Exercise Sheet 6
(11 Punkte)

Exercise Due at Wednesday, June 12, 2019, 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 marked mailbox in front of the secretary’s office of LS 12 (OH16/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

6.1 Self-Suspension Modeling and Scheduling (2 Punkte)

- Give concrete examples why EDF and RM can be very bad when considering tasks with self-suspensions.
- Define the dynamic self-suspension and the segmented self-suspension task models for sporadic real-time tasks. What are their advantages and disadvantages with respect to the expressiveness of the system and the accuracy in the schedulability design/analysis, respectively?

6.2 Self-Suspension (3 Punkte)

Prove that the speedup factor of the Proportional Fixed-Relative Deadline Assignment for 1-segmented self suspension sporadic task systems is at least \( \Omega(n) \). The assignment is

\[
D_{i,1} = \frac{C_{i,1}}{C_{i,1} + C_{i,2}} (T_i - S_i)
\]

\[
D_{i,2} = \frac{C_{i,2}}{C_{i,1} + C_{i,2}} (T_i - S_i)
\]

Hint: Consider the following task set with \( n \) tasks where \( n \geq 5 \):

- \( C_{i,1} = 1, \quad C_{i,2} = 2^i - 1 \),
- \( T_i - S_i = 2^i \cdot (n-1) \), and
- \( T_i = F > 2^n \cdot (n-1) \)
- Therefore, \( D_{i,1} \) is set to \( n - 1 \), and \( D_{i,2} \) is set to \( (2^i - 1) \cdot (n - 1) \).

You can assume that this task set can be feasibly scheduled by using equal deadline assignment introduced in the lecture.

6.3 Necessary Condition and Sufficient Condition (2 Punkte)

Consider task systems with constrained deadlines.
• Write down a necessary condition for dynamic self-suspension sporadic task systems under uniprocessor fixed-priority scheduling.

• Write down a sufficient condition for dynamic self-suspension sporadic task systems under uniprocessor fixed-priority scheduling.

Explain/prove your answer.

6.4 Self-Suspension due to Shared Resources (3 Punkte)

Consider an implicit-deadline task set \( T \). Each task \( \tau_i \) in \( T \) is assigned to run only on its designated processor has

• \( C_i \) as worst-case execution time on its assigned processor (which ignores shared resource access)

• \( A_i \) as worst-case execution time on a physical shared resource, e.g., bus, (which ignores computation on its assigned processor).

This means, \( C_i + A_i \) is the worst-case execution time of task \( \tau_i \) if there is no contention on the physical shared resource. Suppose that there is only one physical shared resource. Both shared resource accesses and processor executions are based on preemptive RM fixed-priority scheduling. Prove and explain that the task set is schedulable under the scheduling policy if

\[
\forall \tau_k \in T, \exists t \mid 0 < t \leq T_k \text{ s.t. } \left( C_k + \sum_{t \in hp(\tau_k, c)} \left\lfloor \frac{t + T_i}{T_i} \right\rfloor C_i \right) + \left( A_k + \sum_{t \in hp(\tau_k, r)} \left\lfloor \frac{t + T_i}{T_i} \right\rfloor A_i \right) \leq t,
\]

where

• \( hp(\tau_k, c) \): higher-priority tasks than \( \tau_k \) assigned to the same core as task \( \tau_k \), and

• \( hp(\tau_k, r) \): higher-priority tasks than \( \tau_k \) on the shared resource.

6.5 Challenge on Arbitrary Schedules with 1-Segmented Self-Suspension (optional) (1 Punkt)

Prove the following necessary condition for any implicit-deadline arbitrary 1-segmented self-suspension sporadic task model:

\[
\forall t > 0, \sum_{\tau_i \in T} df_i^*(t) \leq t.
\]

where

\[
df_i^*(t) = \begin{cases} 
0, & 0 \leq t < T_i - S_i \\
C_{i,\text{max}} + \left\lfloor \frac{t - (T_i - S_i)}{T_i} \right\rfloor (C_{i,1} + C_{i,2}), & t \geq T_i - S_i
\end{cases}
\]

General Hints: