CYBER-PHYSICAL SYSTEMS AND CO-SIMULATION

AARHUS
UNIVERSITY
DEPARTMENT OF ENGINEERING

FORMALISE
2 JUNE 2018

CASPER THULE
PHD STUDENT

AGENDA

Cyber-Physical Systems

Co-Simulation

INTO-CPS

Tool Development

Future Work

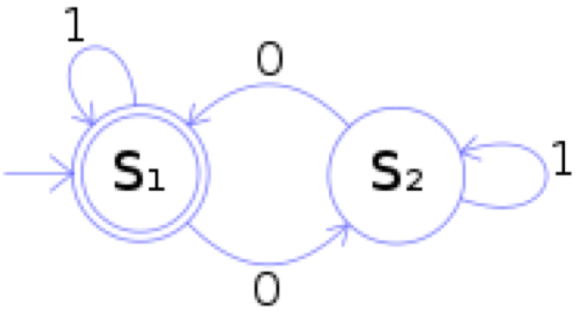
ME – CASPER THULE

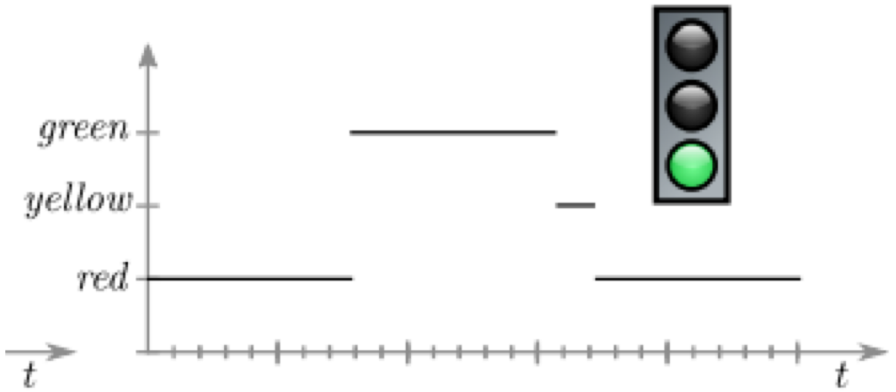
MSc. in Computer Technology at Aarhus University in 2016

PhD Student at Aarhus University Department of Engineering

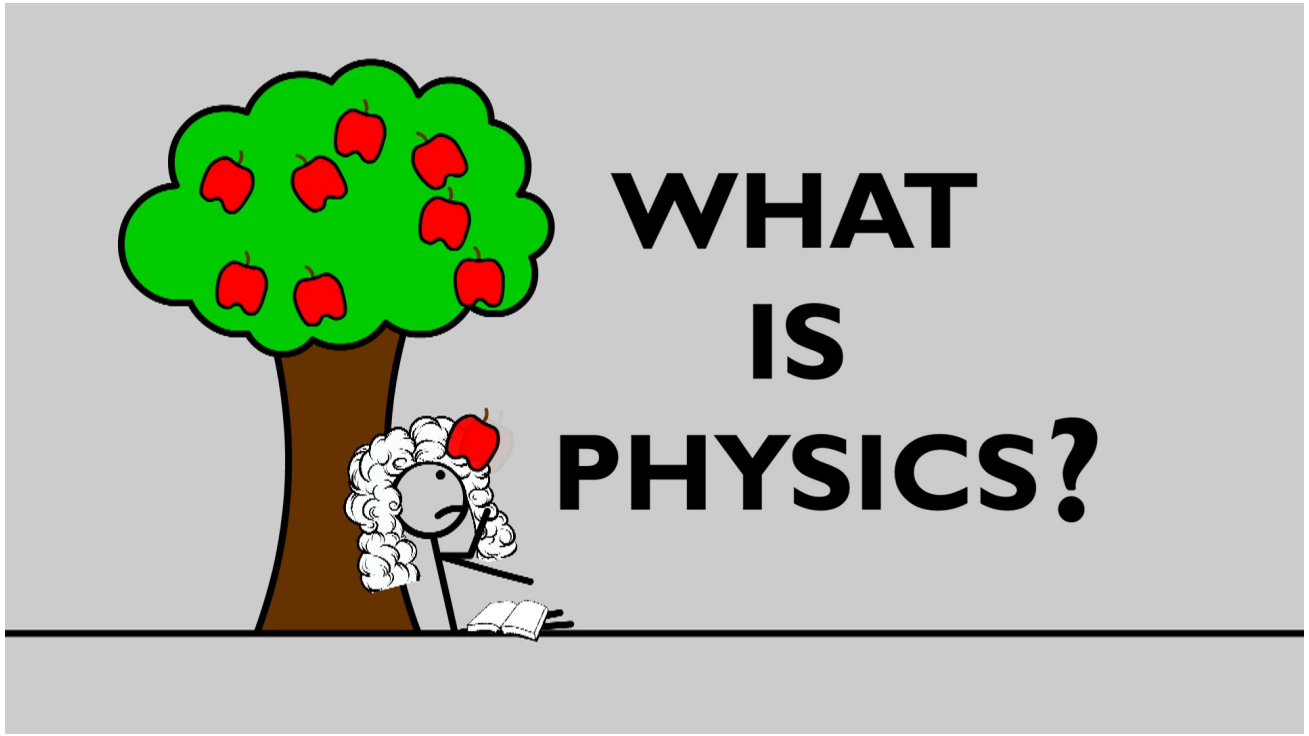
Software Engineering Research Group led by Professor Peter Gorm Larsen

