Re-exam for Real Time Systems

2015 Jan 12, 14:00 – 19:00 (five hours!)

Philipp Rümmer and Wang Yi

Important Instructions:

1. No course material or computer/calculator are allowed, only a pen and a dictionary.
2. Please mark which course you are registered for:

◯ **5hp** (1DT063)	◯ **10hp** (1DT004)
You need to solve problems 1–4 only.	You need to solve *all* problems.

3. Please answer all questions precisely and concisely. To help you with this, we indicate how long the answer of each question is (at most) expected to be. Excessively verbose answers will not be counted, whereas it is fine to provide shorter answers. (200 words is about 1/2 page in A4 format).

.....

Problem 1 (20 points)

1. Describe briefly the main difference between embedded and general-purpose computer systems. *(100 words)*
2. Describe briefly three main features of an RT programing language like Ada. *(100 words)*
3. Describe briefly why it is difficult to design predictable real-time systems. *(100 words)*
4. Explain briefly why worst-case execution time analysis assumes that the number of iterations of a loop is bounded by some constant. *(100 words)*
5. Describe briefly how caches are handled in worst-case execution time analysis. *(100 words)*
6. Explain briefly the concepts: feasibility, schedulability and optimality in real-time scheduling. *(100 words)*
7. What is the essential difference between EDF and DMS? Are they optimal? If yes, why? *(100 words)*
8. Describe briefly two periodic servers. *(100 words)*
9. Describe briefly why we need task models. *(100 words)*
10. Explain briefly how the arbitration mechanism of CAN works. *(100 words)*

Problem 2 (10 points)

1. Explain the unbounded priority inversion problem. *(200 words)*
2. Explain briefly how the following resource sharing protocols work: *(200 words)*

Please turn the page!

- Basic Inheritance Protocol (i.e. BIP)
- Immediate Priority Inheritance (i.e. HLP)

3. Is it possible to avoid deadlocks using these protocols? Explan your answer. If yes, what would you do to avoid deadlocks? *(200 words)*

Problem 3 (10 points)

Assume a set of periodic tasks (T_i, C_i) where T_i stands for period and C_i for computing time.

1. Describe briefly the RMS priority assignment and the run-time behaviour of a RMS scheduler. *(200 words)*
2. Describe how the RMS sufficient schedulability test (i.e. using the utilization bound) works. *(200 words)*
3. Describe how to calculate the worst case response times for each task. You may ignore jitters, and overheads for context switch etc. Modify your calculation for non-preemptive tasks. *(200 words)*

Problem 4 (10 points)

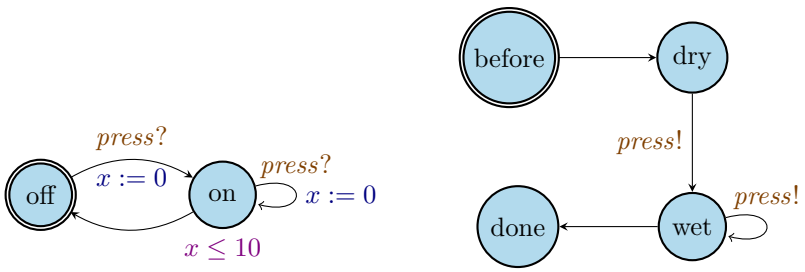
Assume a system with one processor and three periodic tasks:

Task	T_i	C_i	D_i
A	156	36	156
B	90	30	75
C	120	30	36

where T stands for period, C for WCET, and D for deadline.

1. Assume that DMS is used to schedule the tasks. *(200 words + diagrams)*
   (a) What is the priority order?
   (b) Construct the run time schedule for the first 156 time units.
   (c) Is the task set schedulable? Motivate your answer.
2. Assume that EDF is used to schedule the tasks. *(200 words + diagrams)*
   (a) Construct the run time schedule for the first 156 time units.
   (b) Is the task set schedulable? Motivate your answer.

Problem 5 (15 points)



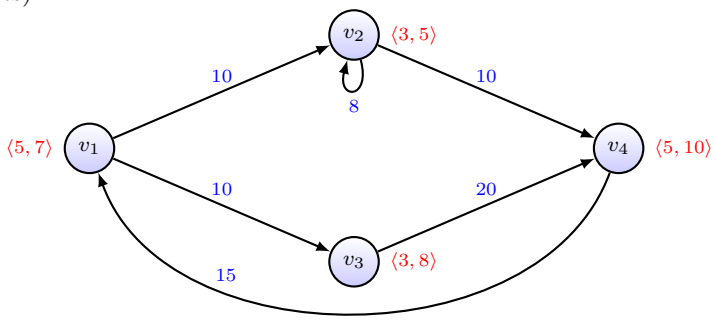
(a) Timed automaton A_{Shower} (b) Timed automaton A_{User}

Figure 1: Two timed automata synchronizing on a channel *press*.

Take a look at the timed automata A_{User} and A_{Shower} in Figure **??**. They model a user that is about to take a shower.

1. The condition "$x \leq 10$" is a *location invariant* on location "on" of automaton A_{Shower}. Explain what this means. *(100 words)*
2. Formulate an UPPAAL query that asks for a deadlock in which A_{User} is *not* in location "done". *(50 words + query)*
3. Is there such a deadlock? Motivate your answer. *(100 words)*
4. Describe a change to the model so that we can ask for the property "It is possible that the user is out of the shower but the water is still running for more than 10 more time units". Formulate the query as well. Is it satisfied? *(100 words + model + query)*
5. Use Part **??** to illustrate the difference between the concepts *Testing* and *Verification*. *(200 words)*

Problem 6 (15 points)



Consider the above task workload in the Digraph (DRT) model. Each node v_i is annotated with WCET and deadline, each edge is annotated with the minimum inter-release delay.

1. Write an Ada program that generates this workload. It is not necessary that your program performs any meaningful computation, it should just use the statements `loop`, `if .. then .. else` and `delay until` to simulate the different jobs and inter-release delays. *(50 words + code)*
2. Use the algorithm introduced in the lectures to draw the demand bound function $dbf(t)$ for this model, for intervals $0 \leq t \leq 30$. *(50 words + diagram)*
3. Is the workload schedulable with an EDF scheduler? Motivate. *(50 words)*
   Hint: you do *not* have to consider the demand bound function to answer this question.
4. What is the maximum utilisation that can result from this model? Motivate. *(100 words)*