Försättsblad till skriftlig tentamen vid Linköpings Universitet

Datum för tentamen	2014-01-13
Sal (3) Om tentan går i flera salar ska du bifoga ett försättsblad till varje sal och ringa in vilken sal som avses	G33 G35 G36
Tid	8-12
Kurskod	TDDD07
Provkod	TEN1
Kursnamn/benämning **Provnamn/benämning**	Realtidssystem Skriftlig tentamen
Institution	IDA
Antal uppgifter som ingår i tentamen	5
Jour/Kursansvarig Ange vem som besöker salen	Simin Nadjm-Tehrani
Telefon under skrivtiden	013-282411, 0702-282412
Besöker salen ca kl.	9.15
Kursadministratör/kontaktperson (namn + tfnr + mailaddress)	Liselotte Lundberg, 281278, liselotte.lundberg@liu.se
Tillåtna hjälpmedel	Miniräknare, lexikon
Övrigt	
Vilken typ av papper ska användas, rutigt eller linjerat	rutigt
Antal exemplar i påsen	

Tentamen vid Institutionen för Datavetenskap, Linköpings universitet

TENTAMEN TDDD07 Realtidssystem

DATUM: 13 January 2014
TID: 8-12
PLATS: G33, G35, G36
ANSVARIG JOURLÄRARE: Simin Nadjm-Tehrani (013-282411, 0702 282412)

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. 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 question numbers.

Make sure that **all** 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 the questions in English (the course language) or Swedish.

Hints: Read the question carefully to find the focus of the question. Make sure your answer is to the point and relevant for the question asked. Take the opportunity of asking questions about unclear issues during the exam session. Otherwise, whenever in doubt about the question, write down your interpretation and assumptions, and answer the question based on the interpretation. Try to dispose of your time on each question in proportion of the assignment points.

Results are reported no later than January 29th 2014.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

a) The next generation of pacemakers have much more functionality than the first embedded pacemaker in a human heart in 1958 at Karolinska institutet. Consider a dynamic dual-chamber pacemaker in which 4 processes are running concurrently. The activity-estimator process identifies the amount of activity by the human bearing the pacemaker (using sensors like accelerometer, temperature, adrenaline, etc.), and determines the ideal heart rate for the current level of activity. The beat-monitor process senses the atrial beat. The on-demand beat-generator uses the ideal rate by the activity-estimator and after a normal delay triggers a ventricular beat, unless it has already happened. The fourth process checks the operation of the pacemaker itself using a complex observation algorithm, and adjusts the parameters if the sensed beat rate and the ideal beat rate are far apart (signalling a failure of some kind). If needed this process resets the system to operate in a minimal safe mode. The periods and worst case execution times of the four processes are summarised below:

Process	Ti (ms)	WCET (ms)
Activity-estimator	60	20
Beat-monitor	30	10
Beat-generator	120	10
Safety-monitor	240	50

Construct a cyclic schedule for the above set of processes and present your minor and major cycle. (4 points)

b) Consider a new process to be added to the above set and which is used by a specialist to visualise the operation of the pacemaker by sending the generated and observed pulses to an external monitor. This process is a sporadic process that can be enabled with a minimum inter-arrival time of 5 minutes, and it will need 600ms to complete. Would you consider implementing the fifth process on the same microprocessor? Motivate your answer!

(2 points)

c) Consider a new solution where the Safety-monitor process is moved to a separate chip to run independently from the pacemaker operation processes (the other three in part a of the question). Combine the three processes with the fifth process (in part b above), to be scheduled on the same microprocessor using rate-monotonic scheduling (RMS). How can the utilization based tests for RMS be used to answer whether the process set is schedulable or not?

(2 points)

d) In general, what does the additional CPU use of a cyclic executive depend on (i.e. what factors influence the overhead of cyclic scheduling)? Provide three factors on which the executive CPU consumption depends.

(3 points)

Q2: Dependability and predictability

a) Describe two methods for tolerating system faults, one using static redundancy and one with dynamic redundancy. For each method, describe for which fault model is the method appropriate for (i.e. fault classes that can be circumvented by the method).

