Co-simulation of Cyber-Physical Systems using HLA

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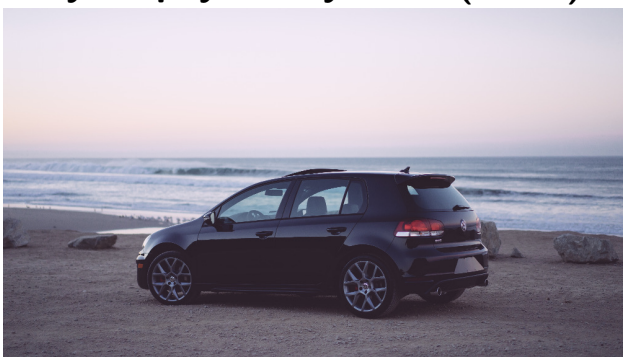
Introduction

Cyber-physical systems (CPSs)



CPS development

- Development of CPSs is a multi-disciplinary process
  - Mechanics, electronics, software, ...

Introduction

Long-term goal

Develop a model-based methodology to improve the multi-disciplinary development process of CPSs.

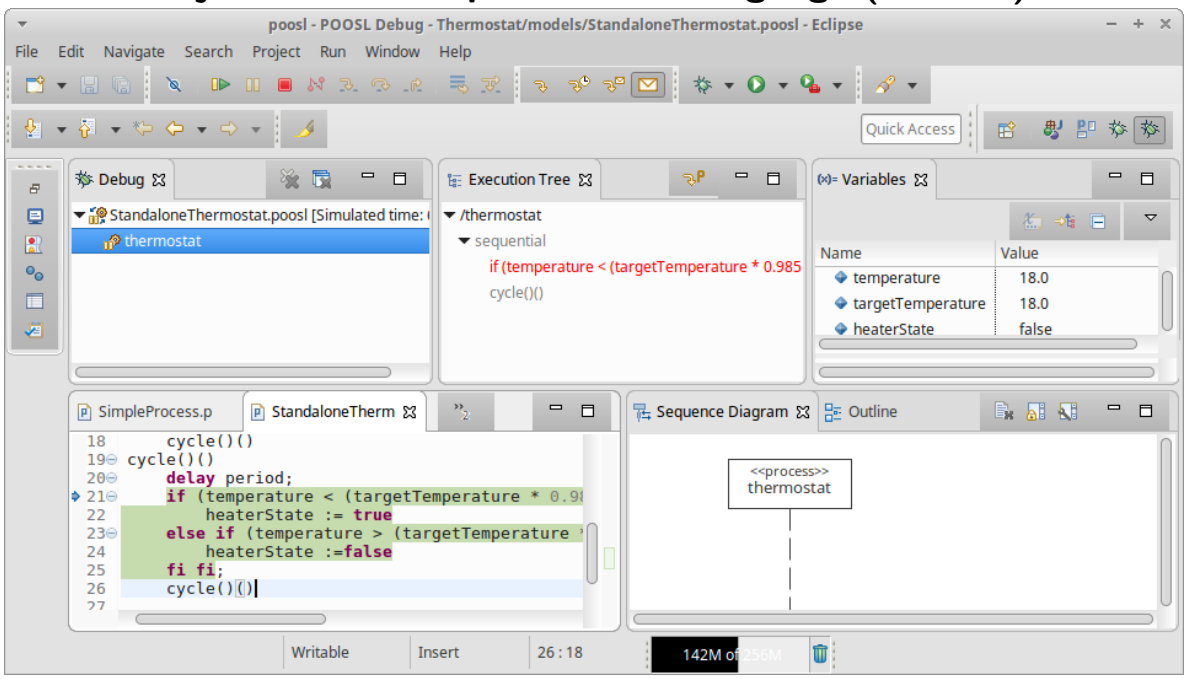
- Virtual prototyping using models of both hardware and software
  - Current models often implicitly contain software components
  - Clear separation of software and hardware layers
- Implementing software alongside the design of the hardware
  - Modular co-simulation

Current goals

- The use of existing standards for our co-simulation
- Separation of software models

