Towards Model-Based Testing of Domain-Specific Modelling Languages

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VTT

Business from technology

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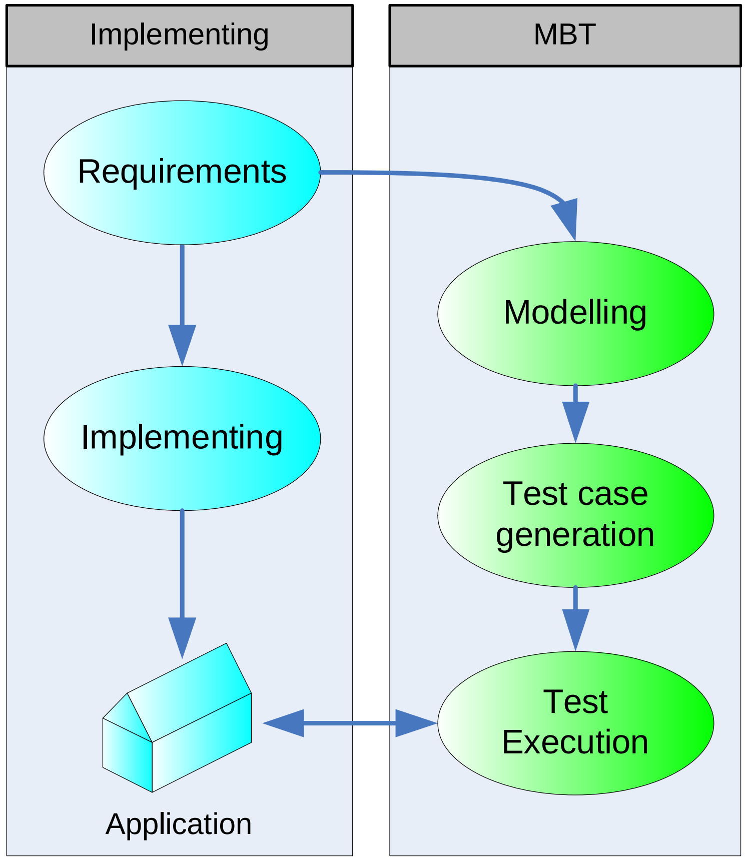
Testing Domain-Specific Modelling Languages (DSML)

- Currently: Manual testing during iterative and incremental DSML development
- Problems:
  - Test applications in synch in metamodel?
  - **Test coverage**
- How DSML testing can be **systematized** and **automated**?

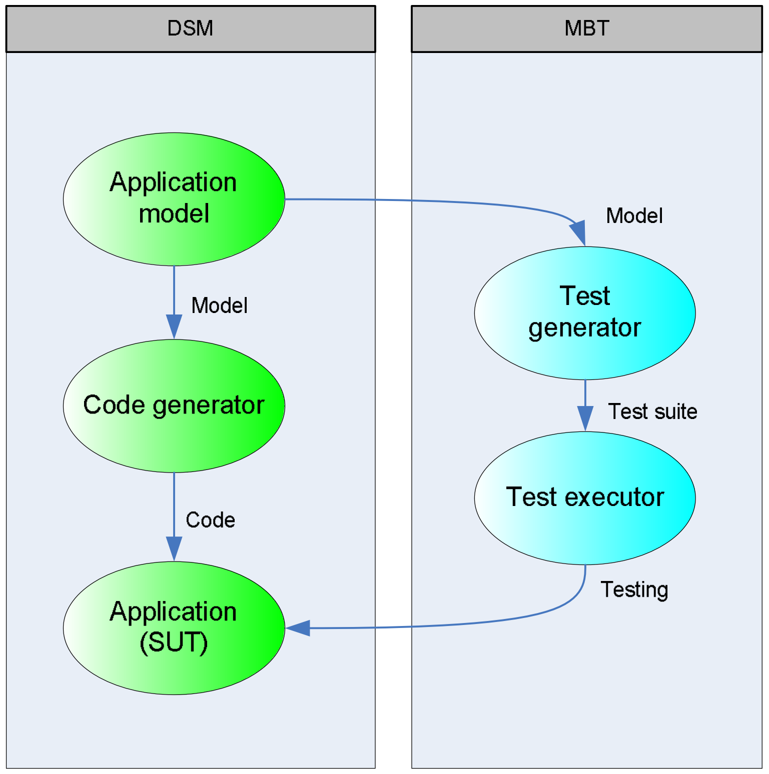
Model-Based Testing (MBT)

- MBT is a black box testing technique
- Phases:
  1. **Modelling**
  2. **Test generation**
  3. **Test execution**
- MBT is decreasing test suite maintenance efforts and improves coverage.



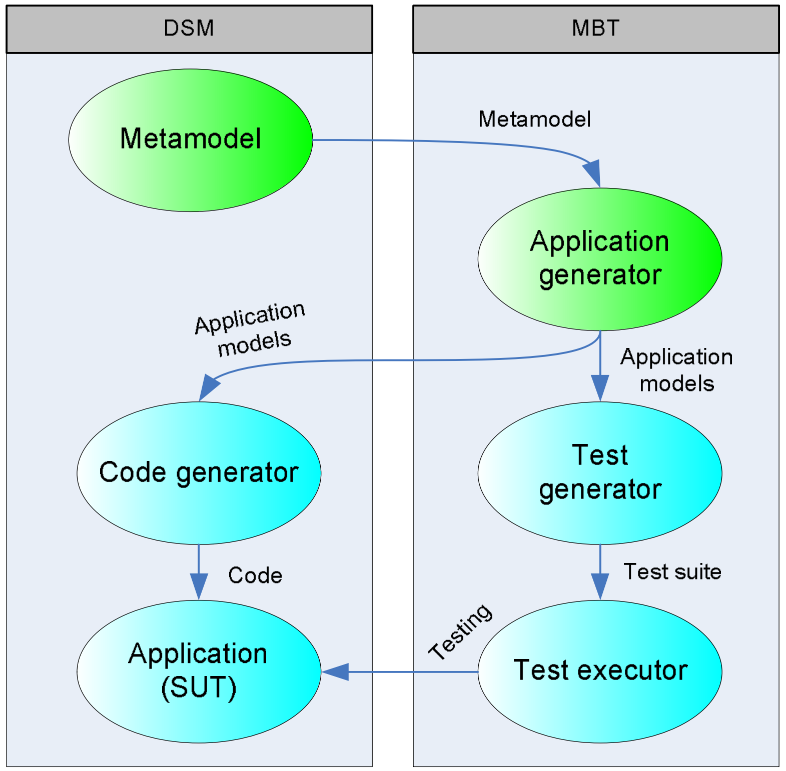
Application Testing

- Tests and the implementation are generated from the same model
- Code generator and metamodel (from the utilized parts) are under testing
- Comprehensive test suite is automatically generated and always in synch with implementation



