K22 - Operating Systems: Design Principles and Internals

Fall 2025 @dit

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Lecture 05

References: Similar OS courses @Columbia, @Stanford, @UC San Diego, @Brown, @di (previous years); and textbooks: Operating Systems: Three Easy Pieces, Operating Systems: Principles and Practice, Operating System Concepts, Linux Kernel Development, Understanding the Linux Kernel

Administrivia

- Where we are today? 52 teams…
  - Drop those kernels boi
  - Team Rocket
  - Οι ωραίοι έχουν χρέη!
  - Skordopsomo
  - Syscall Syndicate
  - Printer Hate Club
  - Συστουργικα Λειτηματα
  - Panic! In the Kernel
  - GadaffiOS
  - We dont byte
  - Onlyfun
  - Too Legit to Buffer (TLB)
  - The Deadlocks
  - Tow and a half man

…

FINAL DISCLAIMER

- Without a team for the programming assignments at this point, the only option is September
    - Final exam: **100% credit**
    - Other requirements? **None**

Overview

- We'll start from hardware and follow a question-oriented approach
  - ~~Intro [Q: What is an OS?]~~
  - ~~Events [Q: When does the OS run?]~~
  - ~~Runtime [Q: How does a program look like in memory?]~~
  - **Processes [Q: What is a process?]**
  - IPC [Q: How do processes communicate?]
  - Threads [Q: What is a thread?]
  - Synchronization [Q: What goes wrong w/o synchronization?]
  - Time Management [Q: What is scheduling?]
  - Memory Management [Q: What is virtual memory?]
  - Files [Q: What is a file descriptor?]
  - Storage Management [Q: How do we allocate disk space to files?]

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Overview

- Processes
  - Q1: What is a process?
  - Q2: Why use a process?
  - Q3: What are the components of a process?
  - Q4: How do we create a process?
  - Q5: How do we run a program?
  - Q6: What are the possible states a process could be in?
  - Q7: How does the OS run multiple processes simultaneously?

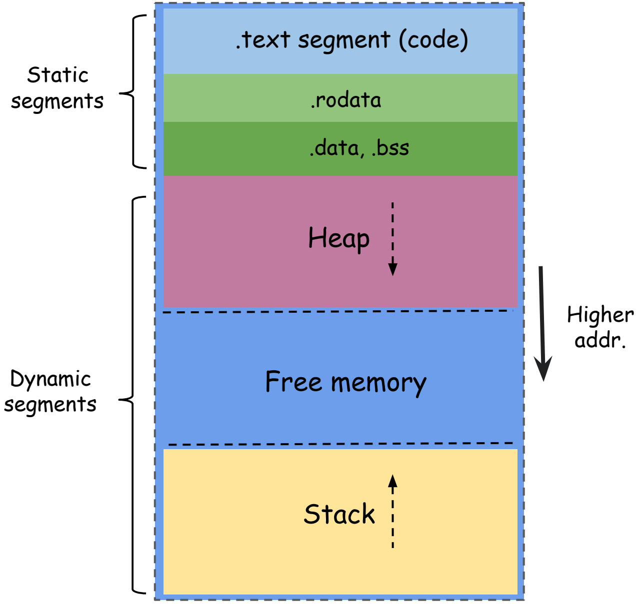
  ...

The process abstraction

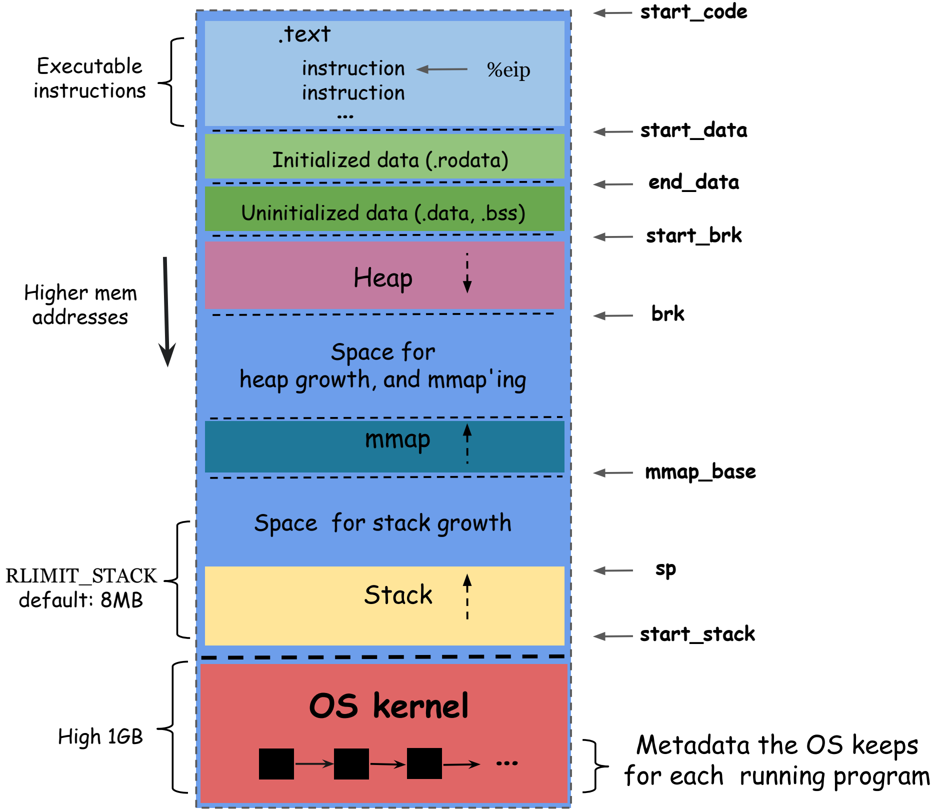
- What is a process? "An address space with one or more threads executing within it." (Strict POSIX definition, 3/189.)

Virtual Address Space (VAS)

Process's view



OS view (the reality)



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- How we use it?
  - Want to run a program? Use a process
  - Want to run multiple programs? Use multiple processes

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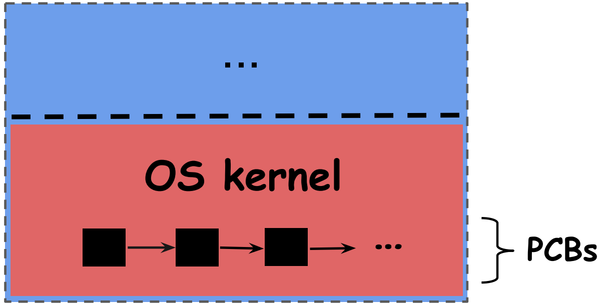
- Noone else will be using using the storage
  - This is for later, but the ideas are similar…
  - Every process may read from a file as if no other is writing to it

Components of a process

- Process Control Block (PCB): A struct used by the OS to keep track of each running process (see task_struct)



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  - Shared system resources: Open files (see files_struct) and open network connections (see struct_sock), and more...

