CS330: Operating Systems

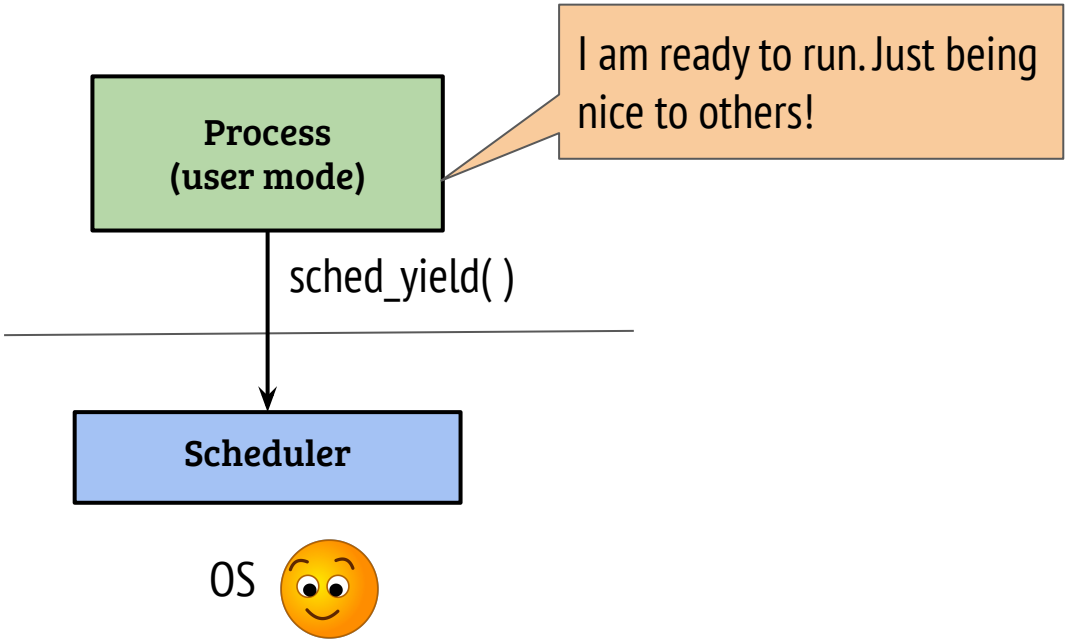
Process scheduling

Recap: OS execution, user-OS mode switch

- Which stack is used by the OS for kernel-mode execution?
- The hardware switches the SP to point it to a pre-configured per-process OS stack on mode switch
- How the user process state preserved and restored?
- The user execution state is saved/restored using the kernel stack by the hardware (and OS)
- Which address space the OS uses?
- A part of the process address space is reserved for OS and is protected

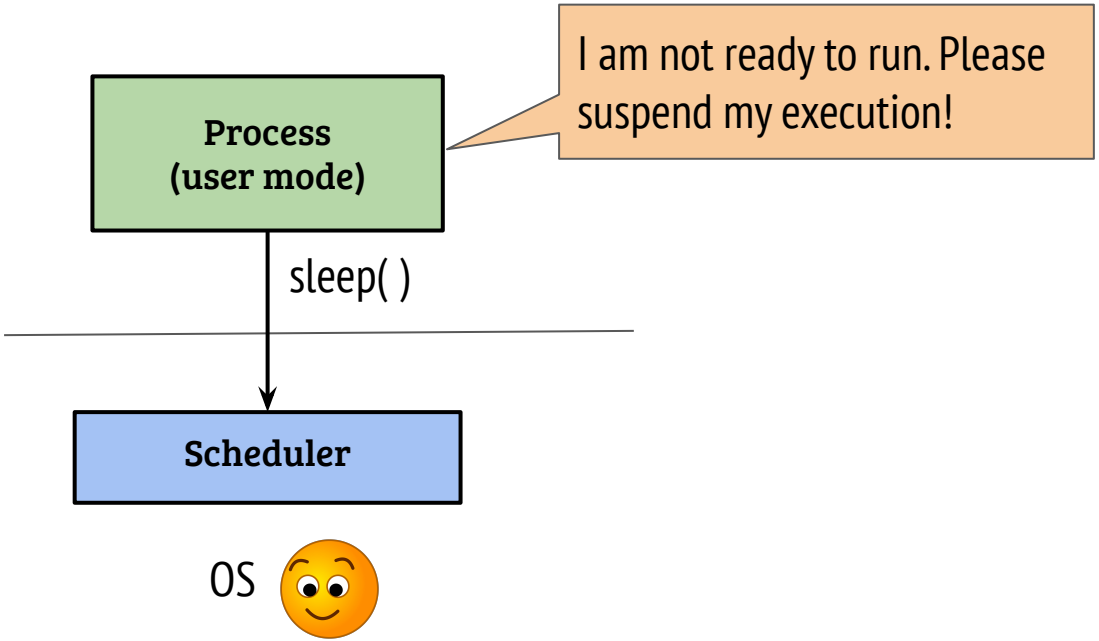
Agenda: Process context switch and scheduling

