🧩 Processes and Threads

> “The OS illusion: making one CPU act like it’s 20.”

💡 Big Idea

Every running program isn't *just code* — it's a **process**,
an isolated world with its own memory, resources, and identity.

The OS juggles hundreds of these, switching between them so smoothly you think it's multitasking.

🧠 Process: The Living Program

A **process** is a running instance of a program with:

- Its own memory space
- CPU time slices
- Open files / I O handles
- Unique process ID (PID)

Analogy:
A person at a desk, working with their own supplies, taking turns at the CPU coffee machine.

⚙️ Process Lifecycle

States

- 🆕 **New** – being created
- 🟢 **Ready** – waiting for CPU
- 🔵 **Running** – currently executing
- 🟡 **Waiting** – blocked for I/O or event
- 🔴 **Terminated** – finished or killed

Transitions: scheduler decisions, I/O events, system calls.

📈 Visual Model

```
New → Ready → Running → Terminated
          ↘️ Waiting ↗️
```

Each arrow represents a system call or interrupt that changes who holds the CPU.

🧩 Threads: The Mini-Processes

A **thread** is a lightweight process inside another process.

All threads share:

- Memory space
- Code / data sections
- File descriptors

Each thread has:

- Own stack
- Own program counter
- Own schedule

🎭 Process vs Thread Comparison

Feature	Process	Thread
Memory space	Separate	Shared
Communication	Slow (IPC)	Fast (shared vars)
Overhead	High	Low
Isolation	Strong	Weak
Typical use	Whole programs	Tasks inside program

🧠 Why Threads Exist

- To do multiple tasks within one program (browser tabs)
- To overlap computation with I/O
- To scale across multiple cores
- To confuse CS students since 1970

🧩 Context Switching

When the CPU switches threads/processes:

1. Save current CPU state (registers, PC, etc.)
2. Load next thread’s state
3. Resume execution

Overhead: switching too often wastes cycles — scheduling aims to minimize that.

🧠 Scheduling Overview (Concept Only)

Schedulers decide:

- Who runs next
- For how long (quantum)
- When to pre-empt

Common strategies:

- **FCFS** – First Come, First Served
- **RR** – Round Robin
- **SJF** – Shortest Job First

🧩 System Calls — The OS Entry Points

Processes interact with the OS via **system calls**:

`fork()`, `exec()`, `wait()`, `read()`, `write()` …

They’re the controlled bridge from **user mode → kernel mode**.

🧠 Process Creation (UNIX Style)

```
pid = fork()
if pid == 0:
    exec("child_program")
else:
    wait(pid)
```

- `fork()` duplicates the process
- `exec()` replaces it with new code
- `wait()` synchronizes parent and child

🧩 Visualization Idea – “Process Zoo”

Simulate multiple processes competing for CPU:

- Random burst and I/O wait times
- Log state transitions
- Scheduler: Round Robin for fairness

Shows the lifecycle in motion instead of static theory.

🧩 Why It Matters

Understanding processes and threads explains:

- Multitasking
- Deadlocks (next week)
- Virtual memory
- Containers and virtualization

Every higher-level abstraction depends on these primitives.

🎯 Exit Prompt

Finish the sentence:

> “A thread is like a __ **because it __**.”

Examples

- “ …like a roommate — shares space but has its own schedule.”
- “ …like a worker bee — independent but part of one hive.”

💾 Summary

Concept	Core Idea
Process	Running program with own resources
Thread	Lightweight execution unit
Scheduler	Decides who runs next
System Call	Bridge to kernel operations
Context Switch	Save/restore between tasks

🧭 Next Topic

Week 01 Topic 03 → Scheduling and Context Switching ▶️

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Next ▶️ Week 01 Topic 03: cheduling & Context Switching

📚 References & Credits

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