

Warteschlangensimulator [unsaved model file]

File Edit View Elements 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 Heatmap

### 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)

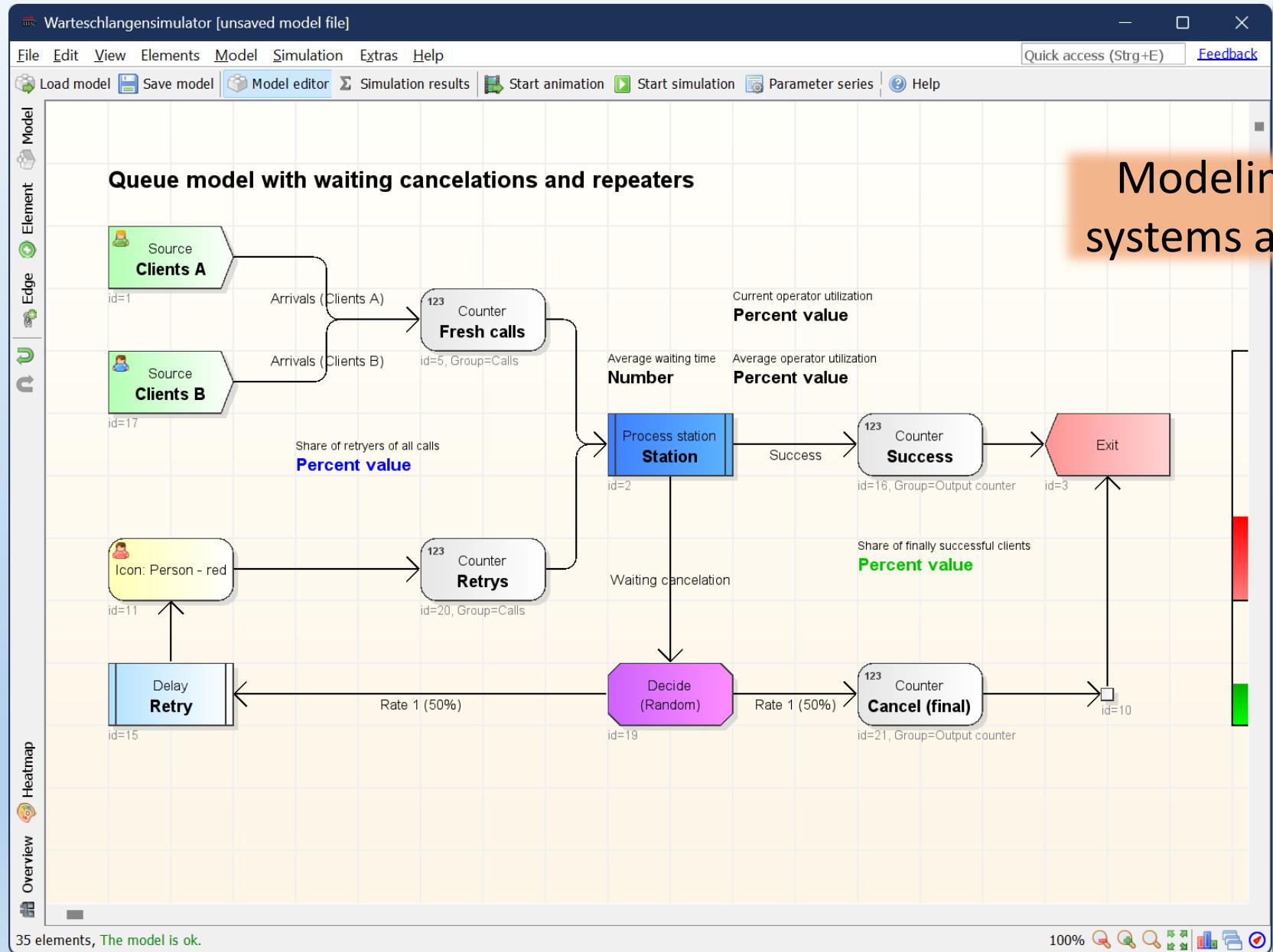
Fraction of time for the numbers of clients

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

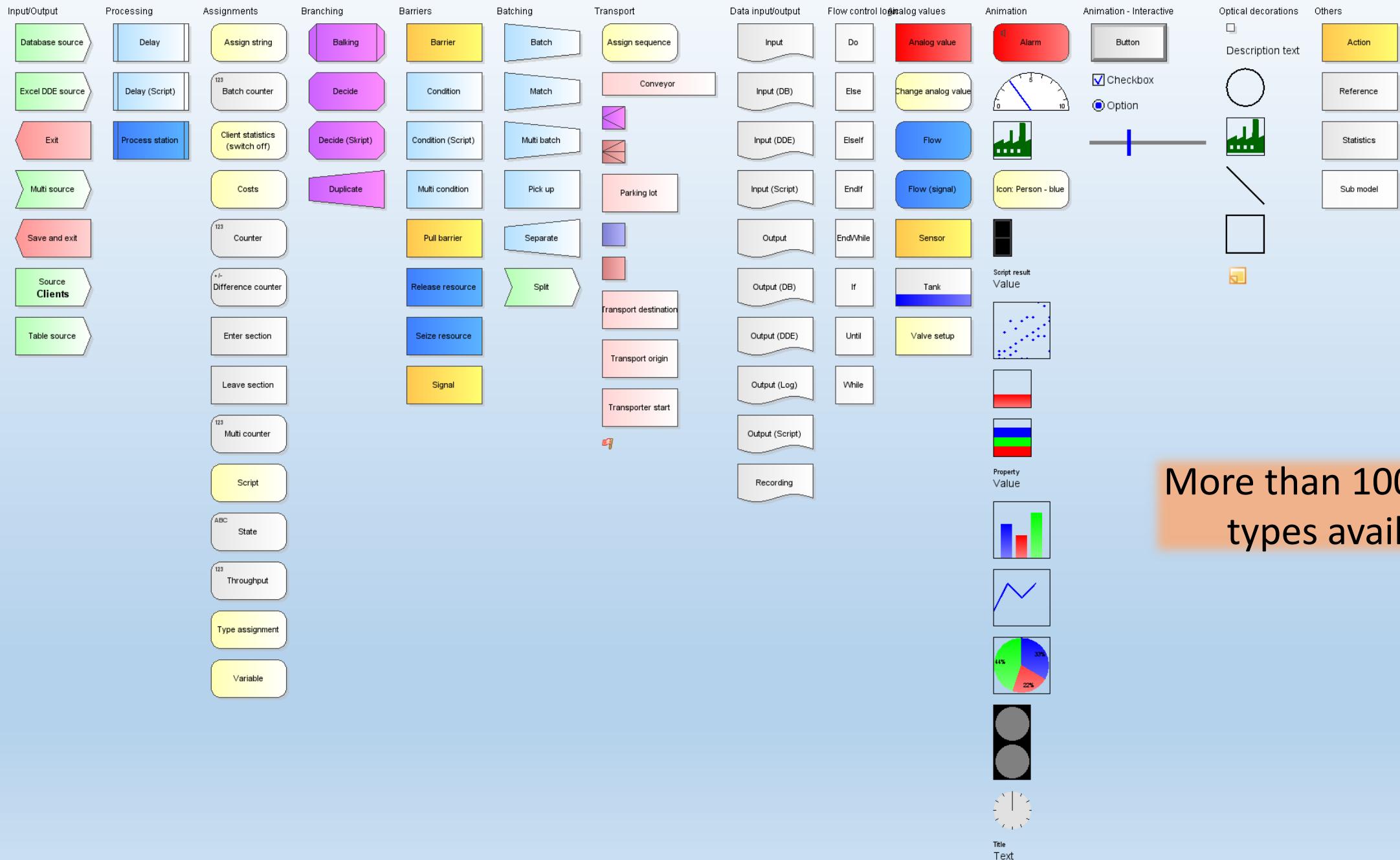
12 elements, The model is ok.

