Exercise Sheet 11

(11 Punkte)

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


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.

<table>
<thead>
<tr>
<th>symbol</th>
<th>identifier</th>
<th>minimum inter-arrival time and relative deadline (µs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0000000001</td>
<td>500</td>
</tr>
<tr>
<td>B</td>
<td>0000001011</td>
<td>800</td>
</tr>
<tr>
<td>C</td>
<td>0000011111</td>
<td>2000</td>
</tr>
<tr>
<td>D</td>
<td>000001110</td>
<td>1400</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>$\tau_1$</th>
<th>$\tau_2$</th>
<th>$\tau_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_i$</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>$T_i$</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>

- 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 $\tau_i$. Moreover, we assume that $T_s \leq T_1$. Prove/explain that the sufficient schedulability test of task $\tau_k$ 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 $\tau_0$ with the highest priority, in which $T_0 = T_s$ and $C_0 = T_s - C_s$.

General Hints: