Möbius Tool

LAB 02

Contacts

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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

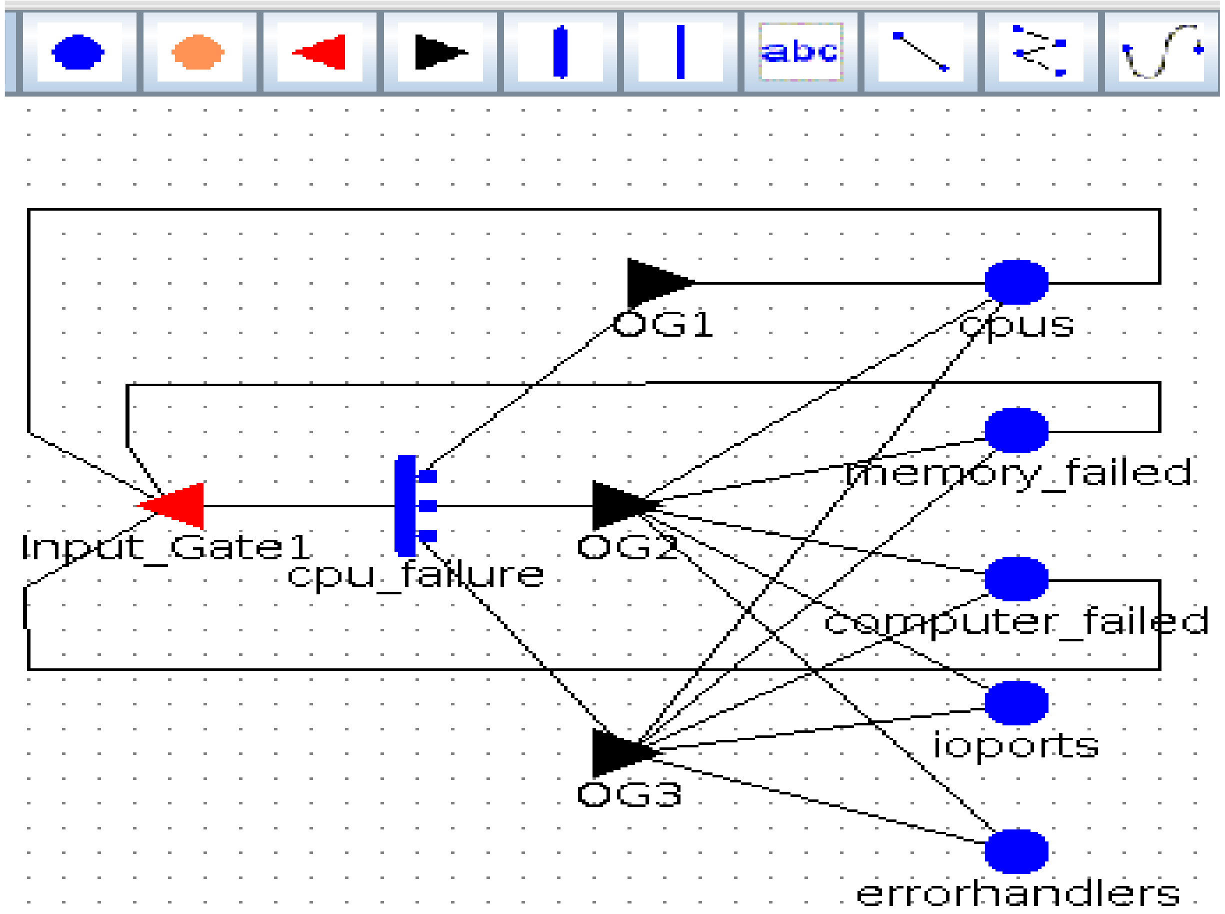
NOTE: *the terms **activity**, **transition** and **action** will be used interchangeably*

- 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)



