Grade 12 A/L ICT · Lesson 5

5.3 Process Management: States, PCB, Schedulers and Waiting Time

Syllabus 5.3. A **process** is a program in execution. The OS creates processes, handles **interrupts**, tracks **states**, stores facts in a **PCB**, switches context, and uses **schedulers**. In this part you also meet **turnaround, response, throughput and waiting time**, with worked **FCFS / SJF** waiting-time calculations.

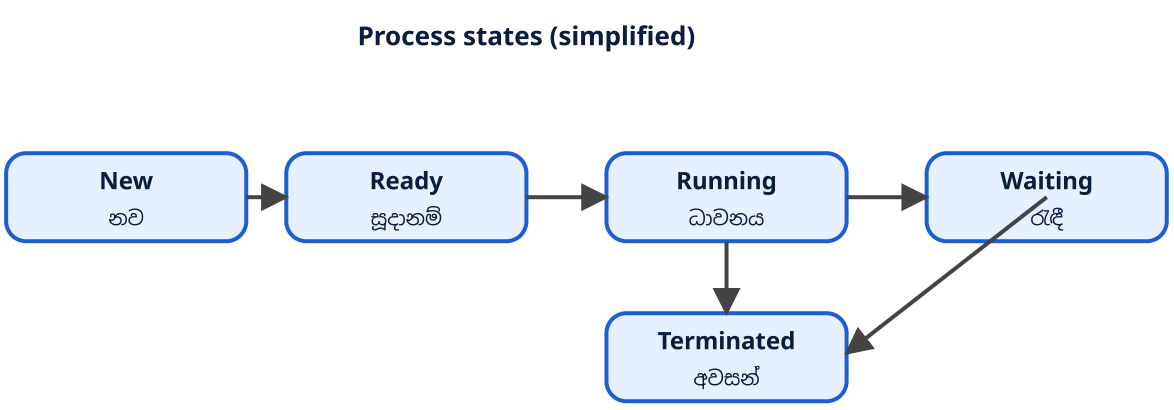
1. Program vs process

A **program** is passive (bytes on disk). A **process** is active: it has a program counter, registers, stack and an address space. Creating a process allocates a **PCB**, loads code, and sets the first state to ready (or new→ready).

2. Interrupts

An **interrupt** is a signal that something needs the CPU's attention (I/O finished, timer tick, error). The OS runs an **interrupt handler**, may save the current process's state, then resumes or schedules another process.

3. Process states and transitions



Simplified process states

- **New** → being created.
- **Ready** → waiting for CPU.
- **Running** → on the CPU.
- **Waiting / blocked** → waiting for I/O or an event.
- **Terminated** → finished or killed.

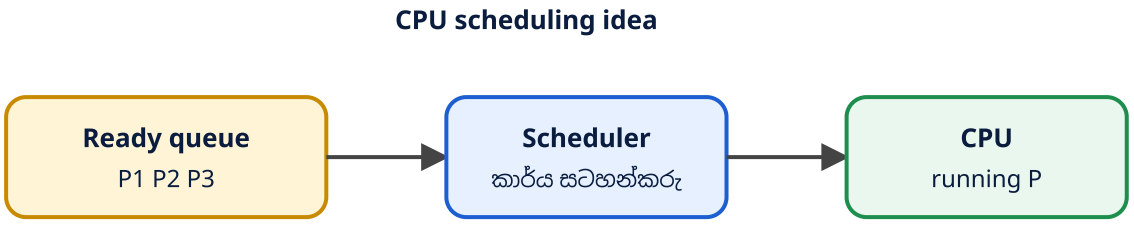
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> 💡 Syllabus diagrams may show up to **seven** states (including suspend/ready-suspend). The five above are the core idea.

4. PCB and context switch

The **Process Control Block (PCB)** holds the process ID, state, program counter, registers, scheduling info, memory maps and open files. A **context switch** saves one PCB's volatile state and loads another's so the CPU can run a different process.

