INFO-F-404 : Operating Systems II

1 Exercises

Exercise 1 : Audsley

Task index	Release time	WCET	Deadline	Period
Task τ_1	100	10	20	30
Task τ_2	50	20	50	50
Task τ_3	0	30	100	150

Table 1: System of 3 periodic, asynchronous tasks with constrained deadline.

a) Find the study interval, use the expression $[O_{\max}, O_{\max} + 2 \cdot P]$.

Answer : First we have to find P and $O_{\max}$, they are given by formulas:

$$P = lcm\left\{T_i \mid i = 1, \ldots, n\right\}$$

$$O_{\max} = \max\left\{O_i \mid i = 1, \ldots, n\right\}$$

So, we have : $P = lcm(30, 50, 150) = 150$ and $O_{\max} = \max(100, 50, 0) = 100$

Now we can find the study interval : $[100, 100 + 2 \cdot 150] = [100, 400]$

b) Plot the scheduling of these 3 tasks in the interval $[0, 400]$ using Audsley. Each job takes its worst case execution time (WCET) to end. Use Figure 1.

Answer : $\tau_1 > \tau_2 > \tau_3$.

c) Find the study interval, use the expression $[0, S_n + P]$.

Answer : In order to find the interval $[0, S_n + P)$ we have to find S_n (from previous exercise we already know that $P = 150$). S_n can be calculated using the following expression (Tasks are sorted by priority):

$S_1 = O_1$

$S_i = \max\left\{O_i, O_i + \left\lceil \frac{(S_{i-1} - O_i)^+}{T_i} \right\rceil \cdot T_i \right\}$ for $i = 2, \ldots, n$

In our case we have $\tau_1 > \tau_2 > \tau_3$, so :

1. $S_1 = O_1 = 100$.
2. $S_2 = \max\{O_2, O_2 + \lceil \frac{S_1 - O_2}{T_2} \rceil \cdot T_2\} = \max\{50, 50 + 1 \cdot 50\} = 100$.
3. $S_3 = \max\{O_3, O_3 + \lceil \frac{S_2 - O_3}{T_3} \rceil \cdot T_3\} = \max\{0, 0 + 1 \cdot 150\} = 150$.

Now we can find the interval : $[0, 150 + 150]$ = $[0, 300]$.

Exercise 2 : Earliest Deadline First

Task index	Release time	WCET	Deadline	Period
Task τ_1	0	10	50	50
Task τ_2	0	20	40	80
Task τ_3	0	10	30	100
Task τ_4	0	50	150	200

Table 2: System of 4 periodic, synchronous tasks with constrained deadline.

a) Find the study interval for this system (for the EDF algorithm).

Answer : The study interval for EDF is $[0, L)$, where L is given by :

$$L = \sum_{i=1}^{n} \left\lceil \frac{L}{T_i} \right\rceil \cdot C_i$$

L can be calculated using the following iterative approach:

$W_0 = \sum_{i=1}^{n} C_i$

$W_{k+1} = \sum_{i=1}^{n} \left\lceil \frac{W_k}{T_i} \right\rceil \cdot C_i$

In our case we have :

1. $W_0 = 10 + 20 + 10 + 50 = 90$,
2. $W_1 = \lceil \frac{90}{50} \rceil \cdot 10 + \lceil \frac{90}{80} \rceil \cdot 20 + \lceil \frac{90}{100} \rceil \cdot 10 + \lceil \frac{90}{200} \rceil \cdot 50 = 120$,
3. $W_2 = \lceil \frac{120}{50} \rceil \cdot 10 + \lceil \frac{120}{80} \rceil \cdot 20 + \lceil \frac{120}{100} \rceil \cdot 10 + \lceil \frac{120}{200} \rceil \cdot 50 = 140$,
4. $W_3 = \lceil \frac{140}{50} \rceil \cdot 10 + \lceil \frac{140}{80} \rceil \cdot 20 + \lceil \frac{140}{100} \rceil \cdot 10 + \lceil \frac{140}{200} \rceil \cdot 50 = 140$

The fixed point is found, now we have our interval: $[0, 140)$

b) Plot the scheduling of these 3 tasks in the interval $[0, 400]$ using EDF. Each job takes its worst case execution time (WCET) to end. Use Figure 1.

c) Find a system of periodic tasks that could be scheduled using EDF, but not using DM.

