

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.

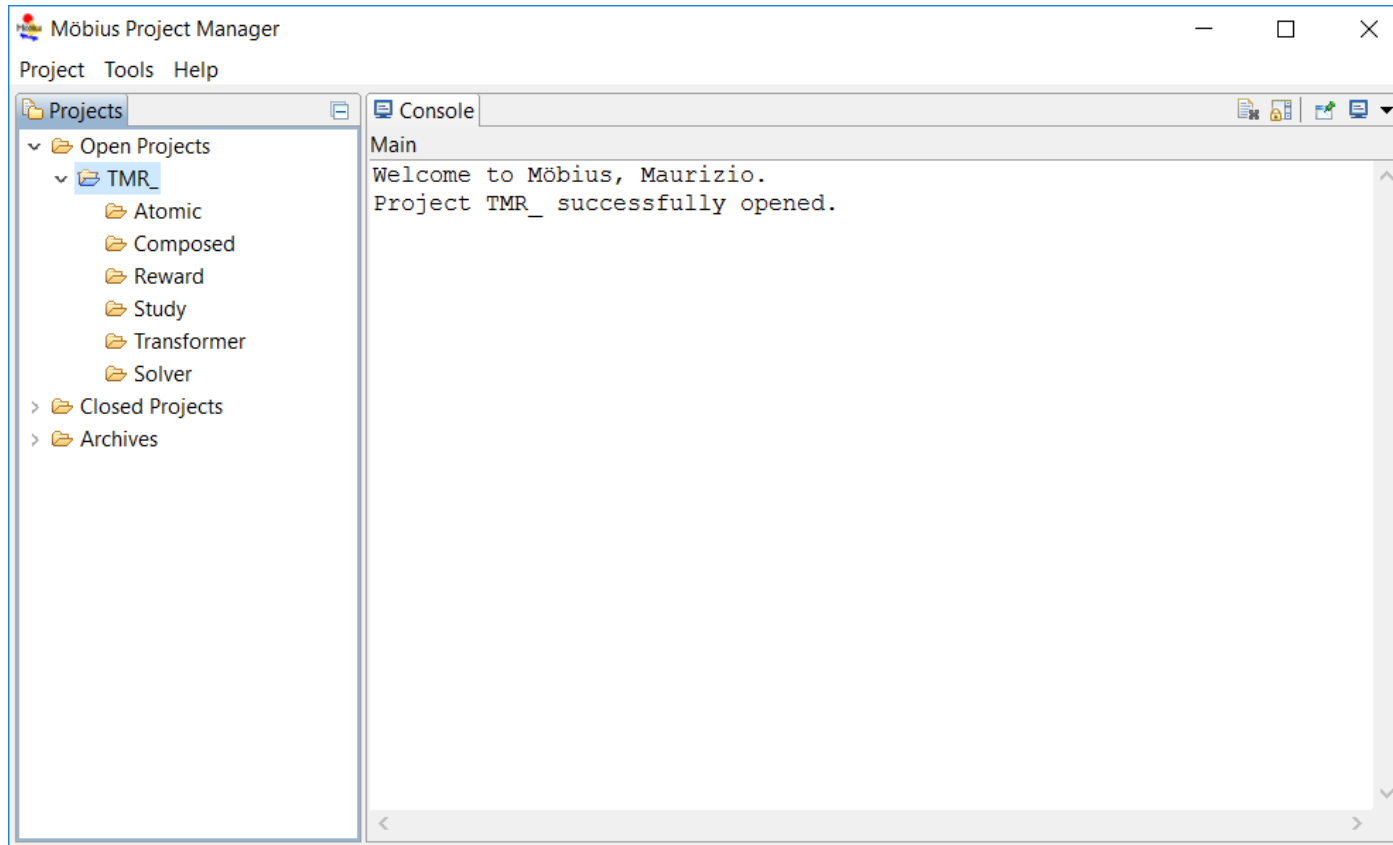
It was originally developed for studying the reliability, availability, and performance of computer and network systems.

