

Chapter 19: Real-Time Systems





Chapter 19: Real-Time Systems

- System Characteristics
- Features of Real-Time Systems
- Implementing Real-Time Operating Systems
- Real-Time CPU Scheduling
- VxWorks 5.x





Objectives

- To explain the timing requirements of real-time systems
- To distinguish between hard and soft real-time systems
- To discuss the defining characteristics of real-time systems
- To describe scheduling algorithms for hard real-time systems





Overview of Real-Time Systems

- A **real-time system** requires that results be produced within a specified deadline period.
- An **embedded system** is a computing device that is part of a larger system (I.e. automobile, airliner.)
- A **safety-critical system** is a real-time system with catastrophic results in case of failure.
- A hard real-time system guarantees that real-time tasks be completed within their required deadlines.
- A **soft real-time system** provides priority of real-time tasks over non real-time tasks.





System Characteristics

- Single purpose
- Small size
- Inexpensively mass-produced
- Specific timing requirements





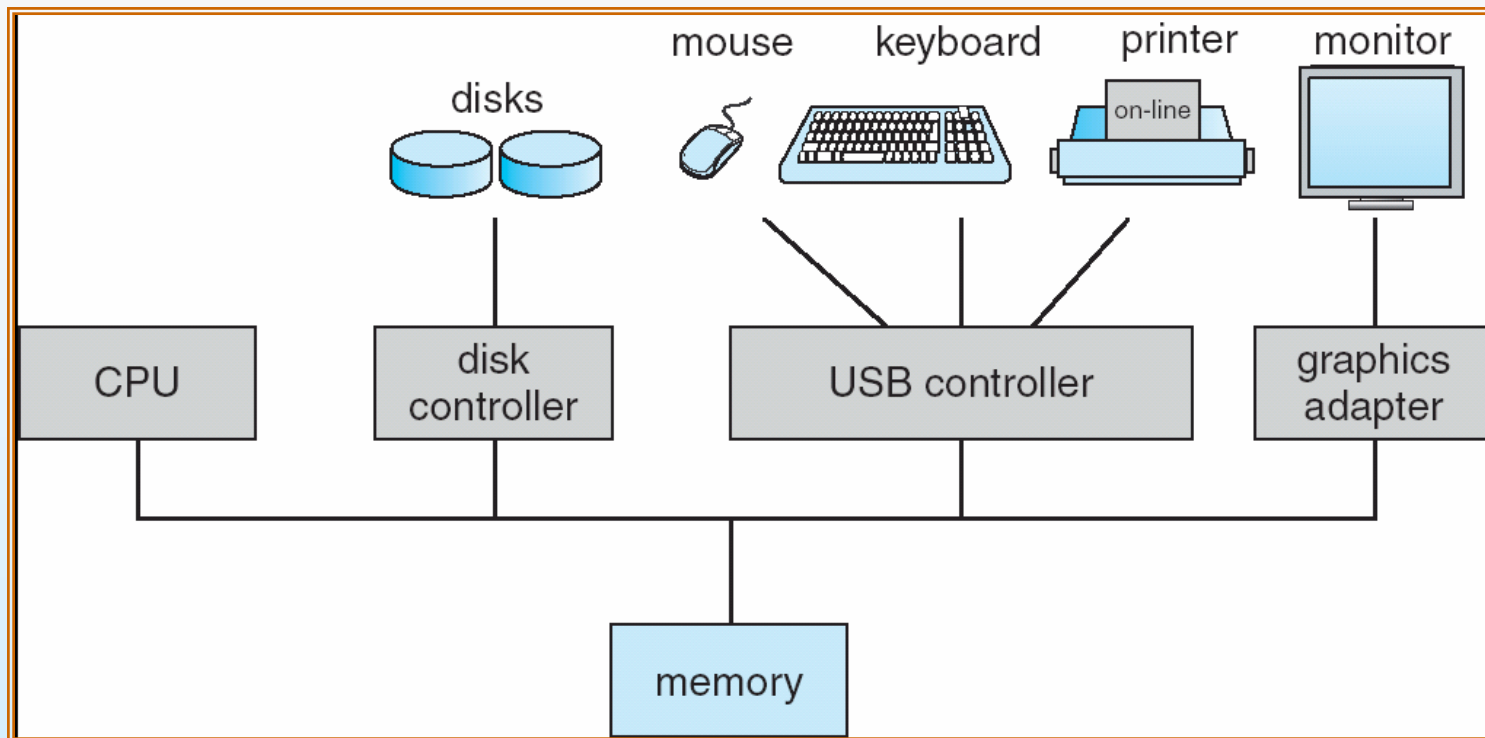
System-on-a-Chip

- Many real-time systems are designed using system-on-a-chip (SOC) strategy.
- SOC allows the CPU, memory, memory-management unit, and attached peripheral ports (l.e. USB) to be contained in a single integrated circuit.





Bus-Oriented System





Features of Real-Time Kernels

- Most real-time systems do not provide the features found in a standard desktop system.
- Reasons include
 - Real-time systems are typically single-purpose.
 - Real-time systems often do not require interfacing with a user.
 - Features found in a desktop PC require more substantial hardware than what is typically available in a real-time system.





