Parallel and Distributed Real-Time Systems
EDA420/DIT170

Final exam, March 15, 2007 at 08:30 – 12:30 in the V building

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Examiner:
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Content:
The written exam consists of 4 pages (including cover), containing 7 problems worth a total of 60 points.

Grading policy:
24–35 ⇒ grade 3
36–47 ⇒ grade 4
48–60 ⇒ grade 5

Restrictions:
Books, notes or calculators are NOT allowed (only writing material and dictionaries)

Solution:
No solution provided.

Results:
Posted on the course home page on Monday, April 2, 2007 at 09:00.

Inspection:
Room 4128, Rännvägen 6 B, on Monday, April 2, 2007 at 13:00–15:00.

Language:
Your solutions should be written in Swedish or English.

IMPORTANT ISSUES

1. Use separate sheets for each answered problem, and mark each sheet with the problem number.
2. Mark the first sheet with your name and "personnummer".
3. Justify all answers. Lack of justification can lead to loss of credit even if the answer might be correct.
4. Explain all calculations thoroughly. If justification and method is correct then simple calculation mistakes do not necessarily lead to loss of credit.
5. If some assumptions in a problem are missing or you consider that the made assumptions are unclear, then please state explicitly which assumptions you make in order to find a solution.
6. Write clearly! If I cannot read your solution, it is wrong.

Good Luck!

PROBLEM 1

State whether the following propositions are TRUE or FALSE. For each correct statement, you will be given 1 point; for each erroneous statement you will be given -1 point; if you make no statement at all, you will be given 0 points. **Quality guarantee**: The total result for this problem cannot be less than 0 points. (6 points)

a) The *jitter* of a periodic task in a schedule reflects the amount of deviation from the expected periodicity of the task's completions.

b) In the Token Ring communication network, it is impossible to guarantee messages with hard deadlines.

c) The *competitive factor* of a scheduling algorithm reflects the amount of slack (surplus time) available in a schedule generated by the algorithm.

d) An optimization problem can never be classified as an NP-complete problem.

e) When there are mutual exclusion constraints in a system, it is impossible to find an optimal on-line scheduling algorithm (unless it is clairvoyant).

f) By *high accuracy* in a clock synchronization context, we mean a small deviation between clocks.

PROBLEM 2

The following questions are related to estimation of worst-case execution times (WCET) of tasks.

a) Explain what the term *infeasible path* refers to in the context of WCET analysis and provide an example of such a path. Also explain why it is useful to identify infeasible paths. (3 points)

b) Give a short description of how the IPET (Implicit Path Enumeration Technique) for WCET analysis works. (3 points)

c) Explain why WCET analysis for a multiprocessor system will be more complicated that for a single processor. (2 points)

PROBLEM 3

The following questions are related to communication networks used for industrial real-time applications.

a) Describe how different types of message transmissions can co-exist on a FlexRay network. (2 points)

b) State whether communication medium access in the Controller Area Network (CAN) is token-based or contention-based. Motivate your answer. (1 points)

c) Describe how response-time-based schedulability analysis can be adapted to message scheduling in CAN. (3 points)

PROBLEM 4

For static (off-line) multiprocessor scheduling, a useful method is the *branch-and-bound* (B&B) algorithm.

a) In many B&B algorithms, the search for an optimal schedule begins with an empty schedule. Describe the general approach used for extending an empty or partial schedule towards a complete schedule (that is, how child vertices are generated.) (3 points)

b) For the type of B&B algorithm mentioned in subproblem a), describe briefly four methods that can be used to avoid examining all possible schedules in search for the optimal schedule. (4 points)

c) In the B&B algorithm by Xu and Parnas, the search for an optimal schedule instead begins with an initial complete schedule. Explain briefly how new improved candidate schedules are generated in that algorithm. In your answer it is not necessary to describe all variables involved in the generation of child vertices, but rather your answer should give the intuition behind the choice of candidates. (3 points)

PROBLEM 5

The following questions are related to global multiprocessor scheduling.

a) Describe the main difference between global and partitioned multiprocessor scheduling. Also list two major advantages with global scheduling. (3 points)

b) One well-known drawback with global multiprocessor scheduling is a dilemma referred to as *Dhall's effect*. Describe the basic features of Dhall's effect and also give an example of a task set that suffers from the effect. (4 points)

c) Describe three types of system changes that can cause scheduling anomalies in global multiprocessor scheduling. (3 points)

PROBLEM 6

Consider a real-time system with two periodic tasks and a run-time system that employs preemptive rate-monotonic (RM) scheduling. For each task τ_i it applies that its deadline D_i is equal to the period T_i. Both tasks arrive the first time at time 0. It is known that the tasks' utilizations $U_i = C_i/T_i$ are $U_1 = 0.75$ och $U_2 = 0.25$, respectively. However, the individual execution times C_i for the two tasks are not known.

a) If the tasks' periods T_i are not known either, is it possible to decide if the tasks are schedulable with RM? Motivate your answer. (3 points)

b) If we know that $T_2 = 2T_1$, is it then possible to decide whether the tasks are schedulable or not with RM? Motivate your answer. (3 points)

PROBLEM 7

Consider a real-time system with four periodic tasks and a run-time system that uses preemptive earliest-deadline-first (EDF) scheduling. The table below shows C_i (WCET), D_i (deadline) and T_i (period) for the four tasks.

	C_i	D_i	T_i
τ_1	3	9	12
τ_2	3	12	12
τ_3	6	15	18
τ_4	3	33	36

a) Construct a timing diagram that goes from time $t = 0$ to time $t = 36$. Derive the diagram by manually simulating the execution of the tasks in the system under EDF scheduling. (2 points)

b) Show that the tasks are schedulable under EDF scheduling using processor-demand analysis. (4 points)

c) Do a robustness analysis of the given system by assuming that a task can increase its execution time to $C_i \cdot \alpha_i$. Based on the timing diagram constructed in subproblem a) derive, for each task τ_i, the maximum scaling factor α_i for which the system is still schedulable when that, and only that, task increases its execution time. (4 points)

d) Perform the same robustness analysis as in subproblem c), but now assume that the tasks are executed according to deadline-monotonic (DM) scheduling. (4 points)