OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

INF

FAKULTÄT FÜR INFORMATIK

Introduction to Event Modelling with AnyLogic

A Bank and a Mysterious Substance

More AnyLogic Element Types

Plain Variables

- Represent ordinary Java variables (`int`, `float`, …)
- *… just like Parameters*

However, they differ in their *usage:*

- *Parameters* describe **input** parameters to the simulation: they can be modified by the experiment
- *Plain variables* hold the current system state: they act as **outputs,** their values can be read and processed by the experiment

(For temporary value storage, both types can be used)

Events in Simulation

The most important element of a discrete–event simulation is the event

- Events happen instantaneously
- Events happen when they are triggered
- Events change the values of the state variables

Primary event

- Occurrence is scheduled to happen at a certain time

Conditional / secondary event

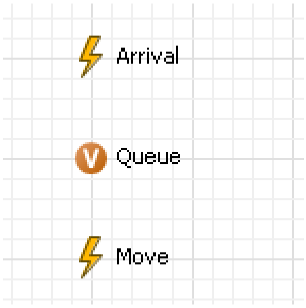
- Triggered by a certain condition becoming true

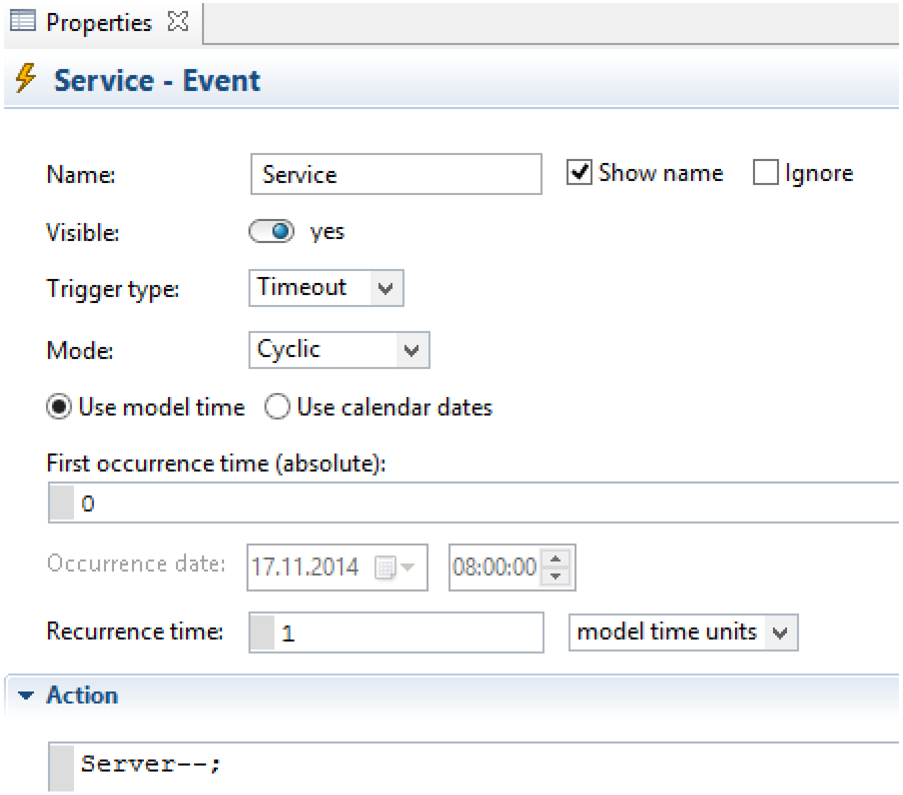
Events in AnyLogic

An event is characterized by its trigger type

- *Timeout* or *Condition*

An event occurrence executes the specified *Action*, which can be any Java code





Service - Event

Name: Service ☑ Show name □ Ignore

Visible: yes

Trigger type: Timeout

Mode: Cyclic

● Use model time ○ Use calendar dates

First occurrence time (absolute):
0

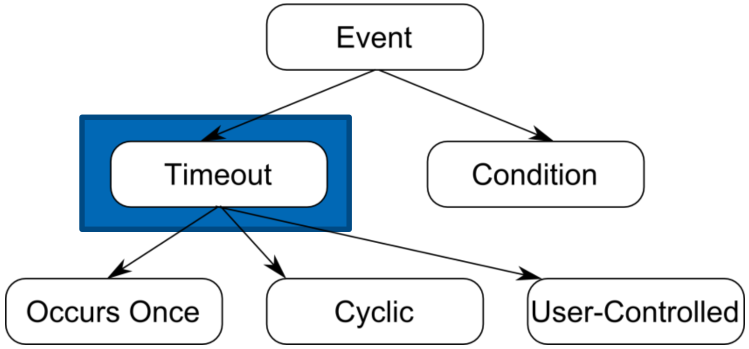
Occurrence date: 17.11.2014 08:00:00

Recurrence time: 1 model time units

Action

```
Server--;
```

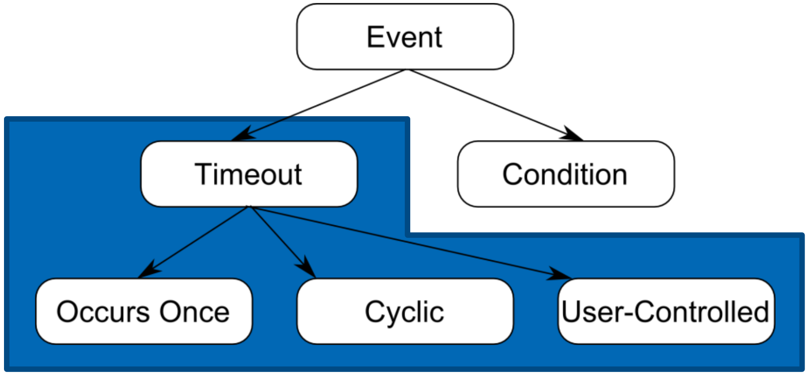
Timeout Triggered Events



Timeout Triggered Events

- Occur a certain time after they have been activated
- Are primary events
- Are collected in the FEL and occur at a specified time
- Timeouts can be described by distribution functions or absolute values