100%

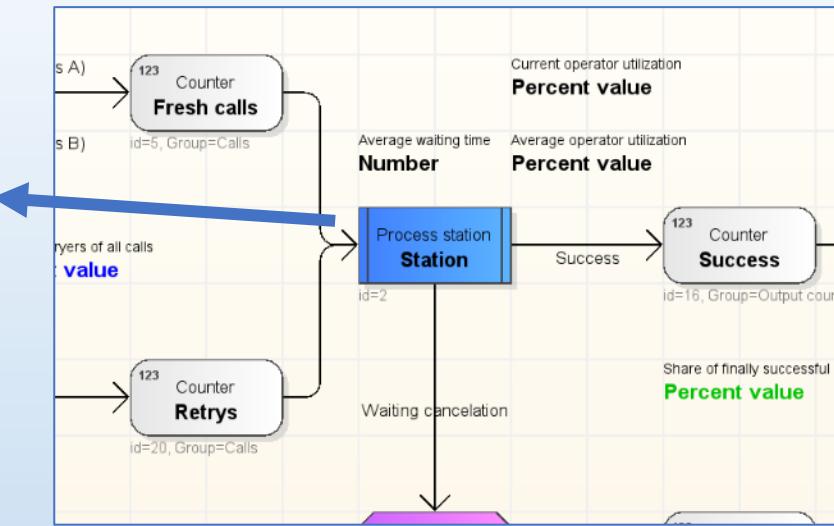
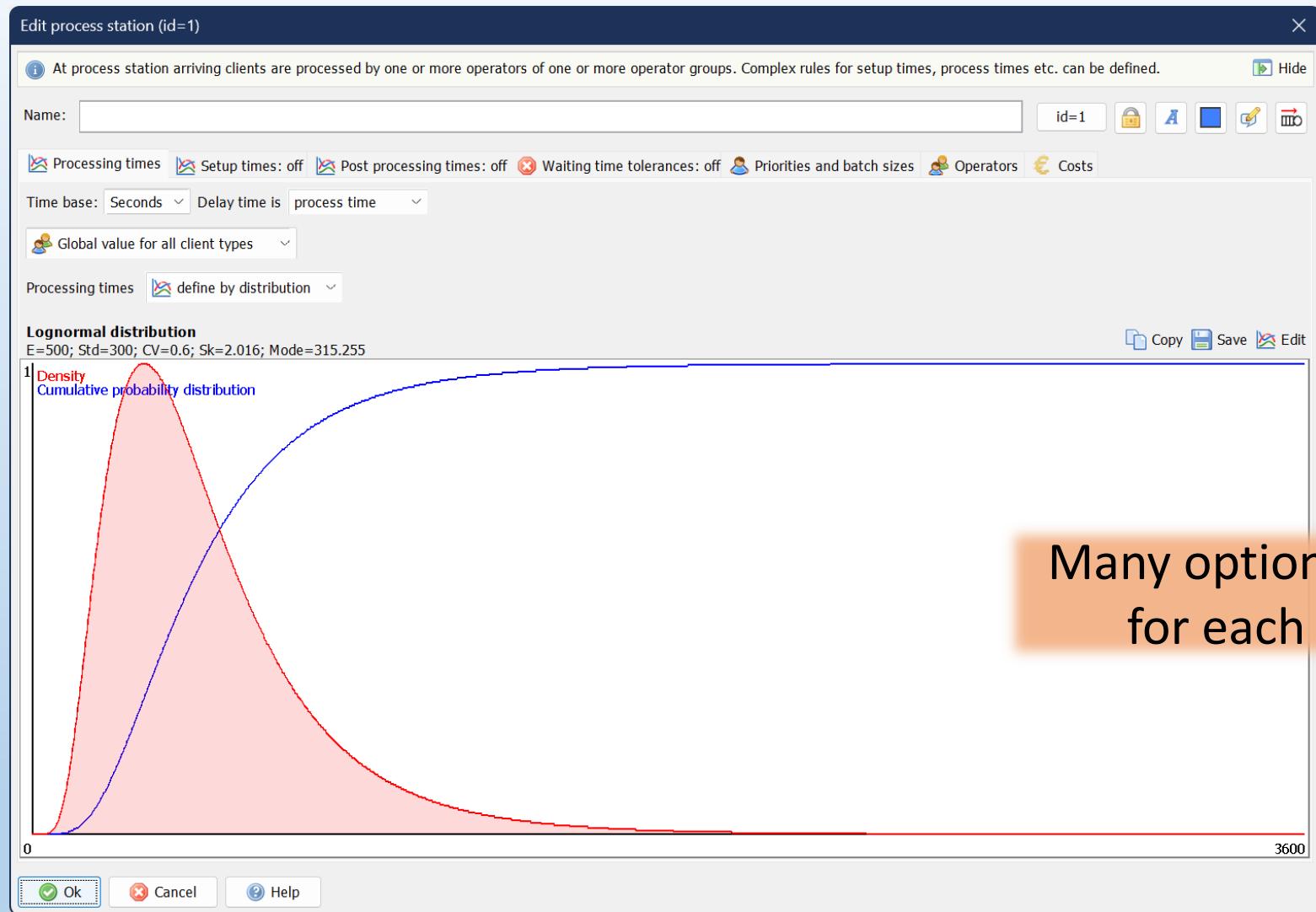
**Warteschlangensimulator**  
Fast and versatile event-driven  
stochastic simulator



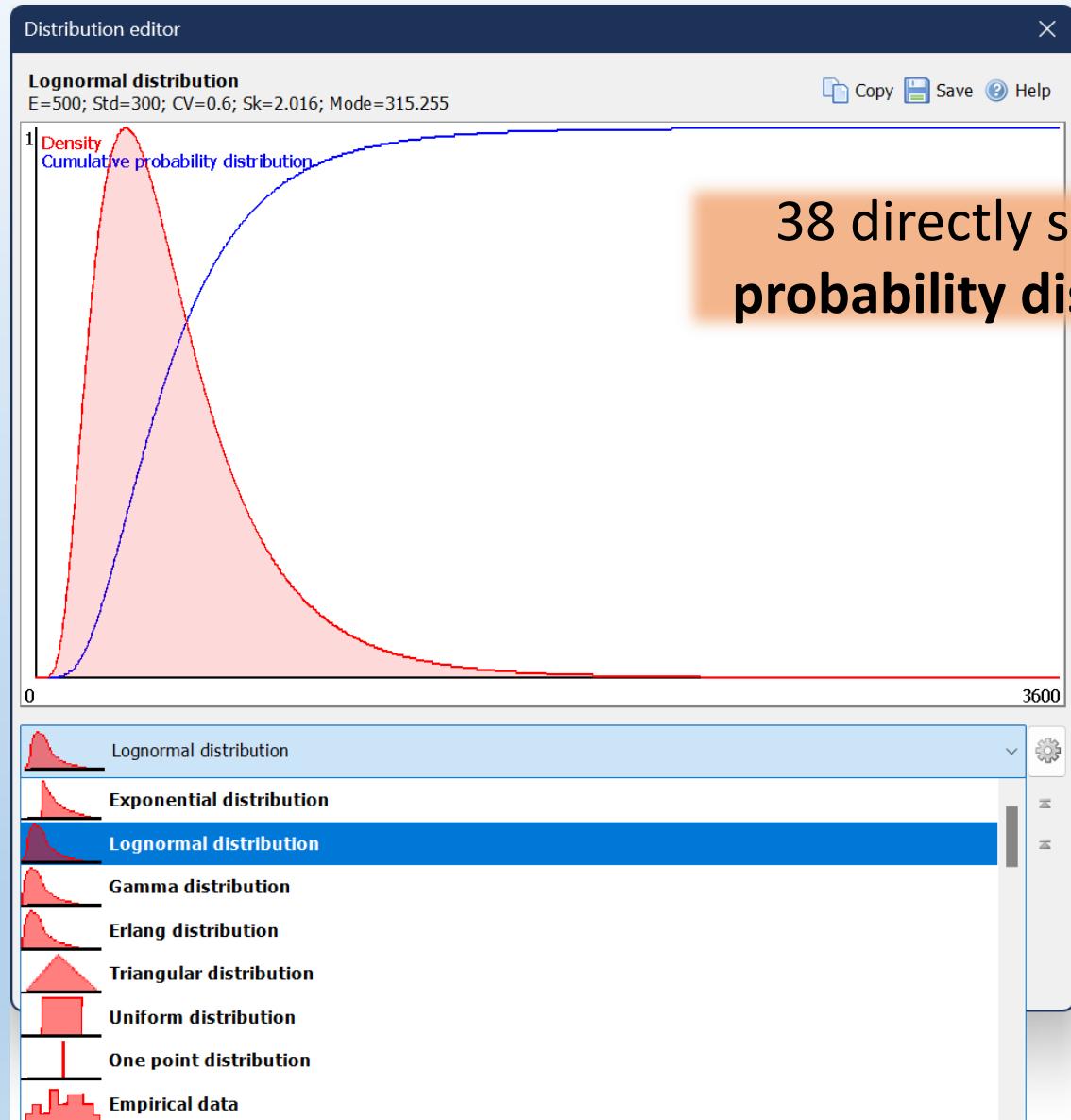
Modeling queueing systems as flow charts



