Operating Systems (INFR10079)

2020/2021 Semester 2

Scheduling

(Basics)

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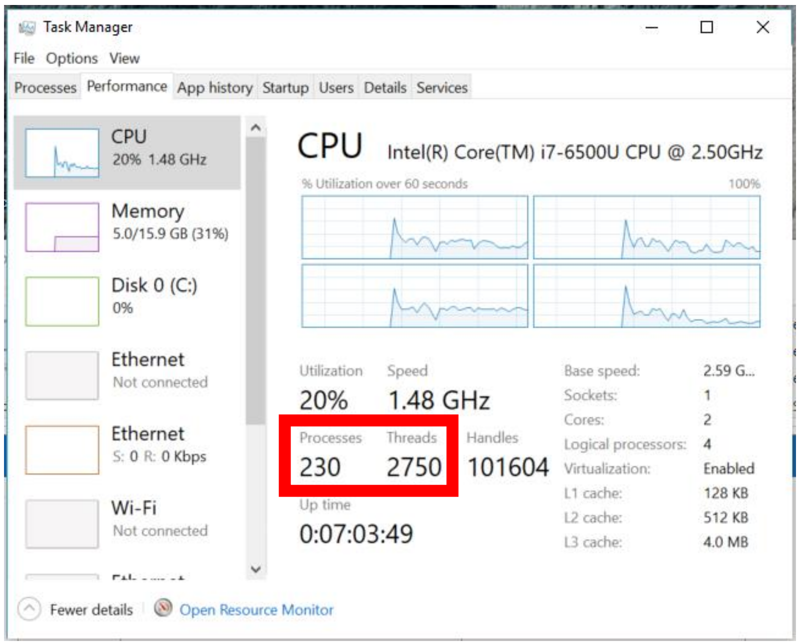
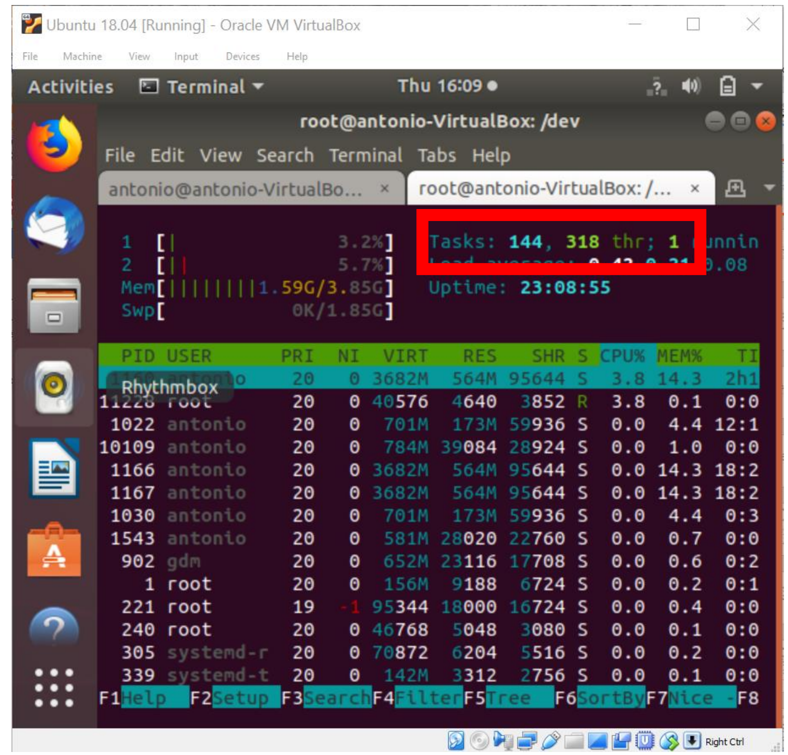
Chapter 5.1, 5.2

How Many Processes or Threads Are Running On My Computer?