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:

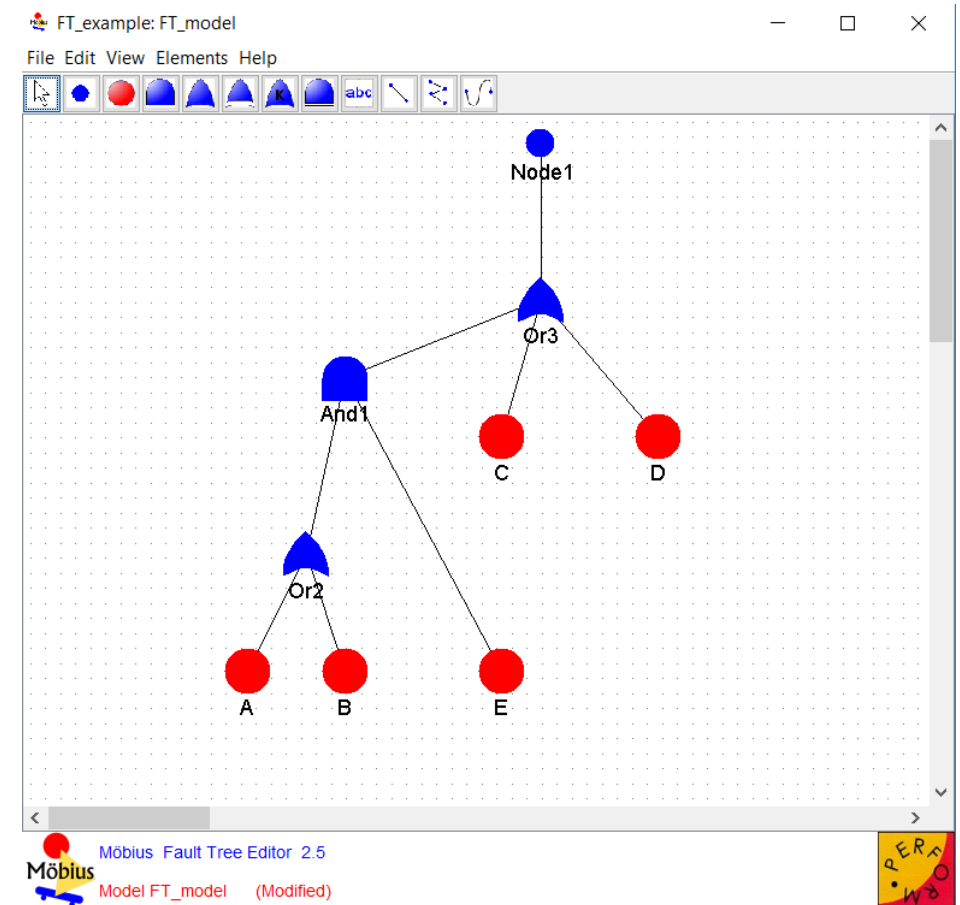
- 1. Atomic Model**
- 2. Composed Model**
- 3. Reward**
- 4. Study**
- 5. Transformer**
- 6. Solver**

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.