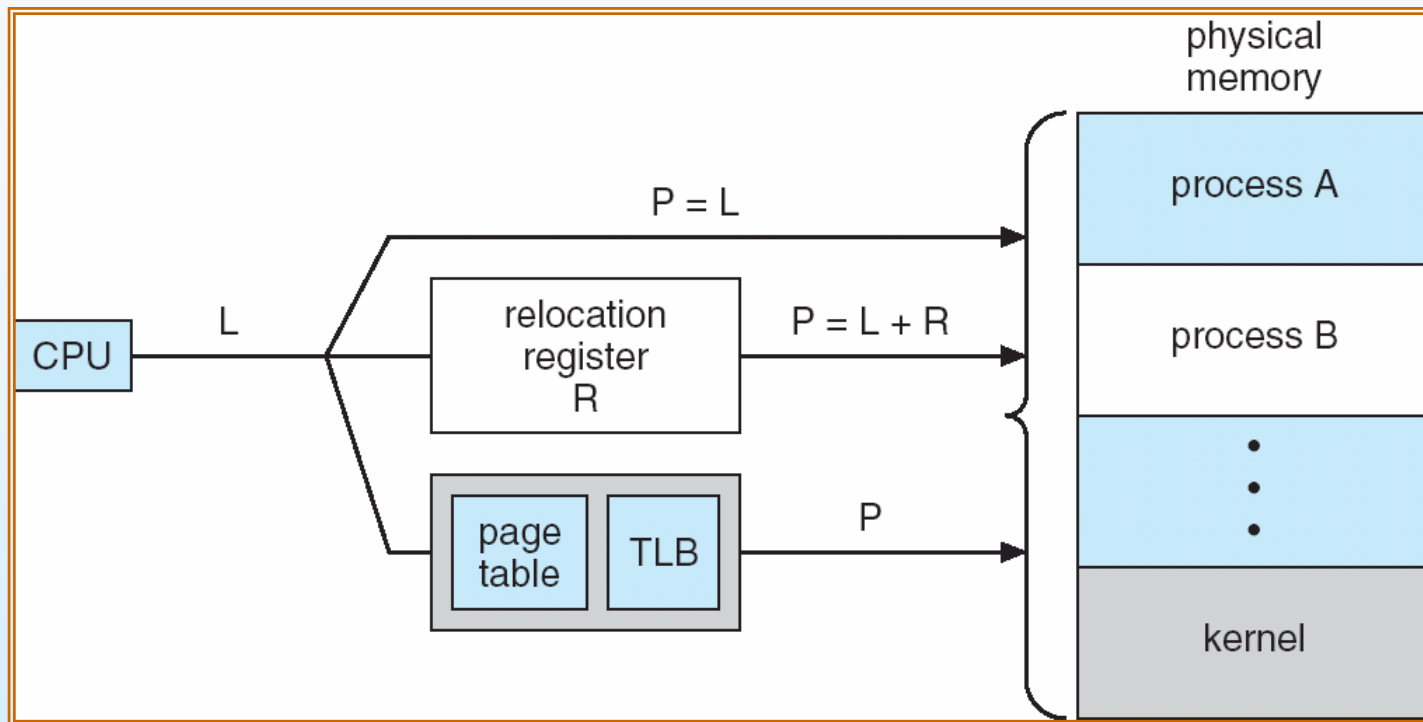
Virtual Memory in Real-Time Systems

- Address translation may occur via:
 - (1) **Real-addressing mode** where programs generate actual addresses.
 - (2) **Relocation** register mode.
 - (3) Implementing full **virtual memory**.





Address Translation





Implementing Real-Time Operating Systems

- In general, real-time operating systems must provide:

