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Exercises for Lecture
Real-Time Systems and Applications
Summer Semster 15

Exercise Sheet 11

(11 Punkte)

Exercise Due at Wednesday, July 1, 2015, 12:00 Uhr

Hinweise: Gruppenarbeit von bis zu drei Personen aus der gleichen Übungsgruppe ist möglich. Bitte vergessen Sie nicht Ihre Namen und Ihre Matrikelnummern auf die Lösung zu schreiben. **Die Abgaben können in den beschrifteten Briefkasten vor dem Sekretariat des LS12 (OH16/E22) eingeworfen oder per Mail (PDF Format) an georg.von-der-brueggen [☺] tu-dortmund.de abgegeben werden.**

Note: It is allowed to work in a group of up to three persons, if these persons are from the same practice group. Please do not forget to write your name and your Matrikelnummer on the solutions. **The solutions can either be placed in the mailbox in front of the secretary's office of LS 12 (OH/E22) or sent by mail (PDF format) to georg.von-der-brueggen [☺] tu-dortmund.de**

Exercise Sessions:
Do, 10:15 - 11:45 OH16/E18
Do, 14:15 - 15:45 OH16/E18

11.1 RTOS and RTPL (4 Punkte)

1. What are the advantages to use Real-Time Programming Languages and Real-Time Operating Systems to design real-time systems, respectively?
2. Explain the concepts behind *Delay* and *Delay until* in Ada. Check the source code of FreeRTOS. What are the corresponding functions in FreeRTOS?
3. Explain why most commercial Real-Time Operating Systems use only a fixed-length table to store the (pointers of) task control blocks (TCB). How does the scheduler in FreeRTOS work?
4. Explain how you will implement the PCP and Priority Inheritance Protocol (PIP) in a Real-Time Operating System.

Hint: 1+1+1+1

11.2 Communication CAN Bus (3 Punkte)

Consider the following case with four sporadic messaging tasks on a CAN. Suppose that the worst-case transmission time of a message is at most 200 μs. Each sporadic messaging task sends only one message per job.

symbol	identifier	minimum inter-arrival time and relative deadline (μs)
A	00000000001	500
B	00000001011	800
C	00000001111	2000
D	00000000110	1400

Can a message of a task be sent before its relative deadline? If not, evaluate whether there exists a feasible schedule to send the messages for these tasks (without changing the timing parameters) on the CAN.

11.3 TDMA (3 Punkte)

Suppose that we use a TDMA (time division multiple access) protocol on a bus to communicate among different processors. The TDMA cycle is 6 time units. Processor 1 is allocated with 3 time units in a TDMA cycle. Suppose that we are given the following 3 sporadic real-time tasks with implicit deadlines on processor 1. (Here, we ignore the computation part of the tasks.) The communication time for each task is defined as C_i. Assume the communication channel is preemptable.

	τ_1	τ_2	τ_3
C_i	1	2	3
T_i	8	12	20

- Can we feasibly schedule the above task sets under RM within the TDMA?
- Suppose that C_s is the slot length of the TDMA assigned to processor 1 and T_s is the TDMA cycle length. What is the sufficient schedulability condition of a fixed-priority scheduling within a given TDMA assignment?

Hint: 1+2

11.4 Challenge: Utilization Bound of TDMA + RM (1 Punkt)

The hierarchical scheduling policy uses different strategies in different level for scheduling. For example, Question 11.3 uses TDMA in the top level and fixed-priority scheduling in the bottom level. Suppose that C_s is the slot length of the TDMA assigned to processor 1 and T_s is the TDMA cycle length. The given tasks are ordered with RM ordering, in which $T_i \leq T_{i+1}$ for all task τ_i. Moreover, we assume that $T_s \leq T_1$. Prove/explain that the sufficient schedulability test of task τ_k of TDMA+RM in Question 11.3 is

$$\prod_{i=1}^{k}(U_i + 1) \leq \frac{2}{2 - \frac{C_s}{T_s}}.$$

Hint: Image that we create a virtual task τ_0 with the highest priority, in which $T_0 = T_s$ and $C_0 = T_s - C_s$.

General Hints: