Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Model-Based Systems Engineering

Master Thesis Proposal

Open System Simulation and Test with SysML, Modelica and Eclipse

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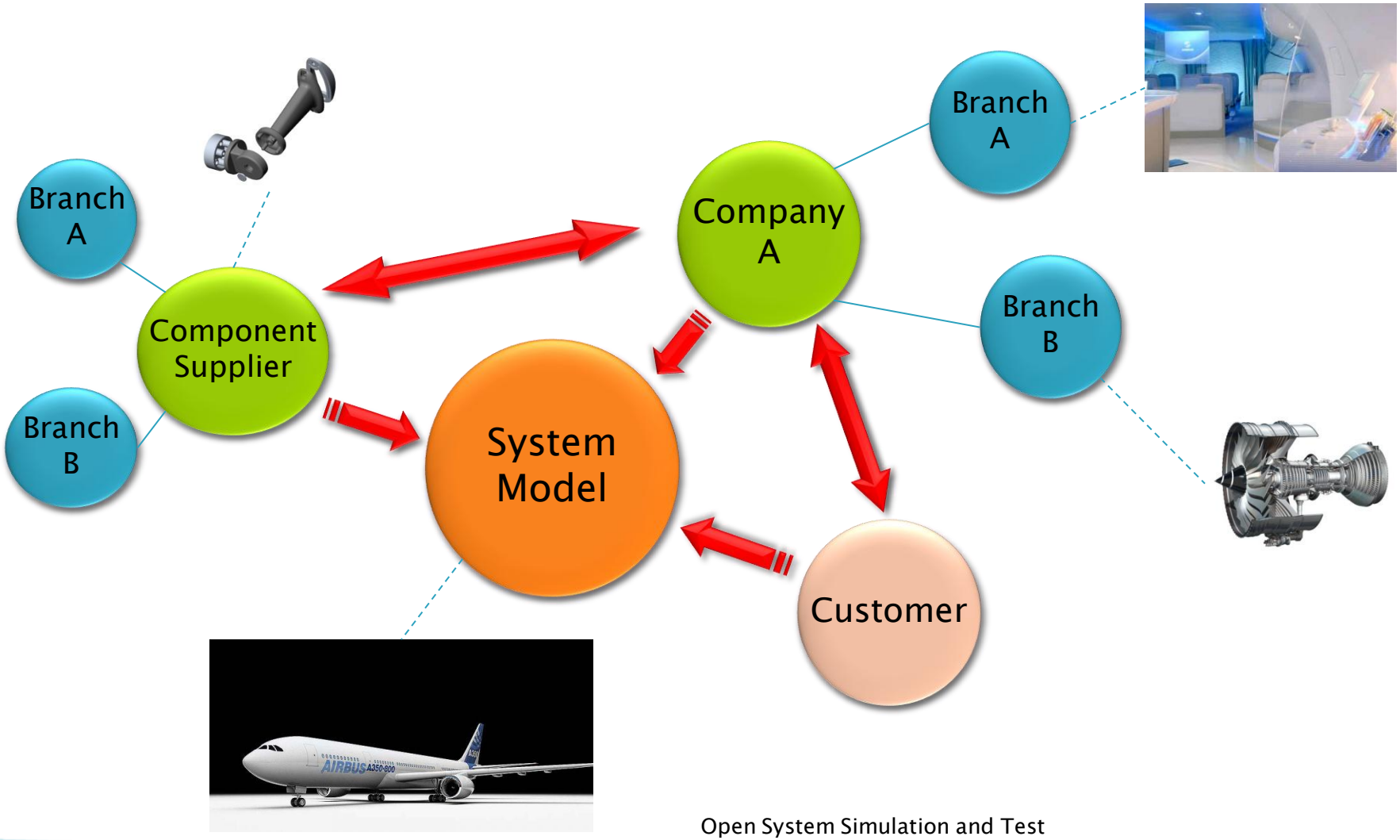
Introduction and Motivation

