Use Cases For Model Execution

Žilvinas Strolia, 2016 May

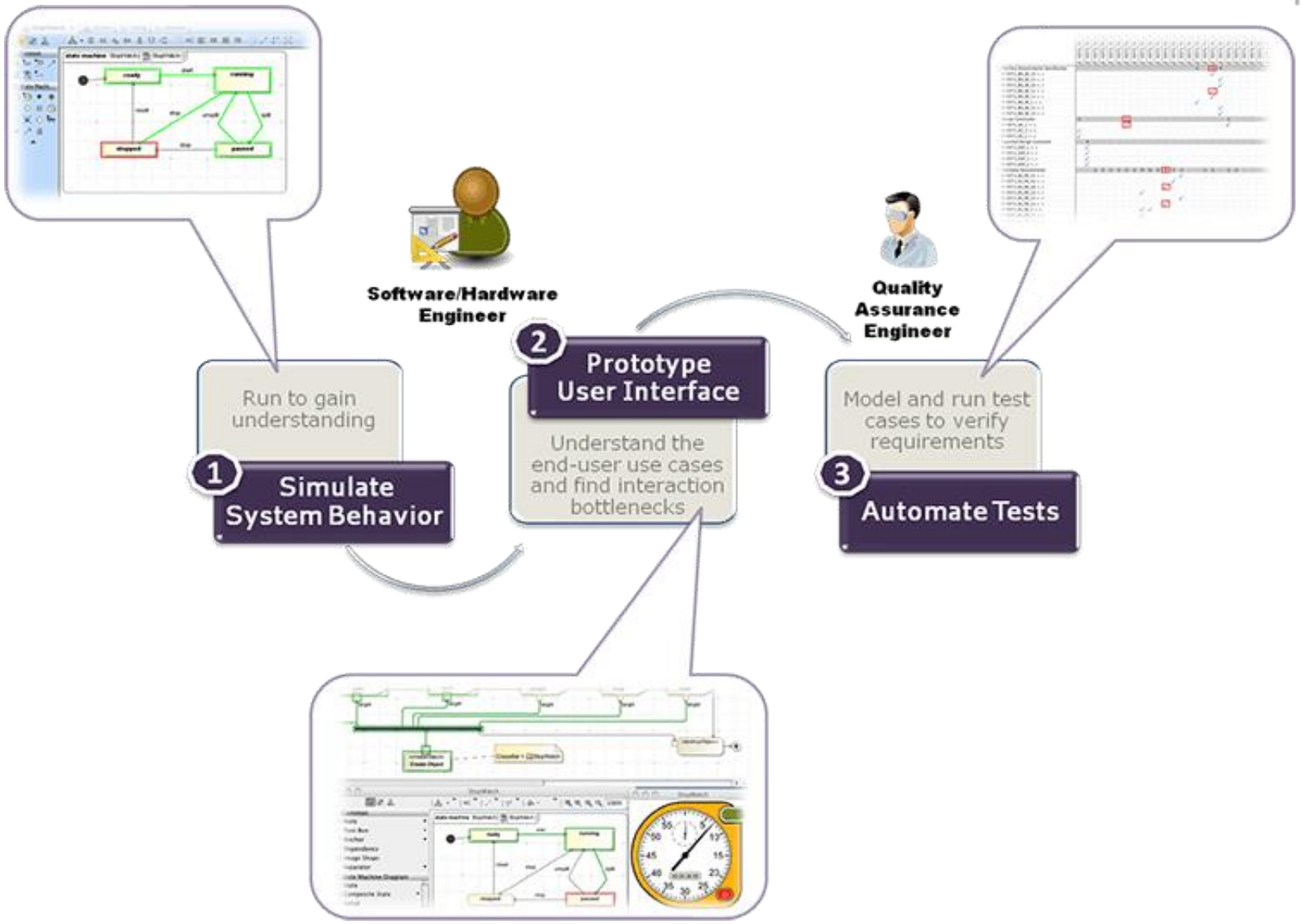
Outline

- Introduction
- Automation and Debugging
- Behavior Simulation
- User Interface Mockups
- Engineering analysis
  - Automated Requirements Verification
  - Trade studies / trade-off analysis
  - Total mass/power/cost rollups
  - Model-based testing
- Integration of Analytics Models

Introduction

Simulation

- The purpose of a simulation is to gain system understanding without manipulating the real system, either because it is not yet defined or available, or because it cannot be exercised directly due to cost, time, resources or risk constraints.
- Simulation is typically performed on a model of the system.



Cameo Simulation Toolkit (CST)

- Model execution framework and infrastructure:
  - Model debugging and animation environment
  - Pluggable engines, languages and evaluators
  - User Interface prototyping support
  - Model driven configurations and test cases

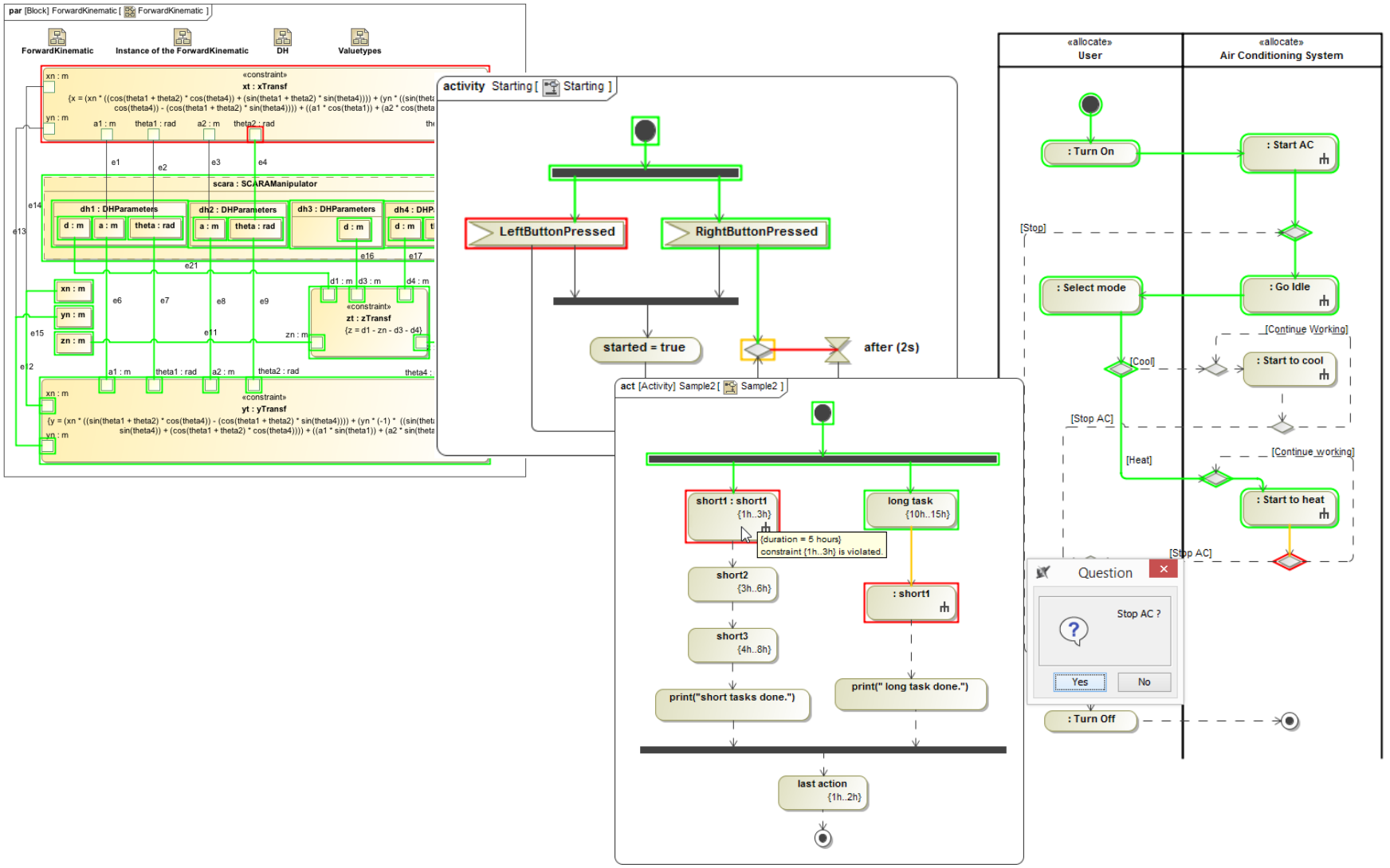
- The standard based model execution of:
  - Activities (OMG fUML standard)
  - Composite structures (OMG PSCS)
  - State Machines (W3C SCXML standard)
  - Actions/scripts (JSR223 standard)
  - Parametrics (OMG SysML standard)
  - Sequence diagrams (OMG UML Testing Profile)

Animation and debugging

Enhance user understanding

- Animating various diagrams during the execution of a dynamic system model representing the system behavior can significantly enhance user understanding.
- A simple simulation can either rely on execution of pre-scripted scenarios, or it can react to specific user interaction (e.g., “toggle this input and see what happens”).