Triggers for process context switch



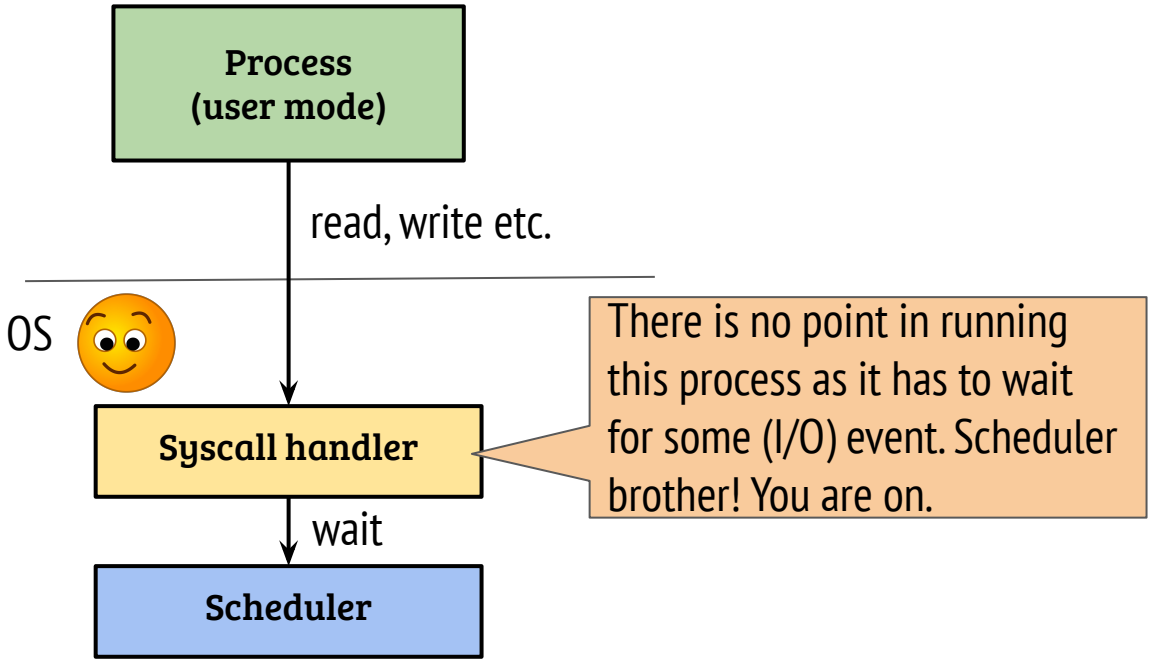
- The user process can invoke the scheduler through explicit system calls like sched_yield (see man page)

Triggers for process context switch



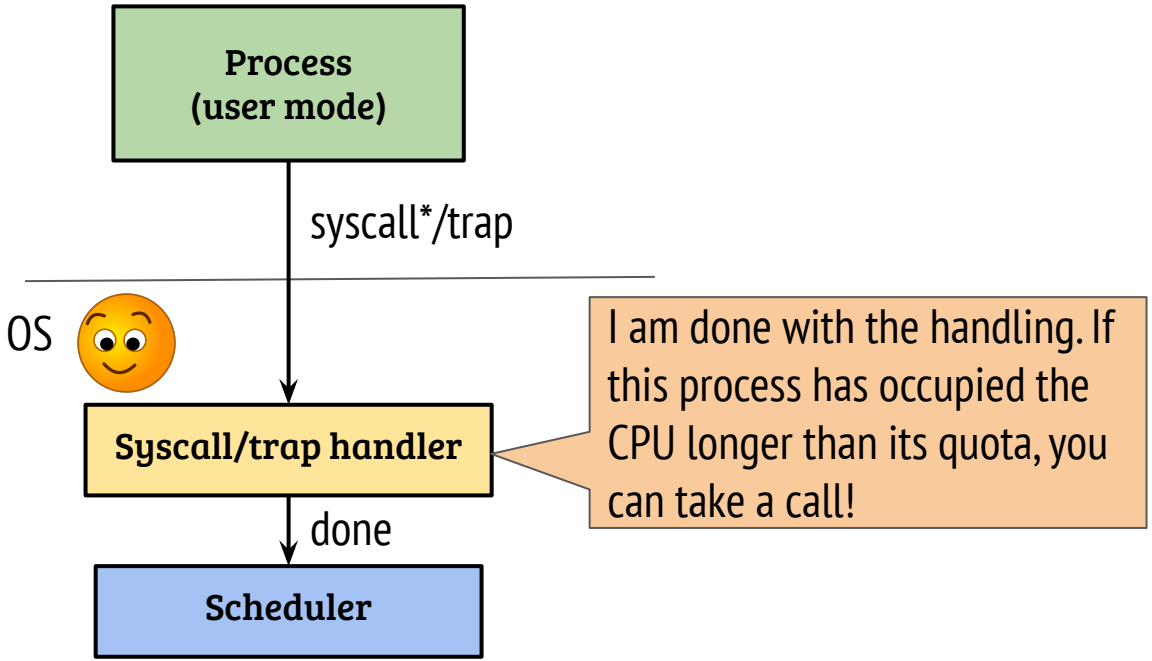
- The user process can invoke sleep( ) to suspend itself
  - sleep( ) is not a system call in Linux, it uses nanosleep( ) system call