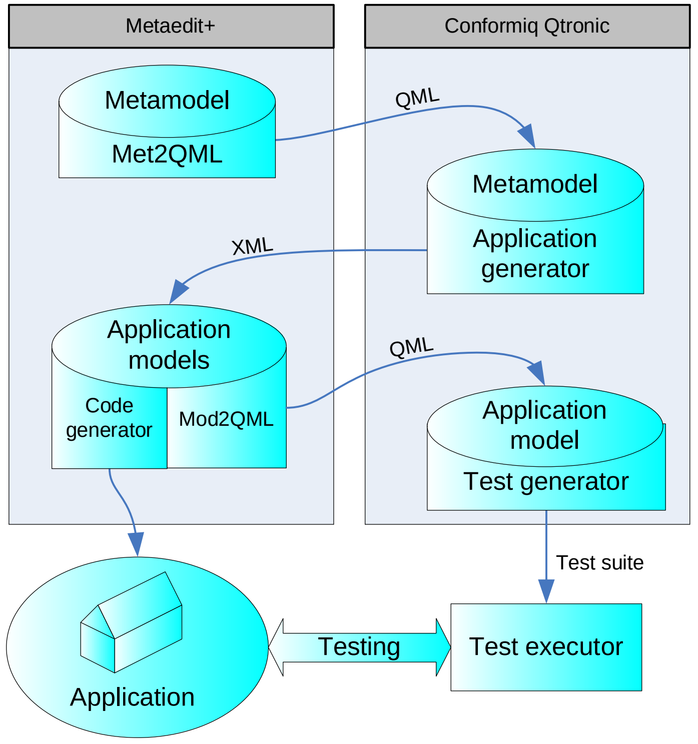
Modelling Language Testing

- One application can be considered as one test case. Multiple test cases are required!
- Metamodel describes rules of the language
- We argue that applications can be generated from metamodel definitions



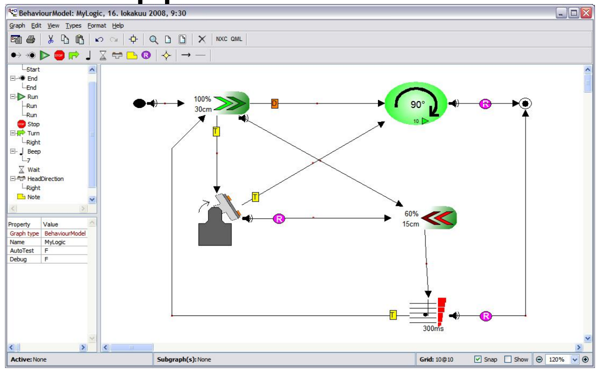
Test Suite Generation in Practice

- DSM tool requirements
  - Allows exporting the metamodel and importing the application models
  - MetaEdit+ fulfils the requirements
- MBT tool requirements
  - Supports model importing and exporting the test cases
  - Conformiq Qtronic fulfils the requirements



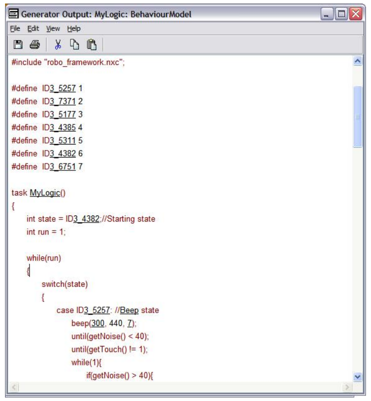
Case Lego: Generating Application

Application model



Property	Value
Graph type	BehaviourModel
Name	MyLogic
AutoTest	F
Debug	F

Generated code



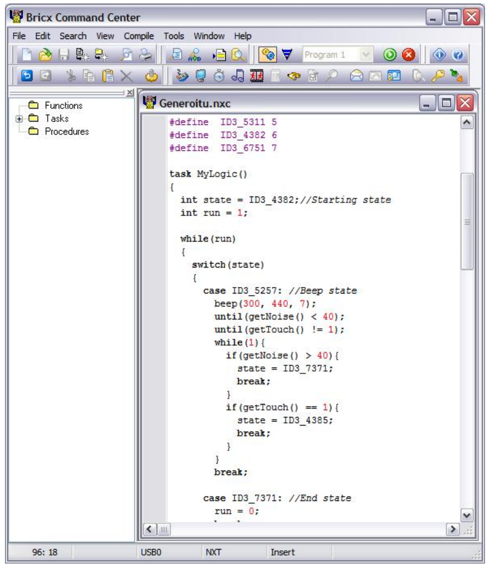
```
#include "robo_framework.nxc";

#define  ID3_5257 1
#define  ID3_7371 2
#define  ID3_5177 3
#define  ID3_4385 4
#define  ID3_5311 5
#define  ID3_4382 6
#define  ID3_6751 7

task MyLogic()
{
    int state = ID3_4382;//Starting state
    int run = 1;

    while(run)
    {
        switch(state)
        {
            case ID3_5257: //Beep state
                beep(300, 440, 7);
                until(getNoise() < 40);
                until(getTouch() != 1);
                while(1){
                    if(getNoise() > 40){
```