Animation



Behavior Simulation

Executing Activity Diagrams

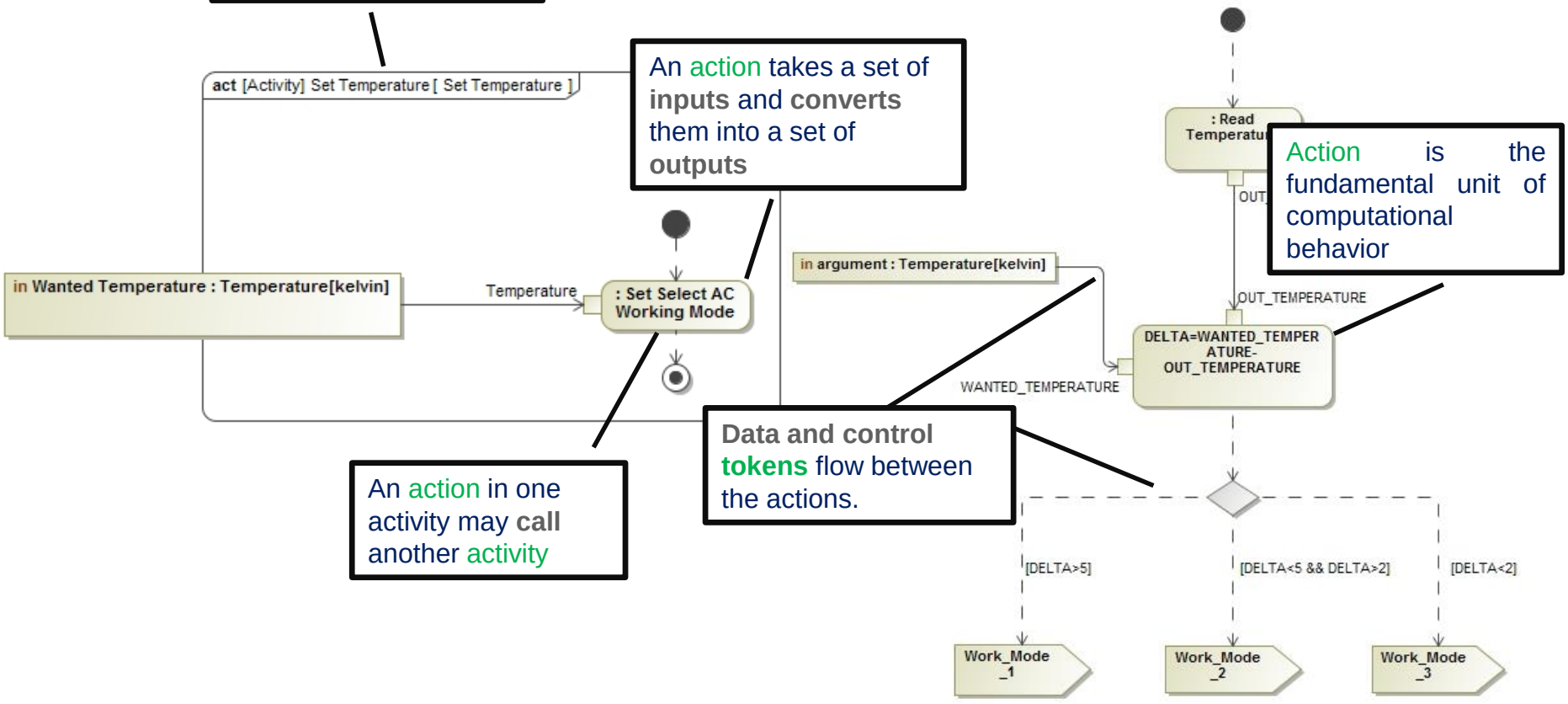
An activity specifies **behavior** as the execution of a set of actions

An action takes a set of **inputs** and converts them into a set of **outputs**

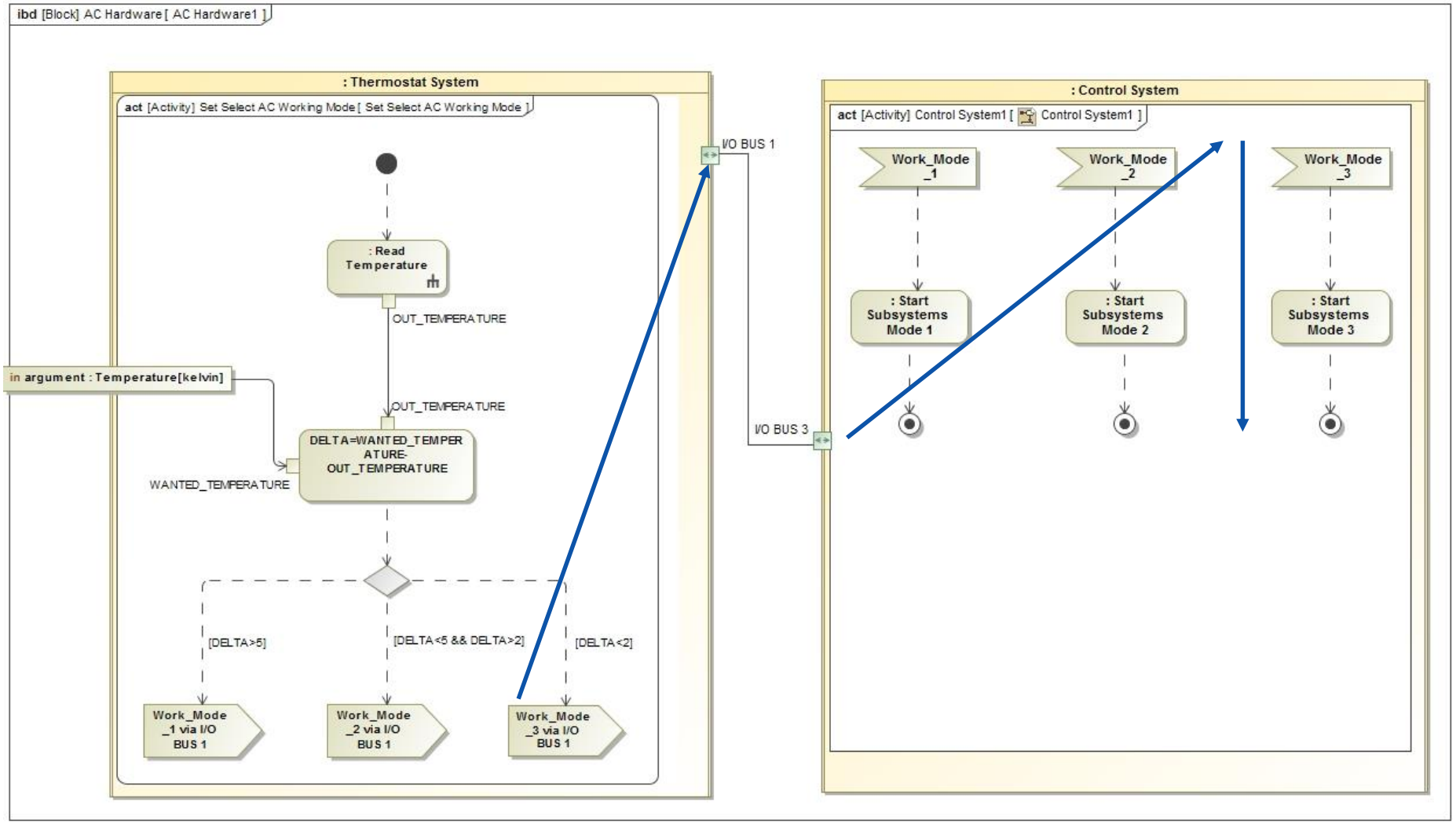
Action is the fundamental unit of computational behavior

Data and control **tokens** flow between the actions.

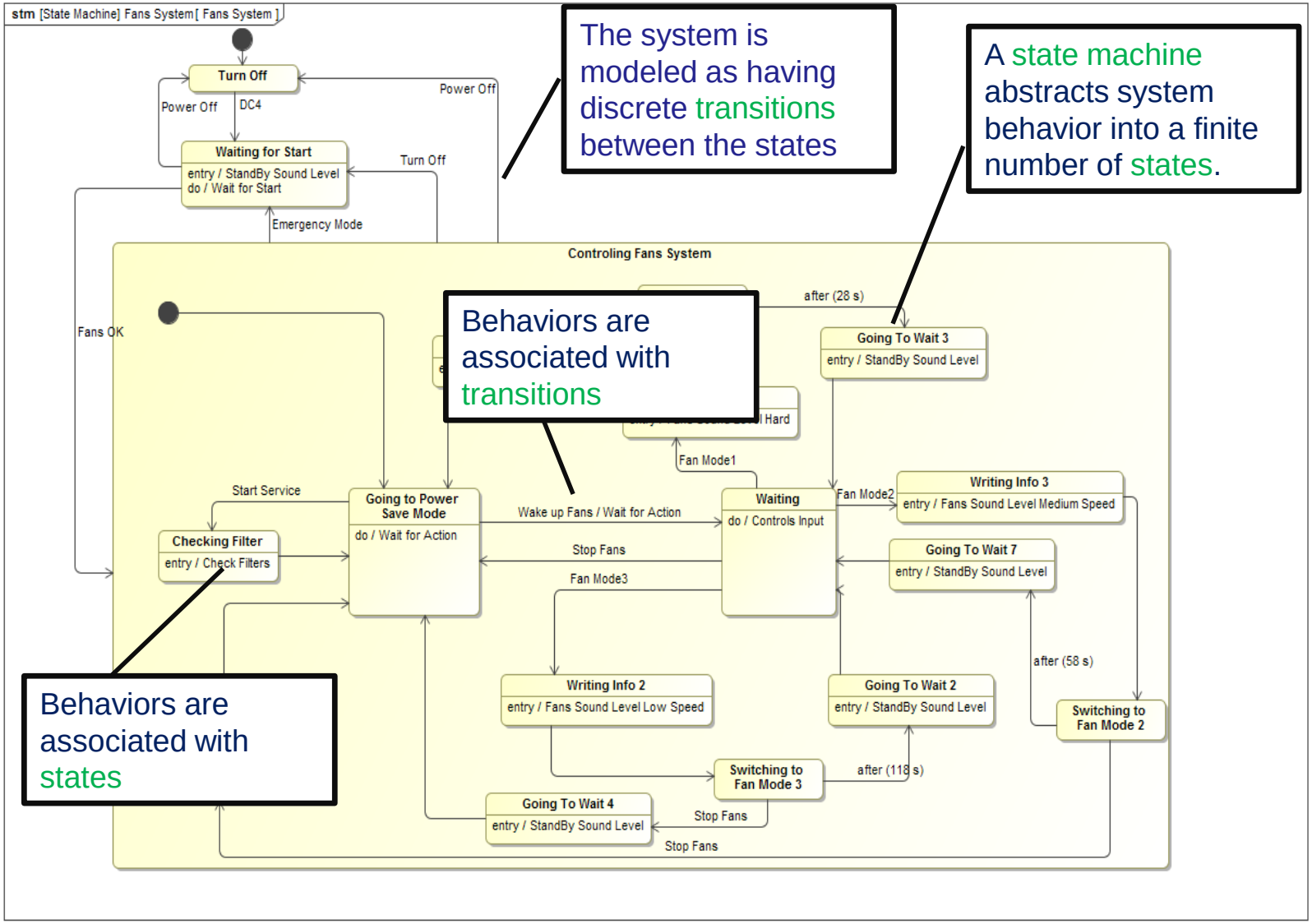
An action in one activity may **call** another activity



