Tentamen vid Institutionen för Datavetenskap, Linköpings universitet

TENTAMEN TDDD07 Realtidssystem

DATUM: 6 April 2010
TID: 14-18
PLATS:
ANSVARIG JOURLÄRARE: Examinator Simin Nadjm-Tehrani (Tel: 013-282411, 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:
Please write your anonymous ID 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 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 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. 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 April 21st.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

a) A space stationed telescope that has been sent to take pictures from far away stars has three different functions that are implemented on the same CPU: A position stablizer that uses a gyro to stabilize the movement around own axes; A star-follower process that tries to fix the orientation so that sharp pictures can be taken; An energy management system that deals with charging of batteries and adaptation to sun hours and angles. Assume that the position stablizer is run every 50 ms and takes maximally 5ms to run, that the energy manager is run every 20 ms with a maximal computation time of 5ms, and the star-follower process takes a picture from a given star every 40 ms and takes maximally 5ms to fix orientation with the help of the picture.
Assume that CPU utilisation and jitter has to be kept to a minimum and construct a cyclic schedule for the above process set. Present the minor and major cycles respectively.

(4 points)

b) Prove that the immediate ceiling protocol when combined with a fixed priority scheduling algorithm prevents deadlocks.

(4 points)

c) Assume that a task set is not schedulable with a given fixed priority when using rate-monotonic scheduling. Can one construct a scheduler with a different policy which uses a different assignment of fixed priorities to the tasks and get schedulability? Motivate your answer!

(2 points)

Q2: Dependability and predictability

a) Explain whether production defects in microchips are an example of faults, errors or failures.

(2 points)

b) Describe the relation between "degraded mode" and "system failure". You may use an example to explain whether these terms are synonyms or have differences.

(3 points)

c) Describe one difference between memory management in a real-time operating system and that in an ordinary operating system.

(2 points)

Q3: Real-Time Communication

a) The following messages take one ms each for being sent over a CAN-bus, and have the following periods and maximal jitter at release time:

Message	period (ms)	Jitter
m1 (high priority)	20	1
m2 (middle priority)	10	2
m3 (low priority)	5	0

Assume that the time taken to transmit one bit is less than 1 ms. Compute the maximum response time for the middle priority message.

(5 points)

b) Where is the MEDL (message descriptor list) of a TTA bus stored and what is its role?

(3 points)

Q4: Distributed systems, QoS

a) Traffic policing close to the edge of a network is a method for ensuring that a source does not violate the negotiated QoS agreements by claiming more resources from the network. Describe how a leaky bucket monitor can be used to support policing the arrival rates of data.

(3 points)

b) Describe why an internal clock synchronisation algorithm in a distributed system needs at least 4 clocks to keep within a given accuracy of δ if there is a risk that some clock acts in a Byzantine way.

(4 points)

c) Give a fault-error-failure chain that applies to a distributed system.

(3 points)

d) What is meant by a soft real-time system?

(1 point)

Q5: Design

Take a stand on the following propositions (true or false) and motivate your answer:

1. Additional test code that is embedded in a system may change the real-time behaviour of the system and cause new errors.
2. Platform-independent design means describing a system using an abstract design language and then finding transformations to map to hardware/software realisations.

(4 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.

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 messages with lower priority than m.
$hp(m)$ = set of messages with higher priority than m.
$hep(m)$ = set of messages 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 $w_m^{\,0}(q) = B_m + C_m q$)

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

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

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

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