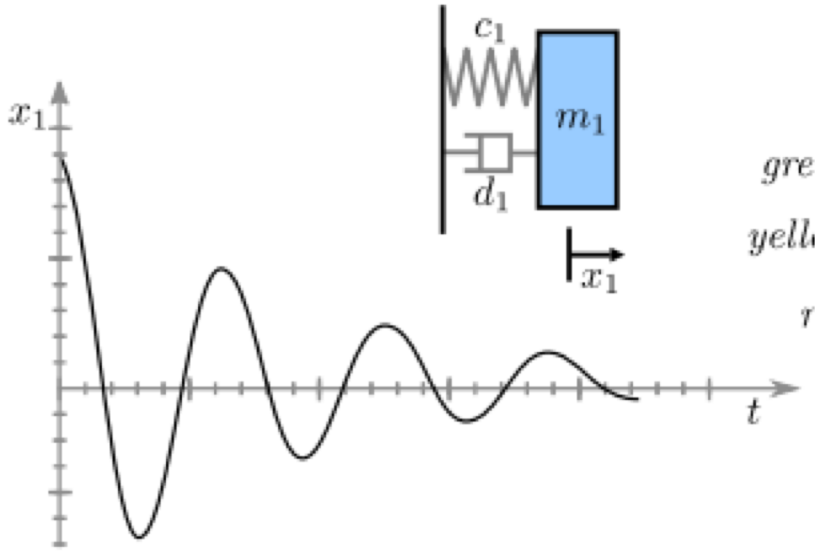
THE WORLD USED TO BE SIMPLE



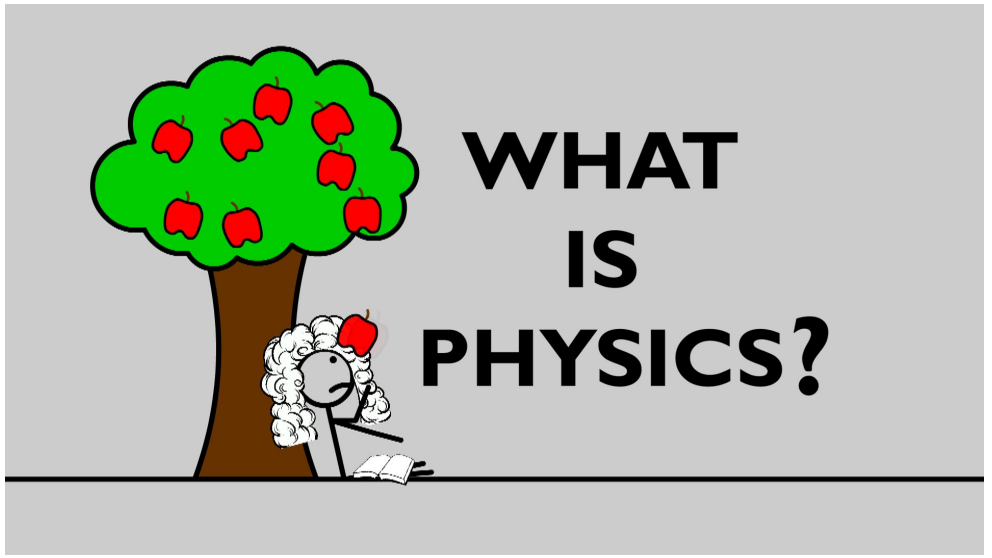


PHYSICS CREEPING IN