Compiling



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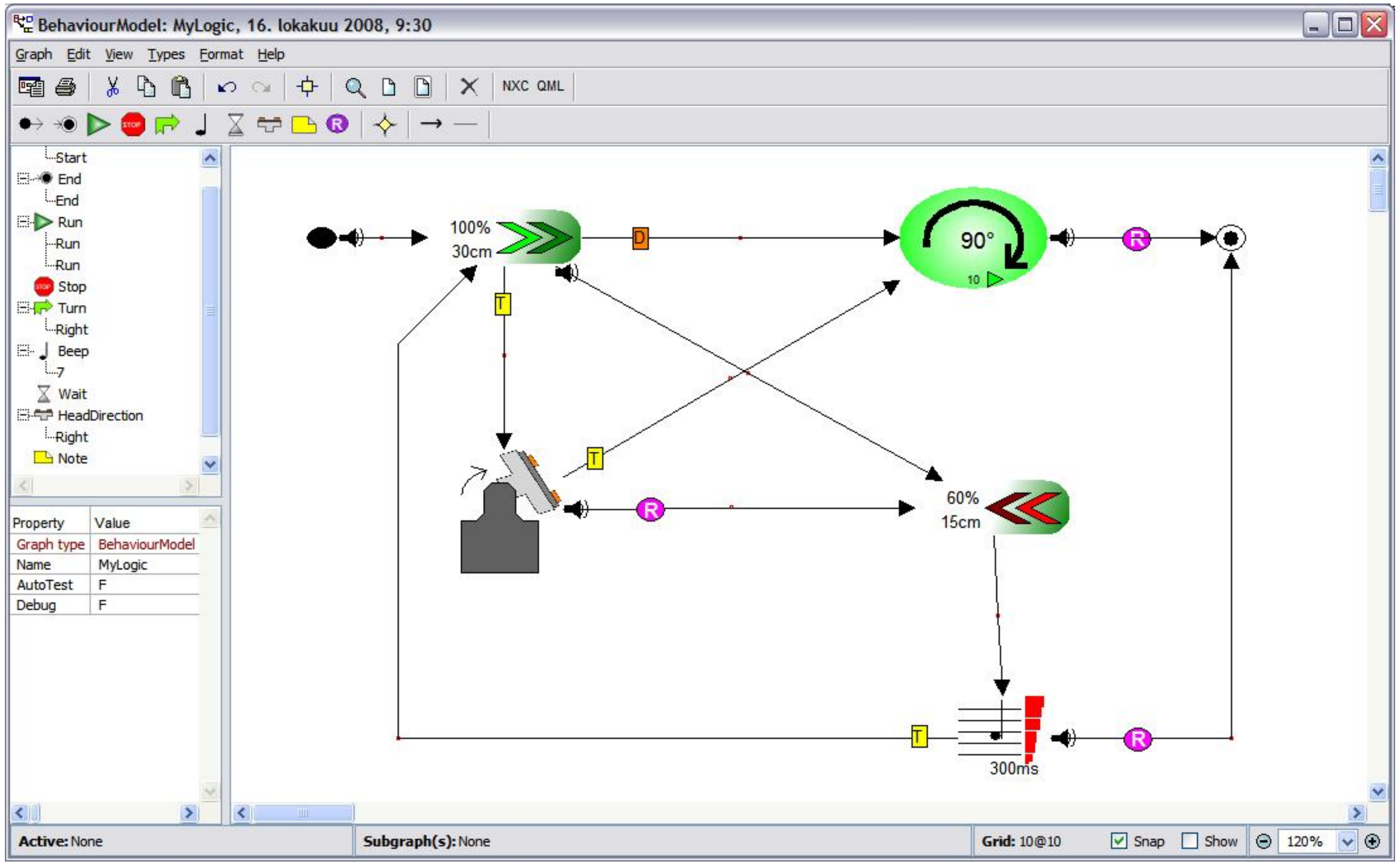
        until(getNoise() < 40);
        until(getTouch() != 1);
        while(1){
          if(getNoise() > 40){
            state = ID3_7371;
            break;
          }
          if(getTouch() == 1){
            state = ID3_4385;
            break;
          }
        }
        break;

      case ID3_7371: //End state
        run = 0;
```

Application Execution

Application Model



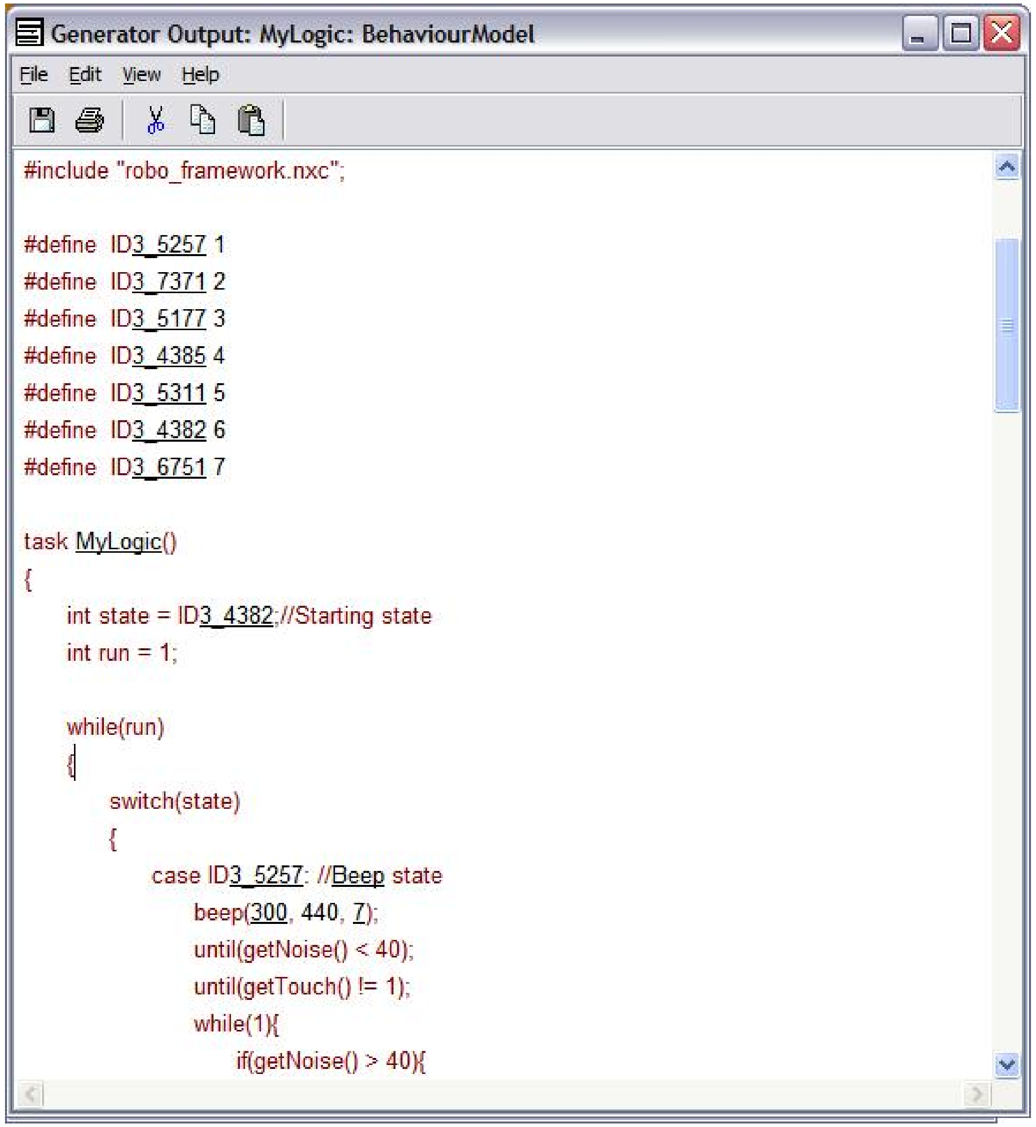
Property	Value
Graph type	BehaviourModel
Name	MyLogic
AutoTest	F
Debug	F

Active: None

Subgraph(s): None

Grid: 10@10 [✓ Snap] Show 120%

Generated Code



