Schedulability Analysis for the Abort-and-Restart (AR) Model

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Outline

- Introduction
- Motivation
- System model
- Analysis
- Priority assignment and results
- Tighter analysis and results
- Conclusion
Introduction
Motivation

- Nowadays, computers have more power of execution than before. In concurrent programming, sometimes programmers consider how to enhance the correctness of programs rather than reduce the overhead. For a real-time system, it is more complicated because of timing constraints and priorities. A concurrency control mechanism for a system is important because it affects the correctness and the schedulability.

- Atomic execution - support P-FRP
- No shared resources problems
- Preemptible Atomic Regions (PAR) - similar
System model

- Fixed priority scheduling
- On a single processor
- Periodic / sporadic tasks
- $D \leq T$
Analysis

- The standard response time analysis cannot apply to the AR model.

- New Formulation

\[ R_i = C_i + \sum_{\forall j \in hpi} \left\lfloor \frac{R_i}{T_j} \right\rfloor \cdot C_j \]

\[ \tilde{C}_j = C_j + \max_{\forall k \in hpi \cap lpi} C_k \]
Example

<table>
<thead>
<tr>
<th>Task</th>
<th>Period</th>
<th>C</th>
<th>$\hat{C}_j$</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_1$</td>
<td>28</td>
<td>2</td>
<td>7(2+5)</td>
<td>1</td>
</tr>
<tr>
<td>$\tau_2$</td>
<td>120</td>
<td>3</td>
<td>8(3+5)</td>
<td>2</td>
</tr>
<tr>
<td>$\tau_3$</td>
<td>140</td>
<td>4</td>
<td>9(4+5)</td>
<td>3</td>
</tr>
<tr>
<td>$\tau_4$</td>
<td>200</td>
<td>5</td>
<td>5(5+0)</td>
<td>4</td>
</tr>
</tbody>
</table>

1. $R_4^1 = 5 + \left( \left\lfloor \frac{5}{28} \right\rfloor \cdot 7 + \left\lfloor \frac{5}{120} \right\rfloor \cdot 8 + \left\lfloor \frac{5}{140} \right\rfloor \cdot 9 \right) = 29$
2. $R_4^2 = 5 + \left( \left\lfloor \frac{29}{28} \right\rfloor \cdot 7 + \left\lfloor \frac{29}{120} \right\rfloor \cdot 8 + \left\lfloor \frac{29}{140} \right\rfloor \cdot 9 \right) = 36$
3. $R_4^3 = 5 + \left( \left\lfloor \frac{36}{28} \right\rfloor \cdot 7 + \left\lfloor \frac{36}{120} \right\rfloor \cdot 8 + \left\lfloor \frac{36}{140} \right\rfloor \cdot 9 \right) = 36$
Priority assignment

Execution-time-toward-Utilisation Monotonic (EUM) priority assignment.

- Execution-time Monotonic (EM) - assigns a higher priority to a task which has a bigger worst-case execution time
- Utilisation Monotonic (UM) – assigns a higher priority to a task which has higher utilisation
Example

<table>
<thead>
<tr>
<th>Task</th>
<th>Period</th>
<th>C</th>
<th>U</th>
<th>Priority</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\tau_1)</td>
<td>60</td>
<td>6</td>
<td>0.1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>(\tau_2)</td>
<td>50</td>
<td>5</td>
<td>0.1</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>(\tau_3)</td>
<td>32</td>
<td>4</td>
<td>0.125</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>(\tau_4)</td>
<td>25</td>
<td>3</td>
<td>0.12</td>
<td>4</td>
<td>30 (X)</td>
</tr>
<tr>
<td>(\tau_5)</td>
<td>100</td>
<td>2</td>
<td>0.02</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>C</th>
<th>U</th>
<th>Priority</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\tau_1)</td>
<td>60</td>
<td>6</td>
<td>0.1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>(\tau_3)</td>
<td>32</td>
<td>4</td>
<td>0.125</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>(\tau_4)</td>
<td>25</td>
<td>3</td>
<td>0.12</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>(\tau_2)</td>
<td>50</td>
<td>5</td>
<td>0.1</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>(\tau_5)</td>
<td>100</td>
<td>2</td>
<td>0.02</td>
<td>5</td>
<td>88</td>
</tr>
</tbody>
</table>
Results

No. of tasks = 8

Schedulability vs. Utilization

- DM
- UM
- EM
- EUM
- ES

The University of York
Tighter analysis

- It is too pessimistic because higher priority tasks cannot always abort the lower priority task with the biggest execution time on each release. In this case, the higher priority task aborts the task with second biggest execution time. The multi-set approach [1] from CRPD has a similar property to the AR model.

Multi-bag approach

- Each task has a bag to contain a series of abort cost from tasks $t_k \in \text{hep}(i) \cup \text{lp}(j)$, with the number is decided by $E_j(R_k)$. A task-set has a number of bags for each task. Therefore, we call this approach, the multi-bag.

<table>
<thead>
<tr>
<th>Task</th>
<th>T=D</th>
<th>C</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_1$</td>
<td>25</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>$\tau_2$</td>
<td>35</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>$\tau_3$</td>
<td>45</td>
<td>3</td>
<td>?</td>
</tr>
</tbody>
</table>
Results

No. of tasks = 5

Schedulability

Utilization

DM
DM-MB
EUM
EUM-MB
Conclusion

- A new formulation to use the standard response time analysis
- EUM is a do-able priority assignment for the AR model
- Tighter analysis is introduced
- Current and future work – Deferred abort
Questions