Operating Systems Design
8. Real-Time Scheduling

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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 msec.
- 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 msec 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
  - 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 msec
    - E.g., decode a vide frame every 67 msec
  - 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 msec
  - we want to decode 2 video frames at 30 frames/sec
  - *We’ll fail*: $2 \times 30 \times 20 = 1200$ msec > 1000 msec

- 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 greatest danger of missing 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 msec

  D (deadline) = 20 msec from now

  slack = D - C = 15 msec

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

- Must know all real-time processes running at the same time and their period

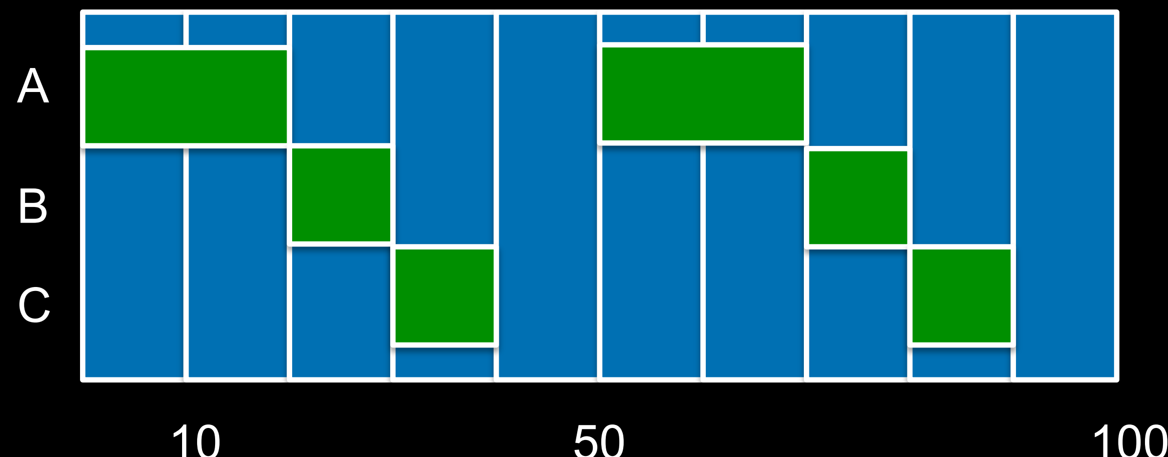
Assigning priorities

- 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

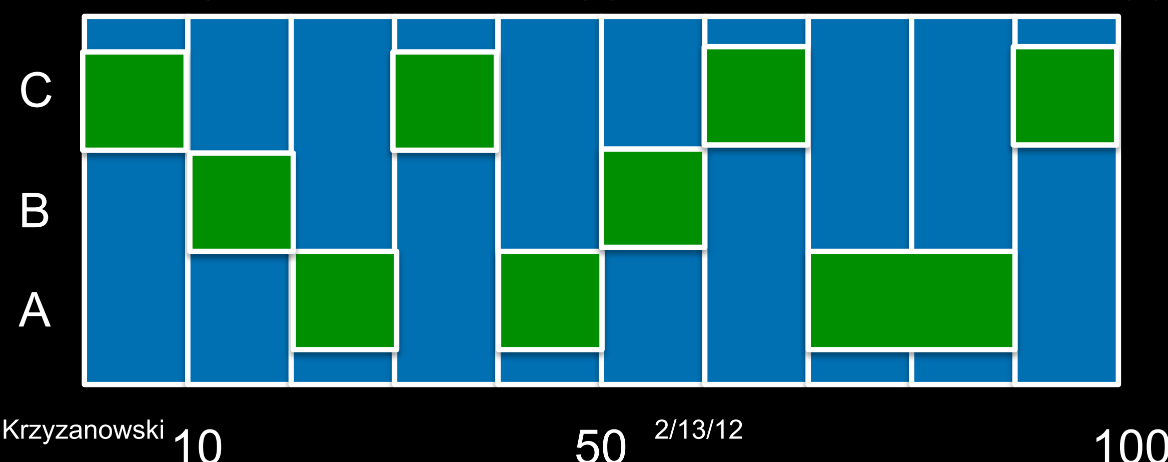
Rate monotonic example

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

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



No rate monotonic priority assignment:
C misses a period!



The End