CHALMERS
UNIVERSITY OF TECHNOLOGY

SSY191 - Model Based Development for Cyber-Physical System

Individual Assignment

Individual Assignment - 3

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1 Problem 1a

Tasks	Period (T)	Computation Time WCET	Priority
1	4	1	2
2	10	7	1

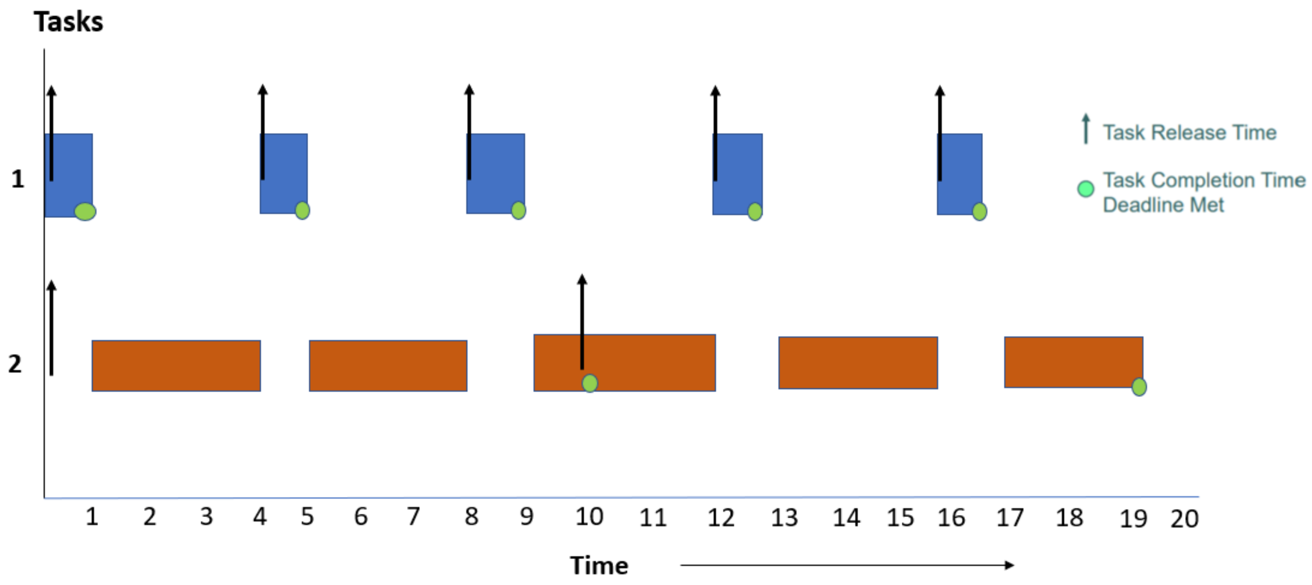


Figure 1: Rate Monotonic Scheduling (RMS) Scheme for 20 time units

2 Problem 1b

If we are using the additional mutex lock, we will be having some problem with fulfilling the deadlines. This is due to the fact that using the lock will require each task to share the lock together and by using priority inheritance, once task 2 has acquired the lock, it will then block the task 1 as the original higher priority while elevating task 2 as the new highest priority. Hence, by the time task 1 is acquiring the lock, its own deadline will be missed.