(1) Preemptive, priority-based scheduling

(2) Preemptive kernels

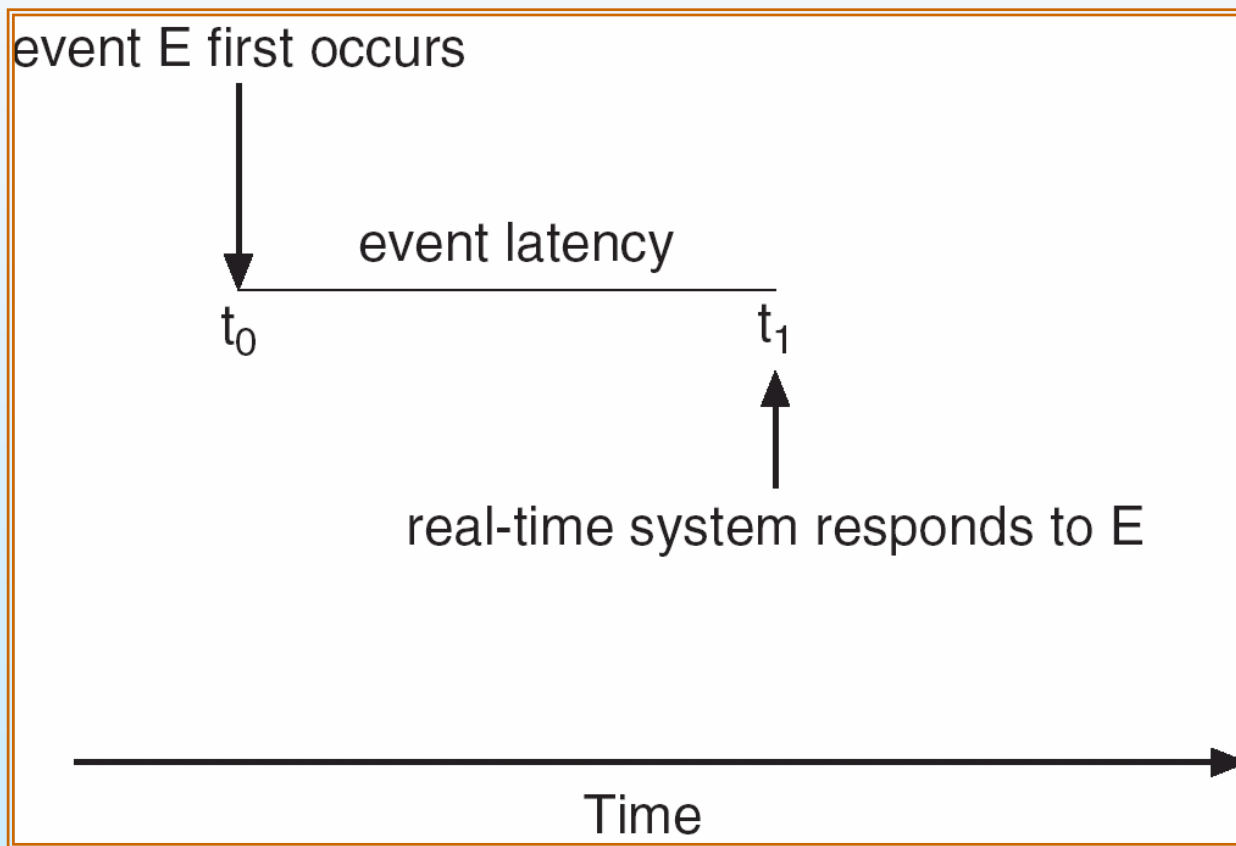
(3) Latency must be minimized





