FMI for Industrial Programmable Logic Controllers

Rüdiger Kampfmann 07.02.2017

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Outline

- Motivation
- Toolchain
- Application
- Limitations

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Challenges

- Increasing complexity
- Higher requirements on flexibility
- Shorter development times

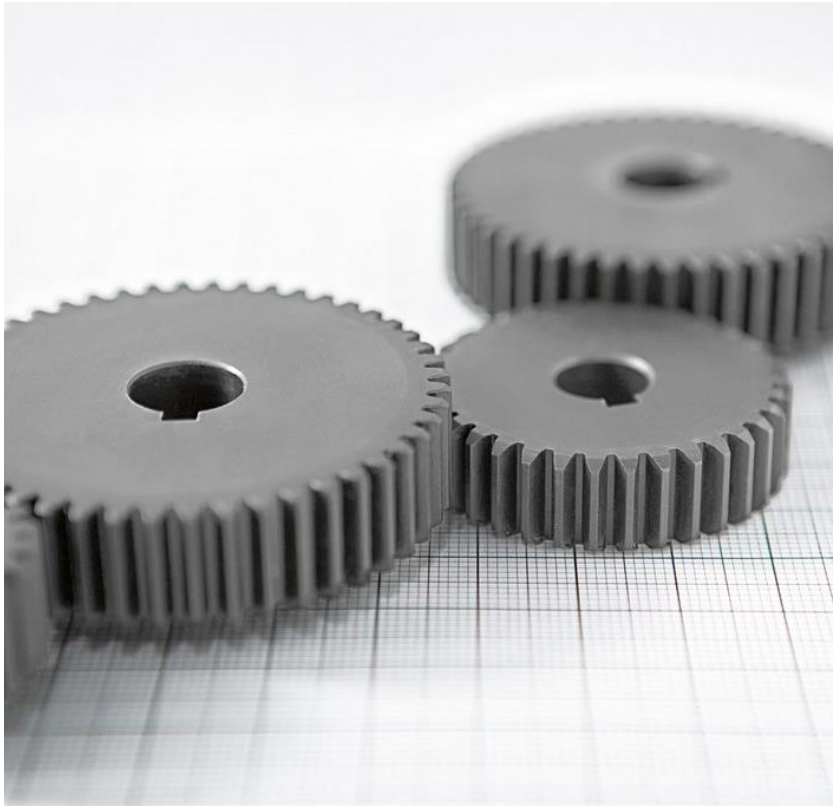
Solution:

Model-based methods e.g.:

- Model-based diagnosis
- Feedforward control using inverse models
- Virtual sensors
- Model predictive control

Benefits

- Reduction of development time
- Significant additional value for customers through new control and diagnosis capabilities
- Improvement in quality



So far…

- Existing toolchains for
  - OpenModelica
  - Matlab/Simulink

- But many customers from various industry sectors with a couple of different tools
- Support all tools?

➢ Unreasonable

Open standard for code generation needed

Sources:
www.openmodelica.org
de.mathworks.com
www.fluidon.com
www.simpack.com
www.maplesoft.com
www.dynasim.se

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Solution

Functional Mock-up Interface:

- Tool independent standard to support Model-Exchange and Co-Simulation
- Also has been foreseen for utilization in embedded systems
- 93 tools supporting this standard

Source: www.fmi-standard.org

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PLC

- **P**rogrammable **L**ogic **C**ontroller
- Real time Operating System VxWorks 6.3/6.9
- Different processors ARM, X86, X64 ...
- Usually programmed in Languages according to IEC61131/3
- With OpenCore Interface also C/C++ possible

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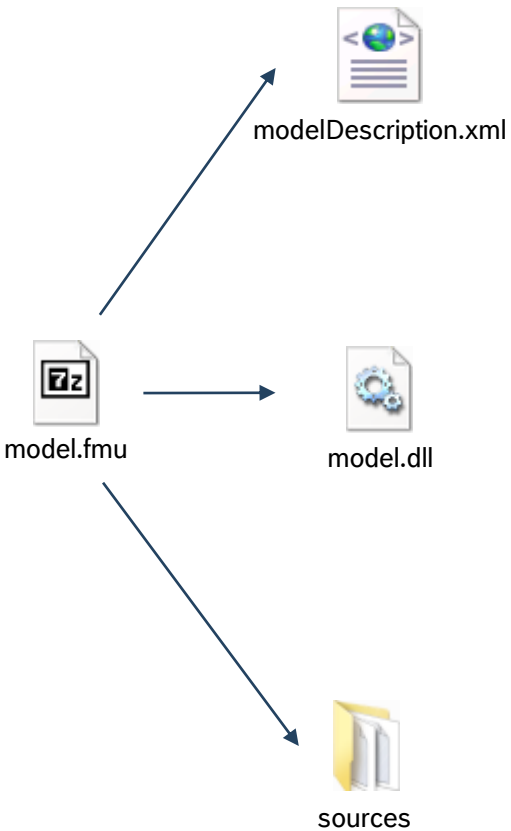
Functional Mock-up Unit



