Möbius Tool

LAB 01

Contacts

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Overview

1. Brief introduction to the Möbius tool
2. Elements of the projects
3. TMR example
4. Exercise

Brief introduction to Möbius Tool

Möbius™ is a software tool for modeling the behavior of complex systems.

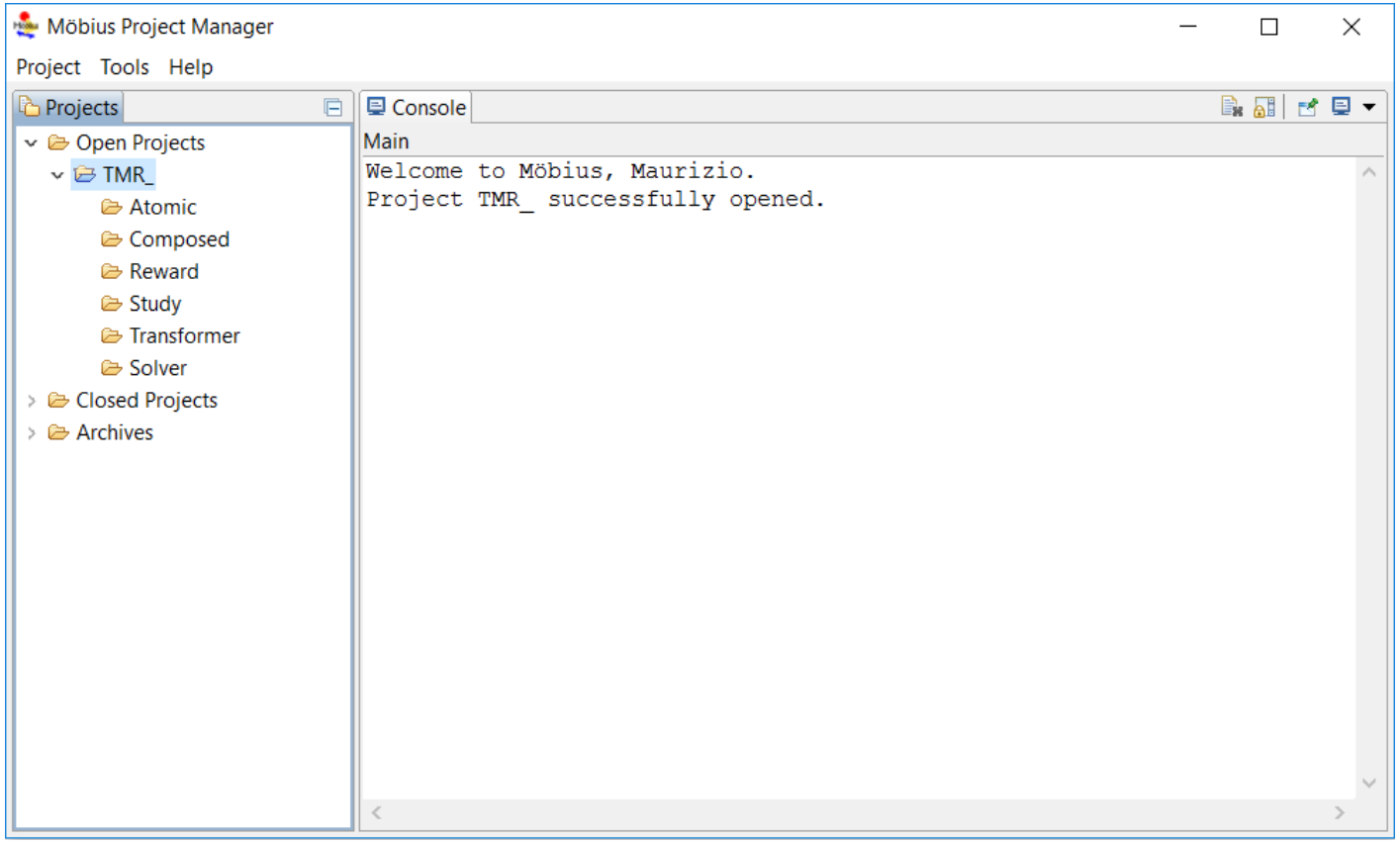
It was originally developed for studying the reliability, availability, and performance of computer and network systems.

It is used for a broad range systems, from biochemical reactions within genes to the effects of malicious attackers on secure computer systems.

Möbius Features

- **Multiple modeling languages**
- **Hierarchical modeling paradigm**
- **Customized measures of system properties**
- **Study the behavior of the system under a variety of operating conditions**
- **Numerical solution techniques**

Project elements



Every project is made of 6 kinds of elements:

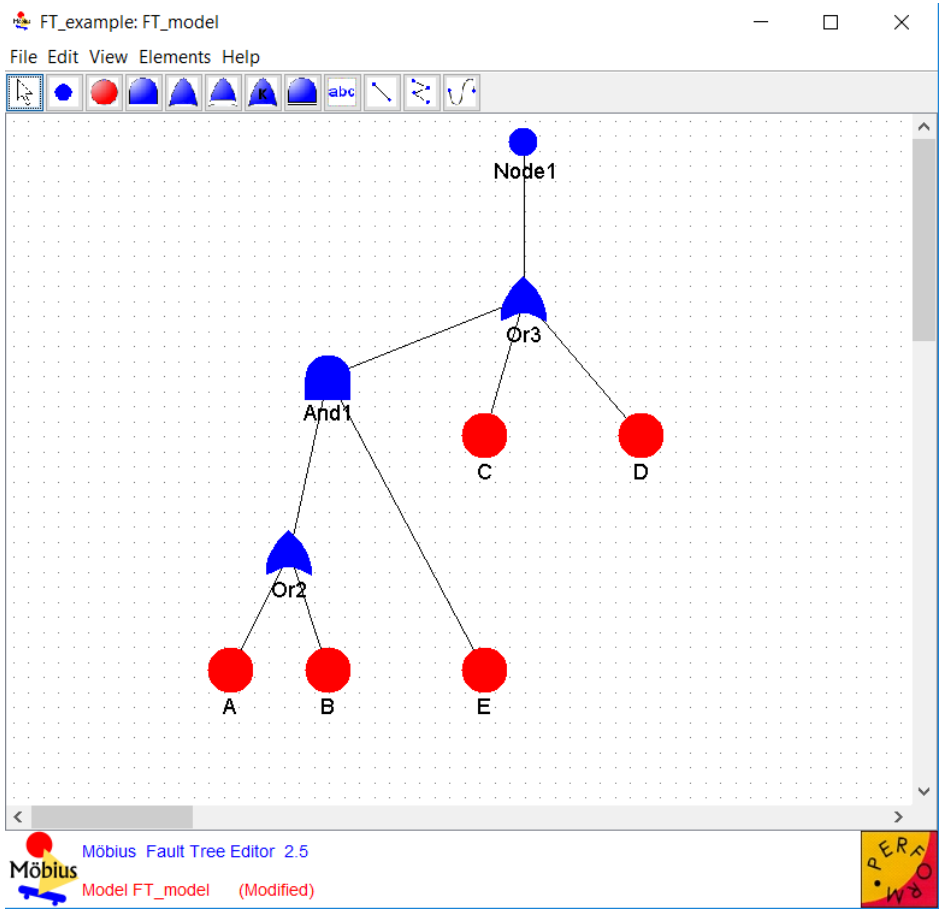
1. **Atomic Model**
2. **Composed Model**
3. **Reward**
4. **Study**
5. **Transformer**
6. **Solver**

Atomic model

Each model is composed of one or more sub-models, also referred to as *atomic models*.

