Sistemi Operativi I

Corso di Laurea in Informatica

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Recap from Last Lecture

- Process is the **unit of execution** (running on a single CPU)
- OS keeps track of process-related information using an ad hoc data structure called Process Control Block (PCB)
- Process can be in one of **5 possible states**: **new**, **ready**, **waiting**, **running**, or **terminated**
- **Context switch** to intertwine the execution of multiple processes
- Process communication either via message passing or shared memory

Today: CPU Scheduling

Policy to establish which process to execute on the CPU

- Basic scheduling concepts
- Scheduling **criteria/metrics**
- Scheduling **algorithms**
- Advanced scheduling concepts

Basic Concepts

- Almost every program has some alternating cycles of CPU computations and I/O waiting
- Even a simple fetch from main memory takes a long time relatively to CPU speed
- Our assumptions: Multi-programmed, uni-processor system

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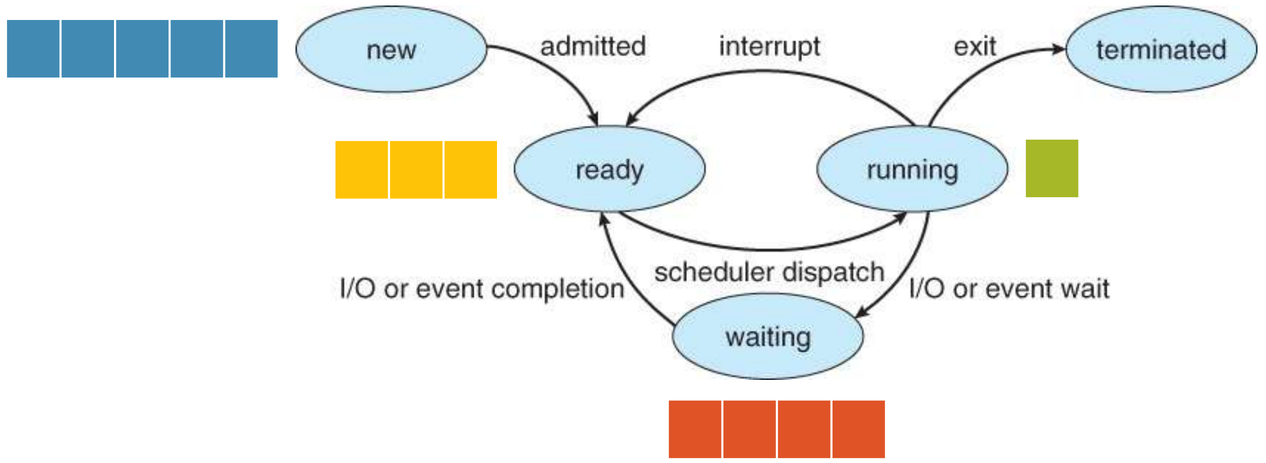
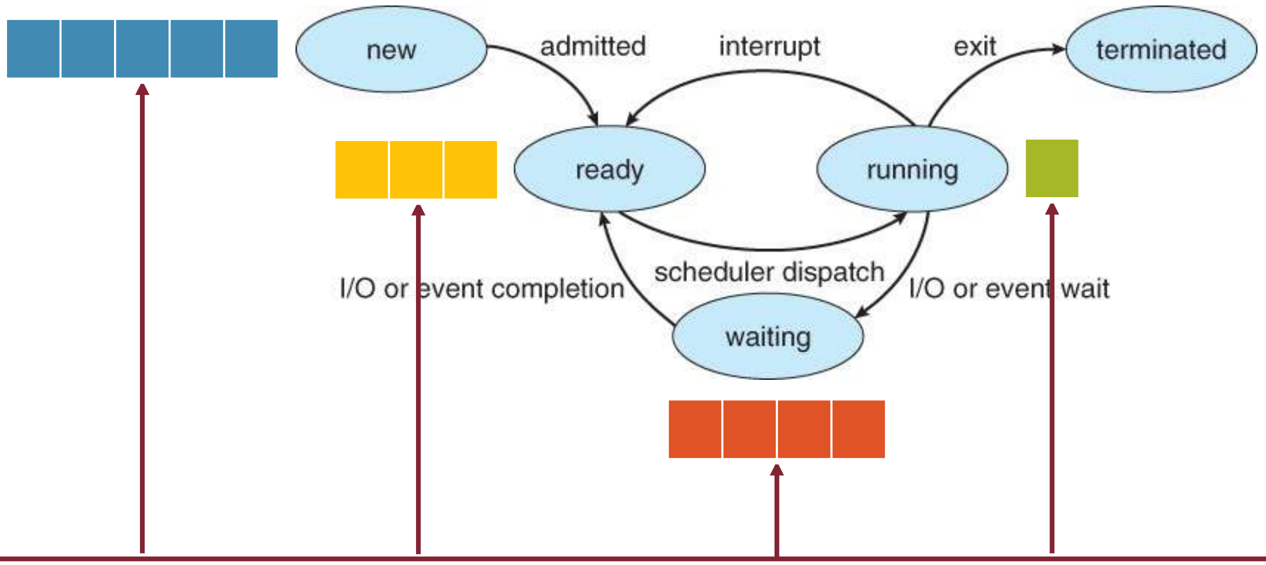
- A scheduling system allows one process to use the CPU while another is waiting for I/O, thereby maximizing system utilization
- **Challenge:** Make the system as "efficient" and "fair" as possible, subject to varying and often dynamic conditions