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DESCRIPTION

pid_t fork(void): Creates a new process by duplicating the calling process

- Returns process ID (PID) of the new process in the "parent" process
- Returns 0 in the "child" process

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SYSCALL_DEFINE0(fork)
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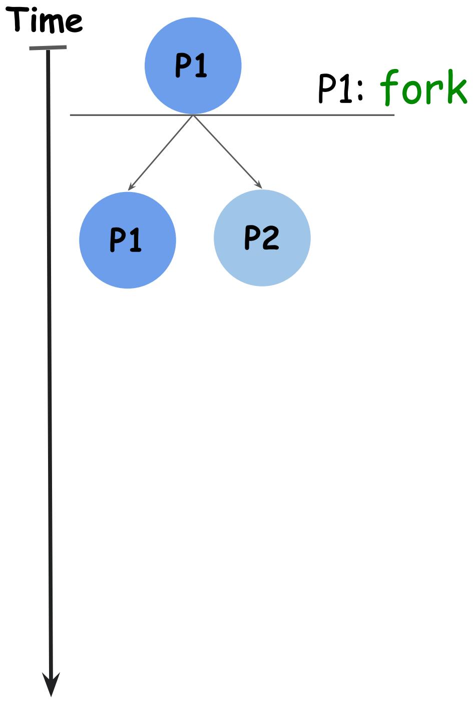

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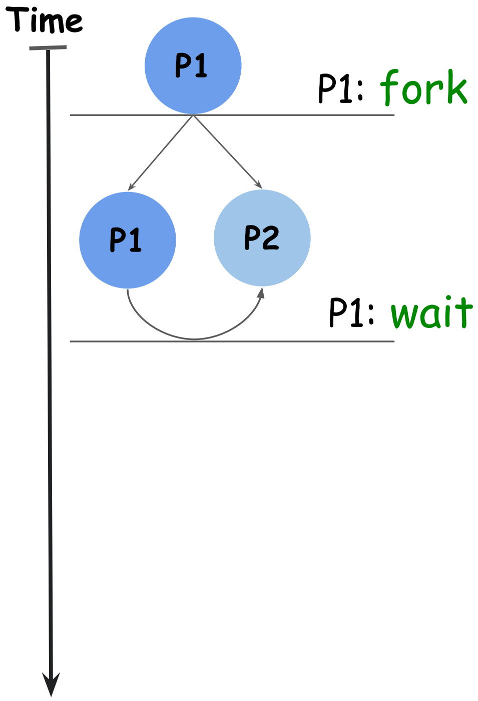

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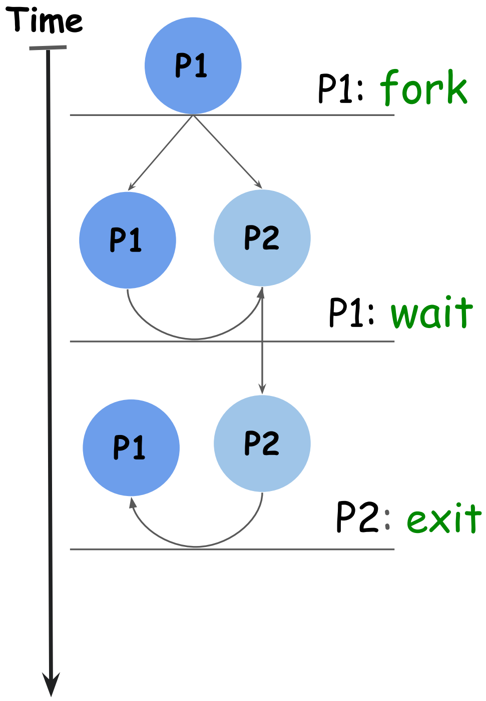

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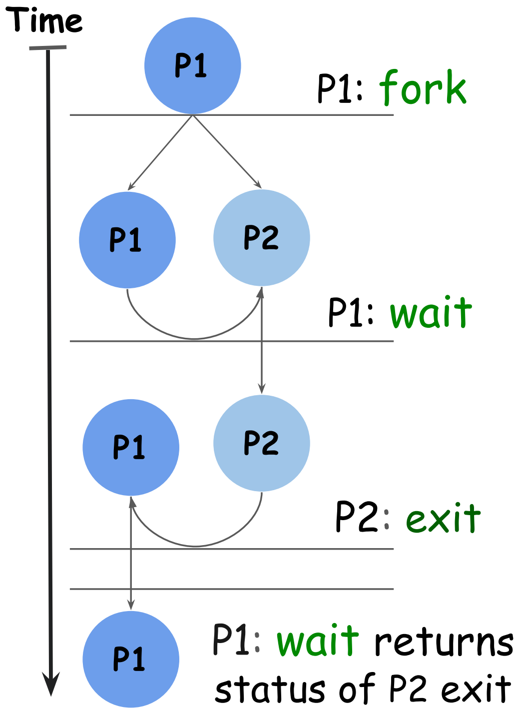

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  - Requires distinguished init process...
- Creating a new process from scratch
  - Create and initialize a new PCB
  - Add a new PCB to the in-kernel queue of PCBs
  - Does not require a distinguished process...but....