Systems Engineering

- Problem: Increasing complexity of technical systems
  - Increased degree of automation
  - Increased number of involved technologies
  - SW and HW development is strongly coupled
  - Component suppliers are increasingly involved into the design process
  - Validation of the functionality long before the first prototype is built
- Motivation:
  - Simplify and Speed systems development
  - Cut time to market
  - Improve Quality
- Solutions:
  - Model- Based Systems Engineering
  - Simulation and Test

Project Description

Model-based Systems Engineering



Project Description

Kind of Systems

- Technical Systems
  - Aerospace, Automotive, ...
- Dynamic
  - Time depended, Behaviour
- Reactive Systems
  - It continuously interacts with its environment

Project Goals

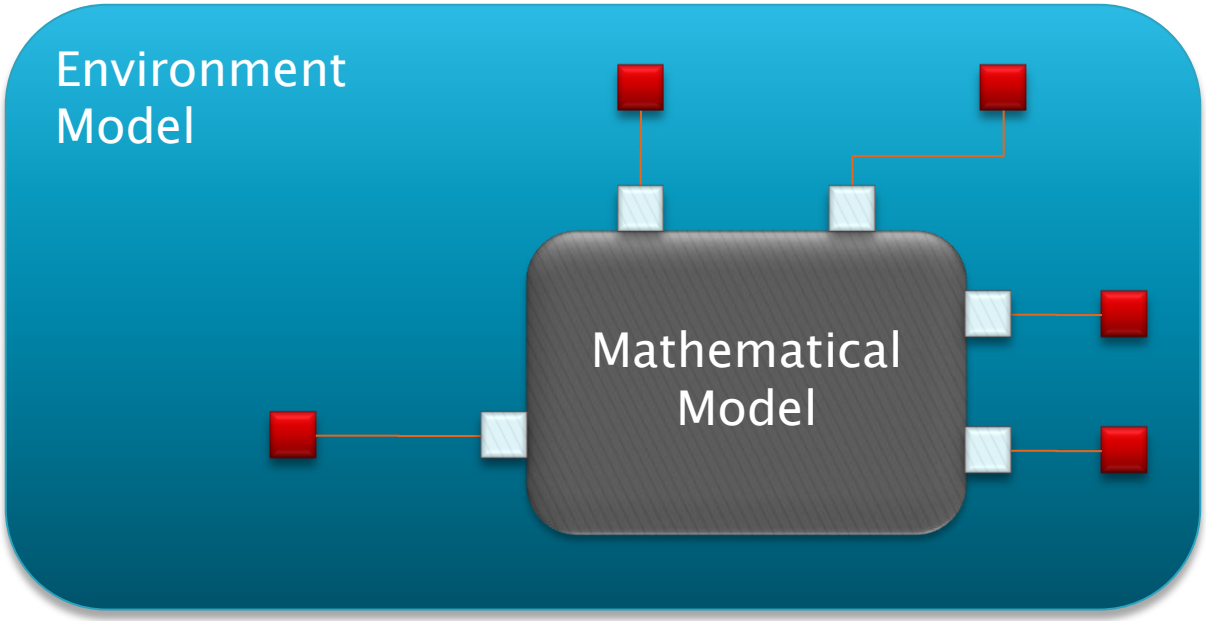
Open System Simulation and Test

- Open Technologies
  - Open Reusable Solutions
- Standardized Model Representation
  - SysML and Modelica
- Simulation
  - Experiment
  - Support Understanding
  - Communication
- Test
  - Searching for a failure caused by fails
  - Improve Quality
  - Verification and Validation

Project Goals

Model Simulation and Test

- Mathematical Model
  - System behaviour expressed in mathematical form
- Model in the Loop (MiL)



Variables (Input & Output)