You can create and edit atomic models using different graphic editors.

These models also allow the definition of **global variables**, usually used to represent rate of events.

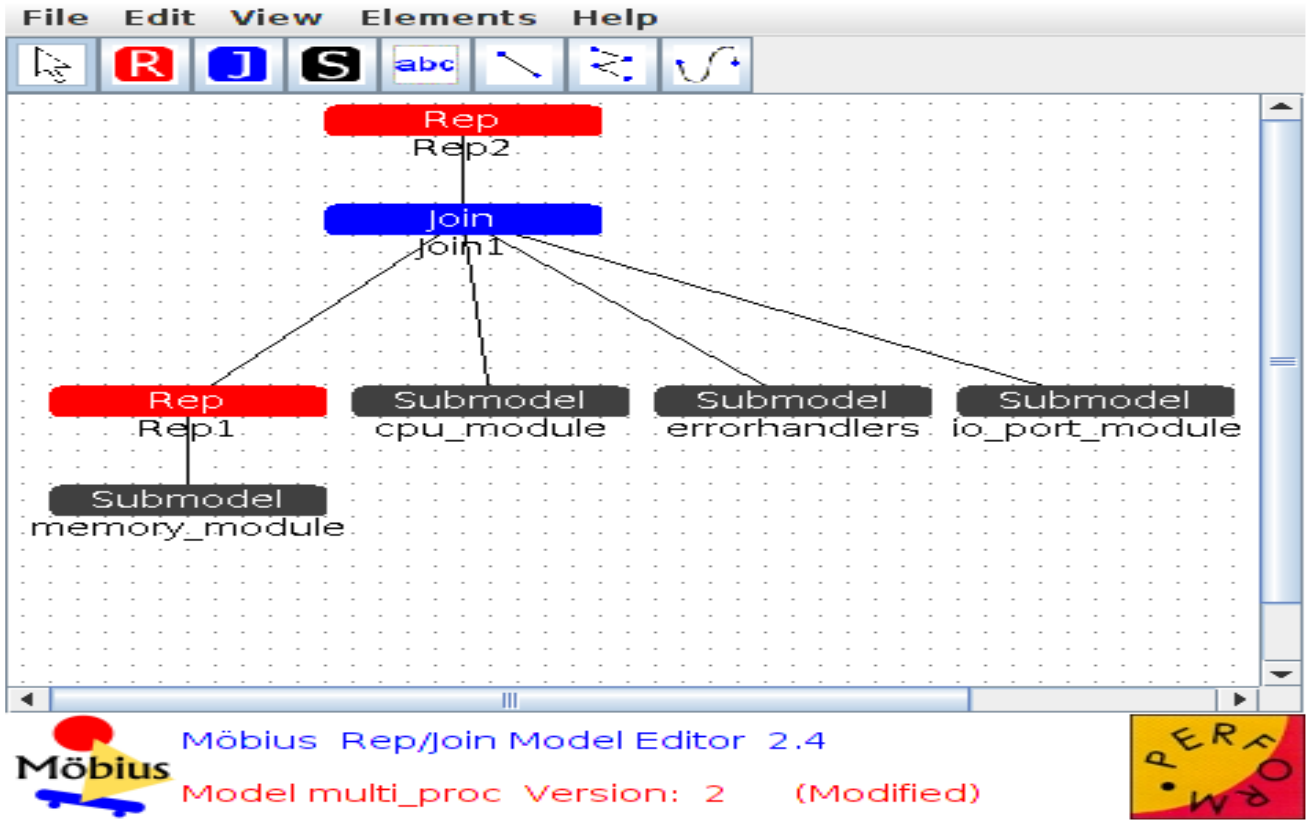


Composed Models

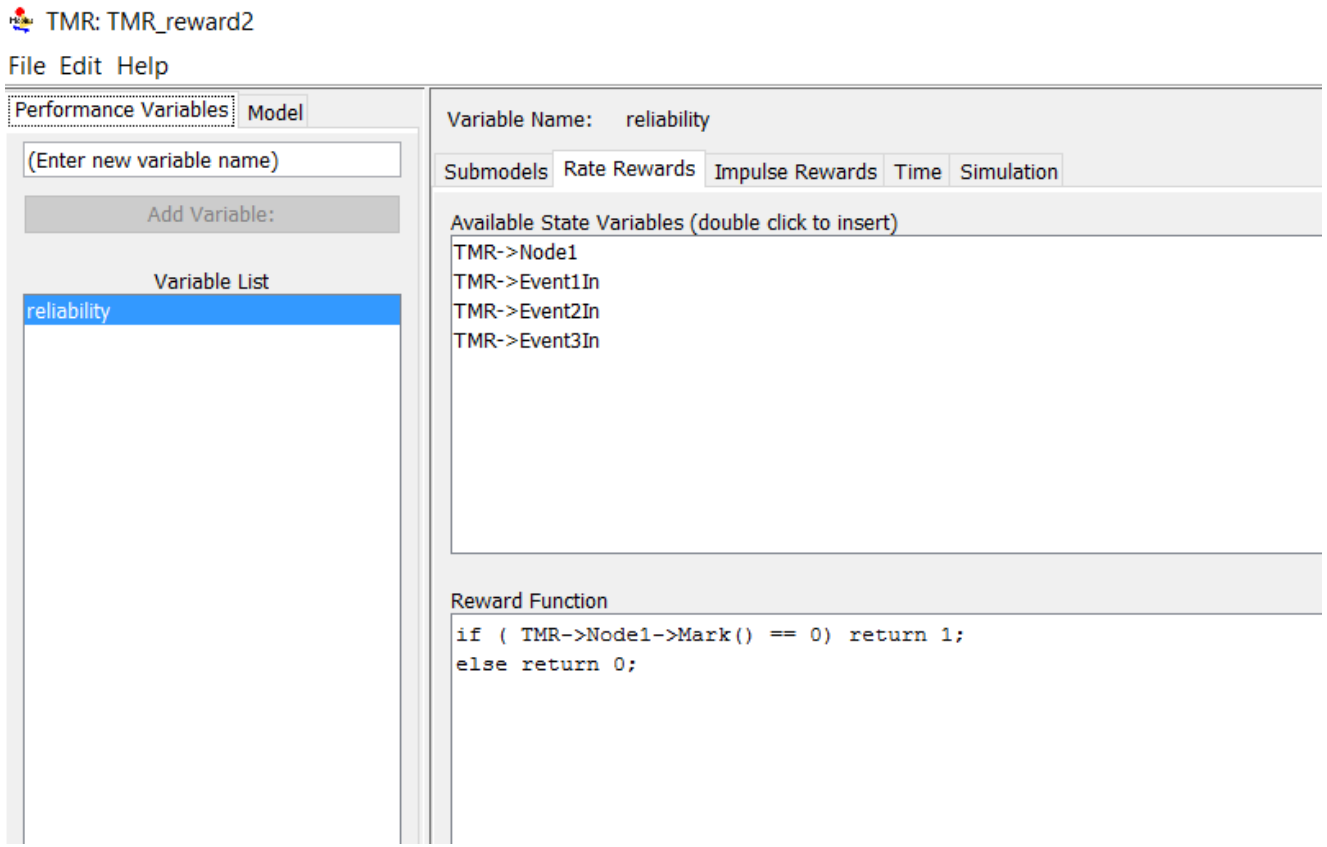
The Möbius tool allows for the construction of *composed models* from previously defined (atomic) models.