Software modelling

Parallel Object-Oriented Specification Language (POOSL)



Connecting models using HLA

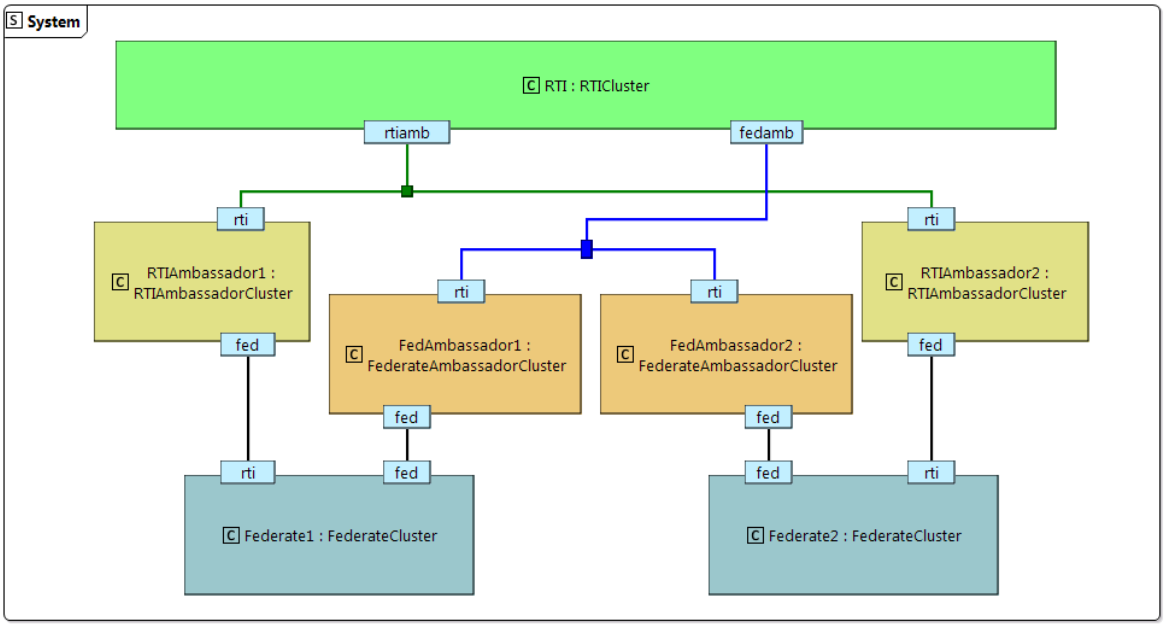
Constructing a co-simulation

- Different types of models to be co-simulated
  - Discrete-time models of software
  - Continuous-time models of hardware
- What should be synchronised across simulations?
  - Time, attributes, interactions, . . .

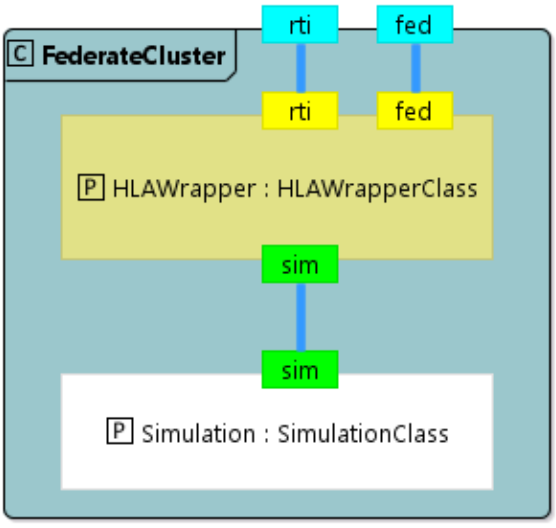
High-Level Architecture (HLA)