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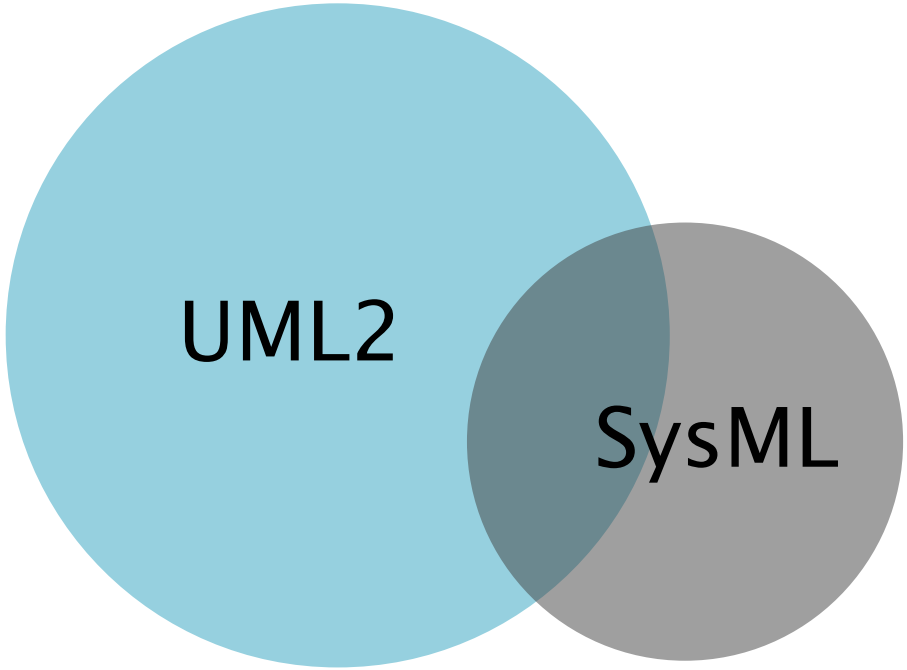
Technologies

The Systems Modelling Language

- OMG UML2 Profil for Systems Engineering
- SysML Version 1.2 (using UML 2.3) (June 16, 2010)

- Diagrams
  - Structure
  - Behaviour
  - Requirements

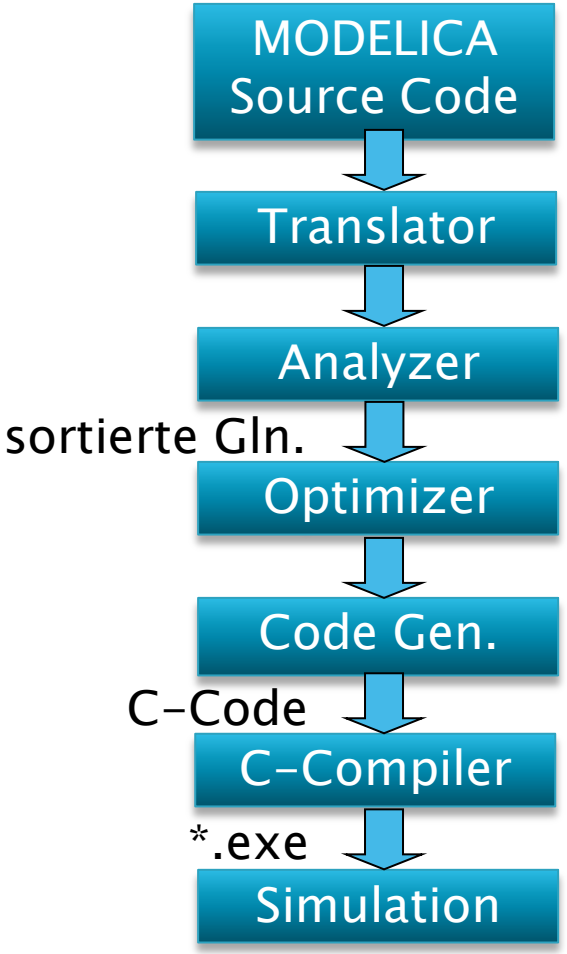


Technologies
Modelica

- Next Generation Modeling- and Simulation Language
- Equation based instead of assignment statements
  - Acausal Physical Modeling
  - Deklarative
- Object Oriented
  - Class Model (+handle complexity)
  - Component based (+reuse)

