

The INTO-CPS Co-Simulation Orchestration Engine –

Experiences with FMI 2.0 and proposed extensions

Christian König, TWT GmbH, Germany
FMI User meeting / Prague

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INTO-CPS



Linköping University

THE UNIVERSITY of York

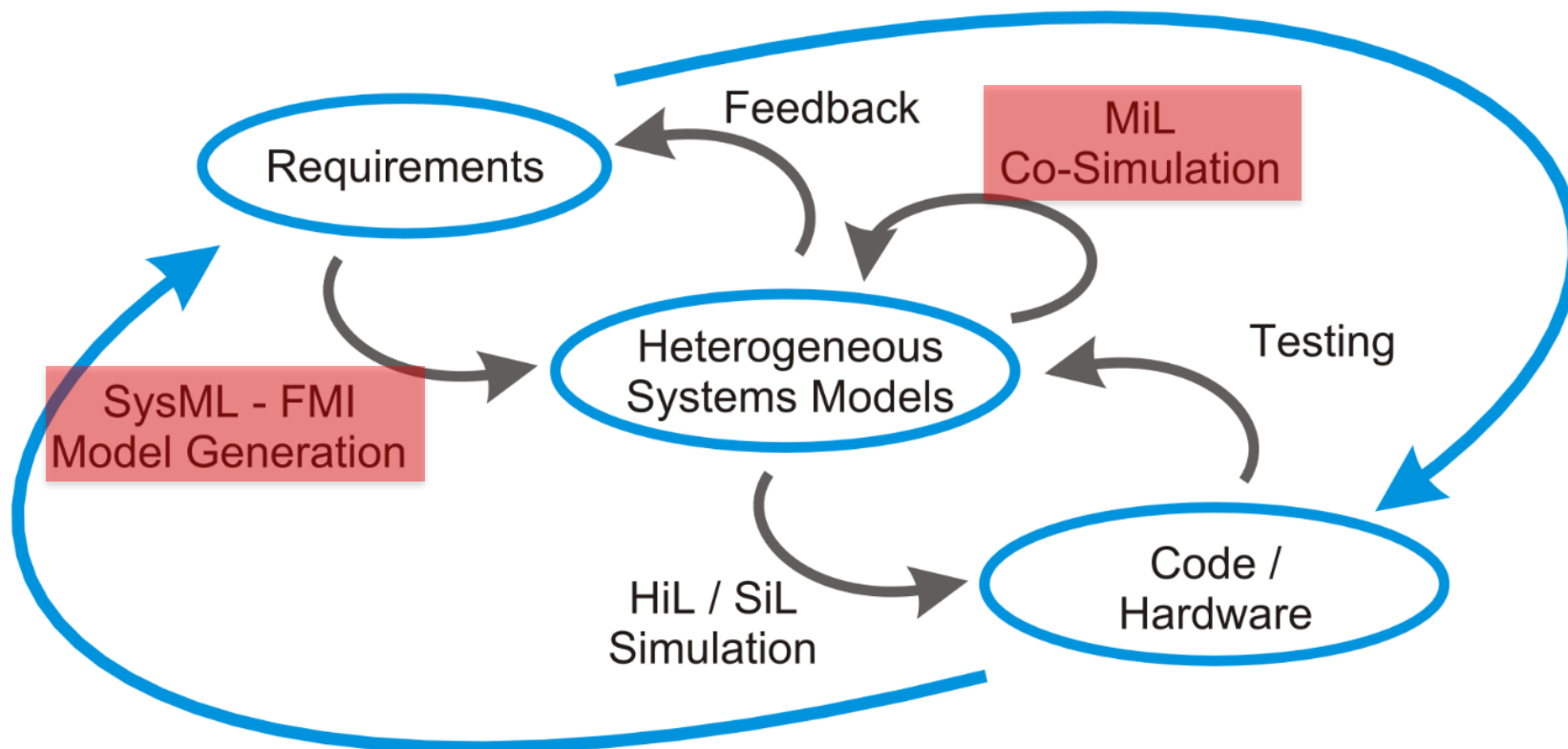




A New Toolchain for CPS Design

FMI related









Design Space Exploration
Test Automation



Strong Traceability
Configuration Management



Co-simulation engine

- Fully FMI 2.0 compliant Master Algorithm
- Support for discrete event (DE) and continuous time (CT) models, using proposed FMI extensions
- Multi-platform, 32/64 bit (Java-based)   
- GUI based on Electron (web-technology)
- Fixed and variable step size algorithms
- FMI 2.0 Import/Export created for Overture, OpenModelica, 20-sim
- Has also been tested with:
 - Dymola 
 - Modelon FMI Toolbox for MATLAB/Simulink 
 - 4DIAC 
 - SimulationX 
 - Unity  Powered by ITI



Performance

- getMaxStepSize() Proposed by D. Broman et al (*Determinate composition of FMUs for Co-Simulation, 2013*)
 - Required to improve simulation speed for FMUs that don't support roll-back (set previous step by `fmi2GetFMUstate` / `fmi2SetFMUstate`)
 - Tools that implement rollback: Dymola, 20-sim
 - getMaxStepSize(): Overture
- pointer references were found to improve performance instead of get/set
 - any other experience?



Parallelization

- Parallelization (here using Scala) showed varying performance enhancement:
 - Parallel execution of `getFMUxxx / setFMUxxx / doStep`
 - Initial results show at 15 - 30% performance increase for a standard Co-simulation model
 - thread synchronization costs time
 - Performance depends strongly on models → logic needed to sort execution of FMUs for optimal performance
- Distributed Co-Simulation
 - Allows using mixed 32/64-bit FMUs



Cross check / build

- Only single FMU simulations are checked, no Co-Simulation
- Suggestion: at least two FMUs should be checked for FMI-CoSimulation
 - All FMUs from same tool / vendor
 - Different tools / vendors
- Compilation information is missing for source FMUs
- INTO-CPS has created a cross-compilation service for all target architectures (Mac, Linux, Windows)
 - <https://sweng.au.dk/fmubuilder/>



Additional resources of interest

- Some FMUs generate additional analytical data
 - Internal timed state transitions, can be used for model checking
 - Tools from Verified Systems generate information on model validity
- Standardized description of internal FMU behaviour is desirable for post-analysis



Discrete systems

- Network protocols can be simulated by combination of strings and booleans
- However, scalability is poor, delays are caused
- **Ether model:** https://github.com/into-cps/case-study_ether
- Guidelines for modelling of discrete systems would be very helpful
- Composite types (e.g. lists) would be desirable for discrete systems, such as controllers



Deliverables and Outreach

- FMI related Deliverables available on website

<http://into-cps.au.dk>

- D4.1d – Design of the INTO-CPS platform
 - D4.2a – User manual
 - D4.2b – Integration of simulators
 - D4.2c – SysML Contracts
 - D2.1d & D2.2d – Foundations for FMI Co-Modelling
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- Industry & Academic Follower Group to be involved with project progress

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