Tasks	Period (T)	Computation Time WCET	Priority
1	4	1	2
2	10	7	1

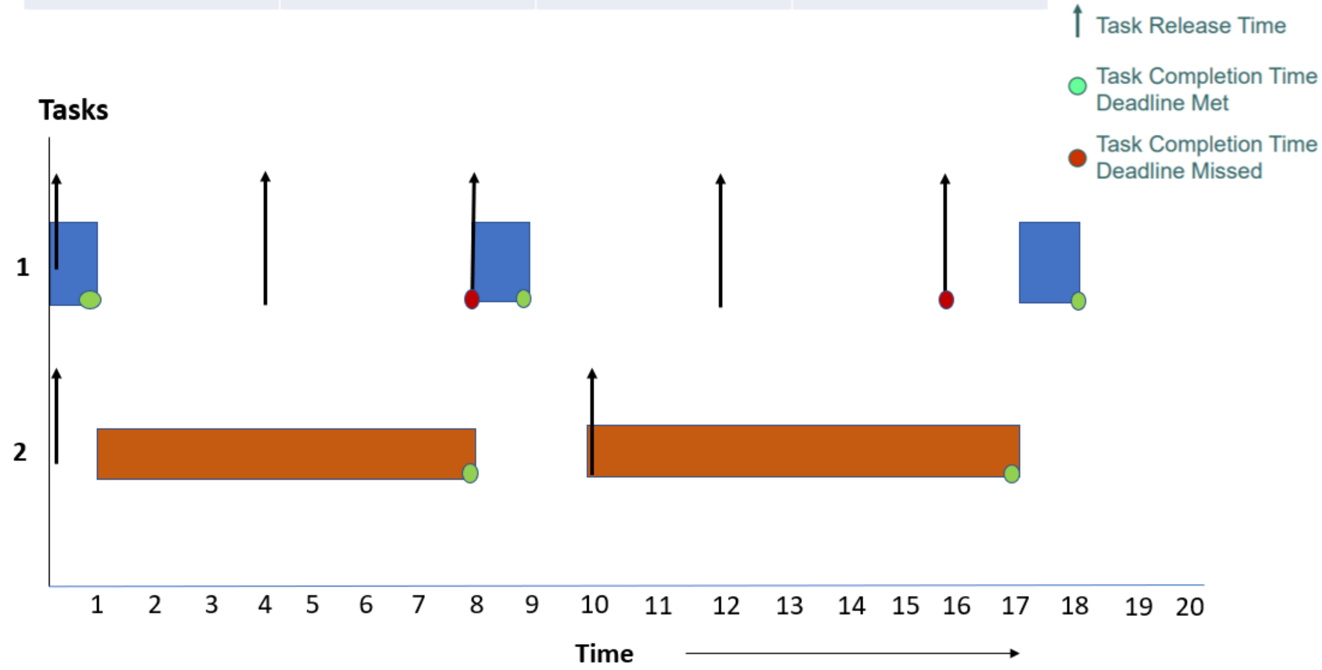
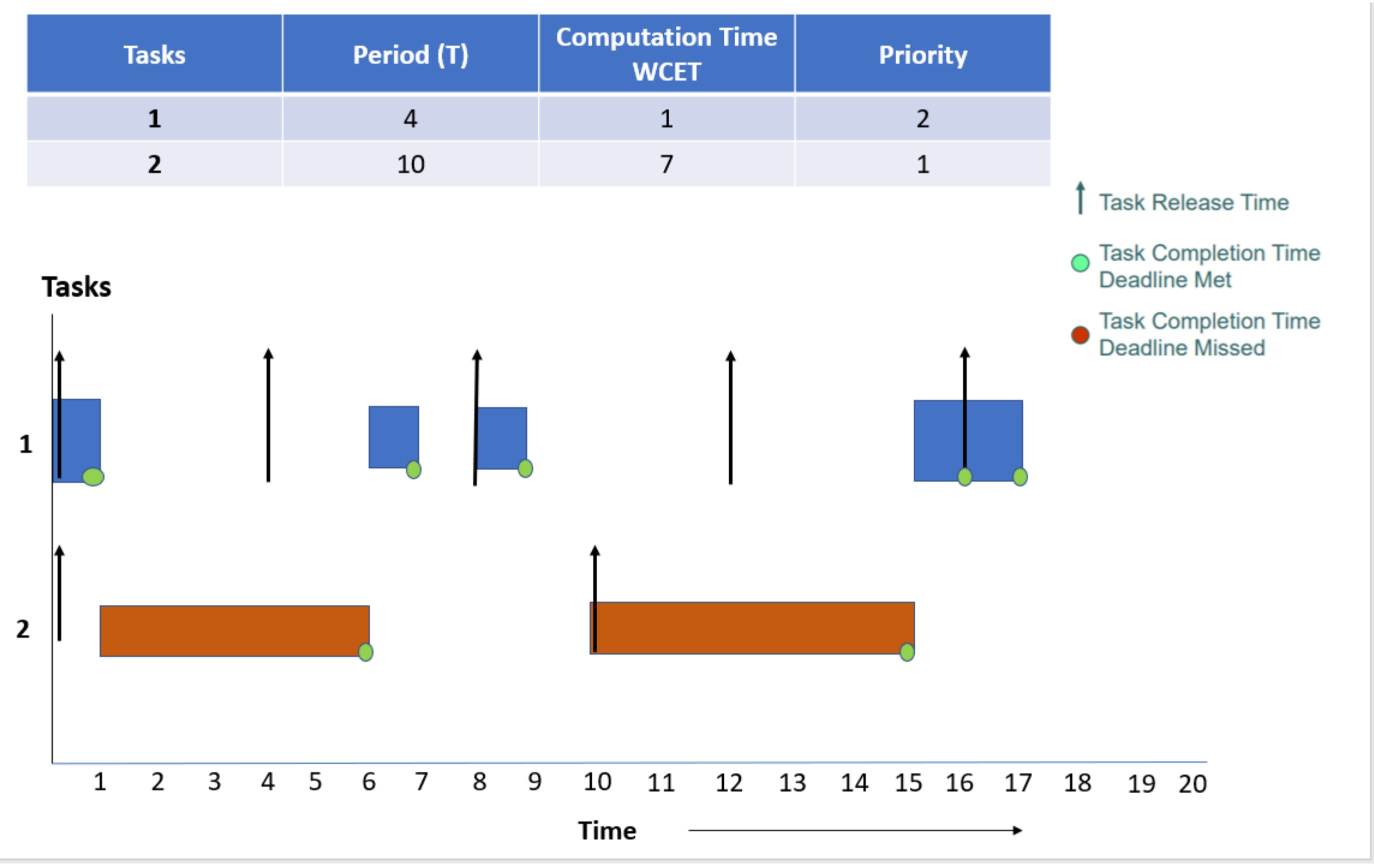


