(Till tentamensvakten: engelsk information behövs)

Exam

Embedded Systems II, DVA404
Västerås, 2018-01-08

Teacher:	Mikael Sjödin, tel: 070 288 2829
Exam duration:	08:10 – 12:30
Help allowed:	Calculator, language dictionary, ruler, and APPENDIX attached to this exam.
Points:	48 p

Grading:

Swedish grades:		ECTS grades:	
< 26	→ failed	< 26	→ F
26 – 34 p	→ grade 3	26 – 29	→ D
35 – 41 p	→ grade 4	30 – 36	→ C
42 – 48 p	→ grade 5	37 – 41	→ B
		42 – 48	→ A

Instructions:

- Answers MUST be written in English.
- Short and precise answers are preferred. Do not write more than necessary.
- Use a new sheet for each of the six assignments.
- If some assumptions are missing, or if you think the assumptions are unclear, write down what do you assume to solve the problem.
- Write clearly. If I cannot read it, you get zero points.

Good luck!!

Assignment 1: (8 points)

Briefly explain the following concepts related to scheduling and schedulability analysis:

1. Hard real-time system (1p)
2. Soft real-time system (1p)
3. Real-time task (1p)
4. Sufficient schedulability condition (1p)
5. Necessary schedulability test (1p)
6. Feasible schedule (1p)
7. Critical instant (1p)
8. Heterogeneous system (1p)

Assignment 2: (8 points)

Determining the execution time of a program is often difficult.

a) Which are the two main sources of variations in execution time? (2p)

b) Describe briefly the three different stages in static WCET analysis, and how they work together to yield a safe WCET estimate. (2p)

Parallel applications become more and more popular to handle the high computational demands of today's embedded applications.

c) A common way to increase the computational power of a processor is to duplicate the CPU cores. In an ideal system, how does the number of CPU cores affect the performance of the application? (2p)

d) Many-core and Heterogeneous systems (CPU + GPU) are two highly parallel hardware architectures. What are the main differences between them and how do they affect the suitability of the respective platform for the different workload characteristics? (2p)

Assignment 3: (8 points)

Assume we have the following three different schedulability tests:

1. $U \leq 0.69$
2. $U \leq 5(2^{1/5}-1)$.
3. $U \leq 1$.
4. Basic response time analysis with critical instant assumption that all tasks are released simultaneously.

Assume further that we have 4 different task sets (independent tasks, no blocking) with following properties:

a. 3 tasks with D=T, priorities according to rate monotonic, and scheduling according to static priorities.

b. 5 tasks with D=T, scheduling according to EDF.

c. 7 tasks with D<T, priorities according to deadline monotonic, and scheduling according to static priorities.

d. 5 tasks with D<T, tasks have offsets, priorities according to rate monotonic, and scheduling according to static priorities.

For every task set classify if the three schedulability tests are:

I. Sufficient

II. Necessary

III. Sufficient and necessary

IV. Nor sufficient nor necessary

V. Not applicable: That is, the test cannot be performed on the task set.

That is, construct the following matrix with 4 rows (the 4 schedulability tests: 1,2,3,4) and 4 columns (the different task sets: a,b,c,d) and for every location in the matrix, classify I, II, II, IV or V.

	Task set a	Task set b	Task set c	Task set d
Test 1	I-V?	I-V?	I-V?	I-V?
Test 2	I-V?	I-V?	I-V?	I-V?
Test 3	I-V?	I-V?	I-V?	I-V?
Test 4	I-V?	I-V?	I-V?	I-V?

Important note: ½ a point for correct classification, -½ for a wrong classification. So guessing is a poor strategy. If you do not know, it is better to leave that position blank.

Assignment 4: (8 points)

a) Given the fixed-priority non-preemptive scheduling and a set of tasks with deadlines at most equal to periods. Explain in your own words why the first job of a task upon a critical instant doesn't necessarily assume the worst-case response time. (2p)

b) Consider the model-based software development process for real-time embedded systems that you have studied in the course, also shown in Figure 1.