Process creation: Not to POSIX

DESCRIPTION

CreateProcessA: Creates a new process and its primary thread

```
BOOL CreateProcessA(
        [in, optional]        LPCSTR                      lpApplicationName,
        [in, out, optional]   LPSTR                       lpCommandLine,
        [in, optional]        LPSECURITY_ATTRIBUTES       lpProcessAttributes,
        [in, optional]        LPSECURITY_ATTRIBUTES       lpThreadAttributes,
        [in]                  BOOL                        bInheritHandles,
        [in]                  DWORD                       dwCreationFlags,
        [in, optional]        LPVOID                      lpEnvironment,
        [in, optional]        LPCSTR                      lpCurrentDirectory,
        [in]                  LPSTARTUPINFOA              lpStartupInfo,
        [out]                 LPPROCESS_INFORMATION       lpProcessInformation
);
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The elegant simplicity of POSIX!

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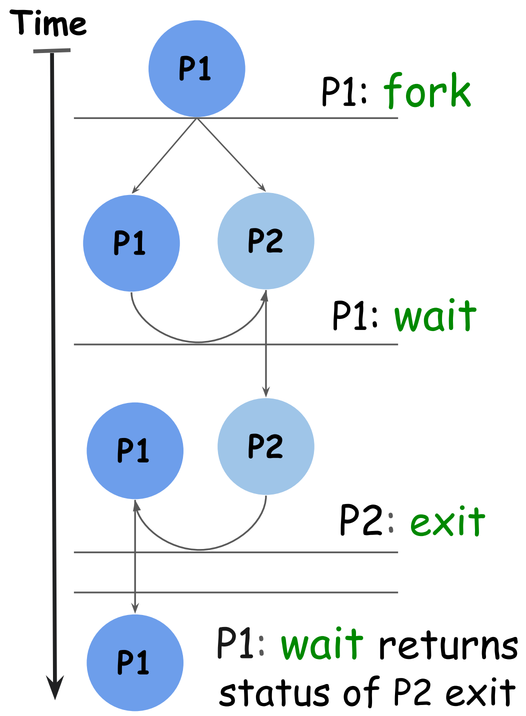

