Real Time Operating Systems and Middleware

Sensitivity Analysis

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Considerations on WCET

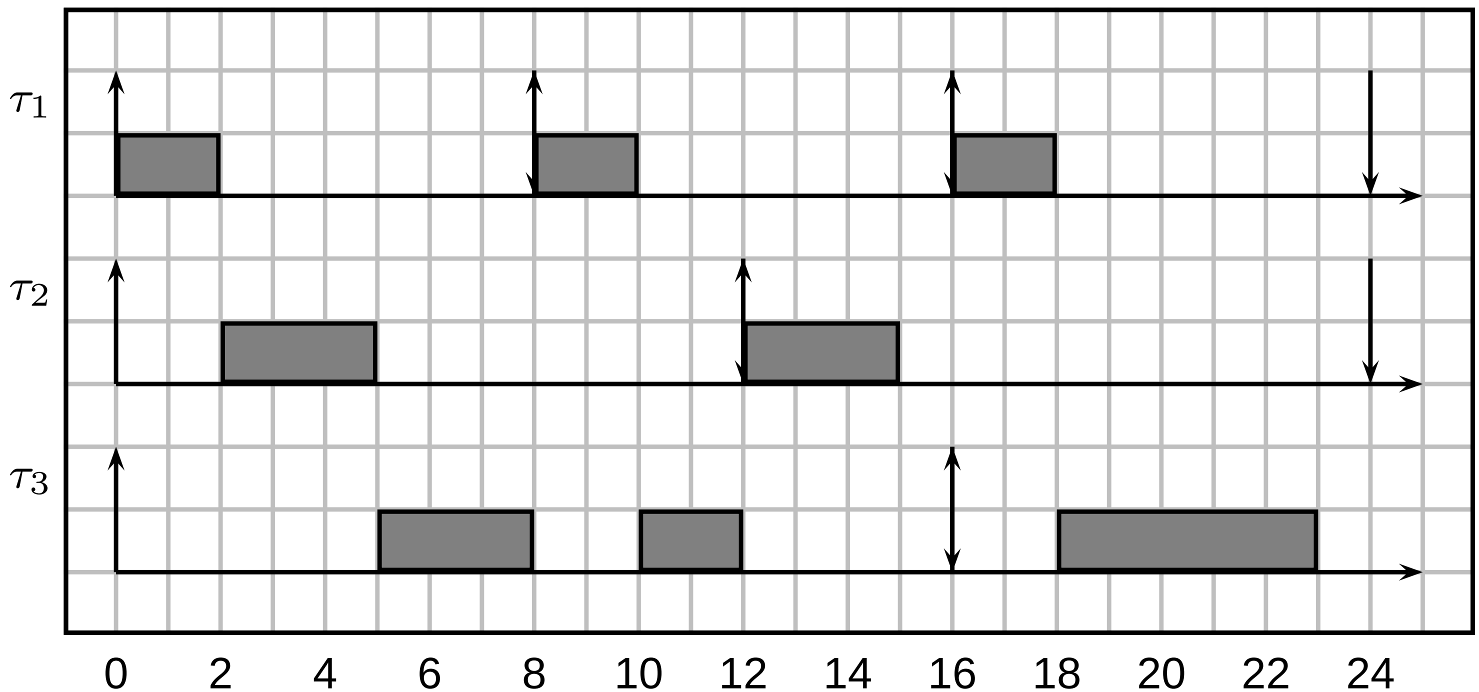
- Both response time analysis and time demand analysis provide a necessary and sufficient schedulability test for fixed priority scheduling
- However, the result is *very* sensitive to the value of the WCET
  - If we are wrong in estimating the WCET (and for example we use a value that is too small), the actual system may be not schedulable
  - For example, in response time analysis a *small* increase in the WCET of a higher priority task makes the response time *jump* to much larger values

Sensitivity to WCET

- We can formulate response time computation or demanded time computation as a sensitivity analysis problem
- How sensible is the response time (or the demanded time) to variations in the WCET?
- Because in the ceilings ($\lceil\rceil$) contained in the equations used to compute R_i and L_i, the answer is not simple...
  - For example, for response time we have a function $R_i = f_i(C_1, T_1, C_2, T_2, \ldots, C_{i-1}, T_{i-1}, C_i)$ that is non-continuous
  - What happens to R_i if a WCET C_h is increased by a small amount δ?

