Stochastic Activity Networks in Mobius

Overview

- Introduction to SAN in Möbius
- Example of Failure-Detection-Repair
- Exercises

Stochastic Activity Networks (SAN)

The Stochastic Activity Networks are a wide-ranging and complex extension to Petri-Nets

Petri Net = places + transitions + enabling conditions + firing rules

Stochastic Petri Net = Petri Net + stochastic transition delay

Stochastic Activity Network = Stochastic Petri Net + stochastic transition outcome + advanced enabling condition + advanced firing rules

SAN in Möbius tool 1/2

NOTE: the terms **activity**, **transition** and **action** will be used interchangeably

Transitions may be timed or instantaneous

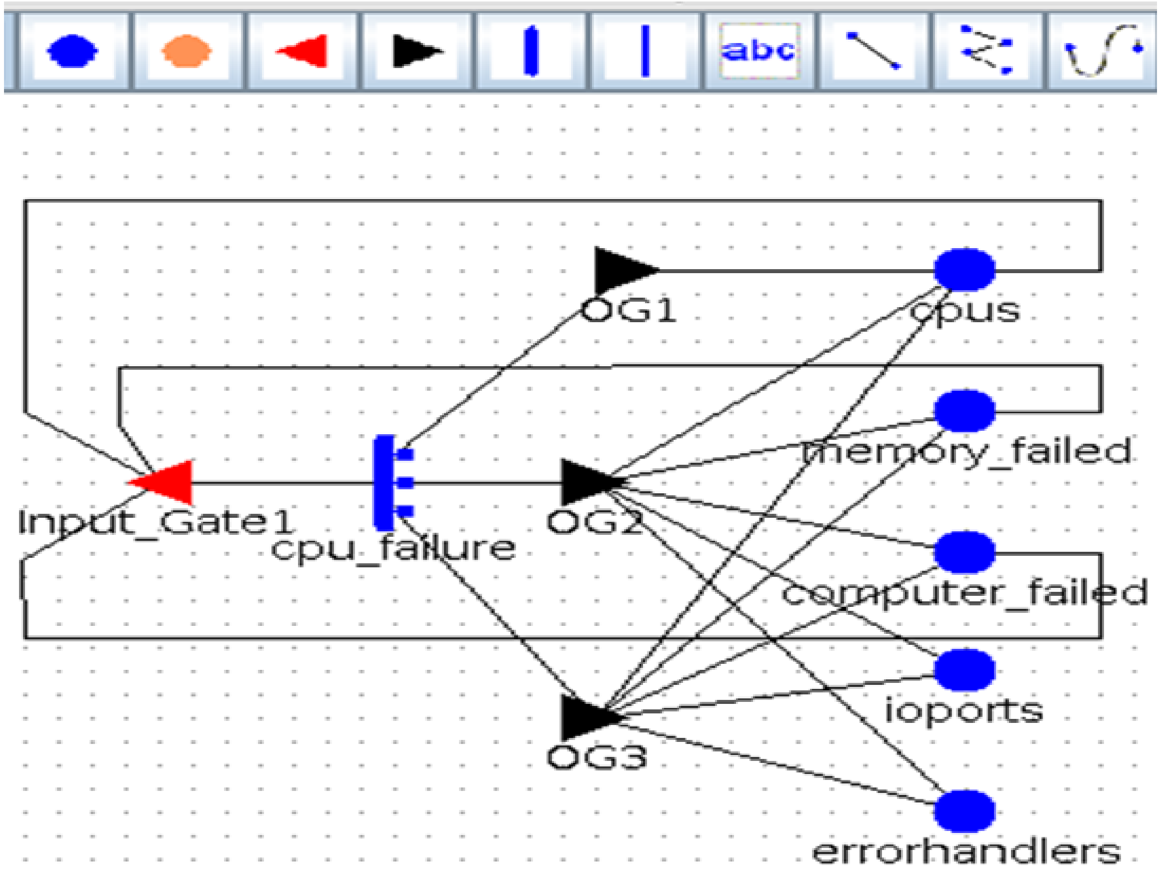
Enabling conditions are defined with input gates associated with transitions

Firing rules: user-defined functions specified in input or output gates

SAN in Möbius tool 2/2

Stochastic transition outcome: Alternative results of a transition can be specified as mutually exclusive cases associated with the transition

Each case has a probability defined by a function of the marking (it may be a constant)