The **Join** operator is used to compose different sub-models.

The **Rep** operator is used to compose copies of a same sub-model.



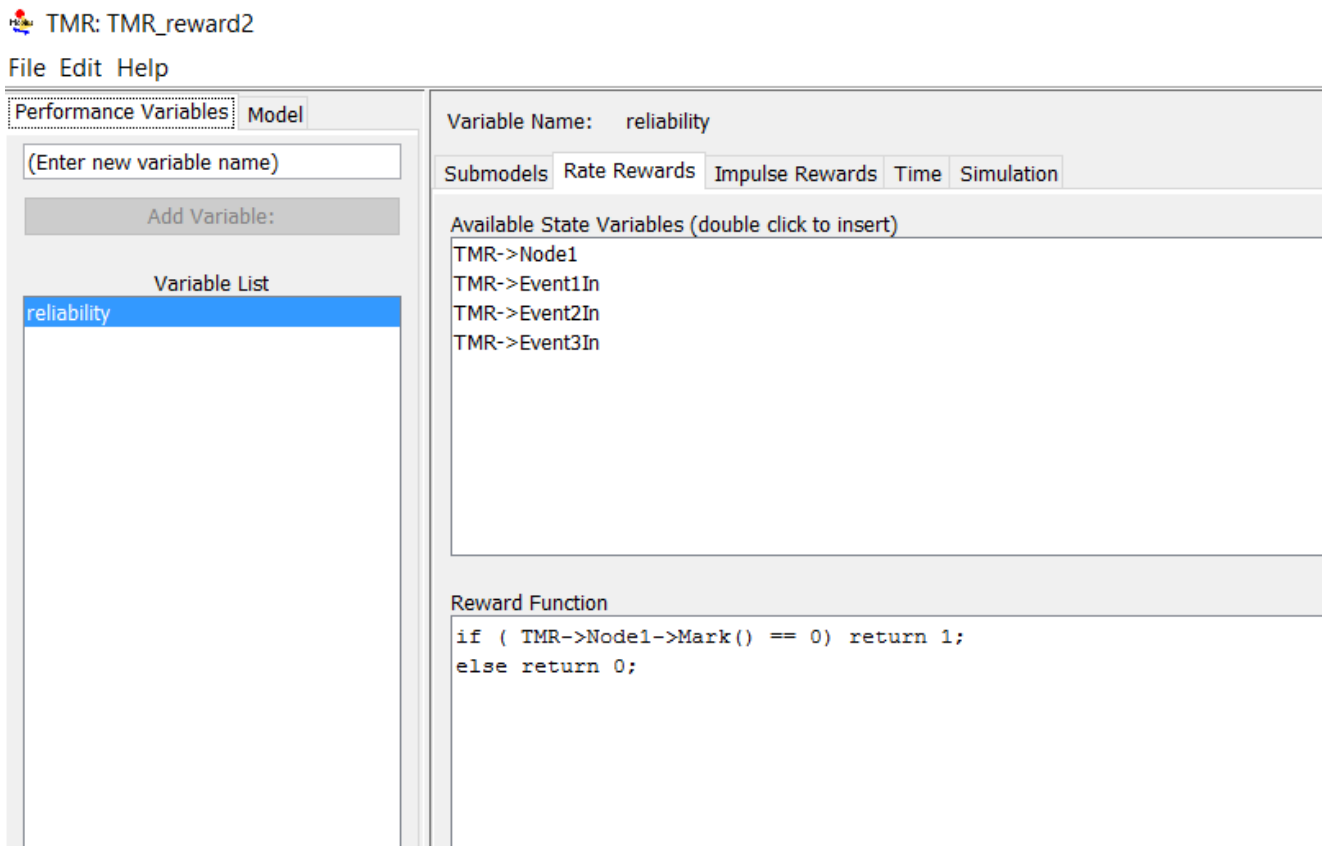
Reward model 1/2



A reward model is a set of **Performance Variable(PV)** that describe system properties

A PV is computed by performing certain operations(e.g. mean) on the set of values returned by an associated **Reward Function(RF)**