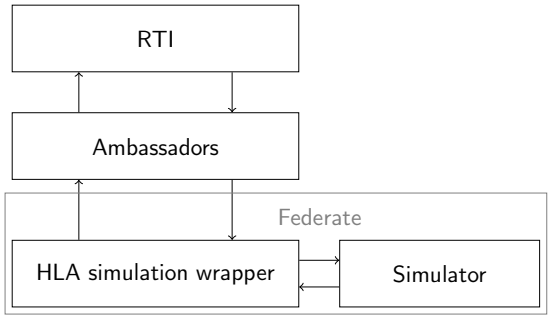
- Standardised (IEEE Standard 1516) interface
  - Public and commercial implementations
  - Various modelling and simulation tools
- Connecting simulations from different tools
- Highly configurable
- Distributed co-simulation

Connecting models using HLA



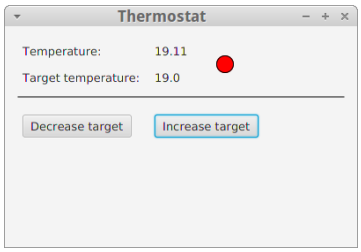
Connecting models using HLA

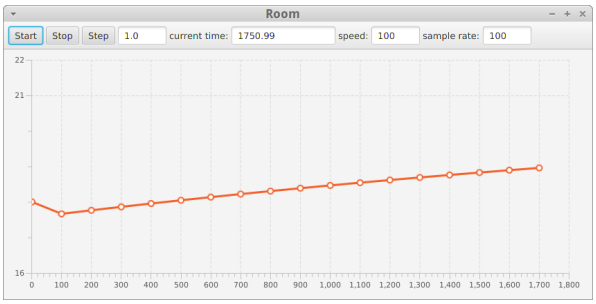




Example: RoomThermostat

- Proof of concept
- Open-source RTI: PoRTIco
- Room environment model
  - Continuous time
  - Created in OpenModelica
  - Exported to FMU
- Thermostat controller model
  - Discrete time model
  - Created with POOSL
  - Simulated by Rotalumis
- Two graphical user interfaces
  - Time control
  - User input

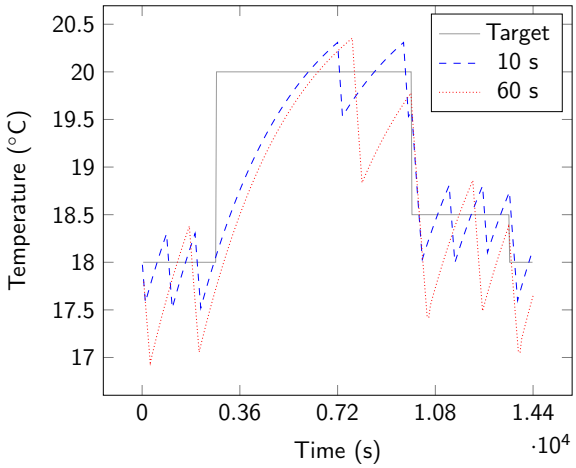


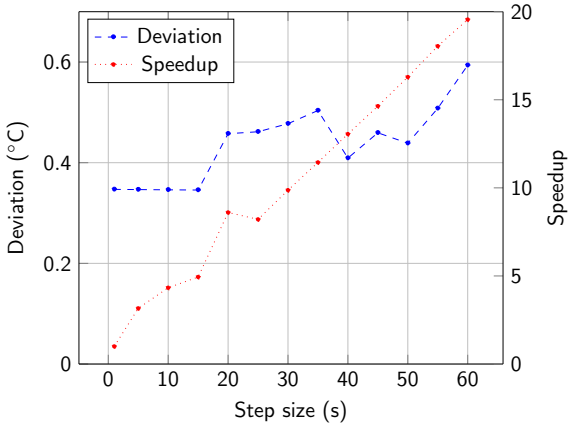


Example: RoomThermostat

Observations

- How does step size of the continuous model affect the simulation?
  - Accuracy
  - Performance





Conclusion

Findings

- FMI supported by many different tools
- HLA standard is very useful for modular setups
- Co-simulation to be used as virtual prototype
  - Allows analysis on system modifications or extensions
    - Alternative exploration
  - Allows testing without hardware
    - Fault injection

Future work

- Apply the approach to an industrial application
- Investigate scalability of the method
- Experiment with distributed simulations
- Code generation from a Domain Specific Language

Questions

Thank you for you attention! Are there any questions?