Triggers for process context switch



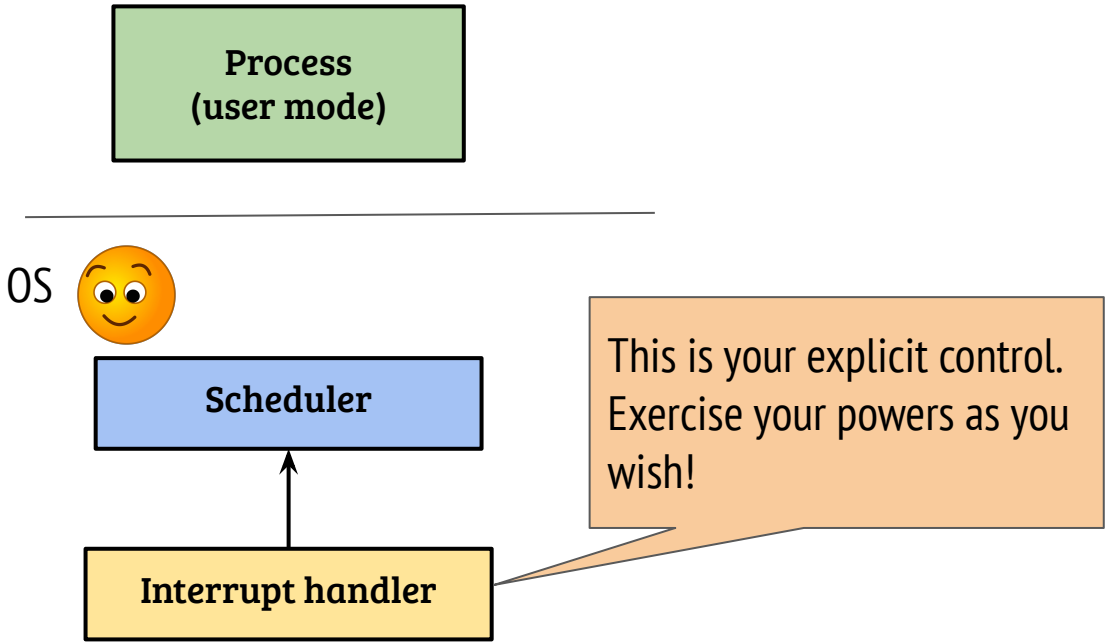
- This condition arises mostly during I/O related system calls
  - Example: read( ) from a file on disk