Reward model 2/2



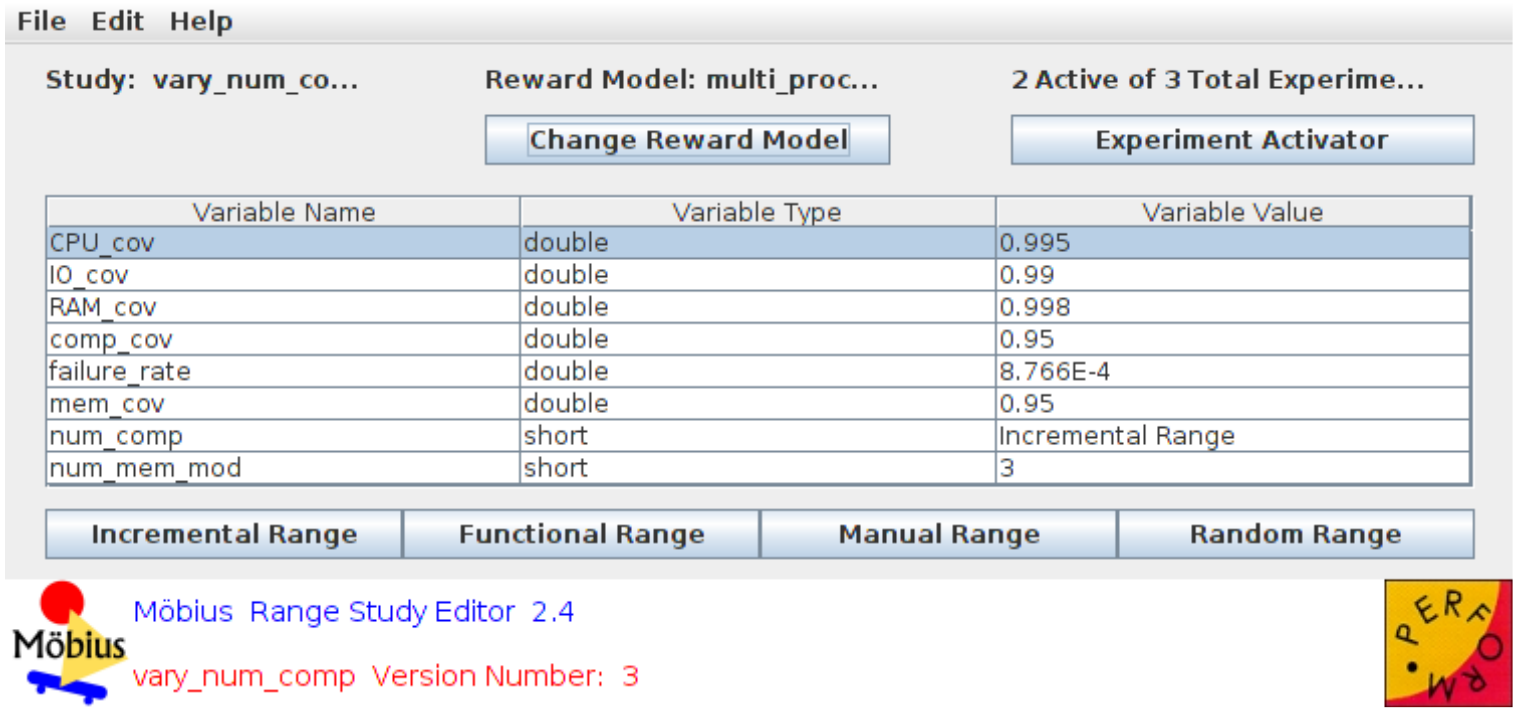
The values of the **RF** can be evaluated:

- **at specified times (Instant of time PV's)**
- accumulated over a specified interval of time (Interval of time PV's)
- averaged over a specified interval of time (Time averaged interval of time PV's)
- or evaluated when the system has reached a steady state (Steady state PV's)

Study

A study defines sets of values that will be assigned to each global variable.

In a **range study**, experiments are generated for all possible combinations of variable values, while in a **set study** only user-defined combinations are used.



Transformer and Solver

In order to solve a model, its state space must be generated by a **transformer**.

We are going to use the **State Space Generator**.

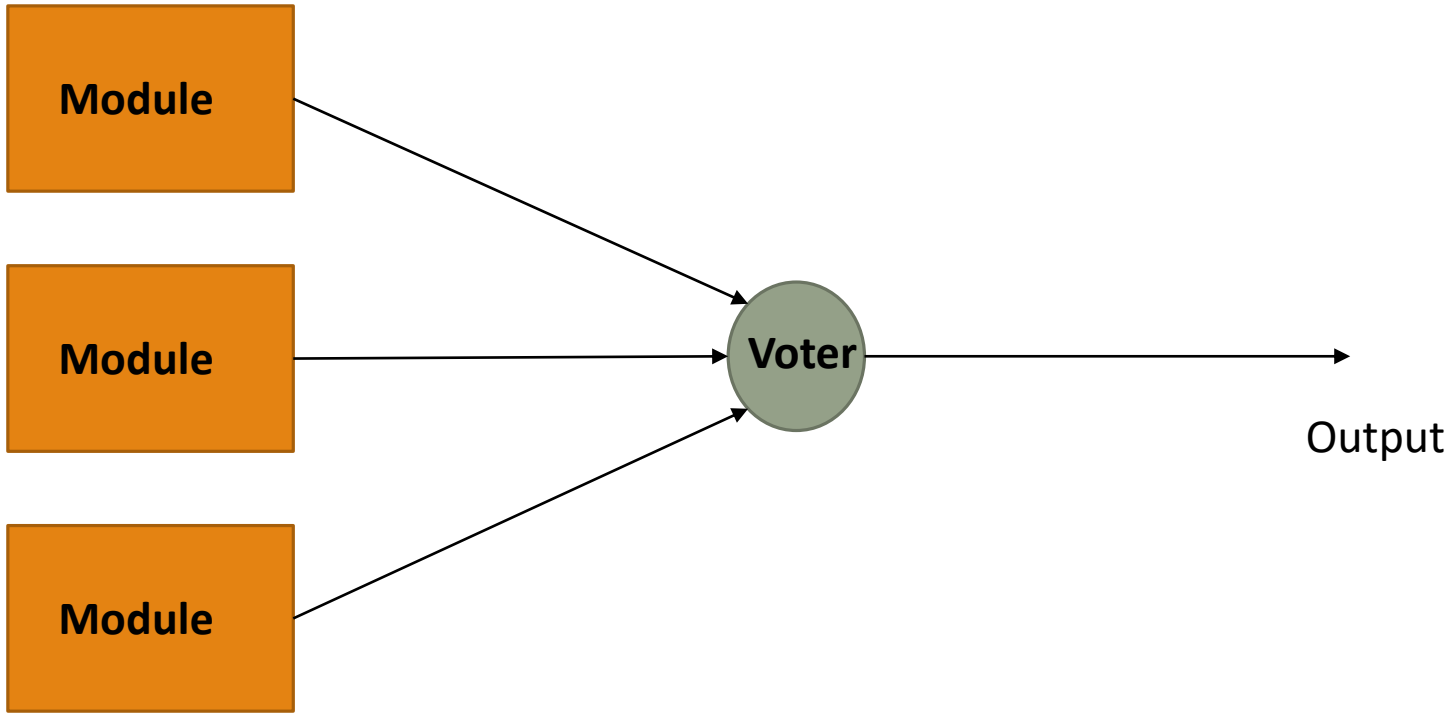
Then we have to select a **solver**

There are two main classes of solver:

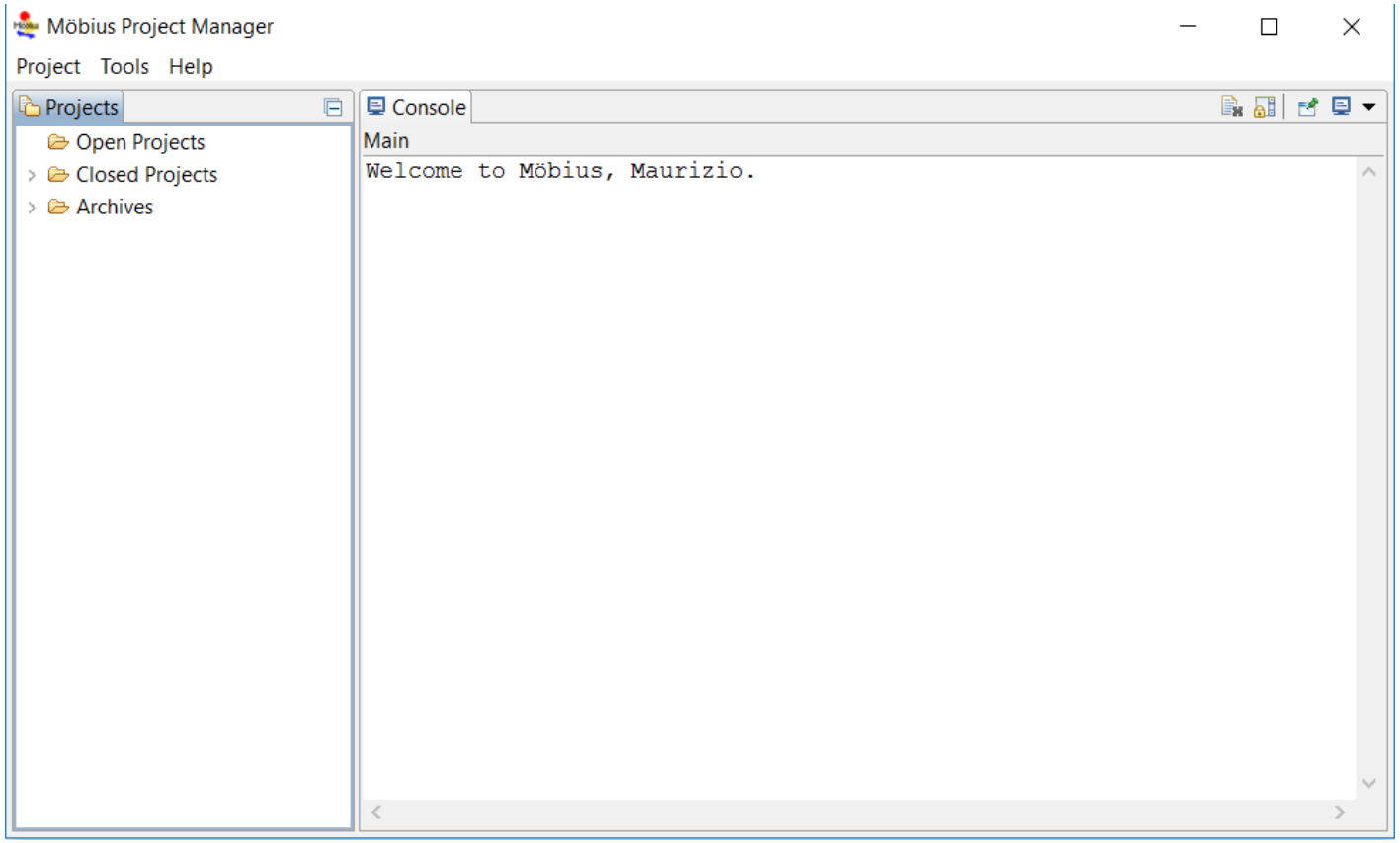
- **Transient**
- Steady-State

We are going to use the **transient solver.**

TMR example



TMR example

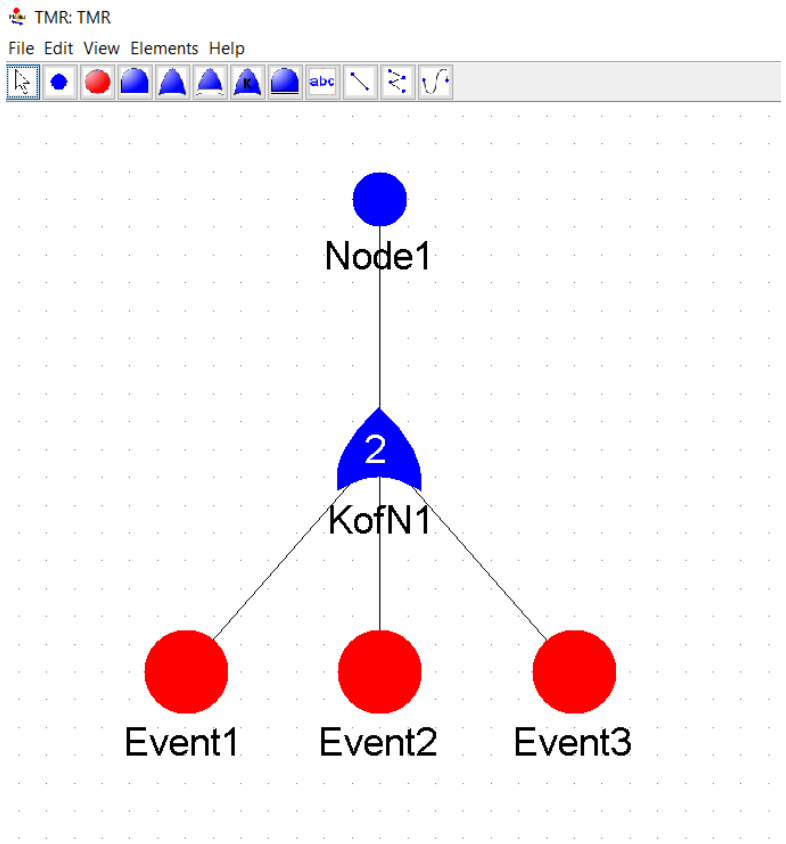


Start with the creation of a new project

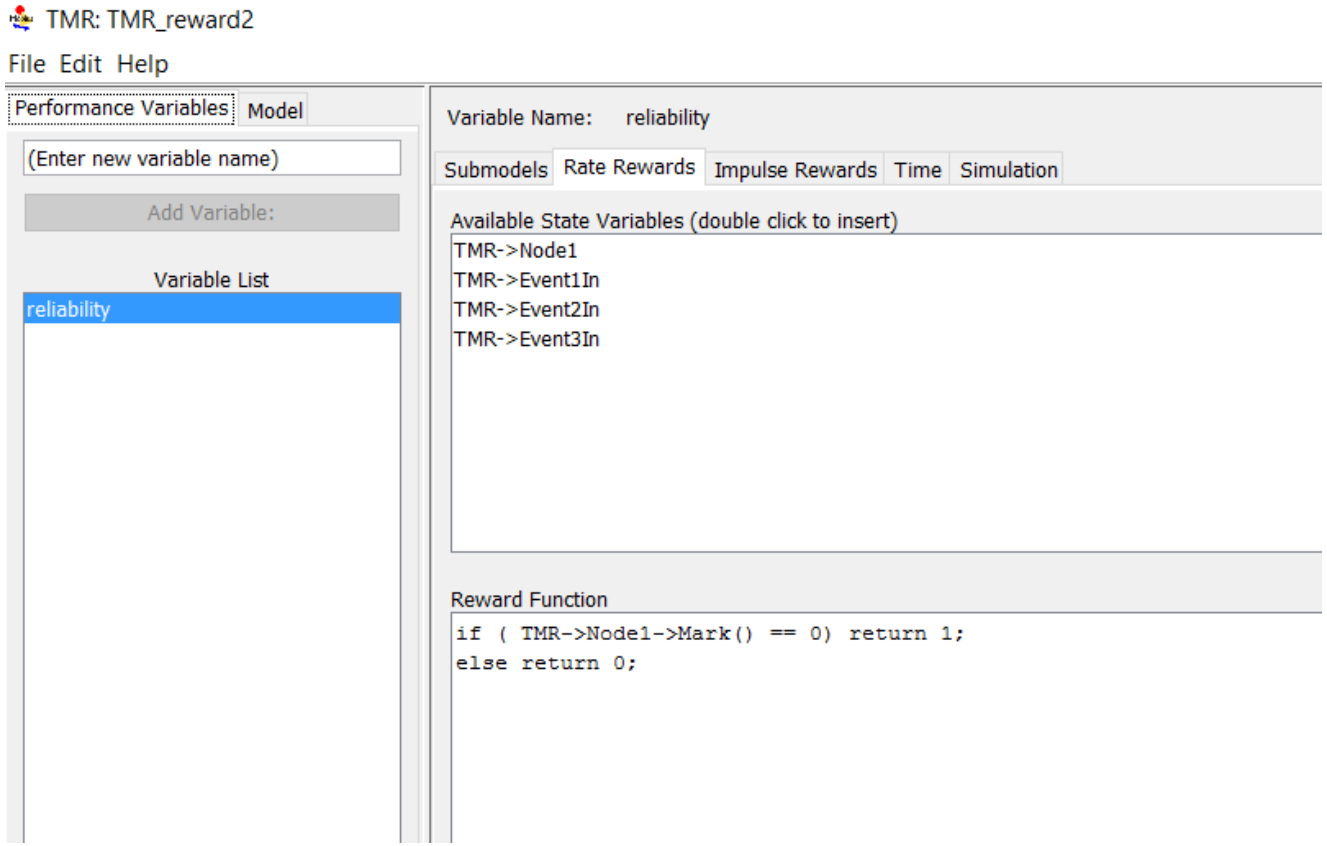
Right click on Open projects-> New project