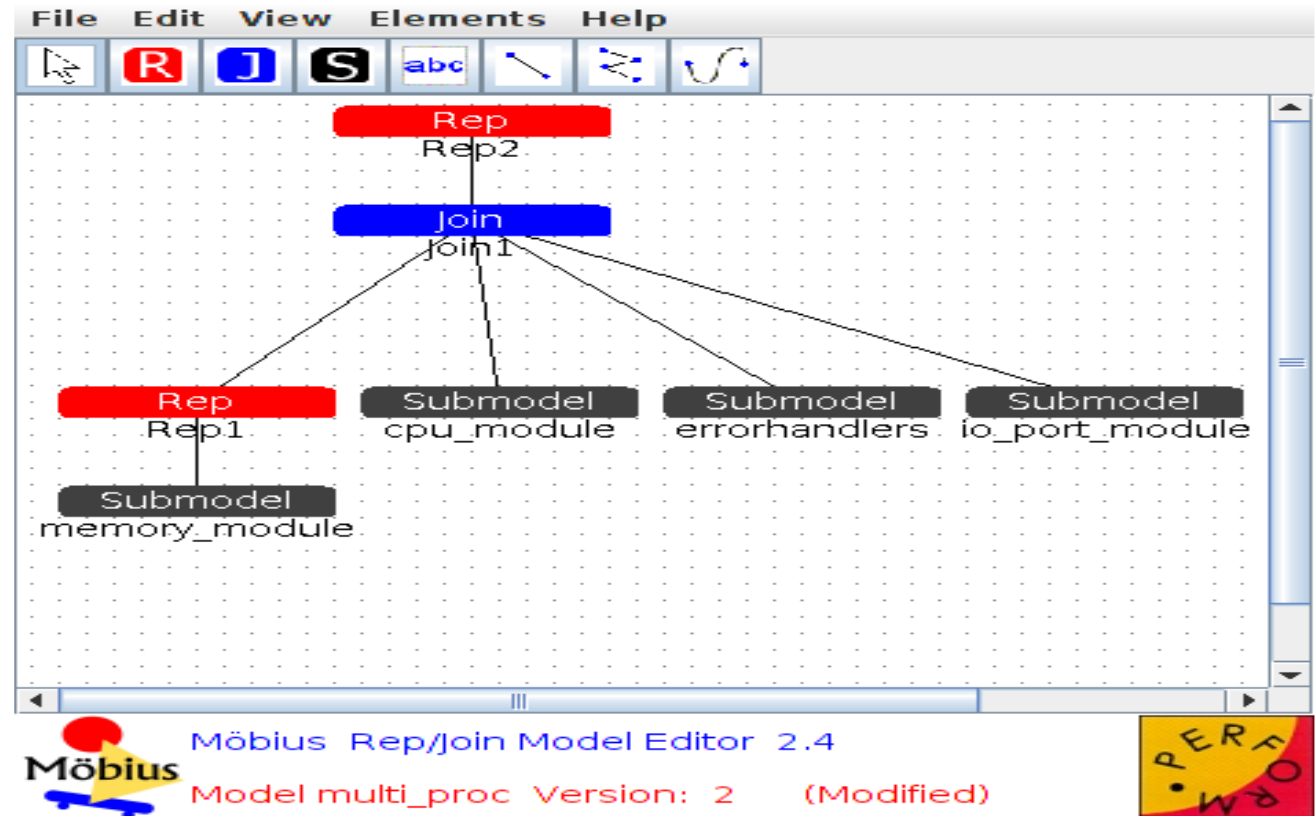


Composed Models

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

The screenshot shows the 'Performance Variables' tab in the TMR: TMR_reward2 application. The 'Variable Name' is set to 'reliability'. The 'Submodels' are 'Rate Rewards', 'Impulse Rewards', 'Time', and 'Simulation'. The 'Available State Variables (double click to insert)' list includes 'TMR->Node1', 'TMR->Event1In', 'TMR->Event2In', and 'TMR->Event3In'. The 'Reward Function' is defined as:

```
if ( TMR->Node1->Mark() == 0) return 1;
else return 0;
```

The 'Variable List' on the left shows 'reliability' as the only variable.

