First Labs on Real-Time Scheduling

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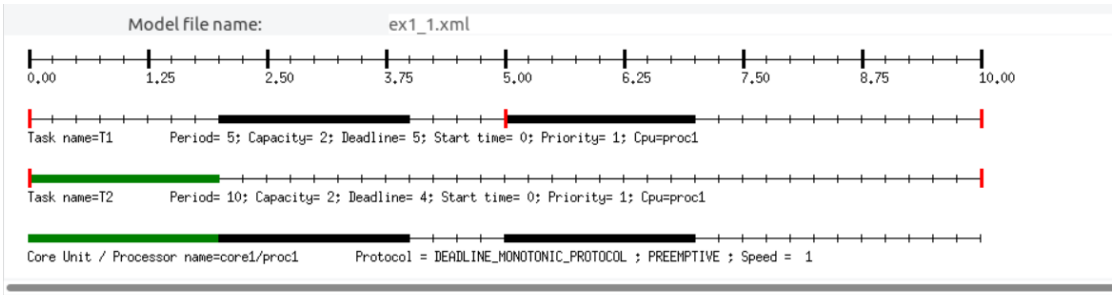
Exercise 1

1. Simulate the following task configuration on one core using *deadline monotonic*.

	First release	WCET	D	P
T_1	0	2	5	5
T_2	0	2	4	10

   a) No deadline missed in the computed scheduling: the task set is schedulable if we computed the scheduling on the feasibility interval.

   b) The worst-case response times of the T_1 is 4 and T_2 is 2.

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Scheduling simulation, Processor proc1 :
- Number of preemptions : 0

Scheduling simulation, Processor proc1 :
- Number of context switches : 1

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 4/worst 2/best 3.00000/average
  T2 => 2/worst 2/best 2.00000/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average
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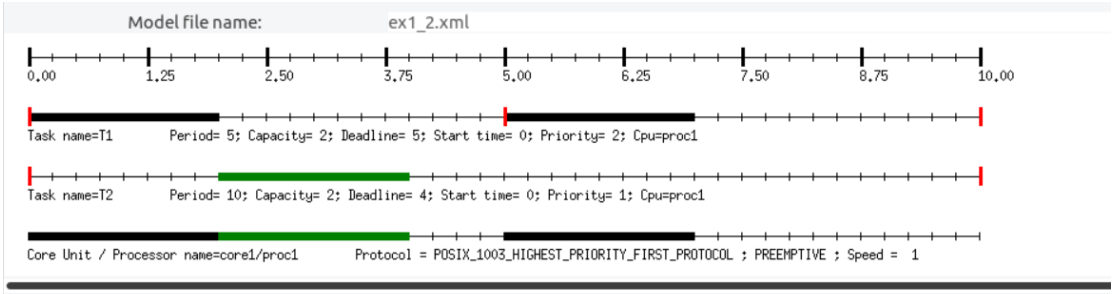
2. When we set T_1 as the first priority and T_2 as the second priority, the results of the simulated scheduling are as follows:
   - "No deadline missed in the computed scheduling: the task set is schedulable if we computed the scheduling on the feasibility interval."



Scheduling simulation, Processor proc1 :
- Number of preemptions : 0

Scheduling simulation, Processor proc1 :
- Number of context switches : 2

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 2/worst 2/best 2.00000/average
  T2 => 4/worst 4/best 4.00000/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

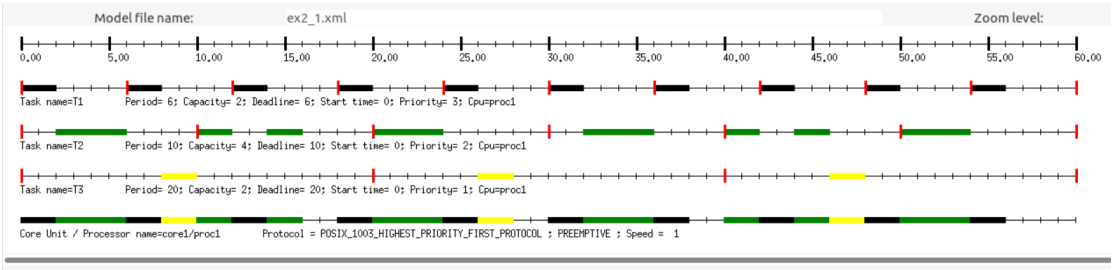
Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average

Exercise 2

1. Let's assume the following independant task configuration.

	First release	WCET	D	P
T_1	0	2	6	6
T_2	0	4	10	10
T_3	0	2	20	20

   - It is schedulable by a fixed priority.