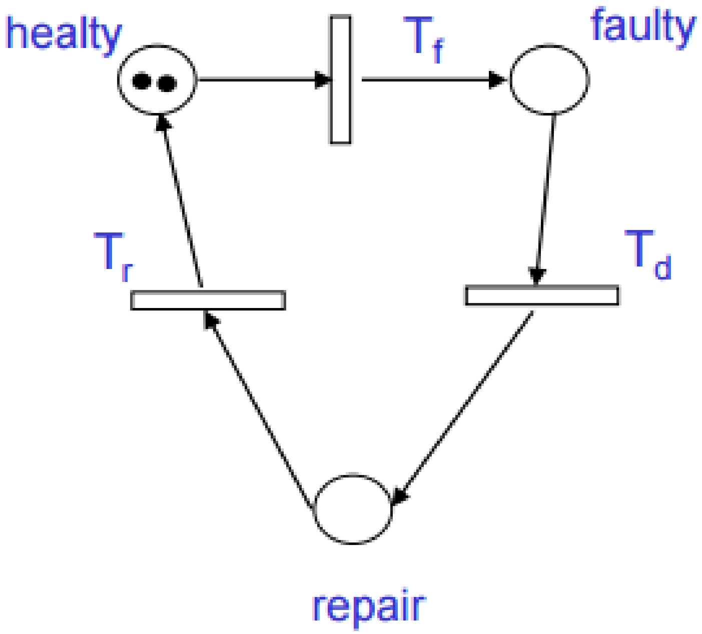
Elements of Möbius tool

- **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)**

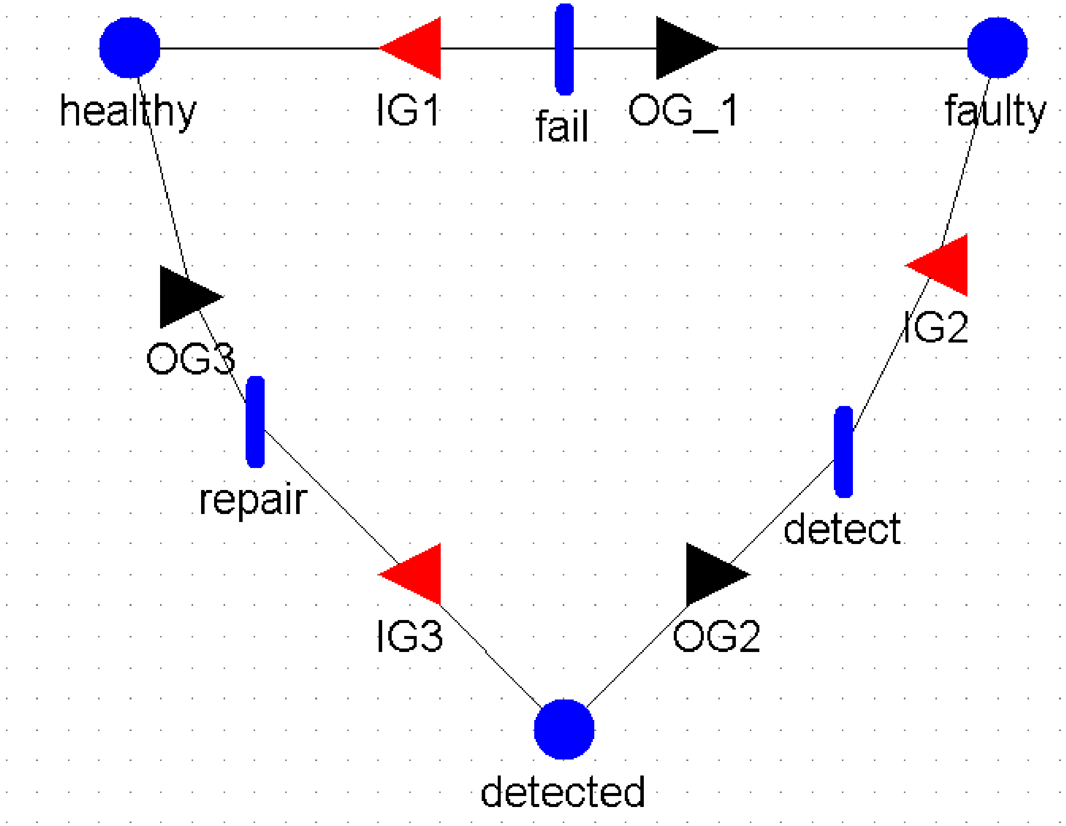
Failure-Detection-Repair

- 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();
```

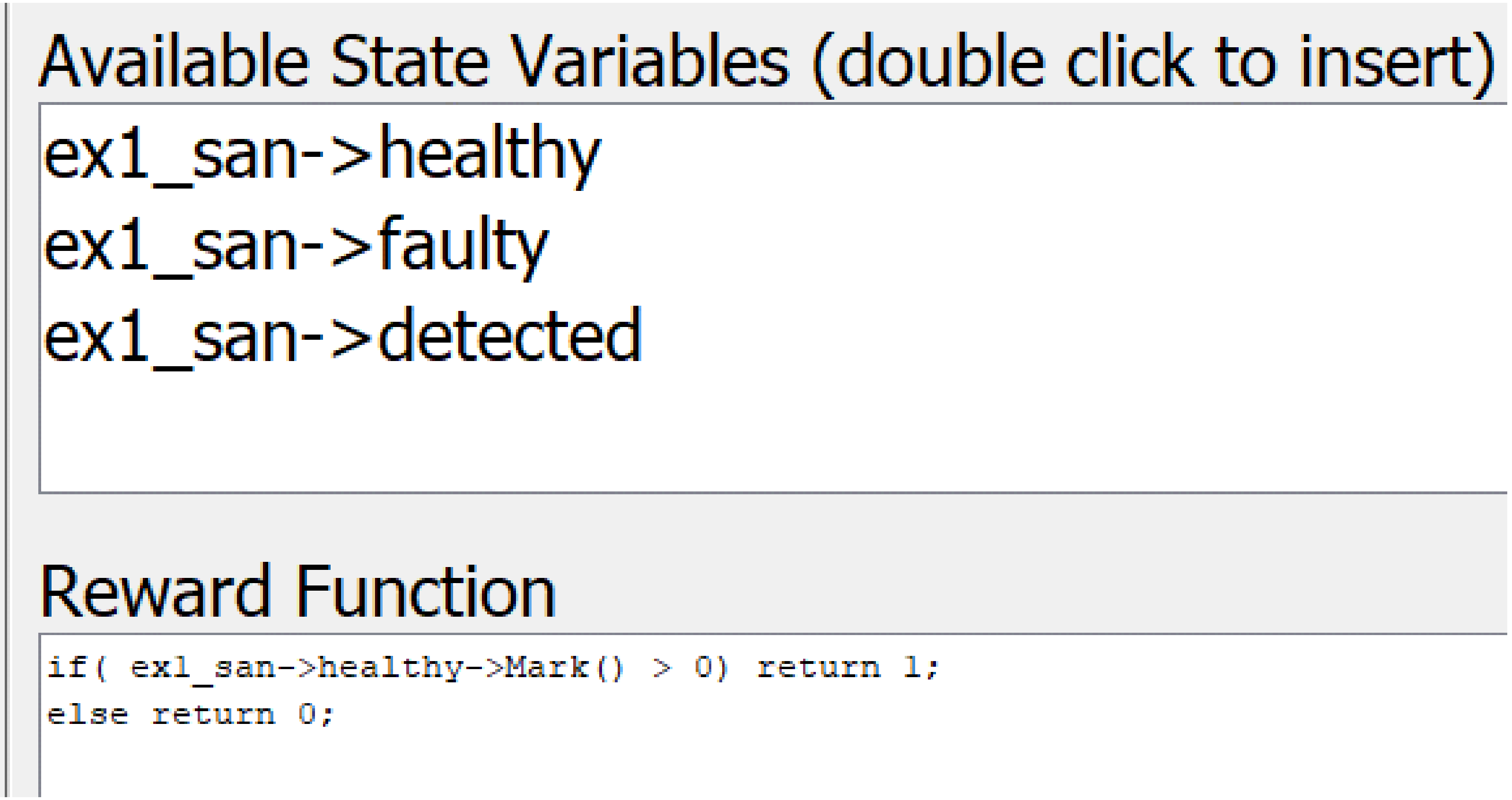
Case quantity: 1

Case 1

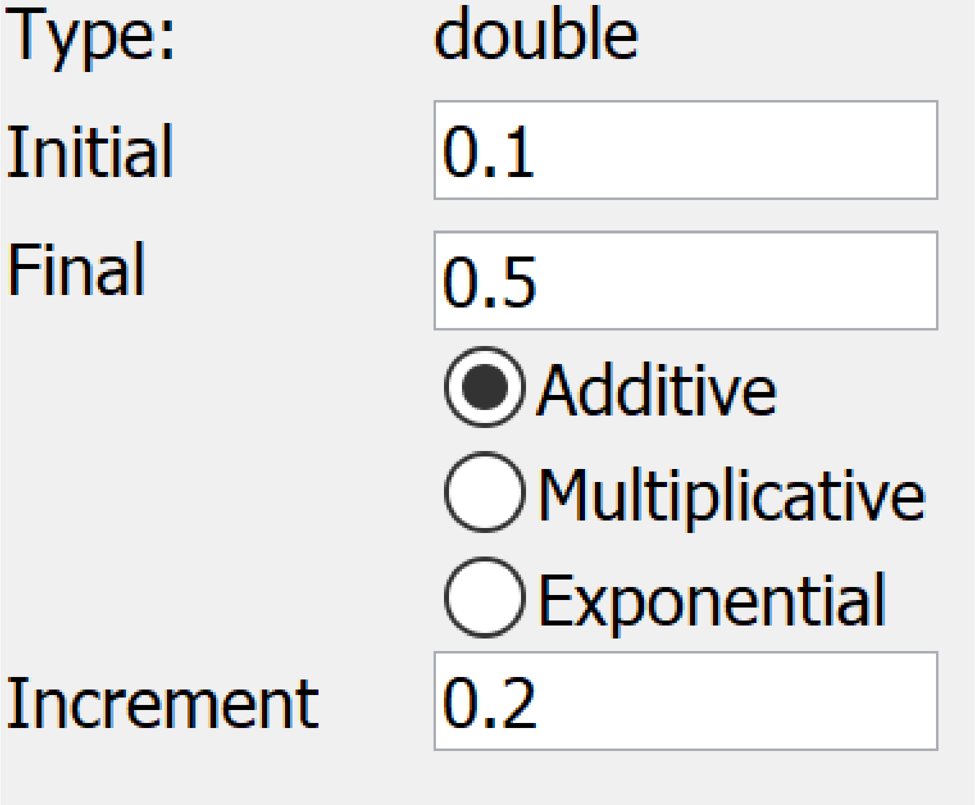
```
1
```

