A Constraint Logic Programming Framework for the Synthesis of Fault-Tolerant Schedules for Distributed Embedded Systems

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Domain

- Safety critical embedded systems
  - Hard real-time
    - Static schedules are necessary
  - Reliability is critical
    - Fault-tolerant
  - Battery powered
    - Energy consumption must be minimised
Example

- Application with
  - Hard deadline
  - Reliability goal: 0.999,999,9
  - Minimise energy

Fastest Schedule:

<table>
<thead>
<tr>
<th>PE_1</th>
<th>P_1</th>
<th>P_2</th>
<th></th>
<th>P_4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PE_2</td>
<td>P_3</td>
<td>P_5</td>
<td>P_6</td>
<td></td>
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</tr>
</tbody>
</table>

Bus 1 2

Deadline

- R = 0.999 999 987
- 100% E\_0

Voltage levels
- N\_1 100% 66% 33%
- N\_2 100% 66% 33%

k = 1
Example

- Application with
  - Hard deadline
  - Reliability goal: 0.999,999,9
  - Minimise energy

Energy Minimised:

<table>
<thead>
<tr>
<th>PE₁</th>
<th>PE₂</th>
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</thead>
<tbody>
<tr>
<td>P₁</td>
<td>P₂</td>
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<tr>
<td>P₅</td>
<td>P₃</td>
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<tr>
<td>P₄</td>
<td>P₆</td>
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</tbody>
</table>

Deadline

- R = 0.999 999 878
- 68% E₀

Voltage levels

- N₁ 100% 66% 33%
- N₂ 100% 66% 33%

k = 1
Example

- Application with
  - Hard deadline
  - Reliability goal: 0.999,999,9
  - Minimise energy
    - Sacrifice 5% energy to meet reliability

Reliable Energy Minimisation:

<table>
<thead>
<tr>
<th>PE₁</th>
<th>PE₂</th>
<th>Bus</th>
<th>PE₁</th>
<th>PE₂</th>
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<tbody>
<tr>
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<tr>
<td></td>
<td>P₃</td>
<td>2</td>
<td></td>
<td>P₆</td>
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</tbody>
</table>

Deadline

R = 0.999 999 920
73% E₀

Voltage levels

<table>
<thead>
<tr>
<th>N₁</th>
<th>N₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>66% 33%</td>
</tr>
</tbody>
</table>

k = 1
Design Optimisation Tool

- Constraint Logic Programming
  - Good performance for NP-complete problems
  - Easily extendable model
- Heuristics
  - Complete: Variable- and value selection to guide search
  - Incomplete: Credit search to limit search to feasible space/time