Process Execution State Diagram

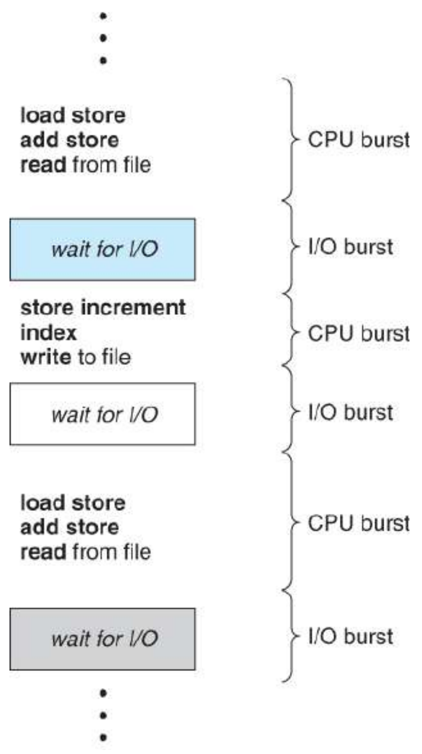


Process Execution State Diagram



Processes managed by the OS reside in exactly one of the state queues

CPU vs. I/O Burst Cycle



All processes alternate between two states in a continuing cycle: CPU burst and I/O burst

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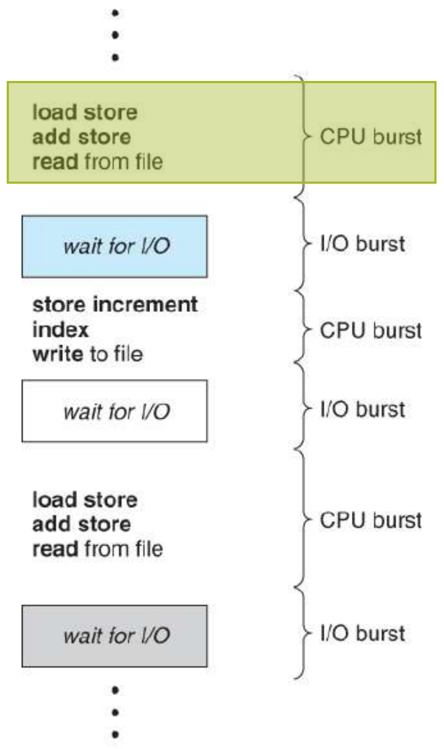

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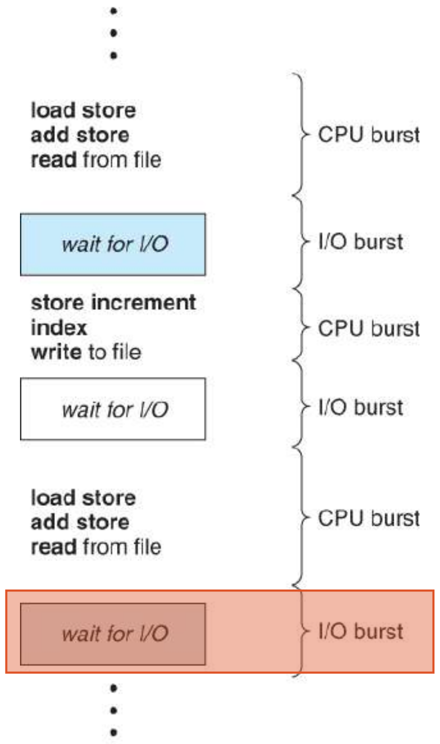
CPU burst → performing calculations