Enter the project name

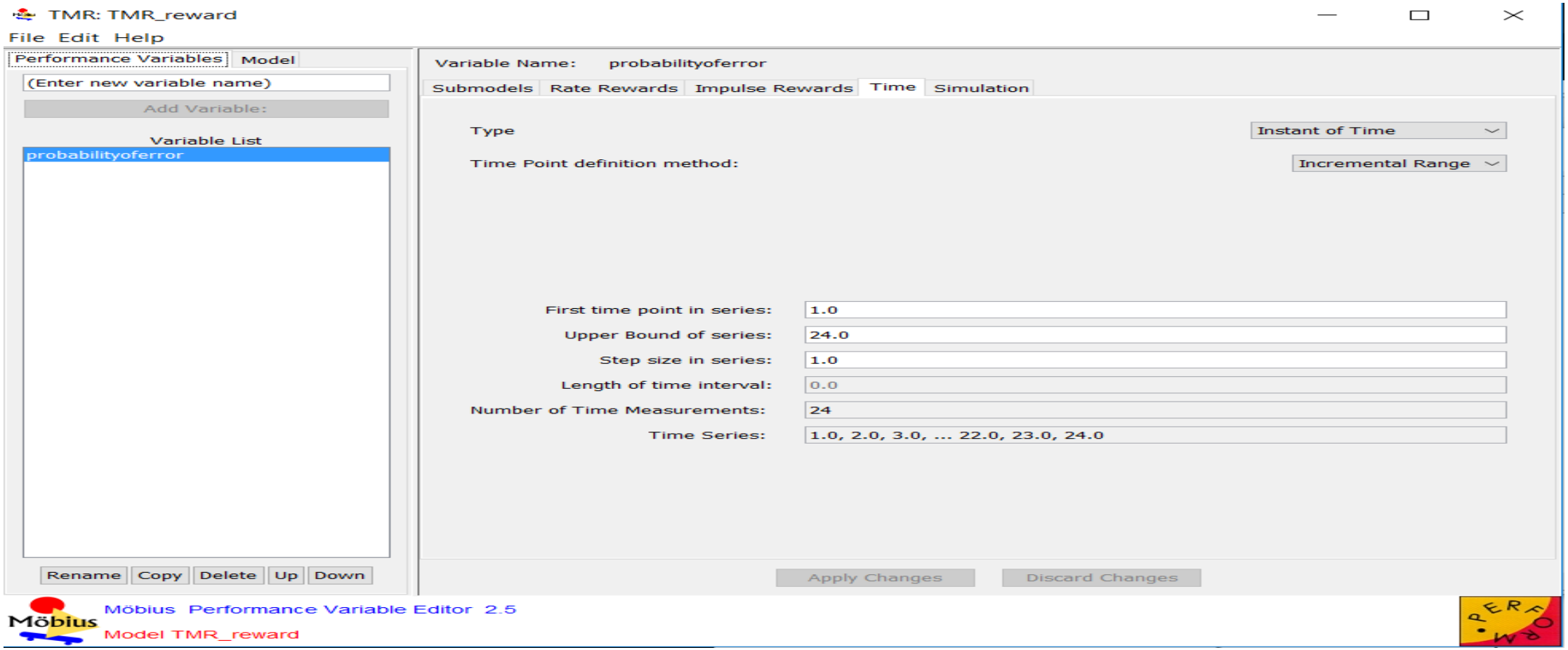
Atomic model of TMR



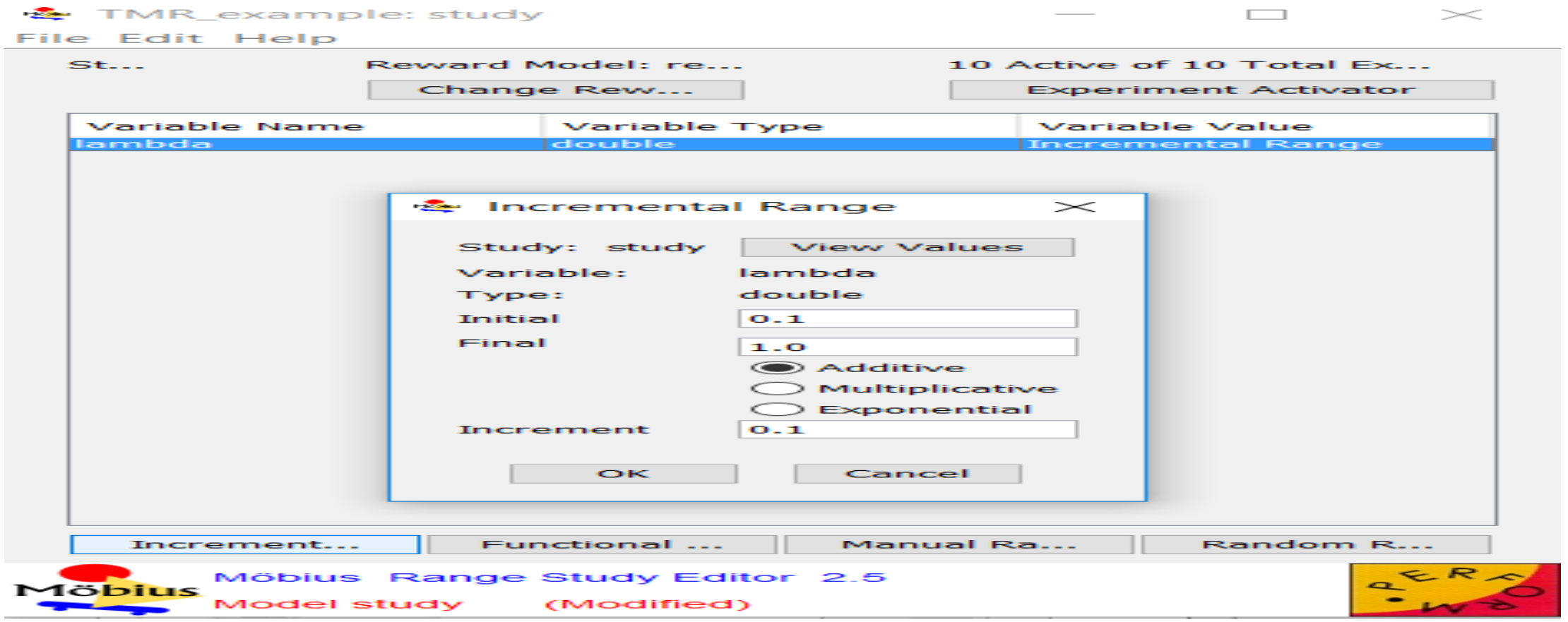
Reward model of TMR 1/2



Reward of TMR 2/2



Study of TMR


TMR_example: study
File Edit Help
St...
Reward Model: re...
Change Rew...
10 Active of 10 Total Ex...
Experiment Activator
Variable Name
Variable Type
Variable Value
lambda
double
Incremental Range
Incremental Range
Study: study
View Values
Variable: lambda
Type: double
Initial 0.1
Final 1.0
Additive
Multiplicative
Exponential
Increment 0.1
OK
Cancel
Increment...
Functional ...
Manual Ra...
Random R...
Möbius
Möbius Range Study Editor 2.5
Model study (Modified)

Analysis of results when λ = 0.1

```
86  ********************************************************************************
87  Performance variable :  reliability_module
88  Time                 :  5.000000
89  Mean                 :  6.065307e-001
90  Variance             :  2.386512e-001
91  Plot files    (pdf)  :  Experiment_1.trs.reliability_module.5.000.pdf.splot
92                (cdf)  :  Experiment_1.trs.reliability_module.5.000.cdf.splot
93  ********************************************************************************
94  Performance variable :  reliability_module
95  Time                 :  6.000000
96  Mean                 :  5.488116e-001
97  Variance             :  2.476174e-001
98  Plot files    (pdf)  :  Experiment_1.trs.reliability_module.6.000.pdf.splot
99                (cdf)  :  Experiment_1.trs.reliability_module.6.000.cdf.splot
100 ********************************************************************************
101 Performance variable :  reliability_module
102 Time                 :  7.000000
103 Mean                 :  4.965853e-001
104 Variance             :  2.499883e-001
105 Plot files    (pdf)  :  Experiment_1.trs.reliability_module.7.000.pdf.splot
106               (cdf)  :  Experiment_1.trs.reliability_module.7.000.cdf.splot
107 ********************************************************************************
108 Performance variable :  reliability_module
109 Time                 :  8.000000
110 Mean                 :  4.493290e-001
111 Variance             :  2.474324e-001
112 Plot files    (pdf)  :  Experiment_1.trs.reliability_module.8.000.pdf.splot
113               (cdf)  :  Experiment_1.trs.reliability_module.8.000.cdf.splot
114 ********************************************************************************