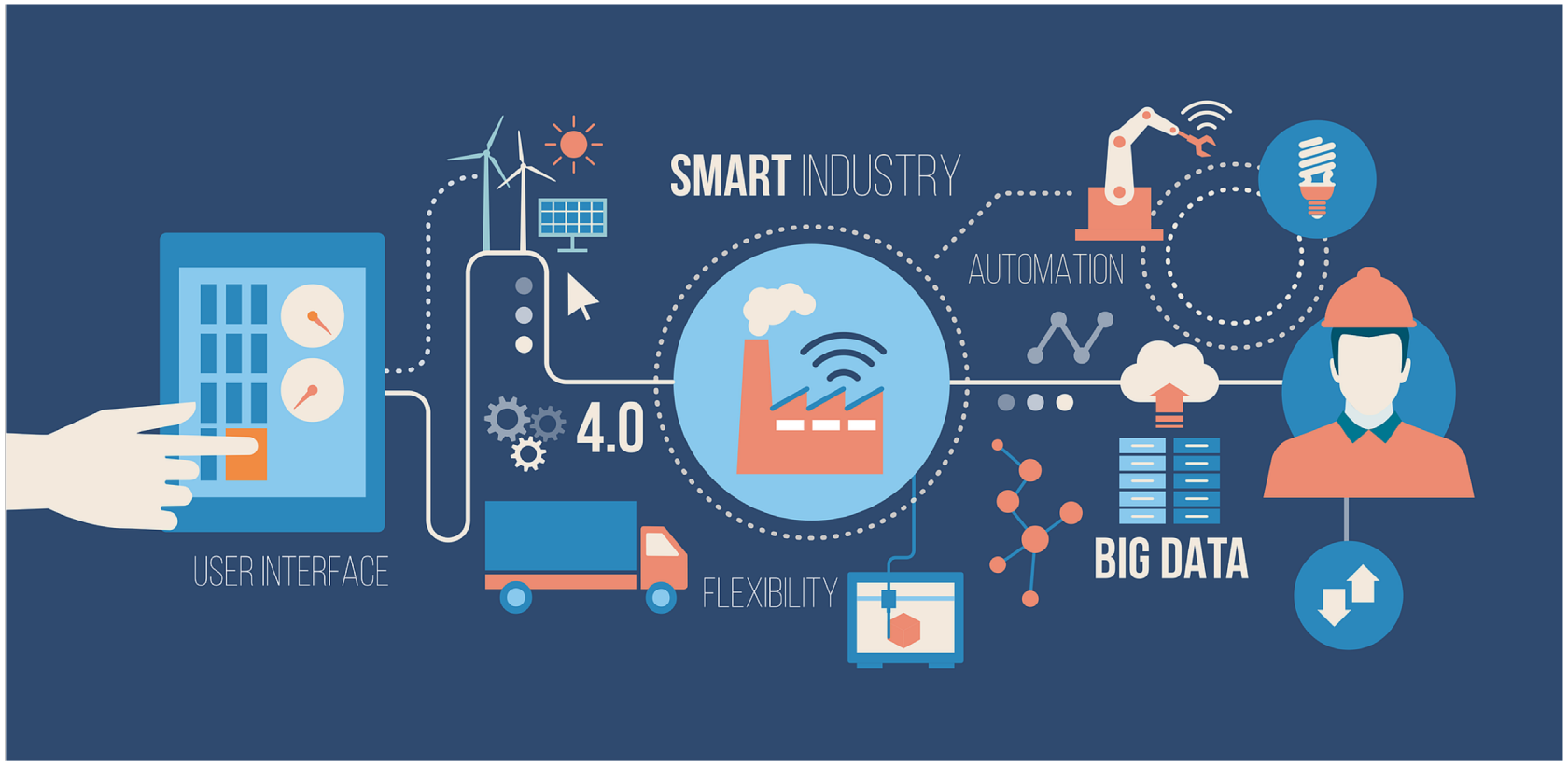


CYBER-PHYSICAL SYSTEMS (CPS)



CYBER-PHYSICAL SYSTEMS – THEY ARE COOL!