Sending Signals via Ports

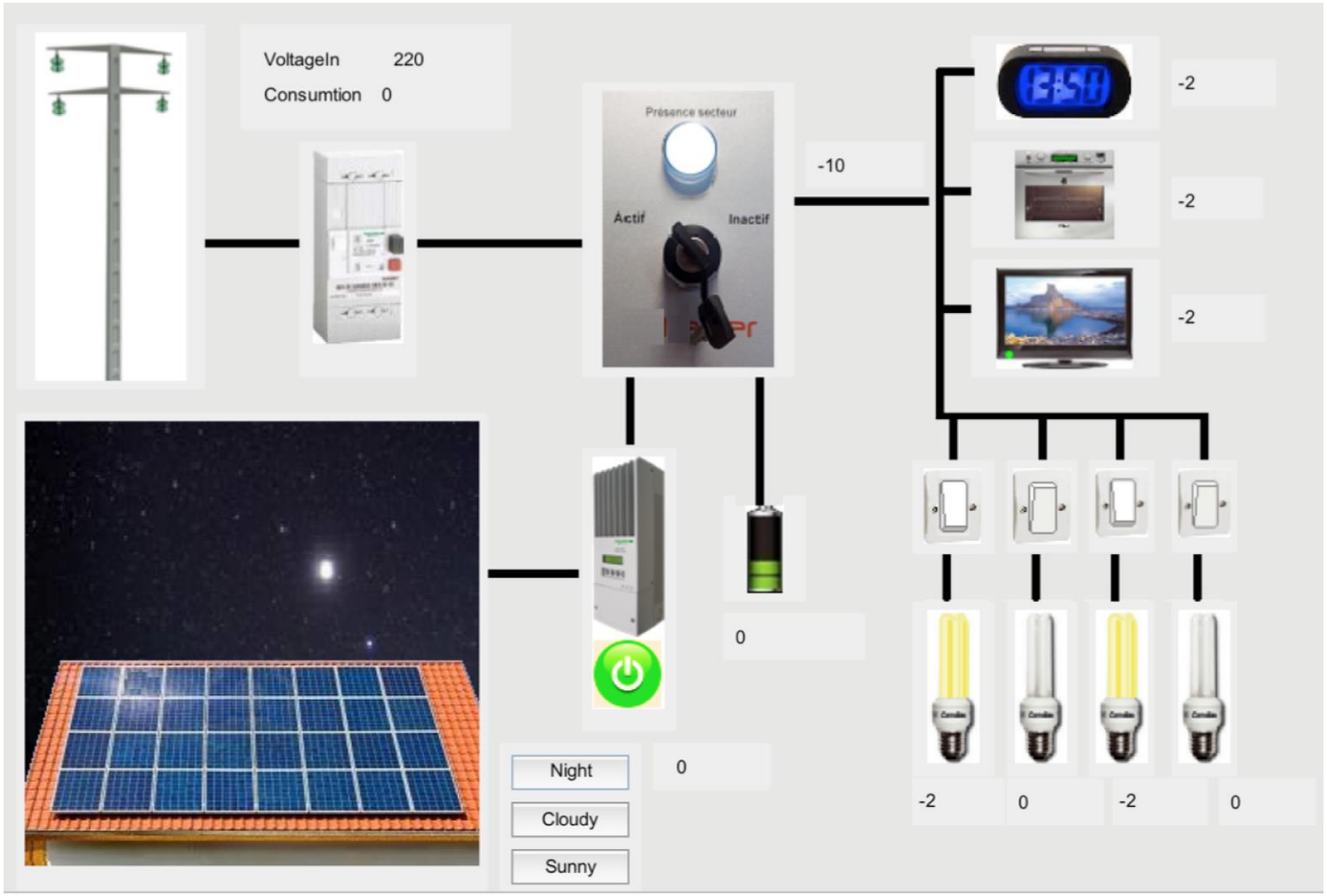


Executing State Machines

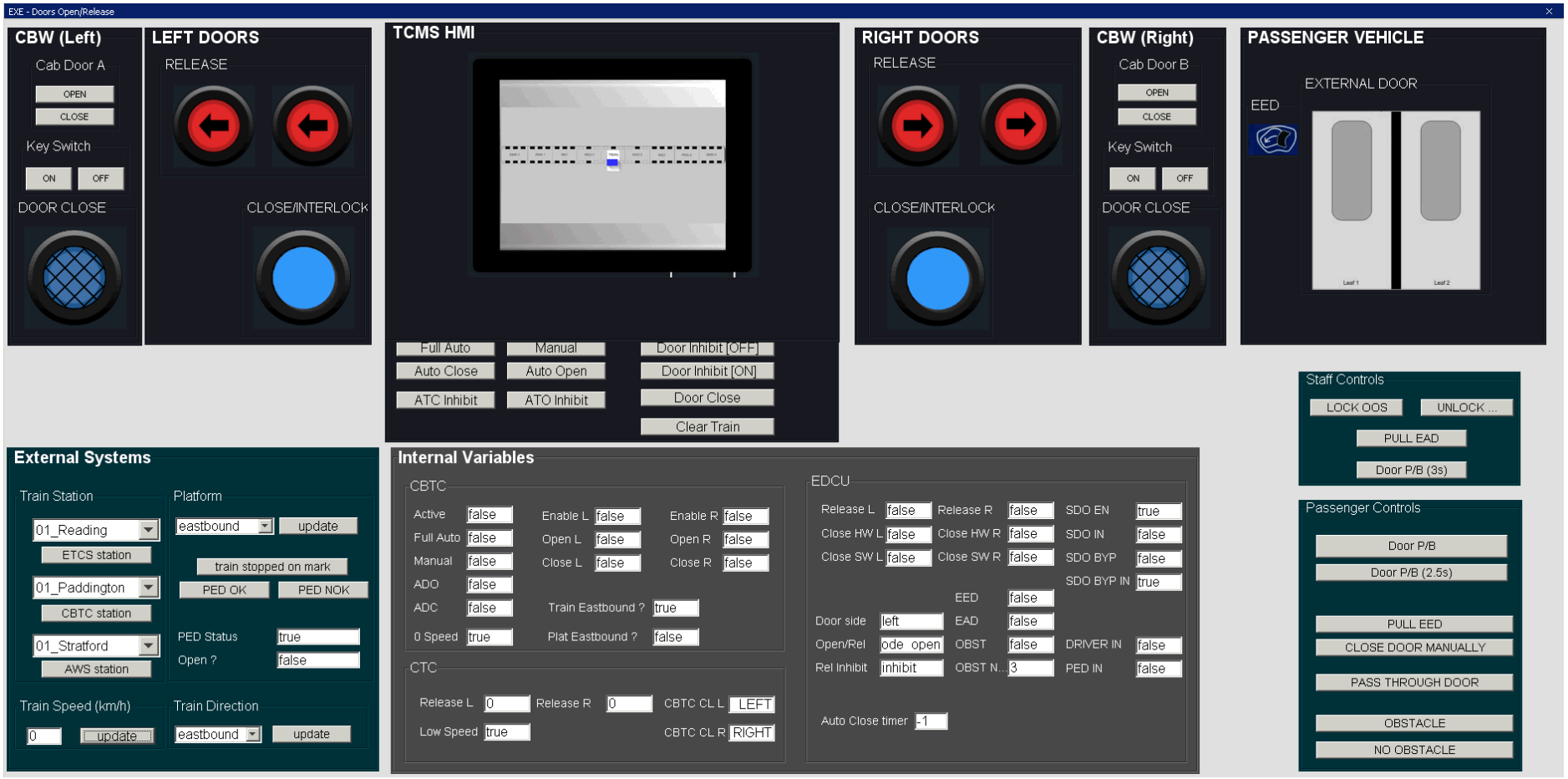


User Interface Mockups

GUI Examples



Train doors



Engineering Analysis

Engineering analysis

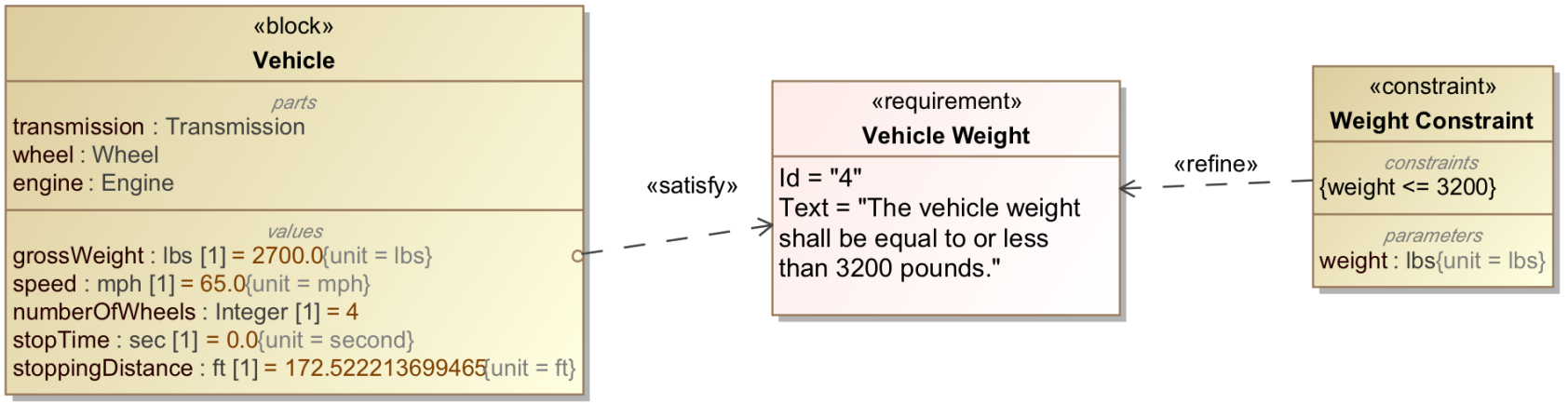
- Automated Requirements Verification
- Trade studies / trade-off analysis
- Total Mass/cost/power rollup
- Model-based testing

Automated Requirements Verification

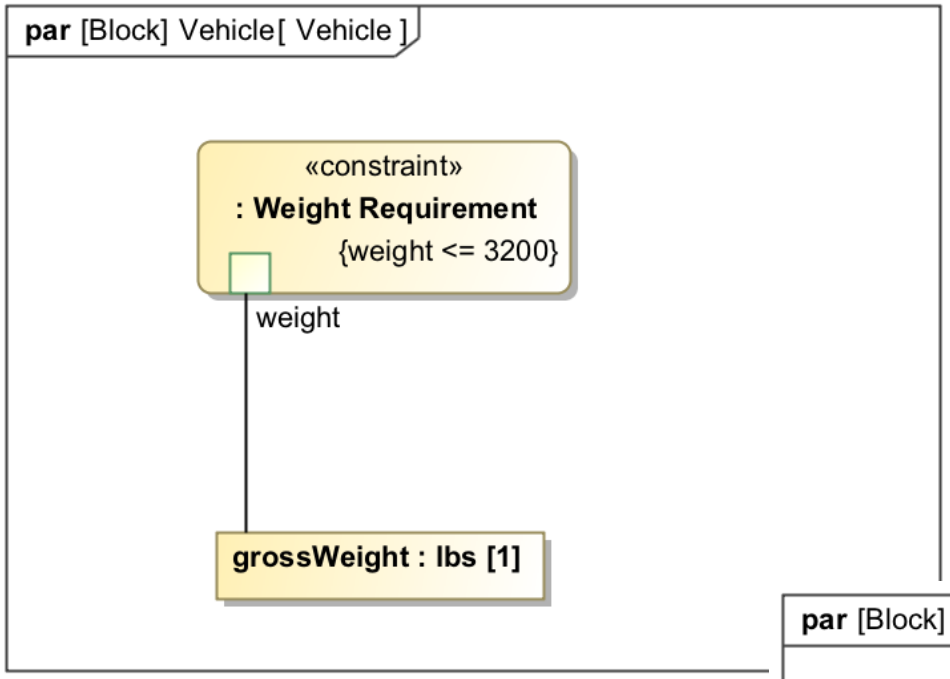
Formalize requirements

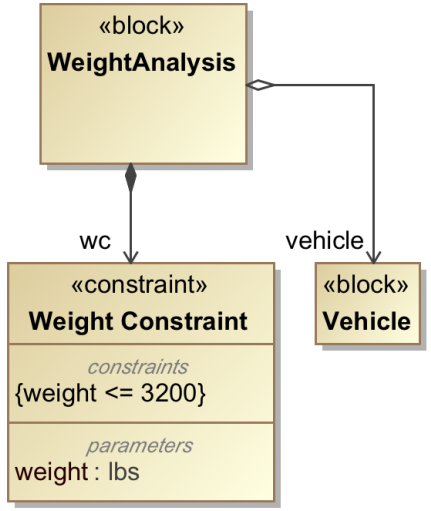
- Represent requirement in BDD
- Identify system parameter which should satisfy the requirement
- Refine requirement into more formal/computable description
- Use constraint block in analysis context
- Bind required system parameters

