

Warteschlangensimulator [unsaved model file]

File Edit View Model Simulation Extras Help Quick access (Strg+E) Feedback

Load model Save model Model editor Simulation results Start animation Start simulation Parameter series Help

**Model**

**Element**

**Edge**

**Overview**

**Erlang C comparison model**

```
graph LR; Clients[Source Clients] -- "Arrivals (Clients)" --> Process[Process station]; Process --> Exit[Exit]
```

This simple model can be fully described by the Erlang C formula.

Number of clients at the process station (current value and average over the complete run time)

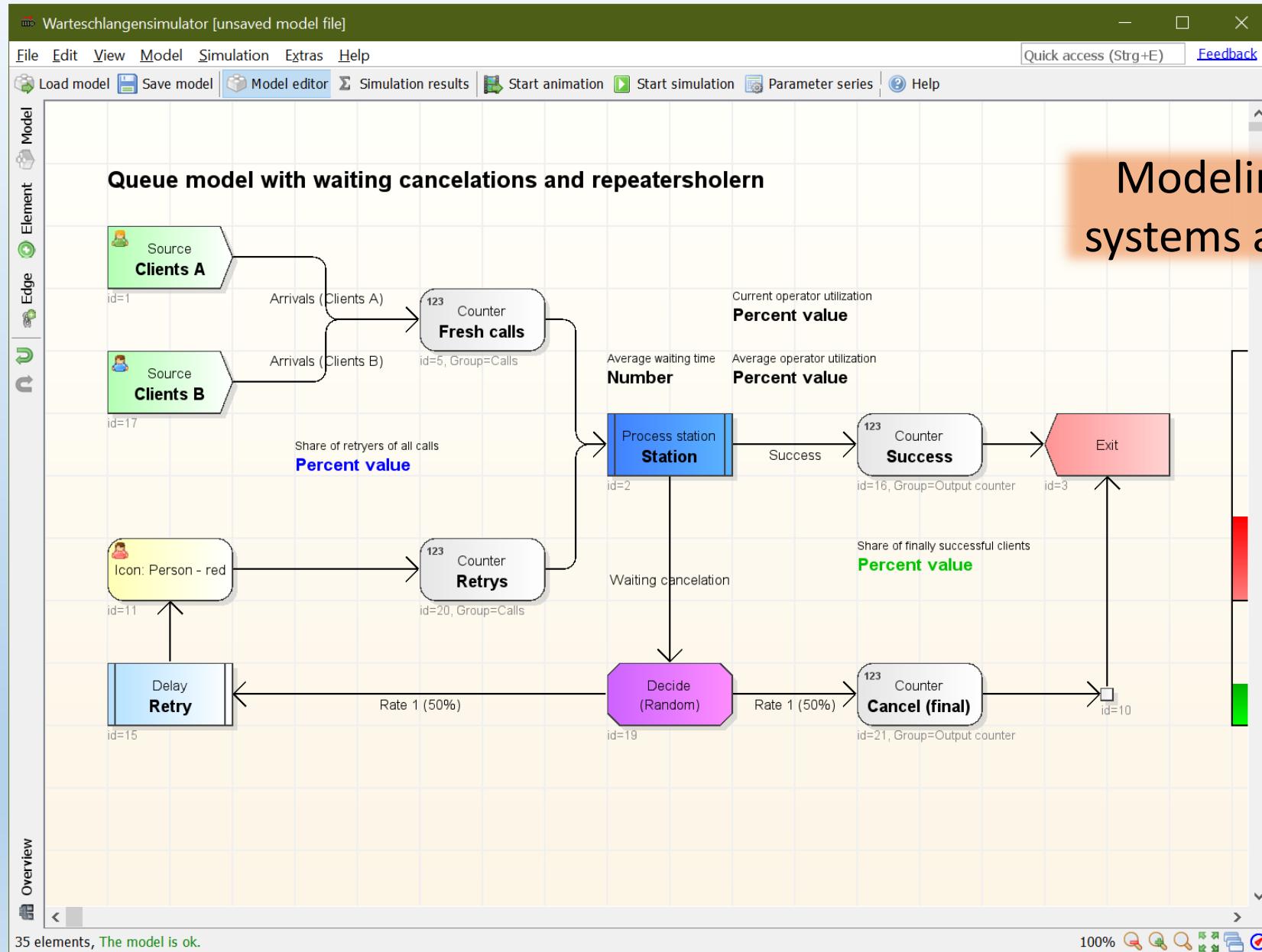
Fraction of time for the numbers of clients

(blue=0, green=1, red=2..10, orange=11...)

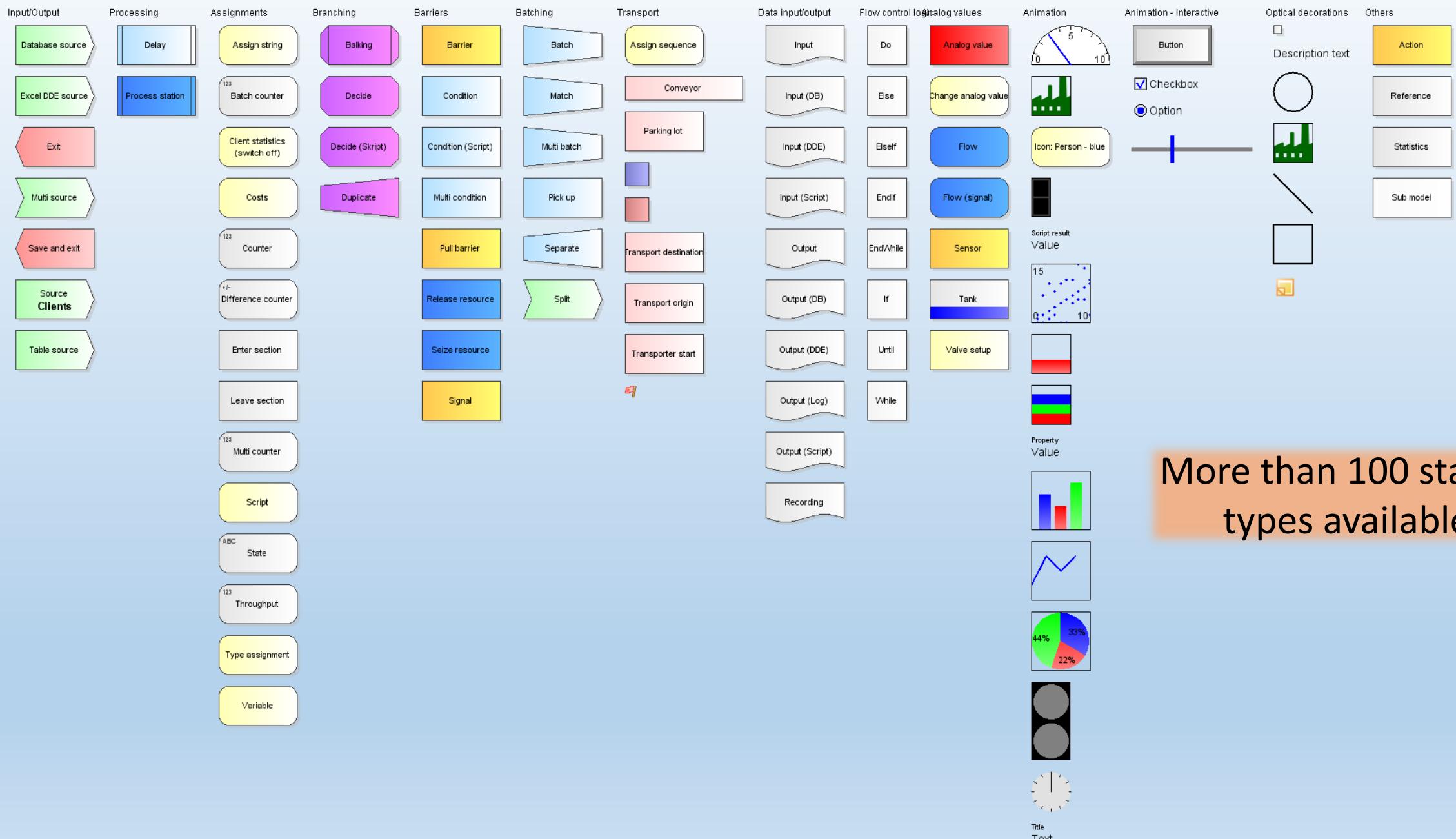
12 elements, The model is ok.

100%

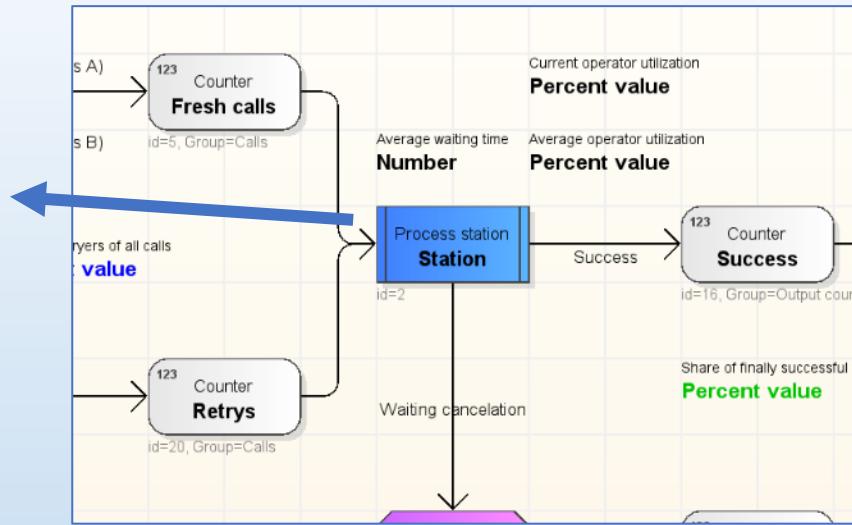
**Warteschlangensimulator**  
Fast and versatile event-driven  
stochastic simulator

