Multiprocessor and Real-Time Scheduling

Chapter 10

Classifications of Multiprocessor

- Loosely coupled multiprocessor
  - each processor has its own memory and I/O channels
- Functionally specialized processors
  - such as I/O processor
  - controlled by a master processor
- Tightly coupled multiprocessing
  - processors share main memory
  - controlled by operating system

Independent Parallelism

- Separate processes running
- No synchronization
- Example is time sharing
  - average response time to users is less

Very Coarse Parallelism

- ✓ Distributed processing across network nodes to form a single computing environment
- ✓ Good when the interaction among processes is infrequent
  - overhead of network would slow down communications

Coarse Parallelism

- ✓ Similar to running many processes on one processor except it is spread to more processors
- ✓ Multiprocessing

Medium Parallelism

- ✓ Parallel processing or multitasking within a single application
- ✓ Single application is a collection of threads
- ✓ Threads usually interact frequently

Process Scheduling

- ✓ Single queue for all processes
- ✓ Multiple queues are used for priorities
- ✓ All queues feed to the common pool of processors
- ✓ Specific scheduling disciplines are less important with more than one processor

Threads

- ✓ Each thread executes separately from the rest of the process
- ✓ An application can be a set of threads that cooperate and execute concurrently in the same address space
- ✓ Running each thread on a separate processor yields a dramatic gain in performance

Multiprocessor Thread Scheduling

- Load sharing
  - processes are not assigned to a particular processor
- Gang scheduling
  - a set of related threads is scheduled to run on a set of processors at the same time

Multiprocessor Thread Scheduling

- Dedicated processor assignment
  - threads are assigned to a specific processor
- Dynamic scheduling
  - number of threads can be altered during the course of execution

Load Sharing

- ✓ Load is distributed evenly across the processors
- ✓ Assures no processor is idle
- ✓ No centralized scheduler required
- ✓ Use global queues
- ✓ Uniprocessor scheduling directly applies to this case
- ✓ The most common method

Disadvantages of Load Sharing

- Central queue needs mutual exclusion
  - may be a bottleneck when more than one processor looks for work at the same time
- With global queue, preempted threads are unlikely to resume execution on the same processor
  - hence local processor cache use is less efficient
- If all threads are in the global queue, eligible threads cannot gain access to the idle processors at the same time

Gang Scheduling

- ✓ Simultaneous scheduling of threads that make up a single process; assignment of threads to processors kept until preempted
- ✓ Useful for applications where performance severely degrades when any part of the application is not running
- ✓ Rationale: threads often need to synchronize with each other

Dedicated Processor Assignment

- When application is scheduled, its threads are assigned to a processor for the duration of application's execution
- Disadvantage: Some processors may be idle
- Advantage: Avoids process switching

Dynamic Scheduling

- Number of threads in a process changes dynamically (by the application)
- Operating system adjusts the processor load using some of these strategies:
  - assign idle processors to new threads
  - new arrivals may be assigned to a processor by taking away a processor from some other application that uses > 1 processor
  - hold request until processor is available
  - new arrivals may be given a processor before existing running applications

Real-Time Systems

- ✓ Correctness of the system depends not only on the logical result of the computation but also on the time at which the results are produced
- ✓ Tasks or processes attempt to control or react to events that take place in the outside world
- ✓ These events occur in "real time" and processes must keep up with them

Real-Time Systems

- ✓ Control of laboratory experiments
- ✓ Process control plants
- ✓ Robotics
- ✓ Air traffic control
- ✓ Telecommunications

Characteristics of Real-Time Operating Systems

- ✓ Correctness depends not only on the result produced by computation, but also by the timing and deadlines
- ✓ Deterministic
  - operations are performed at fixed, predetermined times or within predetermined time intervals
  - concerned with how long the operating system delays before acknowledging an interrupt

Characteristics of Real-Time Operating Systems

- Responsiveness
  - how long, after acknowledgment, it takes the operating system to service the interrupt
  - includes amount of time to begin execution of the interrupt
  - includes the amount of time to perform the interrupt

Characteristics of Real-Time Operating Systems

- User control
  - specify paging
  - what processes must always reside in main memory
  - rights of processes

Characteristics of Real-Time Operating Systems

- Reliability
  - degradation of performance may have catastrophic consequences
  - most critical, high priority tasks execute