Minimizing Latency

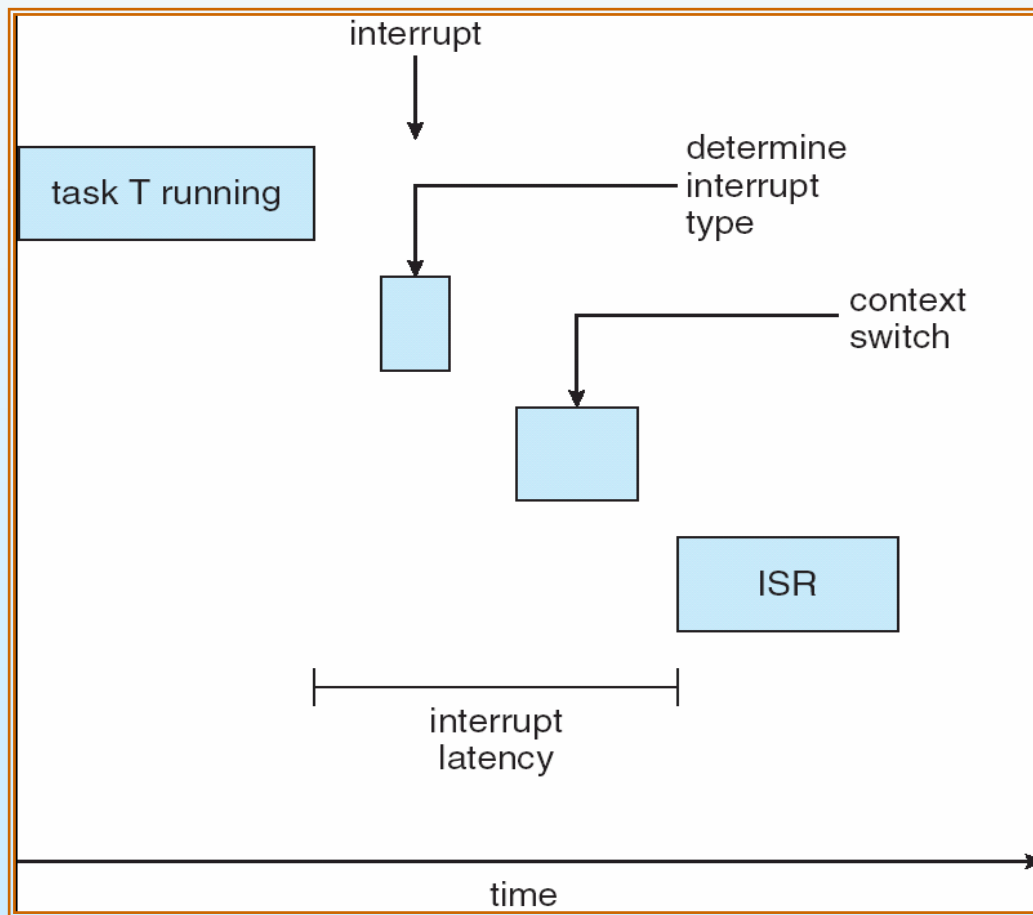
- **Event latency** is the amount of time from when an event occurs to when it is serviced.





