SysML for Modeling Co-Simulation Orchestration over FMI, INTO-CPS Approach

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SOFTEAM R&D
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INTO-CPS
www.into-cps.au.dk

21st International Conference on Reliable Software Technologies
Ada-Europe 2016
SOFTEAM Cadextan / IDENTITY

<table>
<thead>
<tr>
<th>Capital</th>
<th>20 M€</th>
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<tbody>
<tr>
<td>Sales</td>
<td>90 M€</td>
</tr>
<tr>
<td>Staff</td>
<td>930 employees</td>
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- Capital: 20 M€
- Sales: 90 M€
- Staff: 930 employees

- Investment Banking, Asset Management: 50%
- Retail banking: 20%
- Energy, Services: 20%
- Business Consulting: 25%
- Technology Consulting: 10%
- Insurance: 10%

Senior engineers: 650
Architects: 250

.Net, JEE, C++, web, BI
Architects, urbanists, experts, project managers, project directors
Modelio for System Engineering

• UML editor with 25 years’ history
  – SysML, MARTE, BPMN
  – Code generation
  – Documentation
  – Available under open source at Modelio.org
Modelio System Architect Solution

Dedicated to System architects modelling with SysML, UML or BPMN and carrying out Requirements based analysis

- Modelling with UML, SysML and BPMN
- Requirements Modeling
- Tabular editors
- Import/export MS Excel & Word
- Embedded Systems modelling via MARTE
- Traceability Editor
- Impact Analysis
- Document Generation
- Support for Collaborative activities (Constellation, SVN)
- Automatic diagrams creation
- Customisable, interfaces to external tools
Cyber-Physical Challenges

Agricultural Logistics
- Need to model control and planning/re-planning
- Models of locality and mobility
- Real-time behaviour modelling
- Domain-specific reference models

Smarter Building Design
- Models of large-scale, open, diverse data integration
- ... coupled with models of physics
- Need to model learning behaviour
- Possible integration of models of human behaviour
INTO-CPS: a 8 M€ H2020 Project

An integrated “tool chain” for comprehensive Model-Based Design of Cyber-Physical Systems
INTO CPS Objectives

1. Build an open, well-founded tool chain for multidisciplinary model-based design of CPS that covers the full development life cycle of CPS
2. Provide a sound semantic basis for the tool chain
3. Provide practical methods in the form of guidelines and patterns that support the tool chain
4. Demonstrate in an industrial setting the effectiveness of the methods and tools in a variety of application domains.
5. Form an INTO-CPS Association to ensure that project results extend beyond the life of the project
CPS co-modelling

requirements

architecture models

automated co-model analysis
design space exploration

models of cyber elements
shared computing
shared network
models of physical elements
models of cyber elements
stub model generation
co-simulation (MiL)
SiL HiL

environment model
code generation
realisation

real code
laboratory testing
real plant

analysis plug-ins
test automation
model checking
Tools

- Modelio: SysML modelling
- Overture: Discrete-event modelling
- 20-sim: Continuous-time and physical-systems modelling
- OpenModelica: Co-simulation solutions
- Crescendo: Test automation / model checking
- TWT Engine
- RT-Tester
Model-driven Design

• Modern systems are complex
• To cope with this, we can build models beforehand
  – To perform analysis (e.g. static analysis, proof, model checking, \textit{simulation})
  – Clarify our assumptions
  – Evaluate potential designs
  – Avoid expensive prototypes
• Different modelling paradigms for different aspects
The Initial INTO-CPS Vision

Design Space Exploration
Test Automation

Requirements

Feedback

MiL Co-Simulation

Testing

SysML - FMI Model Generation

Heterogeneous Systems Models

HiL / SiL Simulation

Code / Hardware

Strong Traceability
Configuration Management
Requirements Modelling

- **SysML**
  - Use Case diagrams
  - Requirements diagrams
    - Informal (link and traceable)
    - Formal (LTL, Test automation)
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The Functional Mockup Interface (FMI) is a tool-independent standard to support both model exchange and co-simulation of dynamic models using a combination of XML-files and compiled C-code.

The FMI standards currently specify two types of protocols:
- FMI for Model Exchange (import and export), and
- FMI for Co-Simulation (master and slave).

For FMI Model Exchange Import, the subsystem model is exported from a simulation tool in the form of an FMU archive containing the necessary FMU information (model description file, optional C source code, etc.); while in the FMI Model Exchange Export, the subsystem model is imported into the simulation system for system simulation.
System Decomposition

• Block Definition Diagram (top level)
System Interface Modelling

- Internal Block Diagram
  - Divide into CT/DE constituent models/systems/components
  - Define interfaces between different components
System Behaviour

- **Parametric Diagram**
  - Define continuous behaviour of CT components
- **State Machines (DE models generated for tests)**
  - Define discrete behaviour of DE components
INTO-CPS Diagrams and INTO-CPS Blocks
Modelio for INTO-CPS (1/3)
Modelio for INTO-CPS (2/3)
Modelio for INTO-CPS (3/3)
Initial Industrial Follower Group

- AGCO, Denmark
- Alcatel-Lucent, Ireland
- Almende, Netherlands
- Altran, UK
- Bachmann electronic, Netherlands
- Bakker Sliedrecht Electro Industrie, Netherlands
- Carrier, France
- CeTIM, Netherlands
- Chemring TS, UK
- Conpleks Innovation, Denmark
- Dredging International, Belgium
- DSTL, UK
- Goodrich, UK
- Grundfos, Denmark

- GN Resound, Denmark
- HMF, Denmark
- Huisman Equipment, Netherlands
- Irmato Industrial Solutions, Netherlands
- Jaguar Land Rover, UK
- National Institute of Informatics, Japan
- ONERA, France
- Rockwell-Collins, France
- Rolls-Royce, UK
- Seluxit, Denmark
- Siemens, Sweden
- Terma, Denmark
- Thales, France
- UTC Aerospace Systems, UK
- West Consulting, Netherlands
Contacts

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Modelio Web Site:
http://www.modelio.org
http://forge.modelio.org/projects/intocps

INTO-CPS Web Site http://into-cps.au.dk/
@https://twitter.com/IntoCps
https://github.com/into-cps
Thanks!

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www.into-cps.au.dk