Features of Real-Time Operating Systems

- ✓ Fast context switch
- ✓ Small size
- ✓ Ability to respond to external interrupts quickly
- ✓ Multitasking with interprocess communication tools such as semaphores, signals, and events
- ✓ Files that accumulate data at a fast rate

Features of Real-Time Operating Systems

- ✓ Preemptive scheduling based on priority
  - immediate preemption allows operating system to respond to an interrupt quickly
- ✓ Minimization of intervals during which interrupts are disabled
- ✓ Delay tasks for fixed amount of time
- ✓ Special alarms and timeouts

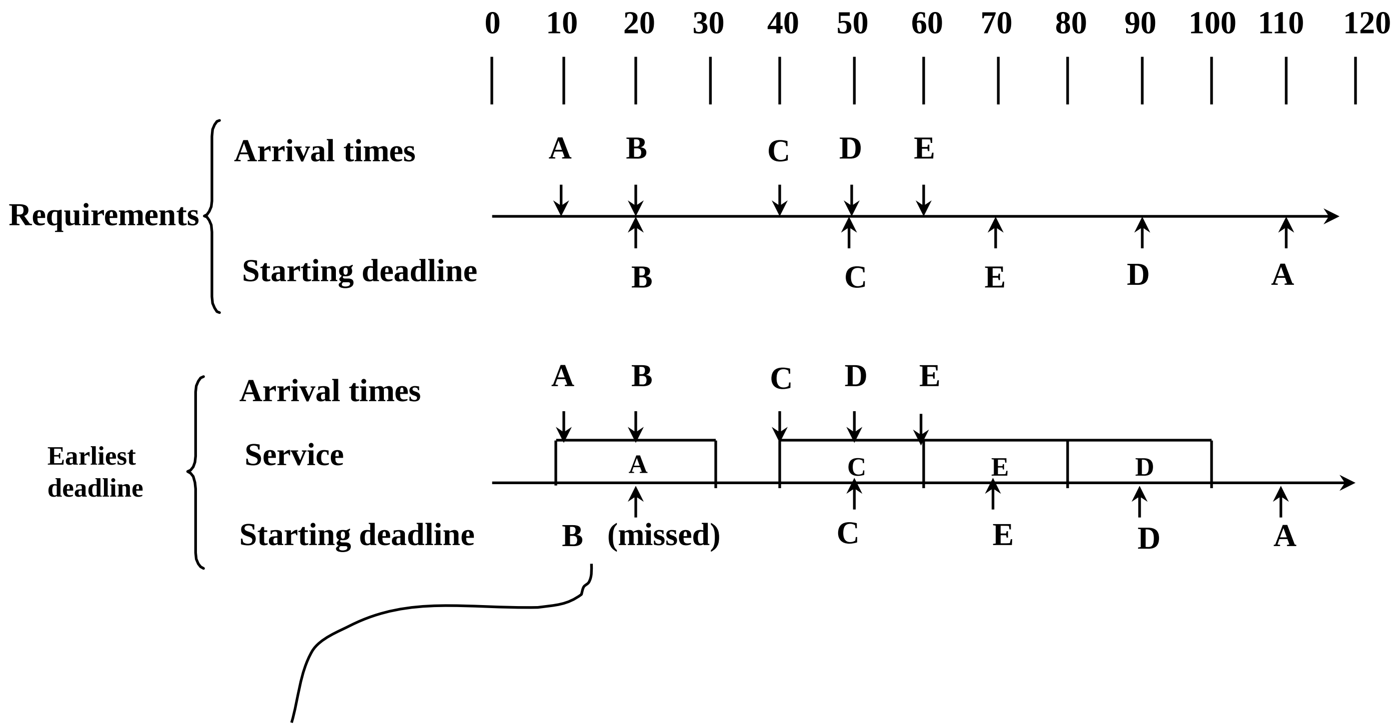
Real-Time Scheduling

- Static table-driven
  - determines statically what the schedule should be; the schedule tells which tasks to dispatch and when
- Static priority-driven preemptive
  - traditional priority-driven scheduler is used
- Dynamic planning-based
  - Like static, but schedules are periodically recomputed
- Dynamic best effort
  - No analysis: OS tries to execute each job before its deadline; a job is aborted, if its deadline is not met