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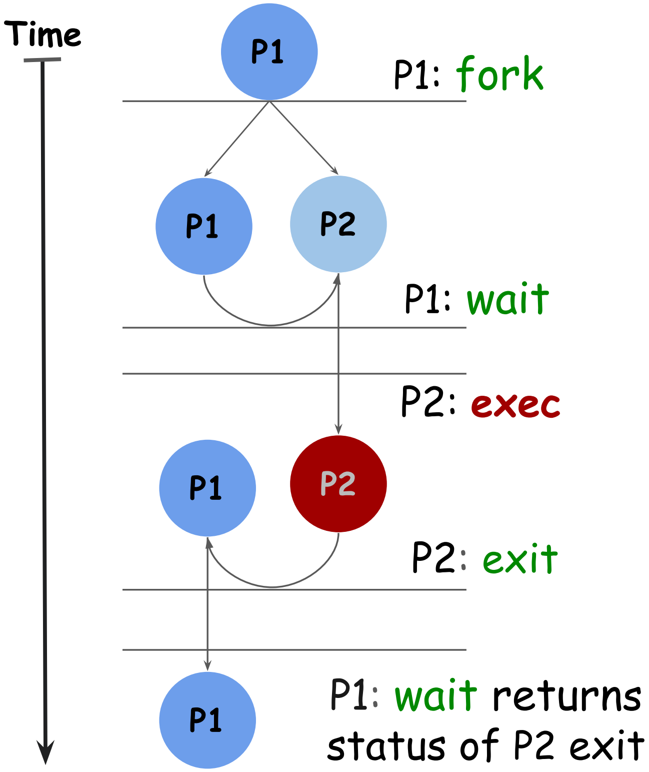

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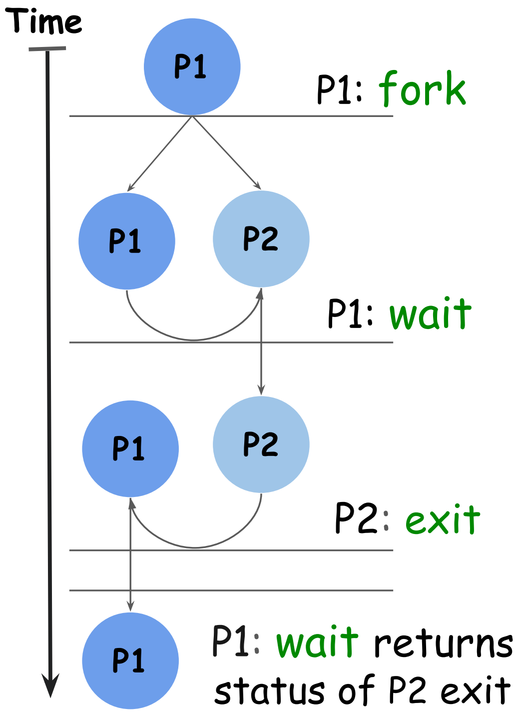

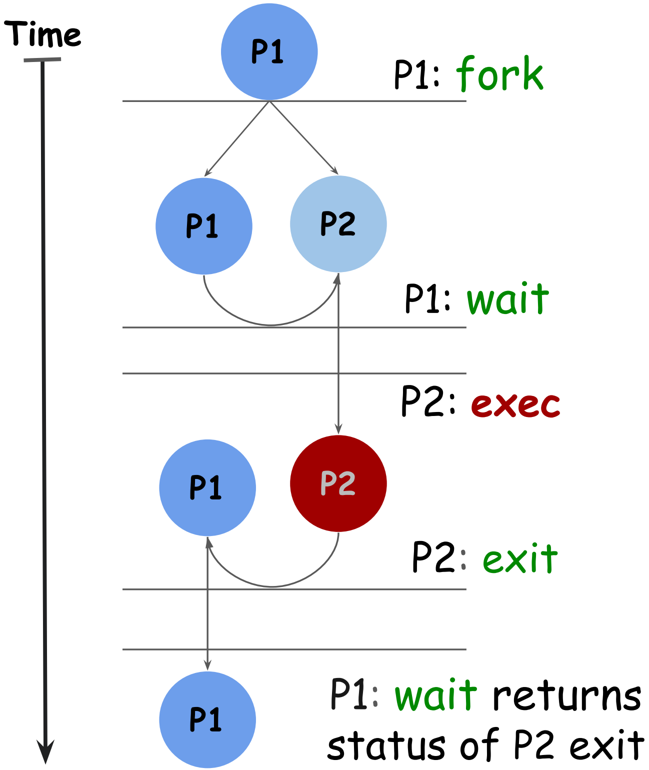

Process states

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- As the process executes ⇒ It transitions from state to state

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- **Terminated**: The process finished execution
  - Normally: By calling exit after its parent has called wait
  - As a "zombie:" The parent exists, but hasn't called wait() yet