Scheduling simulation, Processor proc1 :
- Number of preemptions : 2

Scheduling simulation, Processor proc1 :
- Number of context switches : 20

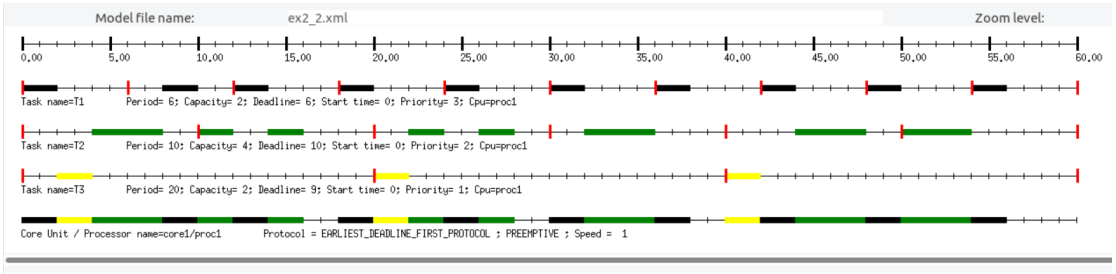
Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 2/worst 2/best 2.00000/average
  T2 => 6/worst 4/best 5.33333/average
  T3 => 10/worst 8/best 8.66667/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average
  T3 => 0/worst 0/best 0.00000/average

2. Same question with the following independant task configuration.

	First release	WCET	D	P
T_1	0	2	6	6
T_2	0	4	10	10
T_3	0	2	9	20

- It is not schedulable by a fixed priority. However, it is schedulable by a Earliest Deadline First: “No deadline missed in the computed scheduling: the task set is schedulable if we computed the scheduling on the feasibility interval.”



Scheduling simulation, Processor proc1 :
- Number of preemptions : 2

Scheduling simulation, Processor proc1 :
- Number of context switches : 20

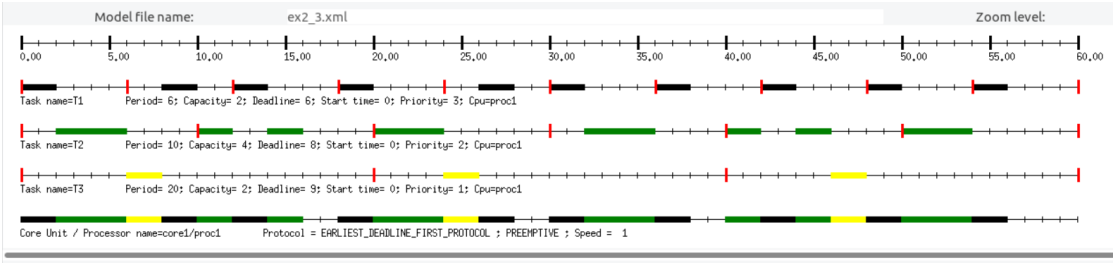
Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 4/worst 2/best 2.20000/average
  T2 => 8/worst 4/best 6.66667/average
  T3 => 4/worst 2/best 2.66667/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average
  T3 => 0/worst 0/best 0.00000/average

3. Same question with the following independant task configuration.

	First release	WCET	D	P
T_1	0	2	6	6
T_2	0	4	8	10
T_3	0	2	9	20

- It is not schedulable by a fixed priority. However, it is schedulable by a Earliest Deadline First: “No deadline missed in the computed scheduling: the task set is schedulable if we computed the scheduling on the feasibility interval.”



