

Formal methods

- Model based on Manna-Pnueli temporal logic of reactive systems.
- Prove separability properties.
 - Requirements for service reliability.

Service-Oriented Architectures for Cyber-Physical Systems

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CPS and SoC: Differences

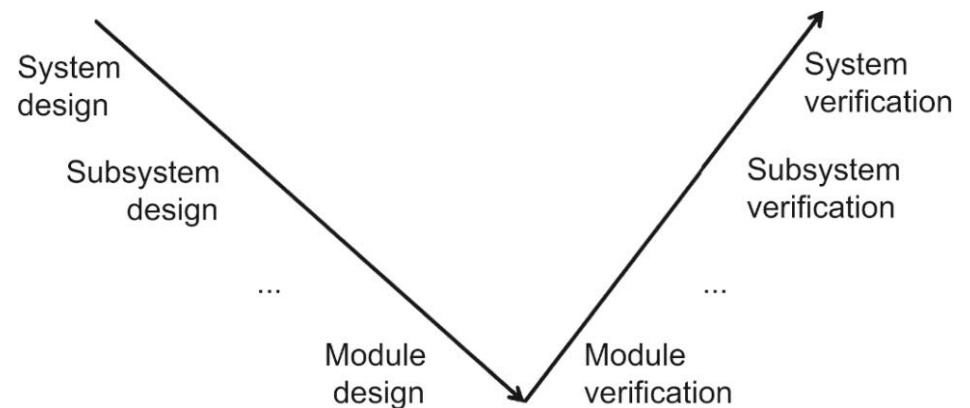
- Locked vs. evolving design:
 - SoC is locked at tapeout.
 - Many networked CPS are long-lived and evolve.
- Mission criticality:
 - Ultra-high reliability less important in consumer electronics.
 - Many advanced CPS that motivate research are mission or safety critical.
- Self-containment:
 - Many CPS designs are constrained by their physical plant.
- Specs:
 - SoC specs are lower level (SystemC).
 - CPS specs are higher level (AADL, step response, etc.).

CPS and SoC: Similarities

- Real-time.
- Software intensive.
- Complex functional specs, demanding non-functional specs.
- Networking:
 - SoCs have internal heterogeneous networks, often synthesized.
 - CPS use heterogeneous networks, many COTS.

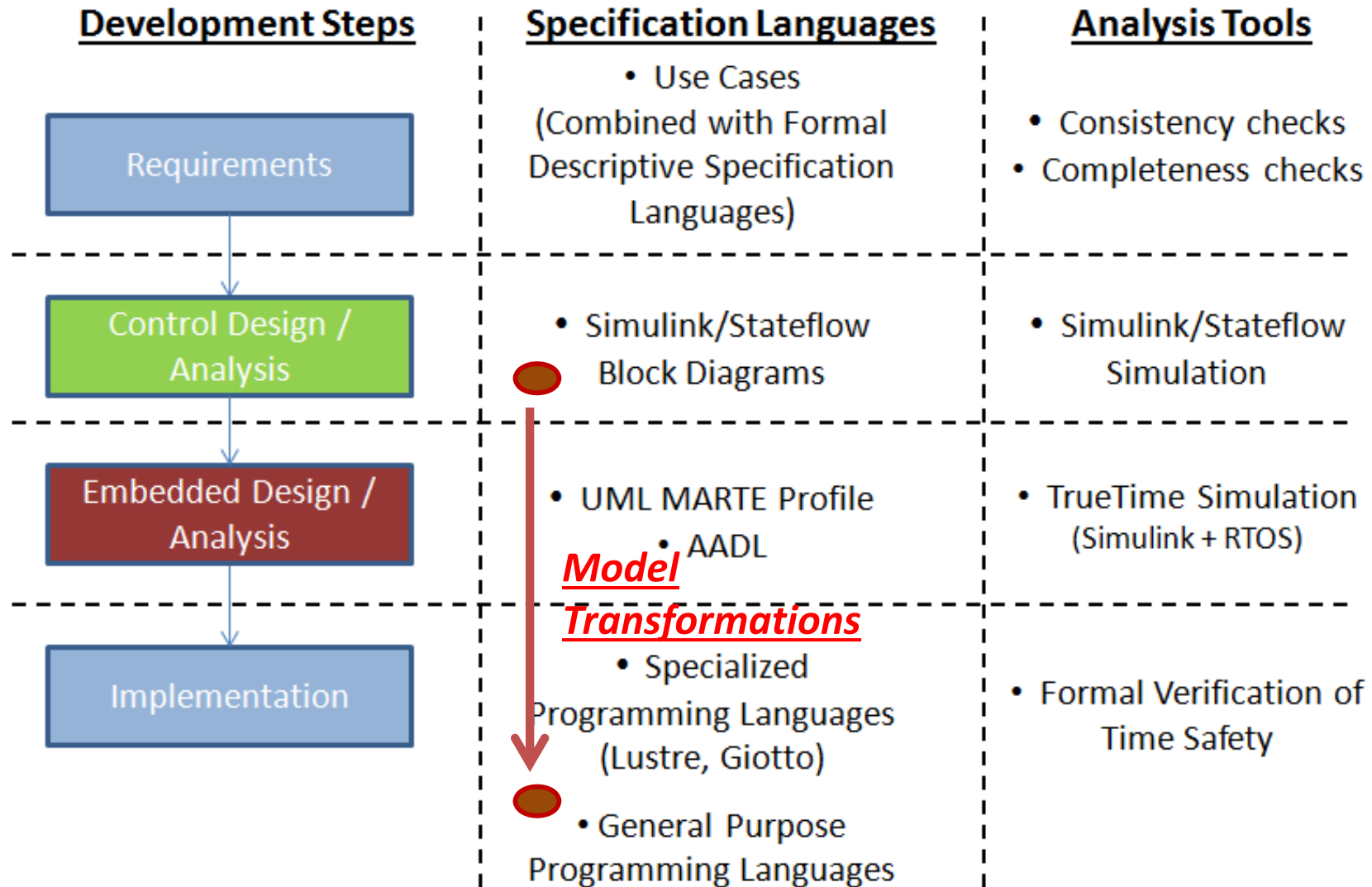
CPS design methodologies

- CPS requires deep design hierarchies, complex verification methodology.
- V-chart: design by top-down refinement, verify bottom-up
- New methodologies:
 - More bottom-up.
 - Supplemental Type Certificate.