More than 100 station types available

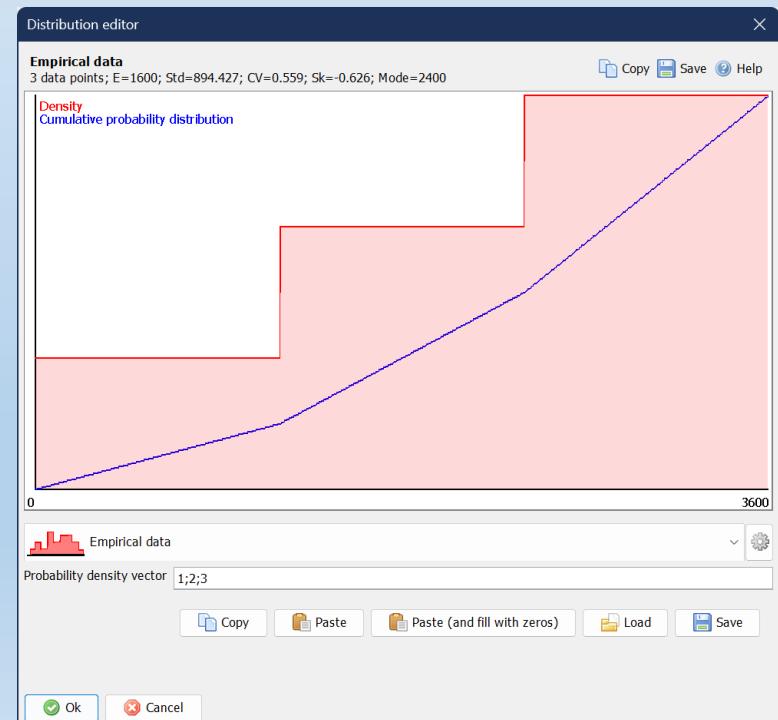


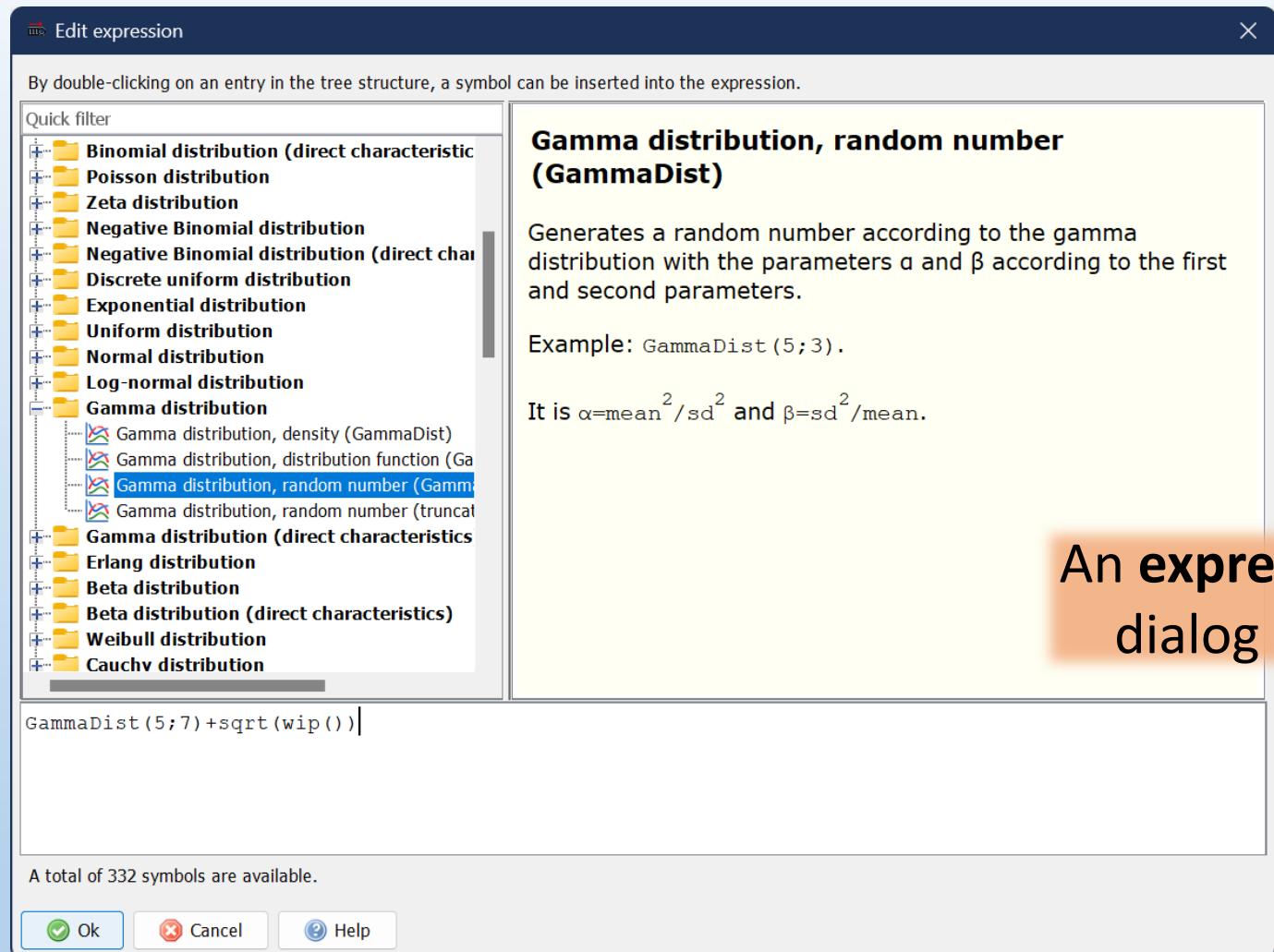
Many optional settings  
for each station



38 directly selectable  
probability distributions

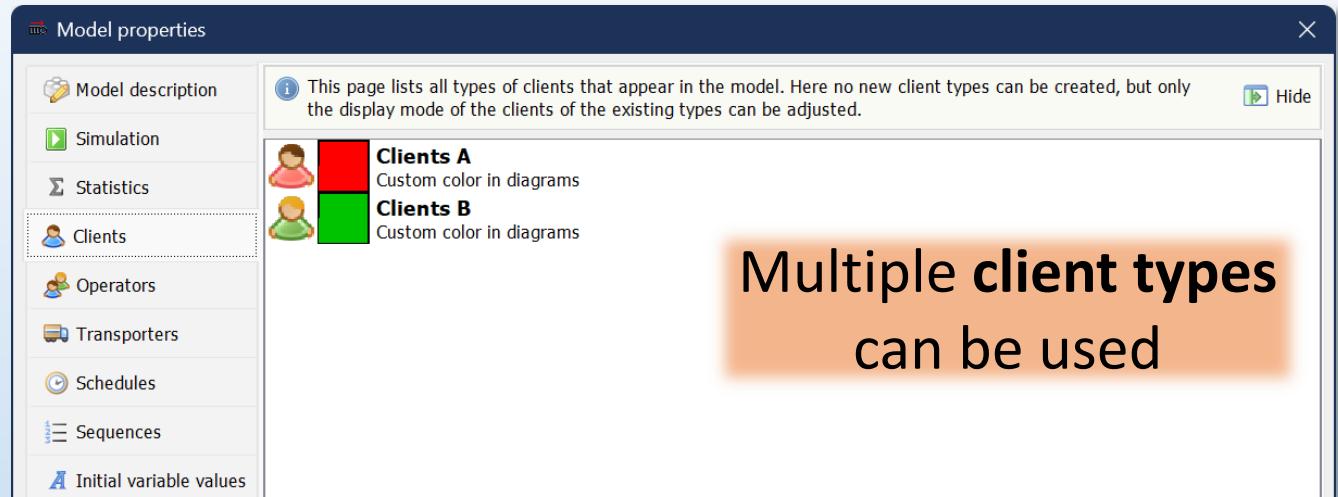
... including the option to use  
loaded empirical data





