# 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<sup>™</sup> 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

🍨 Möbius Project Manager		_	C		×
Project Tools Help					
Projects 📃	Second Console		<b>R R</b>	8 🛃	<b>E</b> -
<ul> <li>Copen Projects</li> <li>TMR_</li> <li>Atomic</li> <li>Composed</li> <li>Reward</li> <li>Study</li> <li>Transformer</li> <li>Solver</li> </ul>	Main Welcome to Möbius, Maurizio. Project TMR_ successfully opened.				^
<ul> <li>&gt; Closed Projects</li> <li>&gt; Archives</li> </ul>					~
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Every project is made of 6 kinds of elements:

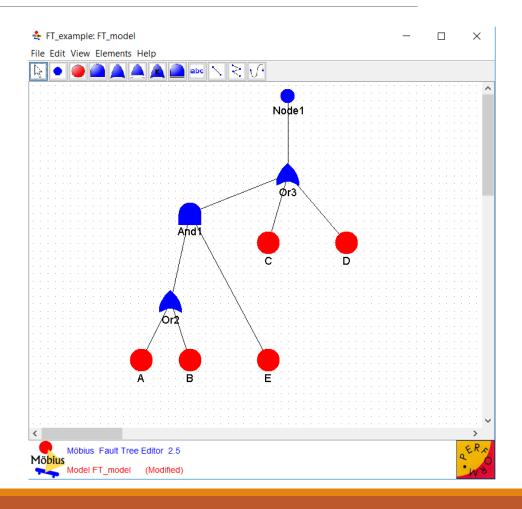
- 1. Atomic Model
- 2. Composed Model
- 3. Reward
- 4. Study
- 5. Transformer
- 6. Solver

# Atomic model

Each model is composed of one or more submodels, 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.

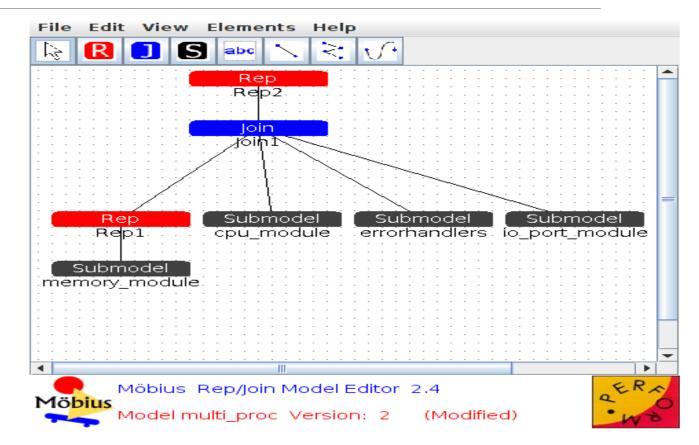


# Composed Models

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

#### 🄹 TMR: TMR\_reward2

#### File Edit Help

Performance Variables Model	Variable Name: reliability
(Enter new variable name)	Submodels Rate Rewards Impulse Rewards Time Simulation
Add Variable:	Available State Variables (double click to insert) TMR->Node1
Variable List reliability	TMR->Event1In TMR->Event2In TMR->Event3In
	<pre>Reward Function if ( TMR-&gt;Node1-&gt;Mark() == 0) return 1; else return 0;</pre>

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

#### 🄹 TMR: TMR\_reward2

#### File Edit Help

Performance Variables Model	Variable Name: reliability
(Enter new variable name)	Submodels Rate Rewards Impulse Rewards Time Simulation
Add Variable:	Available State Variables (double click to insert)
Variable List reliability	TMR->Node1 TMR->Event1In TMR->Event2In TMR->Event3In
	<pre>Reward Function if ( TMR-&gt;Node1-&gt;Mark() == 0) return 1; else return 0;</pre>

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.

e Edit Help Study: vary_num_co	Reward Model: mu	lti_proc	2 Active	of 3 Total Experime		
	Change Reward	Model	E	xperiment Activator		
Variable Name	Variab	le 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		Incremen	tal Range		
num_mem_mod	short		3			
Incremental Range	Functional Range	Manual	Range	Random Range		
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**.