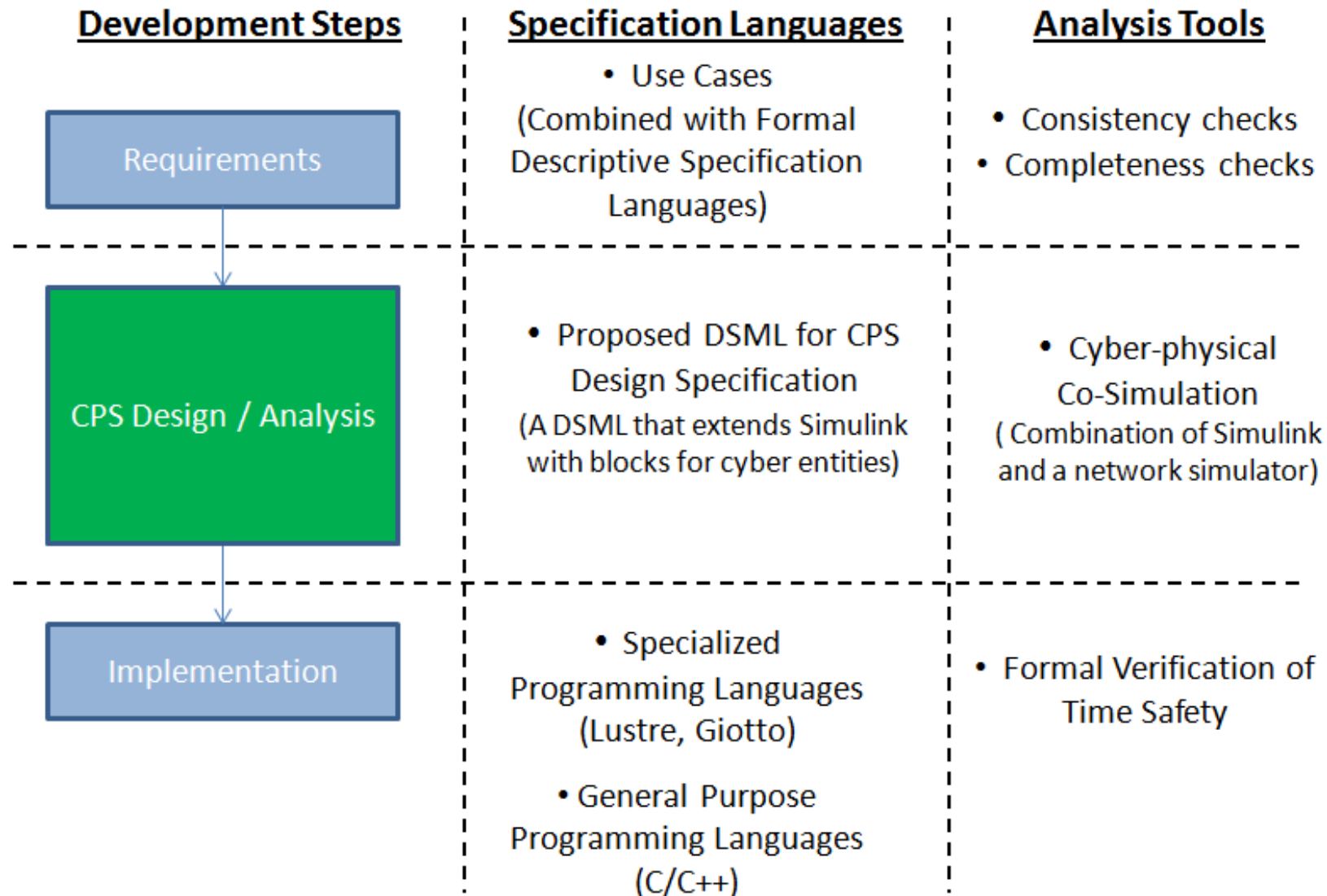


Wolf High-Performance Embedded Computing © 2014

Embedded Control Systems

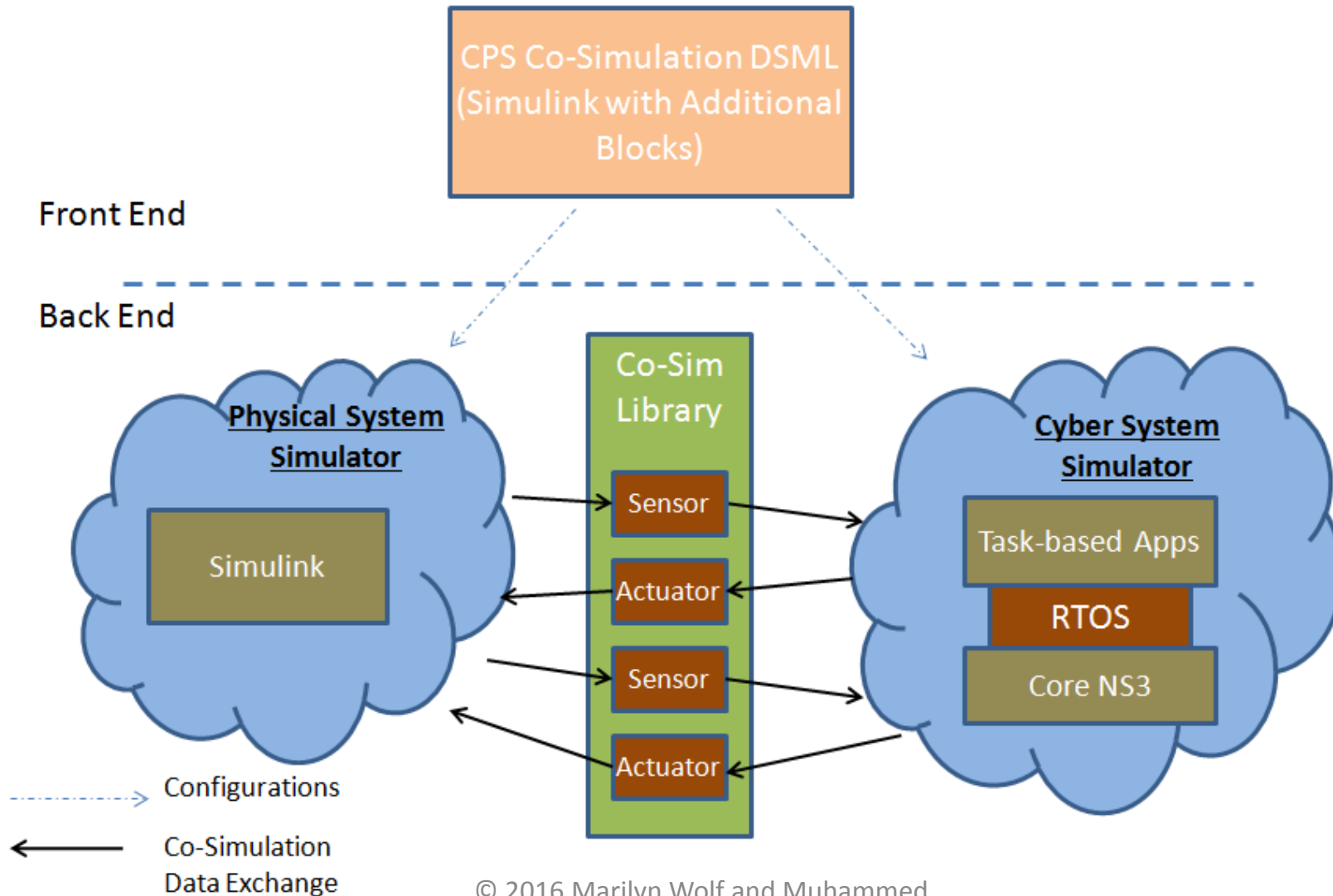


Cyber-Physical Systems



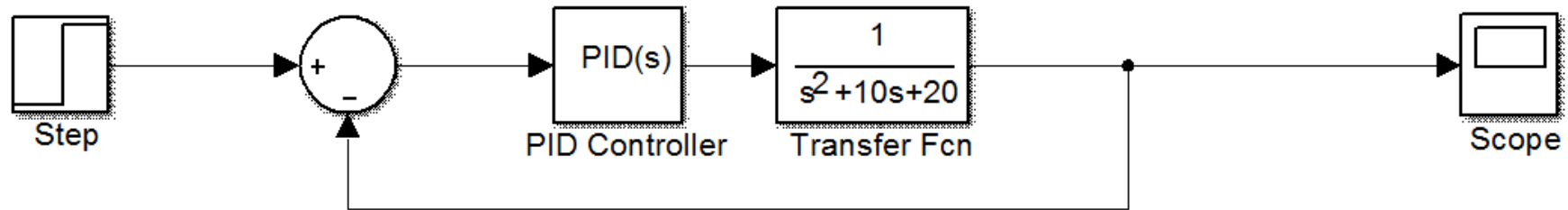
Simulation Framework for CPS: Design

(Automated Configuration of Simulation Engine)