Calculation expressions  
can also be used

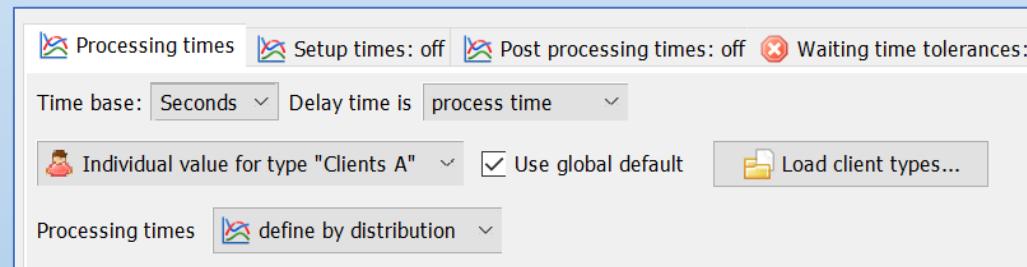
An expression builder  
dialog is available

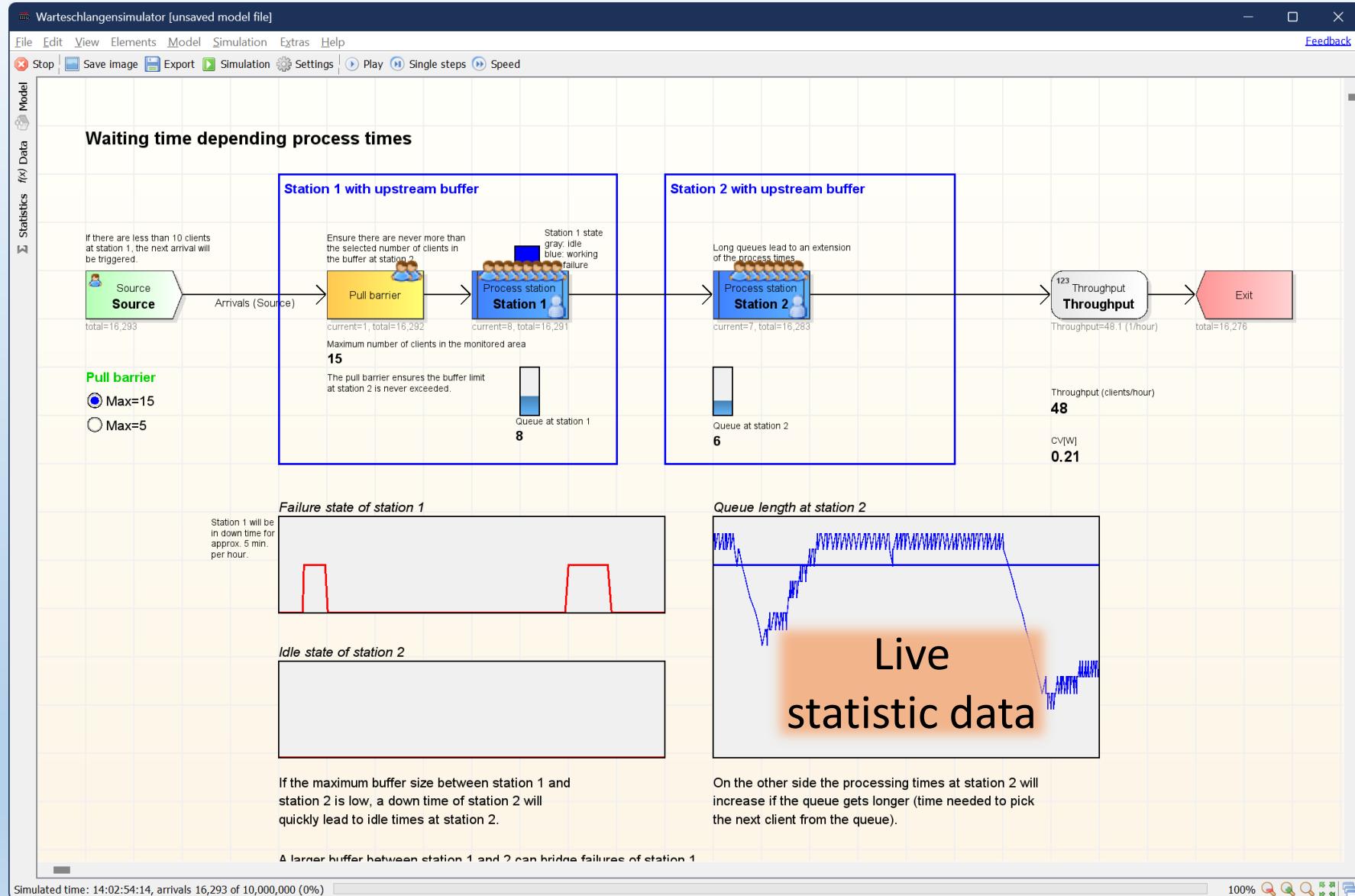


Multiple client types  
can be used



Each type can have an  
individual parameters

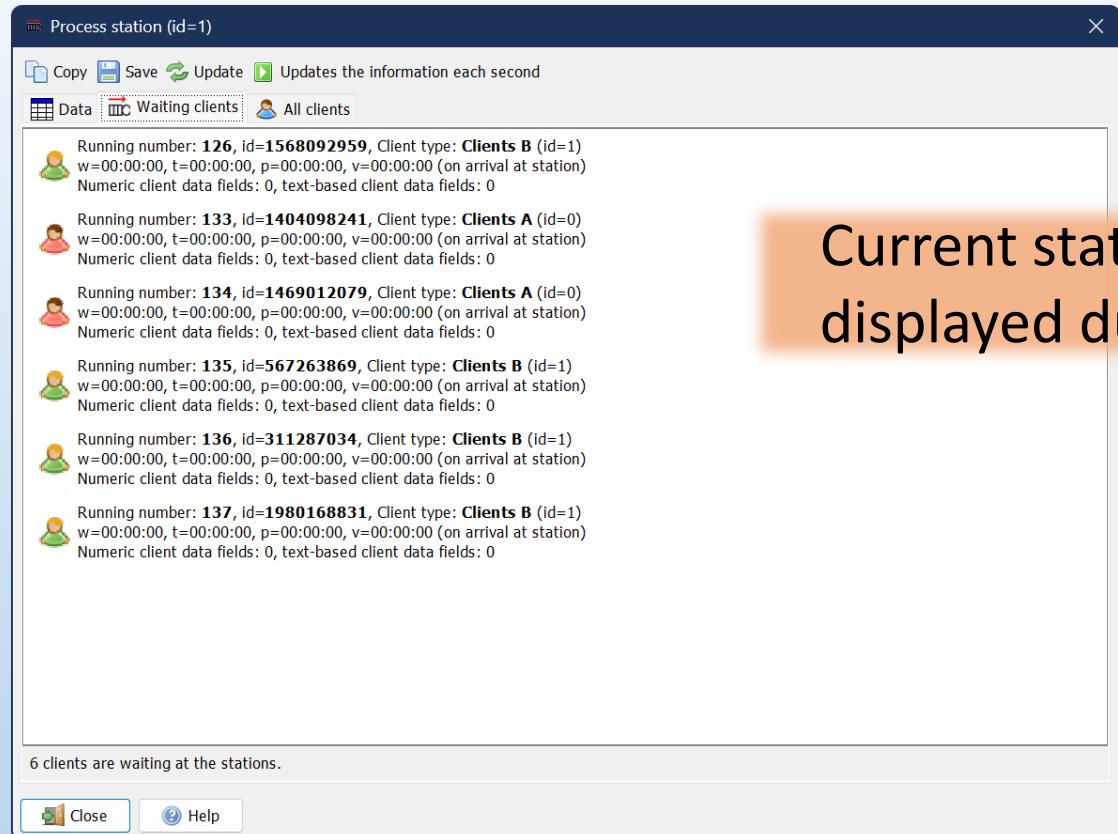




## Animation of models

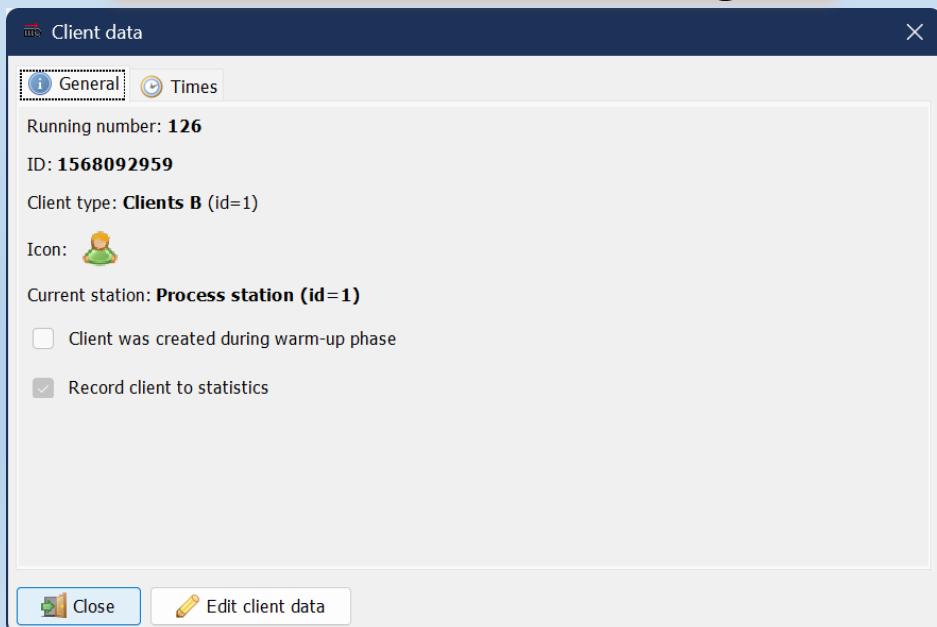
... which can be recorded as videos

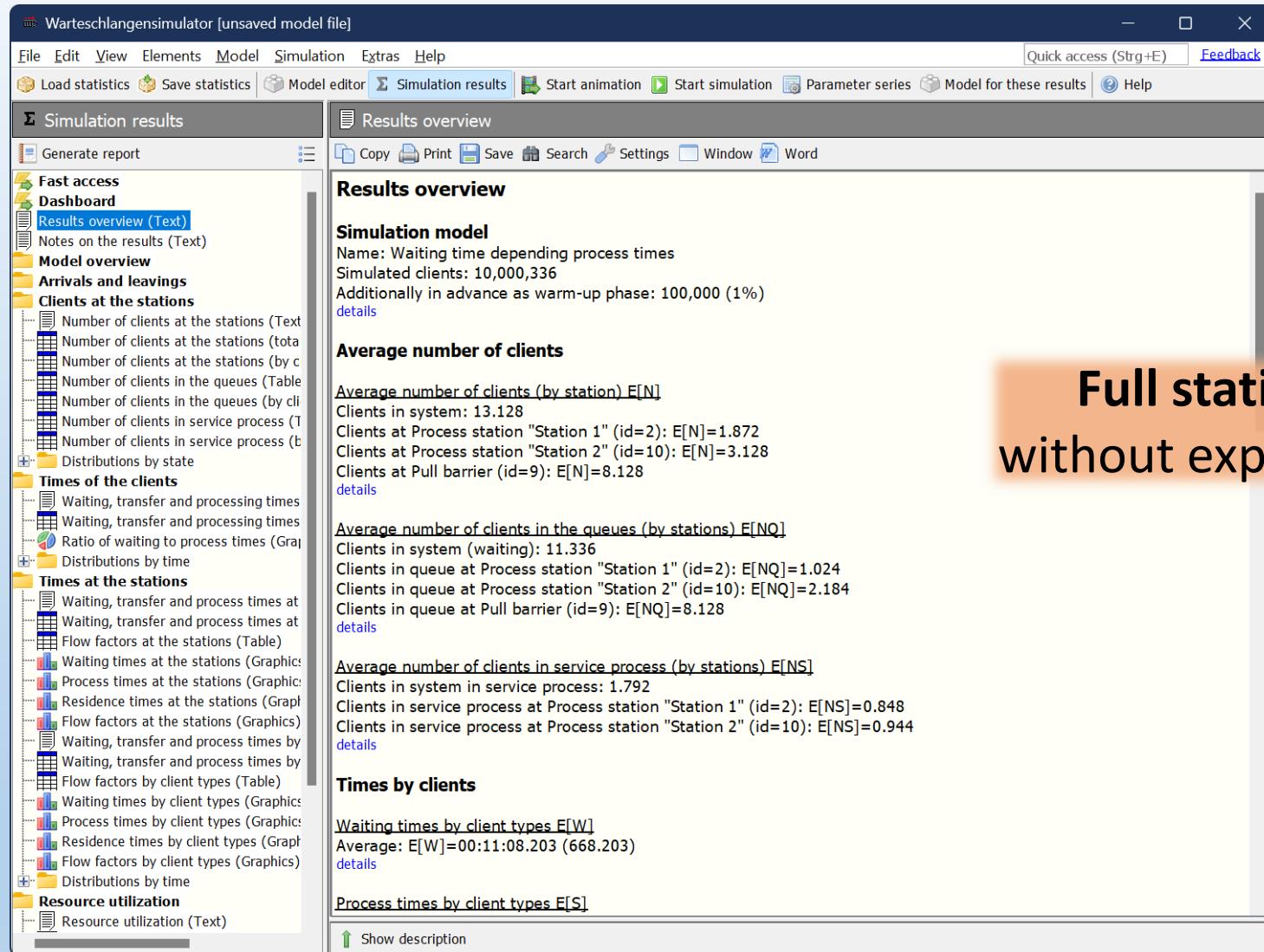
Live  
statistic data



Current station data can be displayed during animation

... and also changed while animation is running





Full statistic recording  
without explicit configuration

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File Edit View Elements 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 Results overview

Generate report Copy Print Save Search Settings Window Word

**Results overview**

**Simulation model**  
Name: Waiting time depending process times  
Simulated clients: 10,000,336  