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 screenshot shows the 'Performance Variables' tab in the 'Model' section of the TMR: TMR_reward2 software. The 'Variable Name' is set to 'reliability'. The 'Submodels' are 'Rate Rewards', 'Impulse Rewards', 'Time', and 'Simulation'. The 'Available State Variables (double click to insert)' list includes 'TMR->Node1', 'TMR->Event1In', 'TMR->Event2In', and 'TMR->Event3In'. The 'Reward Function' is defined as:

```
if ( TMR->Node1->Mark() == 0) return 1;
else return 0;
```

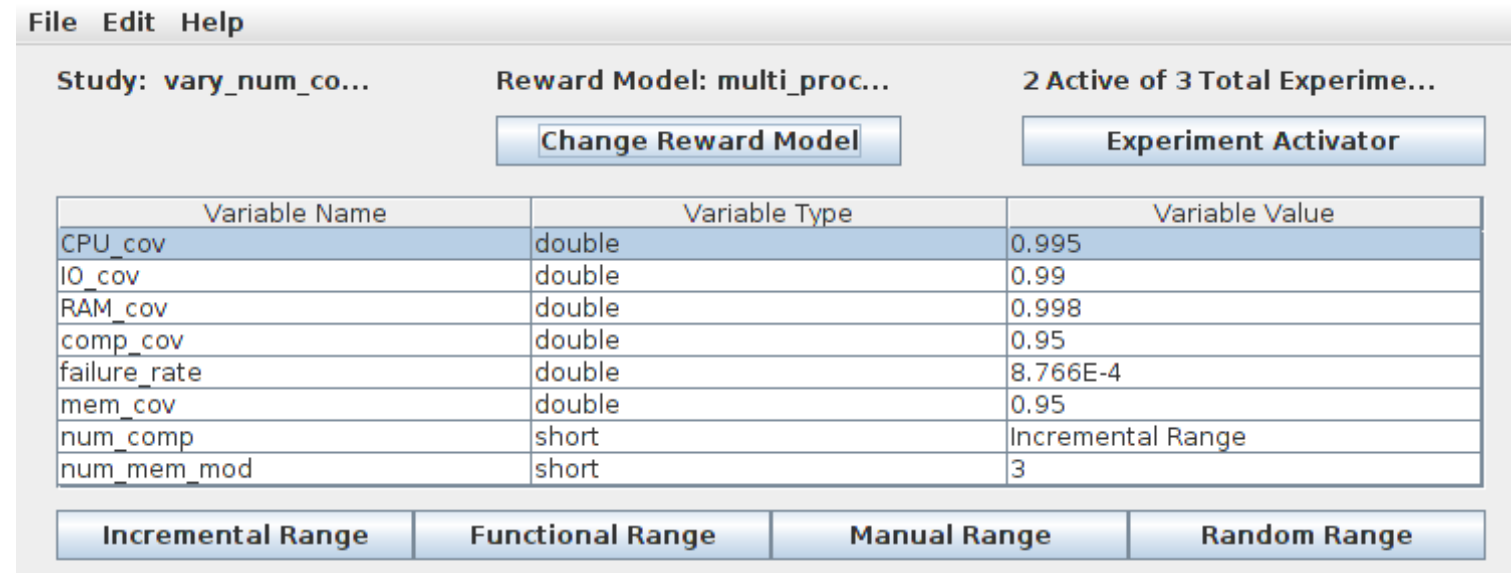
The values of the **RF** can be evaluated:

- **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.



The screenshot shows the Möbius Range Study Editor interface. At the top, there are menu options: File, Edit, Help. Below the menu, the current study is identified as 'Study: vary_num_co...' and the reward model is 'Reward Model: multi_proc...'. There are two buttons: 'Change Reward Model' and 'Experiment Activator'. The main area contains a table with three columns: Variable Name, Variable Type, and Variable Value. The table lists several variables with their respective types and values. At the bottom, there are four buttons: 'Incremental Range', 'Functional Range', 'Manual Range', and 'Random Range'.

Variable Name	Variable Type	Variable Value
CPU_cov	double	0.995
IO_cov	double	0.99
RAM_cov	double	0.998
comp_cov	double	0.95
failure_rate	double	8.766E-4
mem_cov	double	0.95
num_comp	short	Incremental Range
num_mem_mod	short	3



Möbius Range Study Editor 2.4

vary_num_comp Version Number: 3



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**.