  - Orphan: The parent has exited already

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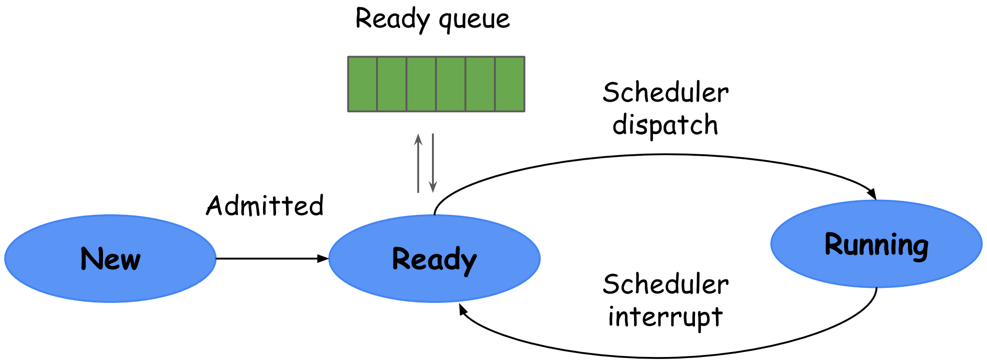

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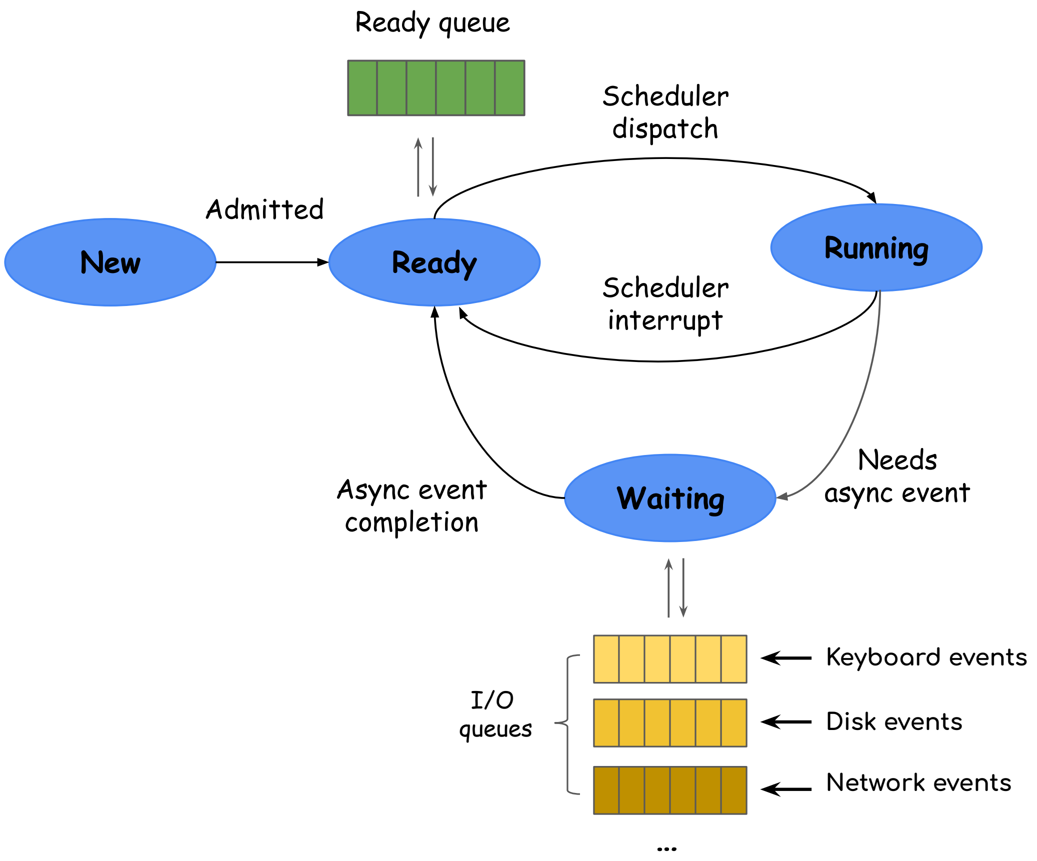

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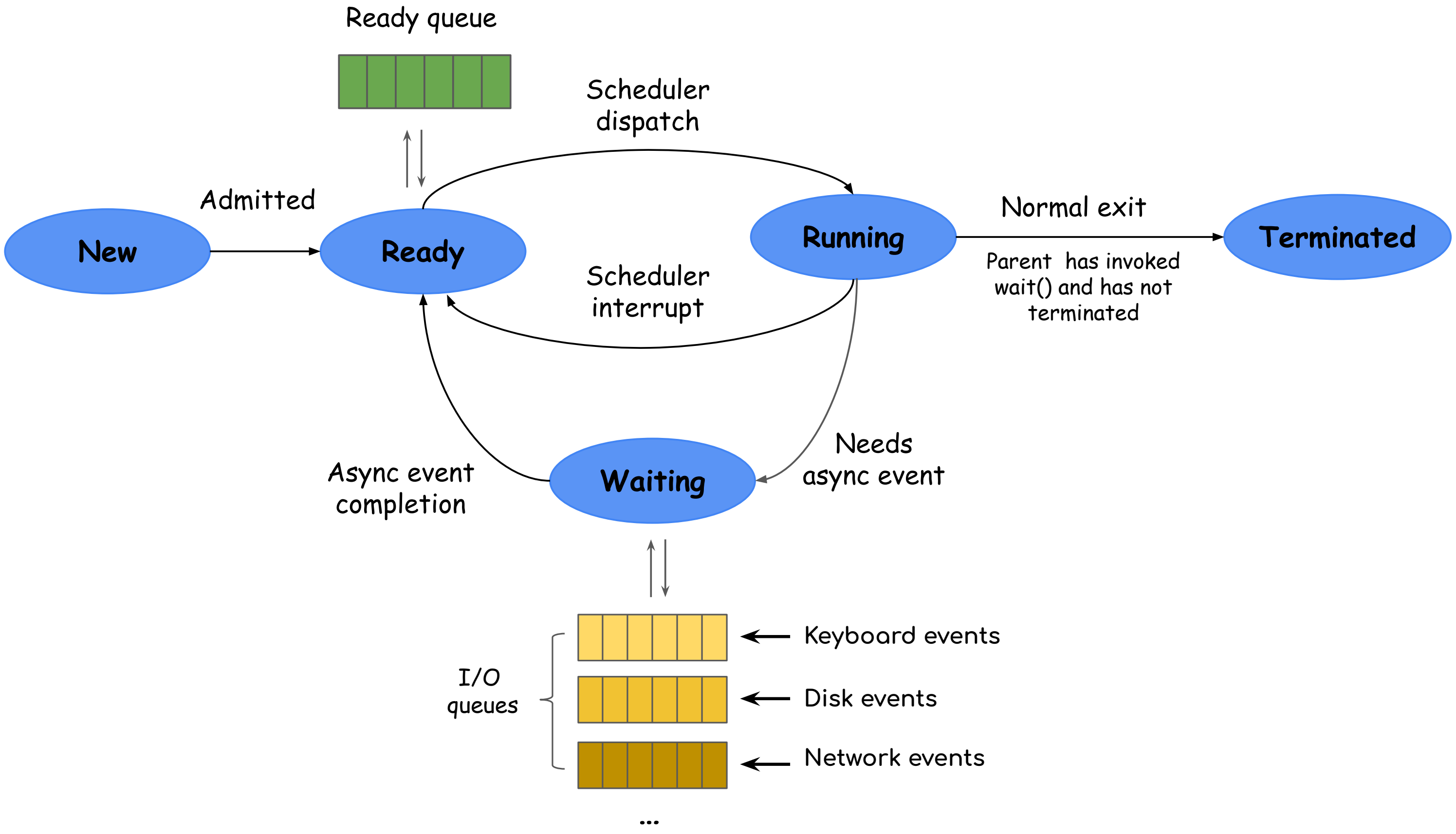

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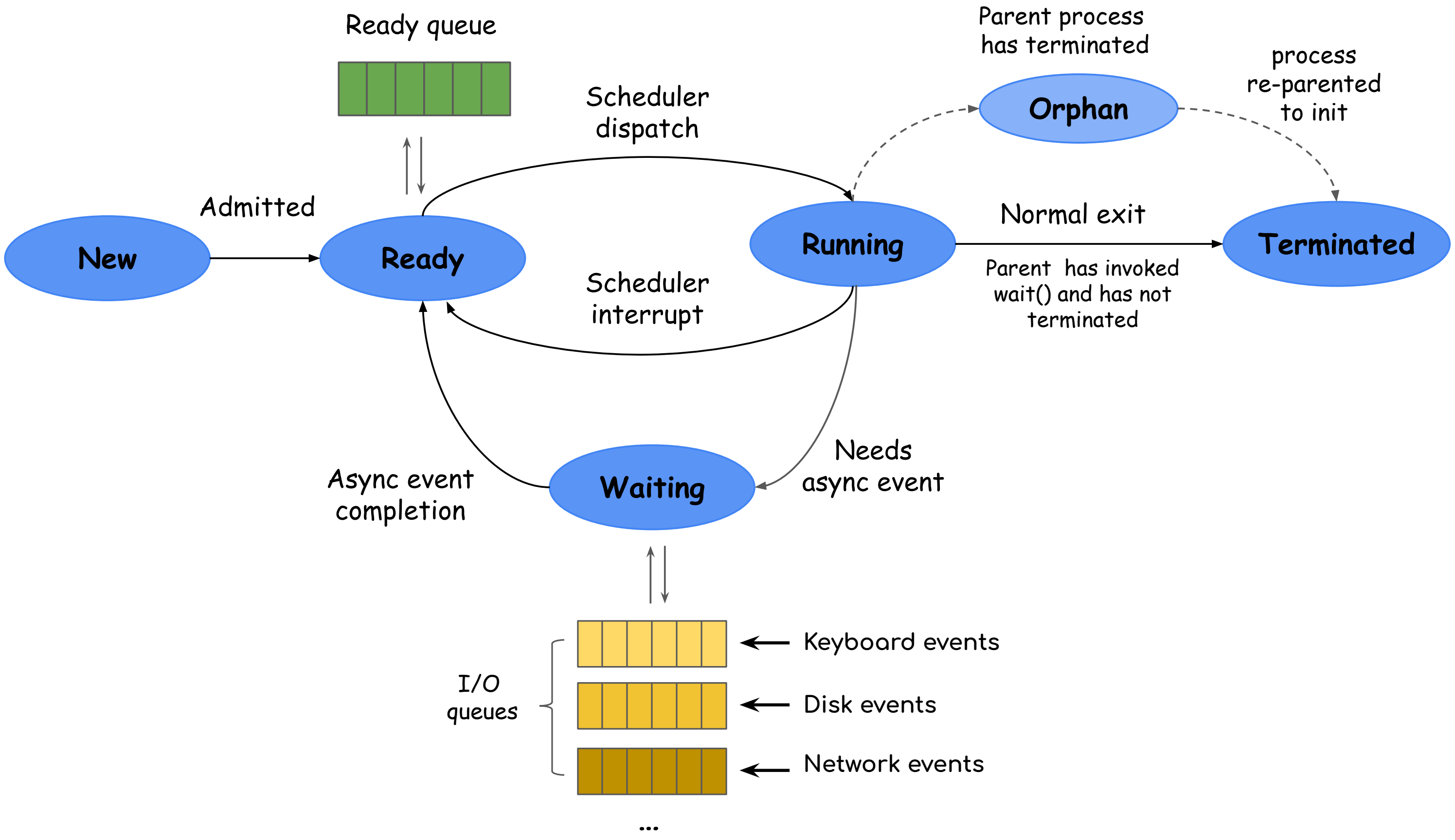

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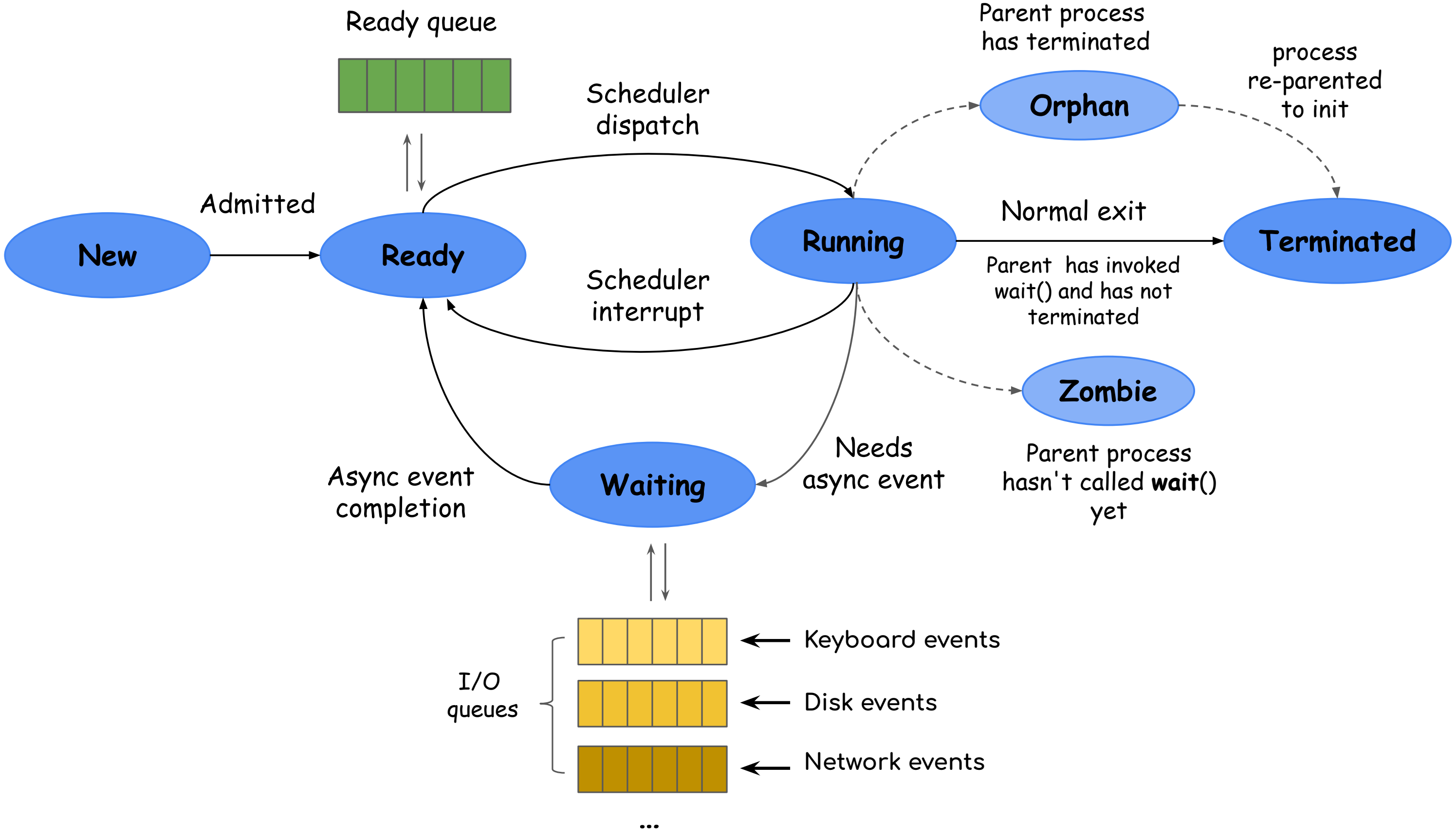

