IL2212 EMBEDDED SOFTWARE

Theoretical Homework 2 (Part B)

VERSION 1.0

Revision History

- Version 1.0: Initial version

Requirements

The total amount of points in the homework is 20 points. To pass the homework corresponding to Part A, 12 points in this homework are required. To pass the theoretical part of the course (TENA; 4.5 credits), 42 points are required from the three individual theoretical homework assignments.

Homework Tasks

1. (3 POINTS) Given is the following set of independent periodic tasks, which shall be scheduled rate-monotonically.

$$T_1 = (3, 1); T_2 = (2, 5, 1, 5); T_3 = (2, 10, 3, 10)^1$$

   (a) Determine, if all tasks will meet their deadline.

   (b) Assume that T_3 has a non-preemptible section with size $b \leq 3$. What is the maximum size of b so that T_2 still meets its deadline?

   (c) Assume that task $T_1 = (3, 1)$ is a periodic task, and task $T_2 = (2, 5, 1, 5)$ is a deferrable server, while task $T_3 = (2, 10, 3, 10)$ remains a periodic task. Determine the worst case response time for task T_3 for the case that the size of the non-preemptible section in T_3 is $b = 1$.

2. (3 POINTS) A system consists of two independent periodic tasks, T_1 = (3,1), T_2 = (6,2). The system is scheduled rate-monotonically.

   (a) In addition to these tasks a deferrable server with a period $p_s = 5$ and an execution budget of $e_s = 1$ shall be integrated into the system. Use a deferrable server with the parameters (p_s, e_s) = (5,1). What are the response times of the following aperiodic jobs: A_1 arrives at 4 and has an execution time of 1.5 and A_2 arrives at 7 and has an execution time of 1. Give the schedule for all tasks and the budget of the deferrable server at all time instances.

[1] The 4-tuple (ϕ_i, p_i, e_i, D_i) gives the phase ϕ_i, period p_i, execution time e_i and relative deadline D_i. In case of a 2-tuple (p_i, e_i) ϕ_i is 0 and D_i is p_i.

(b) If you instead of the deferrable server use a polling server with the parameters (p_s, e_s) = (12,e_s) can you give a maximum integer value of e_s so that the task system is still schedulable?

(c) A system that is scheduled rate-monotonically has two periodic tasks T_1 = (3,1), T_2 = (5,1) and a sporadic server: T_S = (8,1). Aperiodic jobs with firm deadline are scheduled by the server using the earliest-deadline first algorithm. You can assume that acceptance tests are done immediately on arrival of the aperiodic job with firm deadline.

- At a certain unspecified time t_x, where no aperiodic jobs with firm deadline are yet accepted by the system, a new aperiodic job with firm deadlines S_1 = (t_x + 56, 4) enters and is accepted by the system.
- Then at time t_x + 24, another aperiodic job with firm deadline S_2 = (t_x + 48, 3) arrives.

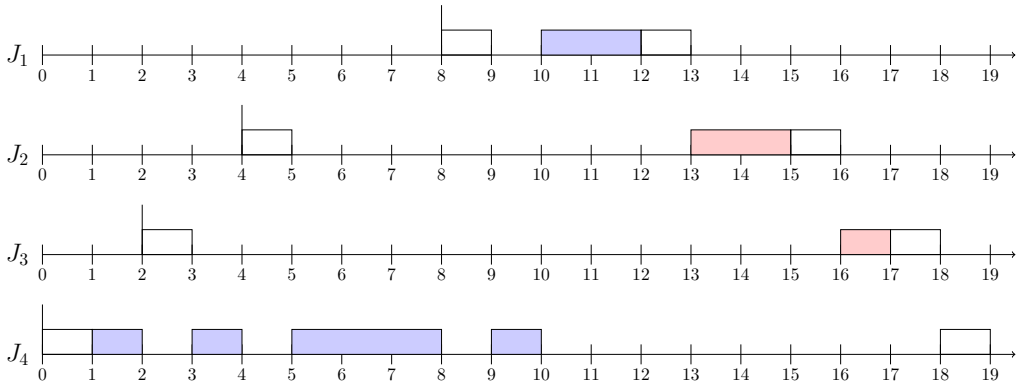
Can the aperiodic job with firm deadline S_2 be accepted by the system? Motivate!