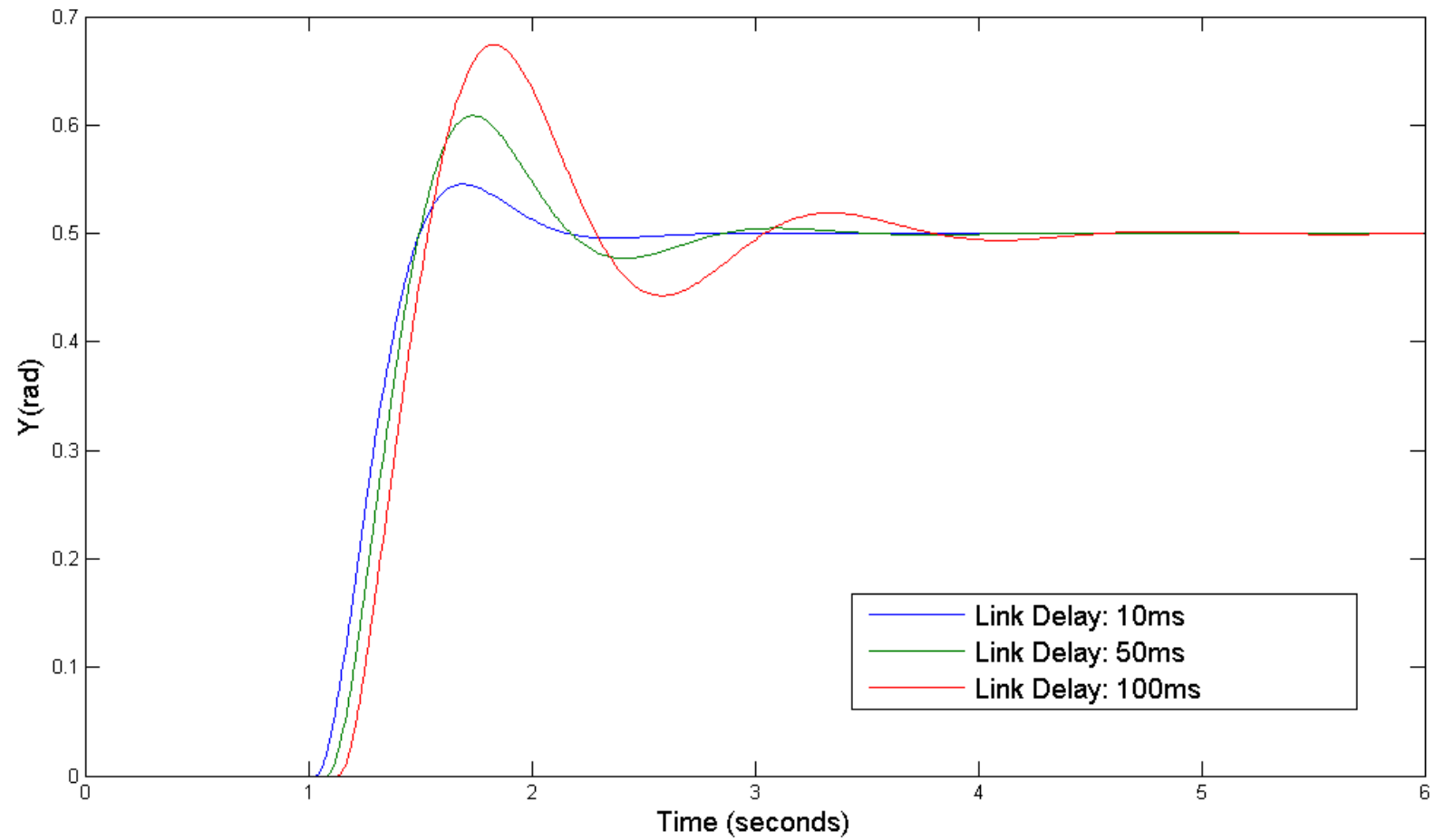
CyPhySim: Design

(Simulink-based Front End)



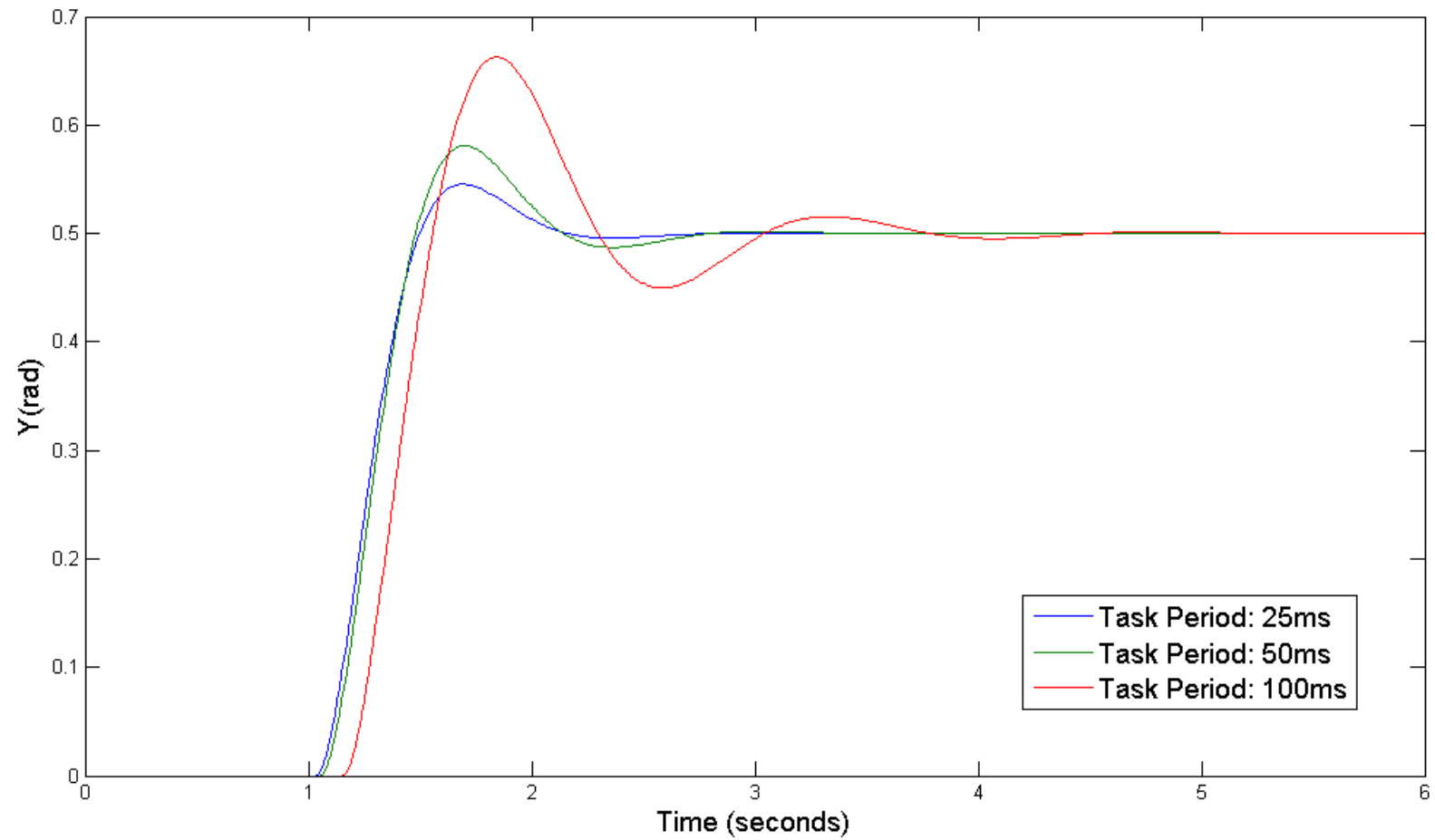
Performance Analysis

(Link Delay)