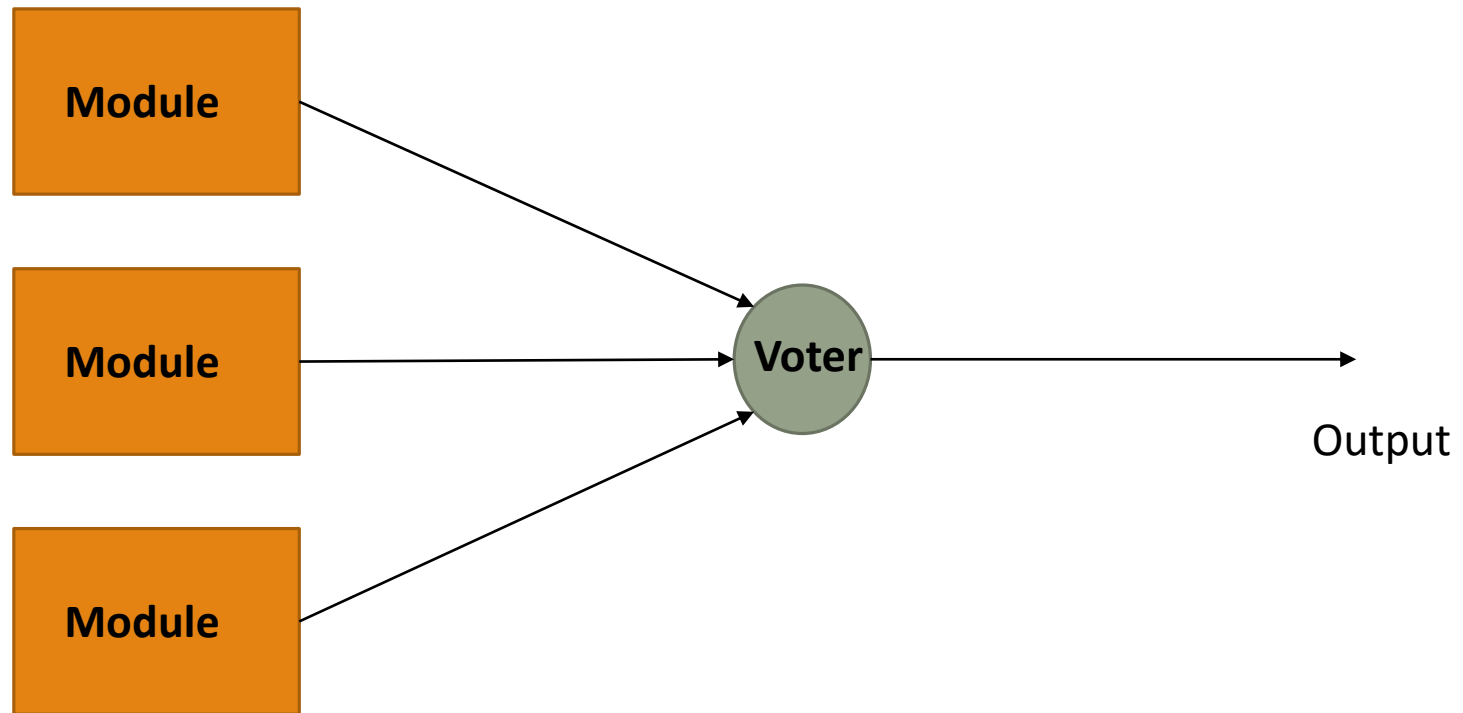
Then we have to select a **solver**

There are two main classes of solver:

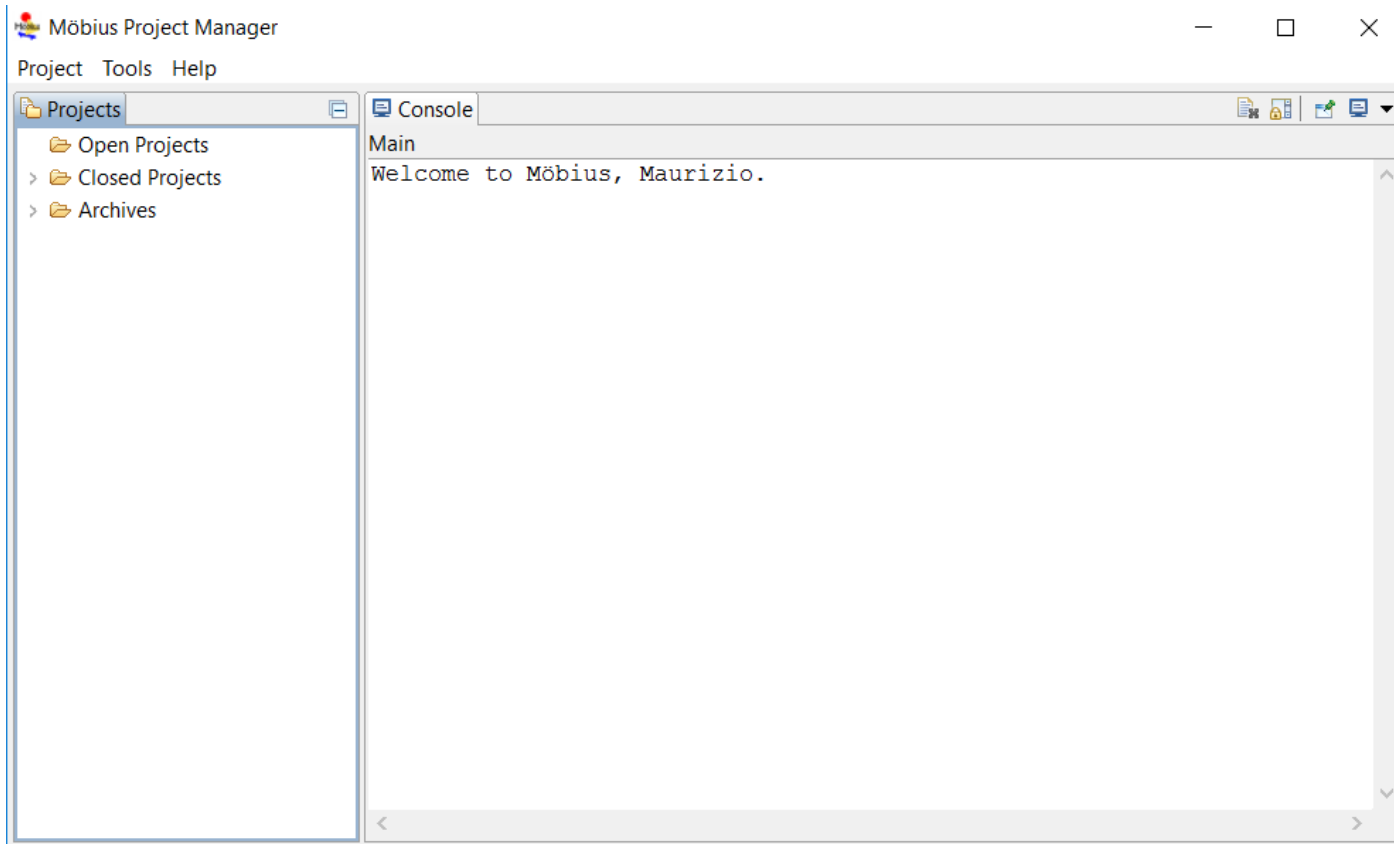
- **Transient**
- Steady-State

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

TMR example



TMR example

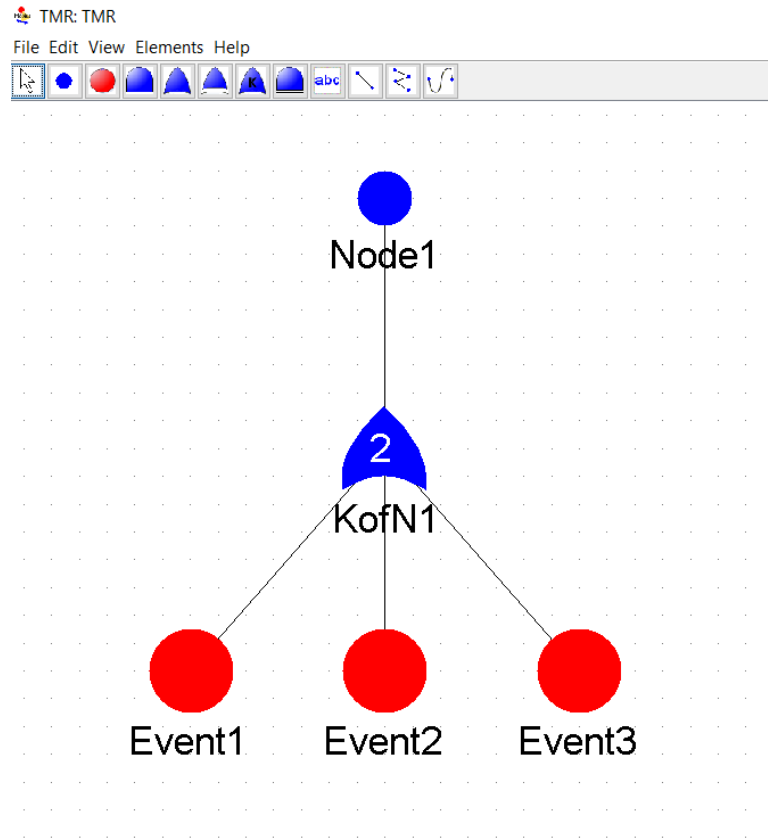


Start with the creation of
a new project

Right click on Open
projects-> New project

Enter the project name

Atomic model of TMR



Reward model of TMR 1/2

TMR: TMR_reward2

File Edit Help

Performance Variables Model

(Enter new variable name)

Add Variable:

Variable List

reliability

Variable Name: reliability

Submodels Rate Rewards Impulse Rewards Time Simulation

Available State Variables (double click to insert)

TMR->Node1
TMR->Event1In
TMR->Event2In
TMR->Event3In

Reward Function

```
if ( TMR->Node1->Mark() == 0) return 1;  
else return 0;
```


Reward of TMR 2/2

The screenshot shows the Möbius Performance Variable Editor 2.5 interface. The window title is "TMR: TMR_reward". The menu bar includes "File", "Edit", and "Help". The interface is divided into two main panels: "Performance Variables" and "Model".

Performance Variables Panel:

- Input field: "(Enter new variable name)"
- Button: "Add Variable:"
- Section: "Variable List"
- List item: "probabilityoferror" (highlighted)
- Buttons: "Rename", "Copy", "Delete", "Up", "Down"

Model Panel:

- Variable Name: "probabilityoferror"
- Submodels: "Submodels", "Rate Rewards", "Impulse Rewards", "Time", "Simulation" (selected)
- Type: "Instant of Time" (dropdown)