3. (4 POINTS) A system contains four jobs. There are two resources X and Y. The following table shows the job parameters and their execution pattern. The execution pattern describes how each job is executed. [R;t] is read as follows: the job requires the resource R for t time units. Here, job J_1 requires no resource for one time unit, the resource X for 2 time units and no resource for one time unit.

Table 1: Job parameters and execution patterns

Job	r_i	e_i	π_i	Execution Pattern
J_1	8	4	1	[-;1][X;2][-;1]
J_2	4	4	2	[-;1][Y;2][-;1]
J_3	2	3	3	[-;1][Y;1][-;1]
J_4	0	8	4	[-;1][X;6][-;1]

(a) Please motivate for each of the following protocols, if this schedule



can be generated by the following protocol:

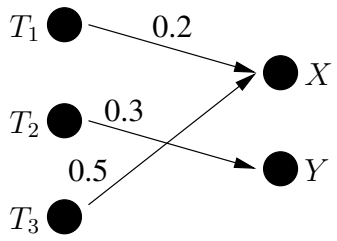
i. Non-preemptive critical section protocol
ii. Basic priority-inheritance protocol
iii. Basic priority-ceiling protocol

(b) Create the resource requirement graph for the jobs J_1 to J_4 and the resources X and Y assuming that all resource requirements are specified in Table 1 and that there are no additional resource requirements.

(c) Give the maximum blocking-time for each job, if

i. the basic priority ceiling protocol is used
ii. the non-preemptive critical section protocol is used

4. (3 POINTS) A system contains the following three periodic tasks: T_1 = (ϕ_1,3,1,3), T_2 = (ϕ_2,5,2,5), T_3 = (ϕ_3,8,1,8)[2]. The resource requirements of the tasks are given in the following figure.



The tasks are scheduled by the rate-monotonic algorithm and the basic priority-ceiling protocol. Calculate the maximum response time for each task. Are the tasks schedulable for any combination of ϕ_1, ϕ_2, ϕ_3?

5. (4 POINTS) A system contains five jobs. There are three resources X, Y, and Z. The following table shows the job parameters and their execution pattern. The execution pattern describes how each job is executed. [R;t] is read as follows: the job requires the resource R for t time units. Here, job J_1 requires no resource for one time unit, the resource Z for 1 time unit, and no resource for one time unit. The job J_4 has a nested critical section, which comprises the following resource requests: the resourse Y is requested and used for two time units but not released, then the resource X is requested for one time unit and released, and finally the resource Y is used for one more time unit and released. The priority of a job J_i is given as π_i, where a lower number means a higher priority.

Job	r_i	e_i	π_i	Execution Pattern
J_1	12	3	1	[-;1][Z;1][-;1]
J_2	7	3	2	[-;1][X;1][-;1]
J_3	3	3	3	[-;1][Y;1][-;1]
J_4	2	6	4	[-;1][[Y;2][X;1][Y;1]][-;1]
J_5	0	5	5	[-;1][Z;3][-;1]

Use the basic priority-ceiling protocol to schedule the system of jobs. Give the schedule and show also the current priority of the executing job and current priority ceiling at all time instants.

6. (3 POINTS) A system consists of six jobs J_1, J_2, ..., J_6. The release time r_i, the absolute deadline d_i and the execution time e_i for each job is given in the following table.

Job	r_i	d_i	e_i
J_1	1	4	3
J_2	0	10	6
J_3	3	14	7
J_4	9	22	6
J_5	2	17	6
J_6	8	20	2

J_1 is the immediate predecessor of J_2, J_3, J_4 and J_5. J_6 is the immediate successor of J_2, J_3, J_4 and J_5. There are no further precedence constraints.

(a) Draw the precedence graph of the jobs.

[2]The 4-tuple (ϕ_i, p_i, e_i, D_i) gives the phase ϕ_i, period p_i, execution time e_i and relative deadline D_i. In case of a 2-tuple (p_i, e_i) ϕ_i is 0 and D_i is p_i.

(b) Assume that the jobs can be executed on two processors, where jobs may be preempted but never migrated. Schedule the jobs using a priority-driven scheduling algorithm with the priority order J_1, J_2, ..., J_6, where J_1 has the highest priority. Will all jobs meet their deadlines?

(c) Assume that due to a faster algorithm, the execution time for job J_3 is reduced to $e_3 = 4$. Give the schedule for this case. Will all jobs meet their deadlines?