Interrupt Latency

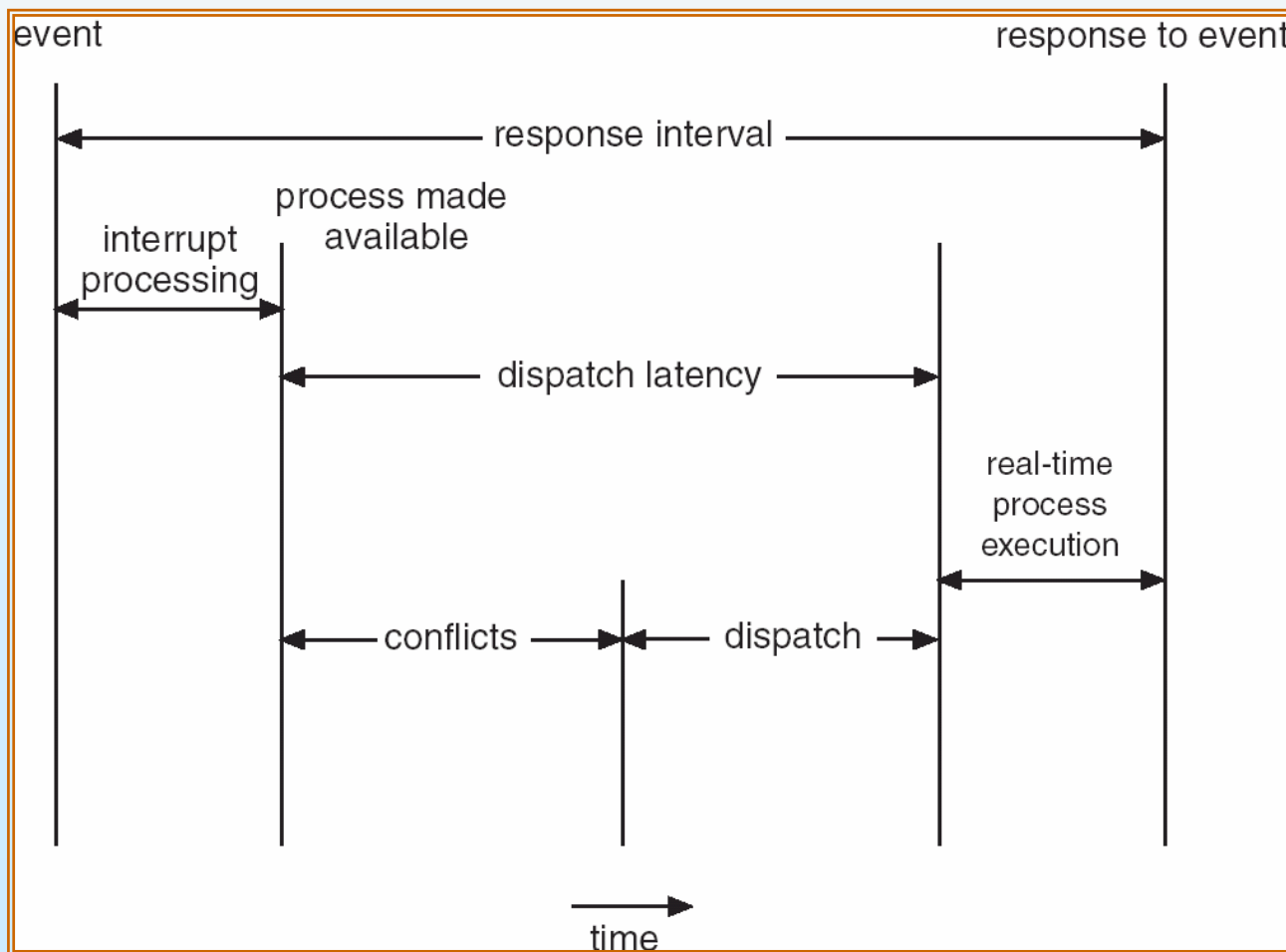
- Interrupt latency is the period of time from when an interrupt arrives at the CPU to when it is serviced.