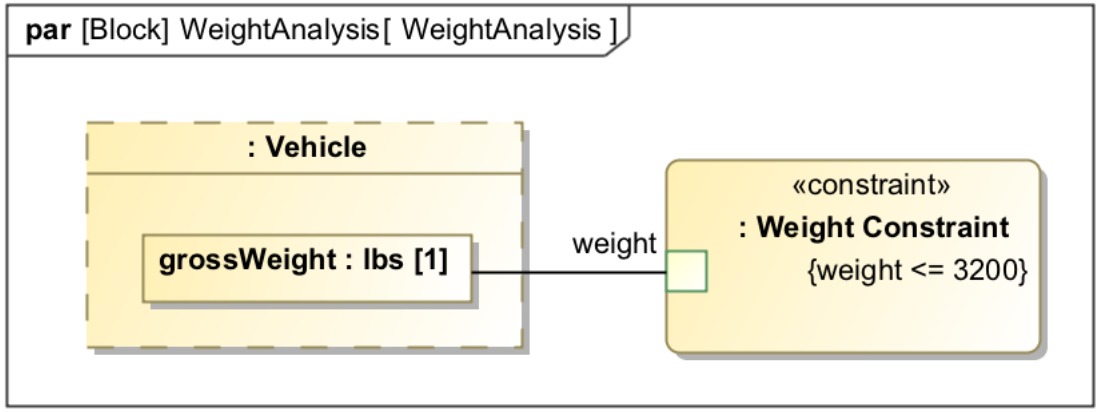
Step 1. Refine (formalize)



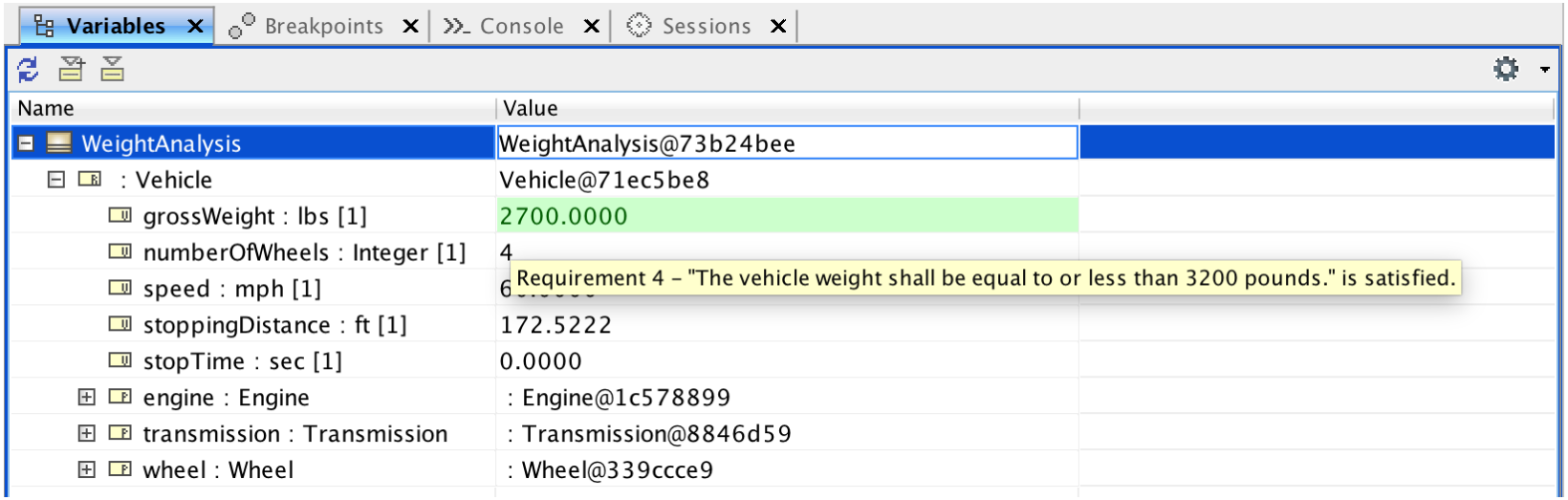
Step 2. Binding

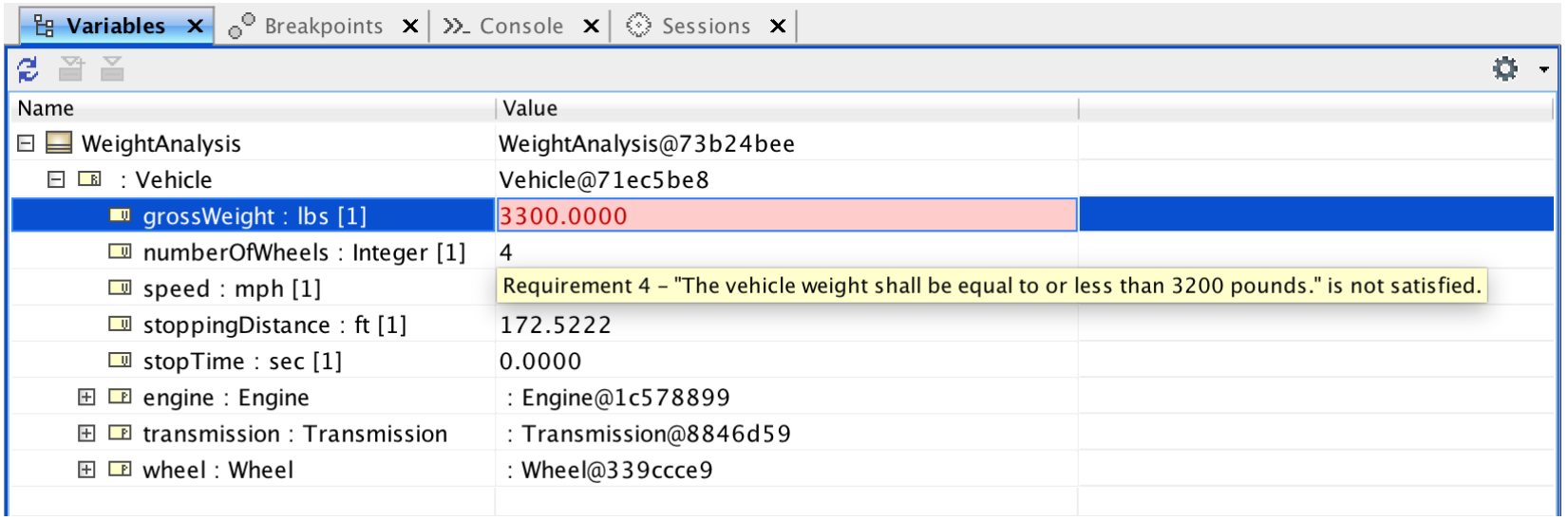






Constraints Verification





Trade Studies/Trade-Off Analysis

What Is A Trade Study?

A trade study or trade-off study is the activity of a multidisciplinary team to identify the most balanced technical solutions among a set of proposed viable solutions

(System Engineering Manual,
Federal Aviation Administration, 2006)

Parametric Trade Study

- Examining various design alternatives by comparison

#	Name	Manufacturer	Capacity	Voltage	Refrigerant	Power	Frequency	Current	Warranty	Price	Application
1	4UKW3	Danfoss	32000.0	230.0	R-22	1.677825	60.0	16.7	1.0	937.0	Home
2	4UKW4	Danfoss	34000.0	230.0	R-22	1.86425	60.0	16.7	1.0	936.0	Home
3	4UKW5	Danfoss	38000.0	230.0	R-22	2.050675	60.0	19.5	1.0	895.0	Home
4	4UKW6	Danfoss	38000.0	230.0	R-22						
5	5AGX7	Bristol	18000.0	230.0	R-22						
6	5AGX9	Bristol	22000.0	230.0	R-22						
7	6AGX9	Panasonic	6926.0	115.0	R-410A						
8	6AGY1	Panasonic	8190.0	115.0	R-410A						
9	6AGY2	Panasonic	8155.0	230.0	R-410A						

#	Name	Manufacturer	Power	Speed Number	RPM	Voltage	Current	Frequency	Price	Shaft Diameter
1	2PRA8	Genteq	0.246081	1	825.0	230.0	1.8	60.0	193.0	0.5
2	2PRD4	Genteq	0.559275	1	1075.0	460.0	2.0	60.0	258.0	0.5
3	3LU99	Dayton	0.559275	1	1075.0	460 460.0	2.0	60.0	218.0	0.5
4	3M265	Dayton	0.246081	1	1625.0	230.0	3.1	60.0	213.0	0.5
5	3RCT2	Century	0.6524875	1	1075.0	230.0	4.6	60.0	417.0	0.5
6	3RCT6	Century	0.7457	1	1140.0	230.0	5.6	60.0	623.0	0.625
7	4M261	Dayton	0.1237862	1	1075.0	230.0	1.3	60.0	106.0	0.5
8	4M263	Dayton	0.37285	1	825.0	230.0	3.1	60.0	216.0	0.5
9	10K094	Genteq	0.37285	2	1625.0	230.0	2.5	60.0	277.0	0.5
10	20RK82	Century	1.11855	1	1140.0	230.0	5.3	60.0	550.0	0.625
11	32NA62	Century	0.186425	1	825.0	230.0	1.2	60.0	175.0	0.5

