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Exercises for Lecture
Real-Time Systems and Applications
Summer Semester 16

Exercise Sheet 6

(11 Punkte)

Exercise Due at Wednesday, June 8, 2016, 12:00 Uhr

Hinweise: Gruppenarbeit von bis zu drei Personen aus der gleichen Übungsgruppe ist möglich. Bitte vergessen Sie nicht Ihre Namen und Ihre Matrikelnummern auf die Lösung zu schreiben. **Die Abgaben können in den beschrifteten Briefkasten vor dem Sekretariat des LS12 (OH16/E22) eingeworfen oder per Mail (PDF Format) an georg.von-der-brueggen [☺] tu-dortmund.de abgegeben werden.**

Note: It is allowed to work in a group of up to three persons, if these persons are from the same practice group. Please do not forget to write your name and your Matrikelnummer on the solutions. **The solutions can either be placed in the mailbox in front of the secretary's office of LS 12 (OH/E22) or sent by mail (PDF format) to georg.von-der-brueggen [☺] tu-dortmund.de**

Exercise Sessions:

Do, 10:15 - 11:45	OH16/U08
Do, 14:15 - 15:45	OH16/U08

6.1 PCP Example (3 Punkte)

Draw the current priority ceiling $\Pi'(t)$ of the system and the current priority of the jobs in the two examples of PCP (i.e., x axis with respect to time and y axis with respect to the priority levels) given in the lecture (i.e., Pages 26 and 27 in Resource.pdf).

6.2 Resource Access Protocols (4 Punkte)

1. What is priority inversion? Is it possible to completely avoid priority inversion in fixed-priority scheduling? If yes, what is the drawback of such schemes? If no, explain your arguments.
2. Explain why the Priority Ceiling Protocol (PCP) is deadlock free.
3. Mr. Smart wants to use PCP in his system which uses dynamic priority scheduling, i.e., EDF (earliest-deadline-first scheduling). Is it possible? What would be the problem(s) that he may face?
4. Explain how you will implement the PCP and Priority Inheritance Protocol (PIP) in a Real-Time Operating System.

6.3 PCP/PIP Schedulability Test (3 Punkte)

Consider the following case with four sporadic tasks and 3 semaphores, where $S_j(\tau_i)$ is the worst-case execution time of a critical section guarded by semaphore "S_j" in task τ_i and $S_j(\tau_i)$ is 0 when task τ_i does not need semaphore S_j.

	$S_1()$	$S_2()$	$S_3()$
τ_1	1	0	0
τ_2	0	0	9
τ_3	8	7	0
τ_4	6	5	4

	τ_1	τ_2	τ_3	τ_4
C_i	2	10	16	16
T_i	10	24	96	96
D_i	10	24	96	96

Suppose that the critical sections are not nested. Note that the worst-case execution time C_i of a task τ_i is derived by assuming that the critical sections are always granted without any blocking.

1. Can RM+PIP feasibly schedule the above task set?
2. Can RM+PCP feasibly schedule the above task set?

6.4 Challenge on Optimal Priority Ordering (optional) (1 Punkt)

Suppose that the following schedulability test is an exact test for PCP: A system $\mathcal{T}$ of periodic, preemptable tasks with constrained deadlines is schedulable on one processor by a fixed-priority scheduling algorithm if

$$\forall \tau_i \in \mathcal{T}\ \exists t \text{ with } 0 < t \leq D_i \ \ and\ \ W_i(t) \leq t$$

holds, where $W_i(t)$ of the task τ_i is defined as follows:

$$W_i(t) = B_i + C_i + \sum_{j=1}^{i-1} \left\lceil \frac{t}{T_j} \right\rceil C_j.$$

The worst-case blocking time B_i for task τ_i is at most

$$\max_{j>i,R} \{C_{j,R} | \Pi(R) \leq i\},$$

where $C_{j,R}$ is the worst-case (consecutively) execution time when resource R is required for executing a job of task τ_j. Please explain that deadline-monotonic scheduling is an optimal fixed-priority scheduling policy under the above schedulability analysis.

General Hints: