Exercise Sheet 11 (Theory)  
(11 Points)

Please note: Solutions must be submitted (individually or in pairs) until 14.01.2019 at 10:00 AM (post box in OH16, ground floor, in front of room E16). Submitting solutions via mail is not possible. Discussion: 16.-18.01.2019..

1  RM Scheduling (2 Points)

Consider the given set of sporadic real-time tasks with implicit deadlines.

\[
\begin{array}{ccc}
\tau_1 & \tau_2 & \tau_3 \\
C_i & 1 & 2 & 3 \\
T_i & 4 & 6 & 10 \\
\end{array}
\]

(a) Determine the priority of each task. Is a rate-monotonic (RM) schedule feasible? Explain why or why not.

(b) What happens, if the minimum inter-arrival time of task \( \tau_3 \) is decreased to 8?

2  Resource Access Protocols (3 Points)

(a) What is Priority Inversion? Is it possible to completely avoid it under fixed-priority scheduling? If yes, what are the drawbacks? If no, why not?

(b) Explain why the Priority Ceiling Protocol (PCP) is deadlock-free.

(c) Mr. Smart wants to use PCP in his system, in which tasks are scheduled according to a dynamic-priority policy. Is this possible? Which problems may occur?

3  Resource Access Protocols (4 Points)

Consider the following tasks and semaphores. \( S_j(\tau_i) \) denotes the worst-case execution time of a critical section of task \( \tau_i \), which is guarded by semaphore \( S_j \). \( S_j(\tau_i) \) is 0 if the semaphore \( S_j \) is not needed by \( \tau_i \).

\[
\begin{array}{c|c|c|c}
\tau_1 & \tau_2 & \tau_3 & \tau_4 \\
S_1 & 1 & 0 & 0 & 0 \\
S_2 & 0 & 0 & 9 & 9 \\
S_3 & 8 & 7 & 0 & 0 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c|c|c|c}
\tau_1 & \tau_2 & \tau_3 & \tau_4 \\
C_i & 2 & 10 & 16 & 16 \\
T_i & 10 & 24 & 96 & 96 \\
D_i & 10 & 24 & 96 & 96 \\
\end{array}
\]

Assume that the critical sections are not nested. Moreover, regarding the computation of the worst-case execution time \( C_i \) of a task \( \tau_i \), the assumption is made that critical sections are always granted (no blocking).
(a) Assume that the above task set is scheduled according to the rate-monotonic algorithm (RM) and that the Priority Inheritance Protocol (PIP) is applied. Draw the scheduling diagram!

(b) Assume that the above task set is scheduled according to the rate-monotonic algorithm (RM) and that the Priority Ceiling Protocol (PCP) is applied. Draw the scheduling diagram!

4 Harmonic Task Systems (2 Points)

Consider the following periodic tasks with implicit deadlines:

<table>
<thead>
<tr>
<th></th>
<th>( \tau_1 )</th>
<th>( \tau_2 )</th>
<th>( \tau_3 )</th>
<th>( \tau_4 )</th>
<th>( \tau_5 )</th>
<th>( \tau_6 )</th>
<th>( \tau_7 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_i )</td>
<td>0.2</td>
<td>2</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>14</td>
<td>28.8</td>
</tr>
<tr>
<td>( T_i )</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>24</td>
<td>24</td>
<td>72</td>
<td>288</td>
</tr>
<tr>
<td>( D_i )</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>24</td>
<td>24</td>
<td>72</td>
<td>288</td>
</tr>
<tr>
<td>( U_i )</td>
<td>0.1</td>
<td>( \frac{1}{6} )</td>
<td>( \frac{1}{6} )</td>
<td>0.0625</td>
<td>0.0417</td>
<td>0.195</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Assume that the tasks are executed on a uniprocessor system.

(a) Determine formally if the rate-monotonic (RM) schedule is feasible.

(b) Determine formally if the earliest deadline first (EDF) schedule is feasible.