Technologies
OpenModelica

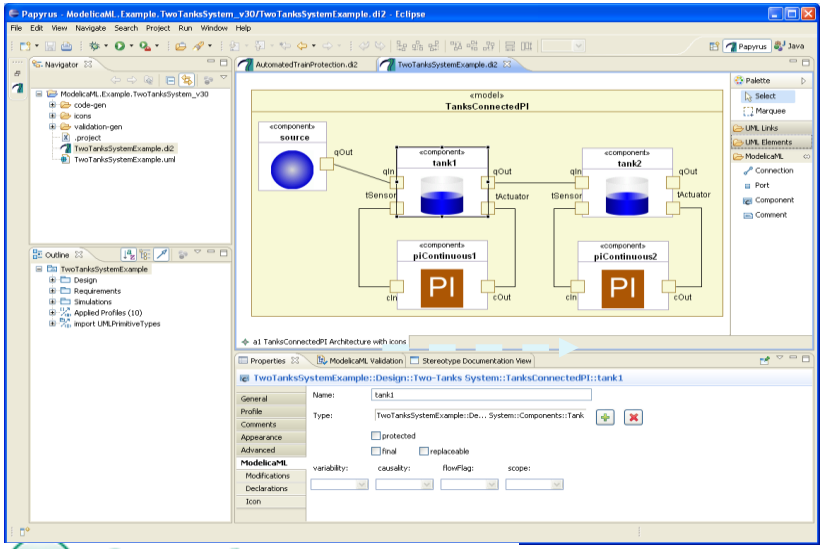
- Open Source Modelica Tool
  - Compiler for Modelica Code
  - Solver for Simulation
    - DASSL, Euler, Rungekutter
- Non-Interactive Simulation
- Interactive Simulation



Technologies
Eclipse & Papyrus

- Eclipse Plug-In Papyrus
  - Papyrus UML as Modeling Environment

Papyrus UML
SysML Profil



Acceleo

Model to Text Transformation

Methods

Modeling: The System Model [1]

- Mathematical Model
  - Behaviour
- Model in the Loop
  - Communication with its Environment using its Inputs and Outputs
- Deterministic Model
  - Same Behaviour (Outputs) using same Inputs

Methods

Modeling: Using SysML [2]

Requirements

OMG SYSTEMS MODELING LANGUAGE

MODELICA

Environment Model

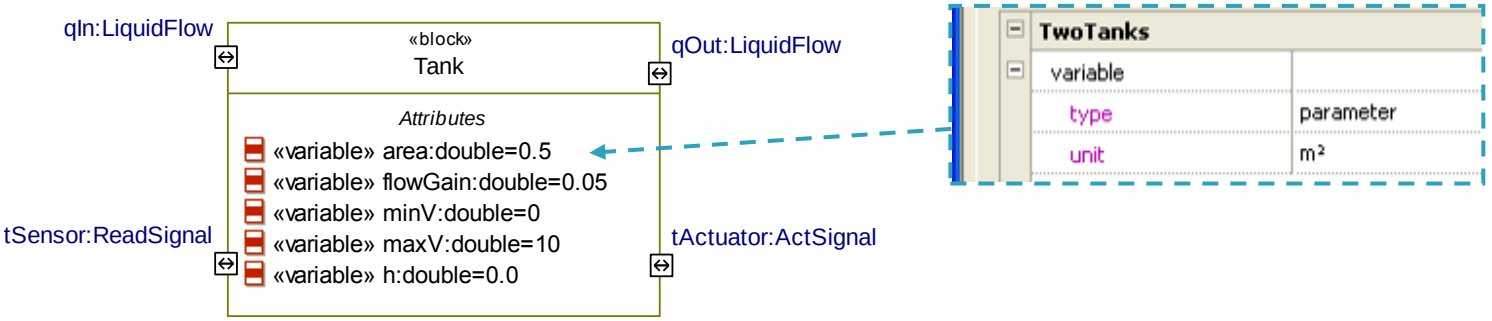
Mathematical Model

Using Structure Diagrams

- Block Definition Diagram
- Internal Block- Diagram
- Parametric Diagrams

Methods

Modeling: SysML to Modelica [3]