- Description of all variables and parameter used
- also information of source code to be compiled can be provided with FMI2.0

- Not useable since different OS

- Have to be compiled directly

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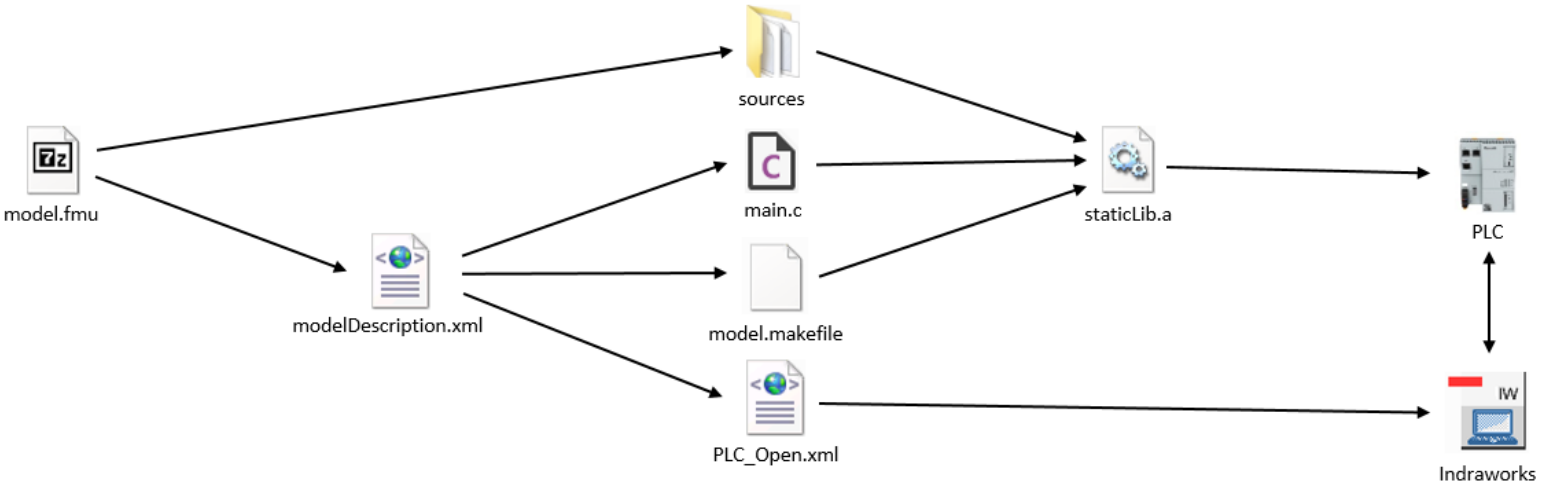
Automatic Toolchain based on FMI



- Automated through python scripts
- Both Model-Exchange and Co-Simulation and FMI 1.0 & 2.0 supported
- Own explicit and linear implicit solvers for Model-Exchange implemented
- Intuitive integration into existing engineering tool

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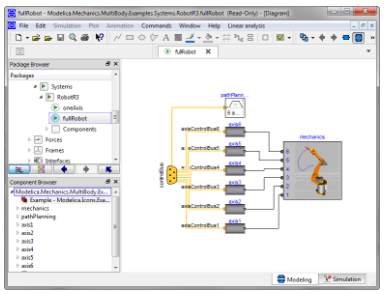
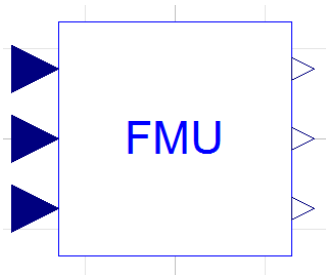
Test procedure using the example of Dymola

Offline test within tool → Test of FMU → HiL Simulation → Real Application





MLPI for Modelica

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Delta Robot

- Parallel kinematic
- Mainly used for Pick and Place Applications
- Many kinematic chains resulting in nonlinear loops
- Mechanic model can be utilized for feedforward control

Source: www.autonox24.de

Delta Robot

- Model exported from Dymola FMI2.0 Model Exchange
- Used cycletime 1 ms
- Indracontrol XM22 equipped with Intel Atom CPU 1.6 GHz
- Required computational time ca. 0.37 ms

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Limitations

Standard of interface is quite good for code generation but tool vendors should face some problems:

- Code quality of generated code
- For some tools manual adaptions required
- Availability of real time capable solvers for Co-simulation
- Only for FMI 2.0 full tool independent automation possible
- No code certification according to functional safety

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