Triggers for process context switch



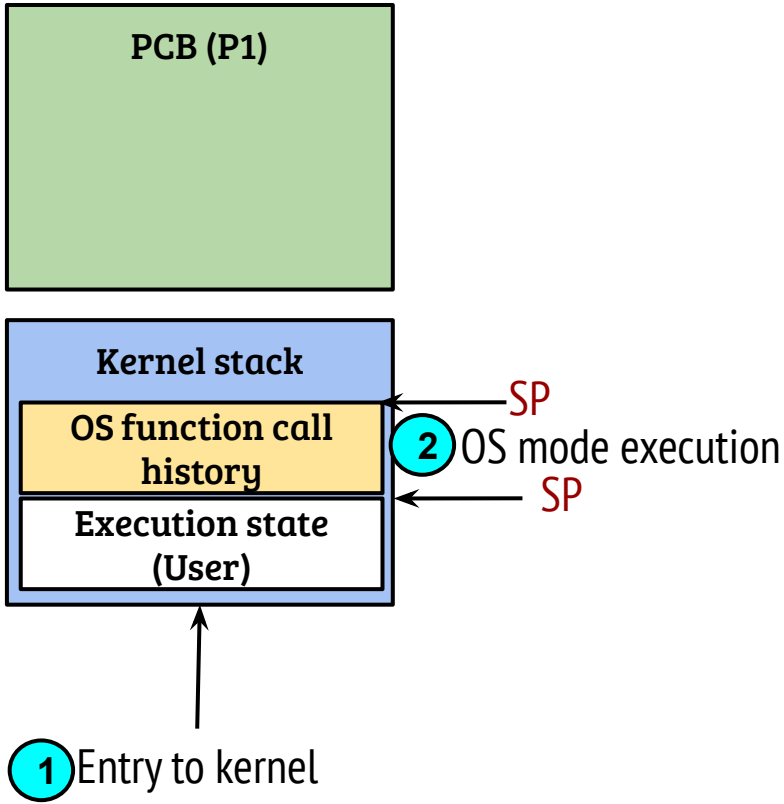
- The OS gets the control back on every system call and exception
- Before returning from syscall, the schedule can deschedule

Triggers for process context switch



- Timer interrupts can be configured to generate interrupts periodically or after some configured time
- The OS can invoke the scheduler after handling any interrupt