- Time Point definition method: "Incremental Range" (dropdown)
- First time point in series: "1.0" (input field)
- Upper Bound of series: "24.0" (input field)
- Step size in series: "1.0" (input field)
- Length of time interval: "0.0" (input field)
- Number of Time Measurements: "24" (input field)
- Time Series: "1.0, 2.0, 3.0, ... 22.0, 23.0, 24.0" (input field)
- Buttons: "Apply Changes", "Discard Changes"

Footer:

- Möbius Performance Variable Editor 2.5
- Model TMR_reward
- PERFORM logo

Study of TMR

The screenshot displays the Möbius Range Study Editor 2.5 interface. The main window title is "TMR_example: study" and it includes a menu bar with "File", "Edit", and "Help". The main area shows a table of variables:

Variable Name	Variable Type	Variable Value
lambda	double	Incremental Range

An "Incremental Range" dialog box is open, showing the following settings:

- Study: study
- Variable: lambda
- Type: double
- Initial: 0.1
- Final: 1.0
- Increment: 0.1
- Radio buttons: Additive (selected), Multiplicative, Exponential

Buttons for "View Values", "OK", and "Cancel" are visible. At the bottom of the main window, there are buttons for "Increment...", "Functional ...", "Manual Ra...", and "Random R...". The status bar at the bottom left shows the Möbius logo and text: "Möbius Range Study Editor 2.5 Model study (Modified)". A logo with the word "PERFORM" is visible in the bottom right corner.