```
#include "robo_framework.nxc";

#define  ID3_5257 1
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#define  ID3_5177 3
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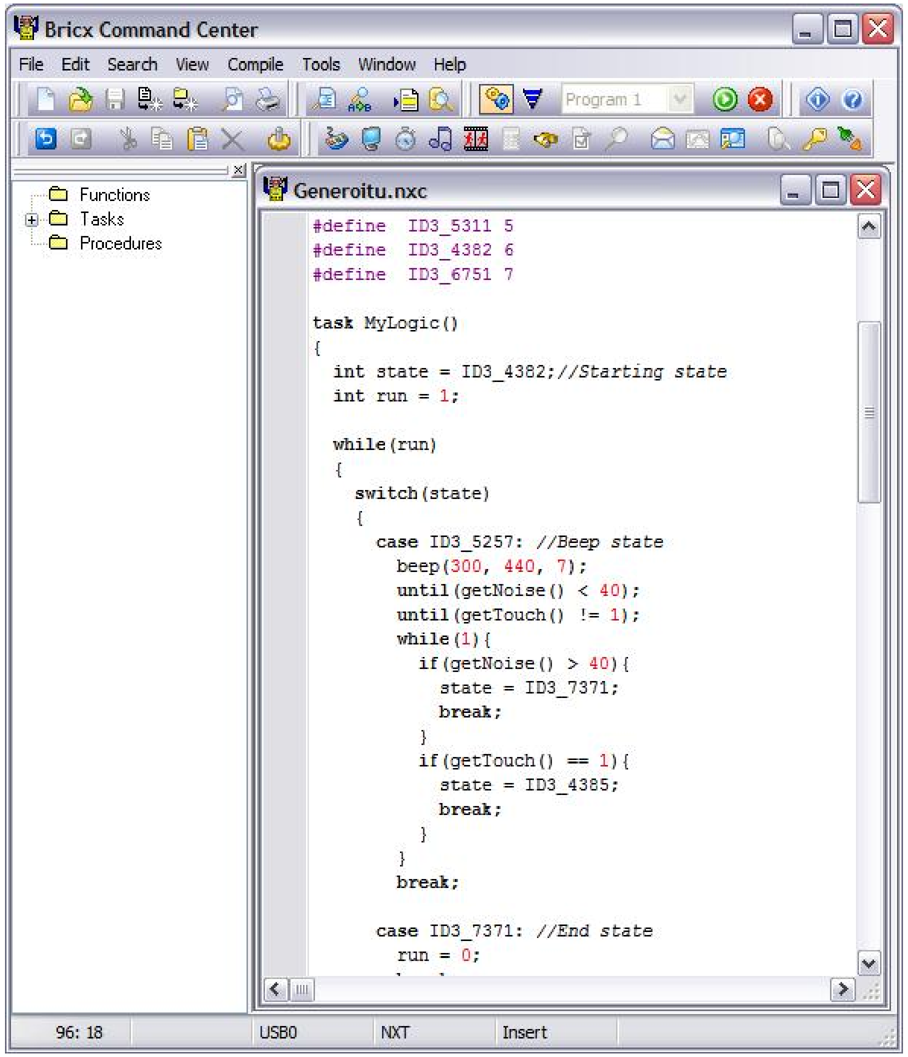
Compiling



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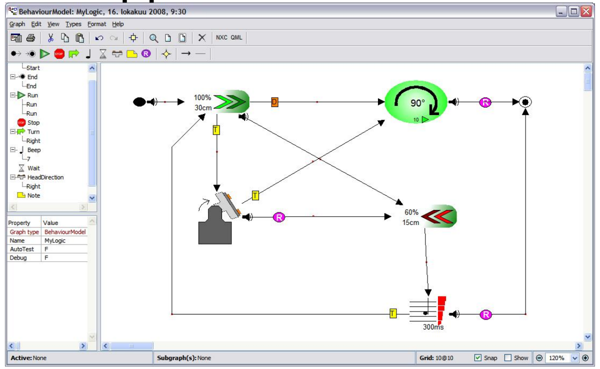
            state = ID3_7371;
            break;
          }
          if(getTouch() == 1){
            state = ID3_4385;
            break;
          }
        }
        break;