Deadline Scheduling

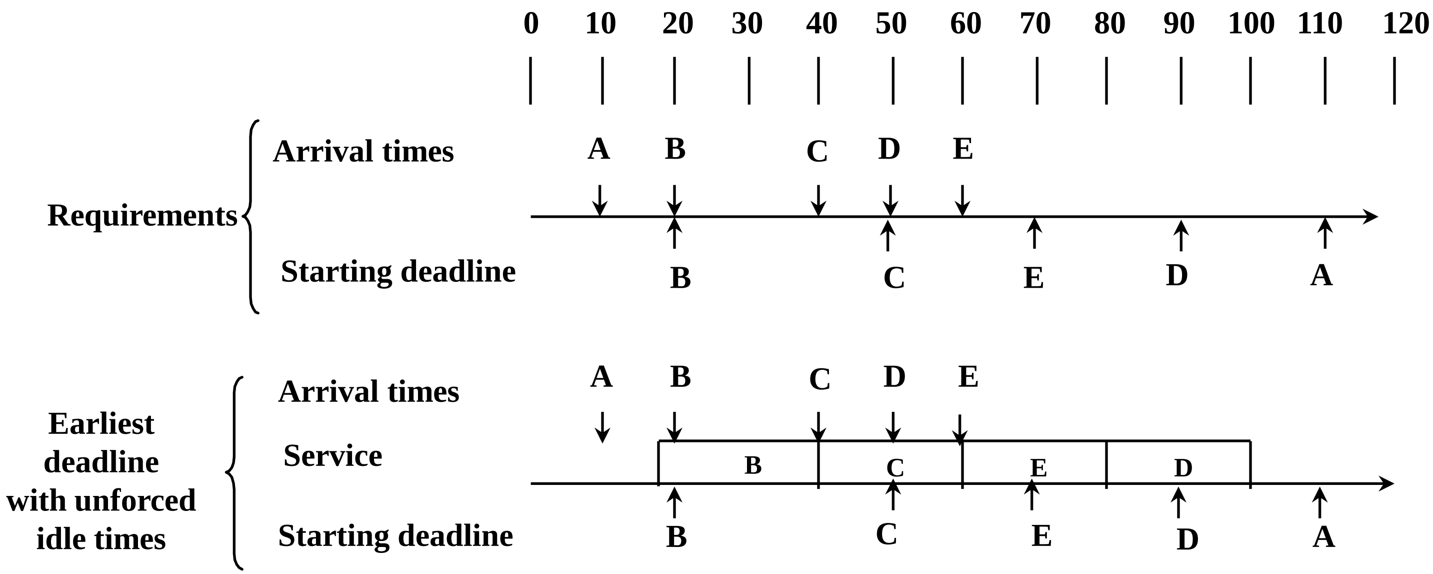
- ✓ Real-time applications are not concerned with speed but with completing tasks
- ✓ Scheduling tasks with the earliest deadline minimized the fraction of tasks that miss their deadlines
  - includes new tasks and amount of time needed for existing tasks