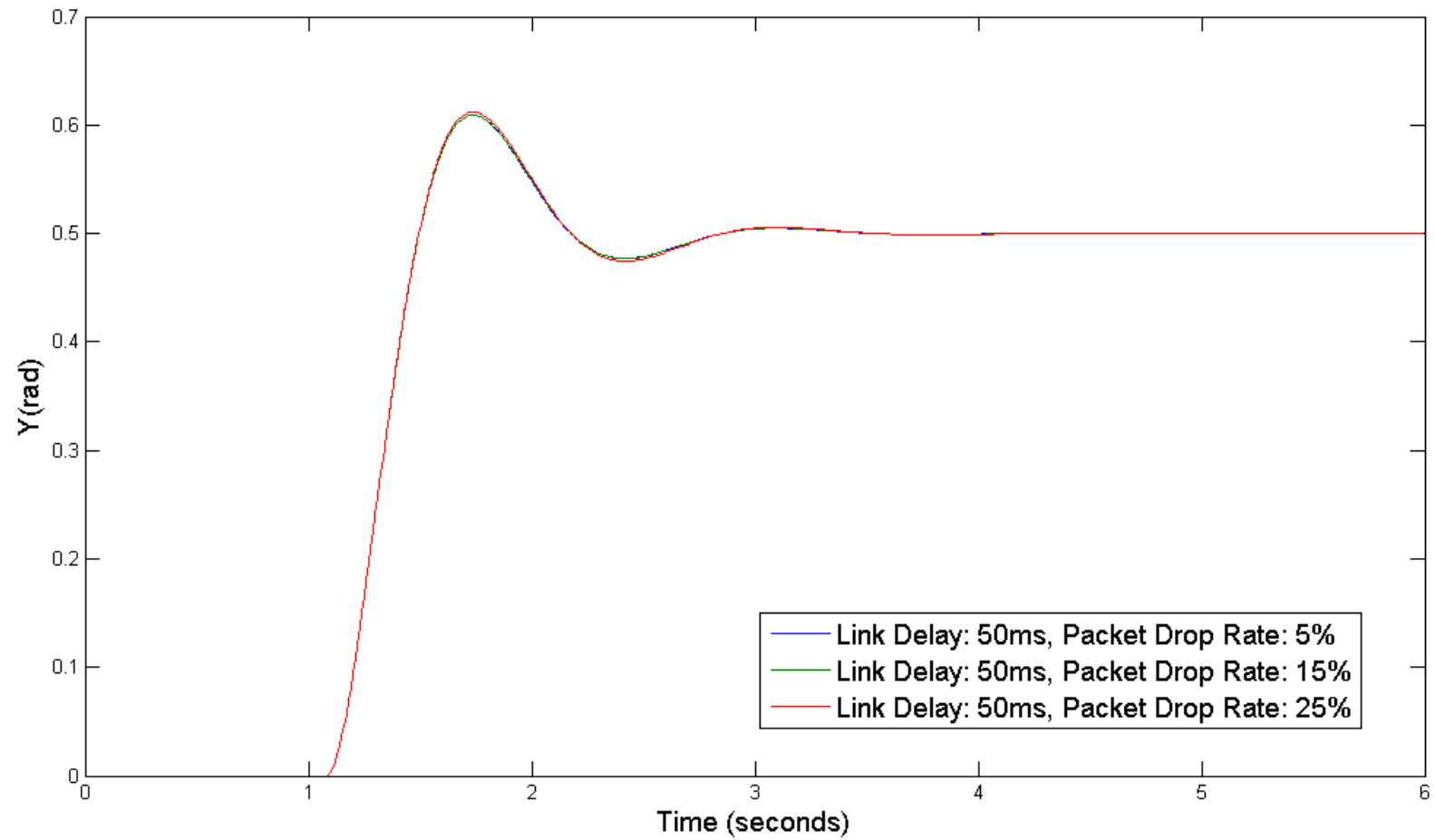
Performance Analysis

(Task Period)