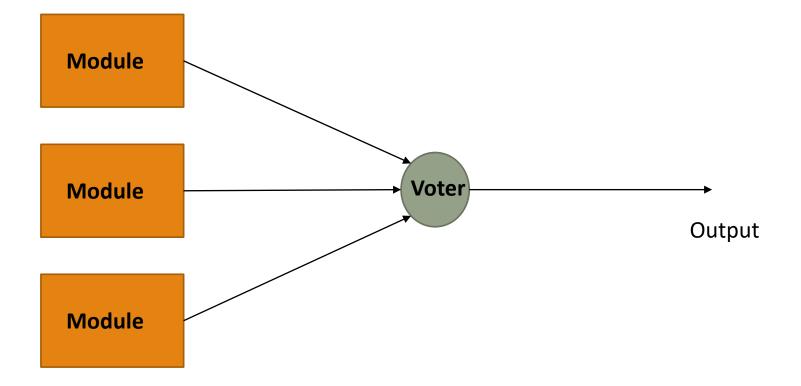
Then we have to select a **solver** 

There are two main classes of solver:

- Transient
- Steady-State

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

# TMR example



### TMR example

🍨 Möbius Project Manager		—		$\times$
Project Tools Help				
Projects	Ē	📮 Console	1 2	<b>E</b> -
🗁 Open Projects		Main		
Closed Projects		Welcome to Möbius, Maurizio.		$\sim$
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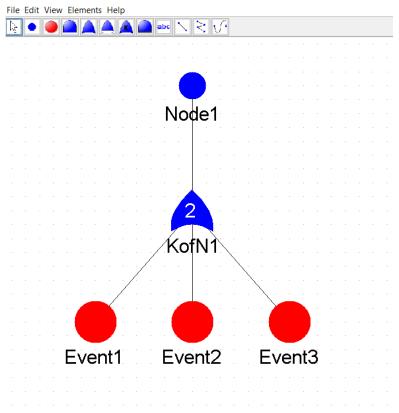
Start with the creation of a new project

Right click on Open projects-> New project

Enter the project name

# Atomic model of TMR

#### 🍨 TMR: TMR



# Reward model of TMR 1/2

#### 🍨 TMR: TMR\_reward2

#### File Edit Help

Performance Variables Model	Variable Name: reliability
(Enter new variable name)	Submodels Rate Rewards Impulse Rewards Time Simulation
Add Variable:	Available State Variables (double click to insert)
Variable List reliability	TMR->Node1 TMR->Event1In TMR->Event2In TMR->Event3In
	<pre>Reward Function if ( TMR-&gt;Node1-&gt;Mark() == 0) return 1; else return 0;</pre>

# Reward of TMR 2/2

🚣 TMR: TMR_reward				—		$\times$
File Edit Help						
Performance Variables Model	Variable Name: probabilityoferror					
(Enter new variable name)	Submodels Rate Rewards Impulse F	Rewards Time Simula	ation			
Add Variable:						
Variable List	Туре			Instant of Tim	пе	$\sim$
probabilityoferror	Time Point definition method:			Incremen	ntal Range	~
				110101101		
	First time point in series:	1.0				
	Upper Bound of series:	24.0				
	Step size in series:	1.0				
	Length of time interval:	0.0				
	Number of Time Measurements:	24				
	Time Series:	1.0, 2.0, 3.0, 22.	0, 23.0, 24.0			
Rename Copy Delete Up Down		Apply Changes	Discard Changes			
Möbius Performance Variable Möbius Model TMR_reward	Editor 2.5					ERA WB



🙅 TMR_examp	ole: study				$\sim$	
File Edit Help						
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	Change Rew		Experin	nent Activator		
Variable Name		Гуре		le Value		
lambda	double		Increm	ental Range		
	🗠 Incremental	Range	$\times$			
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	Variable:	lambda				
	Type:	double				
	Initial	0.1				
	Final	1.0				
			e			
			cative			
		Expone	ntial			
	Increment	0.1				
	ОК	Cance	21			
Increment.	. Functional	Manua	al Ra	Random R	-	
Möbius Range Study Editor 2.5         Möbius Model study (Modified)						

## Analysis of results when $\lambda = 0.1$

86	*****	***	***************************************
87	Performance variable	:	reliability_module
88	Time	:	5.00000
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)	1	Experiment 1.trs.reliability module.7.000.cdf.splot
107		***	***************************************
108	Performance variable		reliability_module
109	Time	2	8.000000
110	Mean	:	4.493290e-001
111	Variance	2	2.474324e-001
and the site	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	2	9.000000
117	Mean	2	4.065697e-001
	Variance	2	2.412708e-001
119	Plot files (pdf)	2	Experiment 1.trs.reliability module.9.000.pdf.splot
120	(cdf)	2	Experiment 1.trs.reliability module.9.000.cdf.splot
121			**************************************