Cyber components controlling physical entities



DIFFICULT

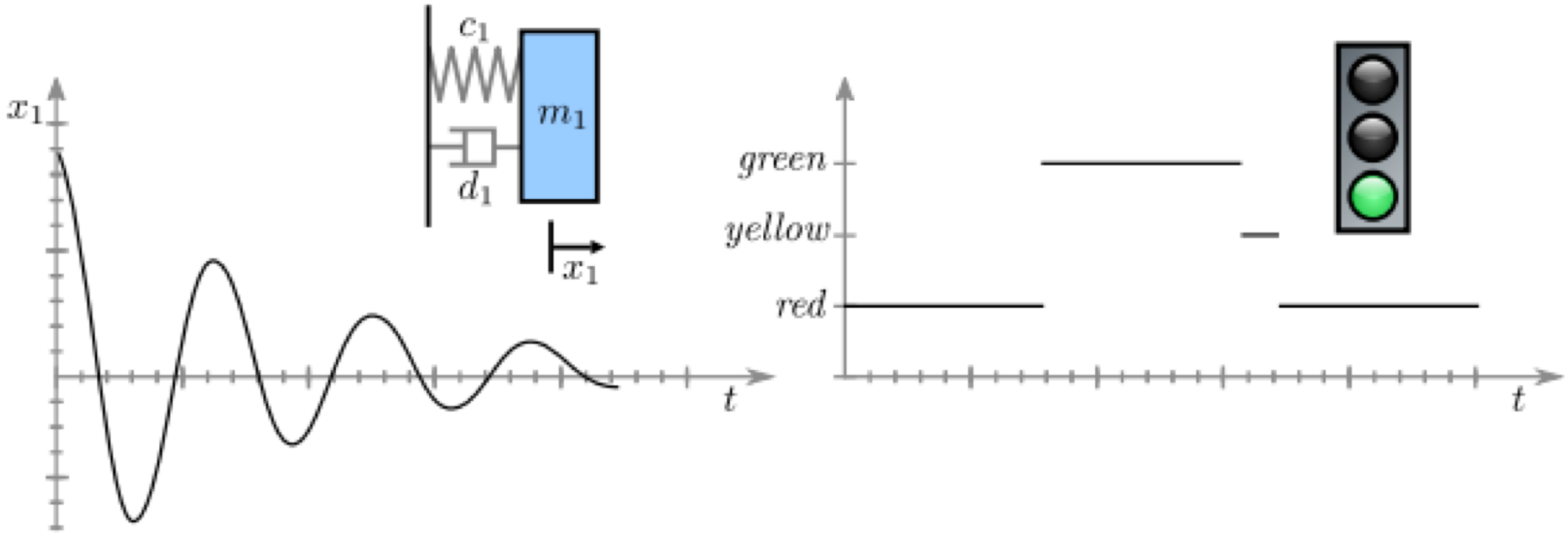
Increasing Complexity

Market Pressure

Different Teams – Different Tools

COLLABORATIVE SIMULATION

Hybrid Co-Simulation



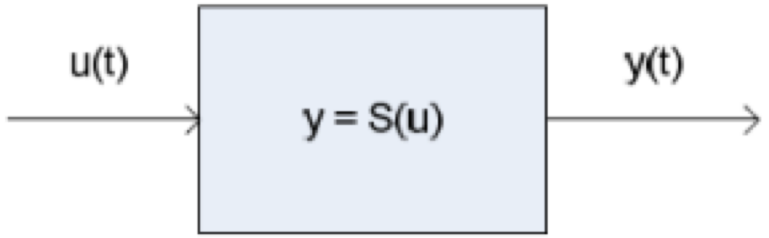
Theory and Techniques for Global Simulation of a Coupled System via Composition of simulators

SIMULATOR

A simulator is a black box mock-up of a constituent system.

Developed and provided by the team responsible for that system.