5. Schedulers



Scheduler picks the next process

Scheduler	When	Job
Long-term	Job admission	Controls multi-programming degree
Short-term (CPU)	Very often	Picks who runs next on the CPU
Medium-term	When memory is tight	Swaps / suspends processes

Multi-programming keeps several processes in memory. **Time-sharing** gives interactive slices. Metrics: **turnaround** = finish − arrival; **waiting** = turnaround − burst; **response** ≈ first-run − arrival; **throughput** = jobs finished per unit time.

> 🧱 **Worked example: 20 jobs finish in 10 seconds. What is the throughput?**
> Throughput = 20/10 = **2 jobs/s**.

6. Worked example – FCFS waiting times

FCFS (First-Come-First-Served) runs processes in arrival order with no preemption.

> 🧱 **Worked example: Jobs P1–P4 with arrivals 0,1,2,3 and bursts 5,3,8,6 (ms). Find each waiting time and the average.**
> Waits = 0, 4, 6, 13. Average waiting time = **5.75 ms**.

Process	Arrival	Burst	Start	Finish	Wait
P1	0	5	0	5	0

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P2	1	3	5	8	4
P3	2	8	8	16	6
P4	3	6	16	22	13

7. Worked example – SJF (non-preemptive)

SJF picks the ready job with the **shortest burst** next.

🧮 **Worked example: Jobs: P1(0,7), P2(2,4), P3(4,1), P4(5,4). Find the average waiting time under non-preemptive SJF.**
Order runs P1, then P3, then P2, then P4. Waits = 0, 6, 3, 7. Average = **4 ms**.

Process	Arrival	Burst	Start	Wait
P1	0	7	0	0
P3	4	1	7	3
P2	2	4	8	6
P4	5	4	12	7

🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026 desktop and phone OS still combine multi-level feedback queues, CFS (Linux) and similar fair schedulers. The exam still expects you to compute FCFS/SJF waiting times by hand – that trains the definitions of waiting and turnaround time.

Key Words

Process – A program in execution with its own state.

Interrupt – Signal that needs CPU attention now.

PCB – Process Control Block – OS record for a process.

Context switch – Saving one process state and loading another.

Ready state – Waiting for the CPU.

Waiting state – Blocked for I/O or an event.

Long-term scheduler – Admits jobs into the system.

Short-term scheduler – Chooses the next process for the CPU.

FCFS – First-Come-First-Served scheduling.

SJF – Shortest-Job-First scheduling.

Waiting time – Time spent in the ready queue (turnaround − burst).

Throughput – Number of jobs finished per unit time.

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Sample Q&A

1. Distinguish a program and a process.

> **Answer:** A program is passive code on storage; a process is that code running with state (PC, registers, memory).

2. What does a PCB store?

> **Answer:** PID, state, PC, registers, scheduling data, memory info, open files (typical contents).

3. What is a context switch?

> **Answer:** Saving the current process's CPU state and loading another process's state.

4. Name the three scheduler types.

> **Answer:** Long-term, short-term (CPU) and medium-term.

5. Define waiting time and turnaround time.

> **Answer:** Turnaround = finish − arrival; waiting = turnaround − burst (time in ready queue).

6. In the FCFS example, what is the average waiting time?

> **Answer:** 5.75 ms.

MCQ

1. A process is

A. a monitor brand
B. a program in execution
C. a static PDF icon
D. a keyboard cable
E. only a file on disk

2. PCB stands for

A. Public Code Base
B. Printer Cable Bus
C. Process Control Block
D. Primary Cache Buffer
E. Page Count Byte

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3. A process in the ready state is

A. waiting only for a printer with no CPU need
B. not yet created
C. finished forever
D. waiting for the CPU
E. in ROM only

4. Context switching

A. formats the disk
B. saves one process state and loads another
C. turns off interrupts forever
D. changes the wallpaper only
E. deletes the OS

5. The short-term scheduler

A. never runs
B. only draws icons
C. only creates user accounts
D. only formats USB sticks
E. selects which ready process runs next

6. FCFS scheduling serves

A. largest memory first
B. random only
C. shortest job first always
D. only I/O bound last
E. in arrival order

7. SJF picks the ready job with

A. the shortest burst time
B. the most open files
C. the longest burst
D. no burst information
E. the latest arrival only