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

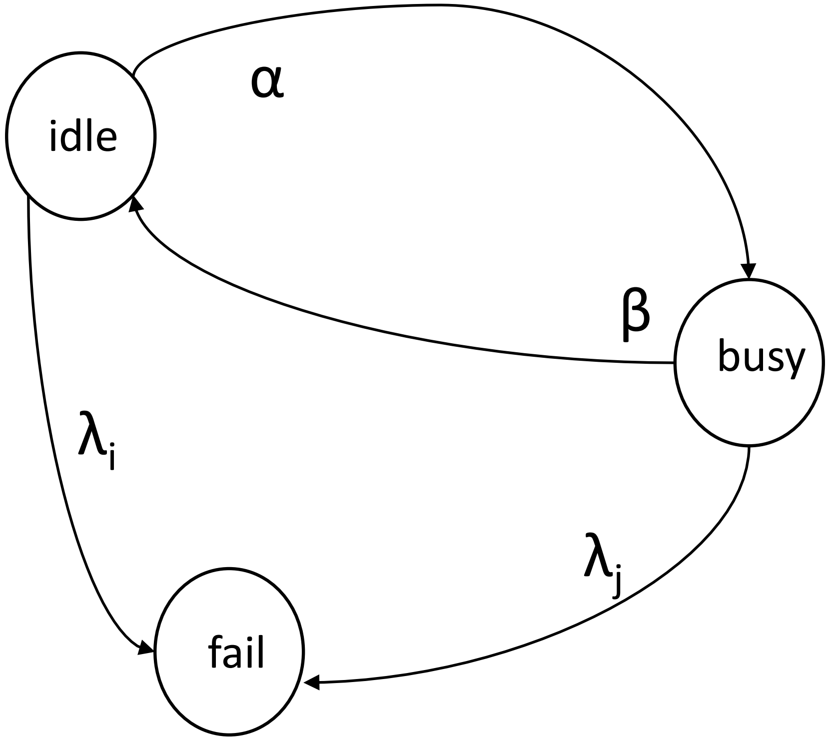
- Experiment 1:
  lambda = 0.1, **delta** = 0.1, **mu** = 0.1 → Availability = 0.55555
- Experiment 14:
  lambda = 0.3, **delta** = 0.3, **mu** = 0.3 → Availability = 0.55555
- Experiment 4:
  lambda = 0.3, **delta** = 0.1, **mu** = 0.1 → Availability = 0.2653
- Experiment 3:
  lambda = 0.1, **delta** = 0.5, **mu** = 0.1 → 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 λ_i when idle;
  - 1.0E-7
- the computer fails at rate λ_j when busy.
  - From 1×10^{-6} to 5×10^{-6}

Evaluate reliability after 24

time units of operation



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

Thanks to prof. Andrea Domenici for previous version of the slides.