EINDHOVEN UNIVERSITY OF TECHNOLOGY

Department of Mathematics and Computer Science

Examination Real-time Architectures (2IN60)
on Thursday, March 12^{th} 2009, 14.00h-17.00h.

First read the entire examination. There are 7 exercises in total. Grades are included between parentheses at all parts and sum up to 11 points. Good luck!

1. A recursive equation to determine the worst-case response time of a periodic task τ_i is given by

$$x = C_i + \sum_{j<i} \left\lceil \frac{x}{T_j} \right\rceil C_j.$$

   (a) (0.5) For which class of scheduling algorithms is this equation applicable?

   (b) (0.5) Give at least four assumptions that need to hold to use this equation.

   (c) (1.0) Is the value ι_i given by

$$\iota_i = \frac{C_i}{1 - U_{i-1}}$$

   an appropriate initial value for the iterative procedure to determine the worst-case response time of τ_i? Motivate your answer.

   Answer: See RTA examination of August 30^{th} 2006.

2. (1.0) The book of Buttazzo illustrates three anomalies expressed by a theorem of Graham for an optimally scheduled task set on a multiprocessor with some priority assignment, a fixed number of processors, fixed computation times, and precedence constraints, i.e. the schedule length can increase when (a) the number of processors is increased, (b) the computation times are reduced, and (c) the precedence constraints are weakened.
   Can the schedule length also increase when the speed of a processor is increased? If no, explain why. If yes, give an example using the precedence graph shown in Figure 1 scheduled on a parallel machine with three processors.
   Answer See examination of August 22^{nd}, 2007.

3. Consider two periodic tasks τ_1 and τ_2, with characteristics as given in the following table, which are scheduled by means of fixed-priority scheduling with deferred pre-emption (FPDS), where τ_1 has a higher priority than τ_2.

	$T = D$	C
τ_1	3	1
τ_2	4	$1\frac{1}{2}$

   (a) (1.0) Determine the worst-case length WL_2 of the level-2 active period.
   Answer: Draw a timeline with a simultaneous release of both tasks at time $t = 0$. Because the pending load becomes zero at time $t = 2\frac{1}{2}$, the worst-case length $WL_2 = 2\frac{1}{2}$.

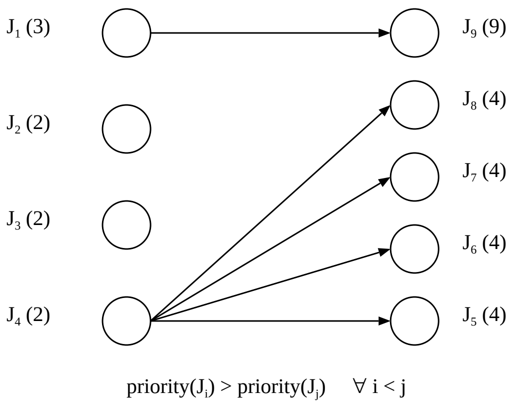

Figure 1: Precedence graph of the task set J; numbers in parentheses indicate computation times.

(b) (1.0) Determine the worst-case response times WR_1^{D} of τ_1 and WR_2^{D} of τ_2 using

$$WR_{ik}^{\mathrm{D}} = \begin{cases} WR_i^{\mathrm{P}}(B_i^{\mathrm{D}} + kC_i - F_i) + F_i - (k-1)T_i & \text{for } i < n \\ WO_i^{\mathrm{P}}(kC_n - F_n) + F_n - (k-1)T_n & \text{for } i = n \end{cases}, \tag{1}$$

and the following recursive equations for $WR_i^{\mathrm{P}}(C)$ and $WO_i^{\mathrm{P}}(C)$, respectively.

$$x = C + \sum_{j<i} \left\lceil \frac{x}{T_j} \right\rceil C_j, \tag{2}$$

$$x = C + \sum_{j<i} \left(\left\lfloor \frac{x}{T_j} \right\rfloor + 1 \right) C_j. \tag{3}$$

Answer: For task τ_1, it is only necessary to consider the first job: $WR_1^{\mathrm{D}} = 2\frac{1}{2}$. Because the worst-case length WL_2 of the level-2 active period contains $\left\lceil \frac{WL_2}{T_2} \right\rceil = 1$ job, we need to consider one job for task τ_2. Hence $WR_2^{\mathrm{D}} = WR_{2,1}^{\mathrm{D}} = 2\frac{1}{2}$.

4. (1.0) Consider a system consisting of a periodic server, which is used to service aperiodic requests, and a set of hard real-time tasks. Describe the consequence of selecting either an *idling* or a *gain-time providing* periodic server for determining the best-case and worst-case response times of hard-real-time tasks.
Answers: The choice only potentially influences the best-case response time of hard real-time tasks with a priority lower than the periodic server; see RTA.Exercises-5 slide 8.

5. (2.0) Let tasks τ_1 and τ_2 both use resources r_1 and r_2. Task τ_1 first locks r_1 and subsequently r_2, and τ_2 first locks r_2 and subsequently r_1, which may give rise to a deadlock without a resource access protocol; see Figure 2. Discuss what happens when a resource access protocol is used and illustrate the behaviour by means of appropriate drawings for PIP, HLP, PCP, and SRP.
Answer: See RTA examination of June 13^{th} 2008 or RTA.Exercises-8+solutions.

6. The course explicitly distinguishes between tasks (related to the model) and processes and threads (platform related notions).

(a) (0.5) Give three reasons for introducing tasks during design.

(b) (0.5) Explain the differences between processes and threads by giving at least two characteristics of each.

Answers See slides '*RTA.C7-platform-and-mapping.pdf*'. This question has been taken from the examination of August 30^{th}, 2006.

7. One of the lectures concerned *A QoS approach for multimedia consumer terminals with media processing in software.*

   (a) (1.0) Explain which real-time problems were addressed.

   (b) (1.0) Explain how these problems have been solved.

   Answers See slides of the lecture. This question has been taken from the examination of August 30^{th}, 2006.

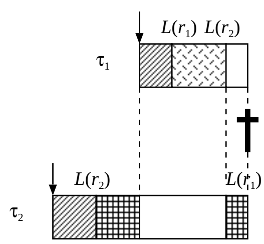

Figure 2: A deadlock situation.