Networked Embedded Systems Lab
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Introduction to Embedded Systems – WS 2022/23

Exercise 4: Scheduling Periodic and Mixed Task Sets

Task 1: Earliest Deadline First (EDF) and Total Bandwidth Server (TBS)

Consider the following set of periodic tasks:

	τ_1	τ_2	τ_3
C_i	1	1	2
T_i	3	5	13

A Total Bandwidth Server (TBS) executes along with the periodic tasks above.

1. What can be the maximum value of U_s such that the whole set (i.e., periodic tasks and the TBS) is schedulable with EDF?
2. Now assume $U_s = 0.25$. Construct the EDF schedule (in Figure 1) in the case in which three aperiodic requests $J_4(r_4 = 0, C_4 = 2)$, $J_5(r_5 = 15, C_5 = 1)$ and $J_6(r_6 = 10, C_6 = 1)$ are served by TBS. Assume that the arrival time of the first instance/job of each periodic task is 0.

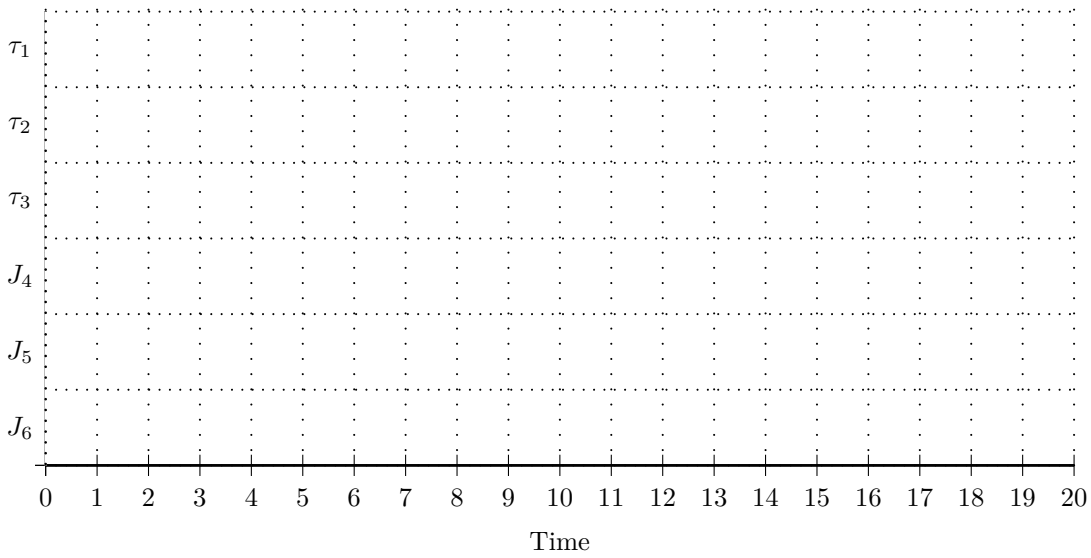

Figure 1: EDF schedule for Task 1

Task 2: Schedulability Test for Fixed Priorities – Rate Monotonic (RM)

	τ_1	τ_2	τ_3
C_i	1	3	2
T_i	3	8	9

1. Test if the given task-set is schedulable under RM, using the sufficient test.
2. Test if the given task-set is schedulable under RM, using the necessary test.
3. Assume that the first job of each task arrives at time 0. Construct the schedule for the interval $[0, 20]$ and illustrate it graphically. In case they exist, identify deadline misses.

Task 3: Scheduling with Polling Server

	τ_1	τ_2	τ_3
C_i	2	2	2
D_i	6	8	16
T_i	6	8	16

In addition to the above periodic tasks, we have an aperiodic job J_a with computation time $C_a = 1$, and relative deadline D_a. The scheduling policy is RM. The aperiodic job is scheduled through a Polling Server (PS).

1. Let the period and computing time of the polling server be $T_s = 25$ and $C_s = 1$, respectively. Compute the aperiodic guarantee available to J_a, i.e., compute the minimum relative deadline of J_a which is guaranteed not to be missed.
2. Using the sufficient test of RM, test if the polling server of (a) is schedulable along with the periodic task-set?
3. [optional] Determine integer parameters (C_s, T_s) of the polling server such that (1) the relative deadline guaranteed to J_a is minimised, and (2) the RM schedule satisfies the sufficient schedulability test.
4. [optional] For the optimal setting of (c) devise a necessary schedulability test with the relative deadline of the aperiodic task $D_a = 32$.

The two optional subquestions of Task 3 and the remaining tasks below are meant for additional practice and will not be discussed in the exercise session. Solutions will be provided online, as usual.

Task 4: Periodic Scheduling with Fixed Priorities – DM

Given the following set of periodic tasks:

	τ_1	τ_2	τ_3
C_i	1	2	3
D_i	5	4	8
T_i	5	6	10

1. Check the schedulability of the task set using the Deadline Monotonic (DM) policy.
2. Construct the schedule graphically. Let the phase $\Phi_i = 0\ \forall i$. In case they exist, identify deadline misses.

Task 5: Mixed Tasks – Polling Server

Two periodic tasks are given, with execution times and periods given in the following table (deadlines equal periods). The phase of the periodic tasks is assumed to be $\Phi_i = 0 \; \forall i$. The given set of tasks should be scheduled with the Rate Monotonic scheduling scheme.

	τ_1	τ_2
C_i	1	2
T_i	5	8

Construct a schedule graphically for following aperiodic requests (a Polling Server with integer parameters should be introduced). The CPU utilization has to be maximized.

	J_1	J_2	J_3
a_i	2	7	9
C_i	3	2	1

Task 6: Mixed Tasks – Total Bandwidth Server

We have to design a system that schedules periodic tasks with EDF and employs a total bandwidth server to serve aperiodic requests. We know of one sporadic aperiodic request with computation time $C_a = 2$ and a relative deadline $D_a = 7$. What is the maximum processor utilization available for periodic tasks if we want to guarantee that this aperiodic task completes within its deadline?

Task 7: Periodic Scheduling

A processor is supposed to execute the following set of tasks described by their execution times C, relative deadlines D and periods T.

	τ_1	τ_2	τ_3
C_i	2	2	4
D_i	5	4	8
T_i	6	8	12

1. Execute the sufficient schedulability test under DM and calculate the result. What statement regarding schedulability can be made based on your result?
2. Execute the sufficient and necessary schedulability test under DM and calculate the result. What statement regarding schedulability can be made based on your result?
3. If there is a feasible schedule for the given task set, construct it graphically. Let the phase $\Phi_i = 0 \; \forall i$.