CPU vs. I/O Burst Cycle



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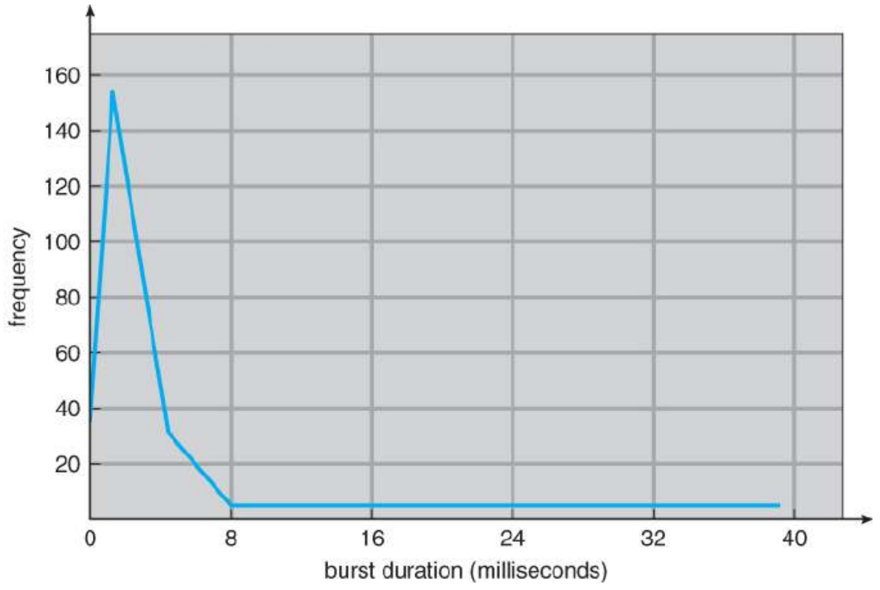
I/O burst → waiting for data transfer in or out of the system

CPU Burst Cycle: Frequency Pattern



Highly skewed distribution

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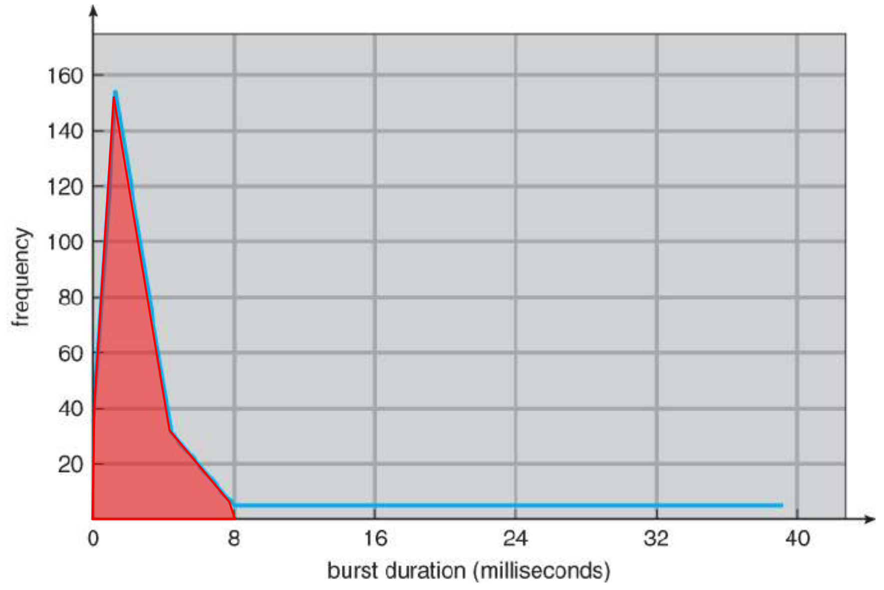

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The vast majority of processes have short CPU bursts