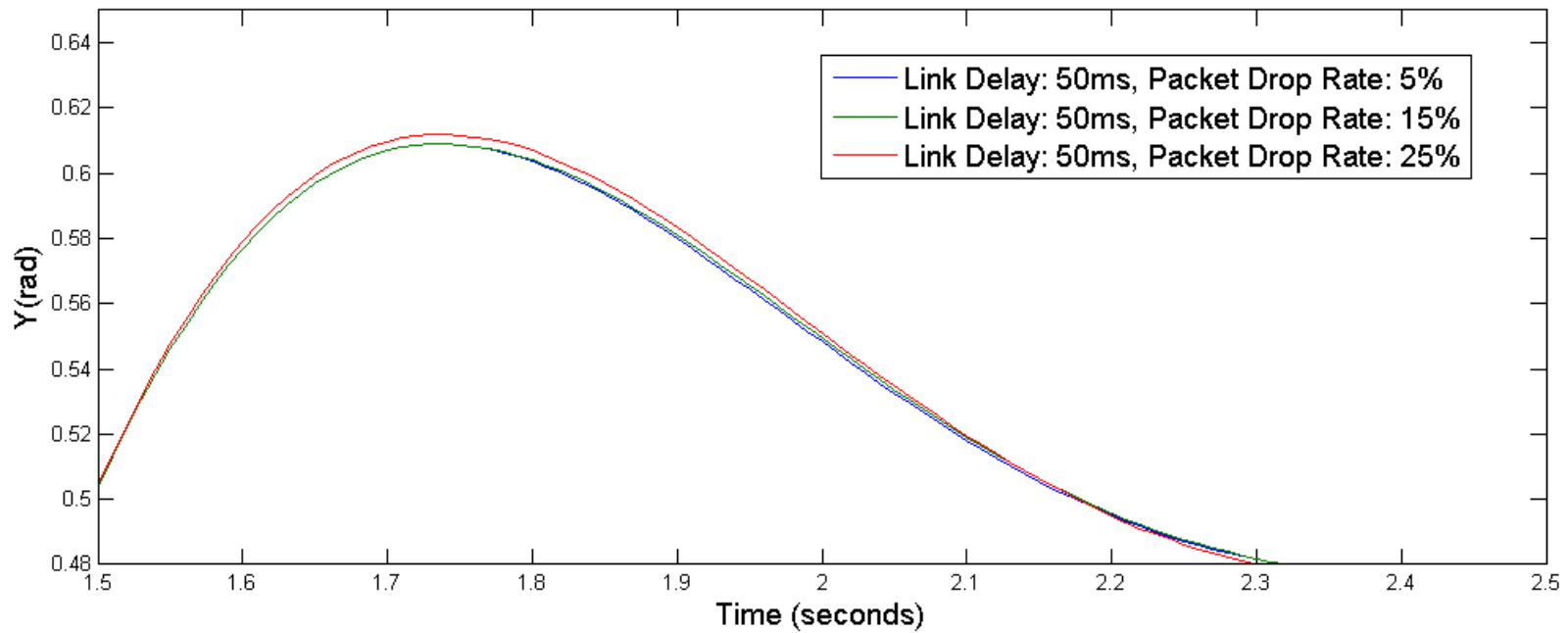
Performance Analysis

(Packet Drop Rate)



Performance Analysis

(Packet Drop Rate)

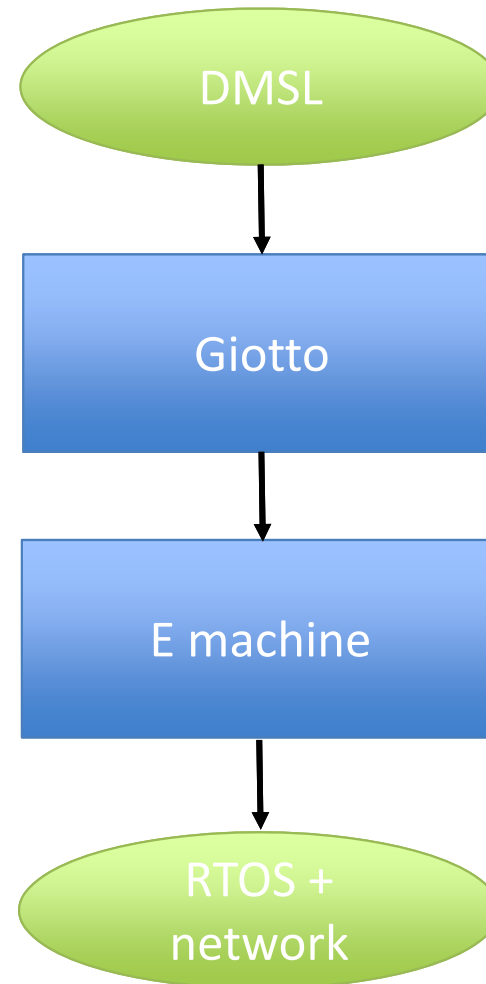


What is a service?

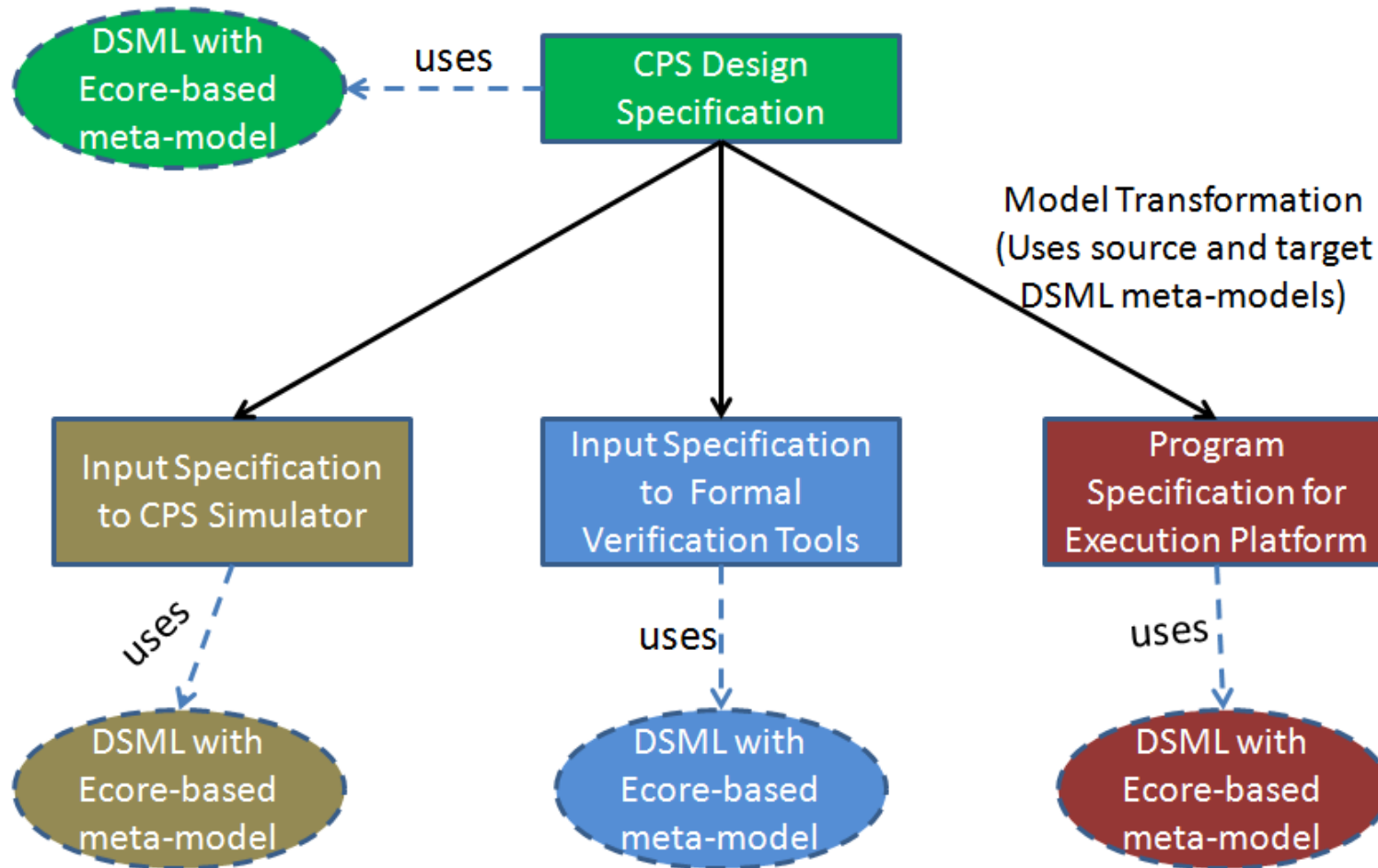
- Cloud/Web services:
 - A function provided in a distributed system.
 - Used through a protocol.
 - Service is provided by components; details are hidden from the user.
- Traditional services are transaction-oriented.