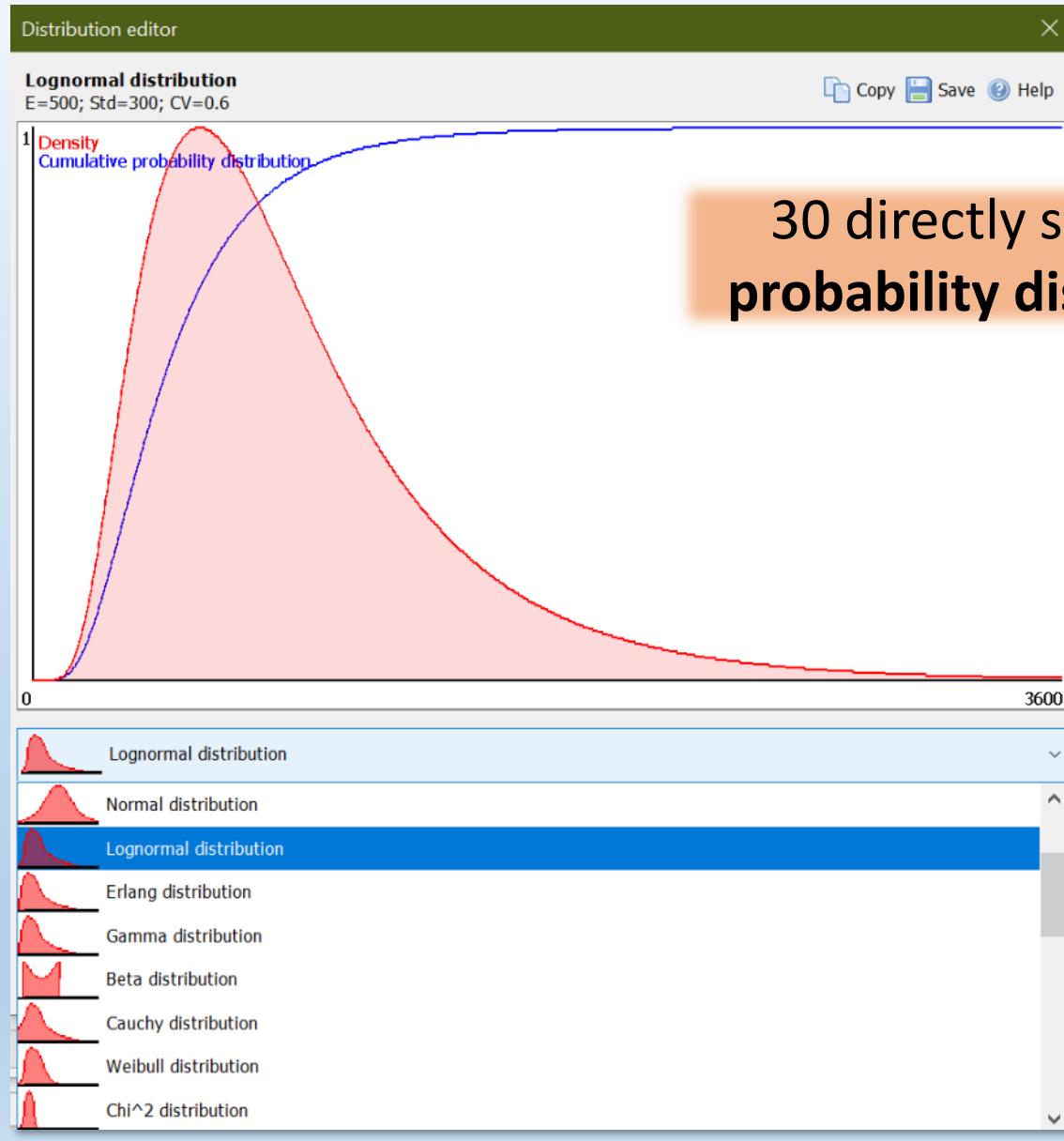


Modeling queueing systems as flow charts



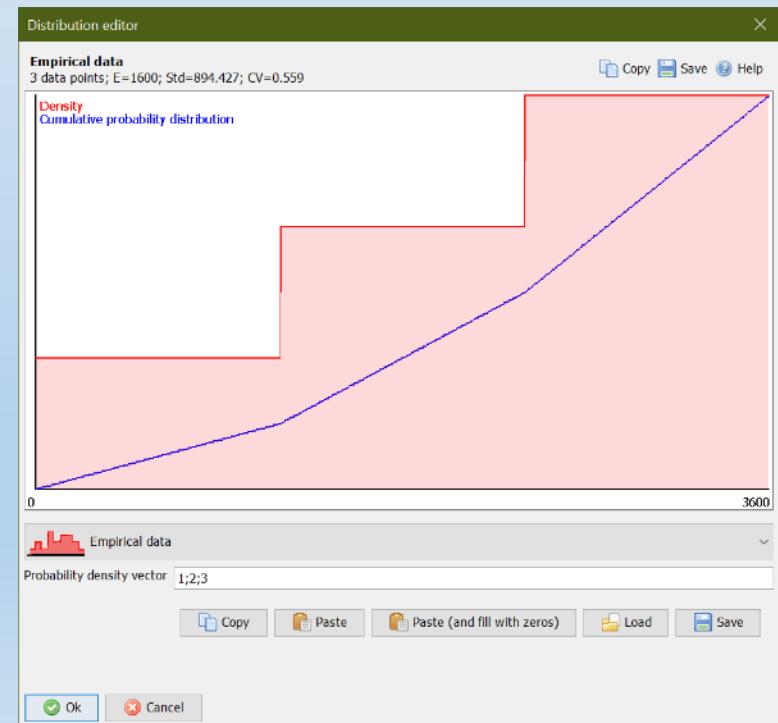
More than 100 station types available

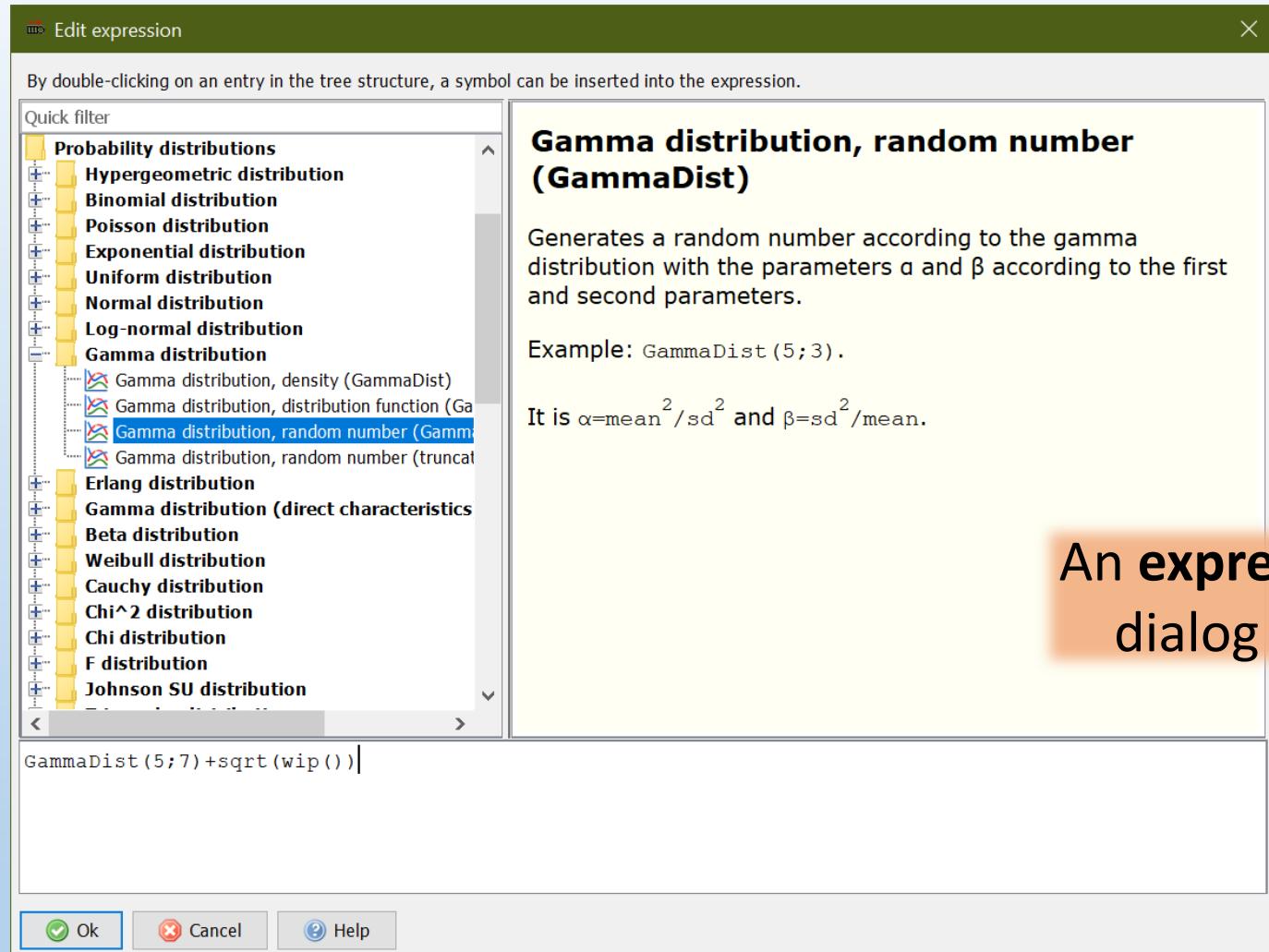




30 directly selectable  
probability distributions

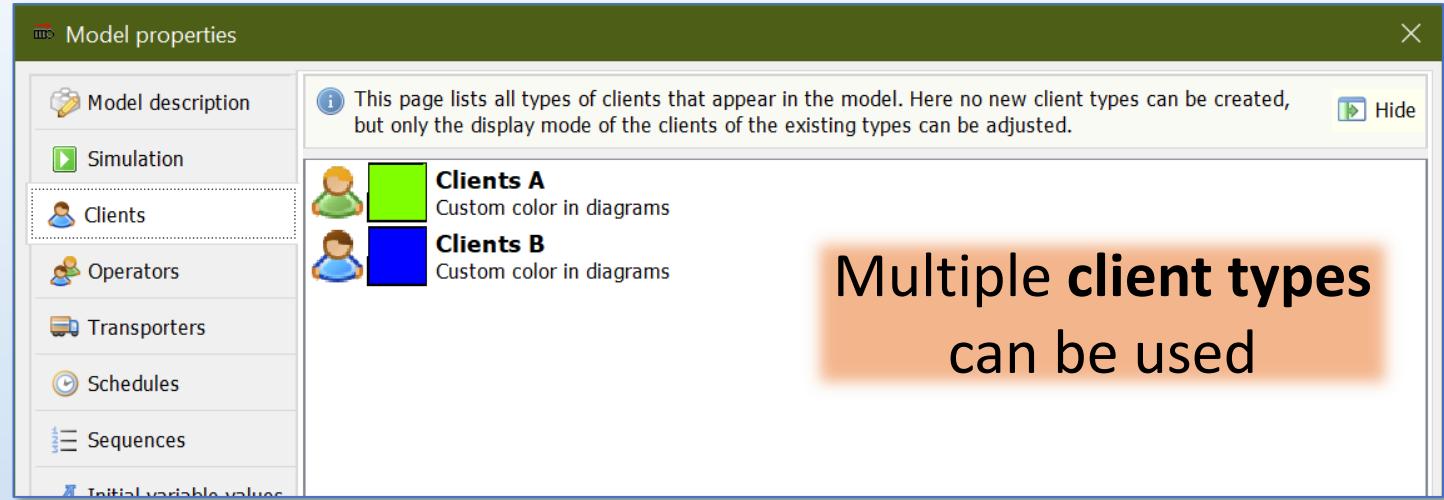
... including the option to use  
loaded empirical data





Calculation expressions  
can also be used

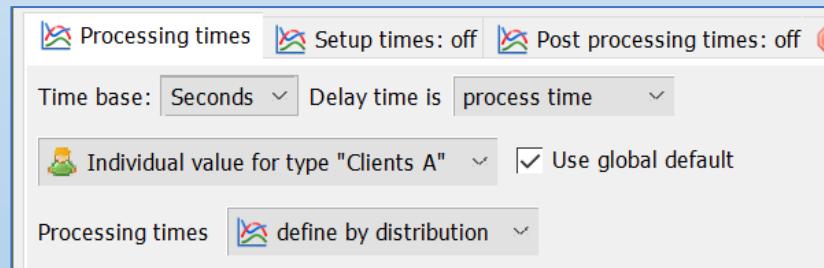
An expression builder  
dialog is available