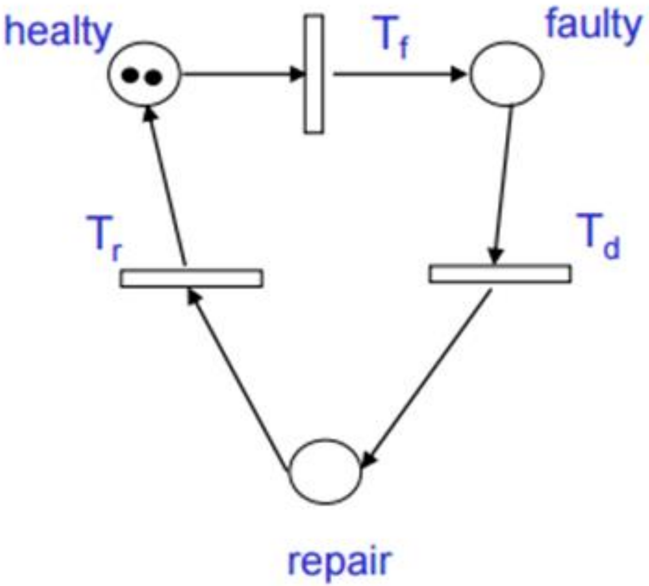
Elements of Möbius tool

Atomic and Composed model, reward, study, transformer and **solver**
are used in the same way they are used for Fault Tree analysis.

Möbius allows to evaluate a Performance Variable
Steady State
Transient (instant of time)

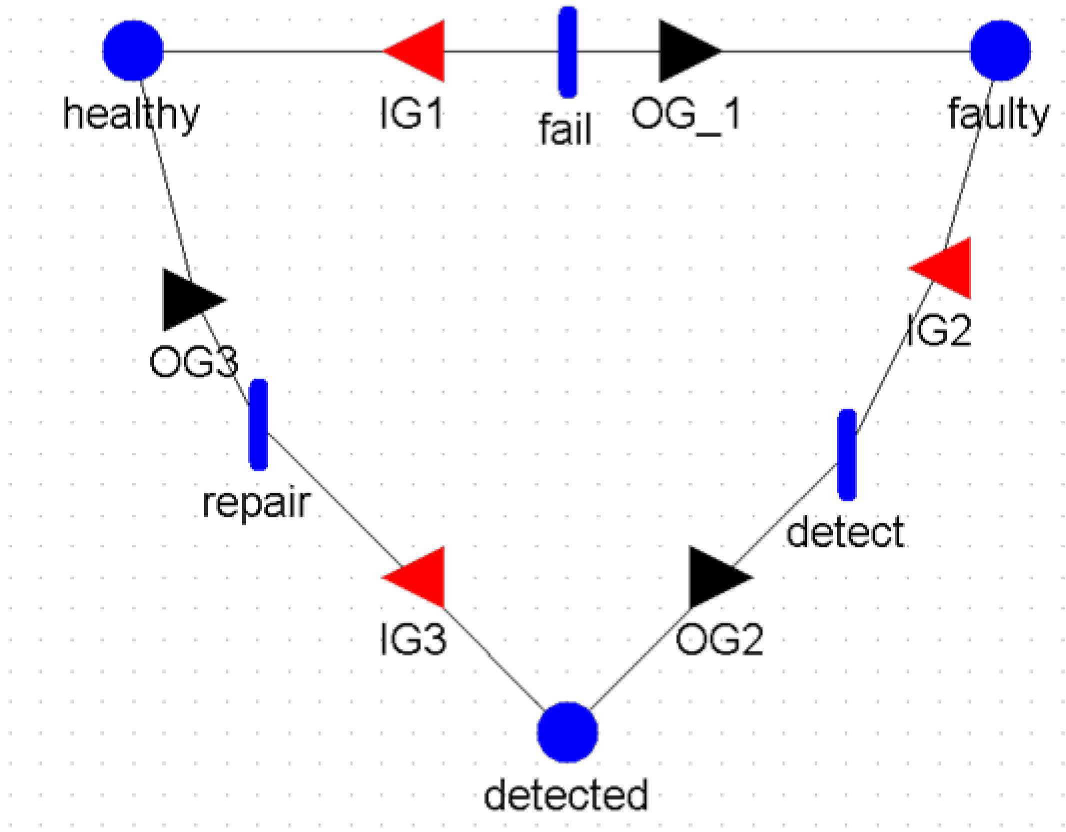
Failure-Detection-Repair

- Two identical CPUs
- **Failure of the CPU:** exponentially distributed with parameter λ
- **Fault detection:** exponentially distributed with parameter δ
- **CPU repair:** exponentially distributed with parameter μ



Evaluate Availability of the system during steady state, considering that the system is working if at least one CPU is healthy

Atomic Model



Remember to edit three global variables

(lambda, mu and delta)

