Name: Solutions

(Bonus: 1pt)

18-648: Embedded Real-Time Systems

Quiz #5

Fall 2017

60 minutes

Instructions

1. Show all relevant work.
2. Partial credit may be given for some questions.
3. The use of a calculator is allowed.
4. The time limit will be *strictly* enforced.
5. Watch the screen for any clarifications.
6. This is a **CLOSED-BOOK/CLOSED-NOTES quiz**.

For Graders' Use Only

Name: _____ / 1

1._____ / 20

2._____ / 9

3._____ / 20

4._____ / 11

TOTAL. _____ / 60

Question 1: True or False?

Enter True or False for the questions below. (20 points)

a. TRUE Blocking can be caused only by lower-priority tasks on uniprocessors but not so on multiprocessors.

b. FALSE It is good to have the blocking duration of a task be a function of the execution times of other tasks.

c. FALSE A message in a CANbus network can never suffer from unbounded delay.

d. TRUE The FlexRay bus is faster than a CANbus.

e. FALSE Schedulability analysis cannot be performed on a periodic message set using the CANbus.

f. TRUE On the FlexRay bus, a node can be assigned more than one slot within the static segment.

g. FALSE On the FlexRay bus, even the highest-priority node cannot be guaranteed bus access within a non-zero dynamic segment.

h. FALSE The priority ceiling of a global mutex M_G in a multiprocessor system using partitioned scheduling is the priority of the highest-priority task that can access M_G.

i. TRUE The priority ceiling of a local mutex M_L in a multiprocessor system using partitioned scheduling is the priority of the highest-priority task that can access M_L.

j. TRUE In a multiprocessor system, when synchronization on a global mutex M_G is required, a task can suspend or spin-wait on M_G.

Question 2. Circle one <u>or more</u> answers for the questions below. (9 points)

a. Which of the following statements are NOT true?

i. A network link usually has a constant propagation delay

ii. Delay in a network is the time taken to deliver a packet

iii. Jitter is the variance of the delay

iv. Packet miss rate is the ratio of packets that are not delivered

b. Which of the following statements are true about CANbus?

i. Communications can be scheduled using fixed-priority scheduling algorithms

ii. CAN has a 11-bit ID field (In other words it can have 2048 message IDs/priority levels)

iii. CAN cannot preempt or interrupt a message once it has started

iv. CAN usually uses zero bit dominance on electrical interconnects

c. Which of the following statements about FlexRay are accurate?

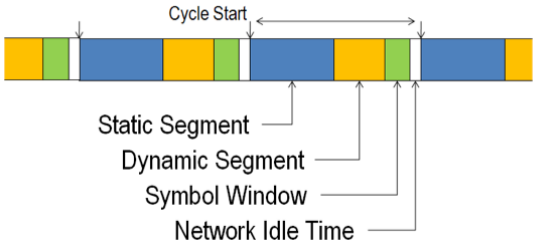
i. FlexRay manages multiple access with a Time Division Multiple Access

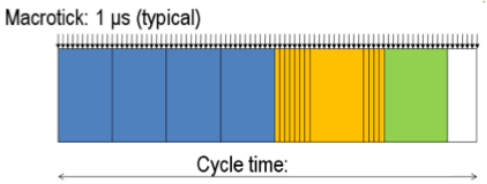
ii. Communication is broken up into different “Segments”

iii. FlexRay uses bit dominance for priority arbitration

iv. “Symbol Window” is used for maintenance and identification of special cycles

Question 3. Flex Your Thinking Muscles (20 points)





Assume you are given a FlexRay bus with a microtick of 1us. The static segment is 600 us long and is divided into 3 equal slots. The dynamic segment is 150 us long, with each minislot equal to a microtick. The symbol window is 40 us long and the network idle time duration is 10 us long. There are 3 ECUs on the bus labeled as E (engine), T (transmission), and C (cruise control).

i. The static segment slots are split equally among the 3 ECUs. The priorites for the ECUs, from the highest to the lowest, are (E->T->C).

ii. In the dynamic segment, each ECU is assigned round-robin slots with the same priority ordering in each round (i.e. E->minislots 1, 4, 7, 10…., T->minislot 2,5,8,11…, C->minislots 3,6,9,12….)