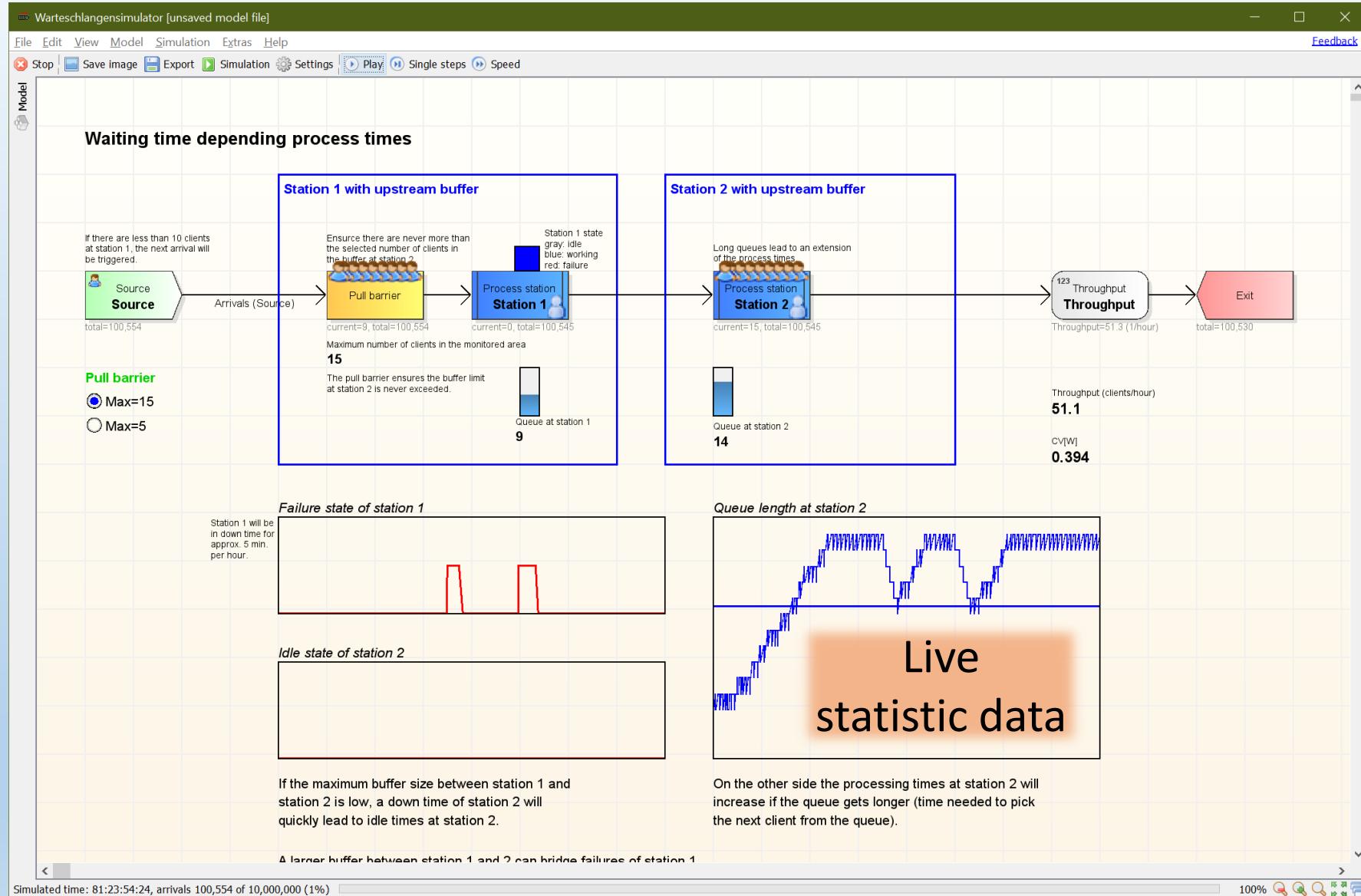


Multiple client types  
can be used



Each type can have an  
individual parameters

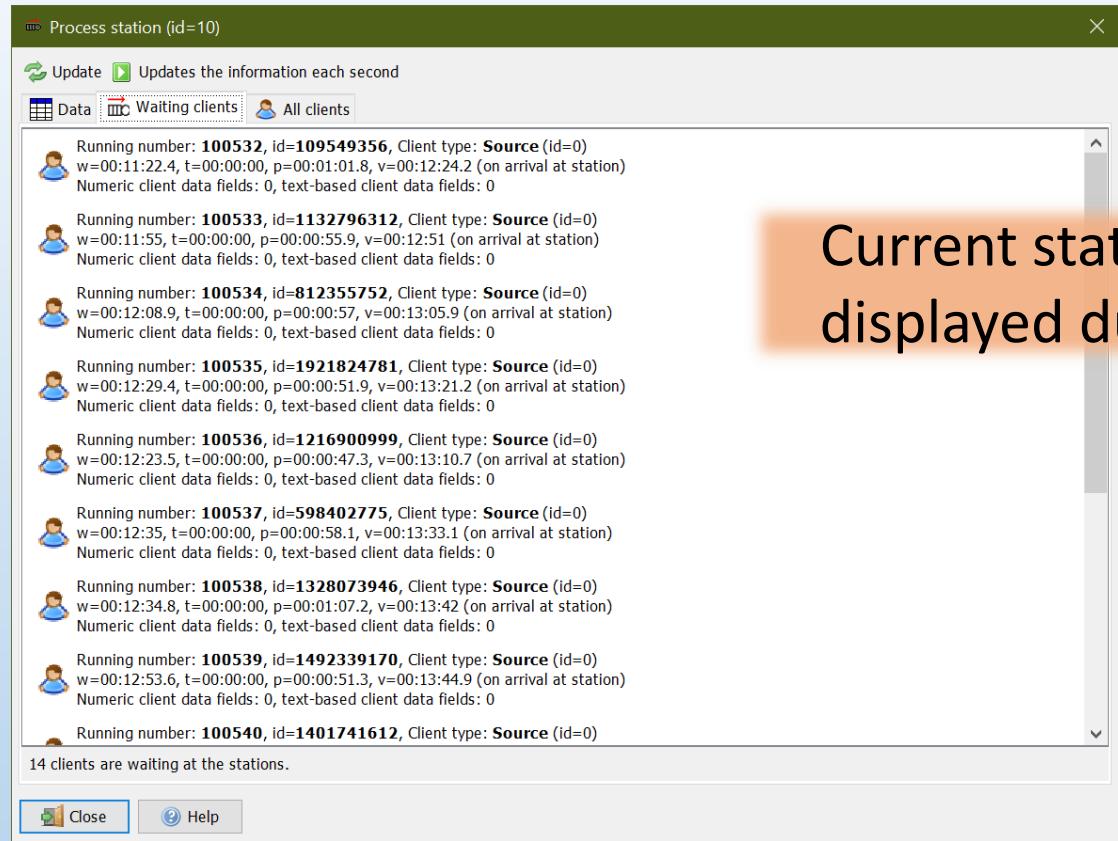




## Animation of models

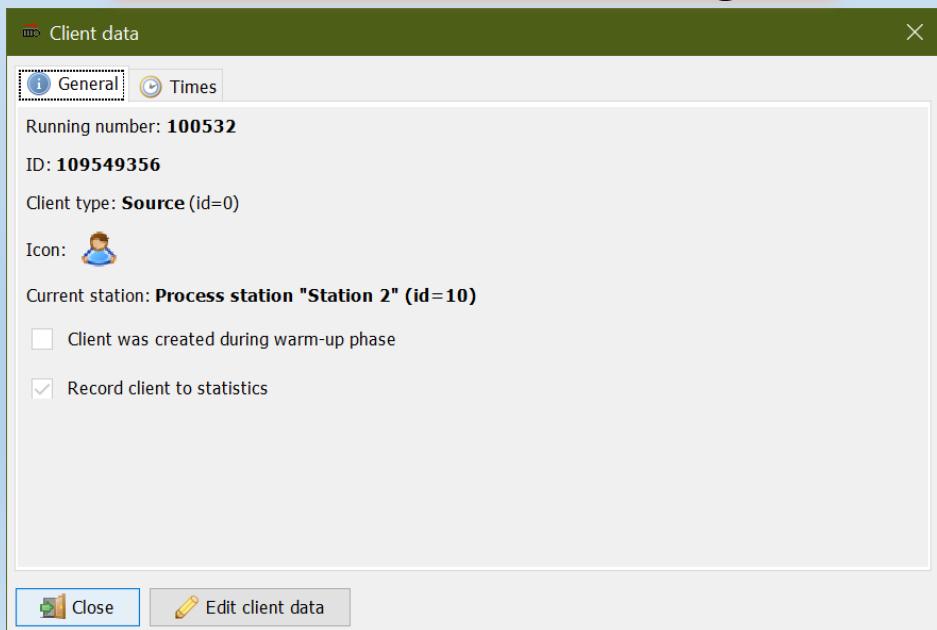
... which can be recorded as videos

Live  
statistic data



Current station data can be displayed during animation

... and also changed while animation is running

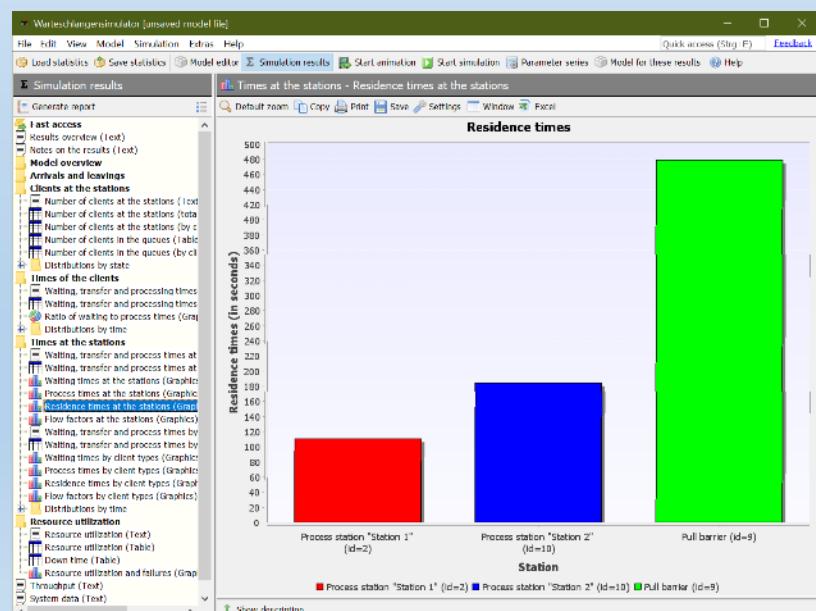
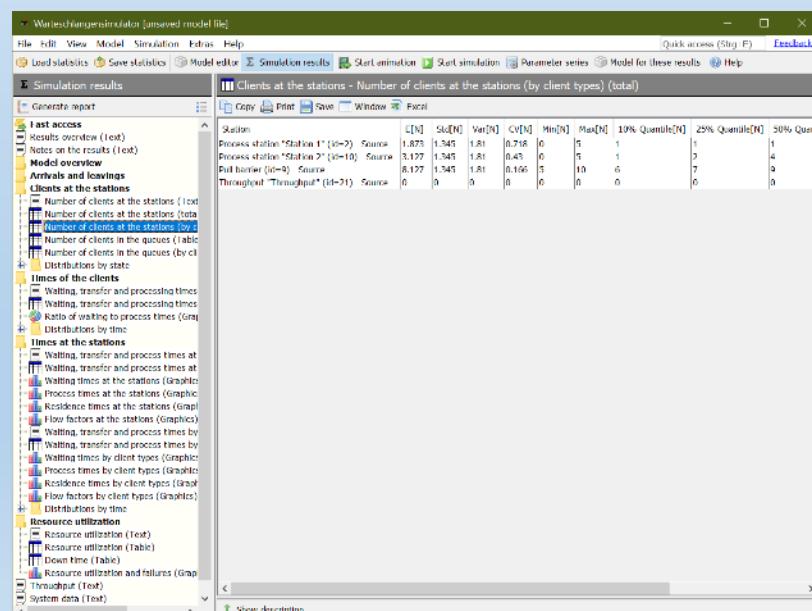
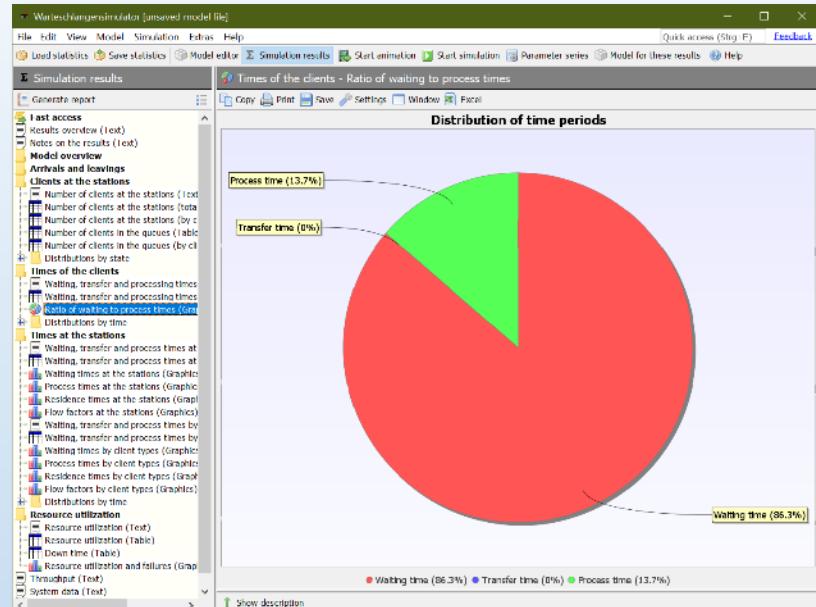
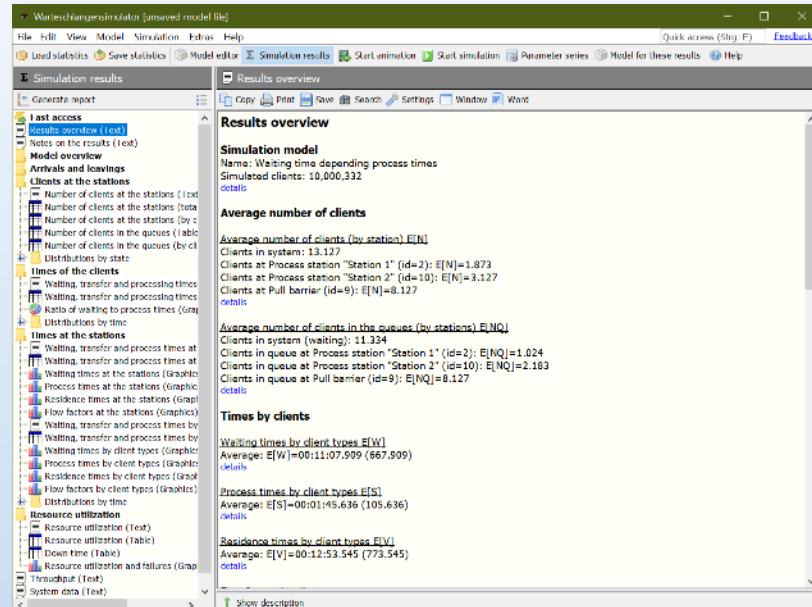


The screenshot shows the Warteschlangensimulator software interface. The main window title is "Warteschlangensimulator [unsaved model file]". The menu bar includes File, Edit, View, Model, Simulation, Extras, and Help. The toolbar contains icons for Load statistics, Save statistics, Model editor, Simulation results, Start animation, Start simulation, Parameter series, Model for these results, and Help. The left sidebar is titled "Simulation results" and lists various categories: Fast access, Results overview (Text), Notes on the results (Text), Model overview, Arrivals and leavings, Clients at the stations, Times of the clients, Times at the stations, Resource utilization, and Throughput/System data. The "Results overview" tab is selected. The main content area displays the "Results overview" section, which includes the "Simulation model" (Name: Waiting time depending process times, Simulated clients: 10,000,332) and several sections with detailed statistics:

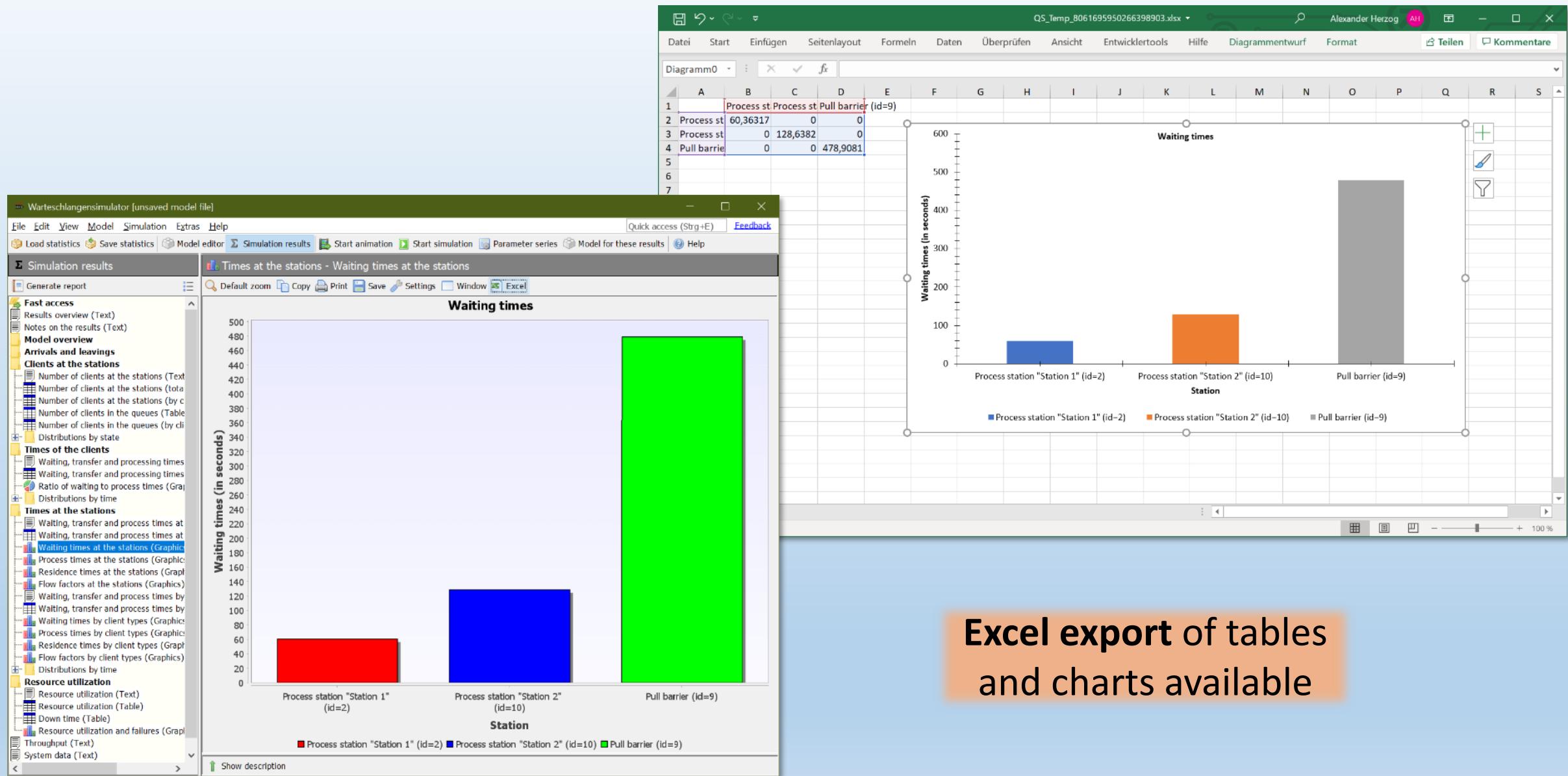
- Average number of clients**:  
Average number of clients (by station)  $E[N]$ :  
Clients in system: 13.127  
Clients at Process station "Station 1" (id=2):  $E[N]=1.873$   
Clients at Process station "Station 2" (id=10):  $E[N]=3.127$   
Clients at Pull barrier (id=9):  $E[N]=8.127$   
[details](#)
- Average number of clients in the queues (by stations)  $E[NQ]$** :  
Clients in system (waiting): 11.334  
Clients in queue at Process station "Station 1" (id=2):  $E[NQ]=1.024$   
Clients in queue at Process station "Station 2" (id=10):  $E[NQ]=2.183$   
Clients in queue at Pull barrier (id=9):  $E[NQ]=8.127$   
[details](#)
- Times by clients**:  
Waiting times by client types  $E[W]$ :  
Average:  $E[W]=00:11:07.909$  (667.909)  
[details](#)
- Process times by client types  $E[S]$** :  
Average:  $E[S]=00:01:45.636$  (105.636)  
[details](#)
- Residence times by client types  $E[V]$** :  
Average:  $E[V]=00:12:53.545$  (773.545)  
[details](#)

