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
curDir = pwd;

myModel = BatteryModel;

% Name
myModel.Name = 'M6C_2014_Bcell_V2';

% Number of cell stacks
myModel.nStacks = 2;

% Number of cells per stack
myModel.nCells = 4;

% Number of tasks for all stacks
myModel.nTasks = 2;

% Solver base execution rate
myModel.baseRate = 1e-3;

% Factor for battery stack rate
myModel.rateFactor = 1;

% Desktop or real-time
myModel.choice = 'desktop';

% Main script
myModel.GE_CreateModel();

df(curDir);
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
Desktop Profiling
Desktop Profiling Results

Average Execution Time

1-task partition

- battery stack: 209 μs
- other: 53 μs

2-task partition

- other: 99 μs

4-task partition

- battery stack: 108 μs
- other: 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_Stack [0.001 0]
- Add_Voltage [0.001 0]
- Timer Interrupt

~60 µs

HP xw4600 with Intel Core2 Quad @2.5 GHz

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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

Time in seconds

- 0.173
- 0.173005
- 0.17301
- 0.173015
- 0.17302
- 0.173025
- 0.17303
- 0.173035
- 0.17304

~23 µs
~20 µs
~22 µs
~21 µs

Desktop

- 65 µs
- 43 µs
- 53 µs
- 70 µs

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

HP xw4600 with Intel Core2 Quad @2.5 GHz
## 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%**
- **54%**
- **28%**
- **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