Process context switch



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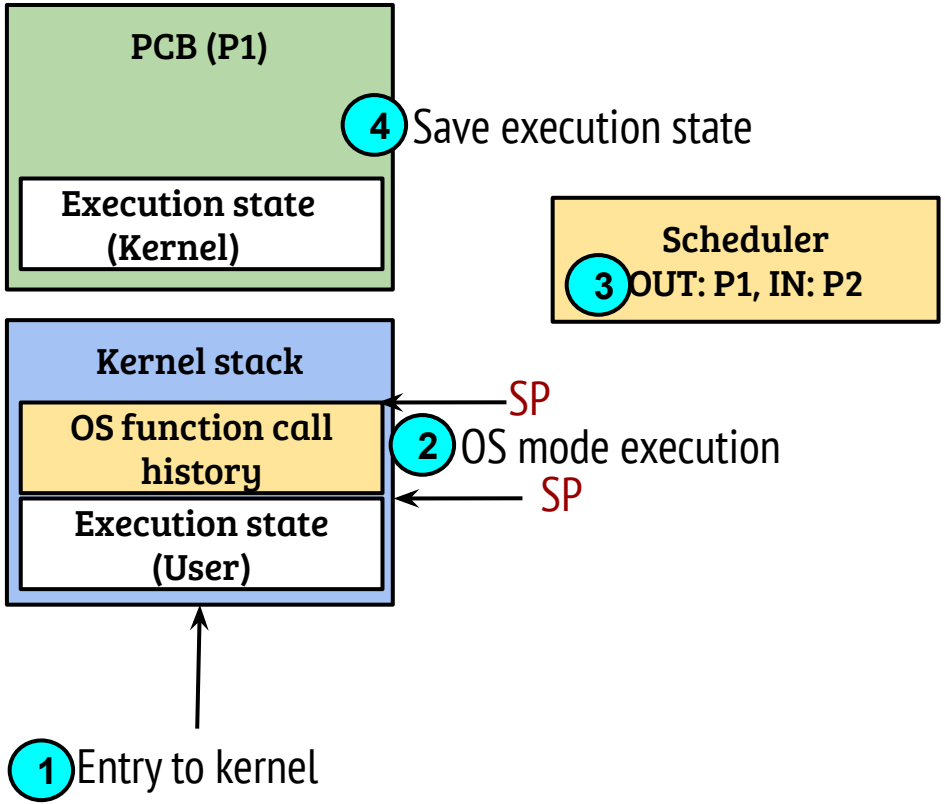
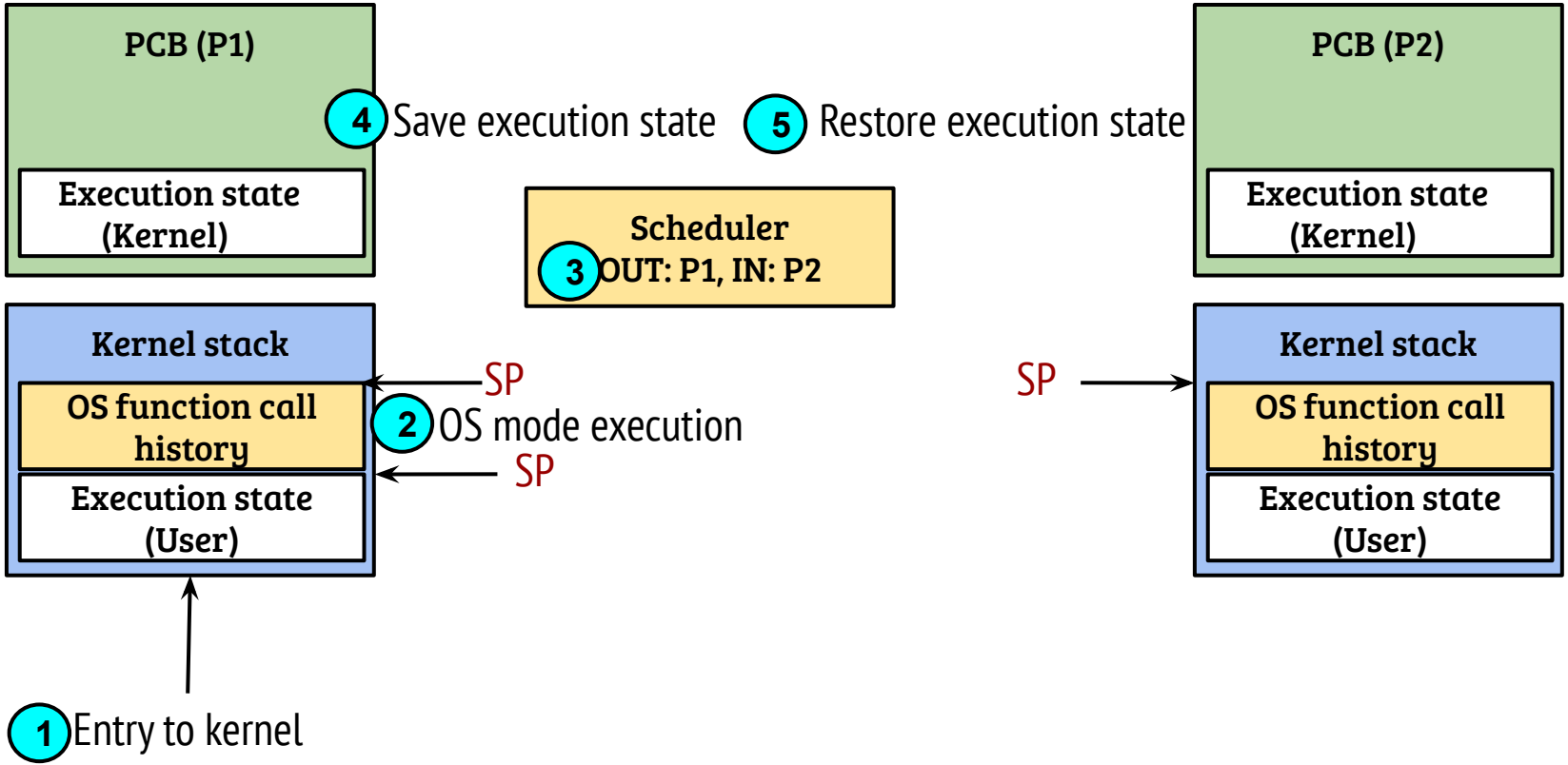