Figure 2: RMS Scheme with mutex

3 Problem 1c



Tasks	Period (T)	Computation Time WCET	Priority
1	4	1	2
2	10	7	1

Figure 3: RMS Scheme with mutex and *anytime algorithm* on the 2nd task

Given that we are applying the anytime algorithm on Task 2, then assuming that Liu-Layland criteria (e.g. N=2 since we have 2 tasks) will give us a schedulable tasks (e.g. deadlines are consistently met).

$$\sum_{i}^{N} \frac{C_i}{T_i} \leq N(2^{\frac{1}{N}} - 1) \tag{1}$$

$$\implies \frac{1}{4} + \frac{e_2}{10} \leq \ 2(\sqrt{2} - 1)$$

$$\implies \frac{1}{4} + \frac{e_2}{10} \leq 0.83$$

$$\implies \frac{e_2}{10} \leq 0.58$$

$$\implies e_2 \leq 5.8$$

The calculation above indicates that in order for our RMS to become feasible, we should be able to execute task 2 at most about 5 seconds.

4 Problem 1d

Modifying the schedule in Figure 1, but with Early Deadline First (EDF) method with task 1 set as the higher priority in a stalemate condition, will give us a new schedule below

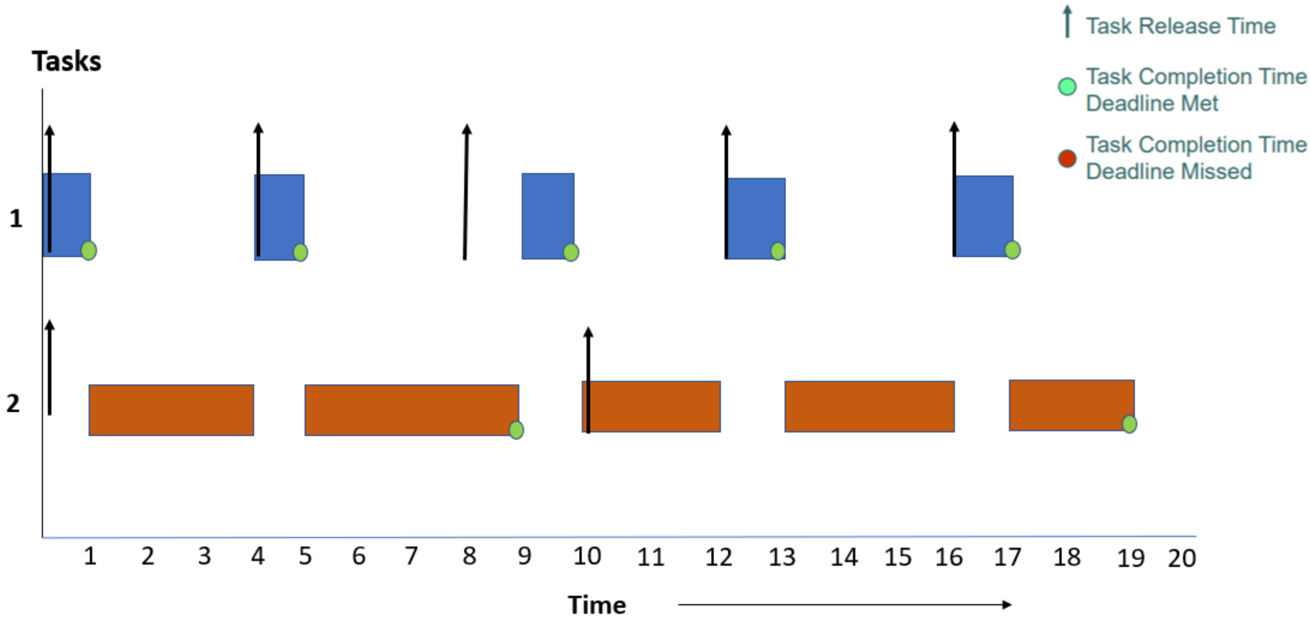


Figure 4: **EDF** Scheme with no mutex

5 Problem 1e

Given that we are applying the *anytime algorithm* on Task 2, then assuming that a much more simple test than Liu-Layland Criteria (e.g. Utilization-based Test) will give us a schedulable tasks (e.g. deadlines are consistently met) for our EDF method

$$\sum_{i}^{N}\frac{C_i}{T_i} \leq 1 \tag{2}$$

$$\implies \frac{1}{4} + \frac{e_2}{10} + \frac{2}{5} \leq 1$$
$$\implies 0.25 + \frac{e_2}{10} + 0.40 \leq 1$$
$$\implies \frac{e_2}{10} \leq 0.35$$
$$\implies e_2 \leq 3.5$$

In order for the scheduling of the tasks to work, the calculation indicates us that we must be able to execute task 2 at most 3 seconds. In addition, adding another task with period, WCET and new condition for tie-breaking as defined in the question will give us the following schedule as shown in Figure 5