Timeout Triggered Events

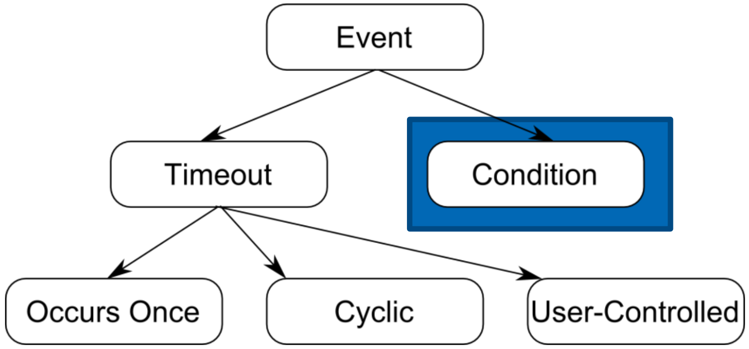


Trigger Mode	Parameters Needed
Occurs once	• Occurrence time
Cyclic	• First occurrence time • Recurrence time in between events
User controlled	• Timeout from activation to occurrence

N.B.: *Rate events* are just a shortcut for:

- timeout triggered, cyclic, exponentially distributed

Condition Triggered Events



Condition triggered events …

- Occur when their condition becomes true

→ Are conditional/secondary events

- Occur only once, unless explicitly reactivated

Controlling Events Through Java

Events can be controlled through Java code

(User controlled) Timeout events are scheduled (placed in the FEL) and conditional events reactivated using

```
<event_name>.restart()
<event_name>.restart(<timeout>)
```

An already scheduled event is deleted from the FEL using

```
<event_name>.reset()
```

The timeout countdown is temporarily interrupted using

```
<event_name>.suspend()
<event_name>.resume()
```

Distribution Functions in AnyLogic

AnyLogic provides a wide variety of non-uniform random numbers generators

- `exponential(lambda)`
- `normal(sigma,mean)`
- `uniform(min,max)`
- ...

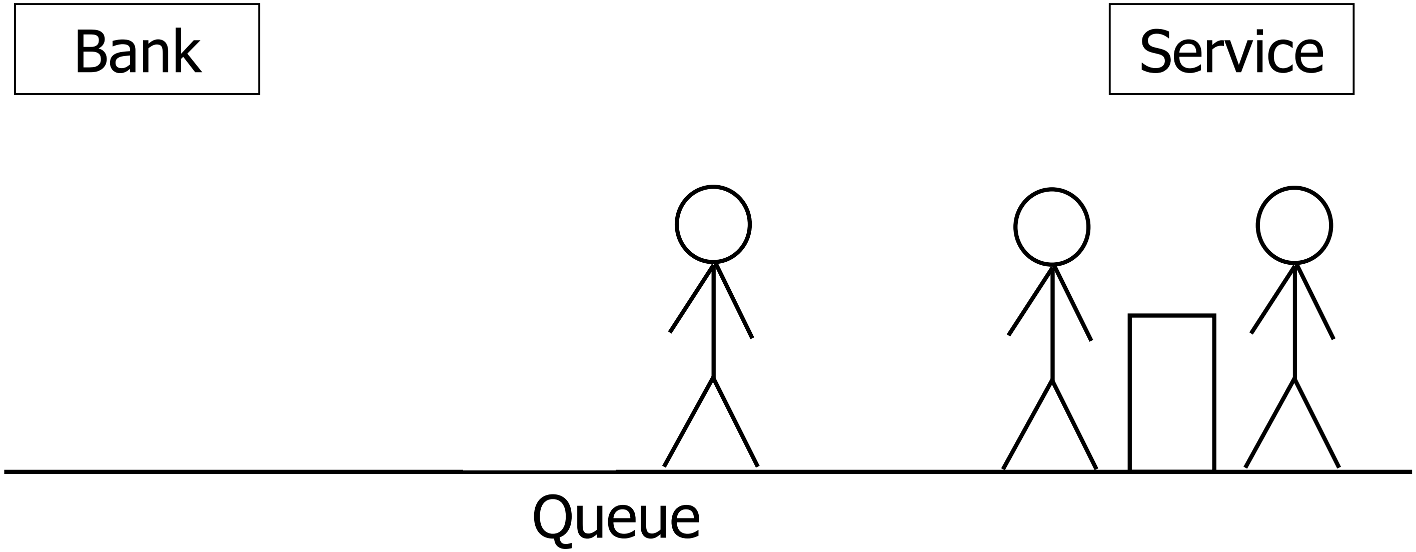
Each call of a distribution function draws a sample from the corresponding distribution

→ Successive calls to the same function with the same parameters will yield *different* values!