Process context switch



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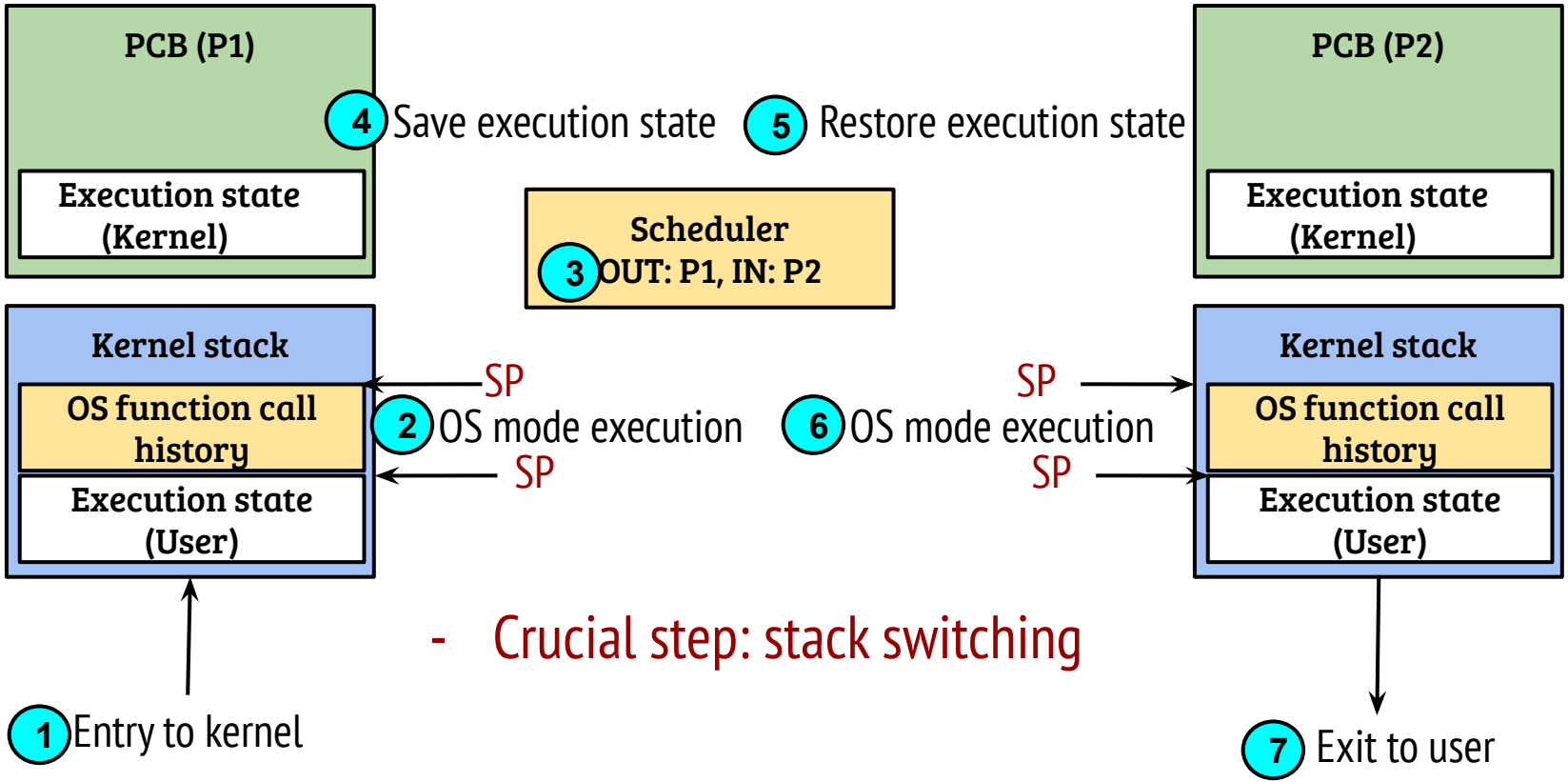
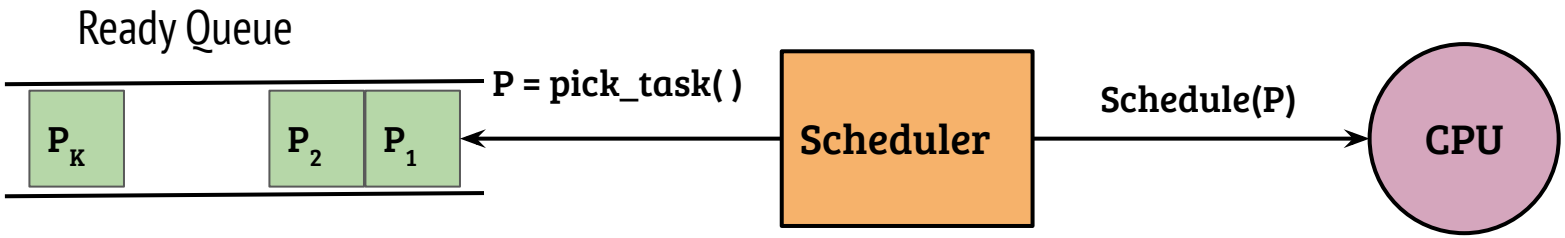


Scheduling



- A queue of processes ready to execute is maintained
- The scheduler decides to pick the next process based on some scheduling policy and performs a context switch
- The outgoing process is put back to ready queue (if required)

Scheduling

- How is the list of ready processes managed?
- What if there are no processes in ready queue? Can that happen?
- Can we classify the schedulers based on how they are invoked?
- What is a good scheduling strategy?