At the bottom of the main content area is a "Show description" button.

Full statistic recording  
without explicit configuration



# Results available as texts, tables and charts



Warteschlangensimulator [unsaved model file]

File Edit View Model Simulation Extras Help Quick access (Strg+E) Feedback

Load statistics Save statistics Model editor Simulation results Start animation Start simulation Parameter series Model for these results Help

**Simulation results**

Generate report

Copy Print Save All None Save tables

Results overview (Text)  
 Notes on the results (Text)  
 Model overview  
 Arrivals and leavings  
 Clients at the stations  
 Number of clients at the stations (Text)  
 Number of clients at the stations (total)  
 Number of clients at the stations (by client types)  
 Number of clients in the queues (Table)  
 Number of clients in the queues (by client types)  
 Distributions by state  
 Times of the clients  
 Waiting, transfer and processing times  
 Waiting, transfer and processing times (Table)  
 Ratio of waiting to process times (Graphic)  
 Distributions by time  
 Times at the stations  
 Waiting, transfer and process times at the stations  
 Waiting, transfer and process times at the stations (Table)  
 Waiting times at the stations (Graphic)  
 Process times at the stations (Graphic)  
 Residence times at the stations (Graphic)  
 Flow factors at the stations (Graphic)  
 Waiting, transfer and process times by client types  
 Waiting, transfer and process times by client types (Table)  
 Waiting times by client types (Graphic)  
 Process times by client types (Graphic)  
 Residence times by client types (Graphic)  
 Flow factors by client types (Graphic)  
 Distributions by time  
 Resource utilization  
 Resource utilization (Text)  
 Resource utilization (Table)  
 Down time (Table)  
 Resource utilization and failures (Graphic)  
 Throughput (Text)  
 System data (Text)

**Generate report**

# Report generator

supporting docx, pdf, tex and html

html Reports can be saved as interactive web viewers

**Waiting time depending process times - Statistics**

**Results overview (Text)**  
 Notes on the results (Text)  
 Model overview  
 Model overview (Text)  
 Model overview (Report)  
 Station descriptions (Text)  
 Arrivals at the stations (Text)  
 Leavings from the stations (Text)  
 Number of arrivals (Table)  
 Inter-arrival times at the system  
 Inter-arrival times (Table)  
 Inter-arrival times (Graphic)  
 Distributions by time  
 Distribution of the inter-arrival times (Table)  
 Distribution of the inter-arrival times (Graphic)  
 Inter-leaving times from the system  
 Inter-leaving times (Table)  
 Inter-leaving times (Graphic)  
 Distributions by time  
 Distribution of the inter-leaving times (Table)  
 Distribution of the inter-leaving times (Graphic)  
 Inter-arrival times at the stations  
 Inter-arrival times (Table)  
 Inter-arrival times (Graphic)  
 Distributions by time  
 Distribution of the inter-arrival times (Table)  
 Distribution of the inter-arrival times (Graphic)  
 Inter-leaving times at the stations  
 Inter-leaving times (Table)  
 Inter-leaving times (Graphic)  
 Distributions by time  
 Distribution of the inter-leaving times (Table)  
 Distribution of the inter-leaving times (Graphic)  
 Inter-arrival times at the stations by client types  
 Inter-arrival times by client types (Table)  
 Inter-arrival times by client types (Graphic)  
 Distributions by time  
 Distribution of the inter-arrival times by client types (Table)  
 Distribution of the inter-arrival times by client types (Graphic)  
 Inter-leaving times at the stations by client types  
 Inter-leaving times by client types (Table)  
 Inter-leaving times by client types (Graphic)  
 Distributions by time  
 Distribution of the inter-leaving times by client types (Table)  
 Distribution of the inter-leaving times by client types (Graphic)

**Results overview**

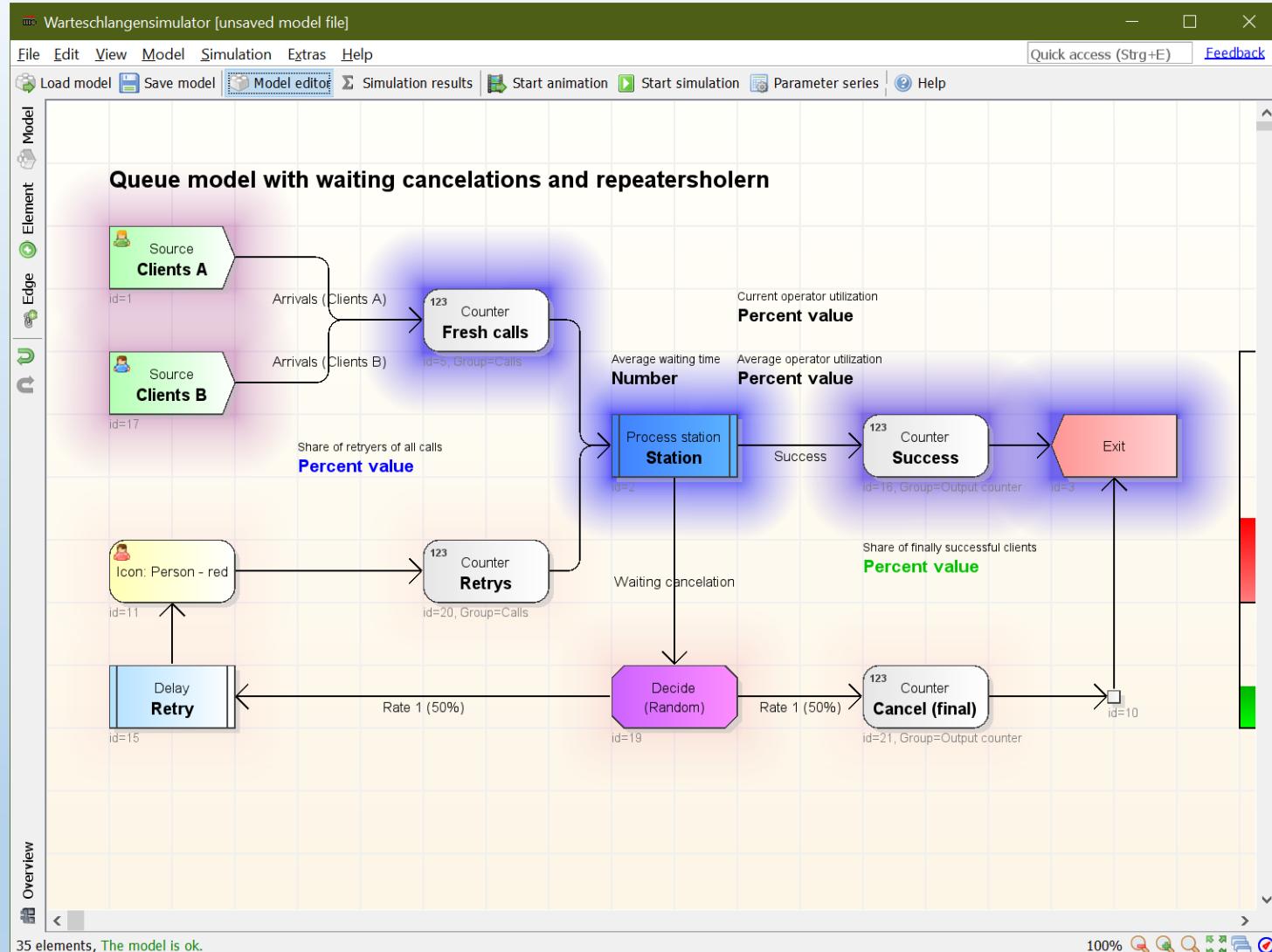
**Simulation model**  
 Name: waiting time depending process times  
 Sim. date: 01.06.2022

**Average number of clients**  
 Average number of clients (by station)  $E[N]$   
 Clients in system: 11.127  
 Client at Process station "Station 1" ( $\lambda=2$ ):  $E[N]=1.875$   
 Client at Process station "Station 2" ( $\lambda=10$ ):  $E[N]=1.188$   
 Client at Full buffer ( $\lambda=4$ ):  $E[N]=0.327$

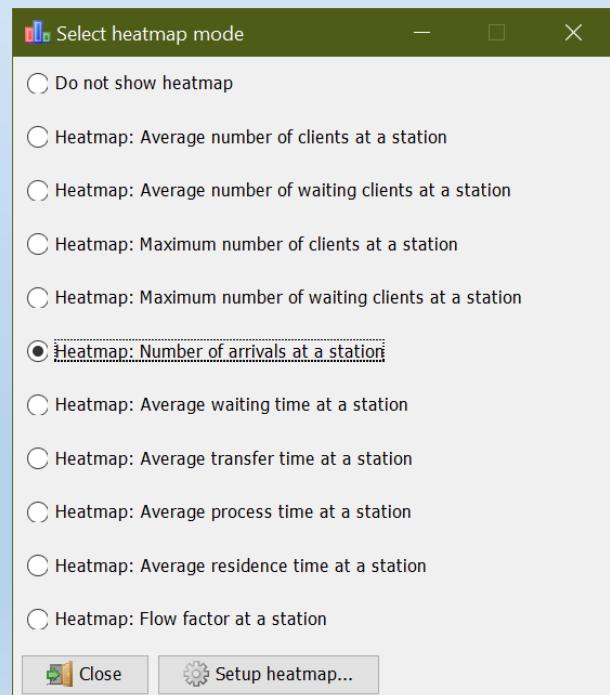
Average number of clients in the queues (by stations)  $E[NQ]$   
 Client in system (out): 11.356  
 Client at Process station "Station 1" ( $\lambda=2$ ):  $E[NQ]=1.324$   
 Client at Process station "Station 2" ( $\lambda=10$ ):  $E[NQ]=1.188$   
 Client at Full buffer ( $\lambda=4$ ):  $E[NQ]=0.327$