115 Performance variable :  reliability_module
116 Time                 :  9.000000
117 Mean                 :  4.065697e-001
118 Variance             :  2.412708e-001
119 Plot files    (pdf)  :  Experiment_1.trs.reliability_module.9.000.pdf.splot
120               (cdf)  :  Experiment_1.trs.reliability_module.9.000.cdf.splot
121 ********************************************************************************
```

```
86  ********************************************************************************
87  Performance variable :  reliability
88  Time                 :  5.000000
89  Mean                 :  6.573780e-001
90  Variance             :  2.252322e-001
91  Plot files    (pdf)  :  Experiment_1.trs.reliability.5.000.pdf.splot
92                (cdf)  :  Experiment_1.trs.reliability.5.000.cdf.splot
93  ********************************************************************************
94  Performance variable :  reliability
95  Time                 :  6.000000
96  Mean                 :  5.729849e-001
97  Variance             :  2.446732e-001
98  Plot files    (pdf)  :  Experiment_1.trs.reliability.6.000.pdf.splot
99                (cdf)  :  Experiment_1.trs.reliability.6.000.cdf.splot
100 ********************************************************************************
101 Performance variable :  reliability
102 Time                 :  7.000000
103 Mean                 :  4.948780e-001
104 Variance             :  2.499738e-001
105 Plot files    (pdf)  :  Experiment_1.trs.reliability.7.000.pdf.splot
106               (cdf)  :  Experiment_1.trs.reliability.7.000.cdf.splot
107 ********************************************************************************
108 Performance variable :  reliability
109 Time                 :  8.000000
110 Mean                 :  4.242536e-001
111 Variance             :  2.442625e-001
112 Plot files    (pdf)  :  Experiment_1.trs.reliability.8.000.pdf.splot
113               (cdf)  :  Experiment_1.trs.reliability.8.000.cdf.splot
114 ********************************************************************************
115 Performance variable :  reliability
116 Time                 :  9.000000
117 Mean                 :  3.614856e-001
118 Variance             :  2.308138e-001
119 Plot files    (pdf)  :  Experiment_1.trs.reliability.9.000.pdf.splot
120               (cdf)  :  Experiment_1.trs.reliability.9.000.cdf.splot
121 ********************************************************************************
```

