CYBER-PHYSICAL SYSTEMS AND CO-SIMULATION
AGENDA

Cyber-Physical Systems
Co-Simulation
INTO-CPS
Tool Development
Future Work
ME – CASPER THULE

MSc. in Computer Technology at Aarhus University in 2016
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Software Engineering Research Group led by Professor Peter Gorm Larsen
THE WORLD USED TO BE SIMPLE
PHYSICS CREEPING IN

WHAT IS PHYSICS?
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
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

start  middle  end
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
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
https://www.youtube.com/watch?v=ww57ZtE53Ic
https://www.cbronline.com/breaches/cost-cyber-crime-hit-8-trillion-next-five-years/
http://daviddewolf.com/hardware-vs-software-software-always-wins/
http://spiff.rit.edu/classes/phys369/workshops/w9a/impulse_ball.html

David Broman: Determinate Composition of FMUs
FMI 2.0 Standard