Window’s Task Manager

UNIX’s htop (or top)



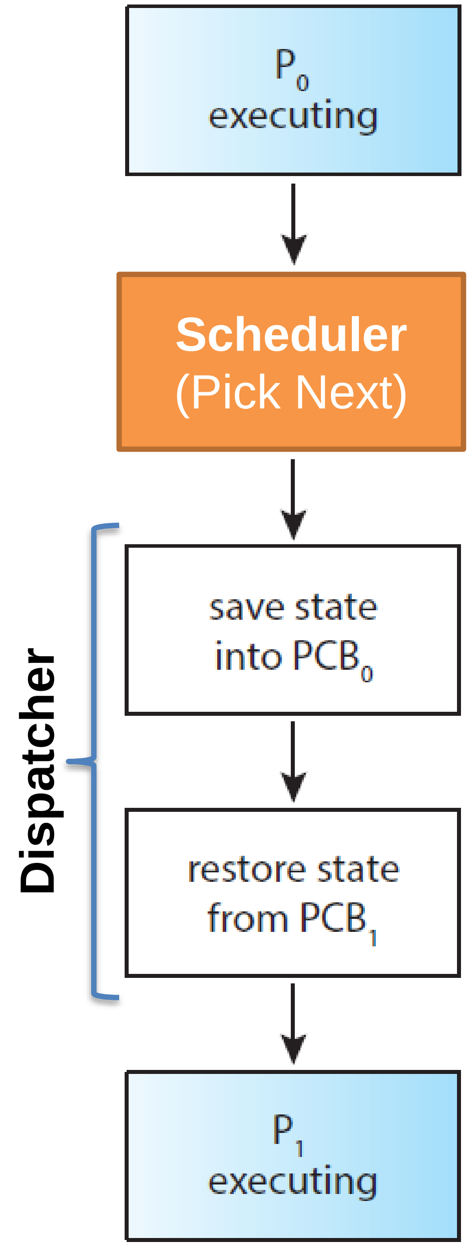
Who will run next?

Scheduling

Single CPU/core

- Decision of who will r**un next**
  - Process or thread
  - **In kernel for kernel-level threading** (slideset' focus)
- **Pick among** the ones in ready queue(s)

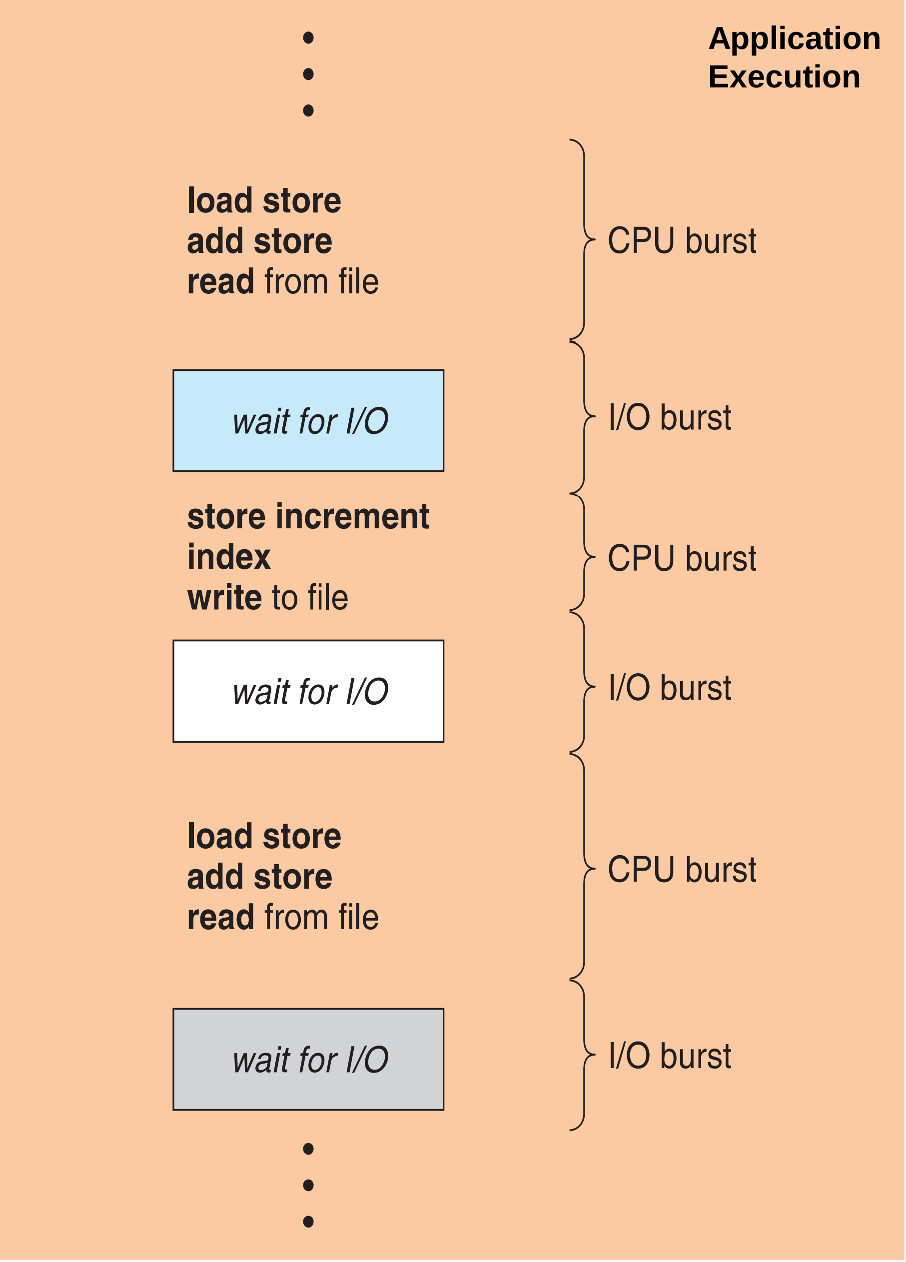
- *When?*
  - Potentially, **all times we switch** to the OS
    - Interrupt (device completion, timer interrupt, etc.)
    - Syscall (including voluntary process/thread termination, or yield)
    - Exception (including involuntary termination)
- *How?*
  - **Scheduler** decides
    - Policy (implemented by an algorithm)
  - Task switched by **dispatcher**
    - Mechanism (kernel or user code)