Modeling a Bank

Modeling a Bank

We would like to model the bank in AnyLogic


Bank

Service

Queue

Modeling a Bank

We have three different events:

- Customer arrives into the queue
- Customer moves from the queue into service
- Customer finishes service

We have two state variables:

- Number of customers in the queue

```
public int Queue;
```

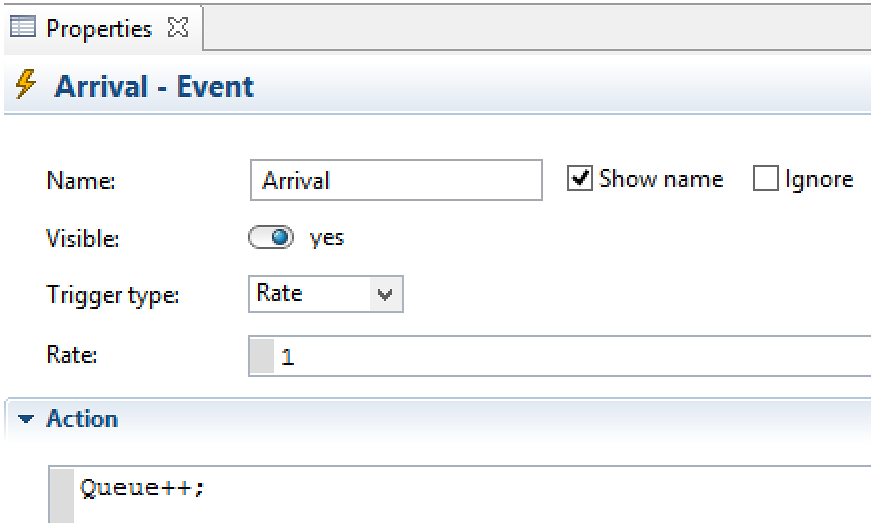
- Number of customers in service

```
public int Server;
```

Event #1: Customer Arrives

Customers arrive with exponentially distributed inter–arrival times with a rate of 1

Each arrival increases the queue length by 1



Arrival - Event

Name: Arrival ☑ Show name □ Ignore

Visible: yes

Trigger type: Rate

Rate: 1

Action

```
Queue++;
```

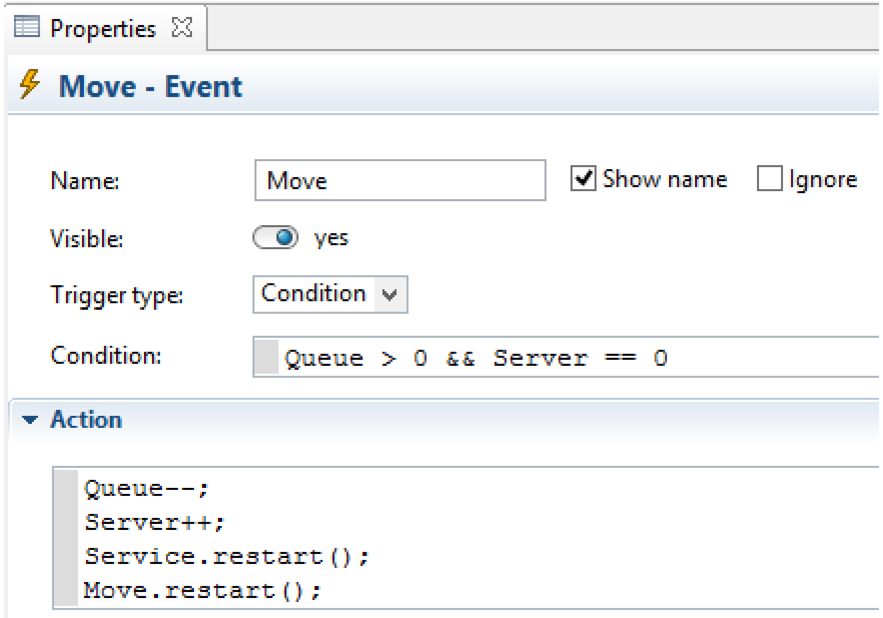
Event #2: Begin Service

The event is triggered when

- There is no one in service
- There are customers waiting in the queue

The event removes one customer from the queue and places him in service

The *service ends* event is scheduled



Move - Event

Name: Move ☑ Show name □ Ignore

Visible: yes

Trigger type: Condition

Condition:

```
Queue > 0 && Server == 0
```

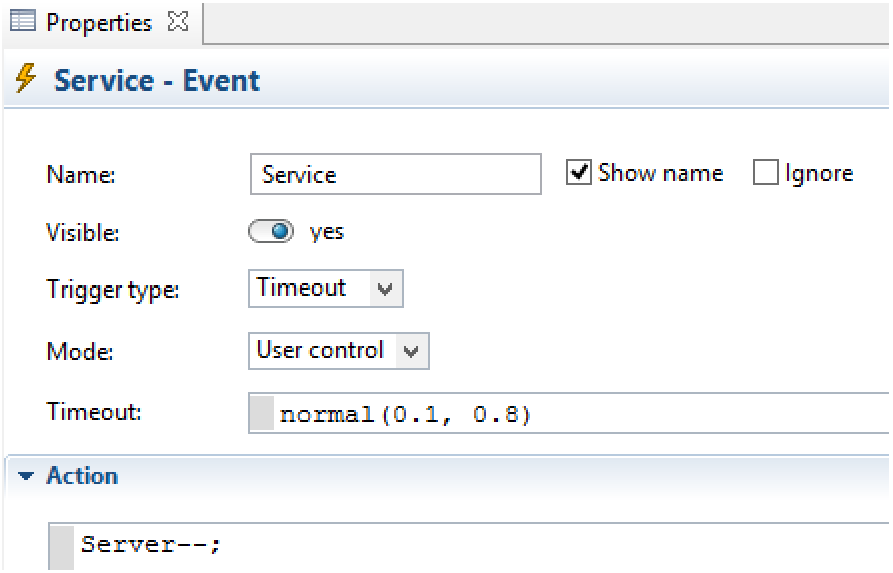
Action

```
Queue--;
Server++;
Service.restart();
Move.restart();
```

