virtual vehicle

Accelerating Innovation

Architectural Patterns for Co-Simulation

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MODPROD Workshop 2021

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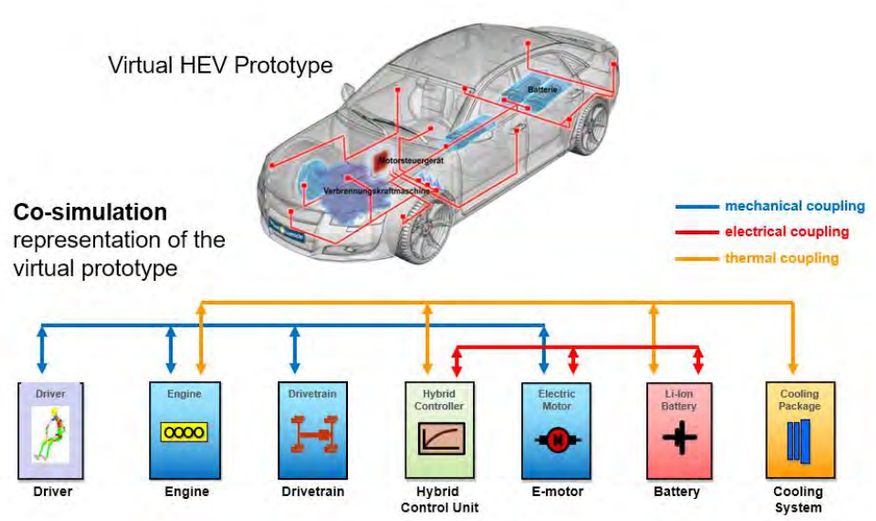
Introduction

MODPROD Theme: “Digital engineering for a resource efficient and circular industry”

- How does industrial simulation relate to that?

Co-Simulation: Standardization efforts

- Distributed simulation: DIS, HLA
- Co-simulation: FMI



Especially FMI contributed to interoperability

- Standardized by Modelica Association from 2011
- www.fmi-standard.org

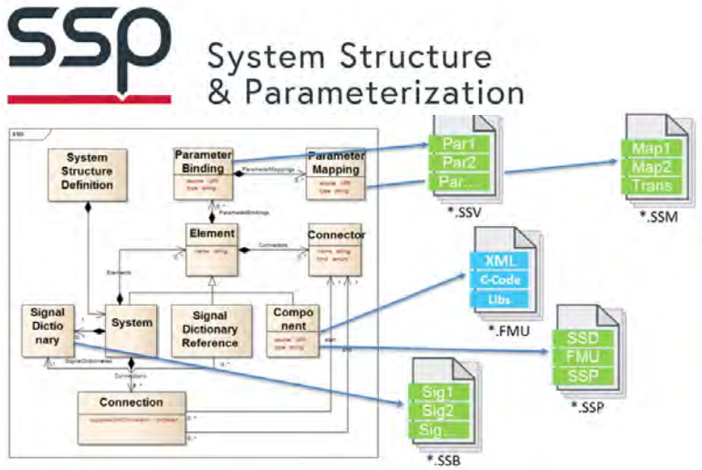
To use FMI, a master-algorithm is needed

- Performs structural integration of FMUs
- Governs data exchange and coupling
- May operate a solver (FMI-ME), or trigger calculation (FMI-CS)

Complementary Standards to FMI

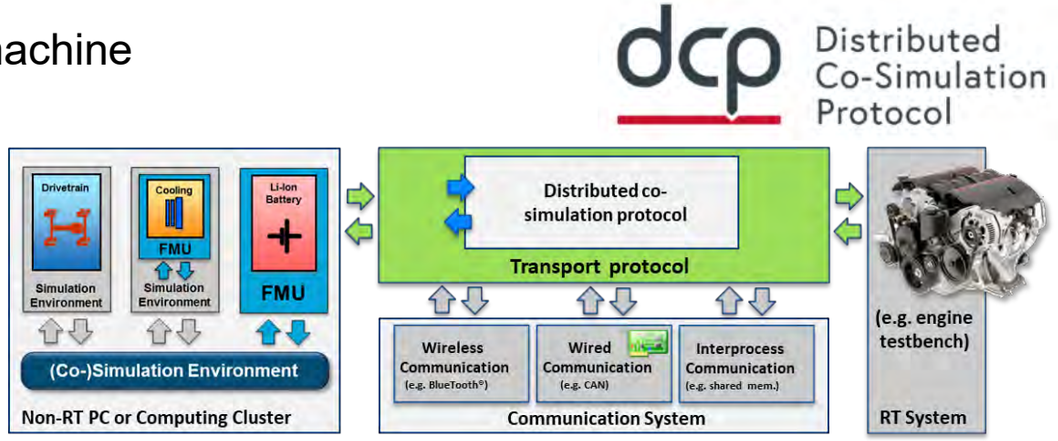
System Structure and Parameterization (SSP)

- XML based data format
- Describes integration of FMUs
- www.ssp-standard.org, maintained by working group of Modelica Association, version 1.0 released in 2019



Distributed Co-Simulation Protocol (DCP)

- Application level communication protocol for distributed co-simulation
- Defines data model, protocol data units (PDUs), and state machine
- FMI-compatible by design, but not dependent
- www.dcp-standard.org, version 1.0 released in 2019



Now, what do we have overall?