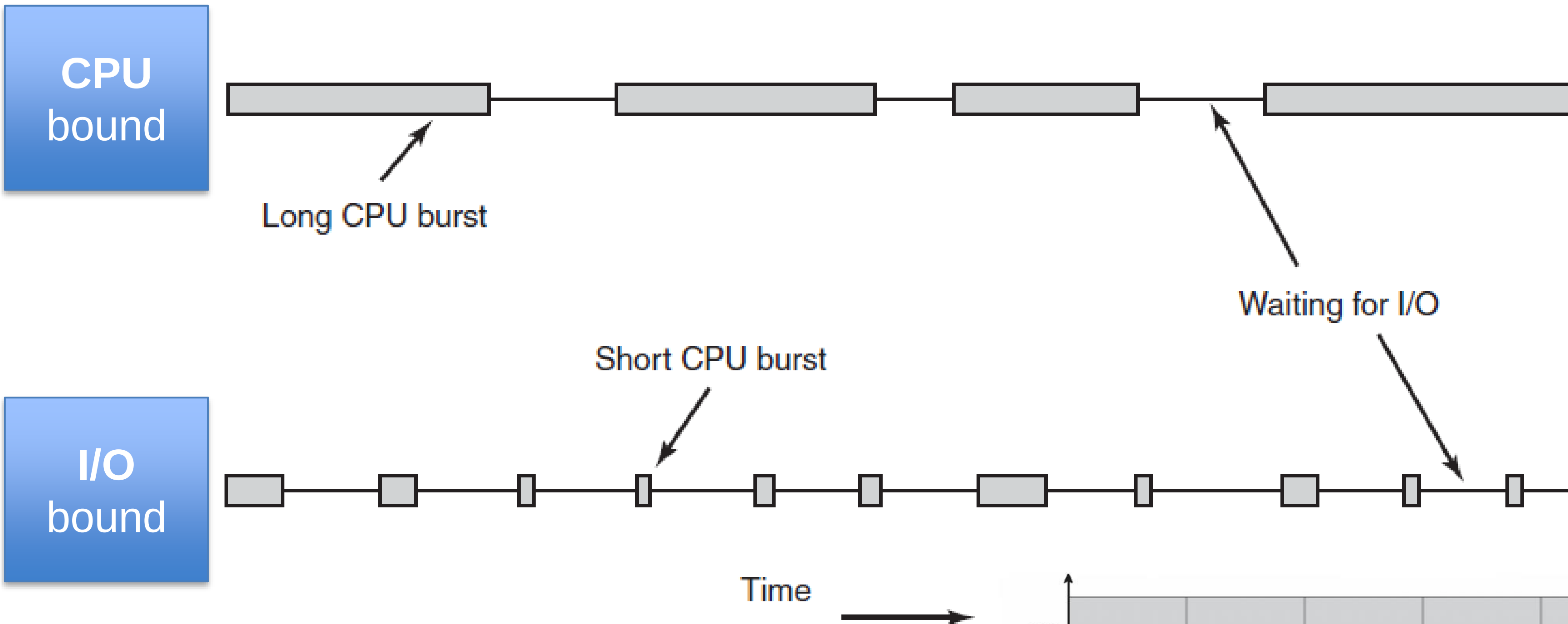
Process or Thread Behavior #1

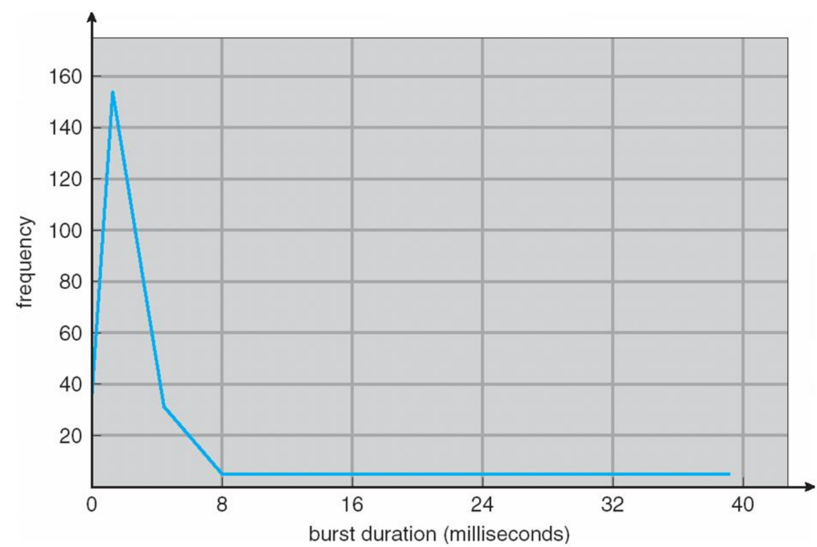
- Process or thread execution consists of cycles of
  - CPU execution: **CPU burst**
  - I/O wait: **IO burst**
- **CPU bursts** distribution is **application dependent**

- **Maximum CPU utilization** with multiprogramming
  - Don’t leave CPU idle
- While a process or thread is waiting for IO **another can run** on the CPU
  - Focus on **single** CPU/core



Process or Thread Behavior #2





While a process or thread is waiting for IO **another can run** on the CPU

Scheduling Goals: Performance

- Many performance goals (which may conflict)
  - Maximize CPU utilization
  - Maximize throughput (`processes completed per time unit`)
  - Minimize turnaround time (`time from submission of task to completion`)
  - Minimize waiting time (`all periods spent waiting in the ready queue from submission`)
  - Minimize response time (`time from submission of request to response is produced`)
  - Minimize energy (`joules per instruction`) subject to some constraint (`e.g., frames/second`)
- In most cases we optimize the **average metric**
  - But sometimes minimize the worst case (e.g., response time)

Scheduling Goals: Fairness

- No single, compelling definition of **"fair"**
  - How to **measure** fairness?
    - Equal CPU consumption? (over what time scale?)
  - Fair per-user? per-process? per-thread?
  - What if one process is CPU bound and one is I/O bound?