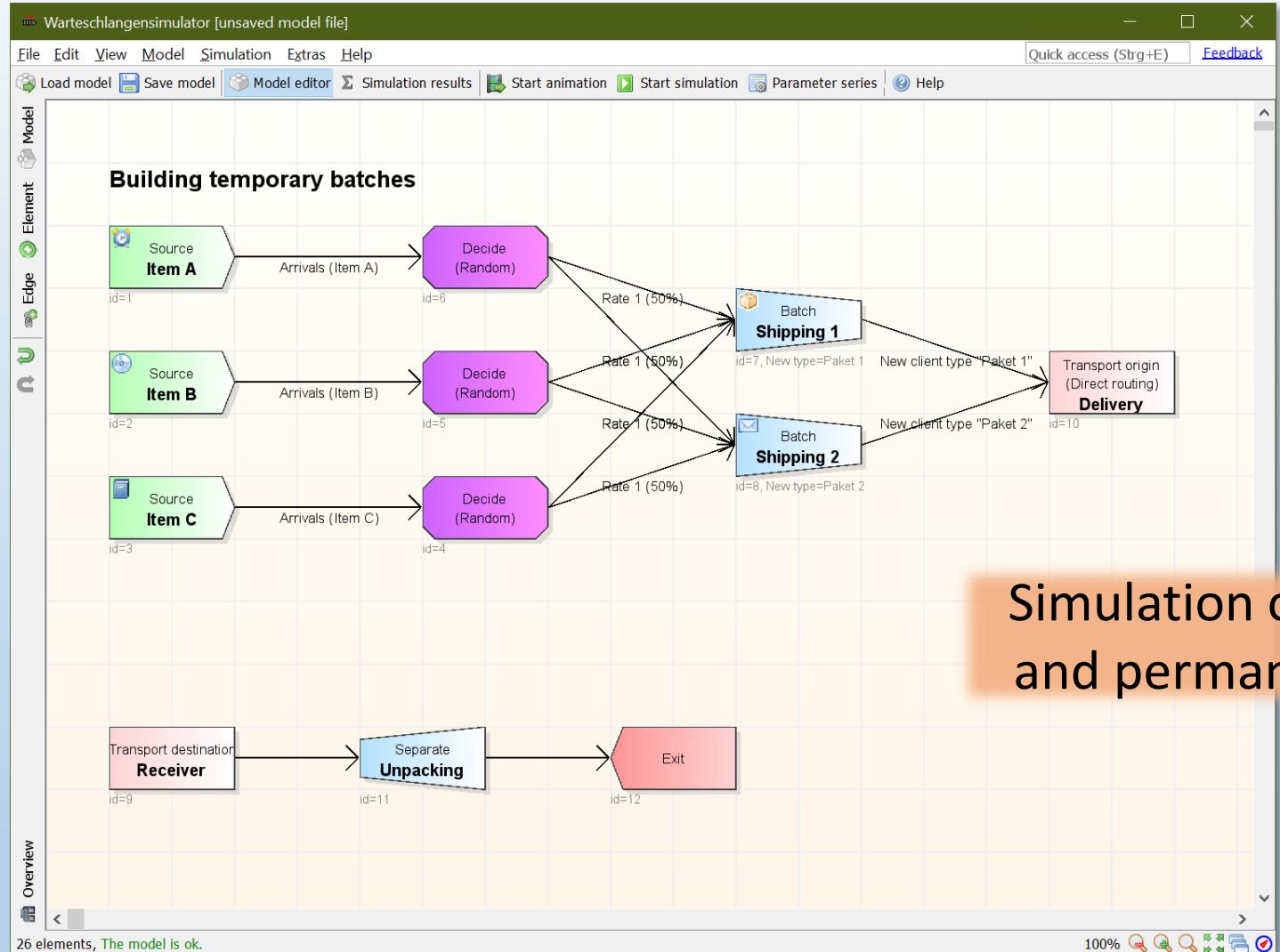
**Times by clients**  
 Waiting times by client types  $E[W]$   
 Average:  $E[W]=0.11$ ;  $SD=0.001$ ,  $min=0.000$ ,  $max=0.263$   
 Process times by client types  $E[T]$   
 Average:  $E[T]=0.01$ ;  $SD=0.001$ ,  $min=0.000$ ,  $max=0.025$   
 Residence times by client types  $E[V]$   
 Average:  $E[V]=0.12$ ;  $SD=0.01$ ,  $min=0.075$ ,  $max=0.275$   
 Flow factors by client types  
 Average: 7.332  

**Times by stations**  
 Waiting times by stations  $E[W]$   
 Process station "Station 1" ( $\lambda=2$ ):  $E[W]=0.01$ ;  $SD=0.001$ ,  $min=0.000$ ,  $max=0.263$   
 Process station "Station 2" ( $\lambda=10$ ):  $E[W]=0.02$ ;  $SD=0.001$ ,  $min=0.000$ ,  $max=0.630$   
 Full buffer ( $\lambda=4$ ):  $E[W]=0.07$ ;  $SD=0.001$ ,  $min=0.060$ ,  $max=0.100$

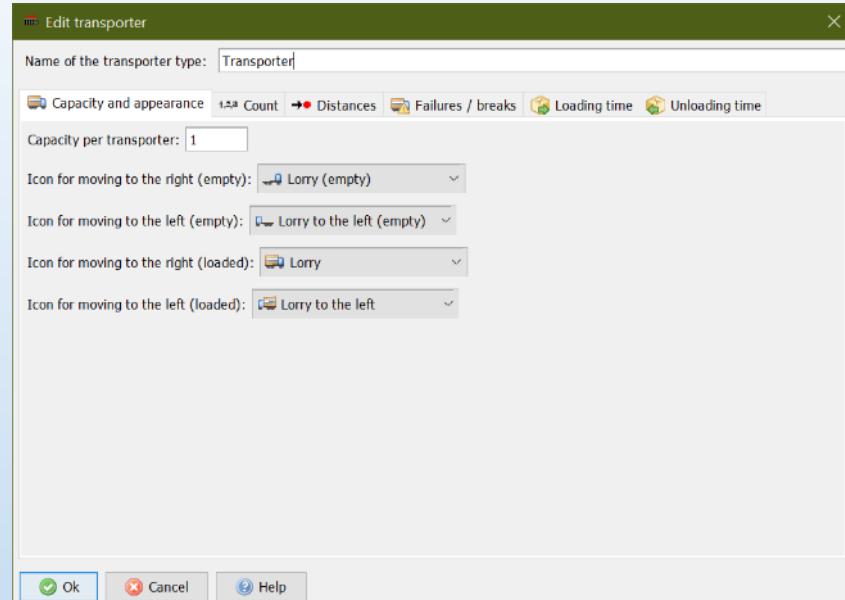
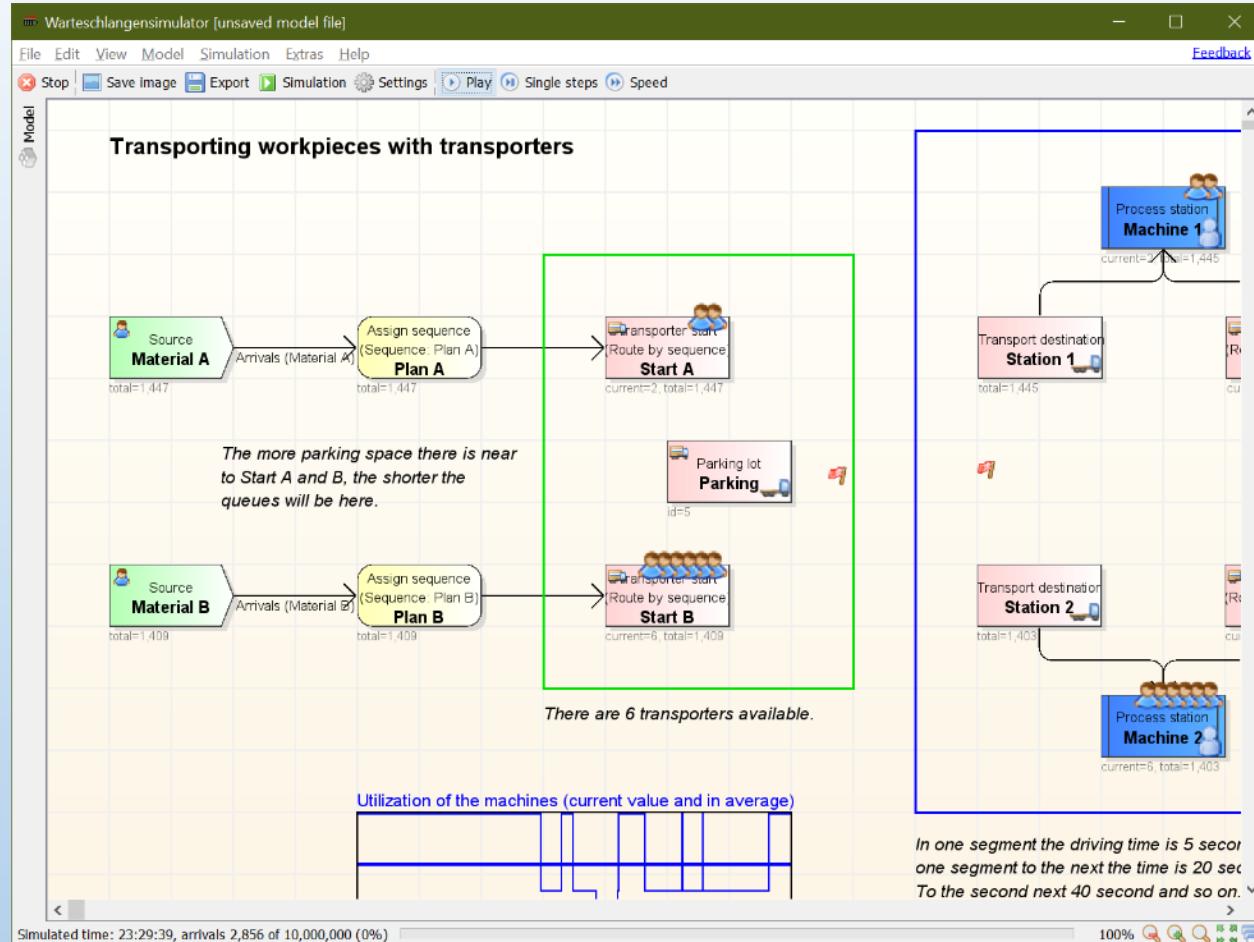