Answer : see Table 3

Task index	Release time	WCET	Deadline	Period
Task τ_1	0	50	100	100
Task τ_2	0	50	130	200
Task τ_3	0	from 1 to 50	150	200

Table 3: Systeme schedulable by EDF but not by DM.

If DM is used, the task τ_3 misses its deadline at $t = 150$.

Exercise 3 : Least Laxity First

Task index	Release time	WCET	Deadline	Period
Task τ_1	0	10	50	50
Task τ_2	0	20	40	80
Task τ_3	0	10	30	100
Task τ_4	0	50	150	200

Table 4: System of 4 periodic, synchronous tasks with constrained deadline.

a) Plot the scheduling of these 4 tasks in the interval $[0, 200]$ using LLF. Consider the case when all priorities are recalculated every 10 time units. Each job takes its worst case execution time (WCET) to end. Use Figure 2.

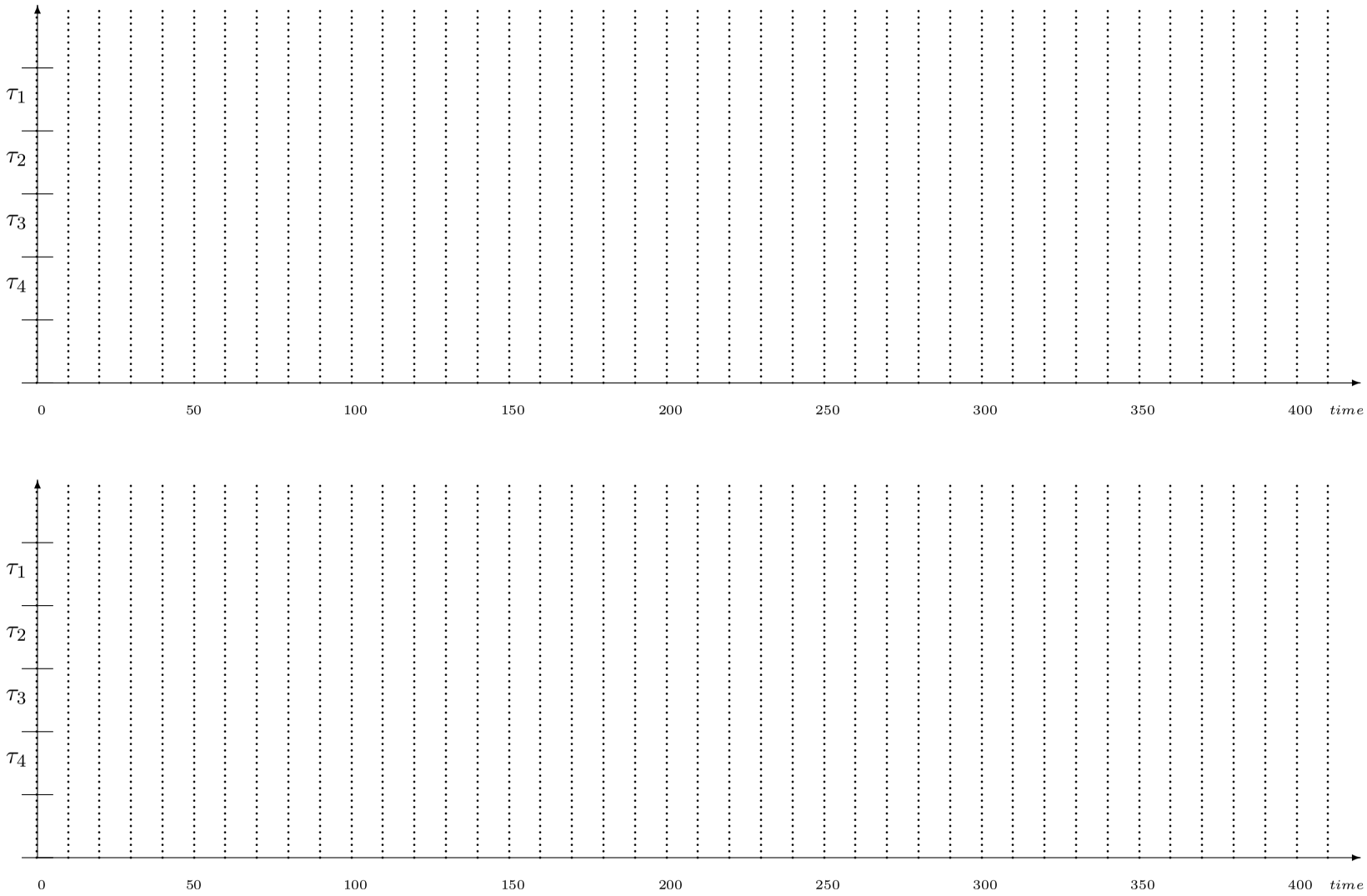

Figure 1: *Scheduling.*

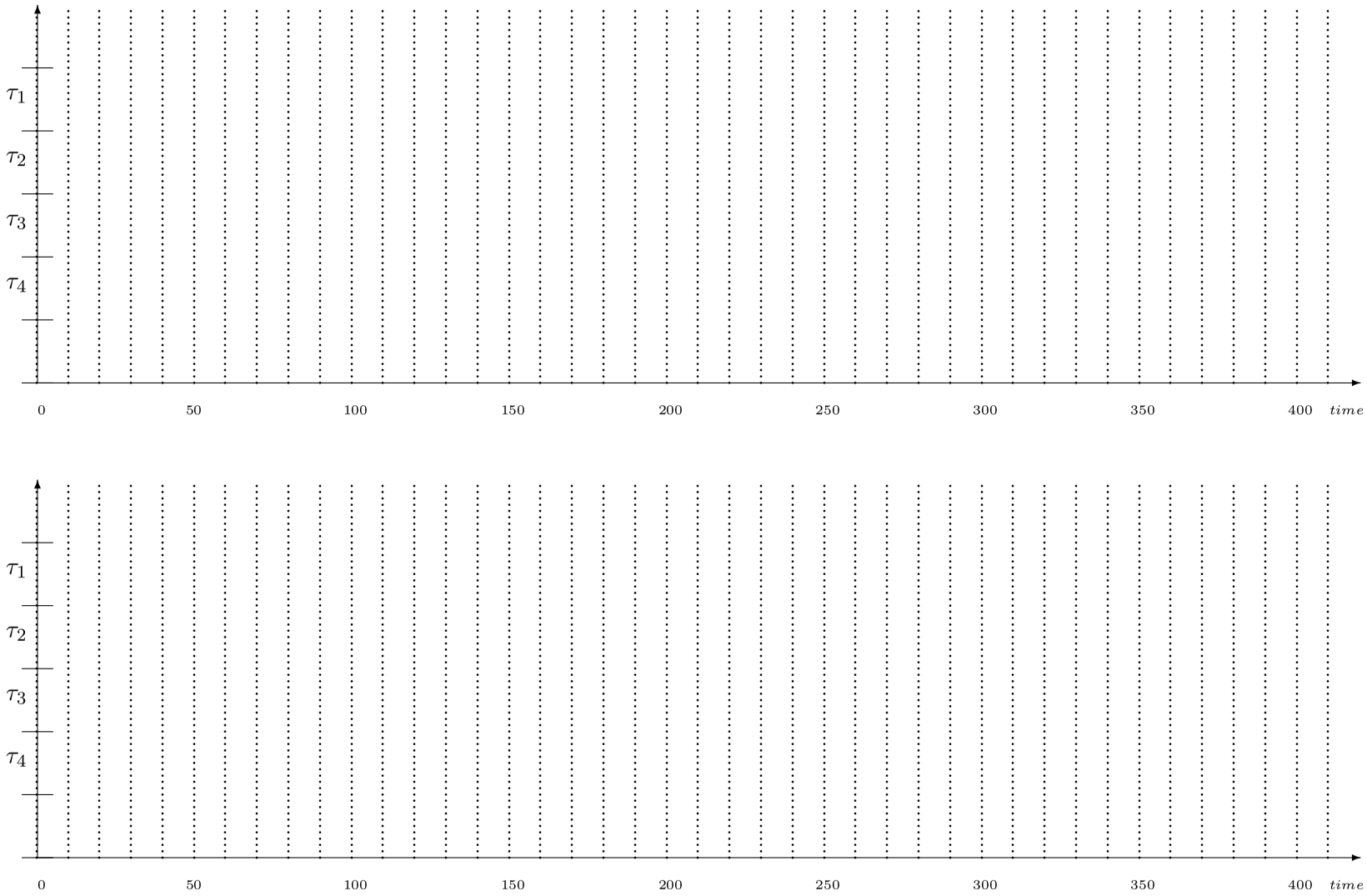

Figure 2: *Scheduling.*