Event #3: Service Completion

The length of a service process is a normally distributed random variable with a mean of 0.8 and a standard deviation of 0.1

Each service completion removes the current customer from service



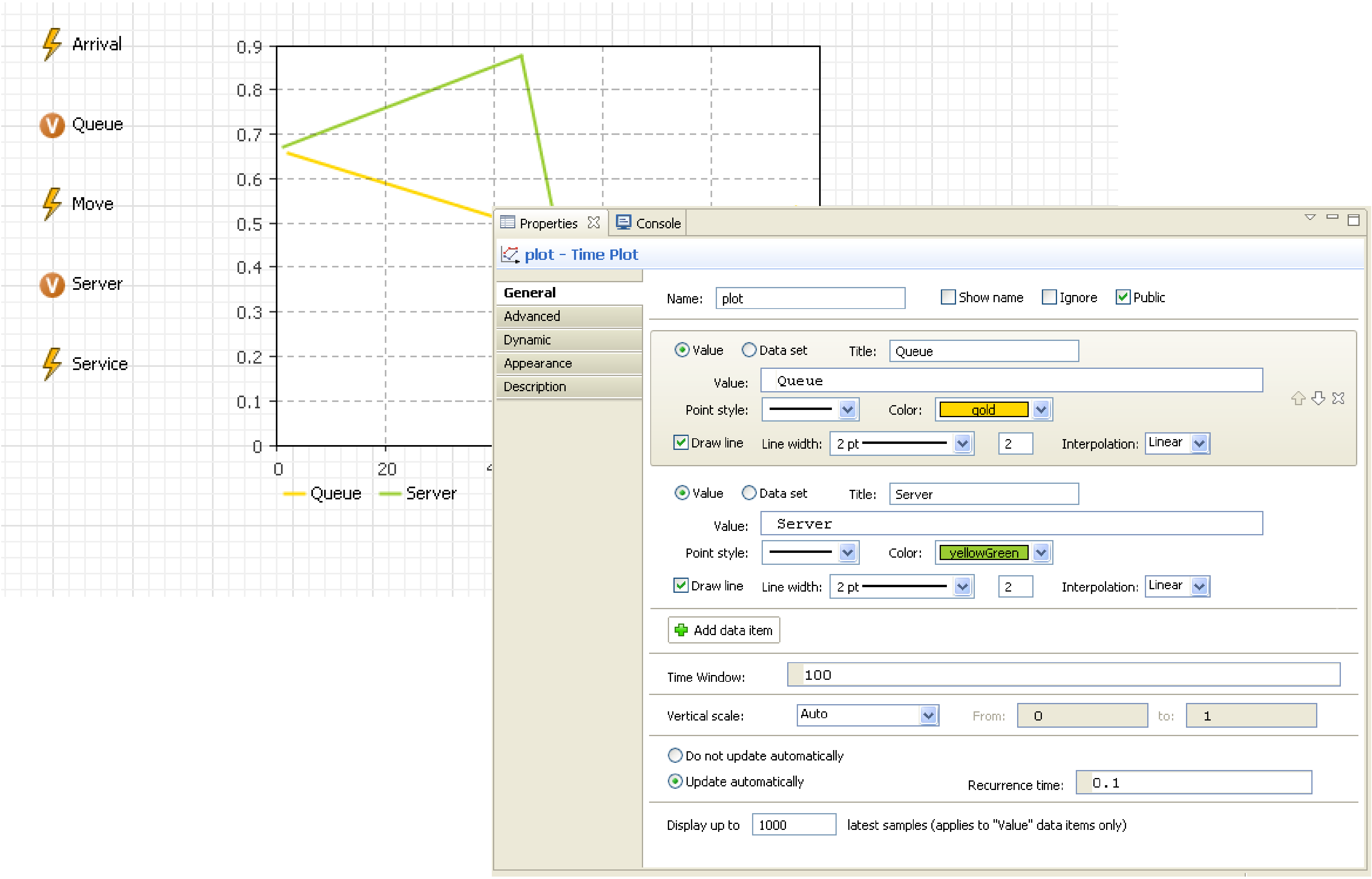
Service - Event

Name:	Service	☑ Show name ☐ Ignore
Visible:	yes	
Trigger type:	Timeout	
Mode:	User control	
Timeout:	`normal(0.1, 0.8)`	