Additionally in advance as warm-up phase: 100,000 (1%)  
details

**Average number of clients**

Average number of clients (by station)  $E[N]$   
Clients in system: 13.128  
Clients at Process station "Station 1" (id=2):  $E[N]=1.872$   
Clients at Process station "Station 2" (id=10):  $E[N]=3.128$   
Clients at Pull barrier (id=9):  $E[N]=8.128$

Average number of clients in the queues (by stations)  $E[NQ]$   
Clients in system (waiting): 11.336  
Clients in queue at Process station "Station 1" (id=2):  $E[NQ]=1.024$   
Clients in queue at Process station "Station 2" (id=10):  $E[NQ]=2.184$   
Clients in queue at Pull barrier (id=9):  $E[NQ]=8.128$

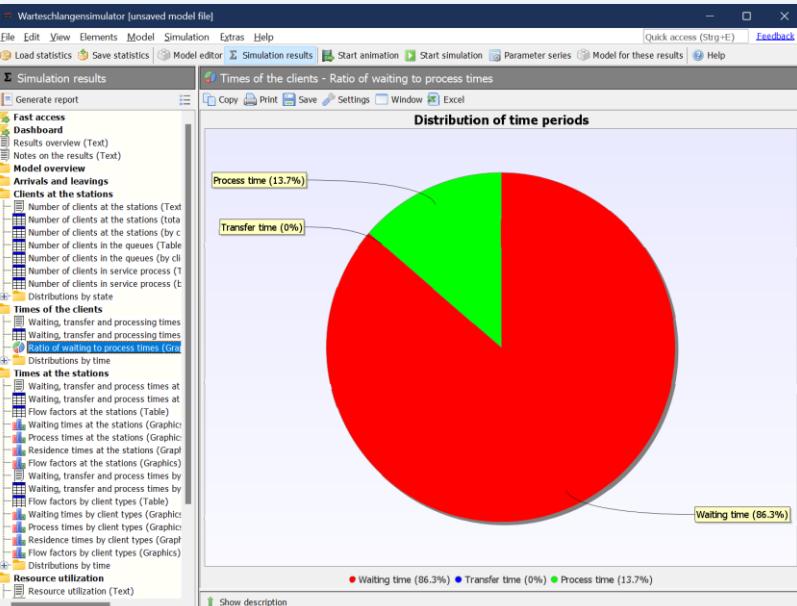
Average number of clients in service process (by stations)  $E[NS]$   
Clients in system in service process: 1.792  
Clients in service process at Process station "Station 1" (id=2):  $E[NS]=0.848$   
Clients in service process at Process station "Station 2" (id=10):  $E[NS]=0.944$