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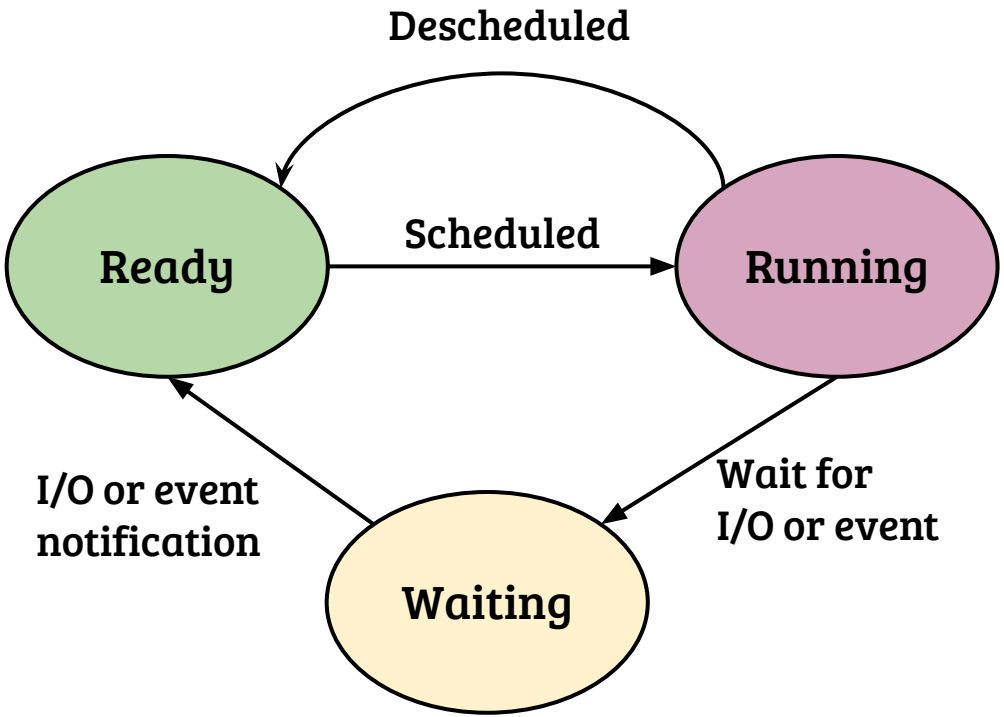
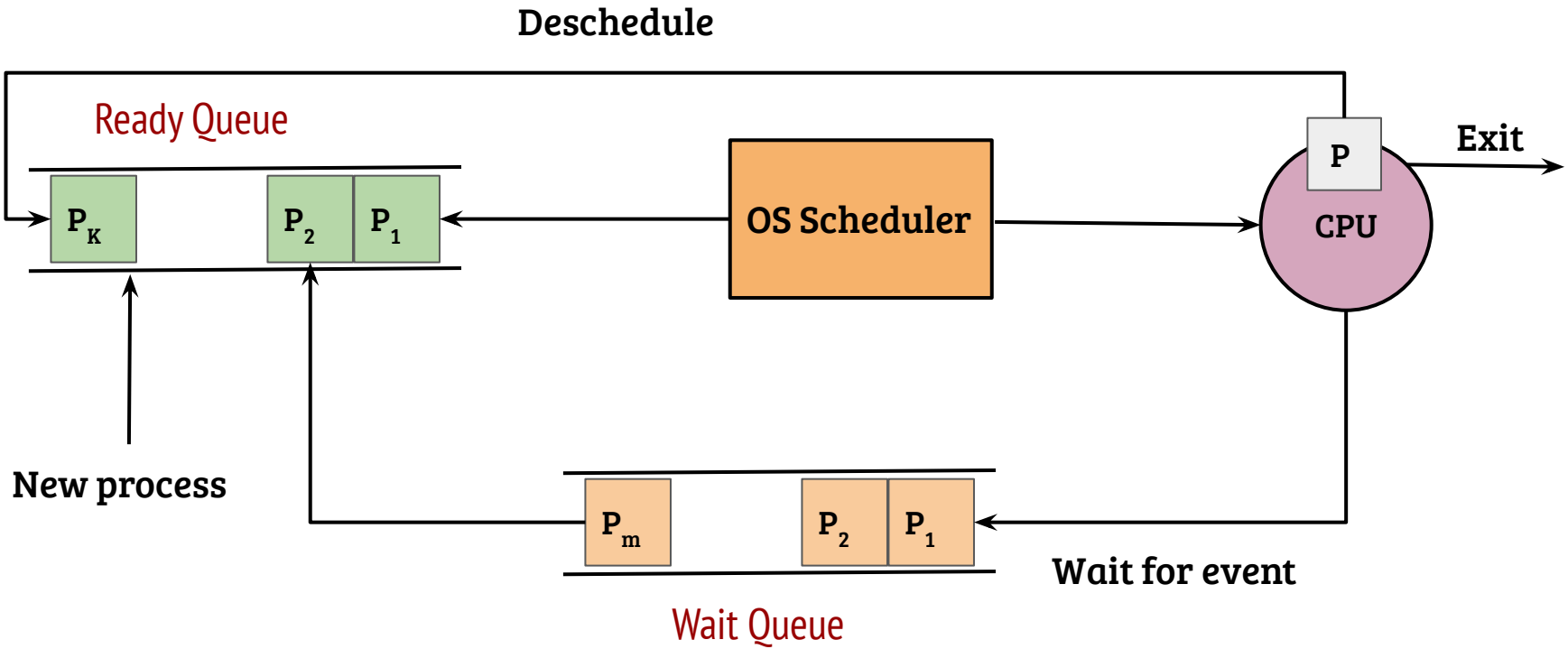
Process states and transitions



