TENTAMEN TDDD07 Realtidssystem

DATUM: 17 January 2019
TID: 8-12
PLATS: TERE, TER3
ANSVARIG JOURLÄRARE: Simin Nadjm-Tehrani (0702 282412)

Material: English-Swedish-English dictionary
Calculator

No of assignments: 6

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.

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 that interpretation. Try to dispose of your time on each question in proportion of the assignment points.

Results are reported no later than 4 February 2019.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

a) Home care robots are expected to take the bulk of mundane work needed to be performed for the elderly and ailing population in parts of the world where qualified human help is more expensive to organise. These robots will be rolling on wheels but otherwise have a humanoid like appearance and communicate through multi-modal interfaces. There will be multiple software processes running for providing basic services (like movement in two dimensions) but also for communicating, sensing, reacting to dynamic events in the vicinity of the robot.

Consider a basic set of processes that will run on such a robot. A navigation process will take the robot to a point of interest as indicated by a human command or prescheduled activity. The navigation output will adjust the position of the robot every 40ms and the computation needed to decide the next move will take a maximum of 5ms. The collision avoidance process will be reading sensor values and decide whether to stop the robot to avoid collisions. This process runs every 20ms and will have 5ms as WCET. The sensor fusion process combines the input from light sensors, sonar, and observed RFID markers to decide the zone in which the robot is currently active in a home. This process has a 60ms period and a WCET of 15ms.

1. Construct a cyclic schedule for the above three processes, provide your chosen minor and major cycle and motivate any assumptions you made in suggesting the schedule. (5 points)

2. Assume now that three new processes are added to the set, namely a process for speech recognition and a process for voice synthesis that communicates with a human in the room. Finally, a decision process that makes sense of the current speech command and given various capabilities in the zone responds to the human with a plan of activity. In this case assume that the six processes are to be processed on the same CPU but share no other resources. Given a period of 50ms for speech recognition and WCET of 10ms, and a period of 50ms with a WCET of 5ms for the voice synthesis, and a period of 80ms and a WCET of 5ms for the decision process respectively, show whether the process set is schedulable with the earliest deadline first (EDF) method or not. Explain which assumptions are relevant for your provided answer.

   (2 points)

3. Consider now that the three new processes under point 2. above, and sensor fusion process from point 1. are to be run on a different CPU. Assume further that the WCET for the processes increases by 30% on the newly acquired CPU. Check whether the four processes in this set are schedulable using Rate Monotonic scheduling (RMS). Motivate your answer!

   (5 points)

4. Consider now that in the setup similar to point 3. (with four processes), the speech recognition and voice synthesis processes share a common data area that needs to be protected by mutual exclusion. Assume further that the speech recognition and voice synthesis processes have a maximal computation and memory access time (i.e. a critical section length) in relation to this shared resource amounting to 2 and 3ms respectively. What additional terms you need to consider in the calculation of the response times? Provide the value for these terms for each process (you need not compute the response times).

   (2 points)

b) Present a proof that a task set which is scheduled using immediate ceiling protocol combined with fixed priorities will not suffer starvation.

(4 points)

Q2: Dependability and predictability

a) On 28th December 2018, The Verge reported: "A nationwide CenturyLink outage has knocked out [the emergency] 911 voice calls in parts of the US and affected everything from Verizon mobile data to ATM withdrawals, lottery drawings, and hospital patient records. The downtime, which also impacts CenturyLink's residential internet customers, began Thursday and has now stretched on for more than 24 hours.

FCC (Federal Communication Commission) chairman Ajit Pai announced Friday that such a delay is "unacceptable" and said the commission is investigating the ongoing outage after reports of people getting busy signals when dialing 911".

Later, Channel partners reported on 6th January, citing the CenturyLink spokeswoman Linda Johnson: "The outage was caused by a faulty network management card from a third-party equipment vendor that caused invalid traffic replication," she said. "Steps are being taken to help prevent the issue from reoccurring."

CenturyLink has established a network-monitoring plan for key parameters that can cause this type of outage, based on advice from the third-party equipment vendor, Johnson said. Enhanced visibility processes will "quickly identify and terminate invalid packets from propagating the network," she said.

A comment on the same site disagrees with the cause that is presented: "A management network should ride on top of and rarely interact with bulk data transport. Just often enough to monitor node data flow and pick up traffic statistics. Management protocols are by default high priority service but with small bandwidth needs. Traffic is defined by particular frame, packet or port types. Multiple steps can and should be taken on any major back bone link to restrict management packets to minimal backbone capacity. Yet one single card replicating management traffic takes out a nationwide network for 2 days including VoIP and 911 service?"

CenturyLink has 30 days to do a full accounting and report back to federal regulators.

Scenarios such as the mentioned one are likely to escalate in coming years. Using the knowledge that you gained from this course, name two fault models from distributed systems that you would consider plausible after reading about the episode. Does the scenario indicate a permanent, transient, or intermittent fault? (3 points)

b) Describe two methods for implementing fault tolerance using redundancy in space, and one method that uses redundancy in time. For each of the methods provide the fault model that the tolerance approach is appropriate for.

(3 points)

Q3: Real-time Communication

Give one service supported by a TTP bus that the CAN bus does not provide, then provide a concrete example application that needs that service.

(2 points)

Q4: Application design & RTOS

a) Take a stand (true/false) on each of the following statements and motivate your answer!

(1) Penetration testing is not an effective fault removal method if attack vectors for a given critical system are not available.

(2) As platforms change within a real-time system's life cycle, one should ignore the platform when analyzing the timeliness properties.

(3) Since time-related aspects cannot be modelled in UML there is no model-based approach to analyzing timeliness, and only test runs remain.

(3 points)

b) Describe the differences between memory management functions in a real-time system and similar functions in a standard (non-real-time) operating system.

(3 points)

c) What is the benefit of having a standard for operating systems in the real-time context? Exemplify the use of sector-specific operating systems (e.g. by referring to a known accident investigation scenario) where their presence or absence is used to show the burden on product suppliers.

(3 points)

Q5: Distributed systems, Quality of Service (QoS)

a) Describe two major functions proposed in a resource-efficient method for scheduling of virtual machines on physical machines in cloud environments as presented in the course literature.

(2 points)

b) What is the problem if two nodes in a distributed system do not have access to the same accurate global clock? What sort of services can then not be provided and what needs to be relied on instead?

(3 points)

Q6: Bonus points

In this question you state if you have any bonus points allocated to your attempts at bonus exercises 1, 2, and 3 during the course. Please sum up all three (if any) of your attempted exercises and write the total attained points here.

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

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

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

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

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