Dispatch Latency

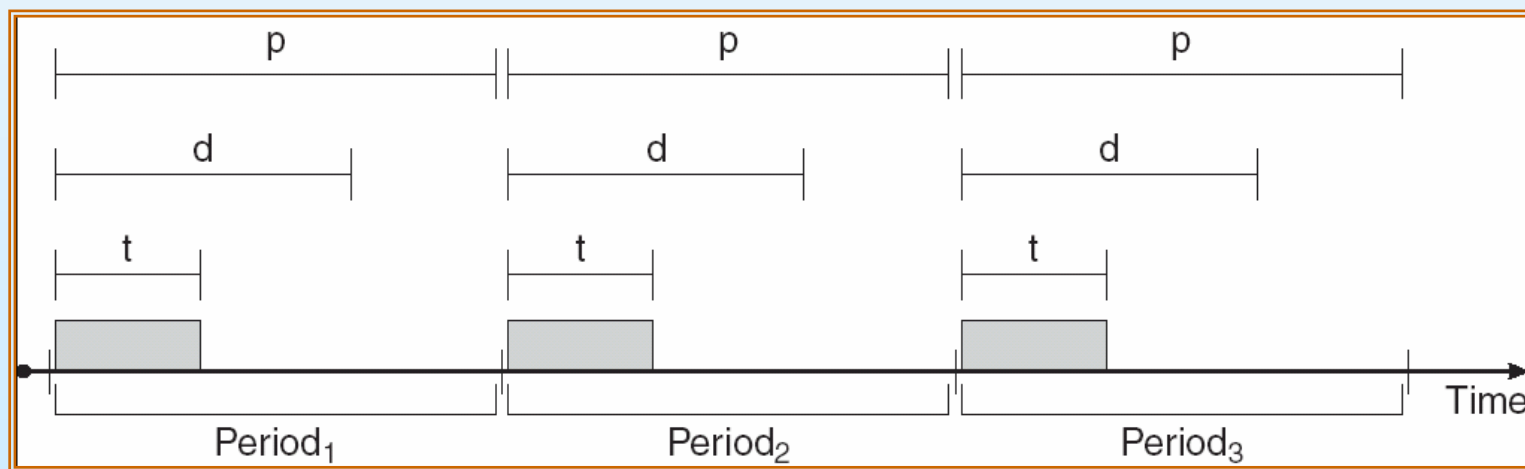
- **Dispatch latency** is the amount of time required for the scheduler to stop one process and start another.





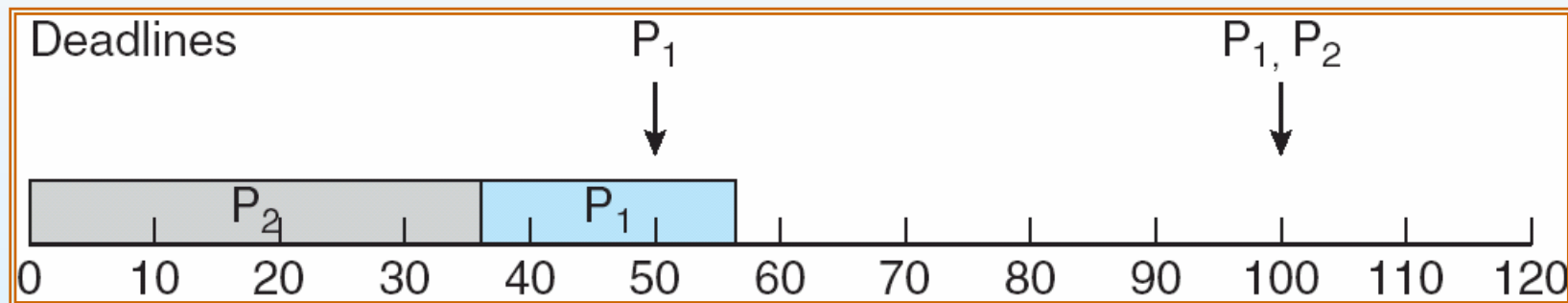
Real-Time CPU Scheduling

- Periodic processes require the CPU at specified intervals (periods)
- p is the duration of the period
- d is the deadline by when the process must be serviced
- t is the processing time