<<block>>Tank → Tank.mo (Modelica)

```
within TwoTanks;
block Tank
    ReadSignal tSensor;
    ActSignal tActuator;
    LiquidFlow qIn;
    LiquidFlow qOut;
    parameter Real area (unit = "m2") = 0.5;
    parameter Real flowGain (unit = "m2/s") = 0.05;
    Real h (start = 0.0, unit = "m");
end Tank;
```

See Bachelor Thesis:
Interactive Simulation of SysML Models using Modelica

Methods

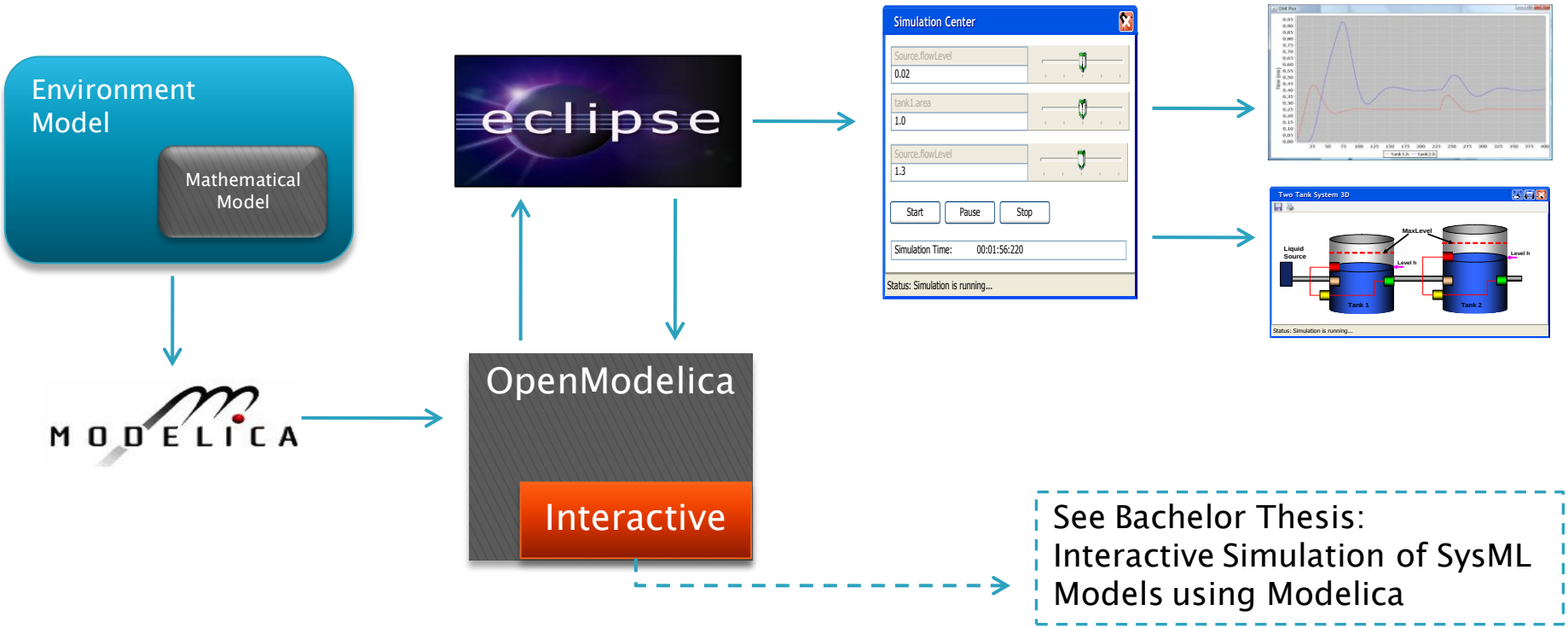
System Simulation [1]