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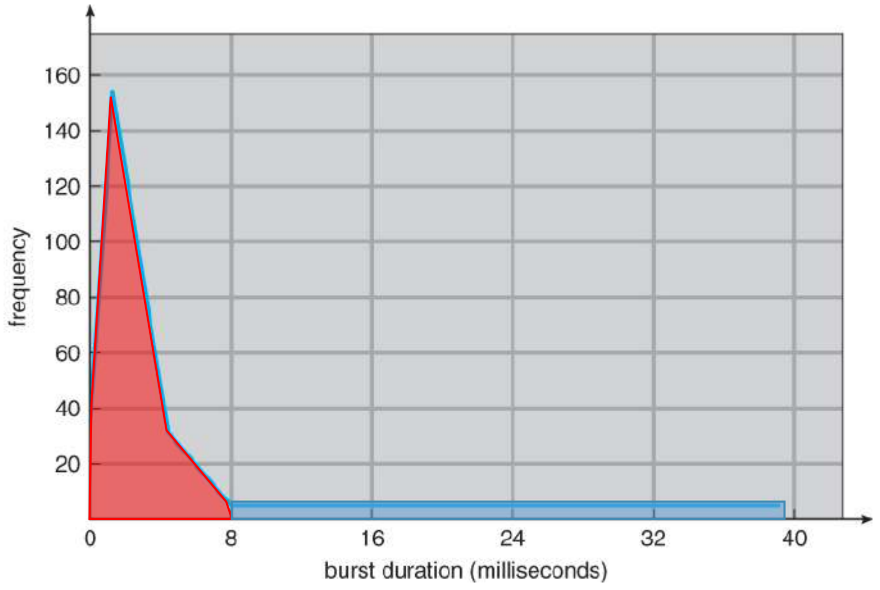

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The vast majority of processes have short CPU bursts

Few processes exhibit very long CPU bursts

Long- vs. Short-term Scheduling

Long-term scheduling

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Policy goals vs. Mechanism implementations

CPU Scheduling: When?

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for an I/O request or invocation of the wait system call

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in response to an interrupt

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after I/O completion or a return from wait

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4. When a process is **created** or **terminates**

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No choice!
A new process must be selected

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Either continue with the current process or select a new one

Non-preemptive vs. Preemptive

Non-preemptive scheduling

If it takes place only when there is no choice (i.e., conditions 1 and 4)

Once a process starts it keeps running until it either voluntarily blocks or it finishes

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Preemptive scheduling

Whenever scheduling takes also place under conditions 2 and 3

Non-preemptive vs. Preemptive: Examples

	Windows	Mac	UNIX-like
Non-preemptive	up to Win 3.x	up to Mac OS 9.x	–
Preemptive	since Win 95	since Mac OS X	since forever

Preemption: Issues

- Preemption might cause troubles if it occurs while:
  - the kernel is busy implementing a system call (e.g., updating critical kernel data structures)
  - two processes share data, one may get interrupted in the middle of updating shared data structures

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should only be done in rare situations, and only on very short pieces of code that will finish quickly

The Dispatcher

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- Its functions include:
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  - Jumping to the proper location in the newly loaded program
- The dispatcher is run on every context switch therefore the time it consumes (**dispatch latency**) must be as shortest as possible

Useful Definitions

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NOTE

I/O waiting time is not considered here!

Useful Definitions

$$T^{arrival} = \text{arrival time}$$

$$T^{completion} = \text{completion time}$$

$$T^{burst} = \text{burst time}$$

$$T^{turnaround} = \text{tournaround time} = T^{completion} - T^{arrival}$$

$$T^{waiting} = \text{waiting time} = T^{turnaround} - T^{burst}$$

Scheduling Criteria/Metrics

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  - CPU utilization
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Scheduling: Trade-off

- Ideally, choose a CPU scheduler that optimizes all metrics simultaneously
- Generally, the above is impossible and a trade-off is needed!
- **Idea:** Choose a scheduling algorithm based on its ability to satisfy a given policy

Scheduling Policies

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  - Provide output to the user as quickly as possible