      case ID3_7371: //End state
        run = 0;
```

Application Execution

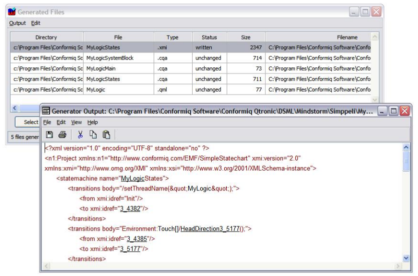
Case Lego: Generating Tests

Application model



Property	Value
Graph type	BehaviourModel
Name	MyLogic
AutoTest	F
Debug	F

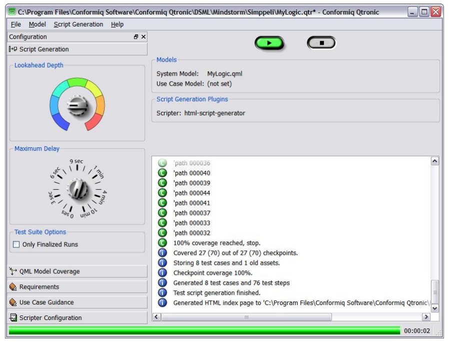
Model into QML format


Generated Files
Output Edit
Select
5 files gener
Generator Output: C:\Program Files\Conformiq Software\Conformiq Qtronic\DSML\Mindstorm\Simppeli\My...
File Edit View Help

Directory	File	Type	Status	Size	Filename
c:\Program Files\Conformiq Sc	MyLogicStates	.xmi	written	2347	C:\Program Files\Conformiq Software\Confo
c:\Program Files\Conformiq Sc	MyLogicSystemBlock	.cqa	unchanged	714	C:\Program Files\Conformiq Software\Confo
c:\Program Files\Conformiq Sc	MyLogicMain	.cqa	unchanged	73	C:\Program Files\Conformiq Software\Confo
c:\Program Files\Conformiq Sc	MyLogicStates	.cqa	unchanged	711	C:\Program Files\Conformiq Software\Confo
c:\Program Files\Conformiq Sc	MyLogic	.qml	unchanged	77	C:\Program Files\Conformiq Software\Confo

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<n1:Project xmlns:n1="http://www.conformiq.com/EMF/SimpleStatechart" xmi:version="2.0"
xmlns:xmi="http://www.omg.org/XMI" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <statemachine name="MyLogicStates">
        <transitions body="/setThreadName(&quot;MyLogic&quot;);">
            <from xmi:idref="Init"/>
            <to xmi:idref="3_4382"/>
        </transitions>
        <transitions body="Environment:Touch[]/HeadDirection3_5177();">
            <from xmi:idref="3_4385"/>
            <to xmi:idref="3_5177"/>
        </transitions>
```

Test generation



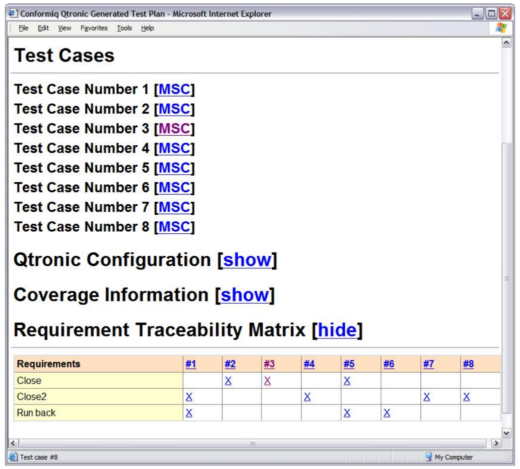
System Model: MyLogic.qml
Use Case Model: (not set)

Scripter: html-script-generator

```
'path 000036
'path 000040
'path 000039
'path 000044
'path 000041
'path 000037
'path 000033
'path 000032
100% coverage reached, stop.
Covered 27 (70) out of 27 (70) checkpoints.
Storing 8 test cases and 1 old assets.
Checkpoint coverage 100%.
Generated 8 test cases and 76 test steps
Test script generation finished.
Generated HTML index page to 'C:\Program Files\Conformiq Software\Conformiq Qtronic\
```

00:00:02

Test cases


Conformiq Qtronic Generated Test Plan - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Test case #8
My Computer

Test Cases

Test Case Number 1 [MSC]
Test Case Number 2 [MSC]
Test Case Number 3 [MSC]
Test Case Number 4 [MSC]
Test Case Number 5 [MSC]
Test Case Number 6 [MSC]
Test Case Number 7 [MSC]
Test Case Number 8 [MSC]

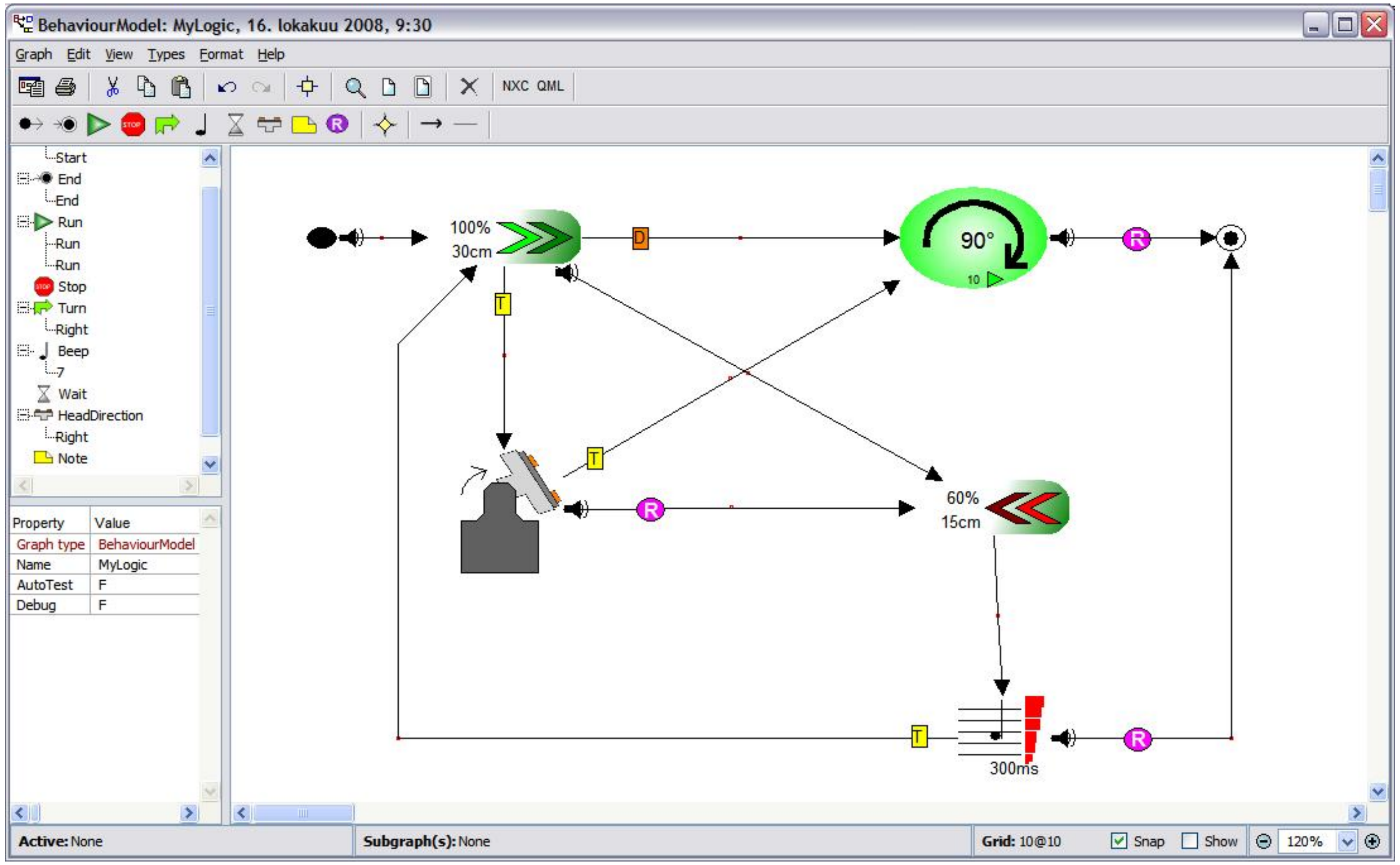
Qtronic Configuration [show]