- Most processes perform a mixture of CPU and I/O activities
- When the process is waiting for an I/O, it is moved to waiting state
- A process becomes ready again when the event completion is notified (e.g., a device interrupt)

Scheduler overview

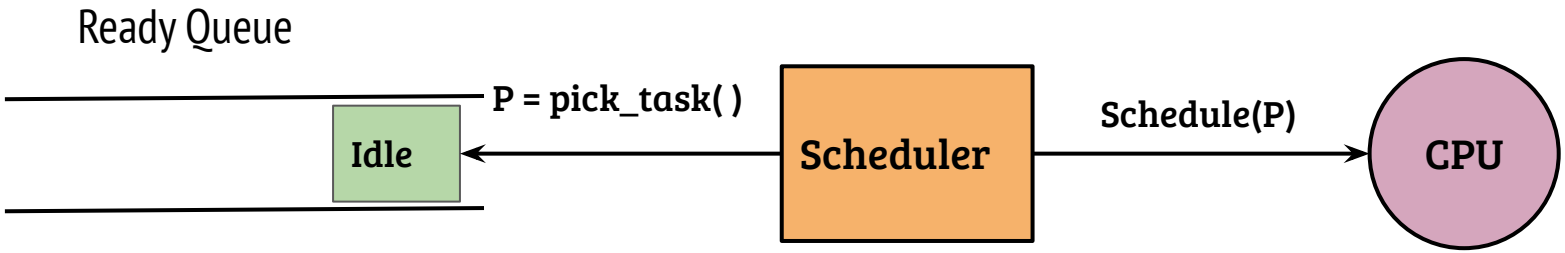


Scheduling

- How is the list of ready processes managed?
- Each process is associated with three primary states: Running, Ready and Waiting. A process can moved to waiting state from running state, if needed.
- What if there are no processes in ready queue? Can that happen?
- Can we classify the schedulers based on how they are invoked?
- What is a good scheduling strategy?

- The outgoing process is put back to ready queue (if required)

System idle process



- There can be an instance when there are zero processes in ready queue
- A special process (system idle process) is always there
- The system idle process halts the CPU
- HLT instruction on X86_64: Halts the CPU till next interrupt

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- There is always an idle process which executes HLT
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Scheduling: preemptive vs. non-preemptive

- There are scheduling points which are triggered because of the current process execution behavior (non-preemptive)
  - Process termination
  - Process explicitly yields the CPU
  - Process waits/blocks for an I/O or event

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- There are scheduling points which are triggered because of the current process execution behavior (non-preemptive)
  - Process termination
  - Process explicitly yields the CPU
  - Process waits/blocks for an I/O or event
- The OS may invoke the scheduler in other conditions (preemptive)
  - Return from system call (specifically fork( ))
  - After handling an interrupt (specifically timer interrupt)

Scheduling

Ready Queue

- How is the list of ready processes managed?
- Each process is associated with three primary states: Running, Ready and Waiting. A process can moved to waiting state from running state, if needed.
- What if there are no processes in ready queue? Can that happen?
- There is always an idle process which executes HLT
- Can we classify the schedulers based on how they are invoked?
- Non-preemptive: triggered by the process, Preemptive: OS interjections
- What is a good scheduling strategy?

Scheduling metrics

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  - Objective: *Minimize turnaround time*

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- Average value of above metrics represent the average efficiency
- Standard deviation represents fairness across different processes