Set the initial state for places)

(healthy = 2, faulty = 0, detected = 0)

Set the rate of each event as the number of token in the input place times the rate of the event

Set the input enabling function, stating that the activities are enabled if there is at least one token in the input place

Set the output function, so that it decreases the number of tokens in the input place and increases the ones of the output place by one

Fail example

Input Predicate

```
healthy->Mark() > 0
```

Output Function

```
faulty->Mark()++;
healthy->Mark()--;
```

Name: fail

Time distribution function: Exponential

1

Rate

```
return lambda*healthy->Mark();
```

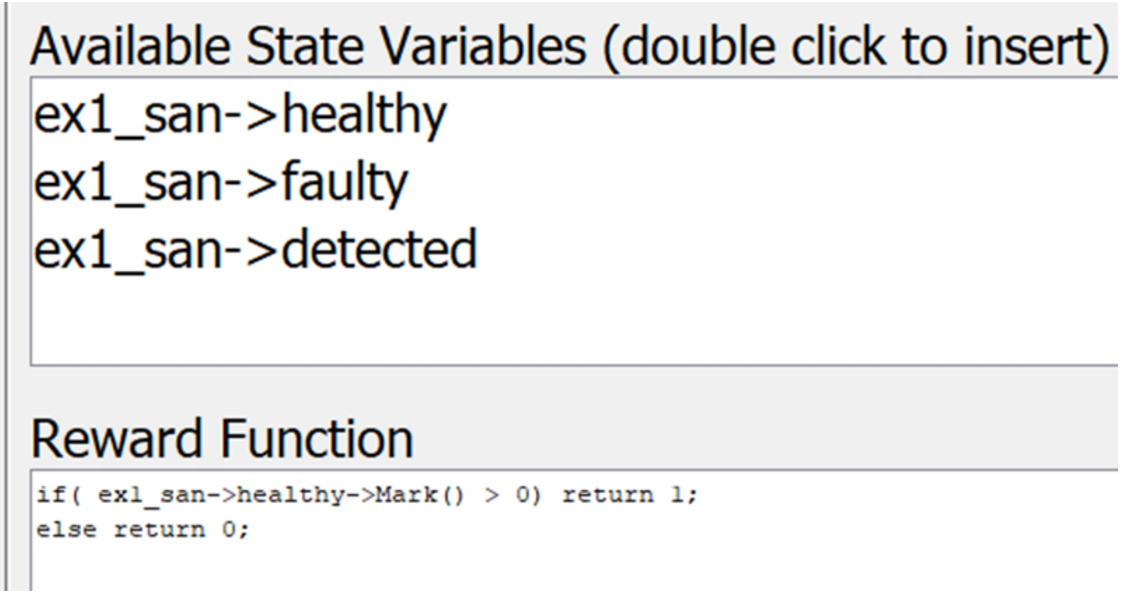
Case quantity: 1

Case 1

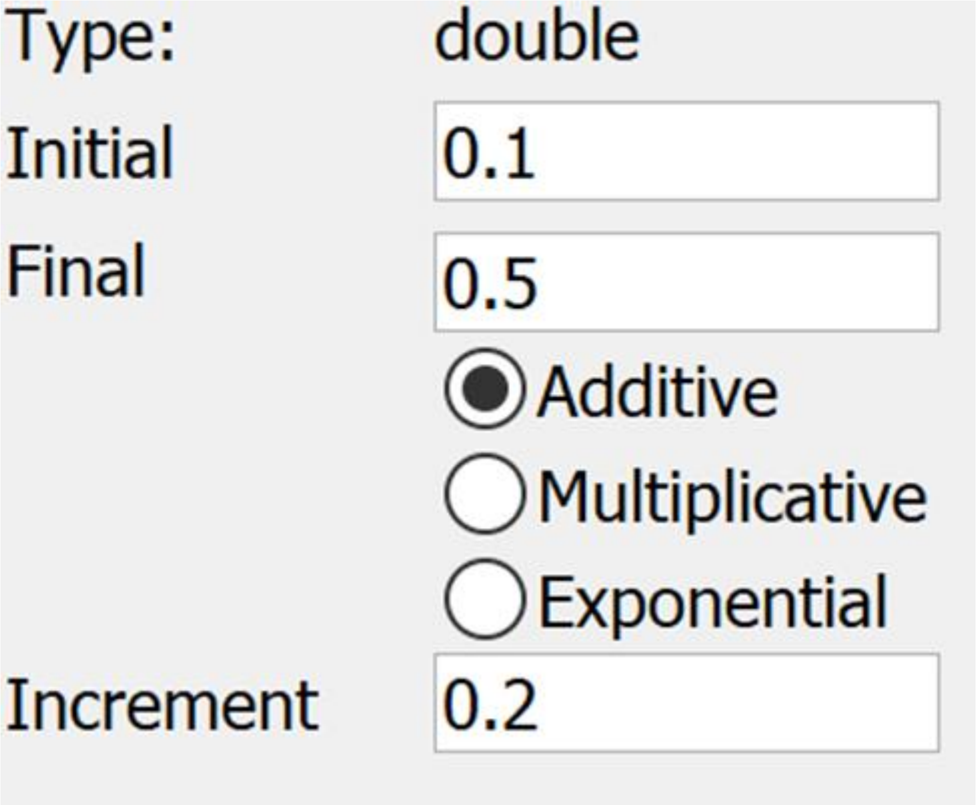
```
1
```

Reward model

- Create a performance variable called **availability.**
- Express its **reward function** according to the condition of correctness of the system.
- Set a steady-state **Time** option with default configurations.



Study model



Set a **range study** model where all the three rates vary from 0.1 to 0.5 with a step of 0.2.

All the possible combinations lead to **27 experiments**

Transformer and Solver

Again use the State Space Generator (NOT Symbolic) as transformer

