EINDHOVEN UNIVERSITY OF TECHNOLOGY

Department of Mathematics and Computer Science

Examination Real-time Architectures (2IN60)
on Thursday, January 20^{th} 2011, 9.00h-12.00h.

First read the entire examination. There are 6 exercises in total. Grades are included between parentheses at all parts and sum up to 11 points. Good luck!

1. Interrupts were described during a lecture addressing "prior knowledge".

   (a) (0.5) Describe the basics of interrupts, i.e. how the outside world "breaks-in" during the execution of instructions.
   Answer: See slide 15 of "2IN60.prior-knowledge-II.pdf".

   (b) (0.5) What does "Interrupts must be transparant" mean? *Hint*: describe the steps taken to handle an interrupt.
   Answer: See slide 16 of "2IN60.prior-knowledge-II.pdf". The essential element for "transparency" is described in step 3.

2. Dr. Damir Isovic 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 chose 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.

3. 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.

4. (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 23^{rd}, 2005.

5. 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. Gonzlez Harbour, *Defects of the POSIX Sporadic Server and How to Correct Them*, In: Proc. 16^{th} IEEE RTAS, pp. 35 45, April 2010."

6. 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.