# Visualizing simulation results as heatmaps

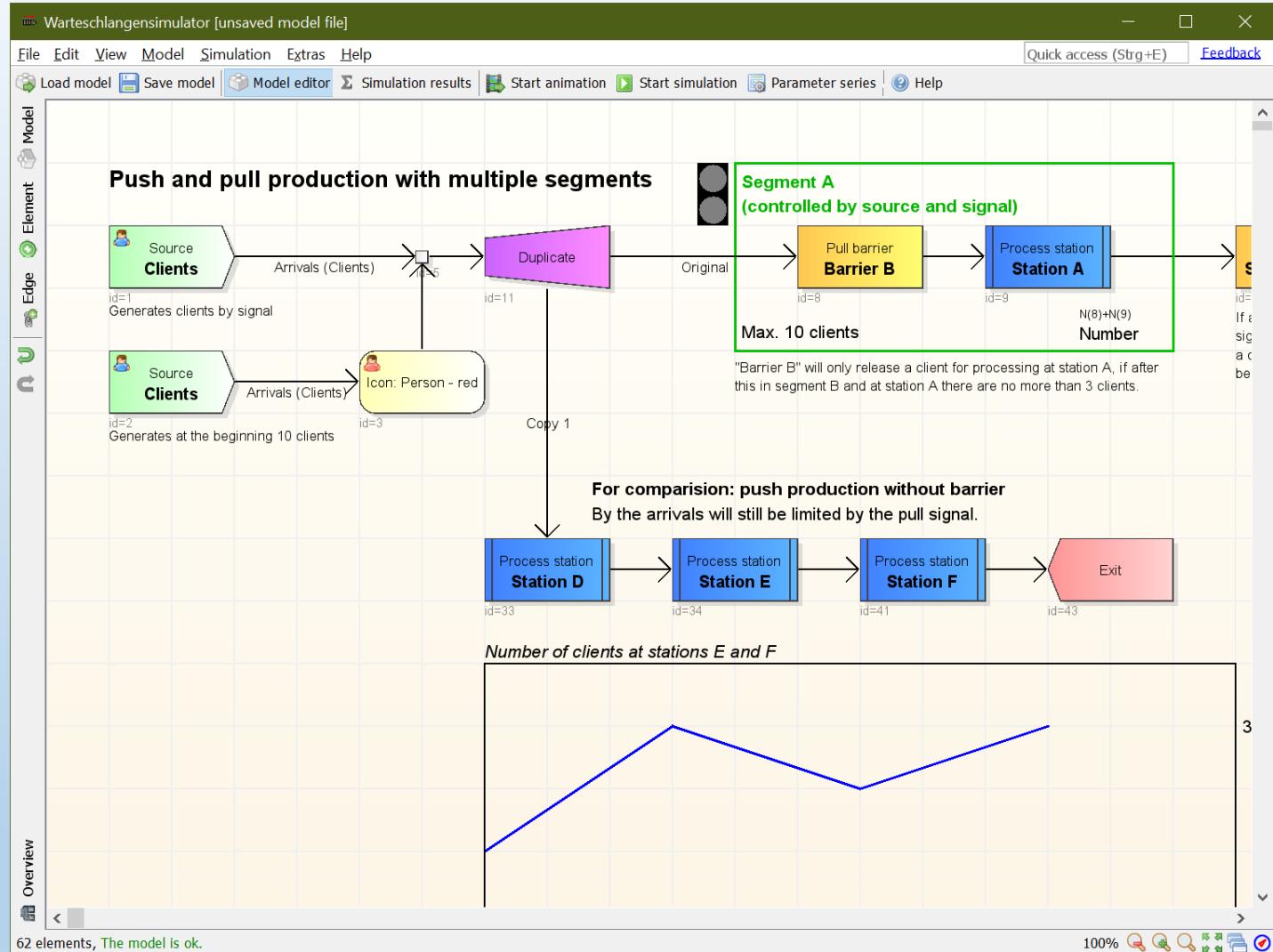




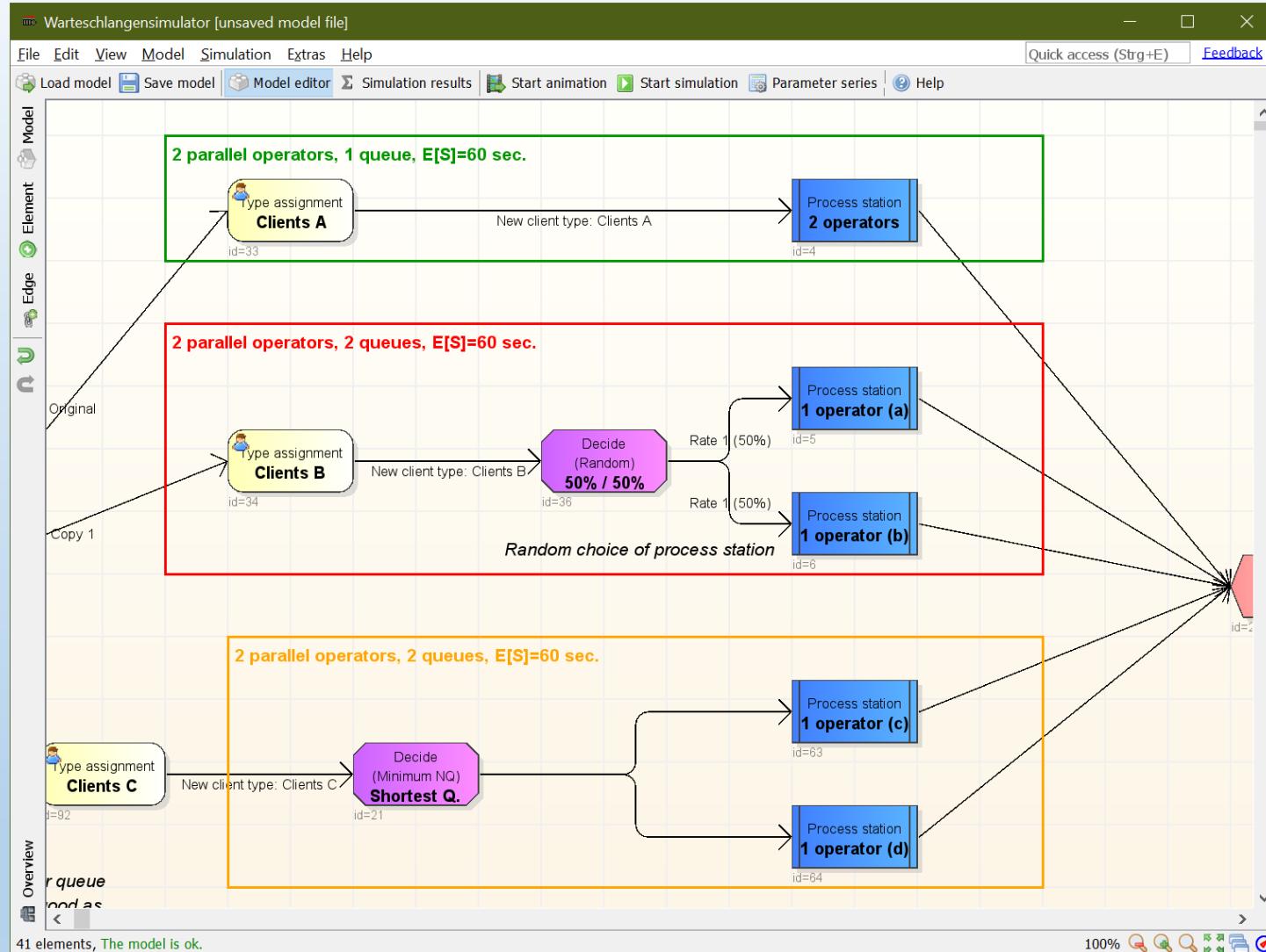
Simulation of temporary  
and permanent **batches**



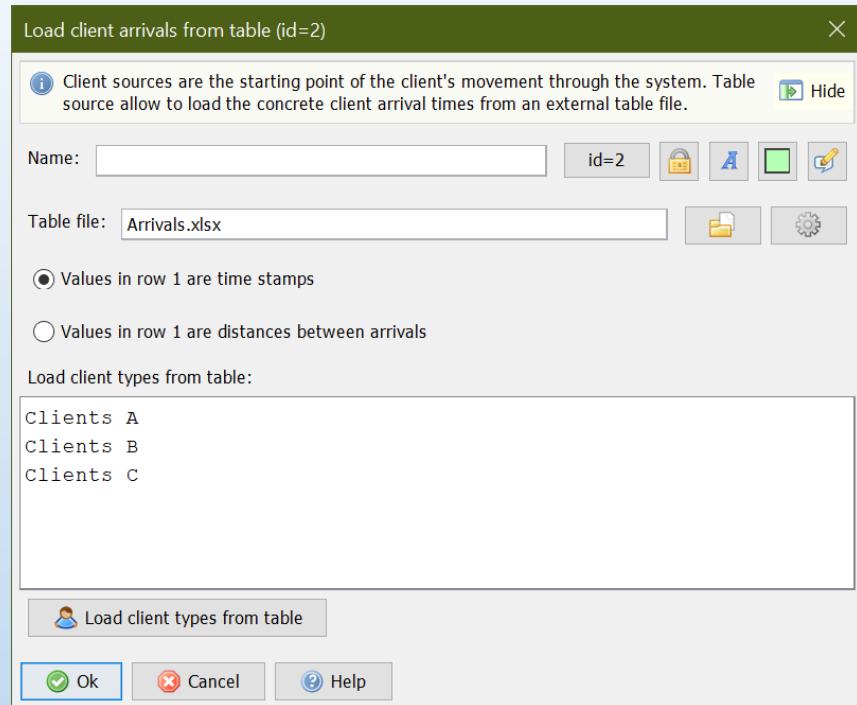
Simulation of transport processes using transporters



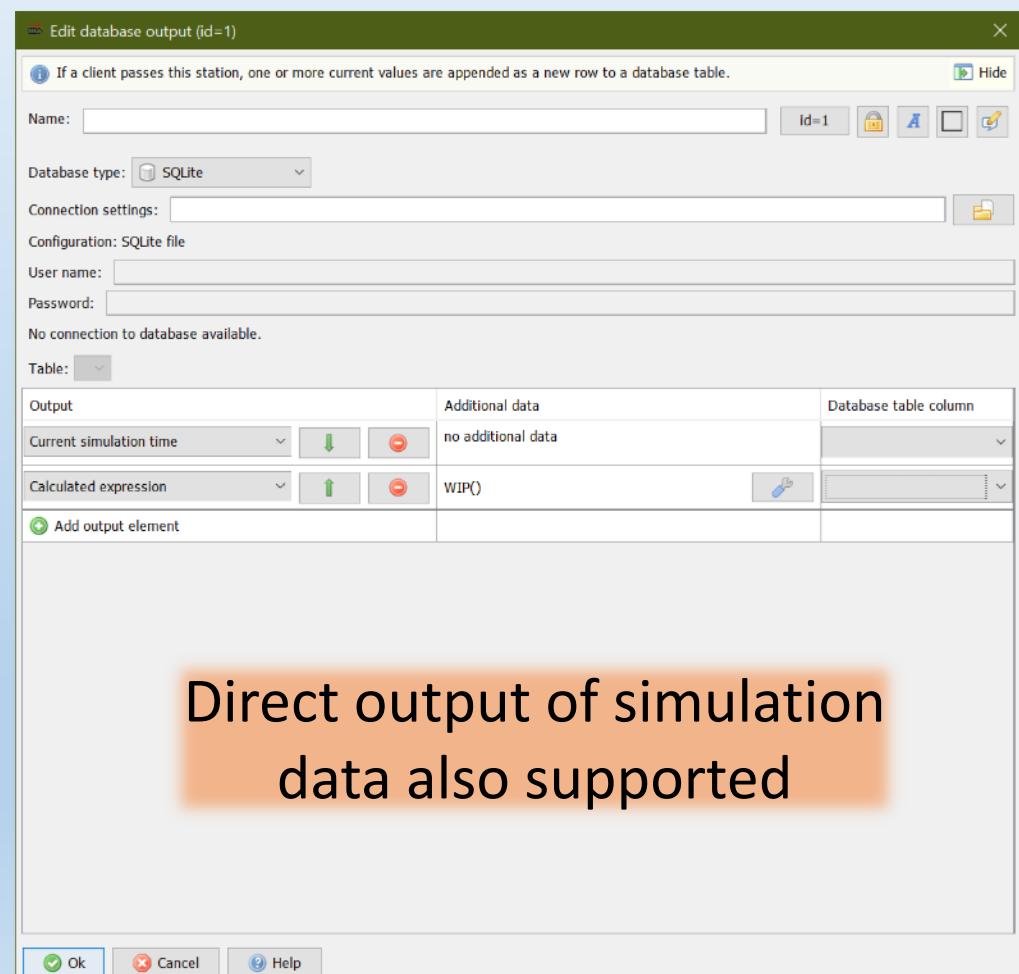
**Push/pull production – and any other kind of condition-based barriers, signals etc.**

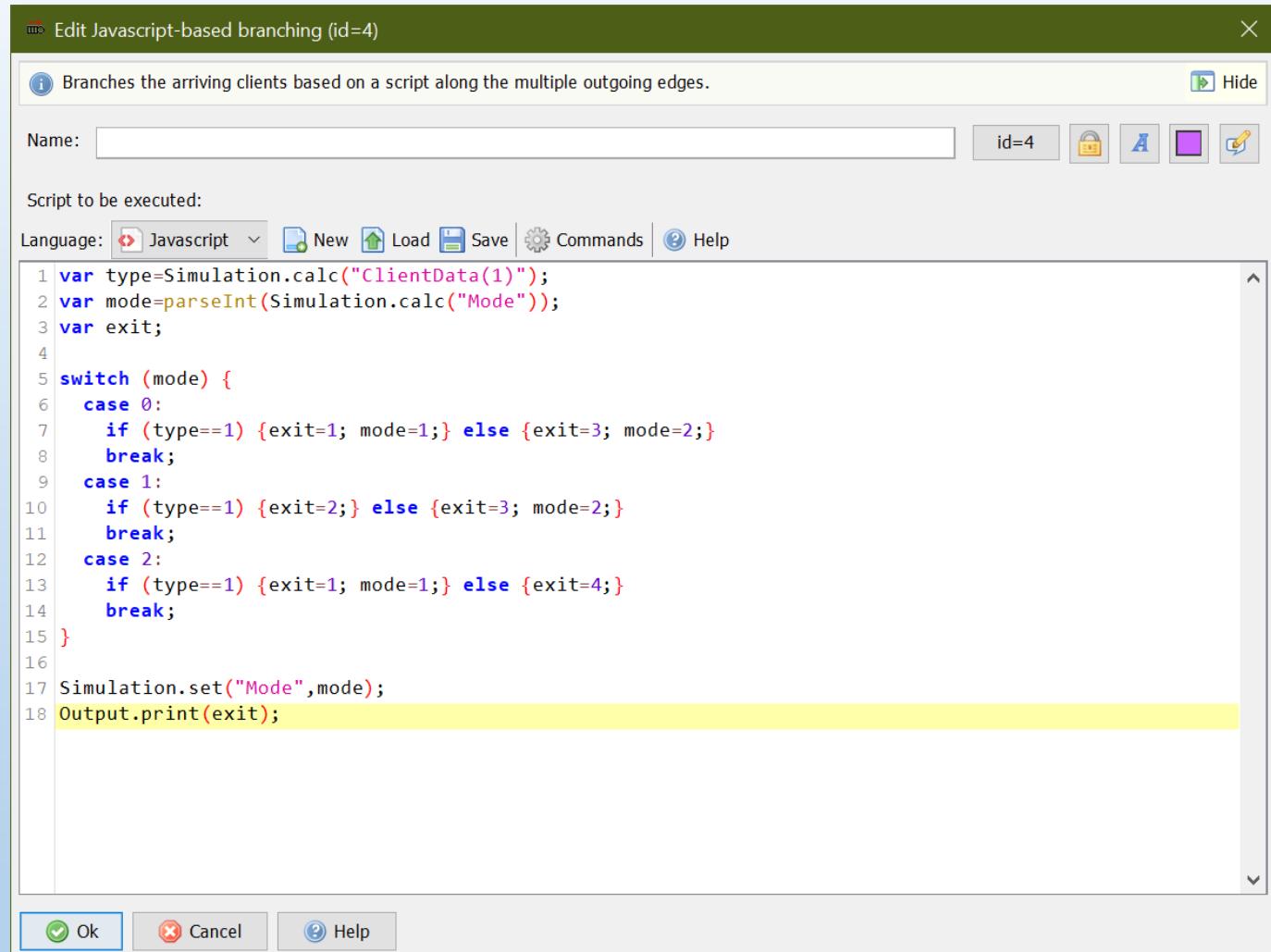


**Branching clients by conditions,  
by chance, script-based, etc.**



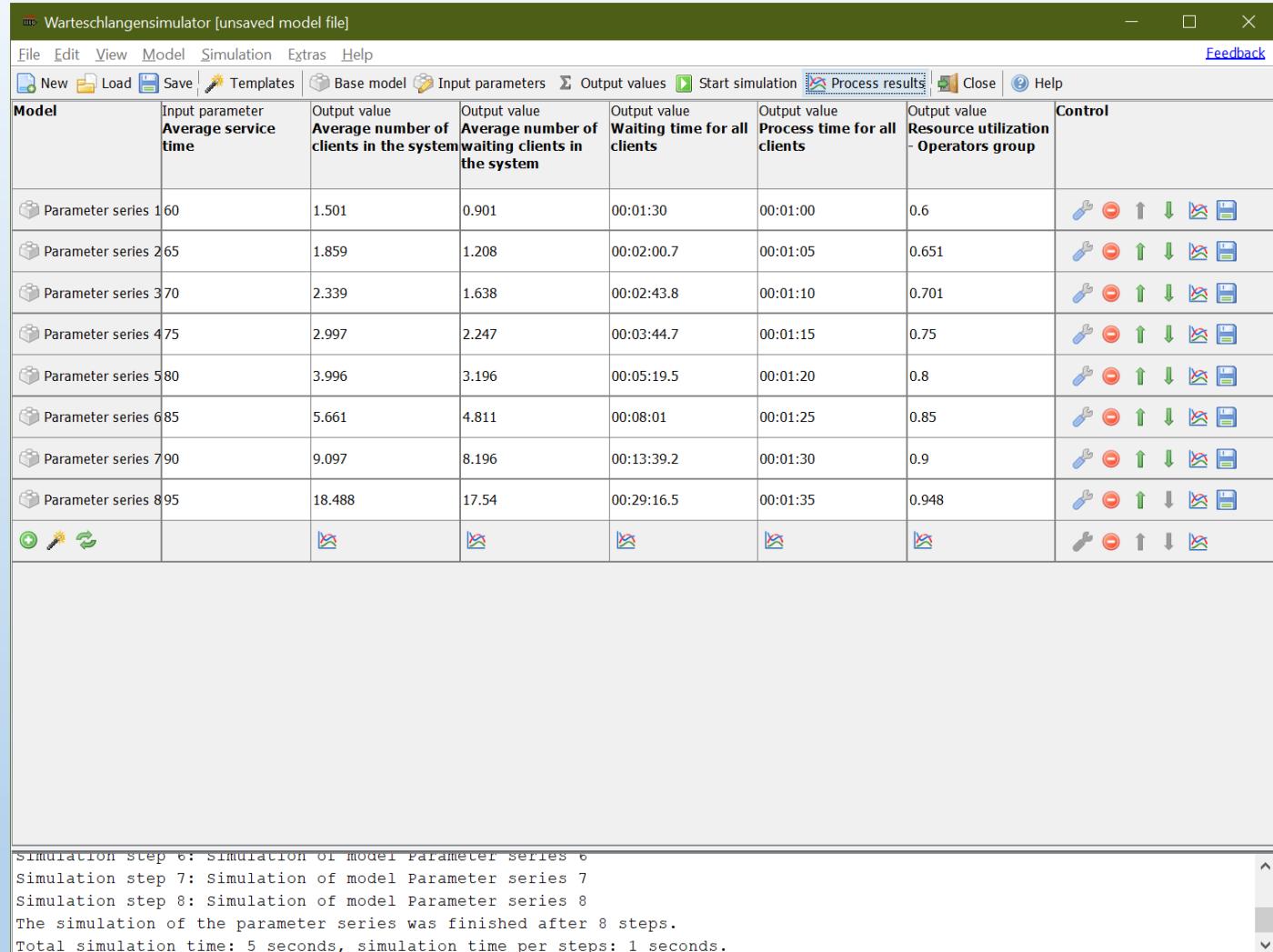
## Using external data for client arrivals and parameters in simulation process