Then, in order to evaluate the steady state behavior choose a Steady State solver.
For simplicity select the Direct Steady State Solver.

The behavior of different solvers can be found in the Möbius wiki.

Results

Experiment 1:

lambda = 0.1, **delta** = 0.1, **mu** = 0.1 è Availability = 0.55555

Experiment 14:

lambda = 0.3, **delta** = 0.3, **mu** = 0.3 è Availability = 0.55555

Experiment 4:

lambda = 0.3, **delta** = 0.1, **mu** = 0.1 è Availability = 0.2653

Experiment 3:

lambda = 0.1, **delta** = 0.5, **mu** = 0.1 è Availability = 0.702

Exercise

A computer is idle, busy, or failed;

jobs arrive at a rate α ;

1000

jobs are completed at a rate β ;

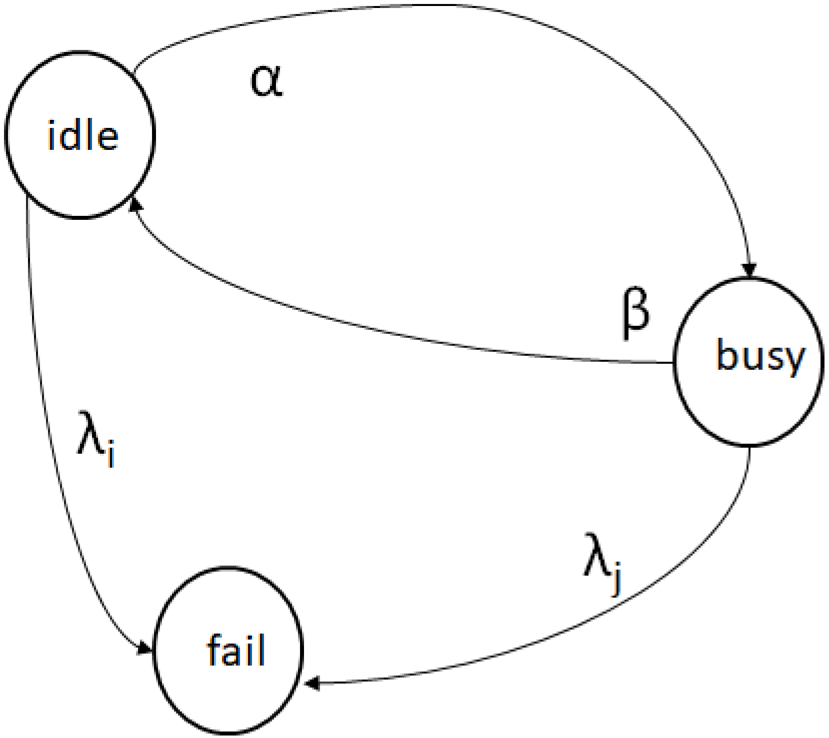
10000

the computer fails at rate λi when idle;

1.0E-7

the computer fails at rate λj when busy.

From 1 x 10-6 to 5 x 10-6



Evaluate availability and then the reliability

References

William H. Sanders and John F. Meyer, ``Stochastic Activity Networks:formal definitions and concepts'', in Lectures on formal methods and performance analysis: first EEF/Euro summer school on trends in computer science, 2002.

https://www.mobius.illinois.edu/wiki/index.php/Möbius_Documentation

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