Action

```
Server--;
```

The AnyLogic Model



Name: plot □ Show name □ Ignore ☑ Public

● Value ○ Data set Title: Queue

Value: Queue

Point style: —— Color: gold

☑ Draw line Line width: 2 pt 2 Interpolation: Linear

● Value ○ Data set Title: Server

Value: Server

Point style: —— Color: yellowGreen

☑ Draw line Line width: 2 pt 2 Interpolation: Linear

Add data item

Time Window: 100

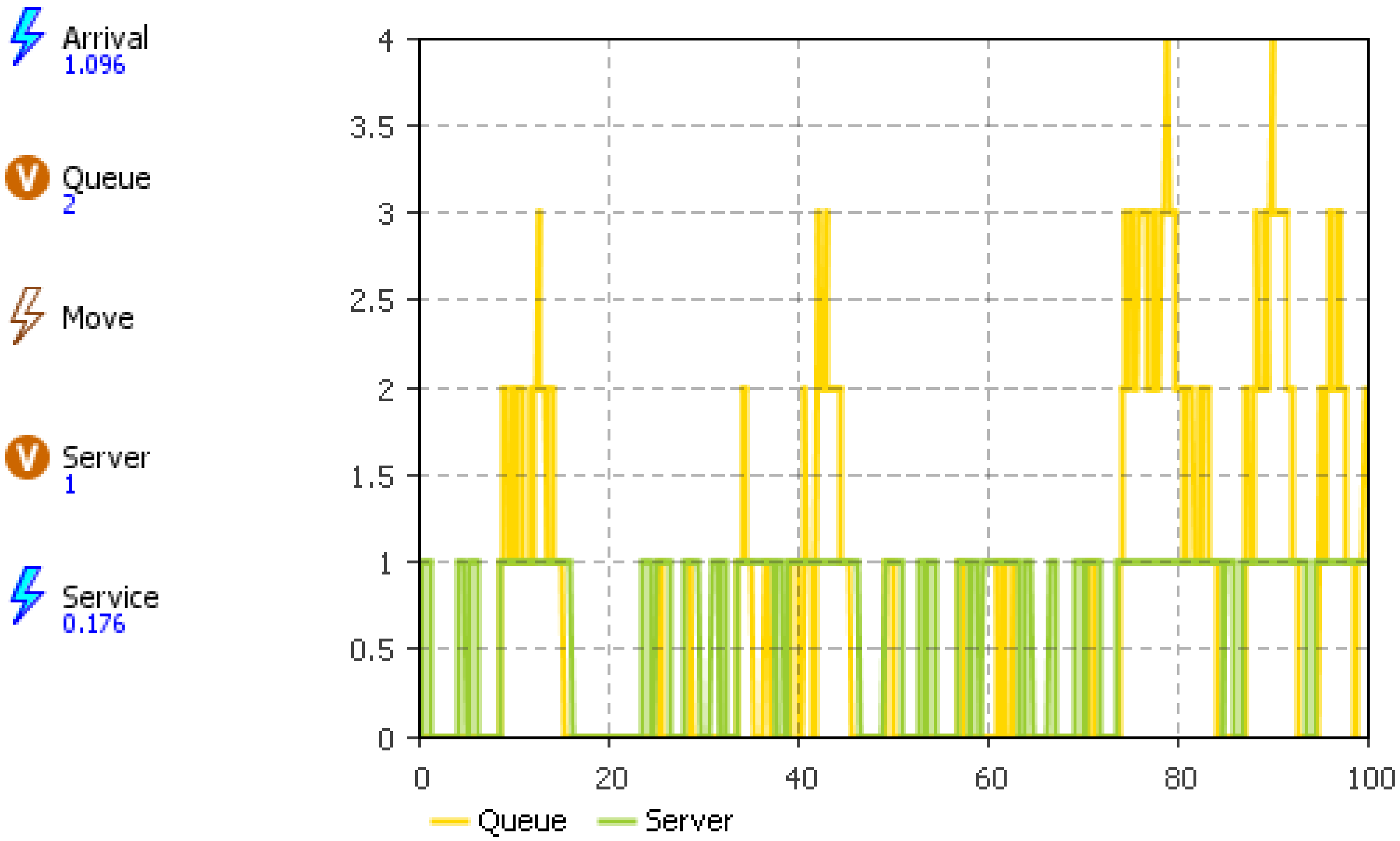
Vertical scale: Auto From: 0 to: 1

○ Do not update automatically

● Update automatically Recurrence time: 0.1

Display up to 1000 latest samples (applies to "Value" data items only)

One Simulation Result



Arrival
1.096

Queue
2

Move

Server
1

Service
0.176

Collecting Statistics in AnyLogic

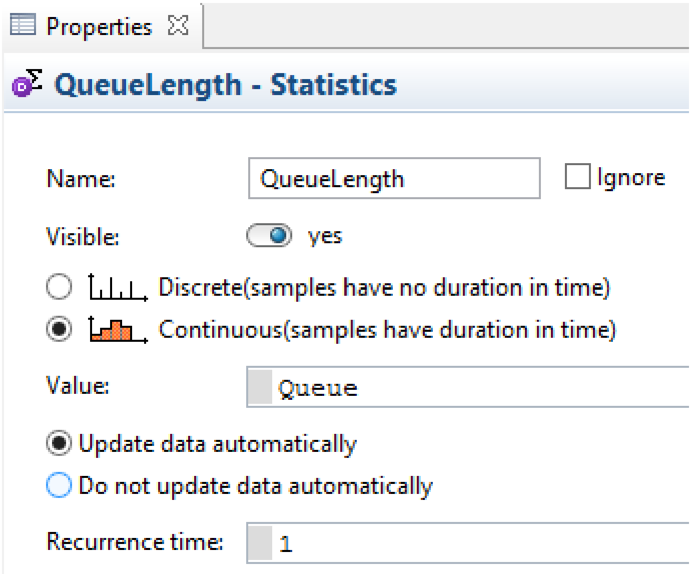
Statistics Objects

- Compute values such as: mean, variance, min, count…
- Can be discrete or continuous in time
- Can be linked to a model element
- Are updated automatically or by explicitly adding values

Histogram Data Objects

- Are needed to draw histograms
- Can be linked to a model element
- Collect the data items in bins (equally sized intervals)
- Have a fixed number of intervals (with variable width)

Statistics for Queue and Server



Properties

QueueLength - Statistics

Name: QueueLength □ Ignore

Visible: yes

○ Discrete(samples have no duration in time)