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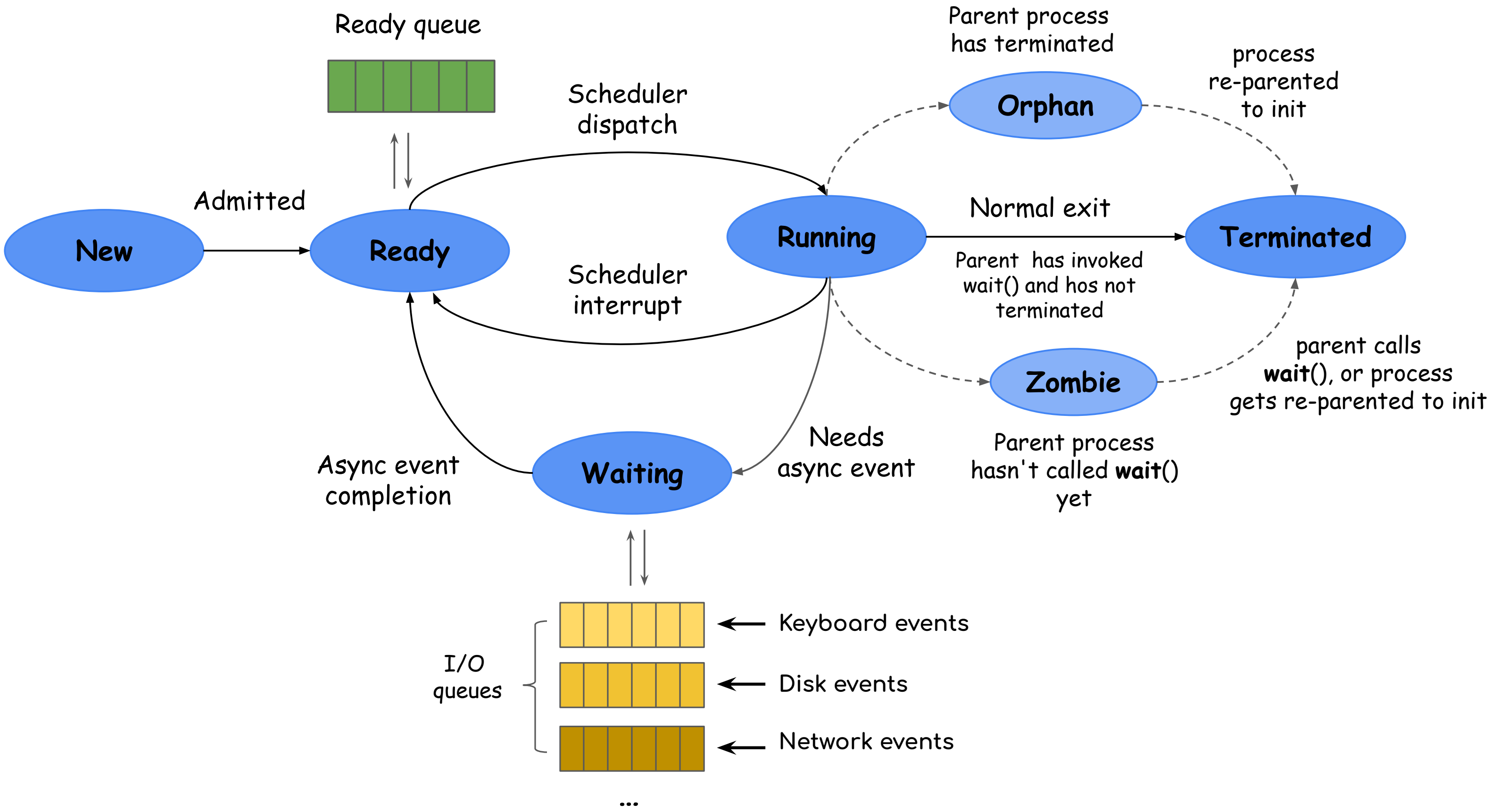

Process dispatching

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- One allocated on the processor

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Multiprogramming

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- Timesharing dispatching loop: Preemption — periodic timer interrupt

do {

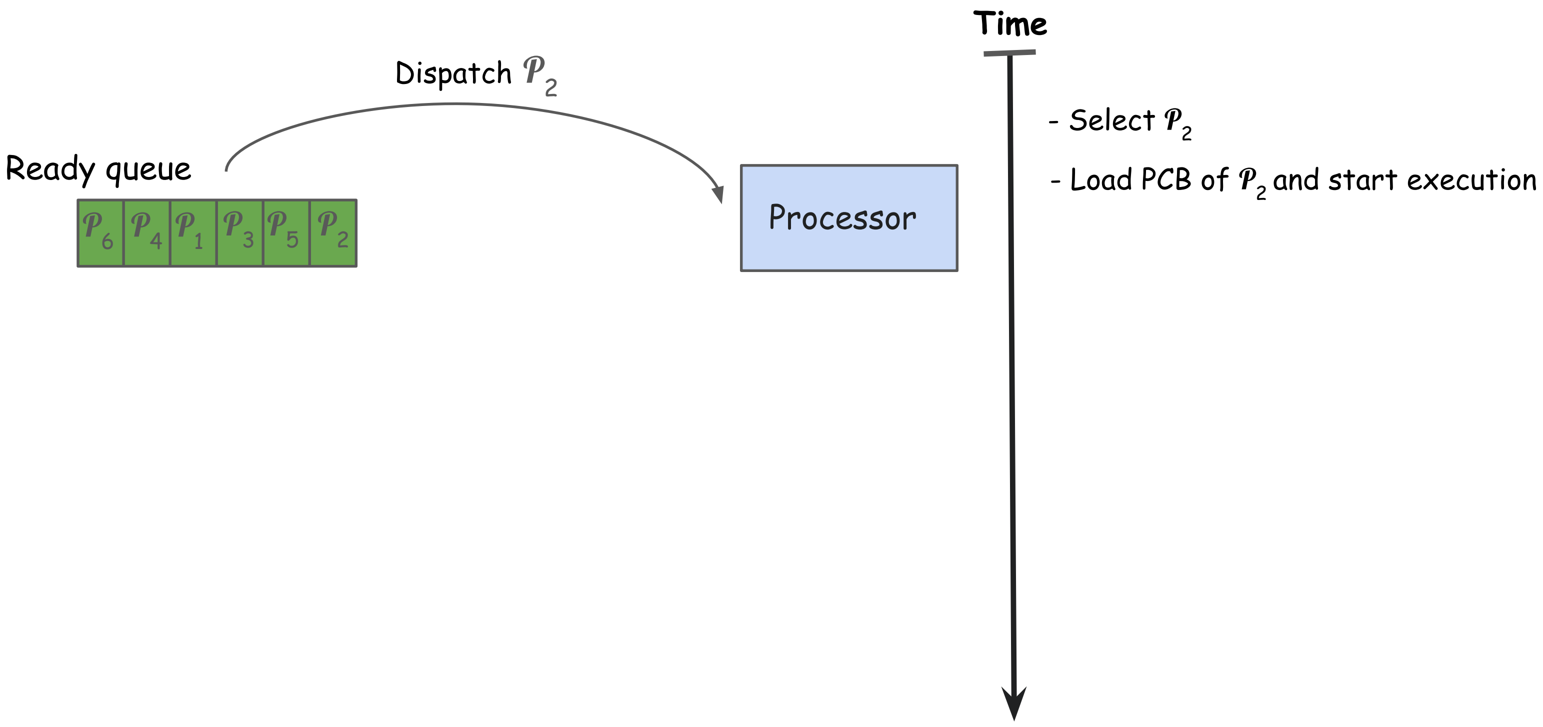
Get a process $\mathcal{P}$ from ready queue

Execute $\mathcal{P}$ until time $\mathcal{Q}$ expires

Put $\mathcal{P}$ back in ready queue

} while(1)

