TENTAMEN TDDD07 Realtidssystem

DATUM: 12 December 2008
TID: 14-18
PLATS: T1, T2
ANSVARIG JOURLÄRARE: Examinator 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:
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 January 7th.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling, QoS

a) Assume that the following task set is to be analyzed for its real-time properties in a new generation of the Mars Rover: (1) the *trajectory following task* for finding the way to a well-defined physical coordinate, (2) *the sensor & measurement task* that configures and reads various sensor's values, (3) a *disk storage task* that is responsible for periodically writing the buffered measured values on a log on persistent memory, (4) a *communication task* for contacting the ground station and sending cached data. The following table summarises the task set's periods and worst-case execution times (WCET) in milliseconds.

Task	*Period*	*WCET*
Trajectory follower	1600	100
Sensor & measurement	400	50
Disk storage	1200	500
Ground communication	400	50

1) Assume that the tasks can be scheduled as independent tasks. Assume further that the task set should be scheduled using a cyclic executive for which the overhead can be considered as negligible. Construct such a cyclic schedule and provide the minor and major cycles for the schedule.

(3 points)

2) In order to make the utilization more effective there is a plan to change to rate monotonic scheduling (RMS) and a communication medium that may be shared between the disk storage task and the ground communication task. To deal with the conflicts over the communication medium the immediate ceiling protocol is to be combined with RMS. Find the maximum blocking time of the communication task assuming that the disk storage task's access to the bus can be bound to 150ms each time it gets access to the bus. Motivate your answer!

(2 points)

b) Prove that the immediate ceiling protocol combined with a fixed priority scheduling algorithm (e.g. RMS) avoids starvation.

(5 points)

c) Describe the difference between IntServ and Diffserv in terms of enforcement policies and performance scalability.

(2 points)

Q2: Dependability

a) Explain the notion of availability, and provide a metric (= means of measuring) that can be used for measuring this attribute in a system.

(2 points)

b) Take a stand on the following propositions (true or false), and motivate your answer:
   1) A reliable program cannot lead to failures as it will not contain faults that make it incompatible with its specification.
   2) Testing a system in its operational environment is a method for fault prevention.
   3) "Redundancy in time" makes real-time systems fault-tolerant in presence of transient faults.

4) Real-time operating systems must use alternative garbage collection techniques compared to normal operating systems.

(4 points)

c) Identify the causal chain in following phenomenon in terms of faults, errors and failures.

1) Loss of the fuel unit during the mission of the space shuttle Discovery due to of adverse environment conditions during take-off that led to loss of some binding mechanical linkage shortly after take off.

2) 50% of invoices for the month of July remain unpaid for organisation X since the electronic authorisation system is dependent on a feature of a given browser that could hang the browser if the correct version is not in use.

3) Booking data from the travel agents arrive with a larger delay than expected at a central ticketing system, so that flights for a given week of summer are oversold by 20%.

(3 points)

Q3: Design

a) What does formal verification bring to the analysis of dependability and timeliness in a system that simulation and test does not? Contrast the named techniques against each other.

(2 points)

b) A real-time system typically includes a set of concurrent tasks. Formal modelling the set of tasks enables discovering the dependencies between the tasks, including the potential for a deadlock. In what way can resource allocation graphs that associate tasks with resources be used to detect potential deadlocks?

(1 point)

Q4: Real-Time Communication

The following table describes the set of messages present in a distributed application in which the CAN bus is used as a communication bus. Given the parameters of the message set, compute the maximum response time for delivery of messages A and B. You may assume that message release jitter is negligible.

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

(5 points)

Q5: Distributed systems

a) Describe two fault models for monolithic systems and two fault models for distributed systems. For each fault model give an example from realistic systems.

(4 points)

b) Give two reasons why it is harder to guarantee the end-to-end timeliness of a service in a distributed system?

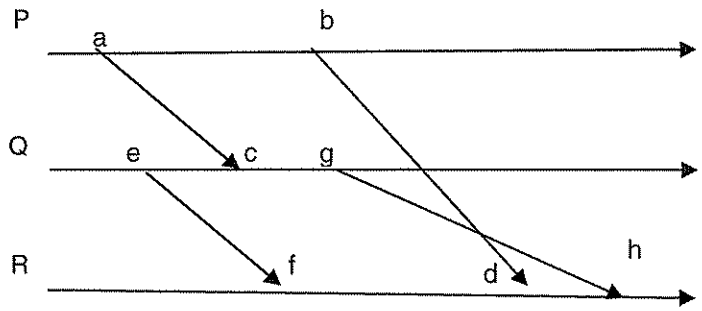
(2 points)

c) In a distributed time-triggered architecture (TTA) the communication bus bandwidth is used efficiently as the information about sender, receiver, time stamp and message size need not be transferred for every message exchanged.

Can the TTA bus be considered as an implementation of a reliable broadcast? Why or why not? Motivate your answer by referring to the components of the TTA design that enforce (or contradict) the essential properties of a reliable broadcast.

(3 points)

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



(2 points)

Notation for Processes

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

Schedulability test for Rate Monotonic:

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

With blocking:

$$\forall i,\ 1 \le i \le n: \frac{C_1}{T_1}+\frac{C_2}{T_2}+...+\frac{C_i}{T_i}+\frac{B_i}{T_i} \le i(2^{1/i}-1)$$

Schedulability test Earliest Deadline First:

$$\sum_{i=1}^{n}\left(\frac{C_i}{T_i}\right) \le 1,\ n=1,2,.....$$

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
L = 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)

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

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

$$w_m(q) = B_m + q \cdot C_m + \sum_{\forall j \in hp(m)} \left\lceil \frac{w_m(q) + J_j + \tau_{bit}}{T_j} \right\rceil \cdot C_j \quad \text{(with } w_m{}^0(q) = 0\text{)}$$

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

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

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

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