Tasks	Period (T)	Computation Time WCET
1	4	1
2	10	7
3	5	2

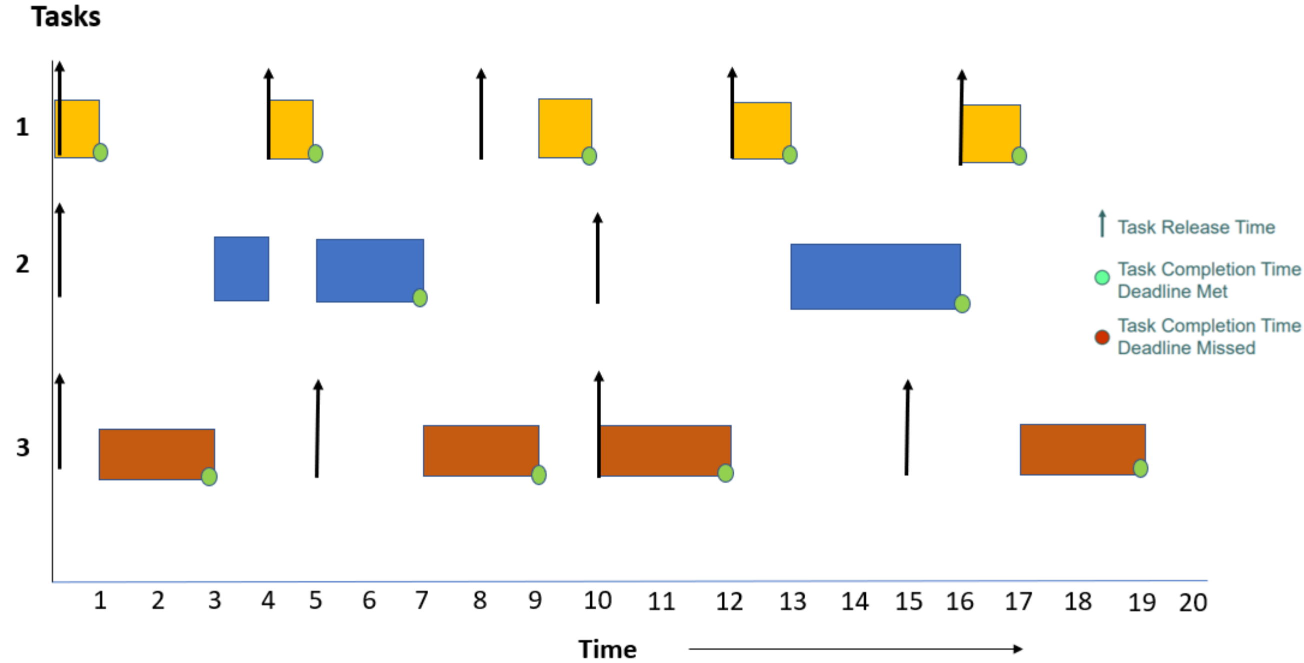


Figure 5: **EDF** Scheme with additional task 3 and *anytime algorithm*

6 Problem 2a : Mutual exclusion

The expression of LTL model is as below

$$\begin{aligned} &Always[\neg(T_{1,\text{use}} \wedge T_{2,\text{use}})] \\ &\implies \Box\neg(T_{1,\text{use}} \wedge T_{2,\text{use}}) \end{aligned} \tag{3}$$

7 Problem 2b : Finite time of usage

The expression of LTL model is as below

$$\begin{aligned} &\neg Eventually[Always\ [T_{1,\text{use}}]] \wedge \neg Eventually[Always\ [T_{2,\text{use}}]] \\ &\implies \neg\Diamond\Box(T_{1,\text{use}}) \wedge \neg\Diamond\Box(T_{2,\text{use}}) \end{aligned} \tag{4}$$

8 Problem 2c : Absence of individual starvation

The expression of LTL model is as below

$$\begin{aligned} &Always[\ T_{1,\text{request}} \rightarrow\ Eventually[T_{1,\text{use}}]\ ] \wedge Always[\ T_{2,\text{request}} \rightarrow\ Eventually[T_{2,\text{use}}]\ ] \\ &\implies \Box(T_{1,\text{request}} \rightarrow \Diamond T_{1,\text{use}}) \wedge \Box(T_{2,\text{request}} \rightarrow \Diamond T_{2,\text{use}}) \end{aligned} \tag{5}$$

9 Problem 2d : Absence of blocking

The expression of LTL model is as below

$$\neg Eventually[Always\ [T_{1,\text{request}}]] \wedge \neg Eventually[Always\ [T_{2,\text{request}}]] \tag{6}$$
$$\implies \neg\Diamond\Box(T_{1,\text{request}}) \wedge \neg\Diamond\Box(T_{2,\text{request}})$$

10 Problem 2e : Alternating access

The expression of LTL model is as below

$$Always[\ T_{1,\text{release}} \rightarrow\ [\neg T_{1,\text{use}} \bigcup T_{2,\text{use}}]\ ] \wedge Always[\ T_{2,\text{release}} \rightarrow\ [\neg T_{2,\text{use}} \bigcup T_{1,\text{use}}]\ ] \tag{7}$$
$$\implies \Box(T_{1,\text{release}} \rightarrow (\neg T_{1,\text{use}} \bigcup T_{2,\text{use}})) \wedge\ \Box(T_{2,\text{release}} \rightarrow (\neg T_{2,\text{use}} \bigcup T_{1,\text{use}}))$$