Tentamen vid Institutionen för Datavetenskap, Linköpings universitet

TENTAMEN TDDD07 Realtidssystem

DATE: 14 April 2009
TIME: 14-18
LOCATION: TER2
AVAILABLE TEACHER: Simin Nadjm-Tehrani (Tel: 0702 282412), Mikael Asplund (Tel: 0707 481462),

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:
Write your anonymous ID number on each sheet of paper that you hand in. Further, pages should only contain one answer per page (answers to sub-questions can be on the same page). You are asked to only answer on the front page of the paper. Sort all the sheets that you hand in with respect to the number of the question.

Your answers can be presented in Swedish or English.

Make sure your answers are presented clearly and precisely. Your answers shall provide the motivation or method for the solution. A correct answer without any explanation will not be given any credits. Negative points are drawn for incorrect answers embedded in partially correct ones.

Points will not be given to answers that cannot be read due to bad handwriting.

Hints: Try to dispose of your time on each question in proportion of the assignment points. In those cases where you are in doubt about the question, write down your interpretation and your assumptions, and answer the question based on the interpretation.
Figures can be of help when describing but should be accompanied by a text description.

<u>Results are reported no later than April 30th.</u>

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling, QoS

a) In advanced industrial robots the same controller can manage several robots at the same time thus increasing performance. For example, while one robot is holding a work unit to be welded another robot welds it, and during the welding one can rotate the work unit so that the welding point is always pointing upwards. The computer system that controls the robots has several processes:

- Steering the positioning of the robots.
- Generating trajectory, i.e. the next position for each robot
- Fault monitoring, i.e. detecting when a robot is not behaving as it should, adjusting the controls in some case and alarming the operator in others.

In the first version two robots are to be steered from the same CPU, and a study of utilisation is performed. Every robot has three positioning regulators with a sampling interval T = 20 ms. Moreover, there are two trajectory generation processes and two monitoring processes (altogether 10 processes). Assume that every positioning process (that is, in $x-$, $y-$ and $z-$directions, for every robot) has a maximal computation time of 2ms. Assume further that the trajectory generation process, and the monitoring process have a maximal computation time of 5ms and 10 ms respectively per robot. The period for the trajectory generation process is 40 ms.

1. Consider "earliest deadline first" (EDF) as scheduling method. If we assume the scheduler's overhead as negligible, what is the theoretical maximum for how often the system can detect faults in the robot behaviour?

   (2 points)

2. Consider the case where fault monitoring does not need to be run more often than every other second. Assume you can run all computations with the same sampling interval as one process (that is, 6 positioning processes as 1, 2 trajectory generators as 1, and 2 fault monitoring processes as 1). Is this process set schedulable with the "rate-monotonic" method?

   (4 points)

3. Other than negligible scheduler overhead which other assumptions are the basis for the analysis under point 1. above? Give one more example!

   (1 point)

4. Assume that the maximum inter-arrival time for faults is expected to be larger and this leads to the monitoring period as 12 seconds,. Also, the computation times for the position steering and trajectory generation can be optimised so that the maximal computation time is halved. With the same CPU capacity and EDF as scheduling algorithm, what is the theoretical limit for number of robots that one can run in the same system?

   (2 points)

b) Prove that in the immediate ceiling protocol combined with a fixed priority scheduling algorithm (e.g. RMS) a process instance is blocked max once in its life cycle.

(3 points)

c) In networked applications quality of service (QoS) can be enforced at different layers and using different mechanisms. Explain the notions of scheduling and admission control in this context.

(2 points)

Q2: Dependability

a) Explain the difference between availability and reliability, using example applications (2 points)

b) In each of the following cases identify whether static, dynamic, or no redundancy is used.

1) Loss of the fuel unit during the mission of a space bound rocket was mitigated by activation of solar cells intended as backup.

2) Invoice processing computer system for organisation X switched to a text-based window for input of the invoice details after an incompatibility with a web browser resulted in the standard interface hanging.

3) Booking at each travel agents are considered as preliminary and only confirmed with the customer when the central ticketing system confirms that there are free places on the flight and reserves them .

(3 points)

Q3: Design

a) Take a stand on the following propositions (true or false), and motivate your answer!
   1) Most faults introduced in a system during software development appear at the coding stage.
   2) End-to-end deadline requirements for an application are not dependent on the hardware in the implementation.

(2 points)

b) Describe three benefits of using a high level design language like UML Statecharts for modelling real-time systems.

(3 points)

Q4: Real-Time Communication

a) The following table describes the set of messages present in a distributed application in which the CAN bus is used as a communication bus. Assume that we expect a jitter of 3ms in the arrival time for message C. Assume B and A arrive with no jitter. Which of the three messages worst case response times are affected by the jitter in the C message.

Message	*Priority*	*Period*	*Max Transmission time*	*Deadline*
A	high	8	2	10
B	medium	12	3	15
C	low	20	4	20

(2 points)

b) In a TTP bus there are several mechanisms to avoid a faulty message - i.e. messages with bad content or sent too early, too late - affecting the transmission of other messages in the system. Describe the role of the two following mechanisms:
1) Clock synchronisation
2) Bus guardian

(4 points)

Q5: Distributed systems

a) Present one method of clock synchronisation for distributed systems, and describe what is the precision requirement and assumptions needed for your algorithm.

(2 points)

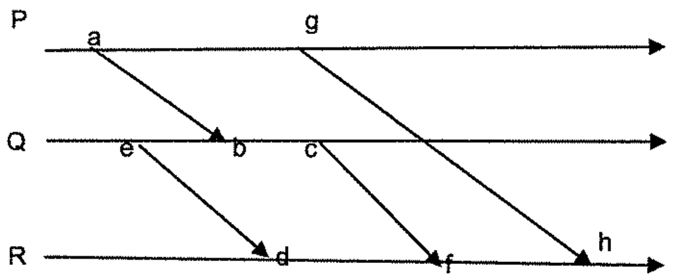
b) Give two examples of timing faults arising in distributed systems.

(2 points)

c) Explain two methods that can be used to guarantee a high level of timeliness for tasks that arrive at a distributed system. Your methods should help to schedule the load among the nodes based on utilisation of resources at each node.

(4 points)

d) Identify the vector clocks VC for events g, a, d and f taking place in processes P, Q, and R below.



(2 points)