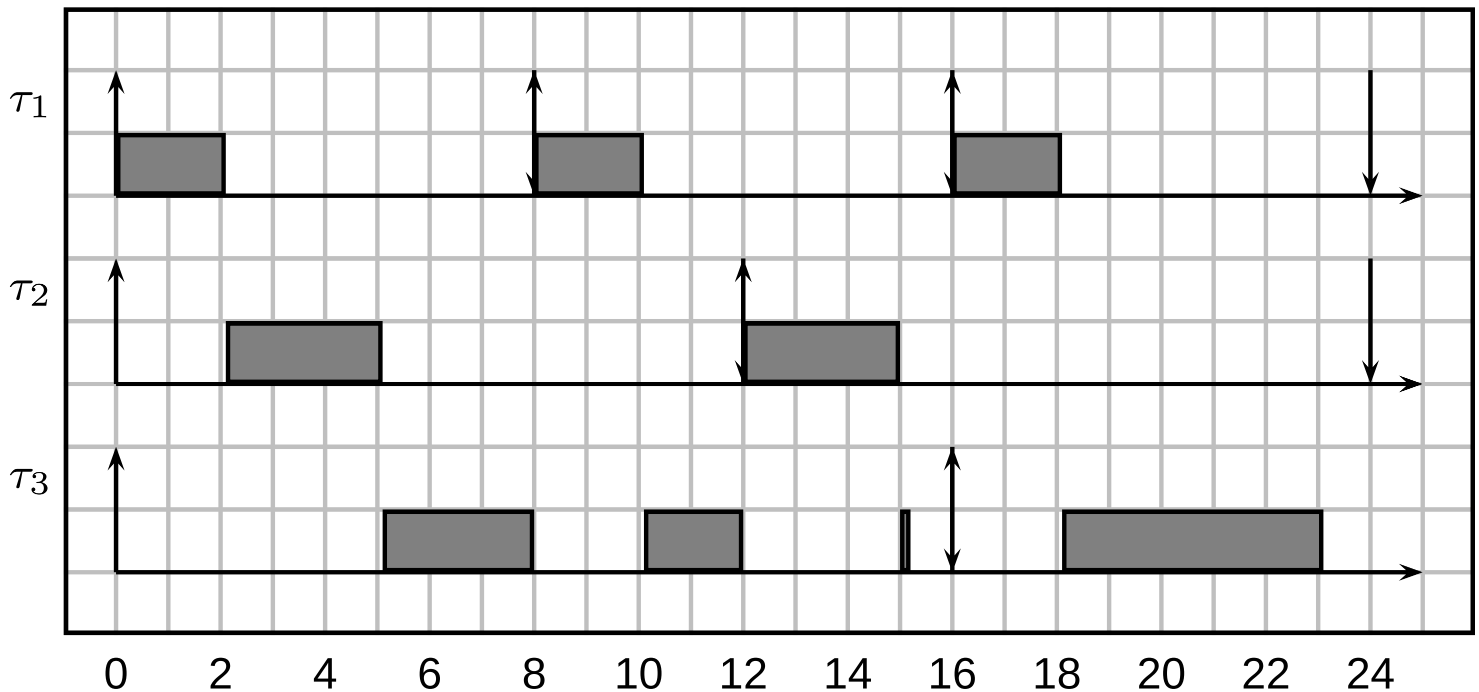
Example of Discontinuity

- Let's consider again one of the previous examples
- $\mathcal{T} = \{(2,8),(3,12),(5,16)\}$



Example of Discontinuity

- Let's consider again one of the previous examples
- Increase C_1 by 0.1



$$R_3 = 12 \rightarrow 15.2$$

What Happened?

- Why did a small increase in C_1 (from 2 to 2.1) cause such a big difference in R_3 (from 12 to 15.2)?
- Let's analyse the problem from the beginning...
  - The response time of a job $J_{i,j}$ depends on its finishing time $f_{i,j}$
  - $J_{i,j}$ must be finished, and all the jobs preempting it (from higher priority tasks $\tau_h | h < i$) must be completed
- After $J_{i,j}$'s completion,
  - Either a lower priority task τ_j ($p_j < p_i$) is scheduled
  - Or the system becomes idle
  - Or a higher priority task τ_h arrives immediately ($f_{i,j} = r_{h,k}$)

Singularities

- If the finishing time $f_{i,j}$ of a job is equal to the arrival time of a job for a higher priority task, time $t = f_{i,j}$ is called i-level singularity point
- In the previous example, time $t = 12$ is a 3-level singularity point, because:
  1. Task τ_3 has just finished
  2. And task τ_2 has just been activated

$$f_{3,1} = r_{2,2}$$

- As we have just seen, a singularity is a “dangerous” point!
- In presence of a i-level singularity point, increasing C_h (with $h < i$) can generate “strange” effects

Sensitivity on WCETs

- A rule of thumb is to increase the WCET by a certain percentage before doing the analysis. If the task set is still feasible, be are more confident about the schedulability of the original system.
- There are analytical methods for computing the amount of variation that it is possible to allow to a task's WCET without compromising the schedulability:
  - The analysis looks for possible singularities and computes the amount of time that is needed to obtain a singularity;
  - The analysis is very complex (NP-Hard) but can be done in a few seconds (at most minutes) on a fast computer.