Real time simulation of battery packs on multi-core targets

Javier Gazzarri – Application Engineering
Real Time

- Complex
- Costly
- High demand

Optimize for HIL before going to HIL
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- Create & modify Simulink models with MATLAB
- Analyze model on your desktop
latencies
overhead
many configuration options
Desktop Profiling

Automatic model creation and configuration
Concurrent Execution
Battery Pack – Three Partitioning Options

1-task partition
2-task partition
4-task partition
Model creation and configuration with MATLAB
Inter-Task Latency?
Validation
Validation Benchmark

- No stack partition
- Variable step solver
Validation Results

Variable step solver
1-task partition
2-task partition
4-task partition

8-cell stack voltage for a one-hour step discharge

<table>
<thead>
<tr>
<th>time (s)</th>
<th>Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>33.5</td>
</tr>
<tr>
<td>500</td>
<td>33</td>
</tr>
<tr>
<td>1000</td>
<td>32.5</td>
</tr>
<tr>
<td>1500</td>
<td>32</td>
</tr>
<tr>
<td>2000</td>
<td>31.5</td>
</tr>
<tr>
<td>2500</td>
<td>31</td>
</tr>
<tr>
<td>3000</td>
<td>30.5</td>
</tr>
<tr>
<td>3500</td>
<td>30</td>
</tr>
</tbody>
</table>
Desktop Profiling
Desktop Profiling Results
Average Execution Time

1-task partition:
- Battery stack: 209 μs

2-task partition:
- 108 μs
- 99 μs

4-task partition:
- 65 μs
- 43 μs
- 53 μs
- 70 μs

Lenovo T520
Intel® Core™ i7-2620M CPU @ 2.7GHz
1-task partition

Real Time

Estimated Execution Timeline

Output [0.001 0]
Load [0.001 0]
Input [0.001 0]
Bat_Slack [0.001]
Add_Voltage [0.001 0]
Timer Interrupt 1

~60 μs

Core #

Desktop

HP xw4600 with Intel Core2 Quad @2.5 GHz

Lenovo T520
Intel® Core™ i7-2620M CPU @ 2.7GHz
2-task partition

Real Time

HP xw4600 with Intel Core2 Quad @2.5 GHz

Lenovo T520
Intel® Core™ i7-2620M CPU @ 2.7GHz
4-task partition

Real Time

Estimated Execution Timeline

Output [0.001 0]
Load [0.001 0]
Input [0.001 0]
Bat(Stack4) [0.001 0]
Bat(Stack3) [0.001 0]
Bat(Stack2) [0.001 0]
Bat(Stack1) [0.001 0]
Add_Voltage [0.001 0]
Timer Interrupt

~23 μs
~20 μs
~22 μs
~21 μs

HP xw4600 with Intel Core2 Quad @2.5 GHz

Lenovo T520
Intel® Core™ i7-2620M CPU @ 2.7GHz
## Execution Time Comparison
Desktop (average) vs. Real Time (snapshots)

<table>
<thead>
<tr>
<th>Case</th>
<th>Desktop (μs)</th>
<th>Real Time (μs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-task partition</td>
<td>209</td>
<td>60</td>
</tr>
<tr>
<td>2-task partition</td>
<td>108, 99</td>
<td>35, 30</td>
</tr>
<tr>
<td>4-task partition</td>
<td>65, 43, 53, 70</td>
<td>20, 21, 35, 37</td>
</tr>
</tbody>
</table>

- **50%**
- **28%**
- **54%**
- **36%**
Summary

Optimize for HIL before going to HIL

- Create & modify Simulink models with MATLAB
  - Automated search for best partitioning architecture

- Analyze model on your desktop
  - Profiling
  - Qualitative indication of real time performance
Thank You