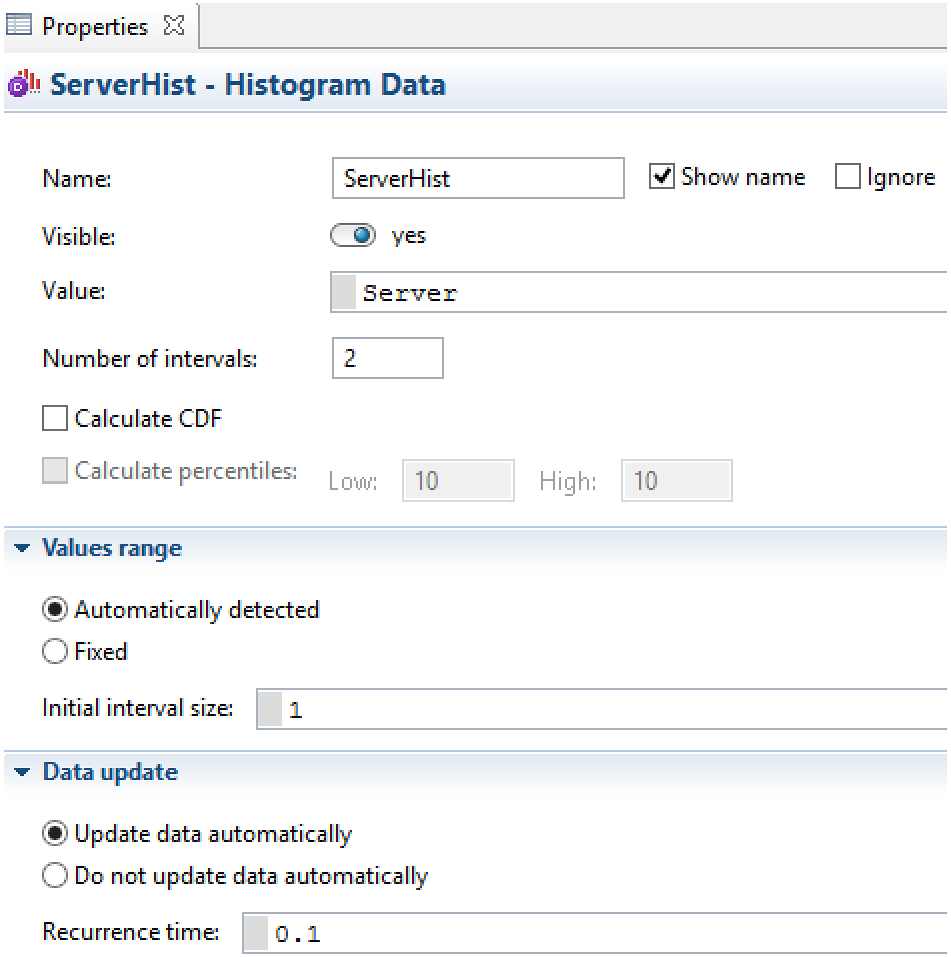
● Continuous(samples have duration in time)

