The INTO-CPS Co-Simulation Orchestration Engine –

Experiences with FMI 2.0 and proposed extensions

Christian König, TWT GmbH, Germany

FMI User meeting / Prague

15/05/2017

INTO-CPS

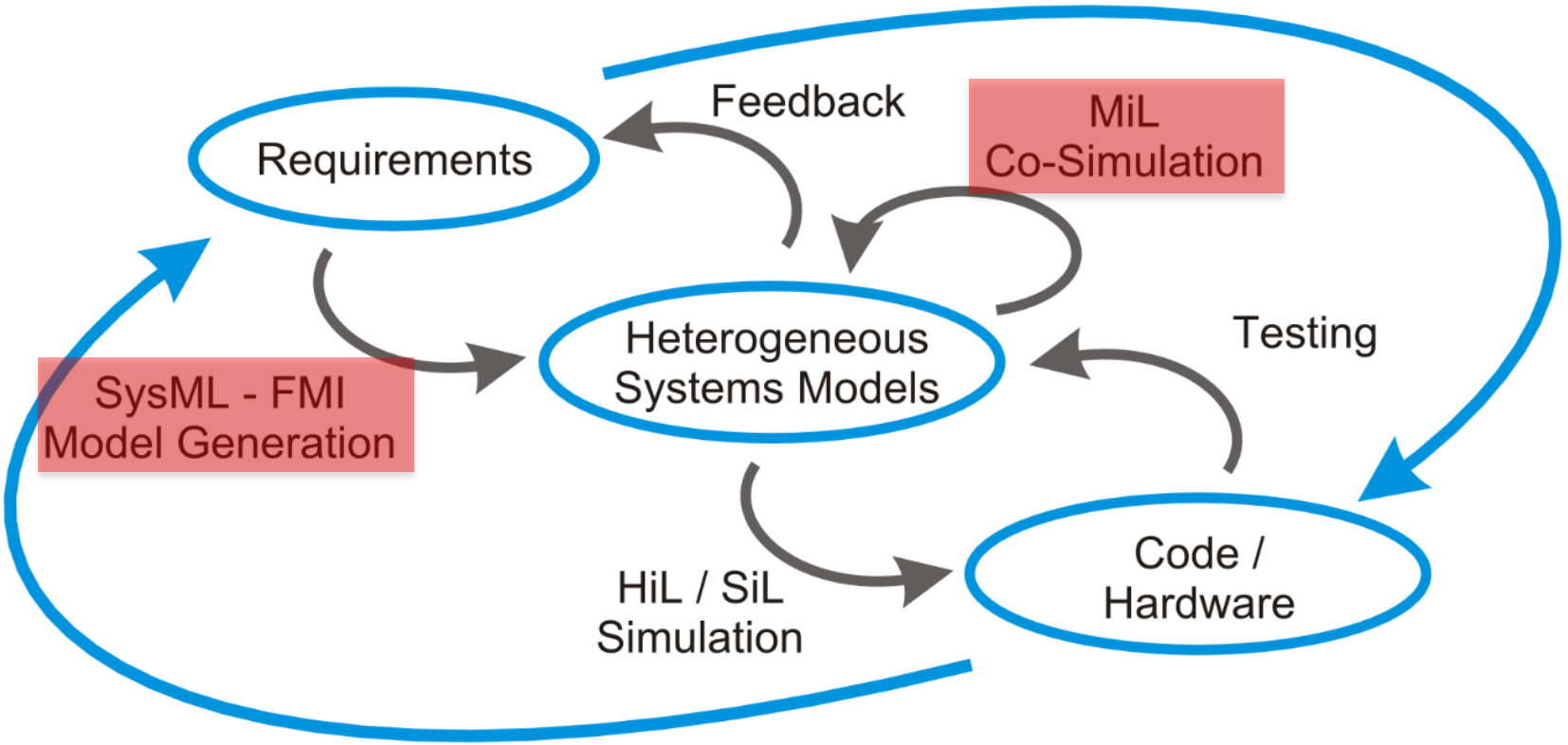
A New Toolchain for CPS Design

INTO-CPS

FMI related

Design Space Exploration

Test Automation



Strong Traceability
Configuration Management

Horizon 2020
Programme

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

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 ressources 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 plattform
  - D4.2a – User manual
  - D4.2b – Integration of simulators
  - D4.2c – SysML Contracts
  - D2.1d & D2.2d – Foundations for FMI Co-Modelling

- Industry & Academic Follower Group to be involved with project progress

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