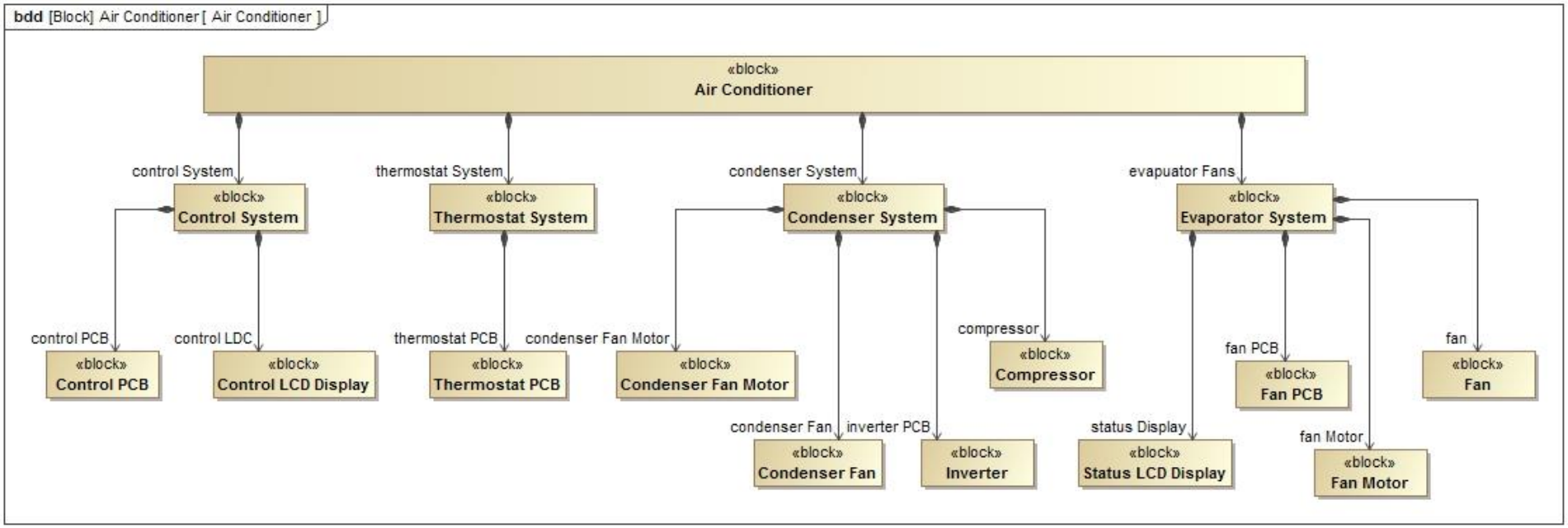
#	Name	Total Power	EER	COP	Compressor	Compressor.Capacity	Condenser Fan Motor	Condenser Fan Motor.Power
1	29AT83_45CE98_	1.677825	10.430170011771192	3.056039813448959	29AT83 : Compressor	17500.0	45CE98 : Condenser Fan Motor	0.559275
2	29AT83_44YU91_	12.30405	1.4222959106960715	0.41673270183394895	29AT83 : Compressor	17500.0	44YU91 : Condenser Fan Motor	11.1855
3	29AT83_40PK42_	1.5659699999999999	11.175182155469136	3.2743283715524565	29AT83 : Compressor	17500.0	40PK42 : Condenser Fan Motor	0.44742
4	29AT83_32NA71_	1.4914	11.73394126324259	3.438044790130079	29AT83 : Compressor	17500.0	32NA71 : Condenser Fan Motor	0.37285
5	29AT83_32NA68_	1.677825	10.430170011771192	3.056039813448959	29AT83 : Compressor	17500.0	32NA68 : Condenser Fan Motor	0.559275
6	29AT83_32NA67_	1.4914	11.73394126324259	3.438044790130079	29AT83 : Compressor	17500.0	32NA67 : Condenser Fan Motor	0.37285
7	29AT83_32NA66_	1.364631	12.823979522669498	3.757426000142163	29AT83 : Compressor	17500.0	32NA66 : Condenser Fan Motor	0.246081
8	29AT83_32NA64_	1.4914	11.73394126324259	3.438044790130079	29AT83 : Compressor	17500.0	32NA64 : Condenser Fan Motor	0.37285

Mass, power, cost rollups

The problem

Requirement:

The total power of air conditioner shall not exceed 1.0 kW.

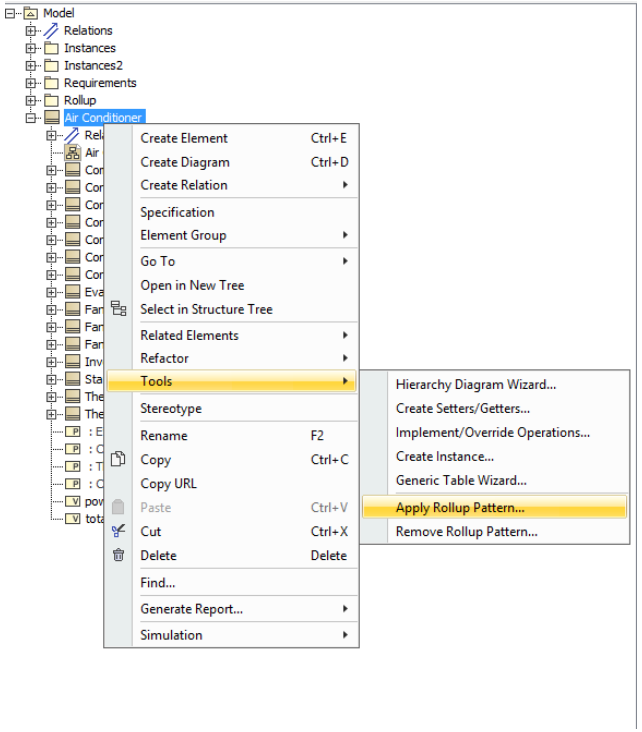


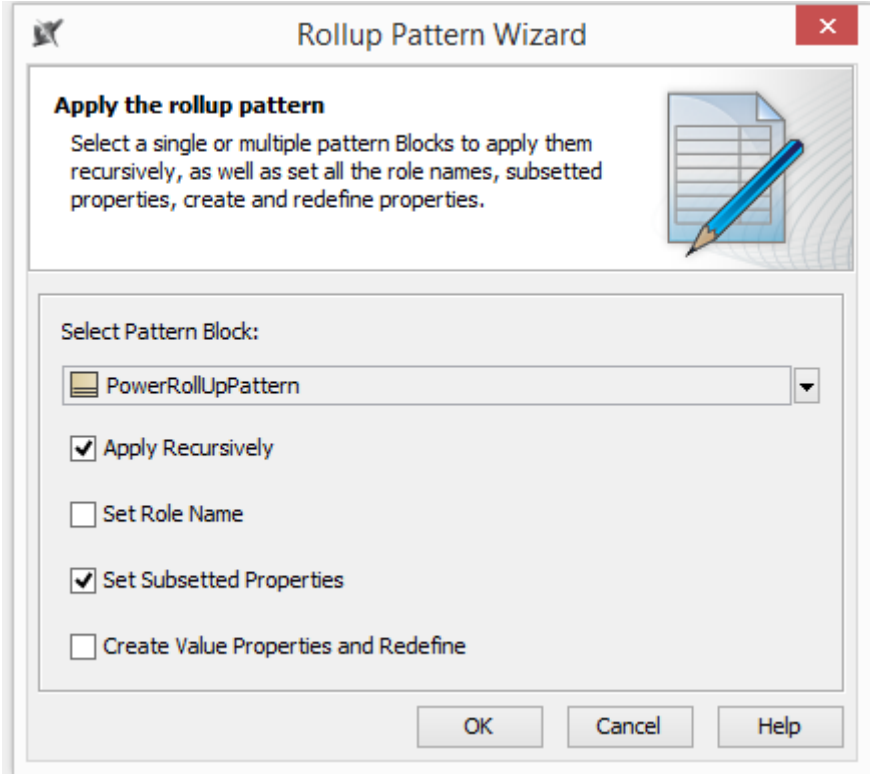
A typical way

- Add property to every block in the structure
- Create Parametric diagrams for every block
- Create “sum(cost1, cost2, …) constraint blocks
- Results
  - many hours of work
  - Polluted model
  - Hundreds of parametric diagrams
  - Need to remodel when add any new part

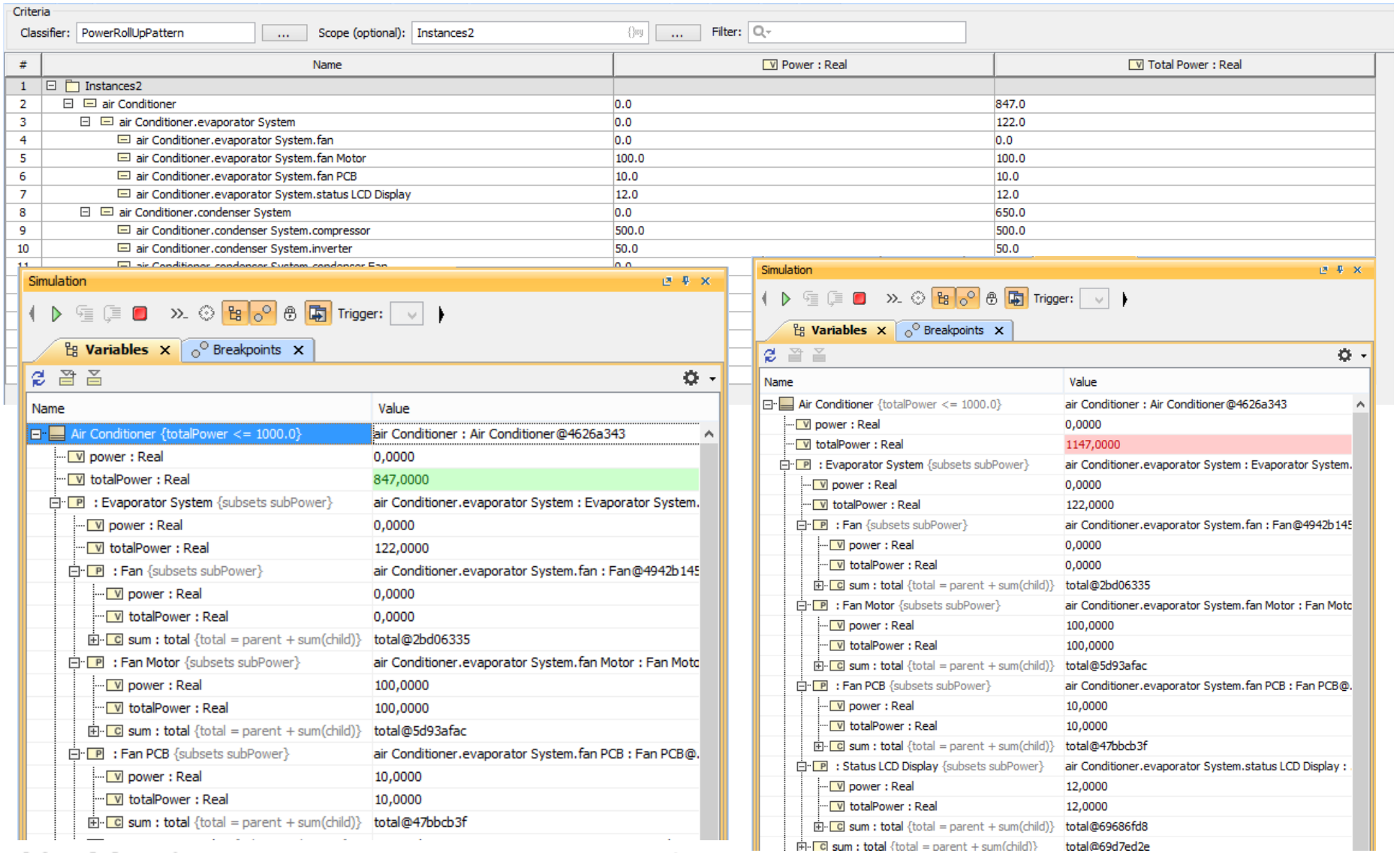
How could we improve that?