**Times by clients**

Waiting times by client types  $E[W]$   
Average:  $E[W]=00:11:08.203$  (668.203)  
details

Process times by client types  $E[S]$

Show description



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Simulation results Clients at the stations - Number of clients at the stations (by client types) (total)

Generate report Copy Print Save Settings Window Excel

Station	$E[N]$	$Std[N]$	$Var[N]$	$CV[N]$	$Sk[N]$	$Kurt[N]$	$Min[N]$	$Max[N]$	10% Quantile[N]	25% Quantile[N]
Process station "Station 1" - Source	1.872	1.347	1.814	0.719	0.856	-0.281	0	5	1	1
Process station "Station 2" - Source	3.128	1.347	1.814	0.431	-0.856	-0.281	0	5	1	2
Pull barrier (id=9) - Source	8.128	1.347	1.814	0.166	-0.856	-0.281	5	10	6	7
Throughput "Throughput" (id=21) - Source	0	0	0	0	0	0	0	0	0	0

**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 c)  
Number of clients in the queues (Table)  
Number of clients in the queues (by cl)  
Number of clients in service process (1)  
Number of clients in service process (t)  
Distributions by state

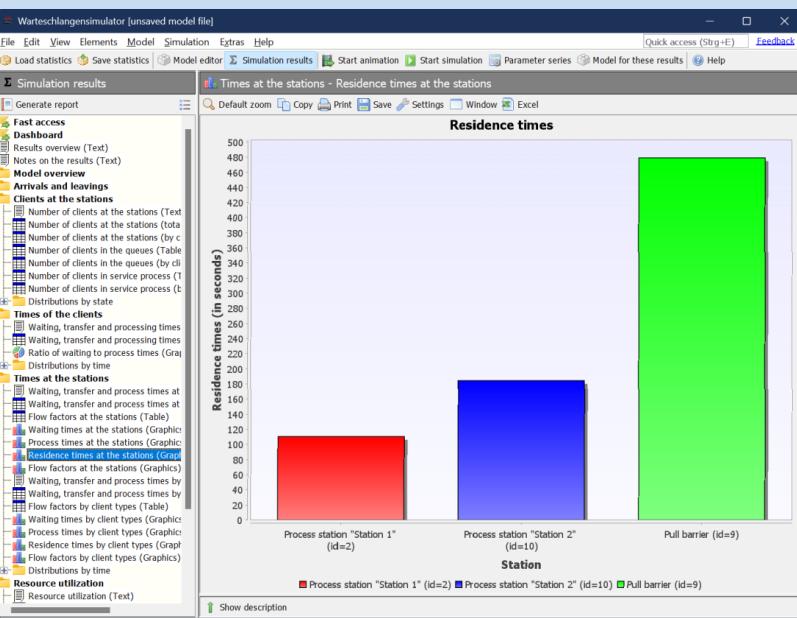
**Times at the stations**

Waiting, transfer and processing times at  
Waiting, transfer and process times at  
Flow factors at the stations (Table)  
Process times at the stations (Graphics)  
Residence times at the stations (Graph)  
Flow factors at the stations (Graphics)  
Waiting, transfer and process times by  
Waiting, transfer and process times by  
Flow factors by client types (Table)  
Waiting times by client types (Graphic)  
Process times by client types (Graphic)  
Residence times by client types (Graph)  
Flow factors by client types (Graphics)

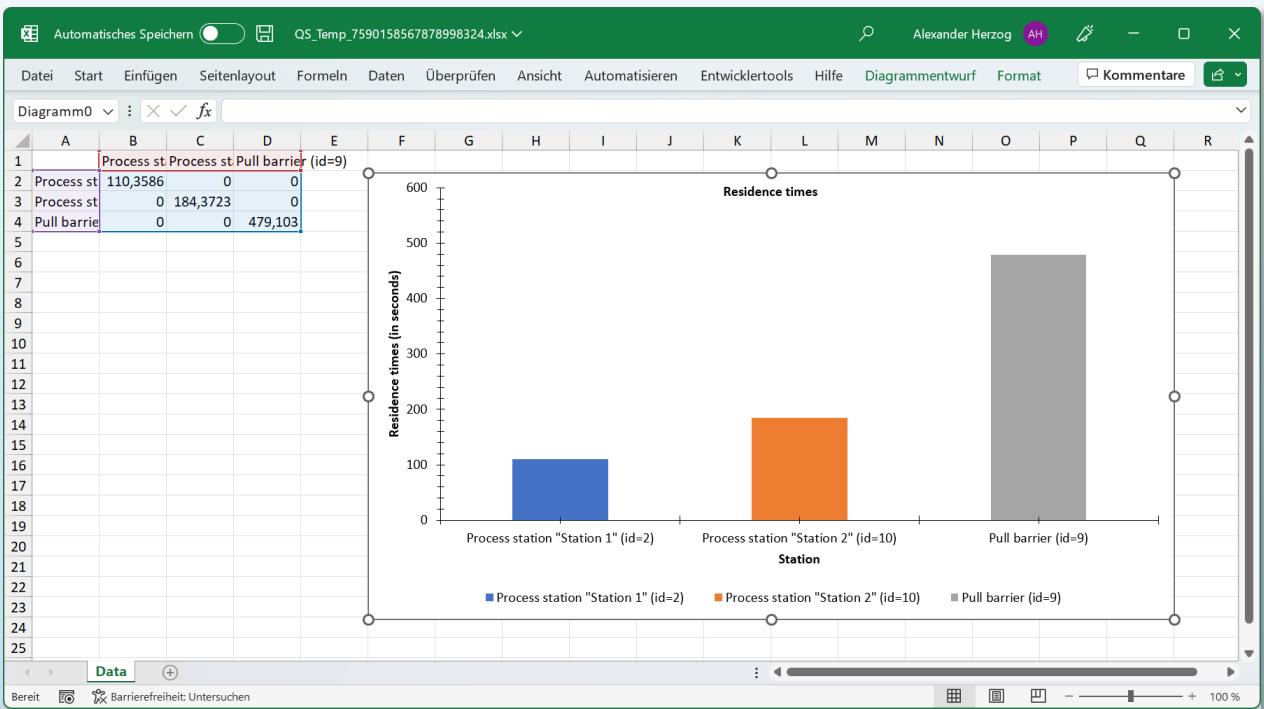
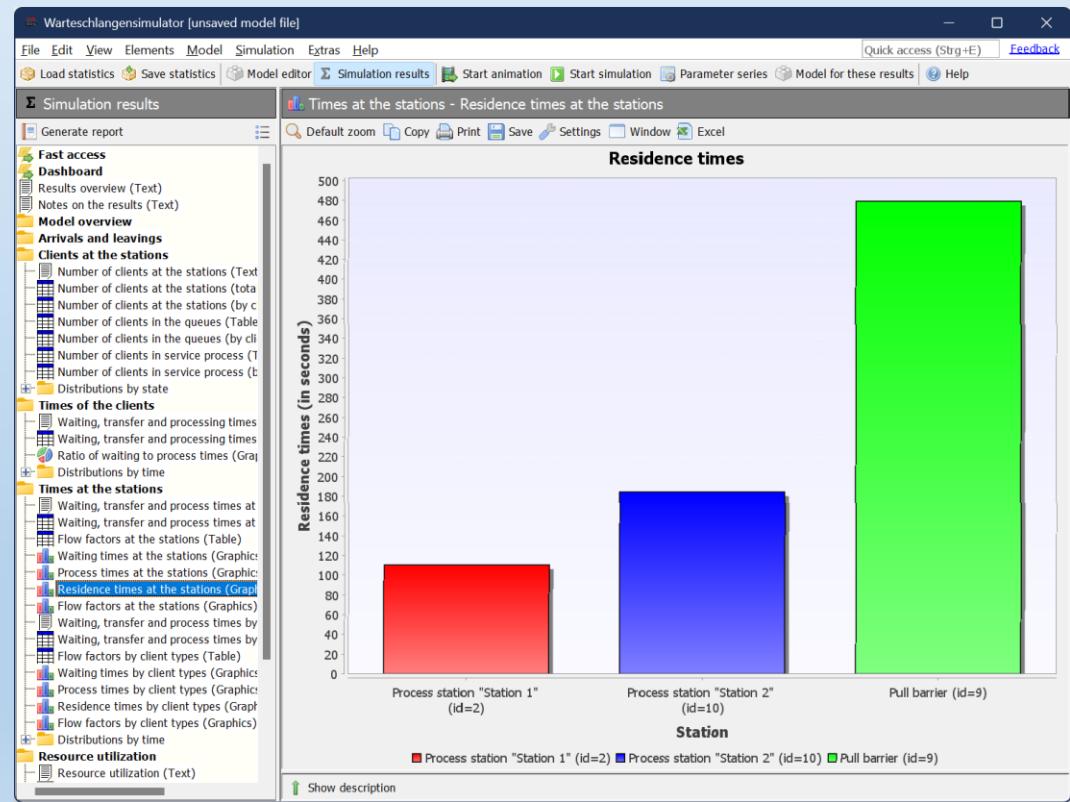
**Resource utilization**