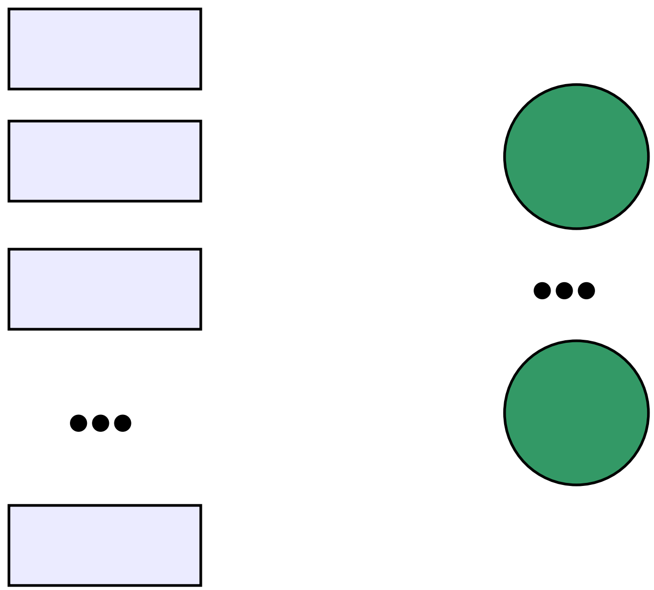
- Sometimes the goal is to be **unfair**
  - Explicitly favor some particular class of requests
    - **Priority system**
  - Avoid starvation
    - Be sure everyone gets at least some service

Classes of Schedulers

- Batch
  - Throughput / utilization oriented
  - *Example:* audit inter-bank funds transfers each night, Pixar rendering, Hadoop/MapReduce jobs
- Interactive
  - Response time oriented
  - *Example:* window-based operating system
- Real time
  - Deadline driven
  - *Example:* embedded systems (cars, airplanes, etc.)

We will **not talk** about real-time scheduling

General Scheduling Problem



Schedulable units
(Processes or Threads)

Resources
(CPU, …)

Scheduling:

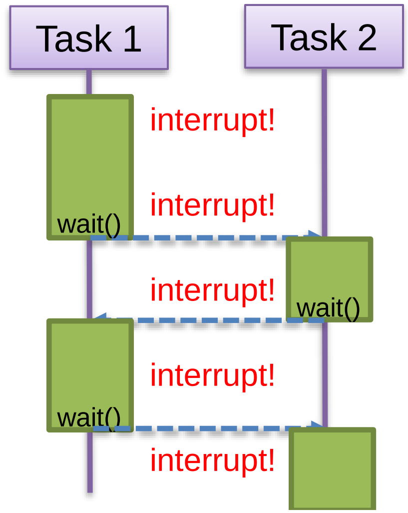
- **Who** to *assign* each resource to
- **When** to re-evaluate your decisions

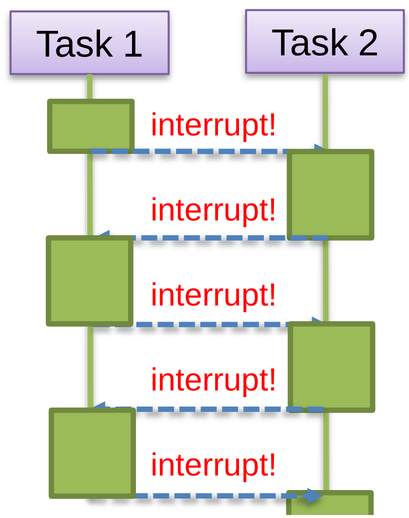
Scheduling **is not** just about assigning *processes and threads* to the CPU, but to **any other HW/SW resource** of the computer

When to Re-evaluate the Decision?

- **Non-preemptive** scheduling
  - Processes/threads execute until completion or until they want
    - **Voluntary process switch**
    - **Process/thread switch on blocking calls**
  - The scheduler gets involved only at exit or on request
    - For every clock interrupt, running process keeps going

- **Preemptive** scheduling
  - While a process/thread executes, its execution may be paused, and another process/thread resumes its execution, etc.
    - **Involuntary process switch**
    - For every clock interrupt, running process may be suspended and switched with another process (if there is any)





wait()s removed to ease the draw