- Use inheritance
  - Define everything in some abstract “CostOwner”
  - Inherit parametrics
- Use subsets – say what roles are children
- Automate the process



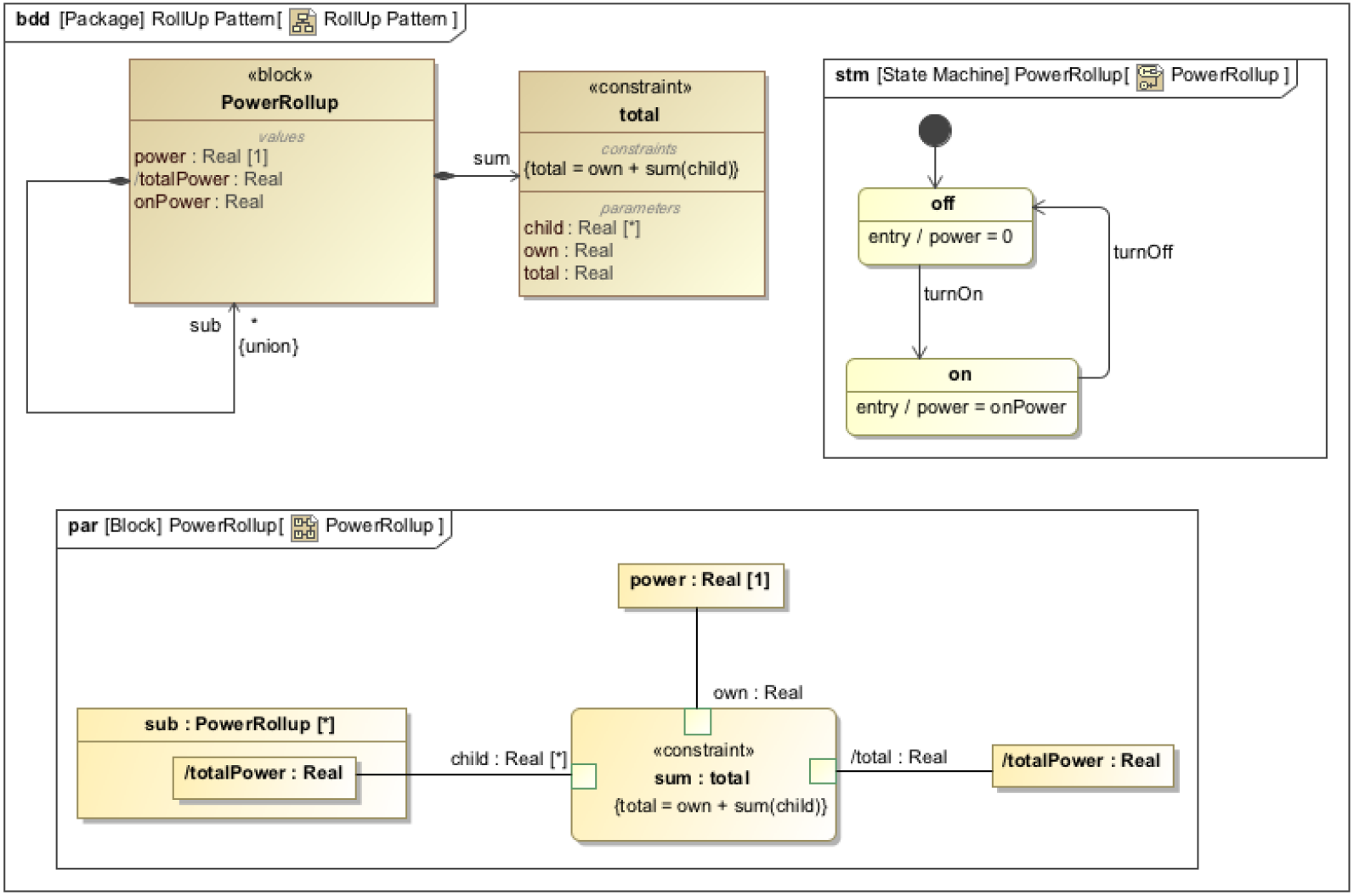


Run Analysis

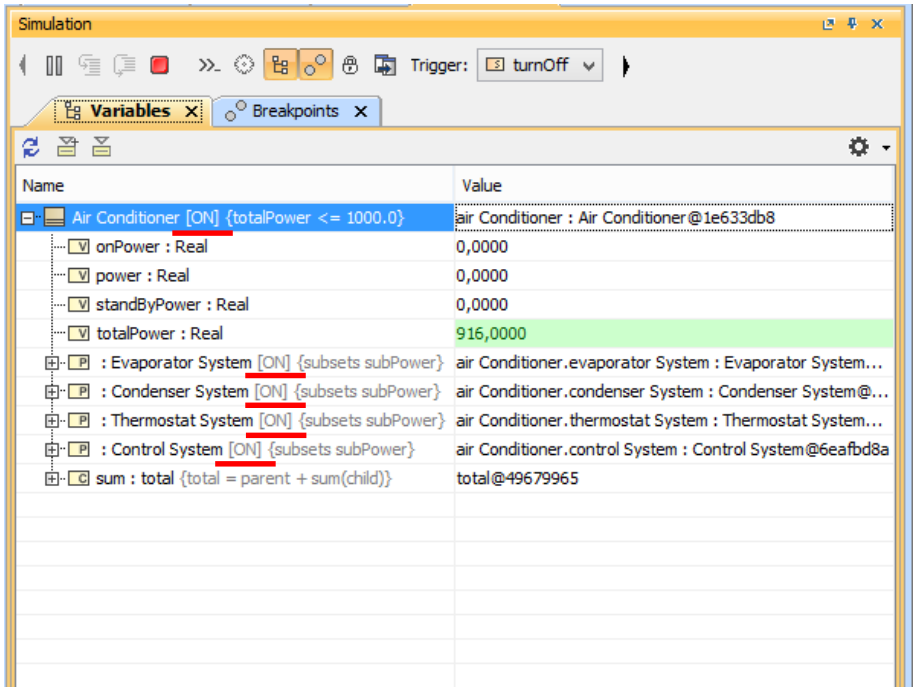


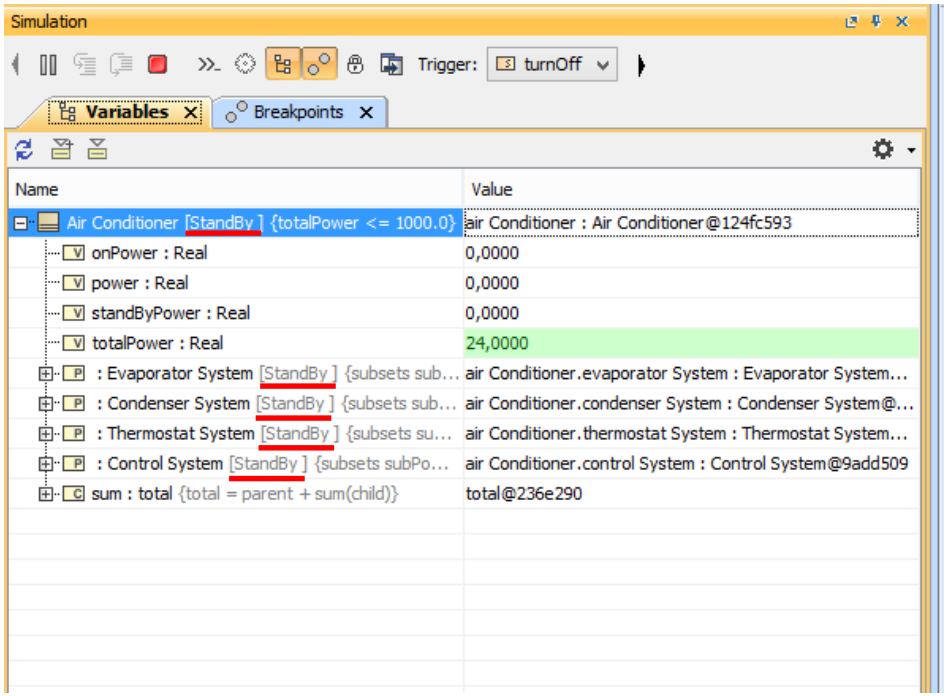
#	Name	Power : Real	Total Power : Real
1	Instances2		
2	air Conditioner	0.0	847.0
3	air Conditioner.evaporator System	0.0	122.0
4	air Conditioner.evaporator System.fan	0.0	0.0
5	air Conditioner.evaporator System.fan Motor	100.0	100.0
6	air Conditioner.evaporator System.fan PCB	10.0	10.0
7	air Conditioner.evaporator System.status LCD Display	12.0	12.0
8	air Conditioner.condenser System	0.0	650.0
9	air Conditioner.condenser System.compressor	500.0	500.0
10	air Conditioner.condenser System.inverter	50.0	50.0