(4 points)

b) Using clear arguments, and the terminology defined by IFIP working group 10.4 on dependable systems, identify the fault-error-failure" chain in the following scenario.

Los Angeles Times, 4 Nov 2013, reported:
"Honda Motor Co. has announced it is voluntarily recalling more than 344,000 Odyssey minivans to correct a problem with the vehicles' stability control software.

The recall affects Odyssey vans from the 2007 and 2008 model years. In certain circumstances, an error in the software can prevent the system from calibrating correctly, leading to pressure building up in the braking system, the National Highway Traffic Safety Administration said.

If pressure builds to a certain point, "the vehicle may suddenly and unexpectedly brake hard, and without illuminating the brake lights, increasing the risk of a crash from behind."

(3 points)

Q3: Real-time Communication

a) What is the role of the communication controller (CC) in a TTP bus architecture?

(3 points)

b) The Scania Truck company uses a 3-colour scheme for scheduling messages sent on the CAN bus segments, generated by its 1000 functions operating in its trucks. Assume that the following table presents 4 messages to be scheduled on one CAN bus segment (where "Tx time" stands for worst case transmission time of a message on the bus). Compute the maximum response time for message m_2 in the set. Assume that deadline is equal to period for each of the messages. Motivate the choices that you have made in the analysis.

Message	Priority	Period (ms)	Tx time (ms)
m_1	High	5	1
m_2	Medium	10	2
m_3	Medium	20	2
m_4	Low	50	5

(3 points)

Q4: Application design & RTOS

a) Take a stand (true/false) on the following statements, and motivate your answer in each case!
   1) The language to use for application design modelling is not dependent on whether a system has real-time constraints or not.
   2) Creating a test environment for testing real-time applications is as important as implementing the application programs in the first place.

(2 points)

b) How does the application designer deal with systems where some components have hard time constraints and some components are less critical? Motivate your answer by relating to industrial examples you have encountered in the course.

(2 points)

c) Describe two of the many services that a POSIX compliant real-time operating system must provide.

(2 points)

d) Explain how treatment of faults at run-time (either by the application program or by the run-time environment) affects the timing aspects of a real-time system.

(2 points)

Q5: Distributed systems, Quality of Service (QoS)

a) Can end-to-end guarantees for real-time response be provided across Internet? Motivate your answer!

(1 point)

b) Describe three common mechanisms for enforcement of quality of service in Internet-wide systems. (3 points)

c) What is meant by a consensus service, and how is the implementation of it related to timing models in distributed systems?

(3 points)

d) Explain why the idea of logical clocks is useful.

(1 point)

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.

Timing Analysis of CSMA/CR

B = blocking time
C = transmission time of entire frame
T = period
τ_{bit} = transmission time of one bit
w = response time for the first bit of a frame to be sent
R = total response time
J = Jitter
t = Longest busy interval
$lp(m)$ = set of frames with lower priority than m.
$hp(m)$ = set of frames with higher priority than m.
$hep(m)$ = set of frames with higher or equal priority than m.
n = number of bytes in message (data field)

$$R_m = \max_{q=0..Q_m-1}(R_m(q))$$

$$R_m(q) = J_m + w_m(q) - q \cdot T_m + C_m$$

$$w_m(q) = B_m + q \cdot C_m + \sum_{\forall j \in hp(m)} \left\lceil \frac{w_m(q) + J_j + \tau_{bit}}{T_j} \right\rceil \cdot C_j$$

(with $w_m^{\,0}(q) = B_m + C_m q$)

$$Q_m = \left\lceil \frac{t_m + J_m}{T_m} \right\rceil$$

$$t_m = B_m + \sum_{j \in hep(m)} \left\lceil \frac{t_m + J_j}{T_j} \right\rceil \cdot C_j \qquad (\text{with } t_m^{\,0} = C_m)$$

$$C_m = \left(8n + 47 + \left\lfloor \frac{34 + 8n - 1}{4} \right\rfloor \right) \tau_{bit}$$

$$B_m = \max_{j \in lp(m)}(C_j)$$