Coverage Information [show]

Requirement Traceability Matrix [hide]

Requirements	#1	#2	#3	#4	#5	#6	#7	#8
Close		X	X		X			
Close2	X			X			X	X
Run back	X				X	X		

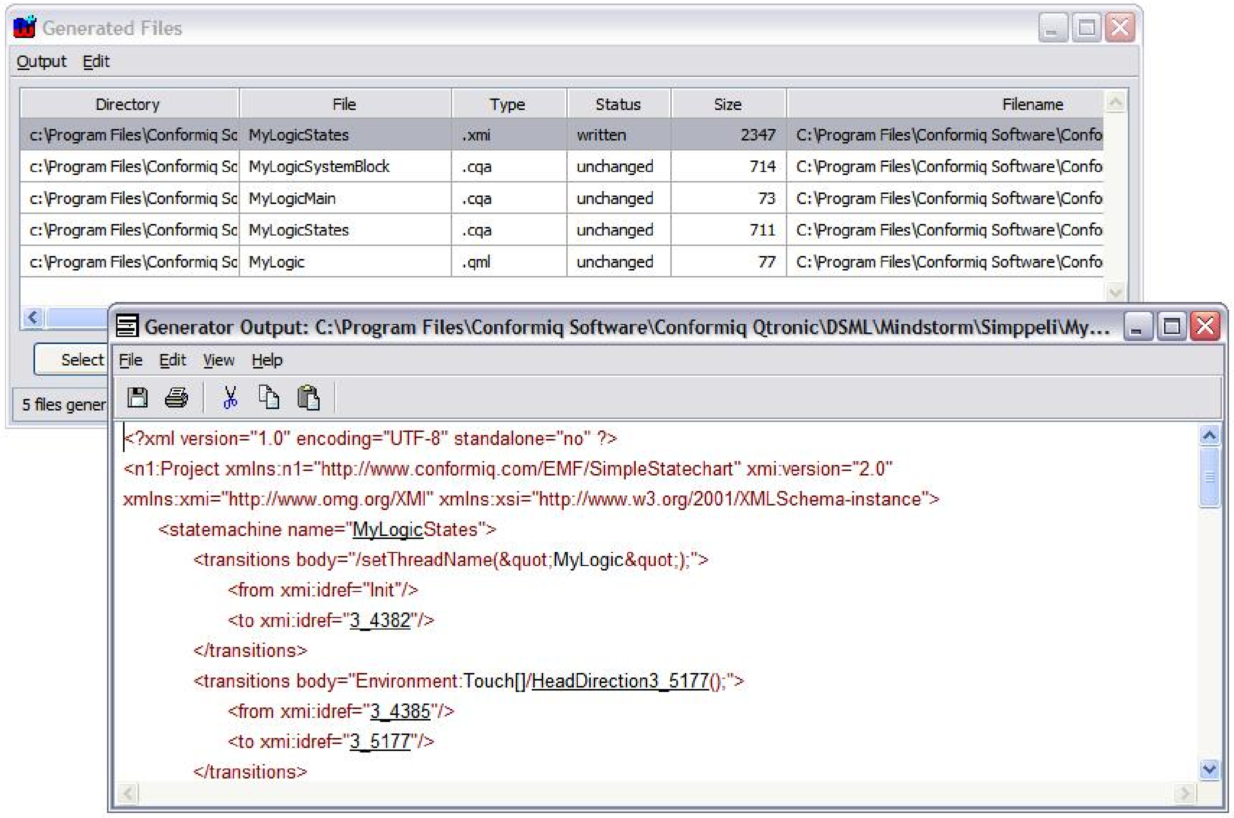
Application Model



Property	Value
Graph type	BehaviourModel
Name	MyLogic
AutoTest	F
Debug	F

Active: None
Subgraph(s): None
Grid: 10@10 ☑ Snap ☐ Show 120%

Transform the Model into QML Format


Generated Files
Output Edit
Select
5 files gener
Generator Output: C:\Program Files\Conformiq Software\Conformiq Qtronic\DSML\Mindstorm\Simppeli\My...
File Edit View Help