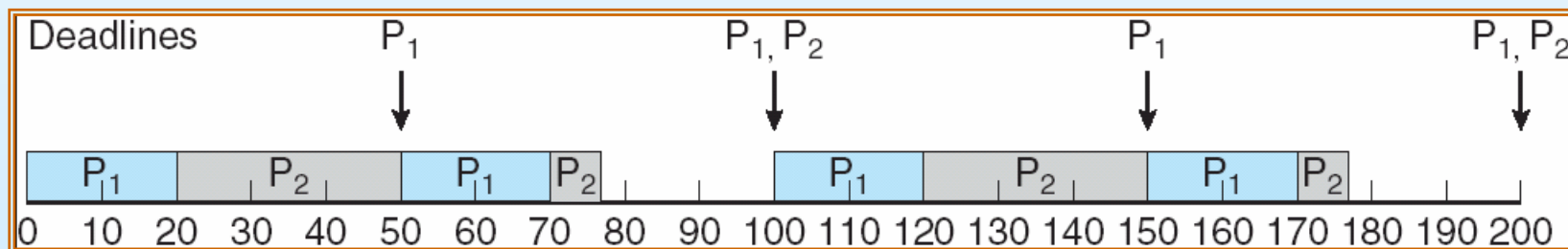
Scheduling of tasks when P_2 has a higher priority than P_1





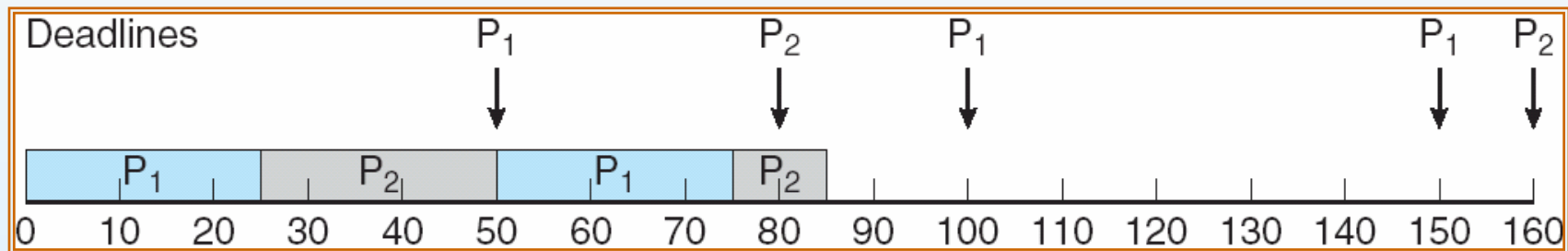
Rate Monotonic Scheduling

- A priority is assigned based on the inverse of its period
- Shorter periods = higher priority;
- Longer periods = lower priority
- P_1 is assigned a higher priority than P_2 .





Missed Deadlines with Rate Monotonic Scheduling



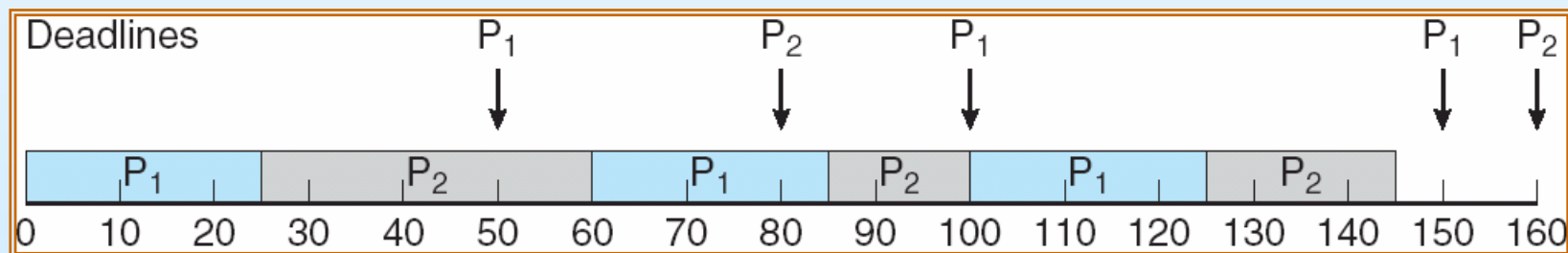


Earliest Deadline First Scheduling

- Priorities are assigned according to deadlines:

the earlier the deadline, the higher the priority;

the later the deadline, the lower the priority.