Analysis of results when λ = 0.8

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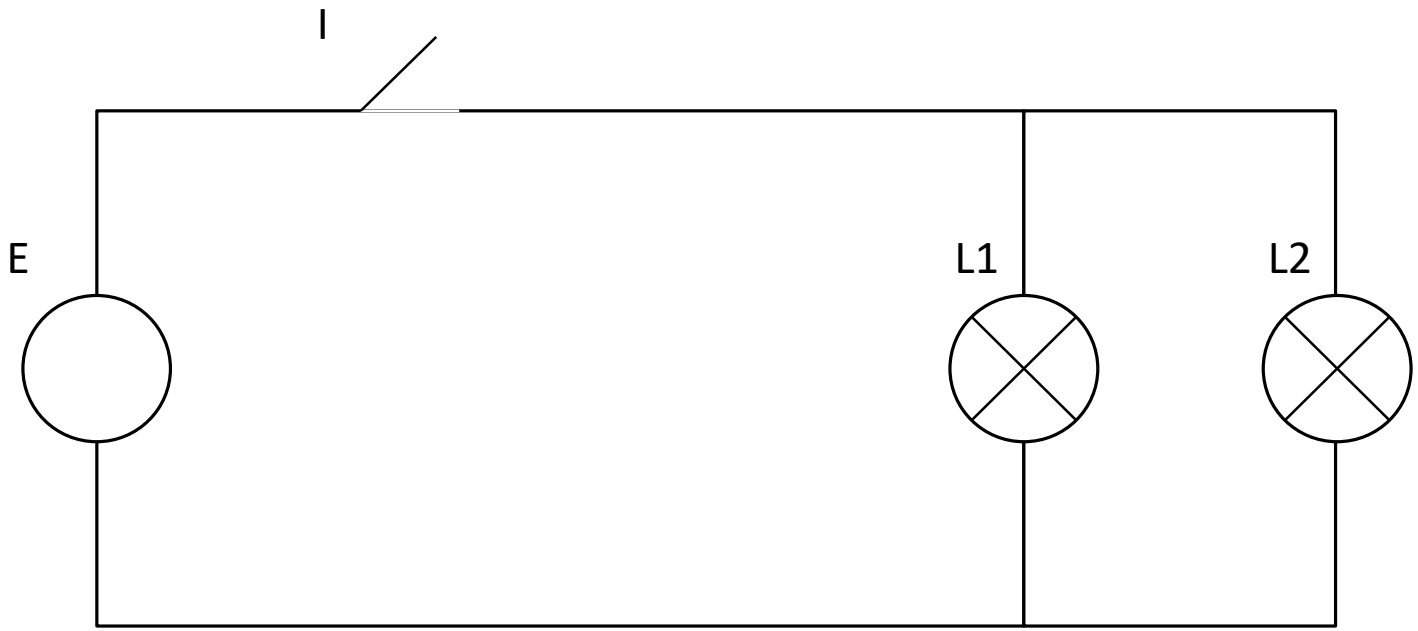
87  Performance variable :  reliability_module
88  Time                 :  5.000000
89  Mean                 :  1.831564e-002
90  Variance             :  1.798018e-002
91  Plot files    (pdf)  :  Experiment_8.trs.reliability_module.5.000.pdf.splot
92                (cdf)  :  Experiment_8.trs.reliability_module.5.000.cdf.splot
93  ********************************************************************************
94  Performance variable :  reliability_module
95  Time                 :  6.000000
96  Mean                 :  8.229747e-003
97  Variance             :  8.162018e-003
98  Plot files    (pdf)  :  Experiment_8.trs.reliability_module.6.000.pdf.splot
99                (cdf)  :  Experiment_8.trs.reliability_module.6.000.cdf.splot
100 ********************************************************************************
101 Performance variable :  reliability_module
102 Time                 :  7.000000
103 Mean                 :  3.697864e-003
104 Variance             :  3.684190e-003
105 Plot files    (pdf)  :  Experiment_8.trs.reliability_module.7.000.pdf.splot
106               (cdf)  :  Experiment_8.trs.reliability_module.7.000.cdf.splot
107 ********************************************************************************
108 Performance variable :  reliability_module
109 Time                 :  8.000000
110 Mean                 :  1.661557e-003
111 Variance             :  1.658797e-003
112 Plot files    (pdf)  :  Experiment_8.trs.reliability_module.8.000.pdf.splot
113               (cdf)  :  Experiment_8.trs.reliability_module.8.000.cdf.splot
114 ********************************************************************************
115 Performance variable :  reliability_module
116 Time                 :  9.000000
117 Mean                 :  7.465858e-004
118 Variance             :  7.460284e-004
119 Plot files    (pdf)  :  Experiment_8.trs.reliability_module.9.000.pdf.splot
120               (cdf)  :  Experiment_8.trs.reliability_module.9.000.cdf.splot
121 ********************************************************************************
```

```
86  ********************************************************************************
87  Performance variable :  reliability
88  Time                 :  5.000000
89  Mean                 :  9.940995e-004
90  Variance             :  9.931112e-004
91  Plot files    (pdf)  :  Experiment_8.trs.reliability.5.000.pdf.splot
92                (cdf)  :  Experiment_8.trs.reliability.5.000.cdf.splot
93  ********************************************************************************
94  Performance variable :  reliability
95  Time                 :  6.000000
96  Mean                 :  2.020714e-004
97  Variance             :  2.020306e-004
98  Plot files    (pdf)  :  Experiment_8.trs.reliability.6.000.pdf.splot
99                (cdf)  :  Experiment_8.trs.reliability.6.000.cdf.splot
100 ********************************************************************************
101 Performance variable :  reliability
102 Time                 :  7.000000
103 Mean                 :  4.092146e-005
104 Variance             :  4.091978e-005
105 Plot files    (pdf)  :  Experiment_8.trs.reliability.7.000.pdf.splot
106               (cdf)  :  Experiment_8.trs.reliability.7.000.cdf.splot
107 ********************************************************************************
108 Performance variable :  reliability
109 Time                 :  8.000000
110 Mean                 :  8.273143e-006
111 Variance             :  8.273075e-006
112 Plot files    (pdf)  :  Experiment_8.trs.reliability.8.000.pdf.splot
113               (cdf)  :  Experiment_8.trs.reliability.8.000.cdf.splot
114 ********************************************************************************
115 Performance variable :  reliability
116 Time                 :  9.000000
117 Mean                 :  1.671339e-006
118 Variance             :  1.671336e-006
119 Plot files    (pdf)  :  Experiment_8.trs.reliability.9.000.pdf.splot
120               (cdf)  :  Experiment_8.trs.reliability.9.000.cdf.splot
121 ********************************************************************************
```

Exercise 1



2 lights
1 switch
1 generator

We want
to avoid
that both
lights stop
working

Exercise 2

Re-create the TMR without using the K-of-N gate.

Compare the results of the new version with the ones previously shown in these slides.