- Standardized containers and descriptive files…

Co-Simulation Architecture

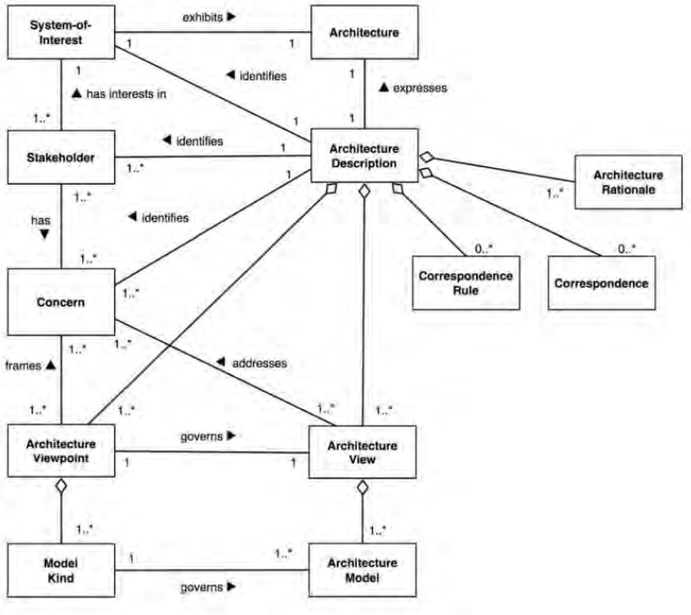
Let‘s talk about „co-simulation architecture“

- Architecture expresses a number of *concerns*, and allows for different *views*
- Consider a setup for simulation and test as a „system-of-interest“

Example properties

- Software – Hardware
- Local – Remote
- Real-time – non-real-time
- Variable time step – Non-variable time step
- …

ISO 42010-2011: Systems and Software Engineering – Architecture Description:

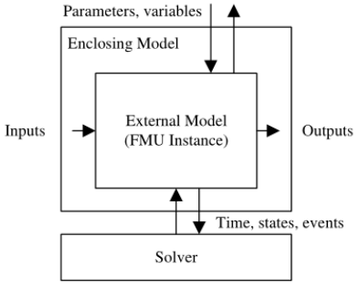


Questions:

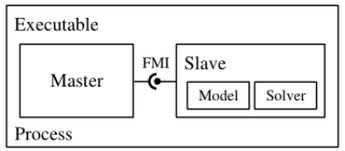
- How can the FMI/SSP/DCP standards be **combined** in terms of architecture?
- Can we find **patterns**, that can be re-used for recurring applications?

Architectural Primitives

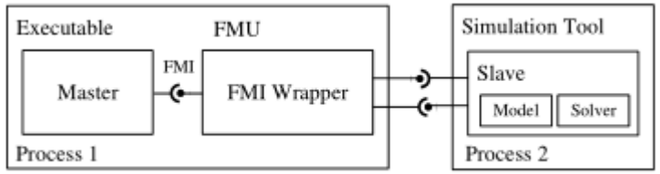
What are architectural primitives?



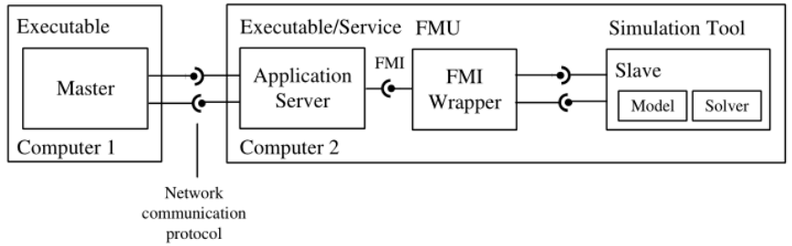
P1: FMI for ME



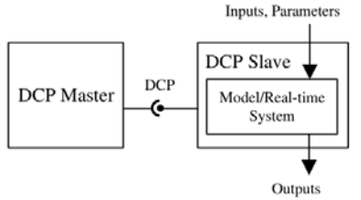
P2: FMI for CS



P3: FMI for tool coupling



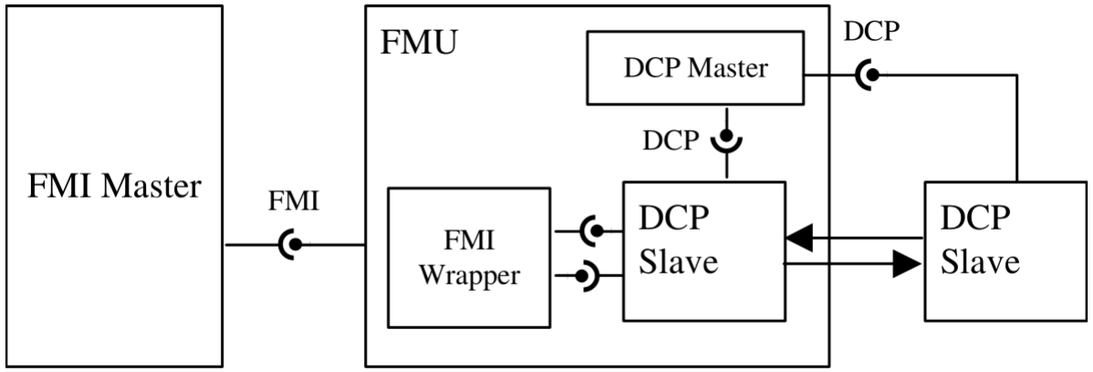
P4: FMI for distributed co-simulation



P5: DCP slave integration

Example Pattern

- Constructed from primitives 2 and 5



Sustainable engineering?

- ✓ Open access/open source standards
- ✓ Well-defined interfaces of components ensure re-use across use cases
- ✓ Patterns exploit multiple standards for recurring applications

THANK YOU

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