Need to couple simulators



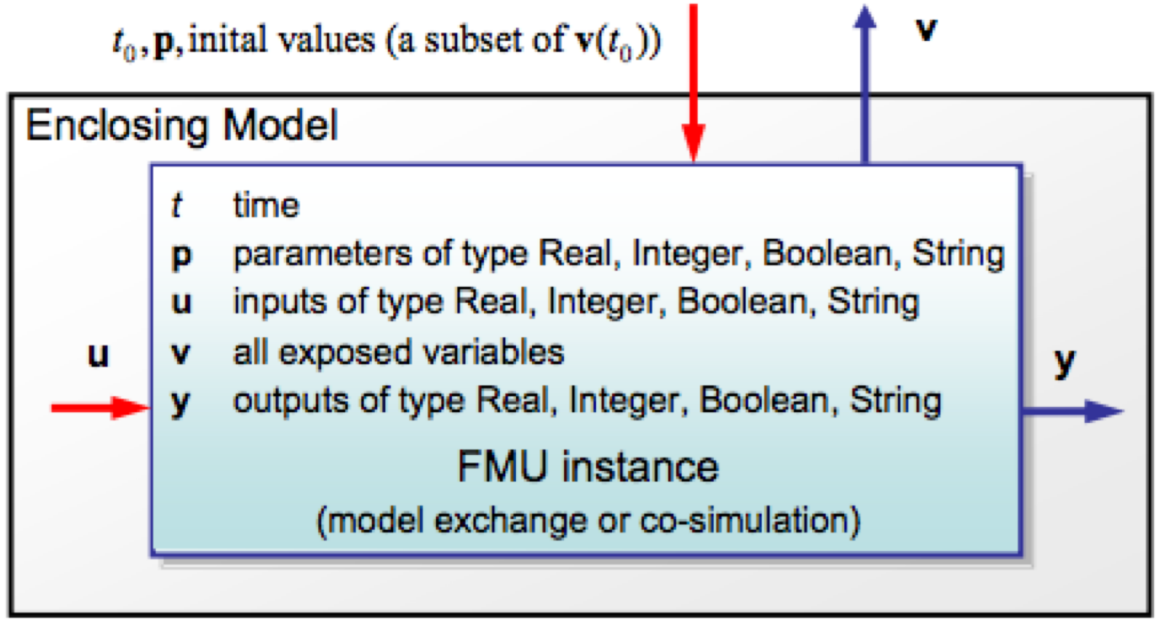
STANDARD – FMI 2.0

Set of C interfaces
- Set Inputs / Get Outputs
- Do Step – Progress in time
- Set State / Get State
- Extension: getMaxStepSize