Service-oriented models

- Control systems need quality-of-service.
- Synthesis must guarantee QoS of the implementation.
 - Task model is memoryless, no state to track QoS.



Role of Proposed DSML



Requirements for CPS Design Specification DSML

- *Capture the Control, Communication, and Computation Aspects of a CPS Design*
- *Convey Independently*
 - *computing platform characteristics*
 - *controller design that needs to be implemented on the computing platform*
- *Serve as Interface between Control Engineer and Embedded Systems Engineer*
 - *Integration with Simulink*
 - *Clear Separation of Control Algorithm from Computing Platform*



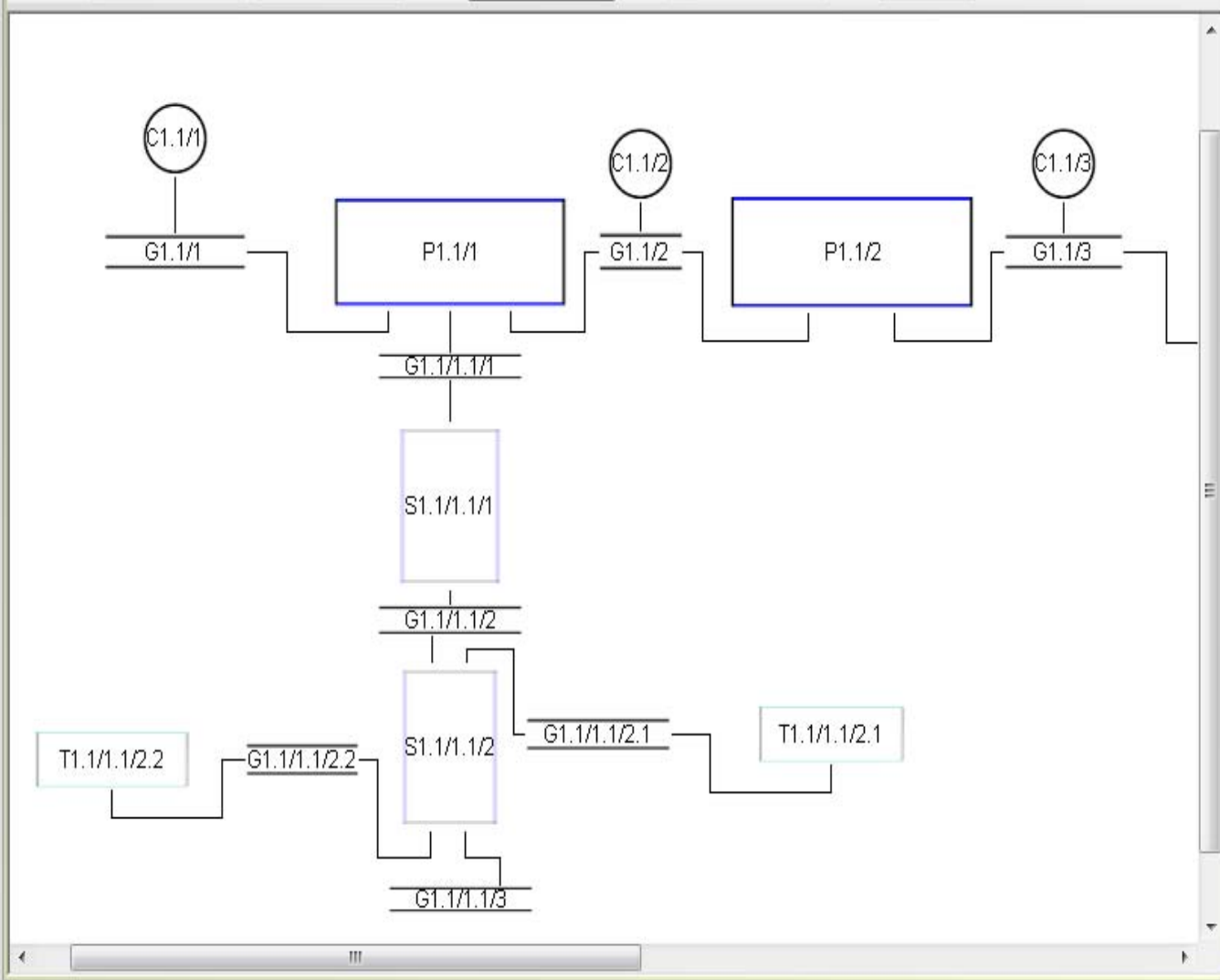
Part Browser