Value: Queue

● Update data automatically

○ Do not update data automatically

Recurrence time: 1



Properties

ServerHist - Histogram Data

Name: ServerHist ☑ Show name □ Ignore

Visible: yes

Value: Server

Number of intervals: 2

□ Calculate CDF

□ Calculate percentiles: Low: 10 High: 10

Values range

● Automatically detected

○ Fixed

Initial interval size: 1

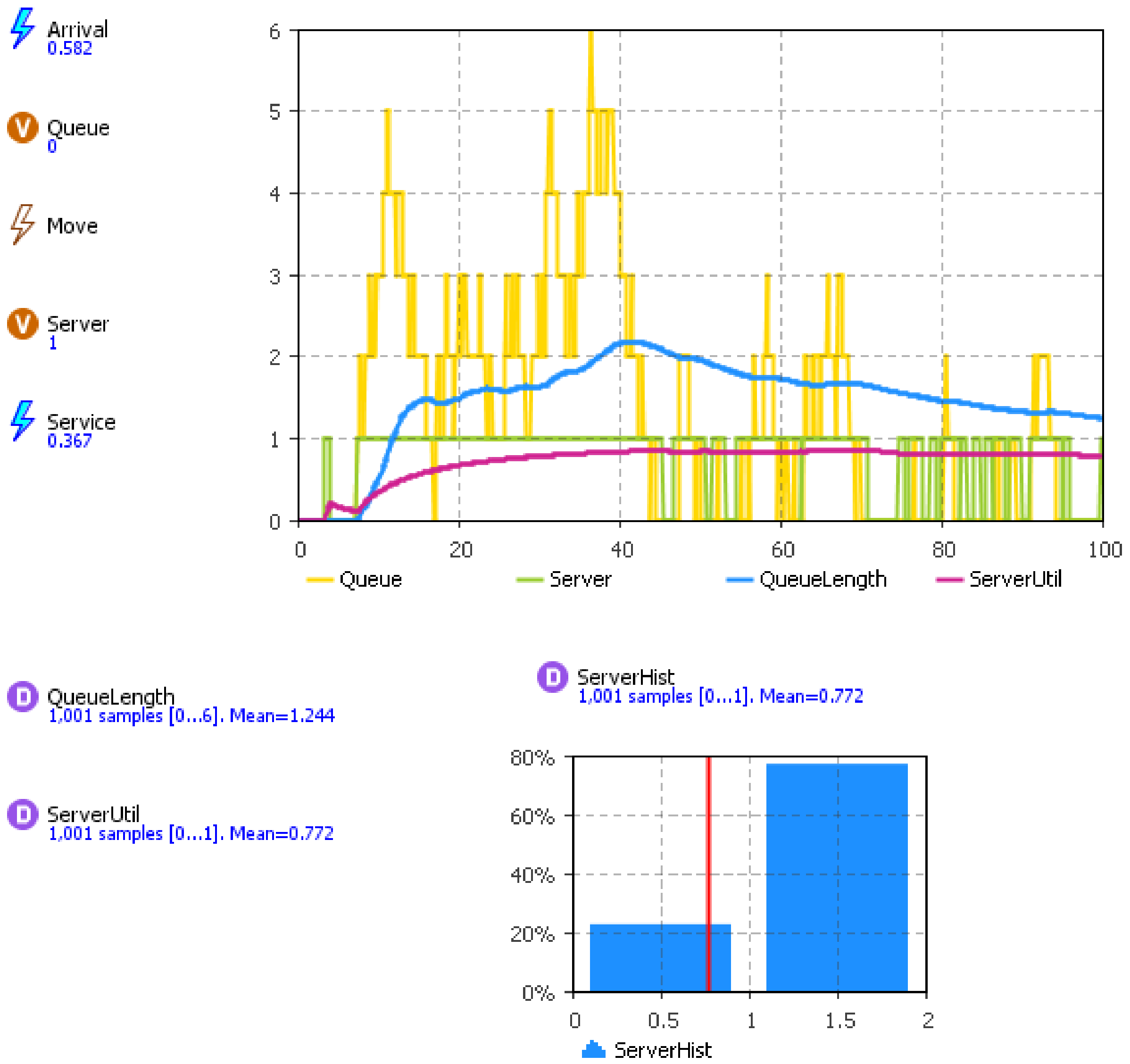
Data update

● Update data automatically

○ Do not update data automatically

Recurrence time: 0.1

Simulation Result Including Statistics



Arrival
0.582

Queue
0

Move

Server
1

Service
0.367

QueueLength
1,001 samples [0...1]. Mean=1.244

ServerUtil
1,001 samples [0...1]. Mean=0.772

ServerHist
1,001 samples [0...1]. Mean=0.772

Modeling a Substance in the Bloodstream

Hybrid Models

Models containing both discrete and continuous elements are called "hybrid" models

AnyLogic supports hybrid models

Events can be used to change the values of continuous variables

Example system: A student at a party

Hybrid Models

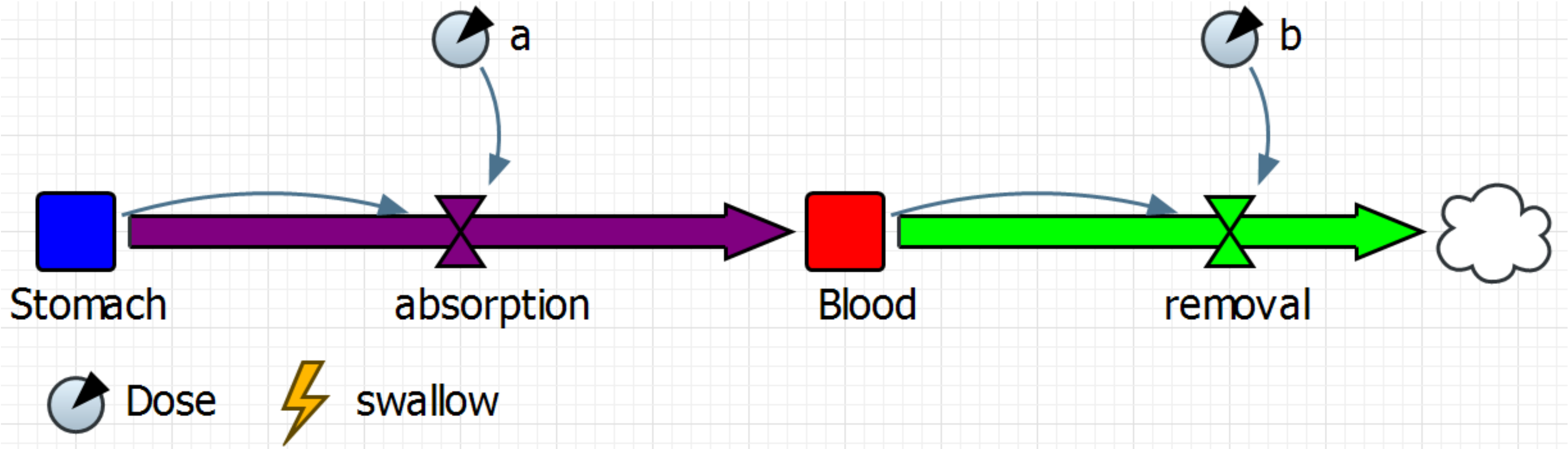
Description of the model:

- He/she swallows pills at regular intervals /
- The pill contains a certain quantity of a "substance"
- The substance starts out in the student's stomach
- It is gradually absorbed into his/her blood
  - Rate $a=0.04$ is proportional to amount in stomach
- The substance in the blood is gradually removed
  - Rate $b=0.02$ is proportional to amount in blood

Continuous mathematical model:

$$\frac{dS}{dt} = -aS \ \ (+\text{ discrete increments}) \qquad \frac{dB}{dt} = aS - bB$$

