

EINDHOVEN UNIVERSITY OF TECHNOLOGY
Department of Mathematics and Computer Science

Examination Real-time Architectures (2XN26)
on Thursday, January 20th 2011, 10.30h-12.00h.

First read the entire examination. There are 5 exercises in total. Grades are included between parentheses at all parts and sum up to 10 points. Good luck!

1. Dr. Damir Isovich gave a guest-lecture on “Offline scheduling”.
 - (a) (0.5) Give at least 2 advantages and 2 disadvantages of offline scheduling compared to online scheduling.
Answer: See slides (page 17).
 - (b) (0.5) How is resource sharing dealt with?
Answer: Mutual exclusion is guaranteed by restricting resource access (critical sections) to a time slot.
 - (c) (0.5) The amount of time that may be needed to find a solution may increase exponentially for each new task added to the system. How can the time needed to find a solution be reduced?
Answer: Use of heuristics, e.g. when the search-tree is traversed, we may choose the task with the shortest deadline or the task with the longest execution time.
 - (d) (0.5) How can flexibility be introduced in offline schedules?
Answer: Two approaches were given: *modes*, where each mode has its own offline schedule, and *slot-shifting*, combining offline and online scheduling.
2. For the schedulability analysis, it is typically assumed that tasks do not suspend themselves.
 - (a) (0.5) What does that mean?
Answer: If a task didn't complete its work yet, i.e. there is still work pending, the task is not blocked, and is granted the processor, it will execute rather than wait.
 - (b) (1.0) Give an example illustrating the problem of suspension.
Answer: Any example illustrating that if a task suspends itself, (*i*) a lower priority task (under FPPS) may miss its deadline due to the delayed interference and (*ii*) the task itself may miss its deadline. Note that self-suspension has a similar effect on lower priority tasks as jitter.
3. (1.5) There are three main classes of schedulability tests: *necessary*, *sufficient*, and *exact*. Give an explanation of these three main classes of tests and an example for each class.
Answer: See exercise 1 of the exam of 2IN25 of June 23rd, 2005.
4. Servers were presented as a means to schedule aperiodic tasks:
 - (a) (0.5) Give an advantage and a disadvantage of using *background scheduling* for aperiodic tasks rather than servers.
Answer: See slides.

- (b) (0.5) Give an advantage and a disadvantage of using a *polling server* for aperiodic tasks when compared to other types of servers.

Answer: See slides.

- (c) (1.0) The description of the *sporadic server* in Buttazzo is wrong. Explain the problem in your own words.

Answer: See paper: “M. Stanovich, T.P. Baker, A.I. Wang, and M. Gonzalez Harbour, *Defects of the POSIX Sporadic Server and How to Correct Them*, In: Proc. 16th IEEE RTAS, pp. 35–45, April 2010.”

5. Consider four periodic tasks τ_1, τ_2, τ_3 and τ_4 (having decreasing priority), which share five resources, A, B, C, D , and E . Compute the maximum blocking time B_i for each task for the following three protocols, knowing that the longest duration $D_i(R)$ for a task τ_i on resource R is given in the following table (there are no nested critical sections).

	A	B	C	D	E
τ_1	6	7	0	10	3
τ_2	0	0	0	8	0
τ_3	4	14	8	0	0
τ_4	0	11	0	9	7

- (a) (1.5) Priority Inheritance Protocol (PIP).

Answer Similar to Exercise 7.5 of the book of Buttazzo. Compared to that exercise, the columns have been exchanged ($A \rightarrow E \rightarrow B \rightarrow A$ and $C \leftrightarrow D$), and all non-zero values have been increased by 1.

- (b) (1.0) Priority Ceiling Protocol (PCP).

Answer Similar to Exercise 7.6 of the book of Buttazzo.

- (c) (0.5) Highest Locker Protocol (HLP).

Answer Same as for PCP.