Directory	File	Type	Status	Size	Filename
c:\Program Files\Conformiq Sc	MyLogicStates	.xmi	written	2347	C:\Program Files\Conformiq Software\Confo
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<n1:Project xmlns:n1="http://www.conformiq.com/EMF/SimpleStatechart" xmi:version="2.0"
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    <statemachine name="MyLogicStates">
        <transitions body="/setThreadName(&quot;MyLogic&quot;);">
            <from xmi:idref="Init"/>
            <to xmi:idref="3_4382"/>
        </transitions>
        <transitions body="Environment:Touch[]/HeadDirection3_5177();">
            <from xmi:idref="3_4385"/>
            <to xmi:idref="3_5177"/>
        </transitions>
```
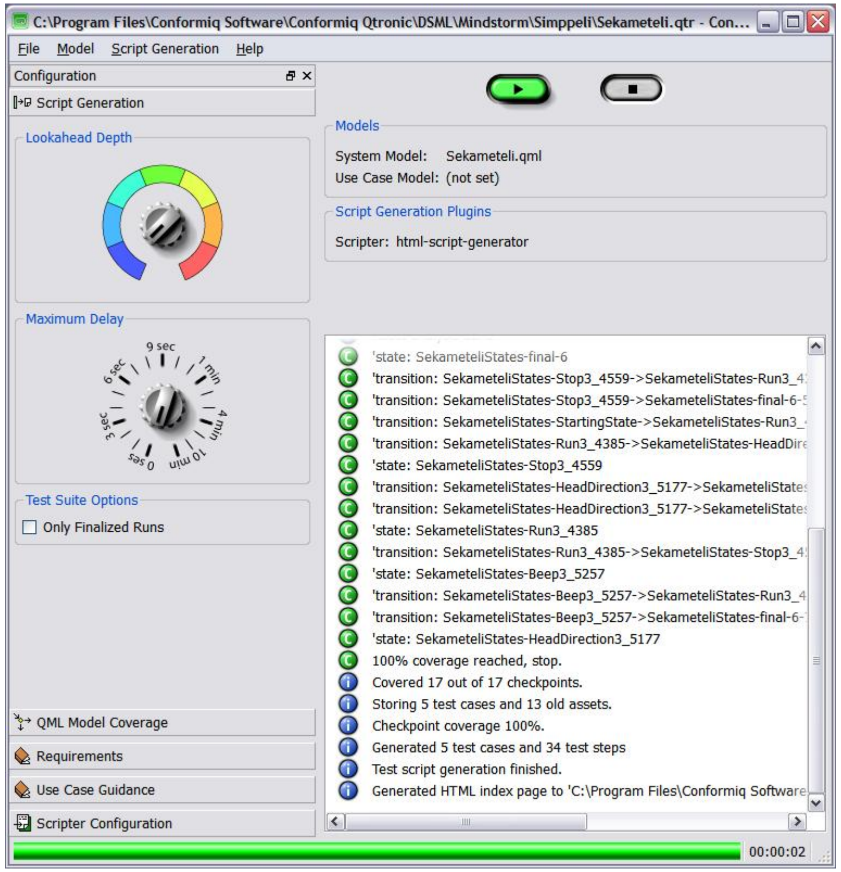

Test Generation



Only Finalized Runs

Models

System Model: Sekameteli.qml
Use Case Model: (not set)

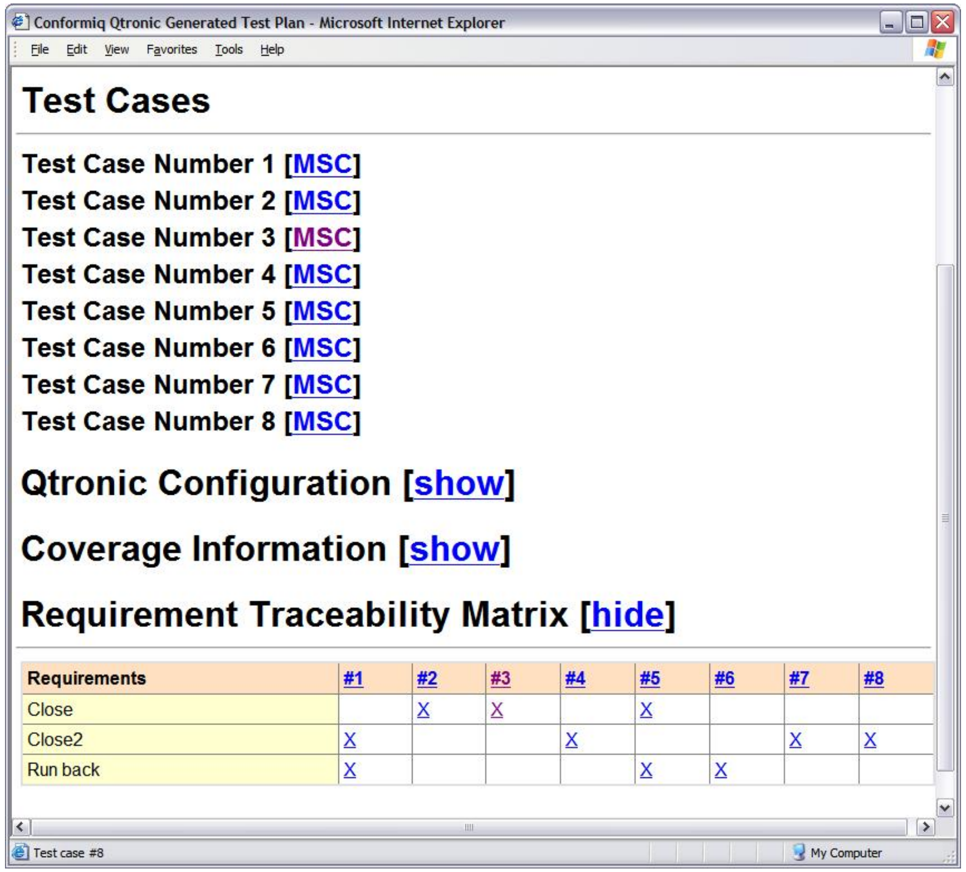
Script Generation Plugins

Scripter: html-script-generator