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Typical of batch systems

A Quick Note on Terminology

JOB/TASK

General unit of CPU execution

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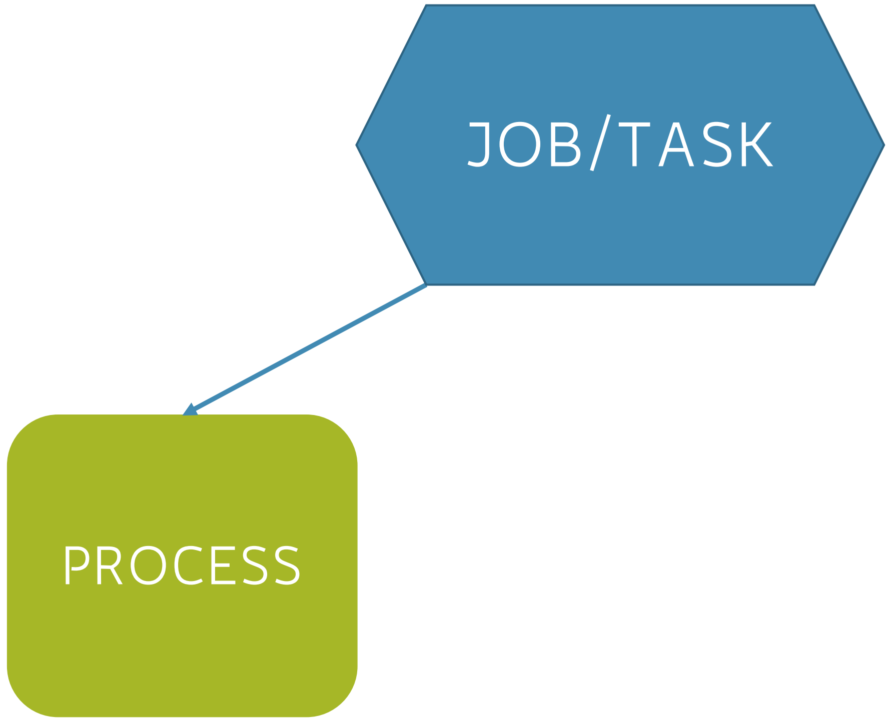

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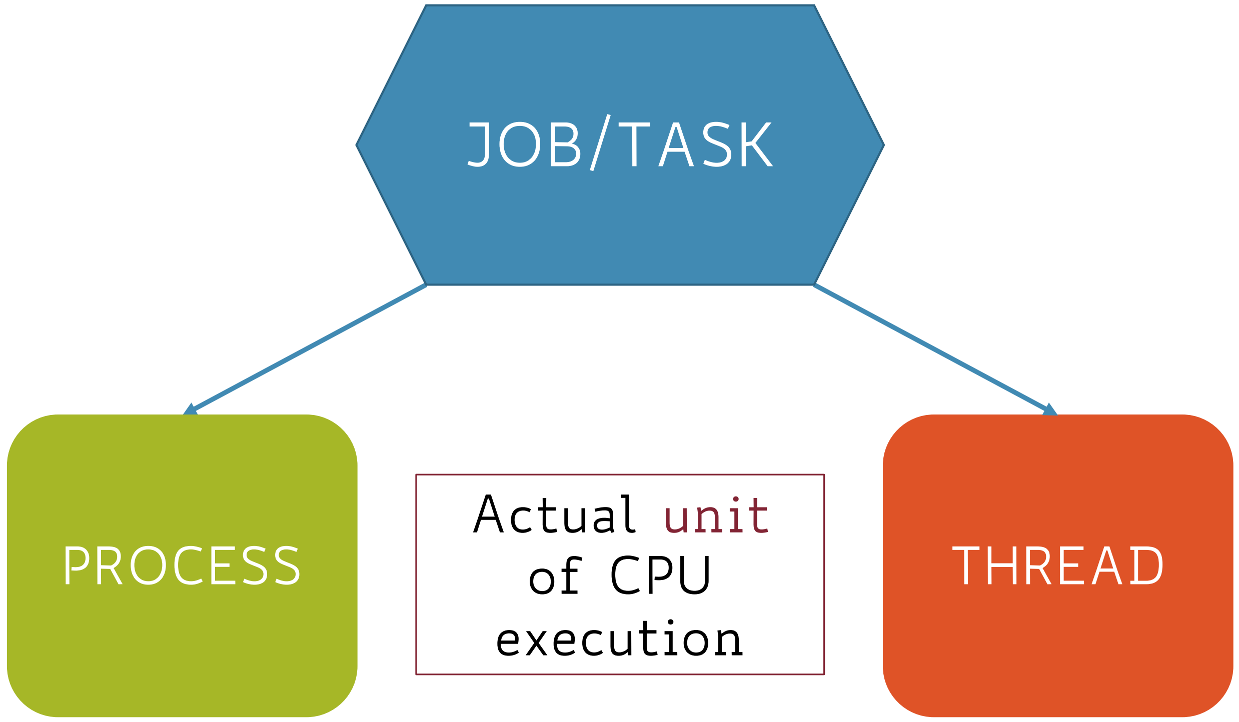

Actual unit of CPU execution

Scheduling Policies: Our Assumptions

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We will talk about threads very soon but for now most of the things we will be discussing remain valid even on a multi-threaded system

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- The goal of scheduling is to maximize system utilization
- non-preemptive vs. preemptive scheduler
- Different scheduling policies optimize different metrics