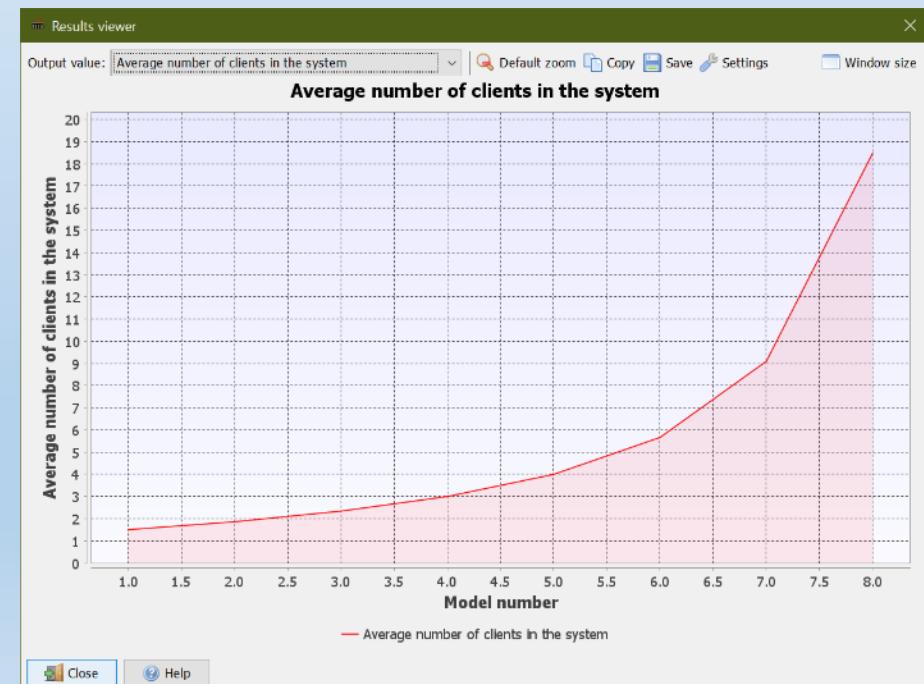
Scripts can be used for  
modelling complex  
control strategies

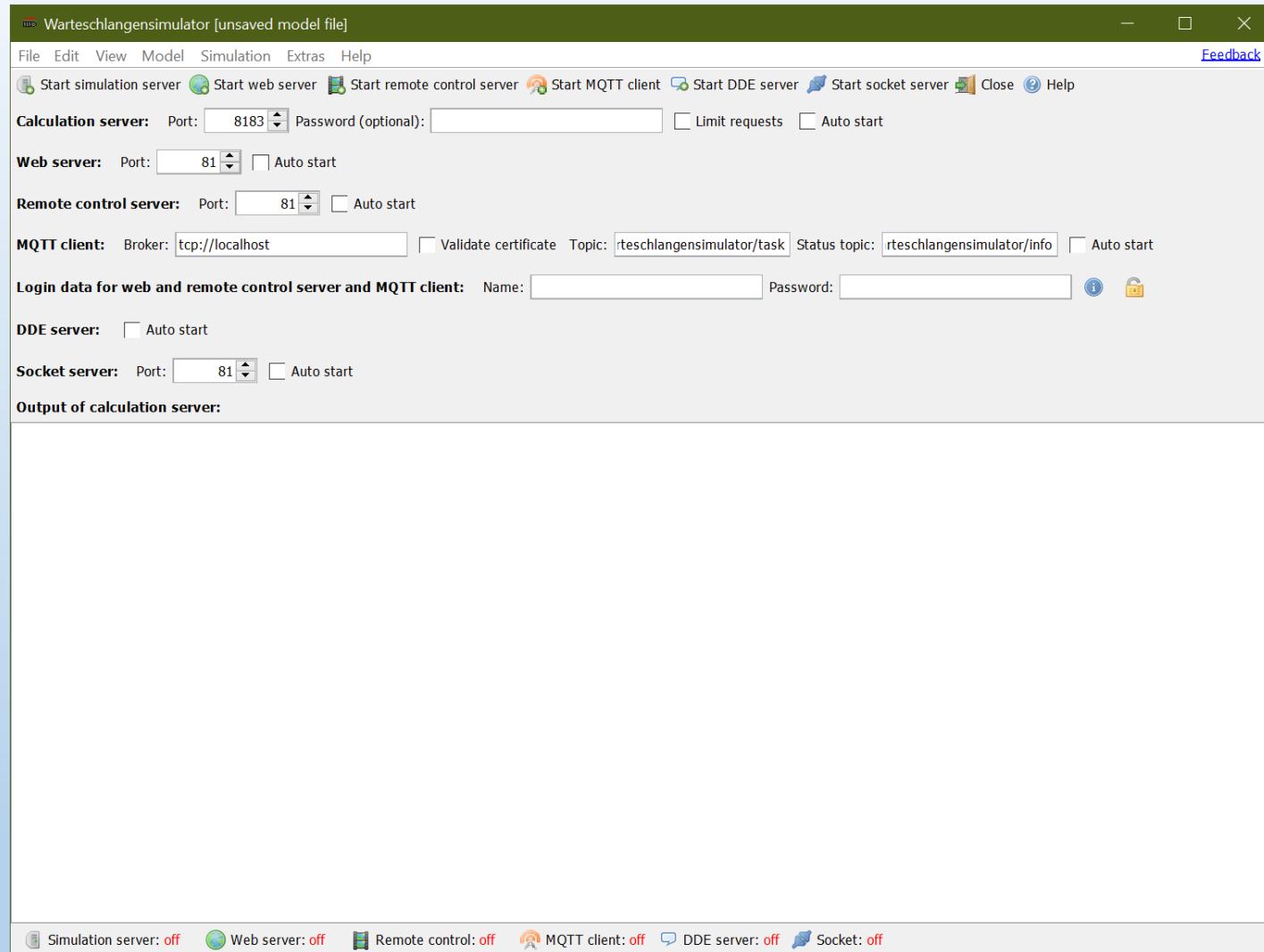
Supported languages:  
Javascript and Java



Optimizer also built-in

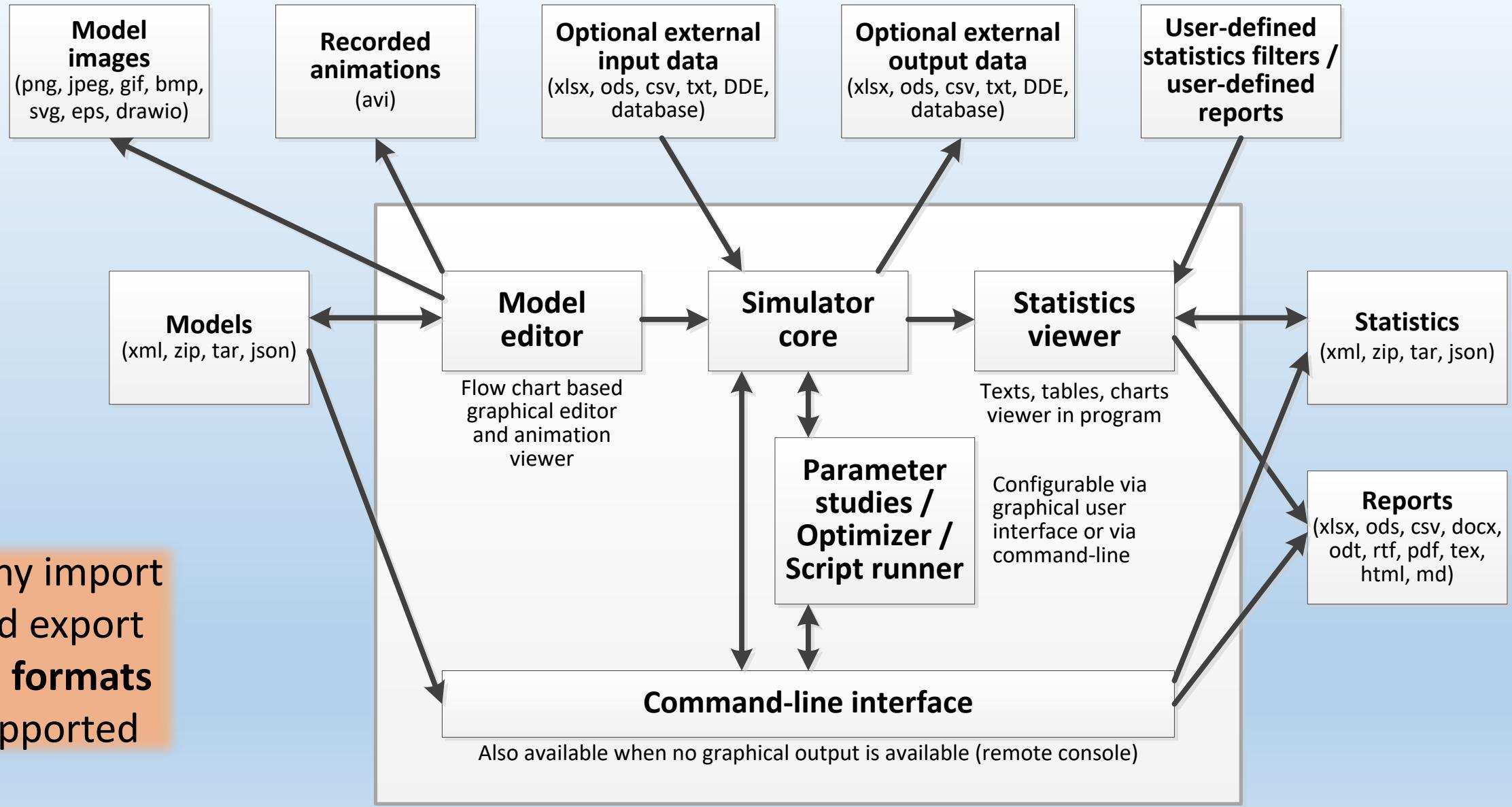
Fast and easy creation of  
parameter studies





Command-line and  
server operation available

Simulator can be used on  
Linux-based HPC systems



Warteschlangensimulator [unsaved model file]

File Edit View Model Simulation Extras Help

Load statistics Save statistics Model editor Simulation results Start animation Start simulation Parameter series Model for these results Help

**Simulation results**

Generate report

**Fast access**

- Results overview (Text)
- Erlang-C comparison (Text)
- Model overview**
- Arrivals and leavings**
- Clients at the stations**
- Number of clients at the stations (Text)
- Number of clients at the stations (total) (Text)
- Number of clients at the stations (by client) (Text)
- Number of clients in the queues (Table)
- Number of clients in the queues (by client) (Table)
- Distributions by state
- Times of the clients**
- Waiting, transfer and processing times of (Text)
- Waiting, transfer and processing times of (Graphic)
- Ratio of waiting to process times (Graphic)
- Distributions by time
- Times at the stations**
- Waiting, transfer and process times at the (Text)
- Waiting, transfer and process times at the (Text)
- Distributions by time
- Resource utilization**
- Resource utilization (Text)
- Resource utilization (Table)
- Resource utilization and failures (Graphics)
- System data (Text)
- Generate report

**System data**

Used simulator version: 4.8.0  
Run date of the simulation: 4/30/21, 10:44 PM  
Threads: 24  
Simulation computer: Windows 10 (amd64), OpenJDK 64-Bit Server VM (16.0.1)  
Author of the model: Alexander Herzog  
User (simulation run): Alexander Herzog