Process dispatching



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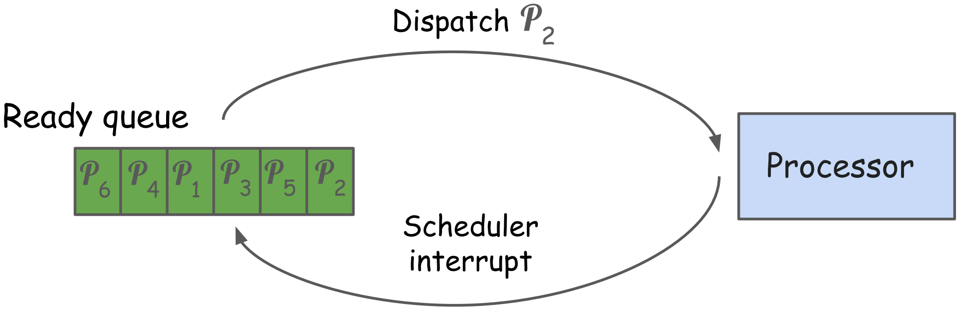
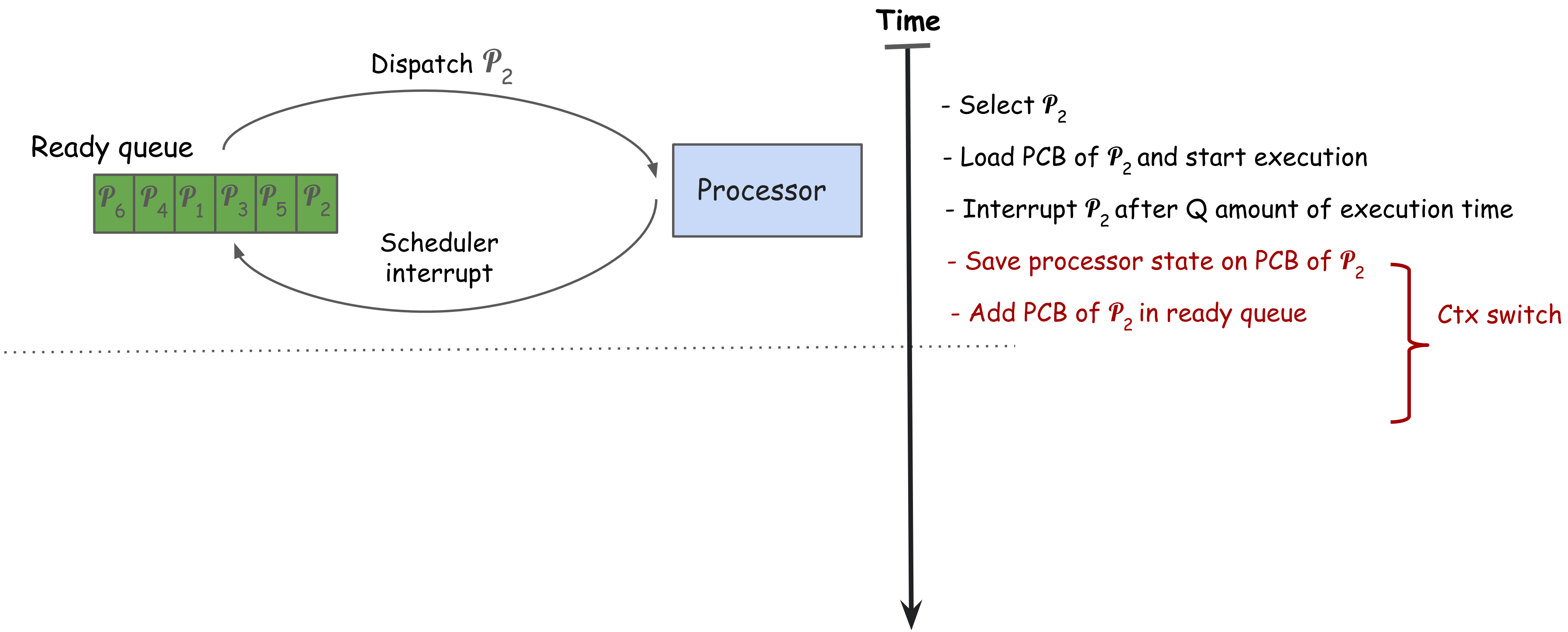


Time

- Select $\mathcal{P}_2$
- Load PCB of $\mathcal{P}_2$ and start execution
- Interrupt $\mathcal{P}_2$ after Q amount of execution time

Process dispatching



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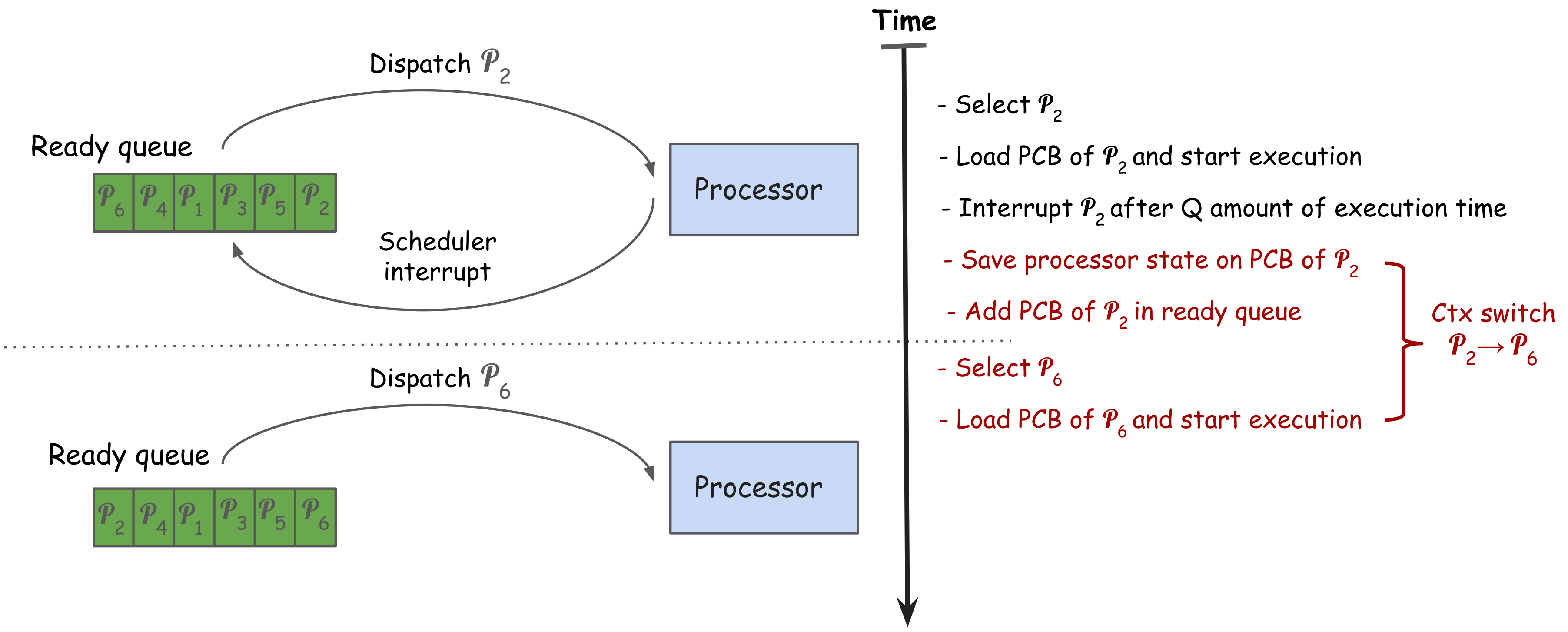

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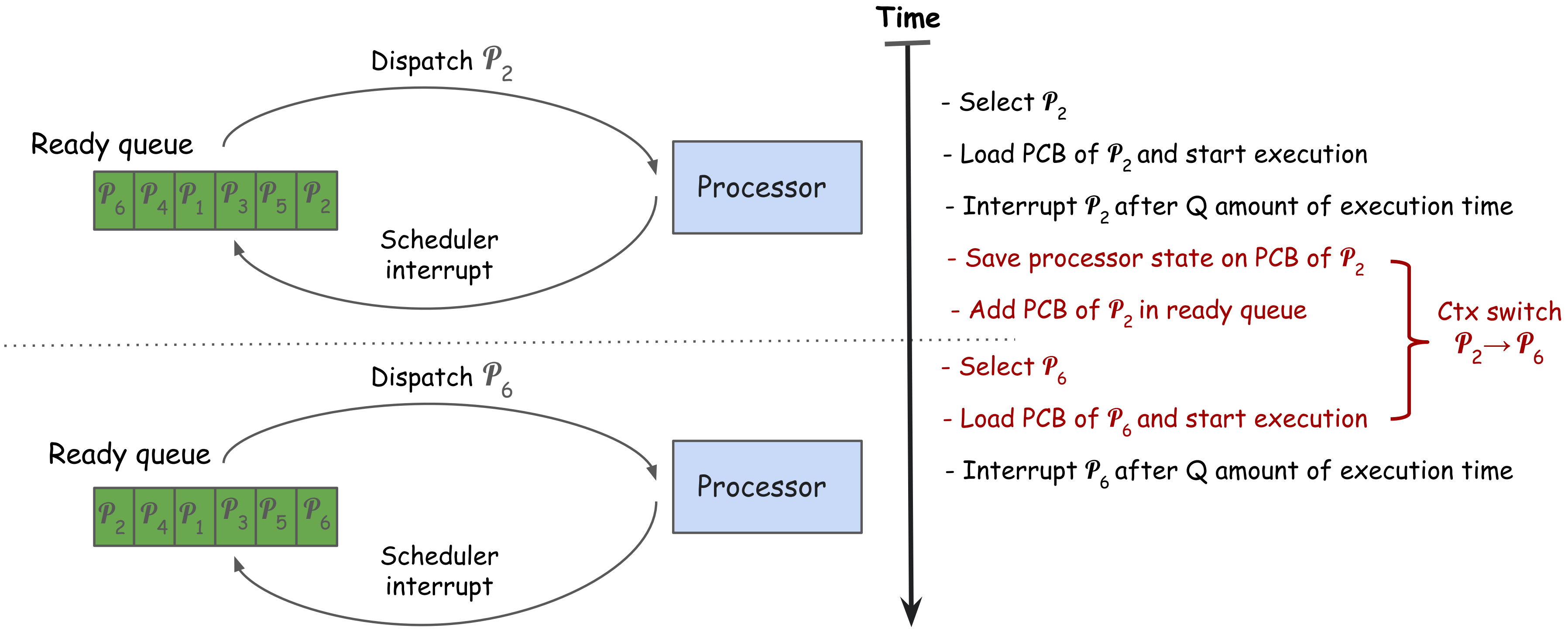

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