4th OpenModelica Workshop, February 6, 2012
Linköping

Lars Mikelsons

Virtual Commissioning in DCE
A Roadmap
# Bosch – Three Business Sectors

<table>
<thead>
<tr>
<th>Bosch Group overall</th>
<th>€47.3B in sales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>283,500 associates</td>
</tr>
<tr>
<td></td>
<td>34,500 of those associates in research and development</td>
</tr>
</tbody>
</table>

**Automotive Technology**
- 59% share of sales
- World and technological leader as an automotive technology supplier

**Industrial Technology**
- 14% share of sales
- Drive & Control Technology, Packaging Technology, Solar Energy

**Consumer Goods and Building Technology**
- 27% share of sales
- World’s largest power tool manufacturer, leading in household appliances, thermotechnology, and safety engineering

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1 Bosch Rexroth AG (100% Bosch)
2 including other segments
# 2010 - Figures

<table>
<thead>
<tr>
<th>Total revenue:</th>
<th>Total associates:</th>
<th>Total research and development:</th>
<th>Total investments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>€5,063M</td>
<td>34,896</td>
<td>Cost share of revenue: 5.3%</td>
<td>€131M</td>
</tr>
<tr>
<td>Germany:</td>
<td>Germany:</td>
<td>Cost share of revenue: 2.6%</td>
<td></td>
</tr>
<tr>
<td>€1,253M</td>
<td>18,226</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe without Germany:</td>
<td>Europe without Germany:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>€1,623M</td>
<td>8,505</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia / Africa / Australia:</td>
<td>Asia / Africa / Australia:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>€1,358M</td>
<td>5,122</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Americas:</td>
<td>Americas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>€829M</td>
<td>3,043</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Complete: Technologies and Services

Hydraulics  Electric Drives and Controls  Pneumatics  Drive Technology  Linear Motion and Assembly Technology  Service and Training

Linear Motion Technology  Electric Drives and Controls
Industrial Hydraulic Controls  Assembly Technology
Transmission Units  Pneumatics  Industrial Hydraulic Cylinders
Power Units, Manifolds, and Hydraulic Accessories
Mobile Controls  Compact Hydraulics  Pumps and Motors
Large Hydraulic Drives  Mobile Electronics  Wind Turbine Gearboxes
Simulation as a Development-Tool

Motivation

- Verification
- Optimization
- Commissioning
Outline

- Motivation
- Vision
- Starting Point
- Future Work
Vision

Automated Toolchain for Virtual Commissioning

- Modelling in a DCE Application
- Compilation of Modelica to C++ using the OMC
- Compilation of the Model and an RT-Interface to ScaleRT
- Communication with Controller
Pieter Schelte

Application Example

- Pieter Schelte
  - Installation and removal oil platforms
  - 382 m length, 117 m width
  - Installation power 95 MW
  - Topside: weight >10,000 t
  - Ready for operation end 2014

- Topside Lifting System (TLS)
  - TLS divides into:
    - Y-Drive
    - Z-Drive
  - Simulation phases:
    - Active Motion Compensation (AMC)
    - Constant Pushing (CP)
Pieter Schelte

Topside Lifting System

- **Components**
  - Hydraulic unit
    - 3-Chamber active heave compensation cylinder
    - 3-Way valve
    - Tank and pressure source
    - Accumulator
  - Electrical drive
  - Rack-pinion and ideal gears
  - Beam and motor carriage mass
  - Force controller

- **Functions**
  - AMC for sea and parasitic motion
  - Applying a constant pushing force at the leg
Outline

- Motivation
- Vision
- Starting Point
- Future Work
Modelica-Based Modelling Application
Running a Modelica-Model on ScaleRT

C++ Runtime

SimManager - Controls the simulation (Main Loop)
System - Holds the DAE equations
Solver - Encapsulates the numerical time integration method
Settings - Configuration of the solver
Communication with a PLC

Communication via Handshake

MAC-8

B&C Engine

Simulation Cycle Finished Event

Stopped

Simulation Cycle

Controller Step

Actual states

Udp Rx

Udp Tx

Udp

UDP-Ethernet

TCb

TCc

TCd

Running

U0 S0

S0

U1 S1

S1

U2

S2

Step n

Step n+1

Step n+2

Terminal State

Stopped

Running

Stopped

Running

TCc

TCb

TCd

TCa

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Application Example

Modelica Model

- Built in Dymola
- Validated with other models
- Model can be (partly) compiled and simulated with OMC

Problem: Simulation Time
Outline

- Motivation
- Vision
- Starting Point
- Future Work
Modelica-Based Modelling Application
Communication with a PLC

Communication in Real-Time

- Actual states
- Controlled variable
- MAC-8
- UDP-Ethernet
- Profi-BUS
- D&C Engine
- SCALE
Visualization

D&C Engine

OMC

C++ Runtime

DataPool

SimKernel

Subsystem1

Solver A

Subsystem2

Solver B

3D GameEngine
Visualization

Torque3D

- Commercial Game-Engine
- DirectX 10
- WYSIWYP Editor
Application Example

Race against Time

- Model Reduction
  - Equation-Based Reduction Techniques
  - Manual simplification

- Choice of appropriate solution method
  - Real-Time Cycle
  - Multi-rate integration
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