Analysis of results when $\lambda = 0.1$

```
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 *****
```

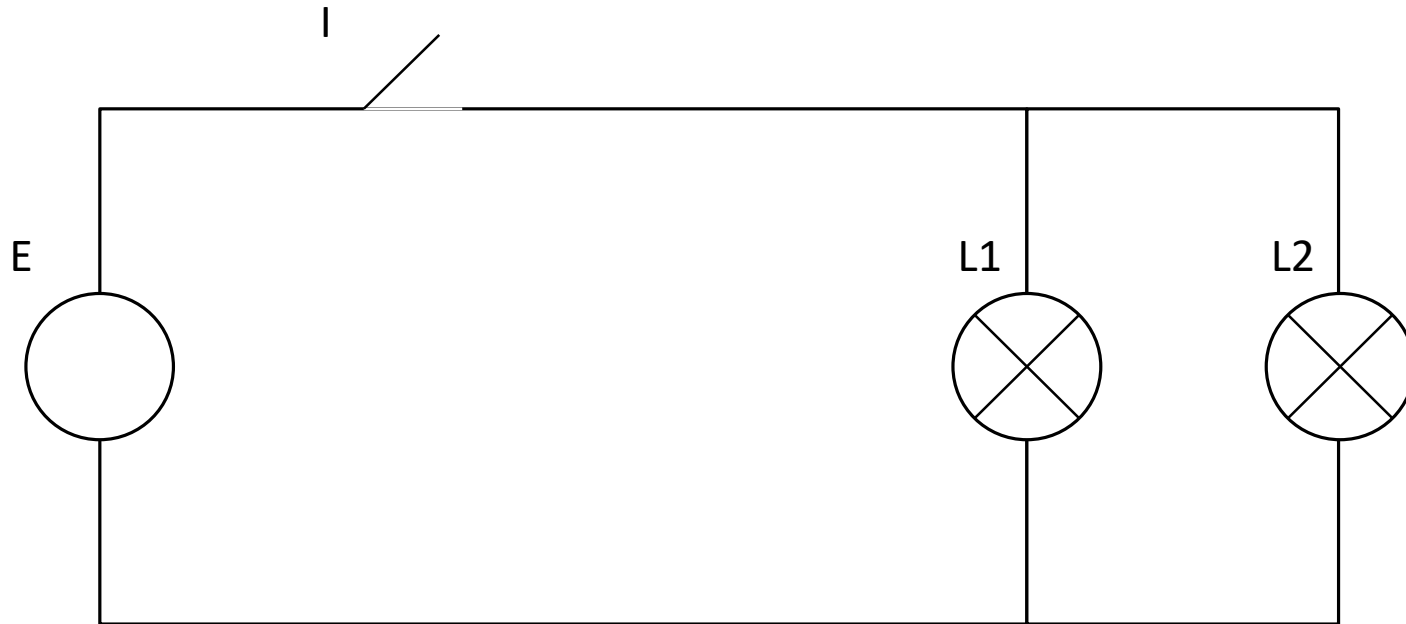
```
86 *****
87 Performance variable : reliability
88 Time                : 5.000000
89 Mean                : 6.573780e-001
90 Variance            : 2.252322e-001
91 Plot files (pdf)    : Experiment_1.trs.reliability.5.000.pdf.splot
92                    (cdf) : Experiment_1.trs.reliability.5.000.cdf.splot
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 $\lambda = 0.8$

```
86 *****
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.