STANDARD – FMI 2.0

Functional Mock-up Unit

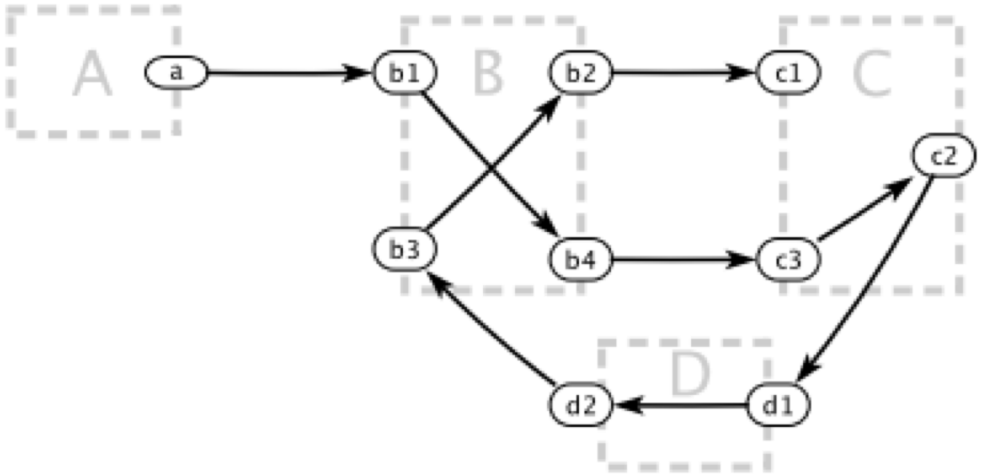
Tool-Wrapper, Web Service, HiL, SiL



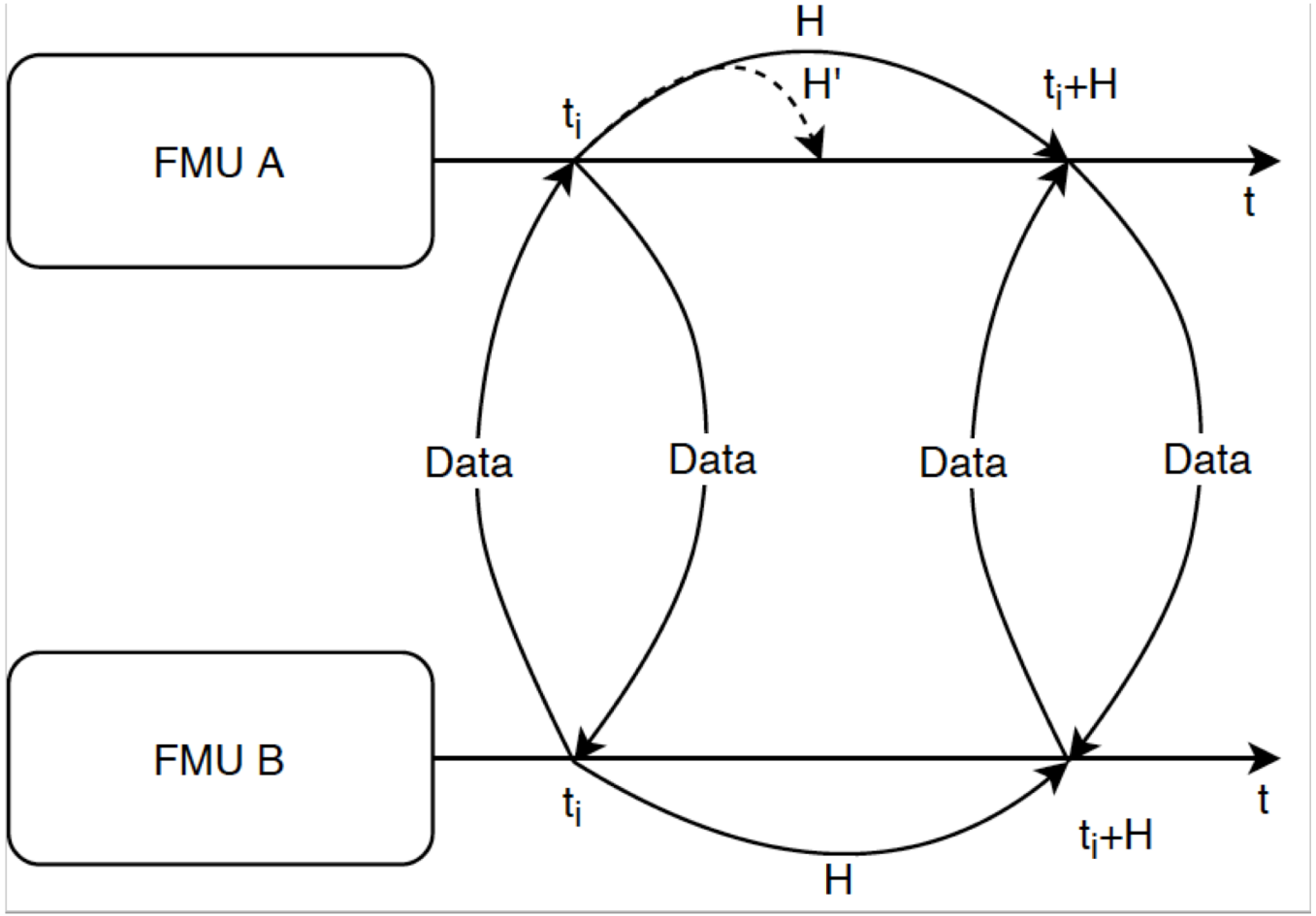
CONNECTING SIMULATORS

Calculate dependencies

Topological sort

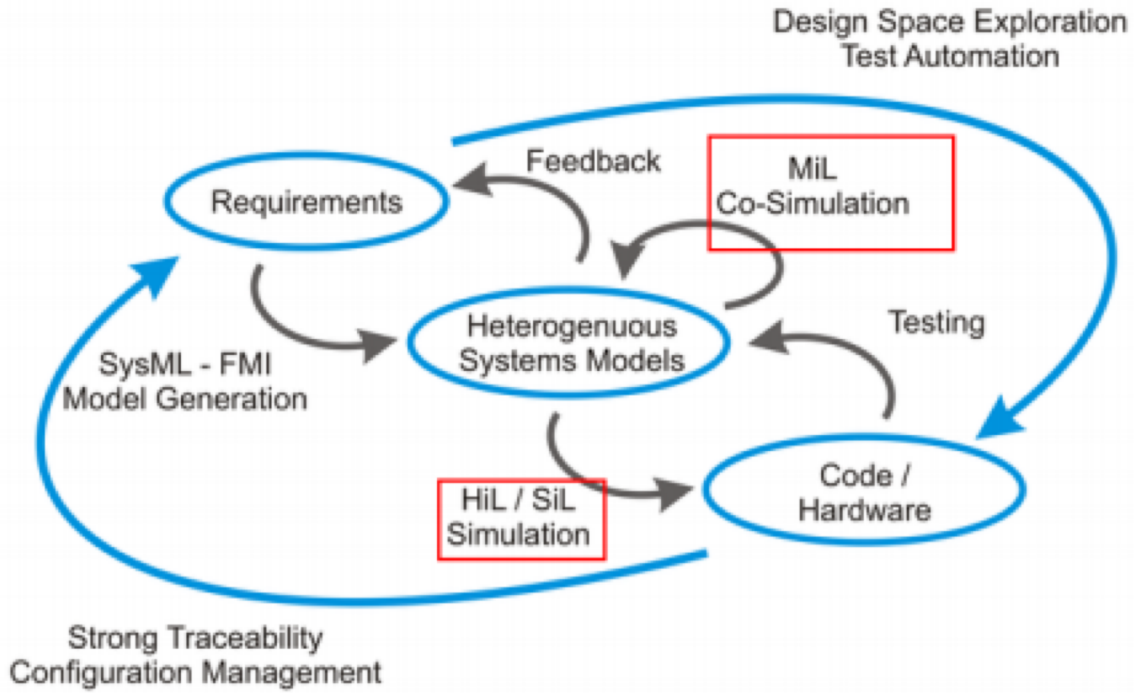


JACOBIAN ITERATION