Aspect

- Controller
- Gate
- Khala
- PrimaryCanal
- SecondaryCanal

NewCanalDiagram x

Name: NewCanalDiagram CanalDiagram Aspect: Aspect Base: N/A Zoom: 100%



Panning Window

GME Browser

Aggregate Inheritance Meta

NewCanalDiagram

- RootFolder
 - NewCanalDiagram
 - C1.1/1
 - C1.1/2
 - C1.1/3
 - C1.1/4
 - C1.1/5
 - G1.1/1
 - G1.1/1/1/1
 - G1.1/1/1/2
 - G1.1/1/1/2.1
 - G1.1/1/1/2.2
 - G1.1/1/1/3
 - G1.1/2
 - G1.1/3
 - G1.1/4

Object Inspector

Attributes Preferences Pro

Console



Case Study: Flood Level Prediction (Open Loop Case)

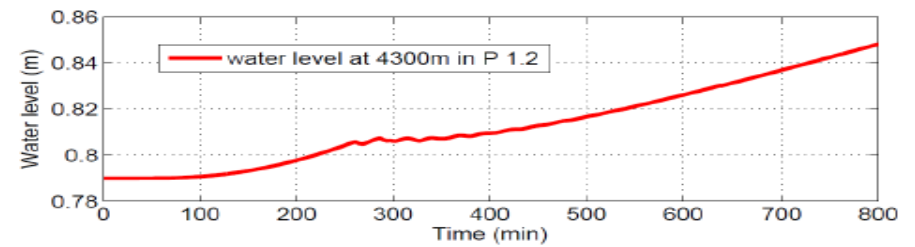
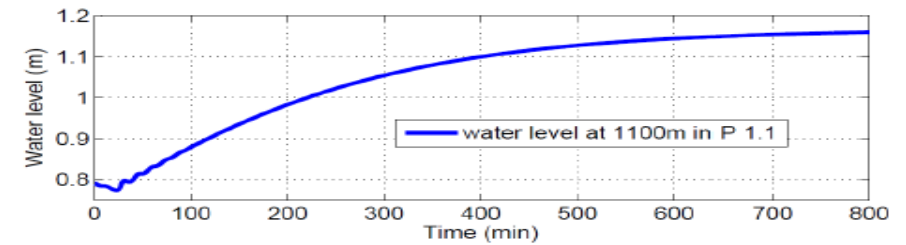
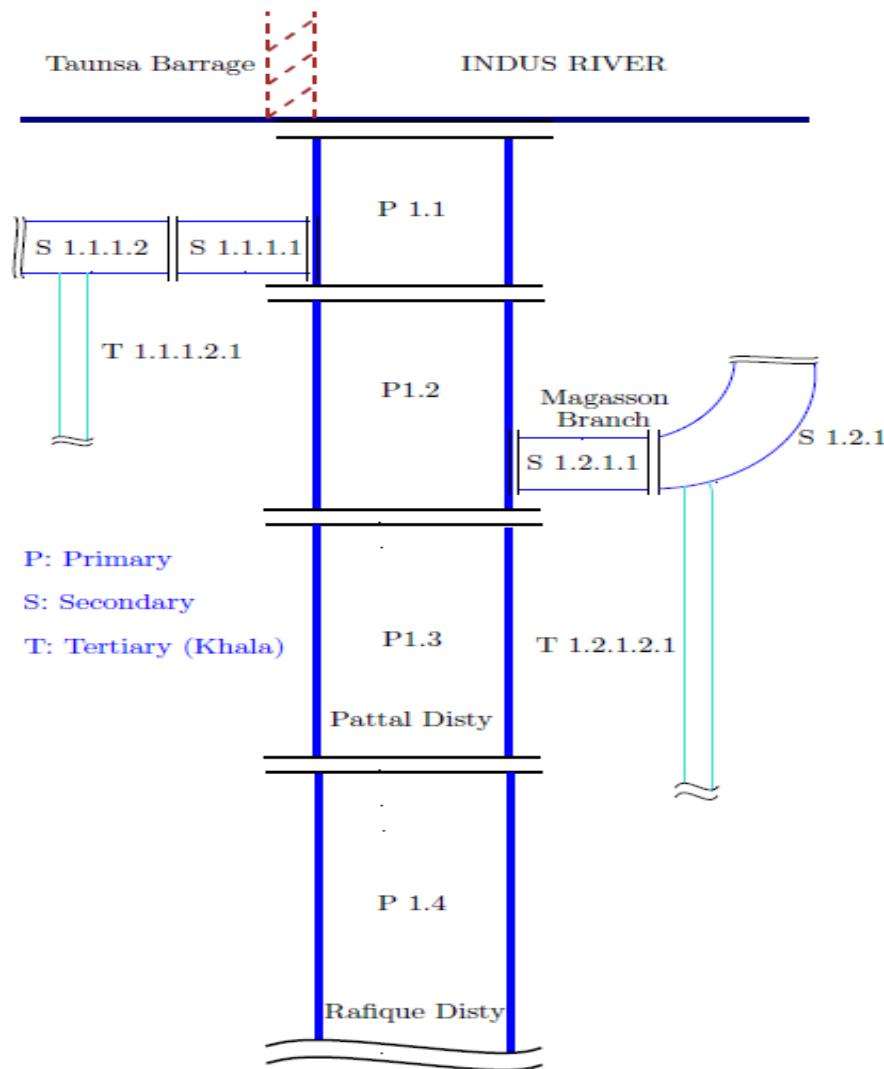


Figure 9. Hydro graph of P 1.1 and P 1.2