Dynamic rollup



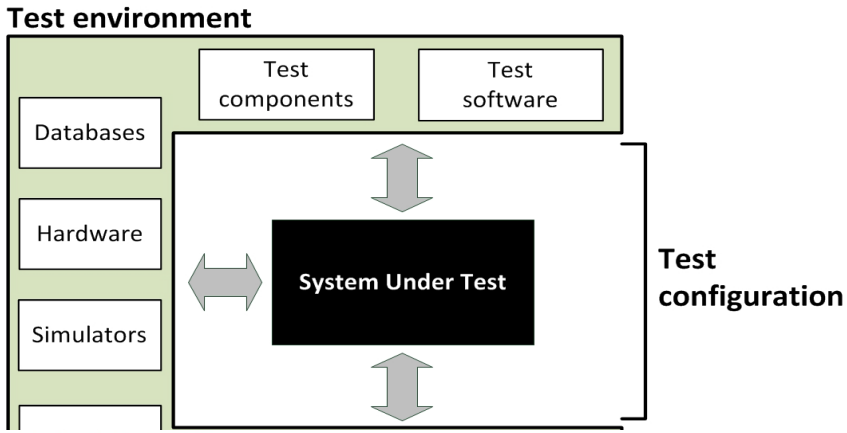
Dynamic rollup

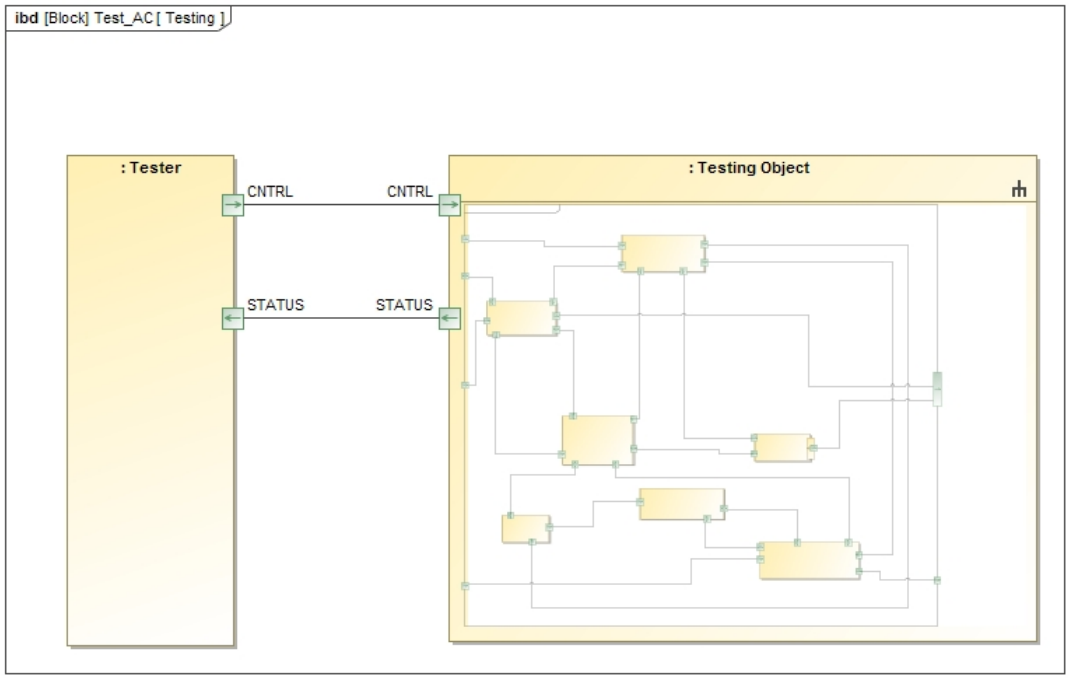


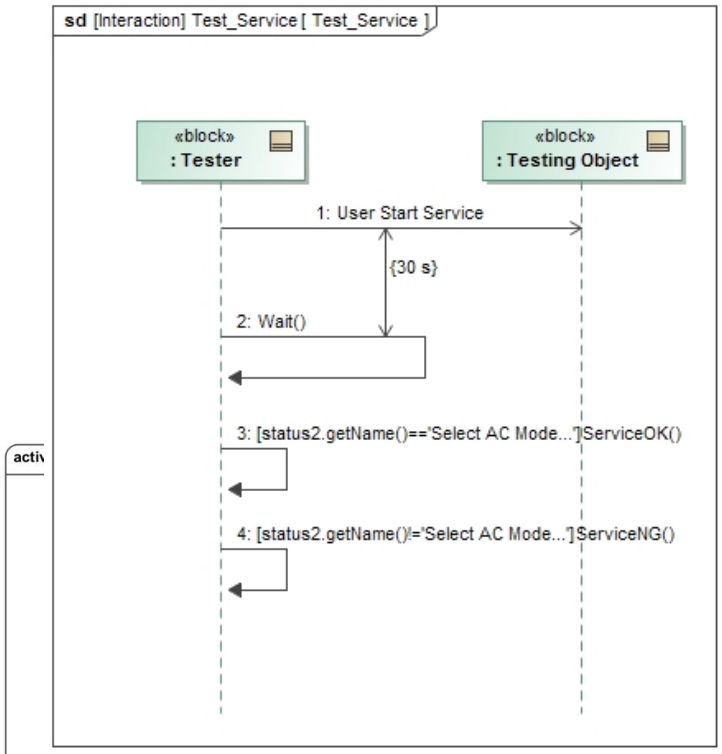


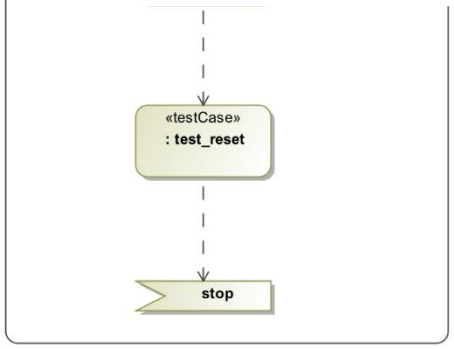
Model based testing

Model-based testing in SysML

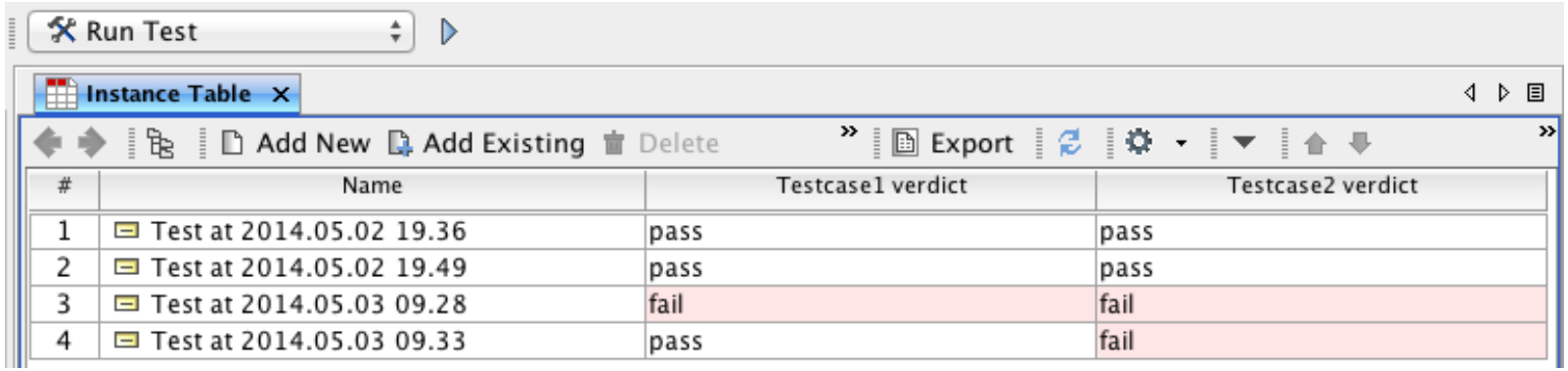








Testing report (Instance Table + Excel)

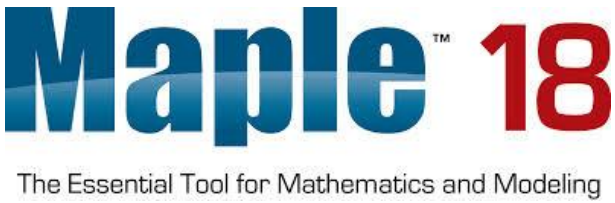


#	Name	Testcase1 verdict	Testcase2 verdict
1	Test at 2014.05.02 19.36	pass	pass
2	Test at 2014.05.02 19.49	pass	pass
3	Test at 2014.05.03 09.28	fail	fail
4	Test at 2014.05.03 09.33	pass	fail

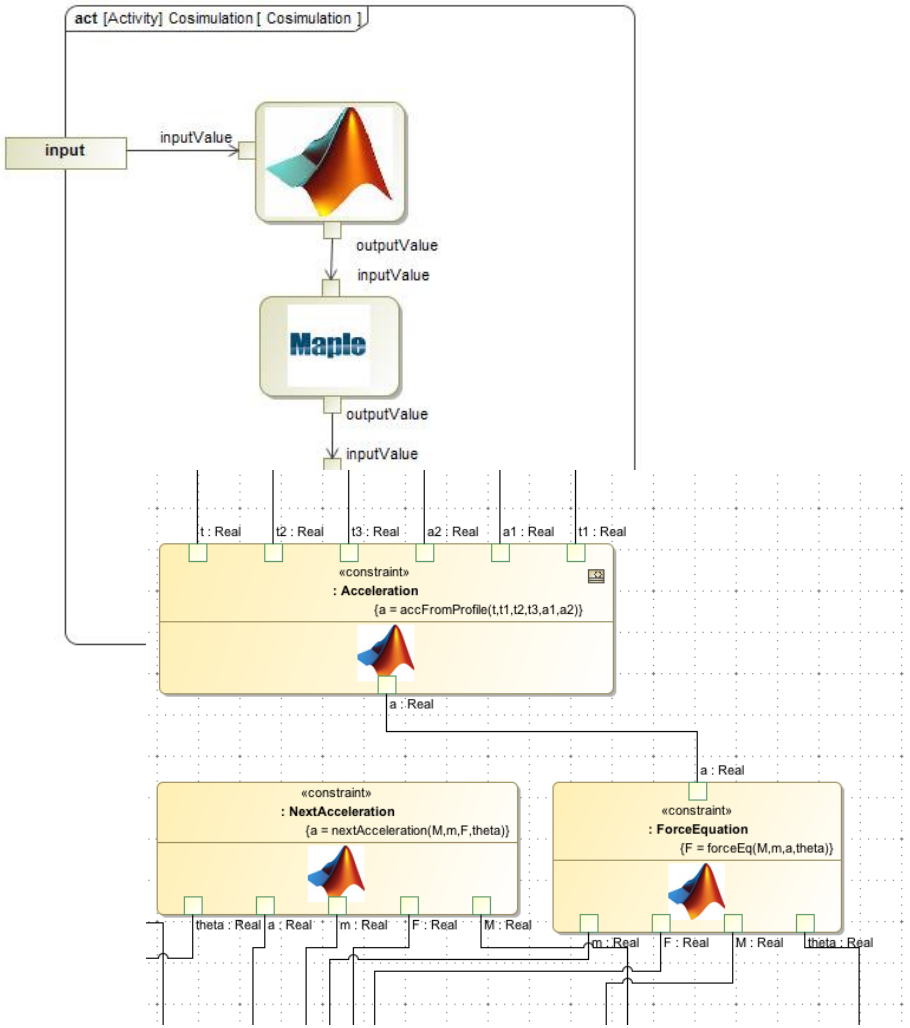
	A	B	C
1			
2	**Test**	**testcase1 verdict**	**testcase2 verdict**
3	Test at 2014.05.02 19.49	pass	pass
4	Test at 2014.05.02 19.36	pass	pass
5	Test at 2014.05.03 09.28	fail	fail
6	Test at 2014.05.03 09.33	pass	fail