INTO-CPS

Integrated Toolchain for Model-based Design of Cyber-Physical Systems



MAESTRO – CO-SIMULATION USING FMI

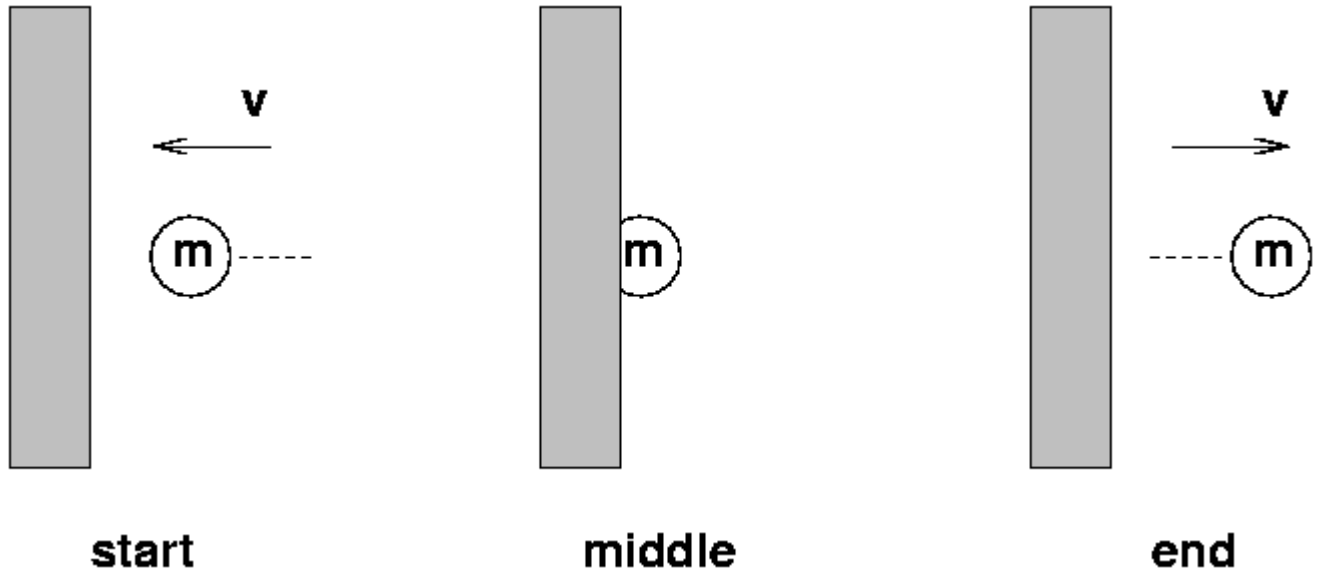
Distributed co-simulation across platforms and architectures

MAN Diesel & Turbo (~80% of two-stroke maritime engines)

Step size constraints:

