	10	15
TAT	4	6	6	7	11
WT	0	3	5	5	6
RT	0	3	5	5	6

} in non-preemptive scheduling, WT=RT

priority based algorithm의 단점

Context Switching : preempt the process and schedule some other process

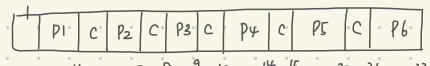
사실은 context switching에 시간이 걸린다 ⇒ decreases the efficiency of CPU = slower (degrade the performance)

[CPU efficiency = Useful time / Total time]

ex) context switching overhead = 1

process Id	1	2	3	4	3	6
arrival time	0	1	2	3	4	5
burst time	3	2	1	4	5	2

Context Switching : CPU is idle



CPU efficiency = 17/23

CPU inefficiency = 6/23

CT	4	7	9	14	20	23
TAT	4	6	7	11	16	18
WT	1	4	6	7	11	16
RT	1	4	6	7	11	16