Integration of Analytics Model

Integration of Analytics Models



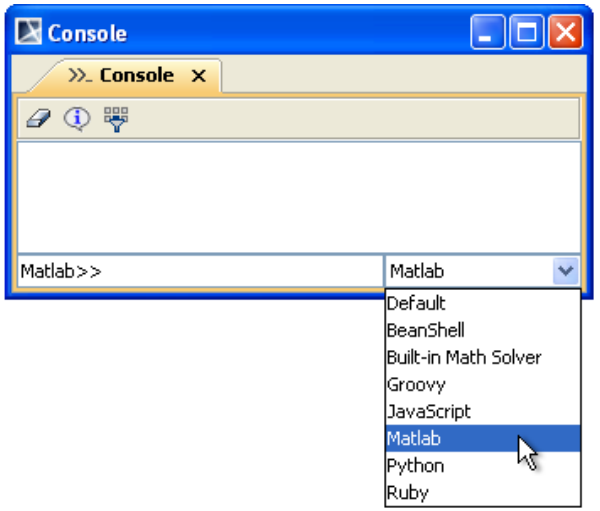
Cameo Simulation Toolkit



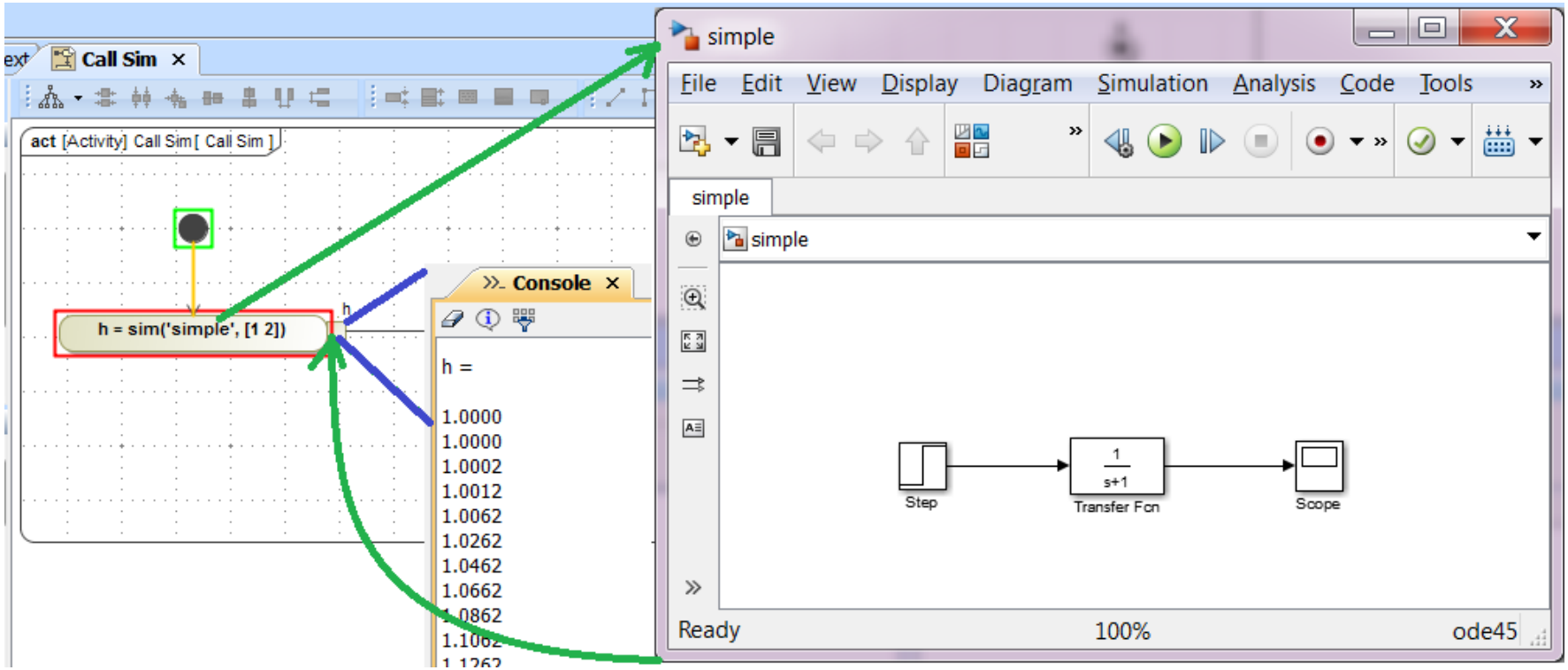
Math engines

- Matlab/Simulink
- Mathematica
- Maple
- Open Modelica

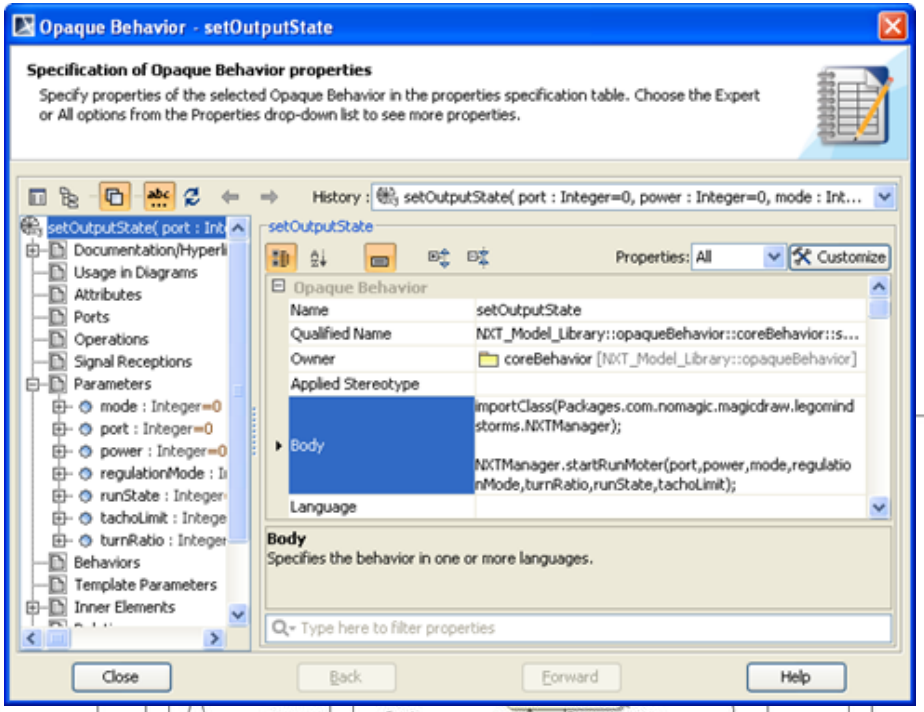
- Scripting
  - Javascript
  - Python
  - Groovy
  - Ruby

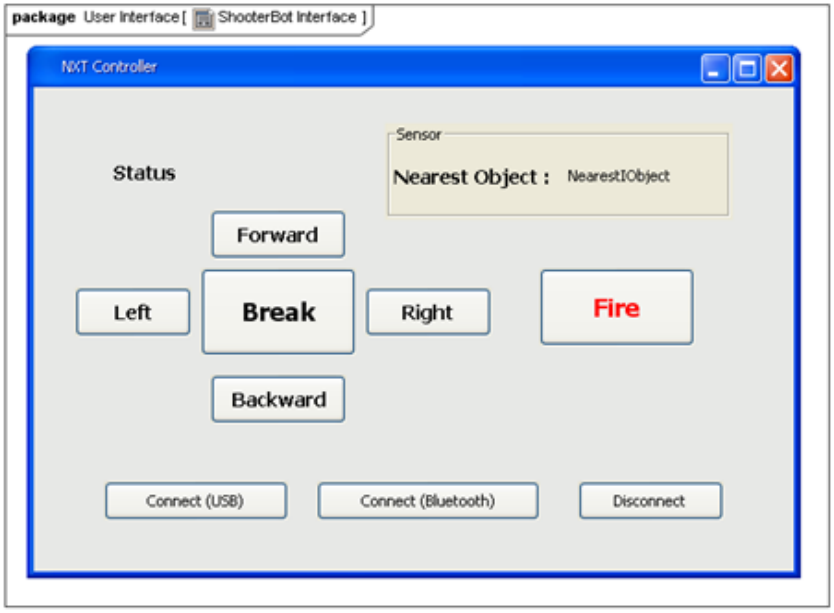


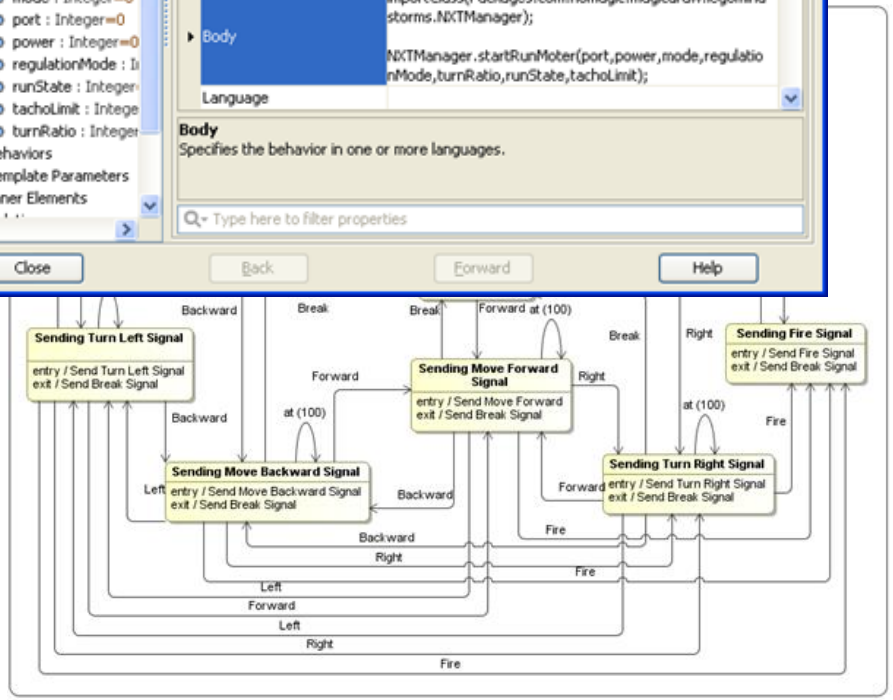
Co-simulation: Invoking Simulink Model



Scripting, external APIs







Summary

With simulation you can:

- Enhance user understanding by using animation and debugging
- Define your system behavior by using activity and states diagrams
- Create user interface mockup
- Do engineering analysis by using rollups, trade studies, system testing
- Integrate with other analytic tools

Thank You !

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