Scheduling simulation, Processor proc1 :
- Number of preemptions : 2

Scheduling simulation, Processor proc1 :
- Number of context switches : 19

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 4/worst 2/best 2.40000/average
  T2 => 6/worst 4/best 5.33333/average
  T3 => 8/worst 6/best 7.33333/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average
  T3 => 0/worst 0/best 0.00000/average

Exercise 3

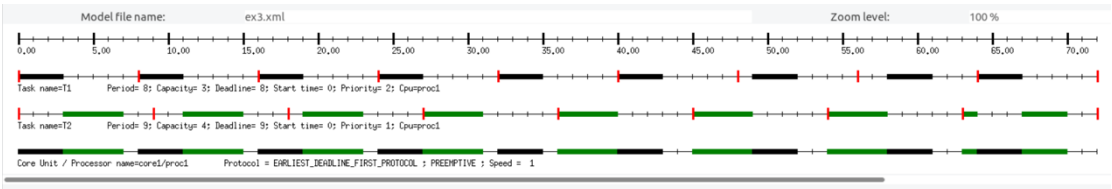
In this exercise we investigate another dynamic scheduling policy: LLF (Least Laxity First). This policy selects the task to run among the ready tasks according to a dynamic priority called 'laxity': the smaller the laxity, the higher the priority. $Li(t)$, the laxity of a task i at time t can be computed by

$$Li(t) = Deadline - remaining(t)$$

where $remaining(t)$ is the remaining capacity of the task at time t.
Let's assume the following independant task configuration.

	First release	WCET	D	P
T_1	0	3	8	8
T_2	0	4	9	9

- Result of scheduling simulation in ***Earliest Deadline First***



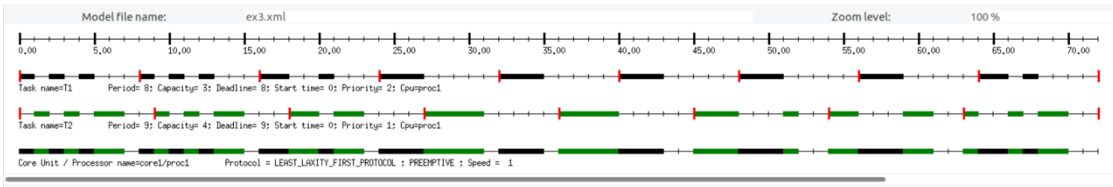
Scheduling simulation, Processor proc1 :
- Number of preemptions : 1

Scheduling simulation, Processor proc1 :
- Number of context switches : 17

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 5/worst 3/best 3.33333/average
  T2 => 7/worst 4/best 5.12500/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average

- Result of scheduling simulation in ***Least Laxity First***



Scheduling simulation, Processor proc1 :
- Number of preemptions : 15

Scheduling simulation, Processor proc1 :
- Number of context switches : 29

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 5/worst 3/best 3.77778/average
  T2 => 7/worst 4/best 5.87500/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average

- Through the two scheduling simulation results, the ***Earliest Deadline First*** algorithm has fewer context switches and preemptions under this task configuration. So it will consume less extra resources and have better performance.

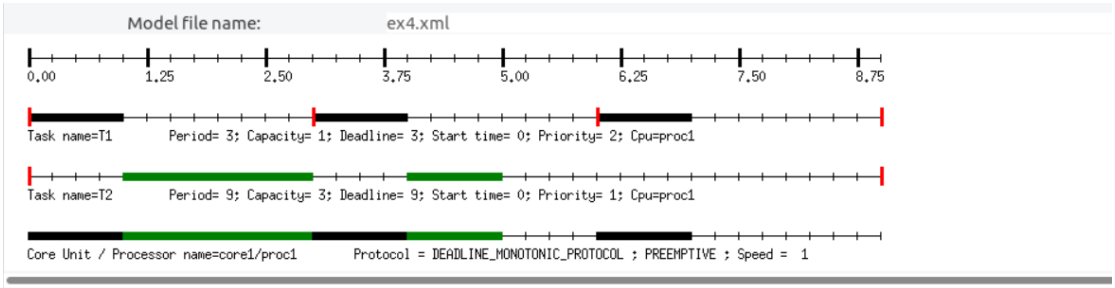
Exercise 4

In this exercise we investigate the effect of non preemption on scheduling.