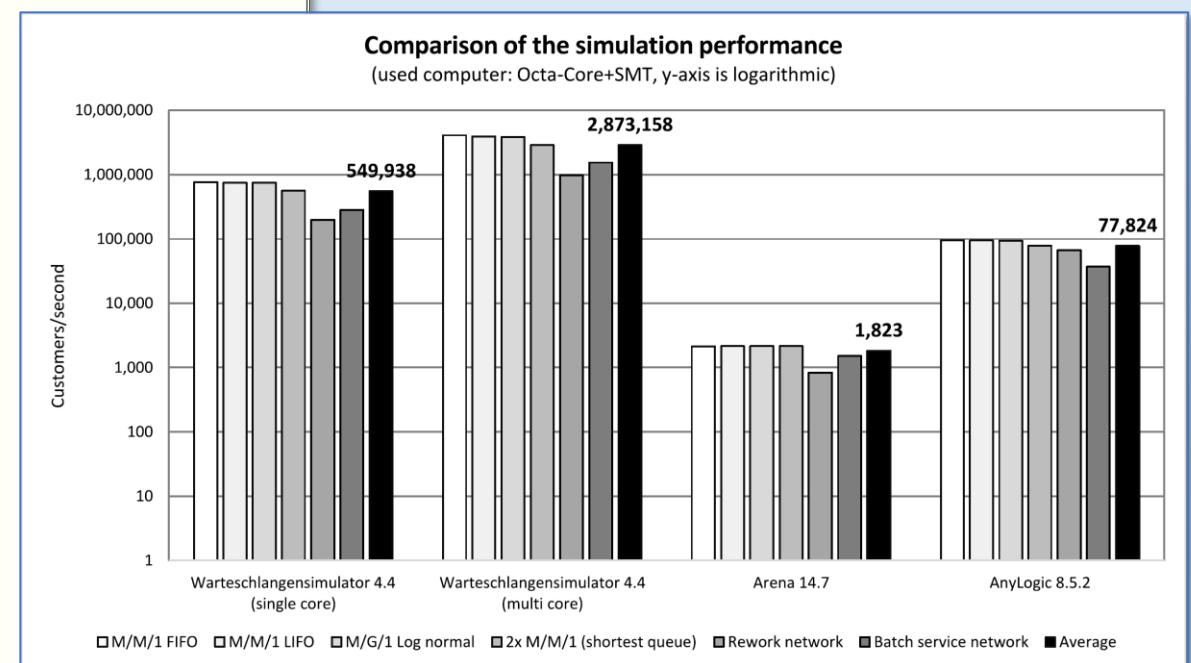
Needed simulation time: 540 ms  
Relative runtime difference between fastest and slowest thread: 4%  
Maximum relative difference in simulated clients between the threads: 34.6%

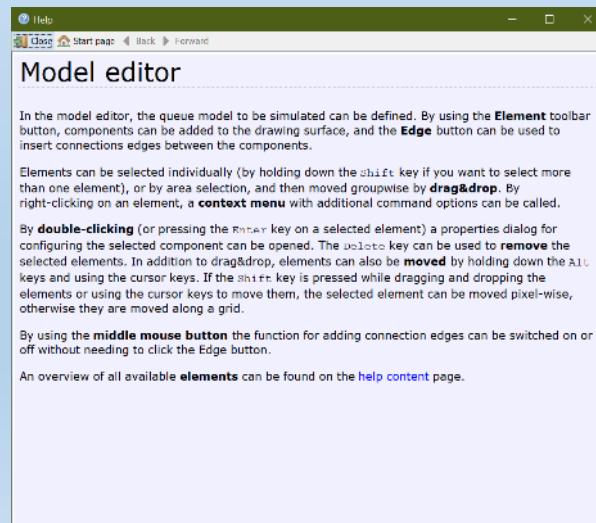
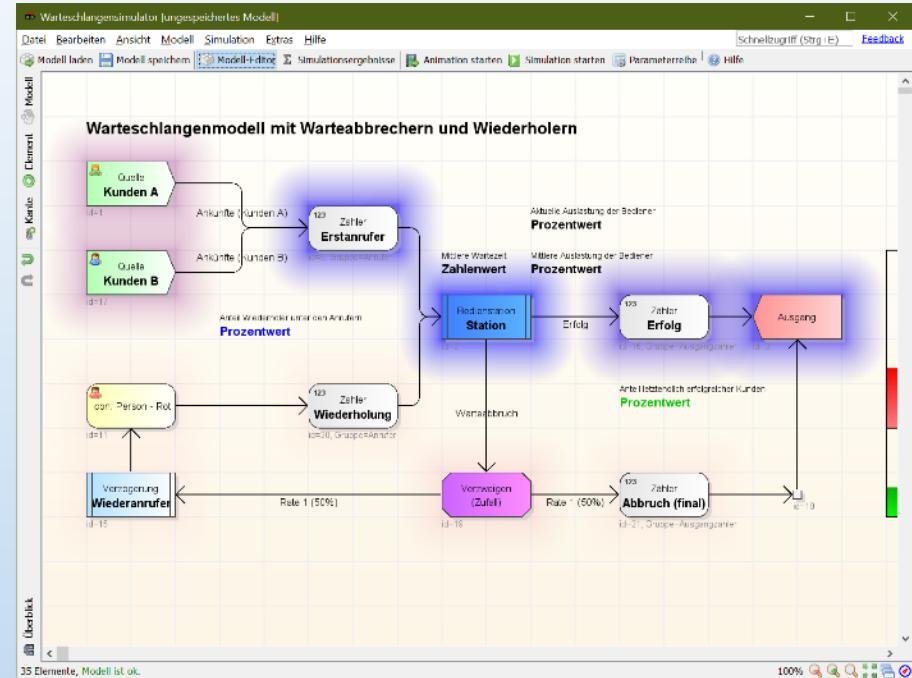
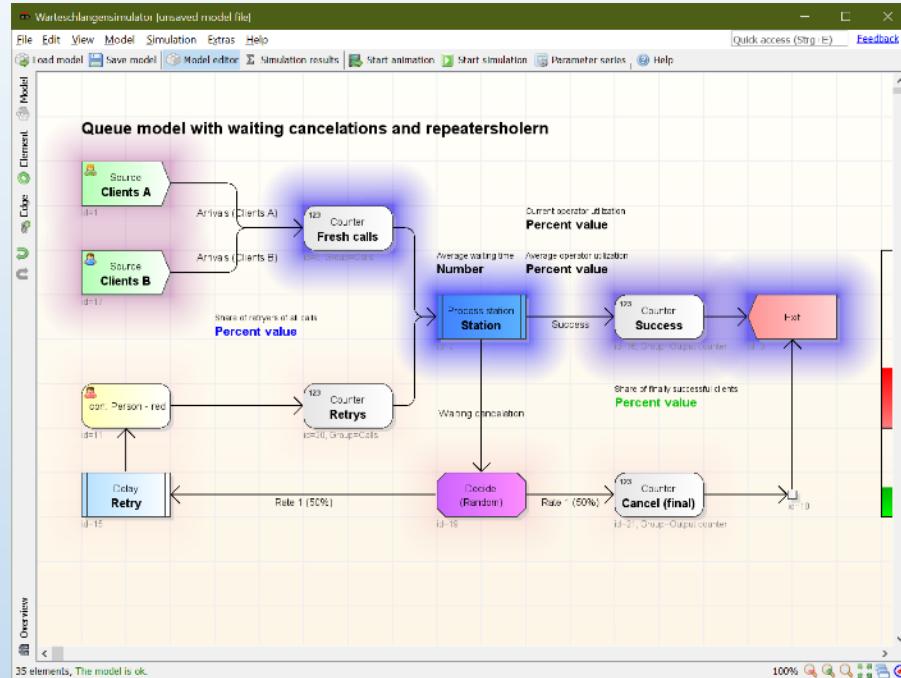
Simulated client arrivals (without warm-up phase): 5,000,153  
Needed calculation time per client (\*): 2.592  $\mu$ s

Simulated events: 18,600,105  
Events per second: 34,444,638  
Needed calculation time per event (\*): 697 ns

The data marked with (\*) indicate the real computing time on a CPU core.

Fast simulation  
supporting multi-core CPUs





User-interface and full documentation available in English and German



## Apache License 2.0

A permissive license whose main conditions require preservation of copyright and license notices. Contributors provide an express grant of patent rights. Licensed works, modifications, and larger works may be distributed under different terms and without source code.

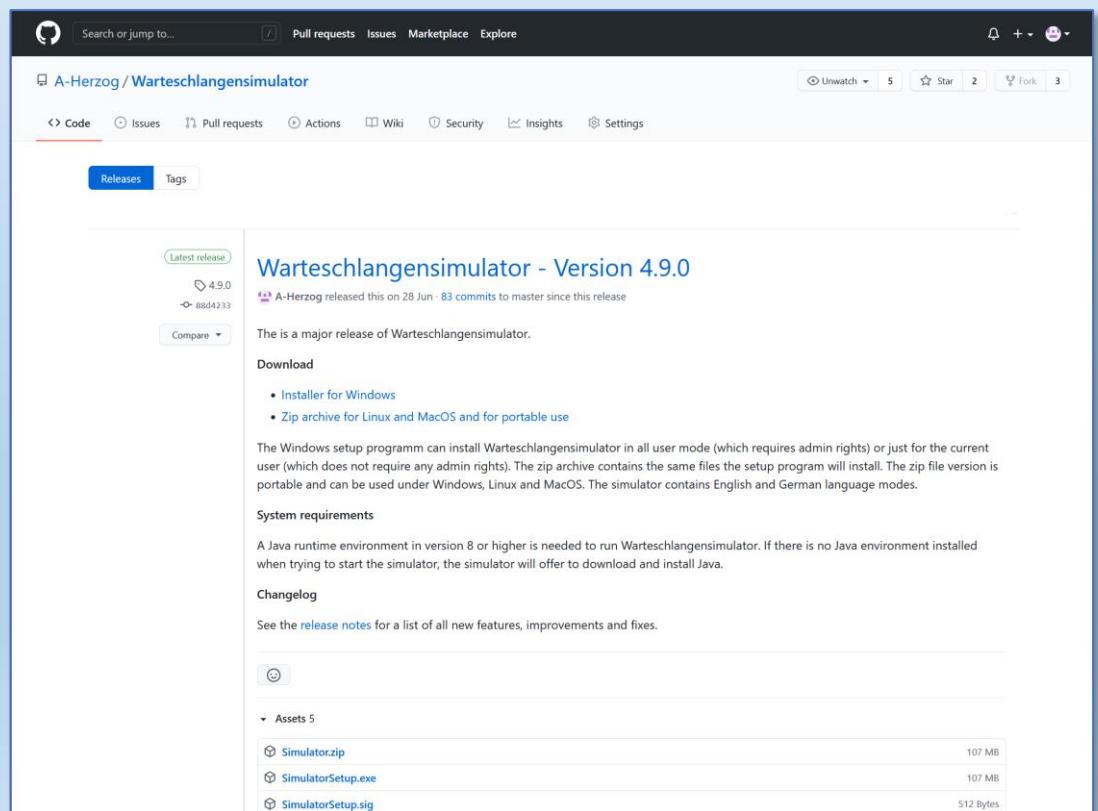
- | Permissions      | Conditions                     | Limitations     |
|------------------|--------------------------------|-----------------|
| ● Commercial use | ● License and copyright notice | ● Liability     |
| ● Distribution   | ● State changes                | ● Trademark use |
| ● Modification   |                                | ● Warranty      |
| ● Patent use     |                                |                 |
| ● Private use    |                                |                 |

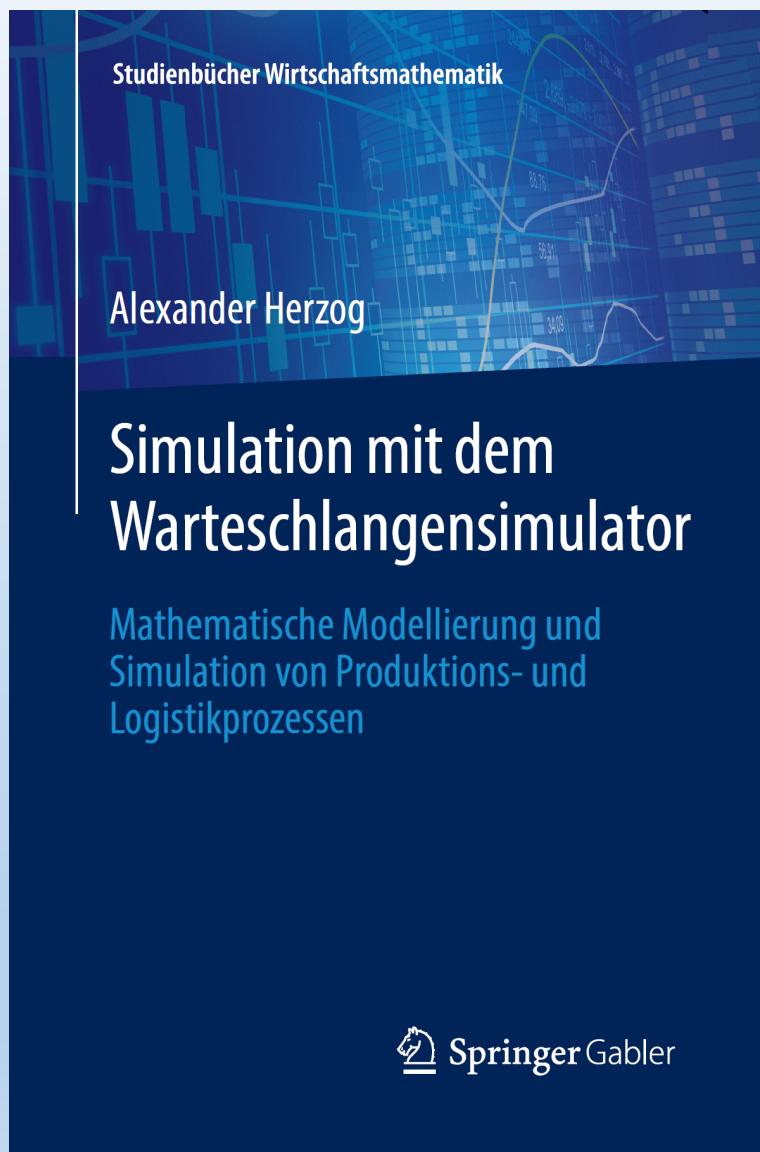





Available as OpenSource  
on GitHub

Windows installer and zip  
file archive (for Windows  
and Linux) available





## Textbook

(in German language)

... but tutorials,  
references, online help  
etc. directly built-in in  
Warteschlangensimulator