- Interactive
  - Real-time, User Interaction
- Non-Interactive
  - As fast as computer power allows, event, condition
- Dangers of Simulation
  - Falling in love with a Model
  - Forcing Reality into the Constraints of a Model
  - Forgetting the model's level of accuracy

Methods

System Simulation [2]

- Interactive & Non-Interactive Simulation
  - Support Understanding, Experiment & Communication



Methods

Test [1]

- Functional Specification
  - Formal Requirements
- Dynamic Testing
  - Model Execution (Simulation)
- Black-Box Testing
  - Input & Output Behaviour
- Model-Based Testing
  - Test Cases Derived from a Model
  - Automatic Test Generation

Methods

Test: Automatic Test Generation [2]

- Specification Language with Formal Semantics
  - Papyrus UML as Modeling Environment

Requirements

Each tank has a continuous proportional-integral (PI) controller connected to it, which regulates the level of liquid contained in the tanks to a reference level. While the liquid source fills the first tank with liquid the PI continuous controller regulates the outflow from the tank depending on its actual level…

Non-Formal Specification

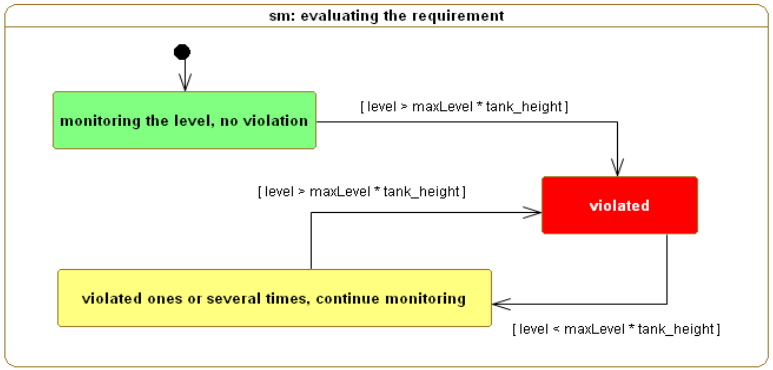
Using SysML Requirements Diagram

Max_level_Tank_A
Id: 001
Description: The level of a tank should not rise over 10m, to avoid a Overflow of liquid.

Non-Formal Specification

Using SysML Behaviour Diagrams

- State Diagram
- Activity Diagram

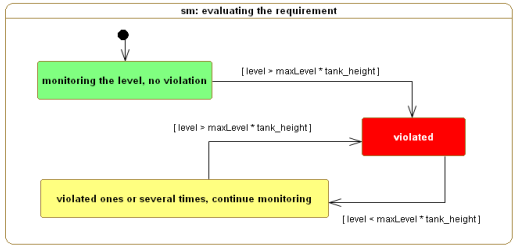


Formal Specification

Methods

Test: Automatic Test Generation [3]