1. Let's assume the following independant task configuration.

	First release	WCET	D	P
T_1	0	1	3	3
T_2	0	3	9	9

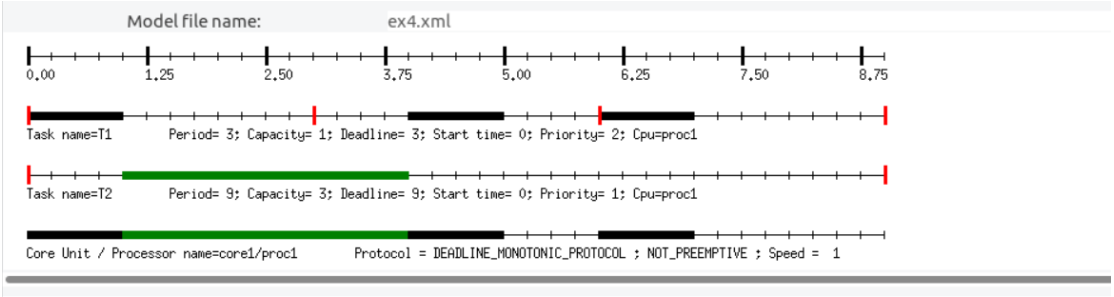
- Result of scheduling simulation in ***Preemptive Rate Monotonic***



Scheduling simulation, Processor proc1 :
- Number of context switches : 4
- Number of preemptions : 1

- Task response time computed from simulation :
  T1 => 1/worst
  T2 => 5/worst
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

- Result of scheduling simulation in ***Non Preemptive Rate Monotonic***



Scheduling simulation, Processor proc1 :
- Number of preemptions : 0

Scheduling simulation, Processor proc1 :
- Number of context switches : 2

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 2/worst 1/best 1.33333/average
  T2 => 4/worst 4/best 4.00000/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

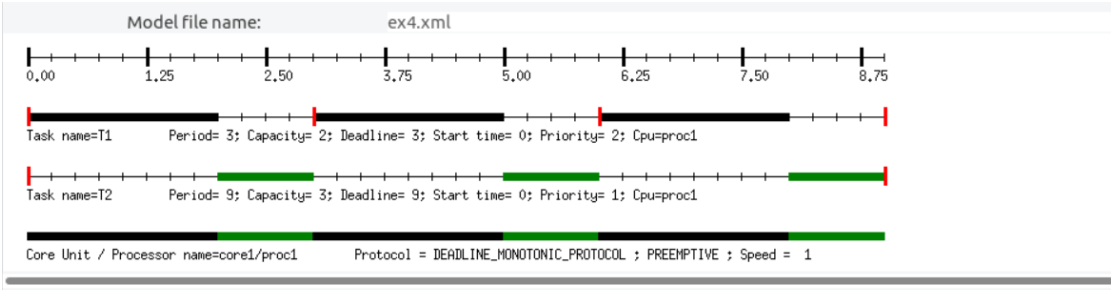
Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average

- In preemptive scheduling, once a task needs to be scheduled (preempted), the CPU will context switch. Therefore, context switching will be more frequent in this scheduling mode.
- In non-preemptive scheduling, the CPU does not respond to preemption (interrupts). Correspondingly, this mode will have fewer context switches

2. Same question with the following independant task configuration.

	First release	WCET	D	P
T_1	0	2	3	3
T_2	0	3	9	9

- Result of scheduling simulation in ***Preemptive Rate Monotonic***



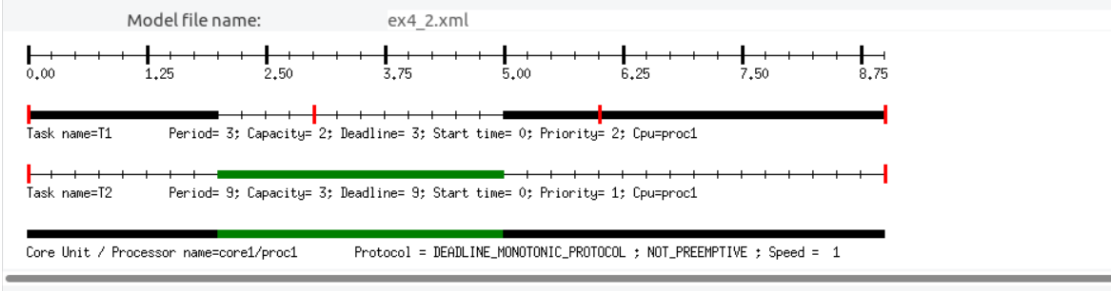
Scheduling simulation, Processor proc1 :
- Number of preemptions : 2

Scheduling simulation, Processor proc1 :
- Number of context switches : 5

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 2/worst 2/best 2.00000/average
  T2 => 9/worst 9/best 9.00000/average
- No deadline missed in the computed scheduling : the task set is schedulable if you computed the scheduling on the feasibility interval.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average

- Result of scheduling simulation in ***Non Preemptive Rate Monotonic***



Scheduling simulation, Processor proc1 :
- Number of preemptions : 0

Scheduling simulation, Processor proc1 :
- Number of context switches : 2

Scheduling simulation, Processor proc1 :
- Task response time computed from simulation :
  T1 => 4/worst 2/best 3.00000/average , missed its deadline (absolute deadline = 6 ; completion time = 7)
  T2 => 5/worst 5/best 5.00000/average
- Some task deadlines will be missed : the task set is not schedulable.