Assume that each ECU will transmit data in any FlexRay slot that it has been assigned to (independent of the fact whether its transmission slot is in the static or the dynamic segment), i.e. data get transmitted by an ECU as soon as possible (this is not normal!). The FlexRay protocol is used as is, otherwise.

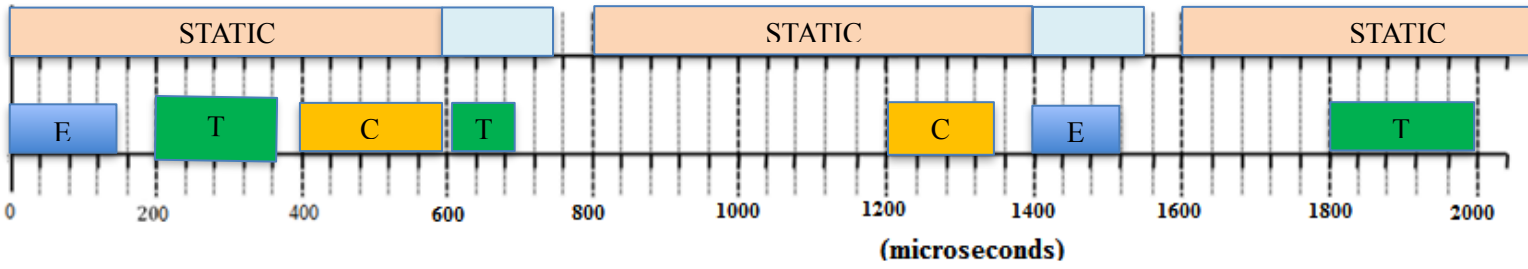
a. What is the cycle-time on this FlexRay bus?

Cycle-time = static segment + dynamic segment + symbol window + idle time
= 600 + 150 + 40 + 10 = 800 µs

b. Now consider the following situation and draw the timeline from time 0 to 2ms. Assume that appropriate symbols are transmitted in the symbol windows.

ECU	Time at which data become ready for transmission (in us)	Frame Length (in us)
E	0	150
T	100	180
C	150	200
T	400	100

E	1000	120
T	1200	200
C	1180	150



Question 3. *CAN you schedule it?* (**11 points**)

Consider the following (simplistic) set of messages that need to be transmitted on a 1Mbps CANbus. Assume that we want to use RMS to schedule these messages on the bus.

ID	Total Length (bytes)	Period (ms)	Message ID (example)	Message Duration (ms)	Utilization	Blocking Time (B_i)
M_1	10	10	0x01 (lowest value)	10*8=80 μs	80/10000=0.8%	200 μs
M_2	15	20	0x02 (next lowest)	15*8=120 μs	120/20000=0.6%	200 μs
M_3	20	60	0x03	20*8=160 μs	160/60000=0.26%	200 μs
M_4	25	120	0x04 (highest value)	25*8=200 μs	200/120000=0.16%	0 μs

(a) Assign a message ID to each message (assuming RMS) and keeping in mind the distributed arbitration mechanism used on a CANbus. Fill the corresponding column above. (**4 points**)

Lower arbitration IDs have higher priority values; M_1 through M_4 must have ascending ID values, within a 11-bit priority field. It may be useful in practice to leave gaps between message ID values to accommodate the additional new message types in the futures.

(b) Is the message set schedulable? Show all work. *Hint*: Think harmoniously, while considering what can block your thinking. (**7 points**)

The message set is a harmonic taskset and hence the taskset (excluding blocking times) will be schedulable up to 100% utilization. The total utilization of this message set is pretty small (0.8+0.6+0.26+0.16=1.82%) for this very simplistic CANbus message set. Since messages cannot get preempted, each message can be blocked by at most the longest lower-priority message. Hence, the B_i for each message is as shown in the last column above.

The schedulability analysis for a *harmonic* message set would be as follows:

M_1: $(C_1 + B_1) / T_1 <= 1$
M_2: $(C_1 / T_1) + (C_2 + B_2) / T_2 <= 1$
M_3: $(C_1 / T_1) + (C_2 / T_2) + (C_3 + B_3) / T_3 <= 1$
M_4: $(C_1 / T_1) + (C_2 / T_2) + (C_3 / T_3) + (C_4 + B_4) / T_4 <= 1$

Given the relatively small numbers for the utilization and blocking times, all messages are schedulable.

Scratch Paper