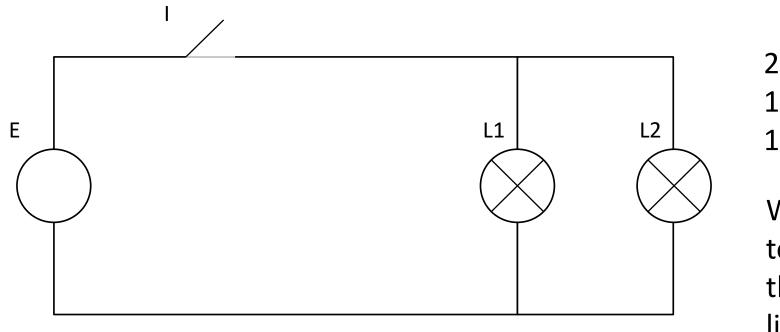
il.	86	****	***	**********
1	87	Performance variable	:	reliability
	88	Time	:	5.000000
	89	Mean	:	6.573780e-001
	90	Variance	:	2.252322e-001
	91	Plot files (pdf)	:	Experiment 1.trs.reliability.5.000.pdf.splot
	92	(cdf)	:	Experiment 1.trs.reliability.5.000.cdf.splot
	93	****	***	*******
	94	Performance variable	:	reliability
	95	Time	:	6.00000
	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			**********
2 H	101	Performance variable	:	reliability
211	102	Time	:	7.000000
21		Mean	:	4.948780e-001
211		Variance		2.499738e-001
6 H.	105	Plot files (pdf)		Experiment_1.trs.reliability.7.000.pdf.splot
21	106	(cdf)		<pre>Experiment_1.trs.reliability.7.000.cdf.splot ************************************</pre>
211	107			
21	108	Performance variable	:	1
21	109	Time	:	8.000000
	the site of	Mean Variance	:	4.242536e-001 2.442625e-001
	112		•	
21	112	Plot files (pdf) (cdf)	:	<pre>Experiment_1.trs.reliability.8.000.pdf.splot Experiment 1.trs.reliability.8.000.cdf.splot</pre>
2 H	114		- 	**************************************
21	115	Performance variable		reliability
	116	Time	1	9.00000
	117	Mean	1	3.614856e-001
	118	Variance	1	2.308138e-001
211	119	Plot files (pdf)	-	Experiment 1.trs.reliability.9.000.pdf.splot
21	120	(cdf)	:	Experiment 1.trs.reliability.9.000.cdf.splot
6 H.	121		***	***************************************
1				

## 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)	:	<pre>Experiment_8.trs.reliability_module.5.000.pdf.splot</pre>
92	(cdf)	:	Experiment_8.trs.reliability_module.5.000.cdf.splot
93	****	***	***************************************
94	Performance variable	:	reliability_module
95	Time	:	6.00000
96	Mean	:	8.229747e-003
97	Variance	:	8.162018e-003
98	Plot files (pdf)	:	<pre>Experiment_8.trs.reliability_module.6.000.pdf.splot</pre>
99	(cdf)	:	<pre>Experiment_8.trs.reliability_module.6.000.cdf.splot</pre>
100	****	***	***************************************
101	Performance variable	:	reliability_module
102	Time	:	7.00000
103	Mean	:	3.697864e-003
104	Variance	:	3.684190e-003
	Plot files (pdf)	:	<pre>Experiment_8.trs.reliability_module.7.000.pdf.splot</pre>
106	(cdf)	:	Experiment_8.trs.reliability_module.7.000.cdf.splot
107			***********
108	Performance variable	:	reliability_module
109	Time	:	8.00000
110	Mean	:	1.661557e-003
	Variance	:	1.658797e-003
	Plot files (pdf)	:	Experiment_8.trs.reliability_module.8.000.pdf.splot
113	(cdf)	:	<pre>Experiment_8.trs.reliability_module.8.000.cdf.splot</pre>
114			***************************************
	Performance variable	:	reliability_module
116	Time	:	9.000000
117	Mean	:	7.465858e-004
	Variance	:	7.460284e-004
119	Plot files (pdf)	:	Experiment_8.trs.reliability_module.9.000.pdf.splot
120	(cdf)	:	<pre>Experiment_8.trs.reliability_module.9.000.cdf.splot</pre>
121	*****	***	***************************************

86	****	*****
87	Performance variable	
88	Time	: 5.000000
89	Mean	: 9.940995e-004
90	Variance	: 9.931112e-004 : 9.931112e-004
91		: 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	
109	Time	: 8.000000
110		: 8.273143e-006
111		: 8.273075e-006
112	Plot files (pdf)	
113	(cdf)	: Experiment_8.trs.reliability.8.000.cdf.splot
114		*****
115	Performance variable	
116	Time	: 9.000000
117	Mean	: 1.671339e-006
118		: 1.671336e-006
119	Plot files (pdf)	
120	(cdf)	: Experiment_8.trs.reliability.9.000.cdf.splot
121		





2 lights1 switch1 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.