Scheduling simulation, Processor proc1 :
- Blocking time from simulation :
  T1 => 0/worst 0/best 0.00000/average
  T2 => 0/worst 0/best 0.00000/average

- In this task configuration, the task set is only schedulable in preemptive mode.
- In non-preemptive mode, T_1 missed its deadline(absolute deadline = 6; completion time = 7).

Exercise 5

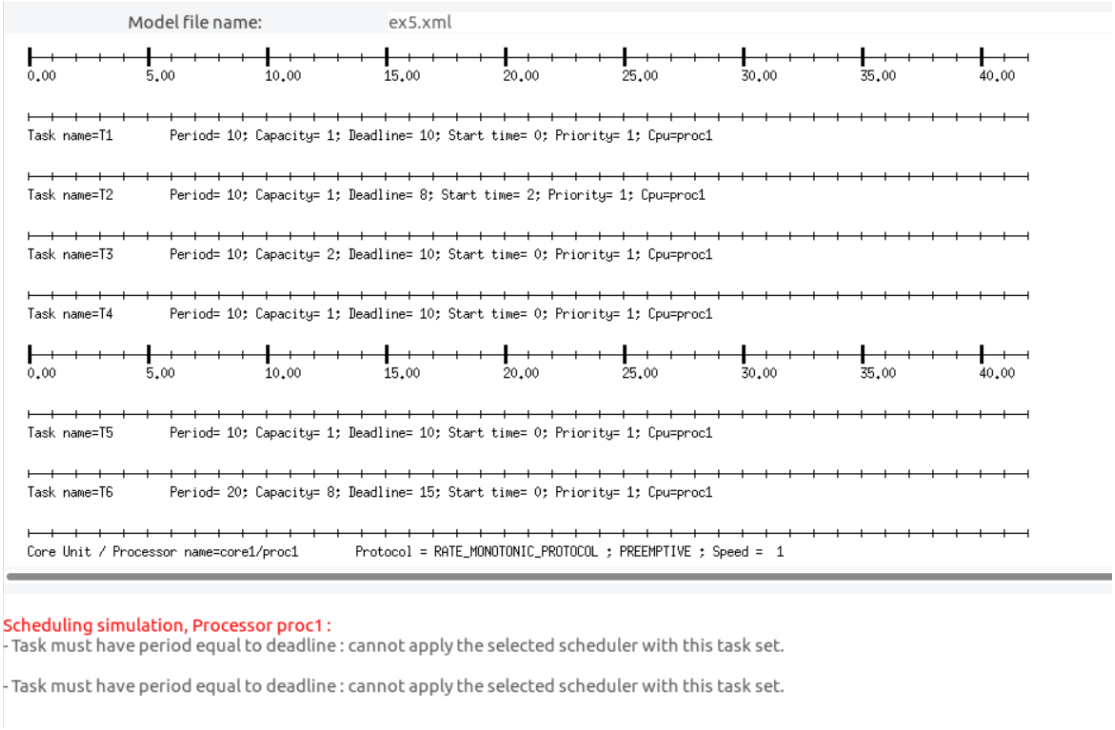
Let's assume the following dependant task configuration:

	First release	WCET	D	P
T_1	0	1	10	10
T_2	2	1	8	10
T_3	0	2	10	10
T_4	0	1	10	10
T_5	0	1	10	10
T_6	0	8	15	20

We have the following precedence constraints:

- T_1 and T_2 have to complete execution before T_3 starts,
- T_3 has to complete execution before T_4 and T_5.

1. It is not schedulable using the rate monotonic approach presented in the lectures.



Scheduling simulation, Processor proc1 :
- Task must have period equal to deadline : cannot apply the selected scheduler with this task set.

- Task must have period equal to deadline : cannot apply the selected scheduler with this task set.

2. It is schedulable using the Earliest Deadline First approach presented in the lectures.