TENTAMEN   TDDD07 Realtidssystem

DATUM: 16 December 2010
TID: 8-12
PLATS: T1, U4, U1, T2, U3
ANSVARIG JOURLÄRARE: Examinator Simin Nadjm-Tehrani (Tel: 013-282411,
0702 282412), Massimiliano Raciti (013-282416),
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 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 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 10th.

Good luck!

Simin Nadjm-Tehrani

Q1:   Scheduling

A system for quality assurance and packing of chocolate bars has been designed using three spectrometers one for each type of chocolate (dark, milk and white chocolate). A chocolate block arrives on a conveyer belt and when reaching the end point it will be subject to sensing of its colour and structure. The block then moves on an adjacent conveyor belt and depending on the classification of a quality test will be discarded or packed into the right packaging. There are five computational processes involved, which run on the same CPU. Two servo motor controllers (one for each conveyor belt) running with the period of 4ms, one sensing process that also analyses the outcome of the spectrometer measurements (same process for all three spectrometers and their analysis), one process for both making the decision on the packaging component and actuating it, and one logging component that collects statistics of packed blocks and sends the data away for stock management. Assume that the sensor analysis process is run every 10ms and takes a maximum of 2 ms to run. Assume further that the actuator process is run at the same rate as the sensor analysis process and takes a maximum of 1ms to complete, and the logging process has a worst case execution time of 2ms. The servo steering processes take a maximum of 0,5ms each to compute.

a) How often can the logging process be run if the process set is to be scheduled with the earliest deadline first scheduling technique? Give one additional assumption necessary for your analysis to hold.

(2 points)

b) Assume now that the logging process will be run with a periodicity of 8ms. Construct a cyclic schedule for the above process set and present the minor and major cycles. You are expected not to increase the processor utilisation, but jitter can be accepted.

(4 points)

c) Now assume that the process set is scheduled using rate monotonic scheduling (RMS) and we intend to account for the access to shared resources in the system using the immediate ceiling protocol. The sensor analysis process outcome is output to a shared memory which the Logging process reads from when reporting on scrapping/packaging outcome. The logging process sends the collected statistics via a local area network. Consider the same parameter set as in part a) above and assume that processes with the same period are run as one process. Include the period for the logging process as 8ms.

Process	Worst case locking to read/write the common data structure	Increase in the WCET for the logging process due to access to the communication network
Sensor analysis & actuator	0,5 ms	
Logging	1 ms	
Logging		1ms

Compute the maximum response time for each process in the rate-monotonic setting to show whether the process set is schedulable.

(4 points)

d) What is meant by a sporadic task in a real-time system? Give two examples of such tasks.

(3 points)

Q2: Dependability and predictability

a) Explain the notion of availability, and contrast with the related notion of reliability.

(2 points)

b) Identify the causal chain of fault-error-failure in the following scenario, including whether the fault was permanent, transient or intermittent.

On 7th October a newspaper in Colorado reported that real-time alerts had ceased for a number of persons being electronically monitored instead of being in jail. BI Inc., a company that provides electronic monitoring for several nationwide agencies, experienced a problem with one of its offender monitoring servers at 7:29 a.m., temporarily disabling the server's notification system and delaying violation notifications to customers. The technical glitch happened when one of BI's servers exceeded its threshold of 2.1 billion records. "The offenders and suspects on the monitoring system did not know their devices were down at the time, the company officials said, and there were no major problems reported as a result of the technical failure."

(3 points)

c) Many real-time applications are built on top of small proprietary kernels that are adaptations of well-known time sharing operating systems, e.g. through adding preemptive priority-based scheduling. Describe three other adaptations needed in a real-time kernel that makes the kernel operations predictable in a real-time setting.

(3 points)

Q3: Design

a) Take a stand on the following propositions (true or false), and motivate your answer:
   1) Application program timing faults can never be detected by the run-time environment.
   2) Simulation of the design of a program can be used to study run-time fault tolerance properties.
   3) Voting systems (e.g. triple modular redundancy) cannot be used to tolerate the same software design fault appearing in every replica.

(3 points)

b) Describe four drawbacks with checking real-time systems for correctness and timeliness only on the platform for which they are intended, as opposed to being tested in a platform-independent design phase first.

(4 points)

Q4: Real-Time Communication

a) The following 3 messages are being sent on a CAN bus that has 0 as a dominant bit:

Message	ID
m1	10000110001
m2	00011110001
m3	11100000110

Assign priority high/medium/low to each message on the bus. Motivate your answer!

(2 points)

b) Describe how the TTP and CAN buses differ from each other in terms of flexibility for applications that evolve over time.

(2 points)

Q5: Distributed systems, QoS

a) Consider 4 nodes in a distributed system in which the local clocks are to be synchronised using the Lamport/Melliar-Smith algorithm (i.e upon exchange of local clock values, a value with a difference higher than delta is replaced by own clock and then the reported values are averaged to produce the value that replaces the own clock value). Consider a case where none of the clocks is a two-face clock (i.e. acts Byzantinely). Explain if the synchronisation requirement is met at node A if node A reads its own clock value t, and receives 3 values from nodes B, C, and D where two out of the readings differ from c by exactly delta.

(4 points)

b) Which one of the two standards Intserv and Diffserv provides a per flow end-to-end guarantee for soft real-time requirements? (1 point)

c) Consider the following three nodes in a client-server architecture which we model using the asynchronous model of distributed systems. Assume that a request by client 2 reaches the server before a request by client 1, followed by the server responding to the queries in FIFO order. Derive the vector clocks of five of the events in the system including at least a send and a receive event, and mark two concurrent events included among the five events.

(3 points)
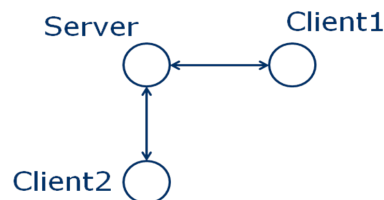
Notation for Processes

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:

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

Schedulability test Earliest Deadline First:

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

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

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

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

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

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