Proportional Share Scheduling

- T shares are allocated among all processes in the system.
- An application receives N shares where $N < T$.
- This ensures each application will receive N / T of the total processor time.





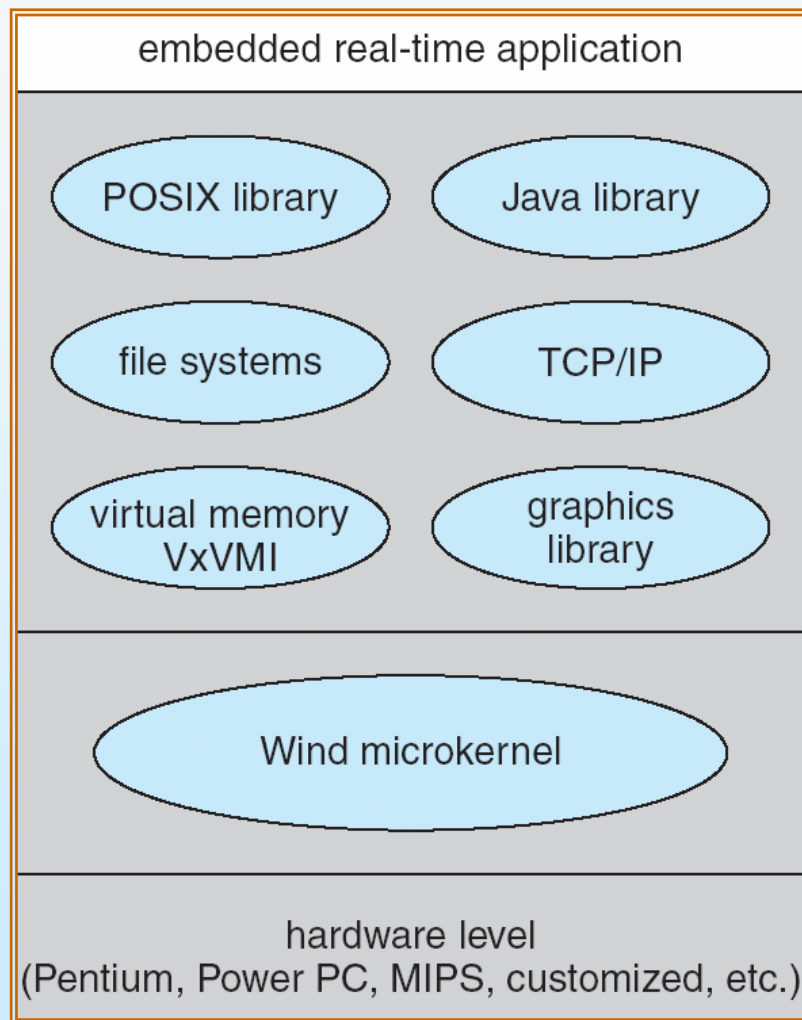
Pthread Scheduling

- The Pthread API provides functions for managing real-time threads.
- Pthreads defines two scheduling classes for real-time threads:
 - (1) `SCHED_FIFO` - threads are scheduled using a FCFS strategy with a FIFO queue. There is no time-slicing for threads of equal priority.
 - (2) `SCHED_RR` - similar to `SCHED_FIFO` except time-slicing occurs for threads of equal priority.





VxWorks 5.0





Wind Microkernel

- The Wind microkernel provides support for the following:

(1) Processes and threads;

(2) preemptive and non-preemptive round-robin scheduling;

(3) manages interrupts (with bounded interrupt and dispatch latency times);

(4) shared memory and message passing interprocess communication facilities.



End of Chapter 19