Formal Specification



Environment Model

Mathematical Model

Algorithm for Test Derivation

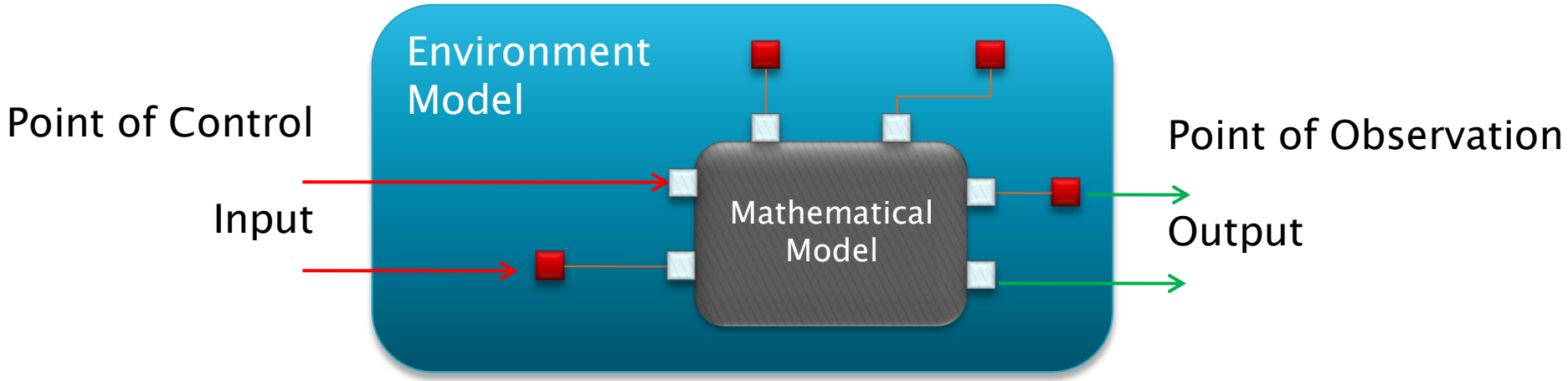
Test Cases
Test Data

Using Behaviour Diagrams

- State Diagram
- Activity Diagram
- Sequence Diagram

Methods

Test: Black-Box [4]

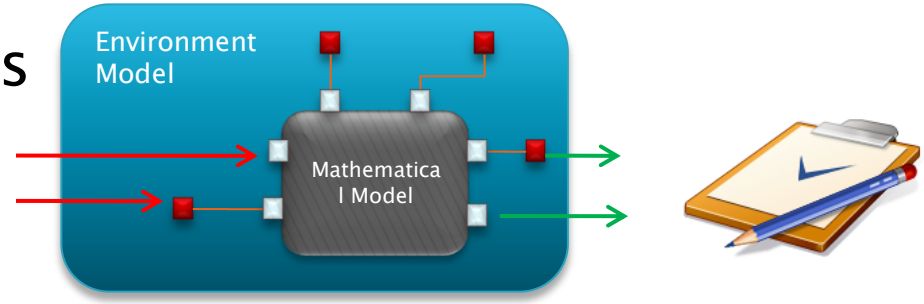


Variables (Input & Output)

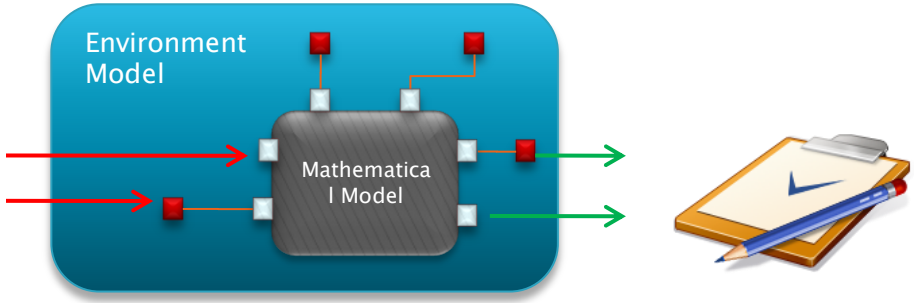
Methods

Test: Test Execution [5]

- Automatically
  - Test Tool forces the Tests
  - Test Script
  - Unit Tests



- Interactive System Test
  - User controls the system interactively
  - Undefined Usage
  - In Real-time



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Risks

- SysML
  - Modelica Profile for UML
  - Test Representation in SysML
- OpenModelica
  - Interactive Simulation Performance
- Automatic Generation of Tests from SysML
  - Generation from UML is still an research topic

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Conclusion and Outlook

- Simulation and Test
  - Support Model-based Systems Engineering
  - Improve System Quality
  - Cut time to market
- Open Reusable Solutions
  - SysML, Modelica, Eclipse
- Next Step: Automatic Test Generation

References

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Thank you for your attention!

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