CS/ECE 561: Hardware/Software Design of Embedded Systems
Fall 2016

Homework 4: Scheduling Algorithms in Real-Time Embedded Systems

Assigned: 3 Nov 2016
Due: 10 Nov 2016

Instructions:

- Please submit your submissions via Canvas. Submissions should include a single PDF or Word file with the solutions/write-up and an archive for any supplementary files (e.g. program code)
- Some questions might not have a clearly correct or wrong answer. In such cases, grading is based on your arguments and reasoning for arriving at a solution.

Q1 (40 points) In our lecture on scheduling algorithms we discussed the following three preemptive scheduling algorithms: (i) rate monotonic (RM), which assigns fixed priority to tasks according to their periods, (ii) earliest deadline first (EDF), which assigns dynamic priority to tasks according to their absolute deadlines; and (iii) least laxity first (LLF), which assigns dynamic priority to tasks according to their relative laxity.

Consider the task set τ composed of the following three independent periodic tasks:

$$\tau 1(r0 = 0, C = 1, D = 3, T = 3)$$
$$\tau 2(r0 = 0, C = 1, D = 4, T = 4)$$
$$\tau 3(r0 = 0, C = 2, D = 3, T = 6)$$

where r0 is the task release (arrival) time, C is execution time in cycles, D is the deadline, and T is the period.

(a) Compute the processor utilization factor and the major cycle of the task set (a major cycle is defined as the time duration [0, least common multiple or LCM of the periods of all the tasks]). (**15 points**)
(b) Build the schedule of the task set under the RM, EDF and LLF algorithms for the major cycle. (**25 points**)

Q2. (**45 points**) Consider the task set τ composed of the following three periodic tasks:

$$\tau 1(r0 = 0, C = 2, D = 8, T = 8)$$
$$\tau 2(r0 = 0, C = 4, D = 12, T = 12)$$
$$\tau 3(r0 = 0, C = 4, D = 16, T = 16)$$

Consider a hybrid task set composed of the periodic task set τ above and one of the following aperiodic requests:

case a: $\tau 4(r = 18, C = 4, D = 12)$
case b: $\tau 4(r = 18, C = 4, D = 20)$

The aperiodic task is scheduled using a server, which is a periodic task whose purpose is to service aperiodic requests. The new task set is $\tau' = \tau + \{\tau s\}$. $\tau s\ (r0 = 0, C = 2, D = 12, T = 12)$ is the task server.

(a) Compute the processor utilization factor of the task set τ' and the major cycle of the task set (**15 points**)
(b) Build the RM schedule for the hybrid task set using case a. What can you conclude? (**15 points**)
(c) Build the EDF schedule for the hybrid task set using case b. What can you conclude? (**15 points**)

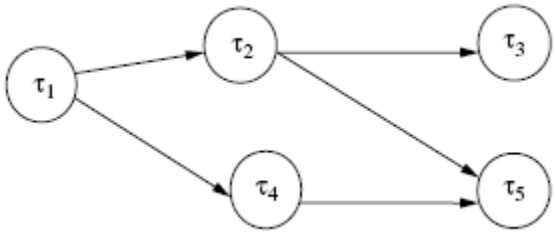
Q3. (**30 points**) Consider three independent periodic tasks described by the classical parameters given in the table below. What we can notice about this task set is that the tasks have different initial release times and two tasks share a critical resource, named *R*, during their whole execution time.

Task	r_i	C_i	D_i	T_i
τ_1	1	2 (*R*)	6	6
τ_2	1	2	8	8
τ_3	0	5 (*R*)	12	12

(a) Compute the processor utilization factor *U* of this task set. Construct the schedule under the EDF algorithm considering no particular critical resource management except the mutual exclusion process. Indicate on the graphical representation the time at which a priority inversion phenomenon occurs. (**15 points**)
(b) In order to prevent the priority inversion phenomenon, we apply the priority inheritance protocol. Construct the new schedule obtained under the EDF algorithm and the priority inheritance resource protocol until time $t = 25$. Indicate clearly on the graphical representation the time at which the task τ3 inherits a higher priority, thus avoiding the priority inversion phenomenon. (**15 points**)

Q4. (**35 points**) Consider five dependent periodic tasks with their precedence graph and details below:

Task	r_i	C_i	D_i	T_i
τ_1	0	3	12	12
τ_2	0	2	11	11
τ_3	0	3	12	12
τ_4	0	1	11	11
τ_5	0	2	9	9



Construct the schedule obtained under the EDF scheduling algorithm for the first 20 time units