8. Waiting time equals

A. burst − arrival
B. page size
C. turnaround time − burst time
D. arrival only
E. throughput × 2

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9. Throughput is

A. jobs finished per unit time
B. RAM size only
C. number of icons
D. password length
E. screen resolution

10. If 20 jobs finish in 10 s, throughput is

A. 200 jobs/s
B. 2 jobs/s
C. 0.5 jobs/s
D. 20 jobs/s
E. 10 jobs/s

11. In the lesson FCFS example, average waiting time is

A. 5.75 ms
B. 50 ms
C. 100 ms
D. 1 ms
E. 0 ms

12. In the lesson SJF example, average waiting time is

A. 0 ms
B. 1 ms
C. 50 ms
D. 100 ms
E. 4 ms

13. Which term means: “A program in execution with its own state”?

A. PCB
B. Waiting state
C. Waiting time
D. Process
E. Short-term scheduler

14. Which term means: “Signal that needs CPU attention now”?

A. Throughput
B. FCFS
C. Context switch
D. Interrupt
E. Long-term scheduler

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15. Which term means: “Process Control Block – OS record for a process”?

A. Ready state
B. Process
C. PCB
D. Short-term scheduler
E. SJF

16. Which term means: “Saving one process state and loading another”?

A. Context switch
B. Interrupt
C. Waiting state
D. FCFS
E. Waiting time

17. Which term means: “Waiting for the CPU”?

A. Long-term scheduler
B. PCB
C. Ready state
D. Throughput
E. SJF

18. Which term means: “Blocked for I/O or an event”?

A. Waiting time
B. Process
C. Context switch
D. Waiting state
E. Short-term scheduler

19. Which term means: “Admits jobs into the system”?

A. Throughput
B. Long-term scheduler
C. Ready state
D. Interrupt
E. FCFS

20. Which term means: “Chooses the next process for the CPU”?

A. Process
B. Waiting state
C. SJF
D. PCB
E. Short-term scheduler

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Structured Questions

1. Distinguish program and process; list three PCB contents. *(2 marks)*

> Program passive / process active (1); PCB: PID, state, PC/registers (or similar) (2).

2. Describe ready, running and waiting states. *(3 marks)*

> Ready: wants CPU (1); running: on CPU (1); waiting: blocked for I/O/event (1).

3. Compare long-term and short-term schedulers. *(2 marks)*

> Long-term admits jobs / degree of multi-programming (1); short-term picks next CPU process often (2).

4. For the FCFS data in the notes, show waits and the average. *(2 marks)*

> Waits 0,4,6,13 (2); average 5.75 (1).

5. Define waiting, turnaround and throughput; give the 20-jobs-in-10-s throughput. *(2 marks)*

> Definitions (2); throughput 2 jobs/s (1).

Summary

- A process is a running program; a PCB stores its OS data.
- States include new, ready, running, waiting, terminated.
- Schedulers: long-term, short-term, medium-term.
- Waiting = turnaround − burst; throughput = jobs per time.
- FCFS and SJF examples show how to compute average waiting time.

MCQ answer key – 5.3

1. **B** – Active execution.
2. **C** – OS process record.
3. **D** – Ready queue.
4. **B** – Switch processes on CPU.
5. **E** – CPU scheduler.
6. **E** – First come first served.
7. **A** – Shortest job first.
8. **C** – Time in ready queue.
9. **A** – Jobs/time.
10. **B** – 20/10=2.
11. **A** – (0+4+6+13)/4.
12. **E** – Computed SJF average.
13. **D** – Process – A program in execution with its own state.

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14. **D** – Interrupt – Signal that needs CPU attention now.
15. **C** – PCB – Process Control Block – OS record for a process.
16. **A** – Context switch – Saving one process state and loading another.
17. **C** – Ready state – Waiting for the CPU.
18. **D** – Waiting state – Blocked for I/O or an event.
19. **B** – Long-term scheduler – Admits jobs into the system.
20. **E** – Short-term scheduler – Chooses the next process for the CPU.

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