Zero Crossing

And others



INTO-CPS APPLICATION

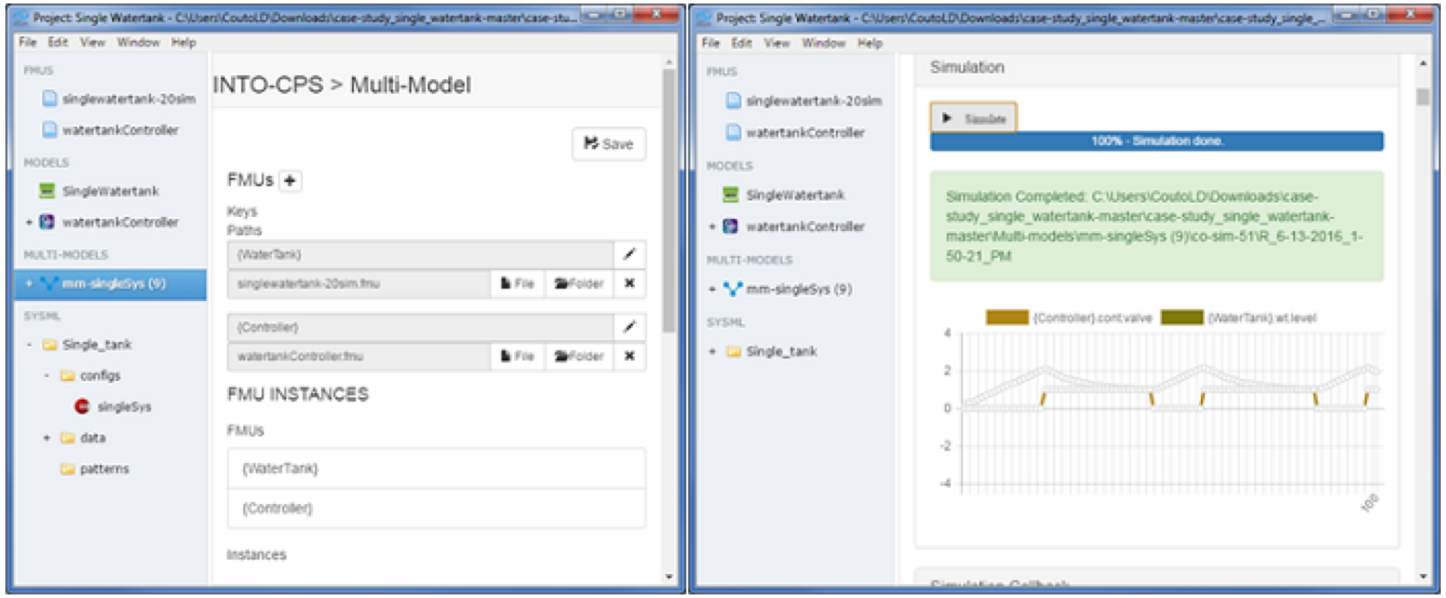
Frontend of INTO-CPS

Cross-Platform

Co-Simulation

Design Space Exploration

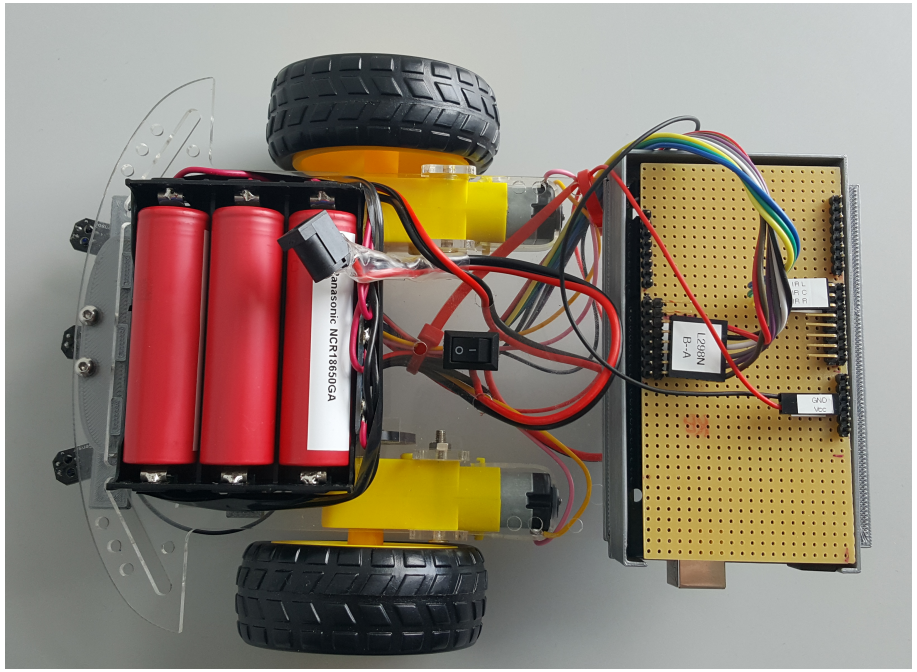
LTL Testing



VDM-RT + OVERTURE FMU

Dialect of VDM to model and analyze Real-Time embedded and distributed systems

Tool-Wrapper and Source Code FMU




```
cpu1 : CPU := new CPU(<FP>, 200);

controller := new Controller(levelSensor, valveActuator);

cpu1.deploy(controller,"Controller");

loop()==
   cycles(2)
   let level : real = levelSensor.getLevel() in ...

thread
periodic(10E6,0,0,0)(loop);
```

FUTURE WORK

Additional Iteration Methods (Gauss-Seidel and Strong coupling)

ESA simulation framework (SMP2)

FMI 2.1

Properties of Master Algorithms

Semantic Adaptation of FMUs

THANK YOU

Crash course on:

- Cyber-Physical Systems
- Co-Simulation
- FMI
- Orchestration
- INTO+CPS
- Co-simulation: a Survey (ACM CSUR)

Figure references:
https://www.alltechbuzz.net/difference-between-programmer-coder-developer-software/
https://en.wikipedia.org/wiki/State_diagram
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http://www.imm.dtu.dk/~jbjo/cps.html
David Broman: Determinate Composition of FMUs
FMI 2.0 Standard