Operating Systems

08. Real-Time Scheduling

Paul Krzyzanowski
Rutgers University
Spring 2014

What's wrong with priorities?

- Fixed priorities:
  - Should I be #4? … #6? … #15?
- Dynamic priorities
  - I have no idea what my priority is because the CPU changes it!

Real-time demands

- We don't always need a LOT of CPU time but we may need it at the right intervals
  - E.g., decode 30 frames per second of video
- We might have tight deadlines
  - E.g., complete task within the next 500 ms
- Conventional process scheduling algorithms focused on fairness, compromise, and providing the best overall experience

Deadlines in real-time systems

- Start time (release time)
  - E.g., response to a sensor: start within 20 ms from sense time
- Stop time (deadline)
  - Scheduler must allot enough CPU time to complete
- Hard deadline
  - There is *no value* to the computation if it completes after the deadline
  - Safety critical system: critical start time and deadline
- Soft deadline
  - The value of a late result diminishes with time

Process types

- Terminating process
  - Runs and exits (e.g., service a sensor event)
  - How much time does it take to run to completion?
  - Deadline = time to finish
- Nonterminating process
  - Interested in time between events
    - E.g., fill a 4 KB audio buffer every 500 ms
    - E.g., decode a video frame every 67 ms
  - Compute time = time to compute periodic event
  - Deadline = time to have periodic results ready

How much can we do?

- Don't expect magic
- E.g.,
  - decoding 1 video frame takes 20 ms
  - we want to decode 2 video frames at 30 frames/sec
  - *We'll fail*: $2 \times 30 \times 20 = 1200$ ms > 1000 ms (1 sec = 1000 ms)
- If T = period, D = deadline, C = compute time:

$$C \le D \le T$$

Earliest Deadline Scheduling

- Each process tells OS its time deadline
- Scheduler picks the process in closest to its deadline
  - Usually one process runs to completion if it has an earlier deadline
  - Will be preempted if a process with an even earlier deadline starts

Least Slack Scheduling

- Consider remaining time and deadline
- Look not only at the deadline but how much we can procrastinate

  slack = (time to deadline) – (amount of computation)
- E.g., suppose

  C (compute time) = 5 ms

  D (deadline) = 20 ms from now

  slack = *D* - *C* = 15 ms

Least Slack vs. Earliest Deadline First

Earliest Deadline First

- We always work on the earliest deadline process and delay others

Least Slack

- Get a balanced result in that we keep the differences to deadlines balanced

If there's not enough time for everything:

- EDF: may hit only the early deadlines
- LS: all deadlines may be missed but roughly by the same amount

Rate monotonic analysis

- Method of assigning static priorities to periodic processes
- Works with a static priority scheduler
- Must know all real-time processes running at the same time and their period
- Rate monotonic priority assignment is optimal
  - If the it is possible for all deadlines to be met then they will be met with rate monotonic assignment

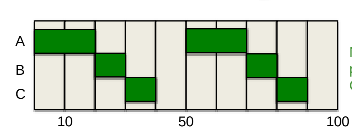
Assigning priorities

- Highest frequency (smallest period) process gets the highest priority
- Successively lower frequency processes get lower priorities
- Scheduling is via a simple priority scheduler
- If two processes have the same priority, they can round-robin

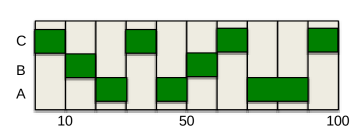
Rate monotonic example

- Process A runs every 50 ms for 20 ms
- Process B runs every 50 ms for 10 ms
- Process C runs every 30 ms for 10 ms

Rate monotonic analysis: Schedule C first, then A or B



No rate monotonic priority assignment: C misses a period!



The End