

**TENTAMEN TDDD07 Realtidssystem**

DATUM: 20 August 2011

TID: 14-18

PLATS: TER4

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Material: English-Swedish-English dictionary  
Calculator

No of assignments: 5

Total no. of points: 40

Preliminary grade limits for grades: 3, 4 and 5

3: 20 - 26 p

4: 27 - 33 p

5: 34 - 40 p

**INSTRUCTIONS:**

Please write your anonymous ID on each sheet of paper that you hand in. Further, pages should only contain answer to one question per page (answers to sub-questions can be on the same page). You are asked to only write on one side of each paper. Please **sort** all the sheets that you hand in, in the order of the question number.

Make sure your answers are motivated and supported by clear explanations. Figures or charts can be used to provide a clearer explanation but should be accompanied by a **textual description**. Points will not be given to answers for which the reasoning cannot be followed or that cannot be read due to bad handwriting. Wrong answers/reasoning which is embedded in partially correct ones will lead to deduction of points. You may answer in Swedish or English as you prefer.

**Hints:** Try to dispose of your time on each question in proportion of the assignment points. In any case where you are in doubt about the question, write down your interpretation and assumptions, and answer the question based on the interpretation. A correct answer that is embedded in errors may give reduction in points, so make sure your answers are to the point.

Results are reported no later than September 5<sup>th</sup>.

Good luck!

Simin Nadjm-Tehrani

**Q1: Scheduling**

- a) An unmanned helicopter can fly autonomously, start and land with no operator intervention. During the flight and under the assumption of no winds the operation of the helicopter can be controlled by three processes steering its movements along the x, y, and z axes. Consider the following task set where Px, Py and Pz denote the above three processes respectively. What is the worst-case response time for Pz, if rate monotonic scheduling (RMS) is used for scheduling the task set?

Task	Period(ms)	WCET(ms)
Px	25	5
Py	25	10
Pz	35	5

(3 points)

- b) Assume we are only interested in fixed priority scheduling. If the task set were not schedulable using RMS for some given parameter set, would the schedulability of the task set be affected if you change the fixed priorities, but keep the periods unchanged?

(2 points)

- c) Earlier Deadline First (EDF) can schedule tasks with a higher CPU utilization compared to fixed priority schedulers. Assume that a fourth task is to be added for logging results of image processing from a camera to be mounted under the helicopter. Assume also that a (separate dedicated) high resolution hardware for image processing leads to a new image being available every 20 ms. If EDF is used as a scheduling policy, what is the maximum execution time one can allow for the new logging task to be run on the existing CPU (with other task parameters the same as in part a)? Provide three assumptions that should hold in order for this analysis to be valid.

(4 points)

- d) Consider a set of three processes, P1, P2, and P3, with the following instances of arrival time and following execution patterns. The processes share two common resources **a** and **b**. The patterns describe a process executing without any resource during one time unit using the notation **E**. When the resource **a** (respectively **b**) is used for one time unit it is listed as one instance of **a** (respectively **b**). Assume that fixed priority scheduling is used combined with immediate ceiling protocol, and highest priority is denoted by 3. Show the actual execution of the three process instances by drawing charts over time lines. Use the notation "P" for a preempted process, "B" for a blocked process in your solution chart. You can use the printed chart at the end of the exam for this purpose.

Process	Pattern	Priority	Release time
P1	EaEbE	2	2
P2	EaabbE	3	0
P3	EbbaaE	1	7

(4 points)

## Q2: Dependability and predictability

- a) Provide one example of event-based service and one example of a time-triggered service in a real-time operating system.

(2 points)

- b) Using clear arguments identify a potential fault-error-failure chain of events in the following scenario, and clarify whether your designated fault is permanent, intermittent, or transient.

“On Saturday 23<sup>rd</sup> July 2011 A high-speed train rammed into a stopped train near the city of Wenzhou in east China's Zhejiang Province, leaving 40 people dead and 191 injured. The accident was caused by "serious design flaws" in railway signaling equipment, an official from the Shanghai Railway Bureau said Thursday morning. A lightning strike triggered a malfunction in the signalling system, which resulted in a green alert light not changing to red, leaving railway personnel unaware of the stopped train.”

(4 points)

## Q4: Real-time Communication

A distributed real-time system's behaviour is strongly affected by both scheduling of CPU as a resource in the nodes, and allocation of bandwidth in the communication channel as a resource. Take a stand on the following statements and declare whether the statement is true or false. Motivate your answer!

- a) The priorities for messages in a CAN network must be the same fixed priorities used in the priority-based scheduling of the processes in the nodes that are connected to the bus.
- b) If one node that is connected to a TTP bus crashes, this can be detected easier by the other nodes than if the system would use a CAN bus.
- c) If a process exceeds its assumed worst case execution time (WCET) at some point in time, it is stopped from sending its final output on a TTP buss.
- d) On a CAN bus a high priority message can only be delayed (blocked) once by messages of lower priority.

(4 points)

## Q3: Design

- a) Consider a collision avoidance component in a flight control system. Decide which of the following properties is a functional property and which is an extra-functional property (also sometimes called a non-functional property):
- 1) When another aircraft is within X meters of own aircraft on the same altitude, the marking on both pilot display screens should change colour within Y milliseconds.
  - 2) For two aircrafts on the same altitude if own aircraft is instructed to rise, the other aircraft has agreed to descend (go down).
  - 3) If the altitude measurement delivered by the altitude-metering system is inaccurate then the collision avoidance system should switch to an alternative source for altitude value.

(3 points)

- b) Describe one reason why modularity is difficult to achieve in real-time systems. (2 points)
- c) Modelling languages for real-time systems should be expressive enough for the complexity of these systems. Give two examples of modelling language constructs that are useful in the real-time context. (2 points)

**Q5: Distributed systems, Quality of Service (QoS)**

- a) Take a stand on the following propositions (true or false) and motivate your answer!
- 1) Real-time networked applications are considered as *inelastic* in the QoS based categories of applications.
  - 2) Video-on-demand is an *intolerant* application in the QoS terminology. (4 points)
- b) Describe the two methods of focused addressing and bidding for distributed scheduling of tasks with hard resource requirements. Explain one weakness of each method. (4 points)
- c) Explain the “happened before” relation ( $\prec$ ) in the context of logical clocks. (2 points)



### **Notation for Processes**

- $C$  = Worst-case execution time
- $B$  = Worst-case blocking time
- $D$  = Relative deadline
- $n$  = Number of processes
- $T$  = Period
- $R$  = Worst-case response time
- $J$  = Release jitter

### **Schedulability test for Rate Monotonic:**

$$\sum_{i=1}^n \left( \frac{C_i}{T_i} \right) \leq n(2^{1/n} - 1)$$

### **Schedulability test Earliest Deadline First:**

$$\sum_{i=1}^n \left( \frac{C_i}{T_i} \right) \leq 1$$

### **RMS Response time analysis**

$$w_i = C_i + B_i + \sum_{\forall P_j \in hp(P_i)} \left\lceil \frac{w_i + J_j}{T_j} \right\rceil C_j$$

$$R_i = w_i + J_i$$

$hp(P_i)$  is the set of processes with a higher priority than process  $P_i$ .