Scheduling of Real-Time Tasks

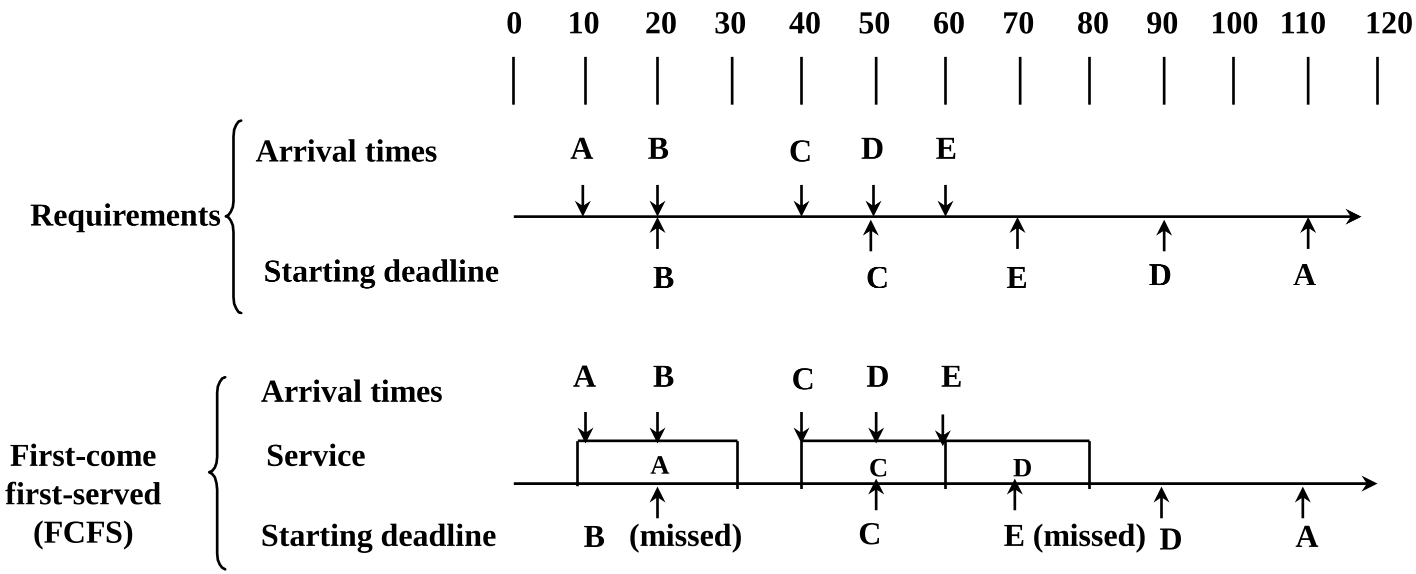


“A” starts because there is no other job. “B” misses its deadline

Scheduling of Real-Time Tasks



Scheduling of Real-Time Tasks



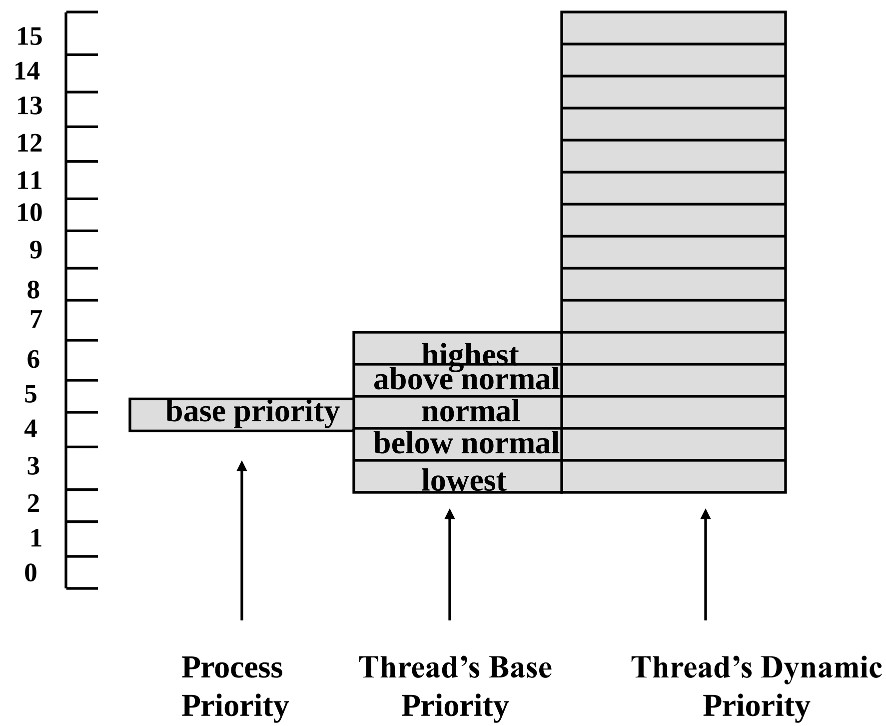
UNIX System V Release 4 Scheduling

- Set of 160 priority levels divided into three priority classes, each with its queue
- Basic kernel is not preemptive; split with *preemption points* to improve processing

Priority Class	Global Value	Scheduling Sequence
Real-time	159 • • • • 100	first ↓
Kernel	99 • • 60	↓
Time-shared	59 • • • • 0	↓ last

Windows NT Priority Relationship

<u>2 *bands of priorities*</u>**: 0-15 *variable*, 16-31 *real-time*. Priorities are fixed in the real-time band Uses round-robin within each priority level.**



Thread's dynamic priority goes up, if thread is interrupted for I/O. It goes down if thread hogs CPU