1) What is the purpose of modeling phase in this process? (2p)
2) What is the difference between analytical analysis and model checking in the context of this process? (2p)
3) What is the purpose of Synthesis phase in this process? (2p)

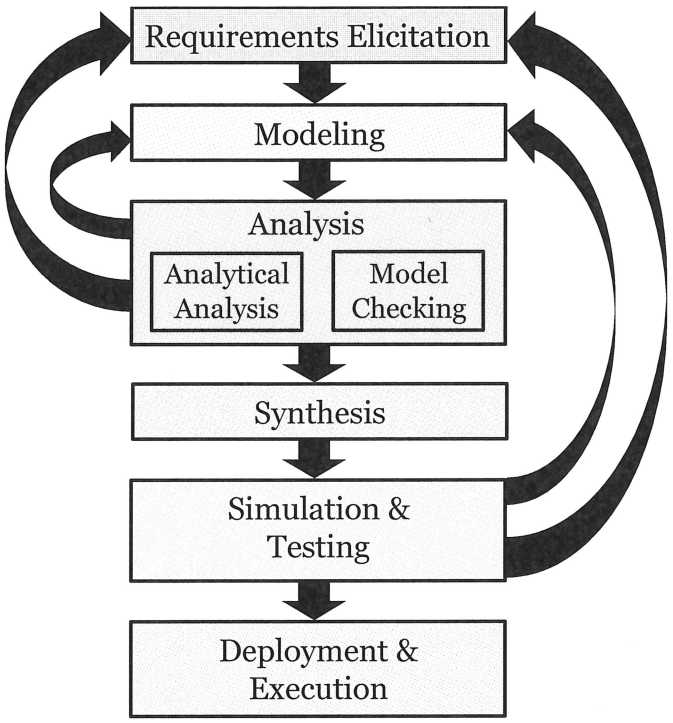


Figure 1: Model-based software development process for real-time embedded systems.

Assignment 5: (8 points)

Assume Rate Monotonic (RM) and Priority Ceiling Protocol (PCP) used to schedule the tasks below. All values in the tables are given in milliseconds.

Task	Period	Execution time	Deadline
A	400	100	400
B	800	150	800
C	1000	100	1000
D	1200	350	800

Under their execution, the tasks use resources R1-R6 that are protected by semaphores. The length of critical section for each resource is the same for each task, and it is given in the table below in milliseconds:

R1	R2	R3	R4	R5	R6
25	50	10	30	12	30

The tasks use the resources R1-R6, according to the following table:

Task	Use Resources
A	R1,R3,R4
B	R1,R2,R5
C	R2,R3,R4
D	R3,R4,R6

Questions:

a) Define the priority order (1p)
b) Calculate the system utilization. (1p)
c) Calculate the blocking factor for each task. (2p)
d) Calculate response times for each task. (4p)

Assignment 6: (8 points)

Consider a multi-rate real-time system as shown in Figure 2. The system consists of only one multi-rate task chain. There are three tasks in the chain. The parameters of the tasks are shown in the Figure 2. For example, Task τ_1 is independently activated by a 8 ms periodic timer. Upon activation, the task reads data from register "Register 0". The priority of τ_1 is Low and its Worst Case Execution Time (WCET) is 1 ms. τ_1 writes data to register "Register 1" at the end of its execution.

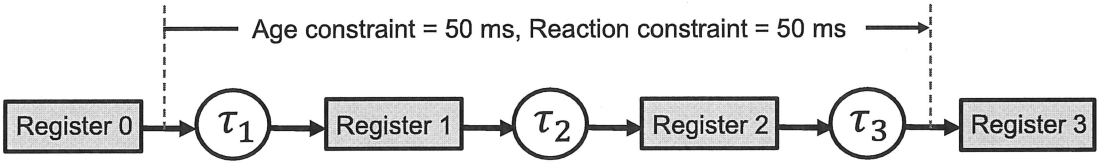
The Age and Reaction constraints specified on the chain are 50 ms each.

Questions

a) Are the specified Age and Reaction constraints satisfied or not? Demonstrate this by calculating the Age and Reaction delays in the multi-rate task chain graphically, i.e., by drawing the execution trace of the system and identifying the age and reaction delays. (6p)

b) Describe significance of the Age and Reaction delays in automotive applications. Discuss one example application for each delay. (2p)

If you need to make any assumptions, please explicitly specify them.



τ_1 is a periodic task,
Independently activated,
Period = 8 ms,
Priority = Low,
WCET = 1 ms

τ_2 is a periodic task,
Independently activated,
Period = 16 ms,
Priority = Medium,
WCET = 1 ms

τ_3 is a periodic task,
Independently activated,
Period = 4 ms,
Priority = High,
WCET = 1 ms

Figure 2: A multi-rate task chain.