```
'state: SekameteliStates-final-6
'transition: SekameteliStates-Stop3_4559->SekameteliStates-Run3_4
'transition: SekameteliStates-Stop3_4559->SekameteliStates-final-6-
'transition: SekameteliStates-StartingState->SekameteliStates-Run3_
'transition: SekameteliStates-Run3_4385->SekameteliStates-HeadDir
'state: SekameteliStates-Stop3_4559
'transition: SekameteliStates-HeadDirection3_5177->SekameteliState
'transition: SekameteliStates-HeadDirection3_5177->SekameteliState
'state: SekameteliStates-Run3_4385
'transition: SekameteliStates-Run3_4385->SekameteliStates-Stop3_4
'state: SekameteliStates-Beep3_5257
'transition: SekameteliStates-Beep3_5257->SekameteliStates-Run3_4
'transition: SekameteliStates-Beep3_5257->SekameteliStates-final-6-
'state: SekameteliStates-HeadDirection3_5177
100% coverage reached, stop.
Covered 17 out of 17 checkpoints.
Storing 5 test cases and 13 old assets.
Checkpoint coverage 100%.
Generated 5 test cases and 34 test steps
Test script generation finished.
Generated HTML index page to 'C:\Program Files\Conformiq Software
```

00:00:02

Test Execution


Conformiq Qtronic Generated Test Plan - Microsoft Internet Explorer
File Edit View Favorites Tools Help

Test Cases

Test Case Number 1 [MSC]
Test Case Number 2 [MSC]
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Test Case Number 6 [MSC]
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Test Case Number 8 [MSC]

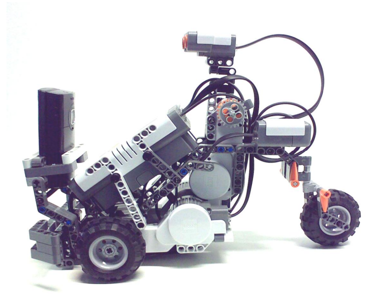
Qtronic Configuration [show]

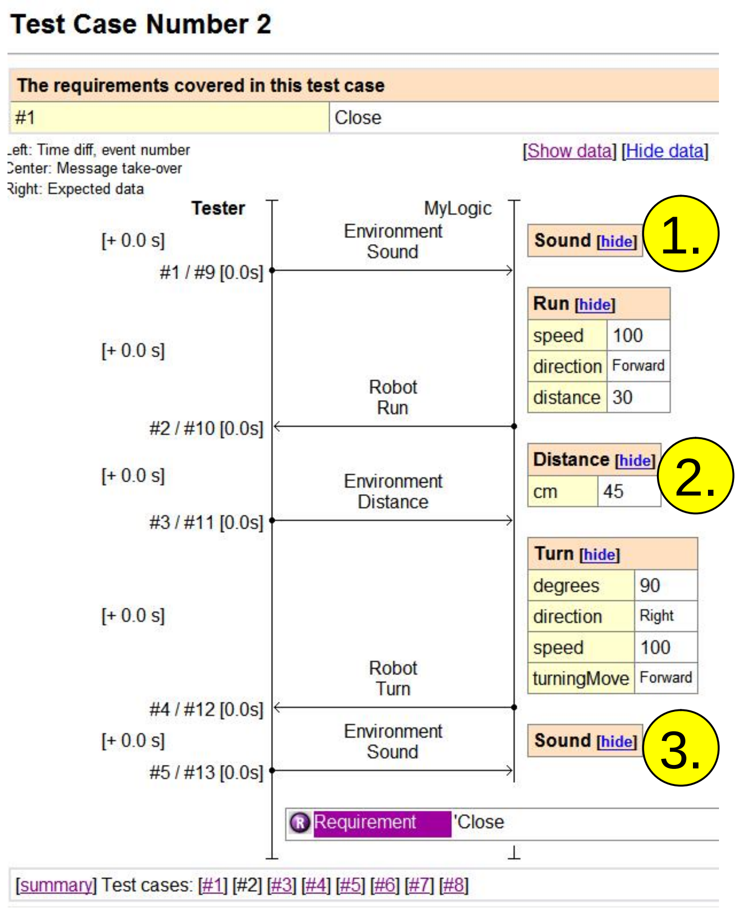
Coverage Information [show]

Requirement Traceability Matrix [hide]

Requirements	#1	#2	#3	#4	#5	#6	#7	#8
Close		X	X		X			
Close2	X			X			X	X
Run back	X				X	X		

Case Lego: One Generated Test Case





Test Case Number 2

The requirements covered in this test case	
#1	Close

Left: Time diff, event number
Center: Message take-over
Right: Expected data

[Show data] [Hide data]

Tester — MyLogic

[+ 0.0 s] Environment Sound → #1 / #9 [0.0s]

Sound [hide] 1.

[+ 0.0 s] Robot Run ← #2 / #10 [0.0s]

Run [hide]	
speed	100
direction	Forward
distance	30

[+ 0.0 s] Environment Distance → #3 / #11 [0.0s]

Distance [hide]	
cm	45

2.

[+ 0.0 s] Robot Turn ← #4 / #12 [0.0s]

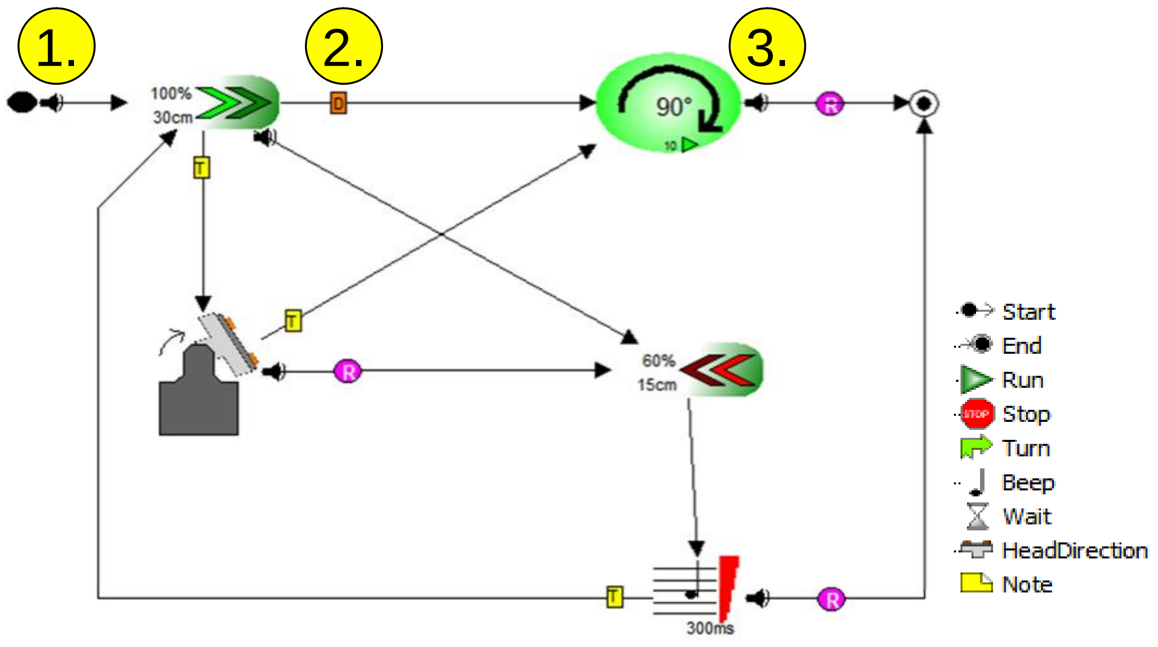
Turn [hide]	
degrees	90
direction	Right
speed	100
turningMove	Forward

[+ 0.0 s] Environment Sound → #5 / #13 [0.0s]

Sound [hide] 3.

Requirement 'Close

[summary] Test cases: [#1] [#2] [#3] [#4] [#5] [#6] [#7] [#8]



Future Research

- More applications model tests
- Metamodel testing and make a demo of that
- Identifying the most potential domains, and possible restrictions.
- Identifying effects in quality, processes…

Questions?