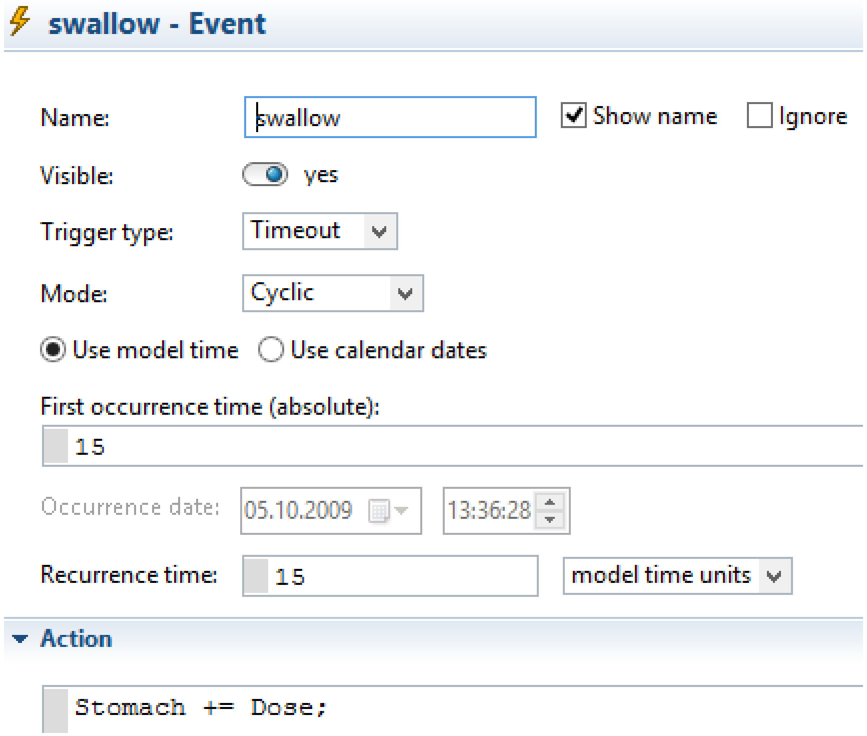
The AnyLogic Model



The Event Influencing the Flow Variable

The swallow event is cyclic and occurs every 15 minutes

Each event increases the amount of substance in the stomach by 1 dose



swallow - Event

Name: swallow ☑ Show name □ Ignore

Visible: yes

Trigger type: Timeout

Mode: Cyclic

● Use model time ○ Use calendar dates

First occurrence time (absolute):
15

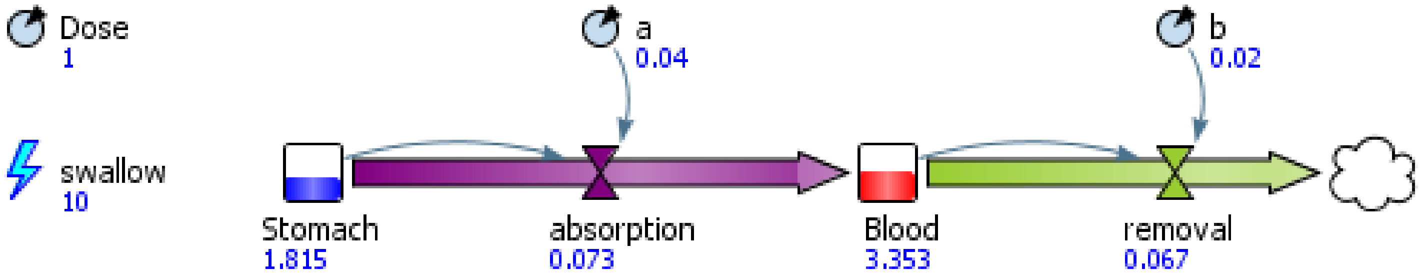
Occurrence date: 05.10.2009 13:36:28

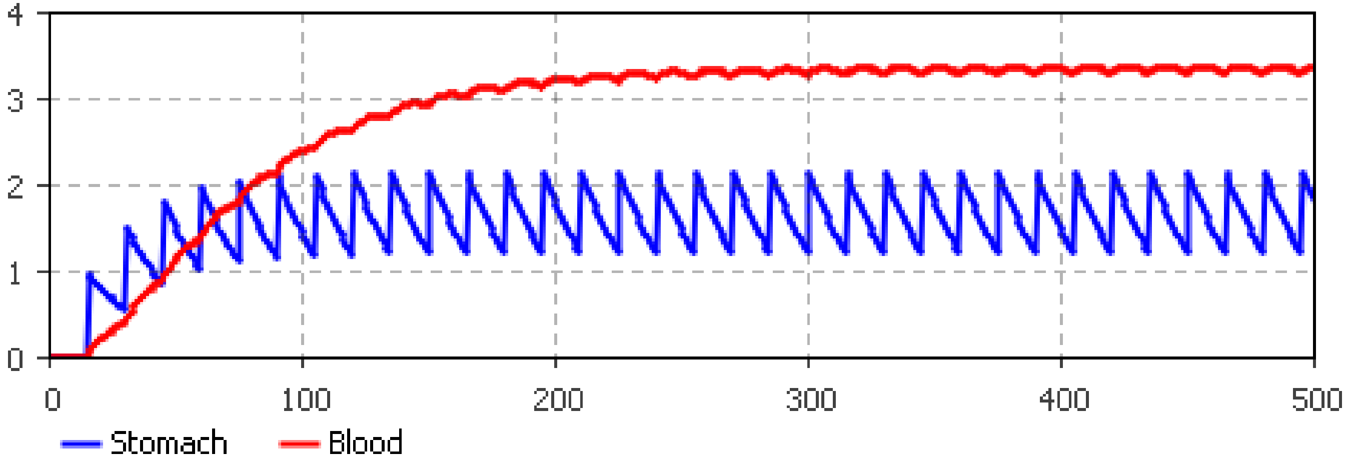
Recurrence time: 15 model time units

Action

```
Stomach += Dose;
```

Simulation Results





Learning Goals

Learning Goals to solve the Semester Assignments:

- The simulation models of the semester assignments are hybrid models

Events change the values of continuous variables

- A call from school can reduce the account balance
- Buying flowers increases moms mood
- …

Events change the values of continuous variables

- A particle hit reduces the shield energy