Modelling Network Connections in FMI with an Explicit Network Model

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This document does not contain any export controlled technical data.

Outline

Introduction

Comms Modelling Challenges

Ether Pattern

Case Study

Conclusions

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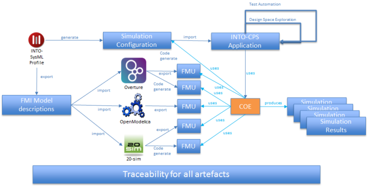
Introduction

- CPS design is challenging
- Multiple stakeholders, disciplines, notations…
- FMI can help couple tools
- Some challenges remain (ex: comms)



Introduction

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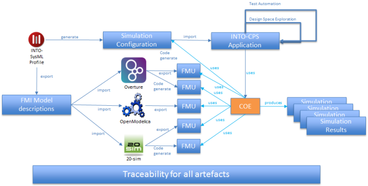
- Multiple stakeholders, disciplines, notations…
- FMI can help couple tools
- Some challenges remain (ex: comms)



~~Extensions~~

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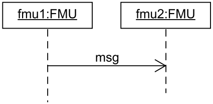
Communications Modelling

Fundamental Challenges



- inter-FMI comms
- Models exported as whole
- Native comms reasoning hidden
- Have to work at FMI level

- No events or message passing
- All signal exchanges continuous
- Can work around but it’s hacky
- Time issues

Communications Modelling

Practical Challenges

Embedding Explicit Comms in FMUs

- Model pollution
- Difficult to see complete picture
- 1:1 FMU data exchange. . . too many connections

Communication Messages Representation

- Only primitive types (bools, strings reals)
- No structured types ☹
  - Multi-ports is too many ports
  - String encoding adds overhead

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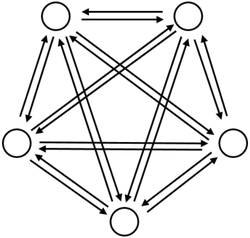
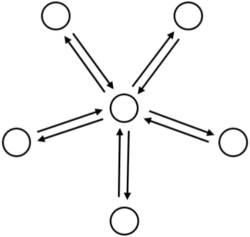
Network Topology in FMI



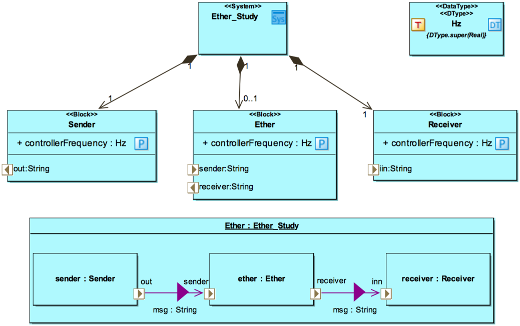


- Direct connection
- Unwieldy
- Inflexible

- Ether pattern
- Communications medium
- Flexible

Ether Pattern

Network Topology in FMI



- Producer/consumer example: one output, one input
- Ether sits between and passes messages
- Requires additional ports for new FMUs

Ether Pattern

Network Topology in FMI

Sender Generates messages, encodes to strings using `VDMUtil`, sets its output.

Receiver Receives messages, decodes using `VDMUtil`.

Ether Each input / output port assigned unique identifer as a **`map`** `Id` **`to`** `StringPort`. Mapping from input to output: **`set of`** `(Id * Id)`. Gathers messages from each input and passes them to outputs.

- Not currently considered: sender identification, confirmation of delivery, maximum transmission unit, message timing

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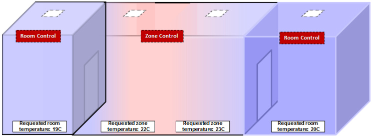
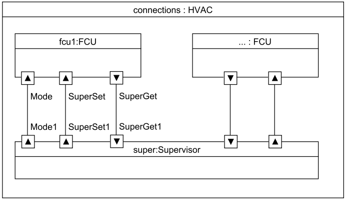
Building HVAC


Room Control
Zone Control
Room Control
Requested room temperature: 19C
Requested zone temperature: 22C
Requested zone temperature: 23C
Requested room temperature: 20C



- 4 Fan Coil Units (FCUs) in rooms and zones
- Networked FCU Controllers
- Supervision

- 4x Simulink FCU Controller FMU
- 1x VDM Supervisor FMU
- Multi-port approach

Case Study

System Class Snippet

```
system System
instance variables
public static super : [Supervisor] := nil;
public static sr1 : [FCU] := nil;
-- ...
operations
public System : () ==> System
System () == (
sr1 := new FCU(1);
sr1.primeFmi(hwi.sr1_spIn,hwi.sr1_spOut,
  hwi.sr1_mode);
cpu1.deploy(sr1,"FCU_SR1");
-- ...
super := new Supervisor({sr1,sr2,z1,z2});
cpu5.deploy(super,"Supervisor");
);
end System
```

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- *As it currently stands*, FMI is limited for CPS (DE comms)
- Ether helped structure the multi-model and study networked controllers for the industrial case study
- The best workaround is still a workaround
- FMI extension can help but broad support is key
- Adding real value will drive adoption