Resource utilization (Text)

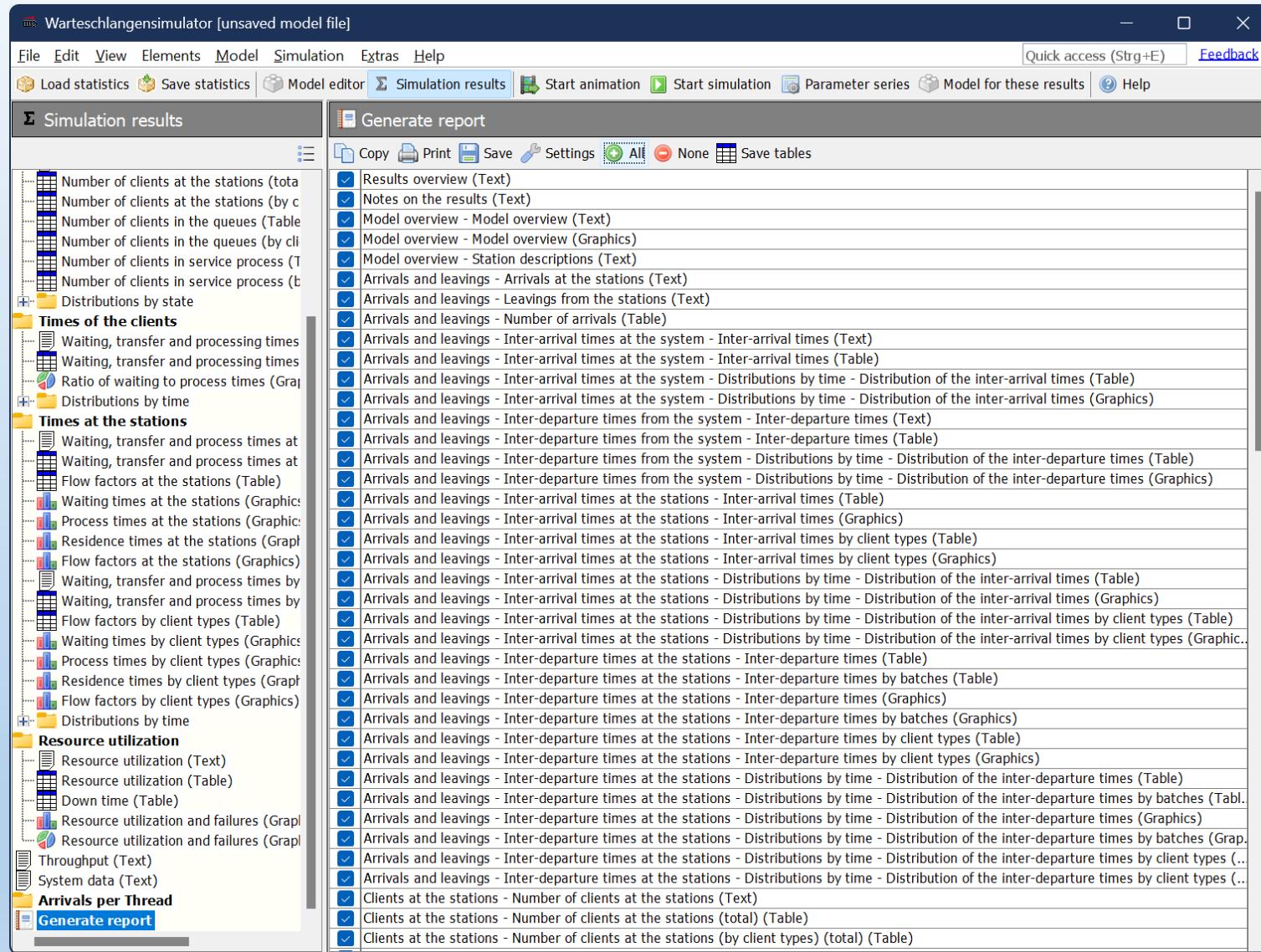
Show description



# Results available as texts, tables and charts



Excel export of tables  
and charts available

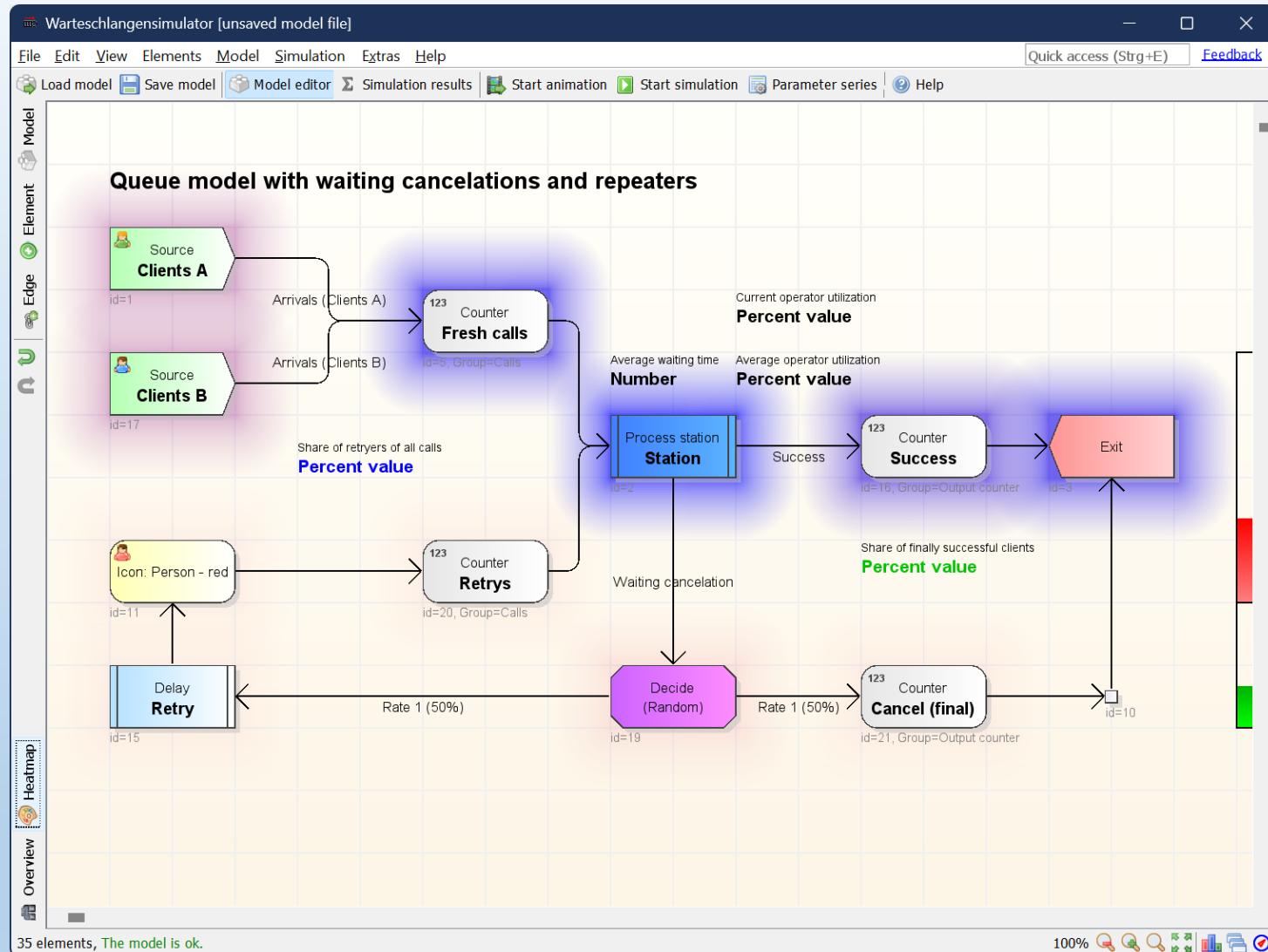


**Report generator**  
supporting docx, pdf,  
tex and html

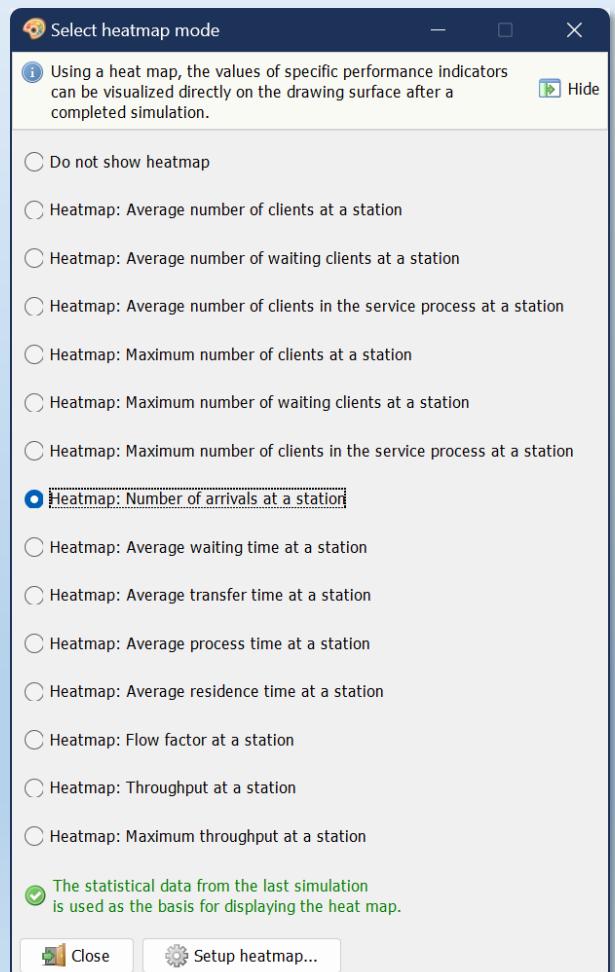
html Reports can be saved  
as interactive web viewers

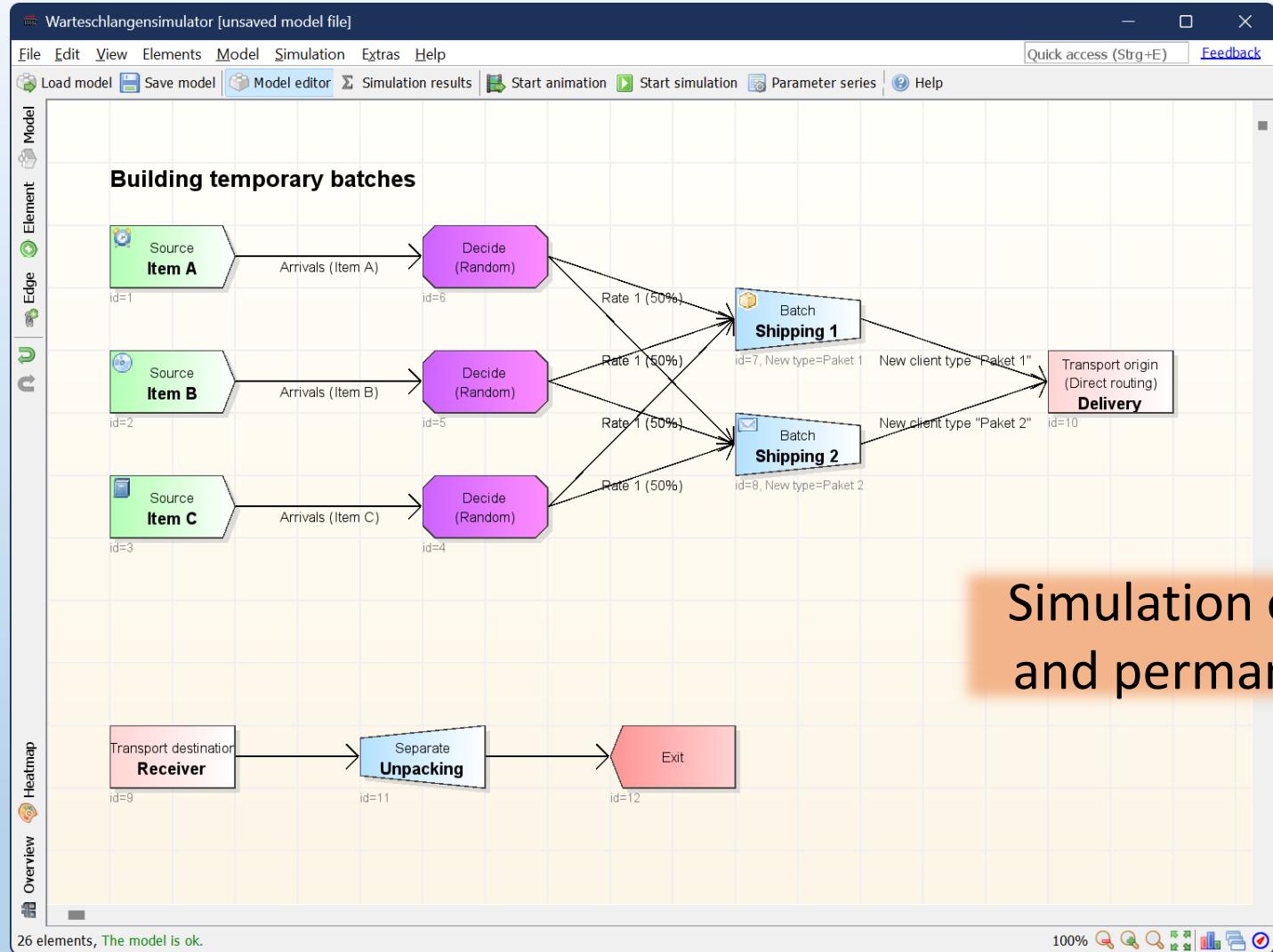
The screenshot shows a detailed report generated by the Warteschlangensimulator. The report is organized into several sections:

- Results overview (Text)**: Contains links to Results overview (Text), Notes on the results (Text), Model overview (Text), Model overview (Graphics), Station descriptions (Text), Arrivals at the stations (Text), Leavings from the stations (Text), Number of arrivals (Table), and Inter-arrival times at the system (Text).
- Simulation model**: Details the name (Waiting time depending process times), simulated clients (10,000,336), and additional information about warm-up phase (100,000 (1%)).
- Average number of clients**: Statistics for clients in system, clients at Process station, clients at Queue station, clients at Full barrier, and clients in queue.
- Average number of clients in the queues (by stations) E[NQ]**: Statistics for stations 1 and 2.
- Average number of clients in service process (by stations) E[N]**: Statistics for stations 1 and 2.
- Times by clients**: Statistics for waiting times by client types E[W].
- Times by stations**: Statistics for waiting times by stations E[W].
- Process times by stations E[S]**: Statistics for stations 1 and 2.

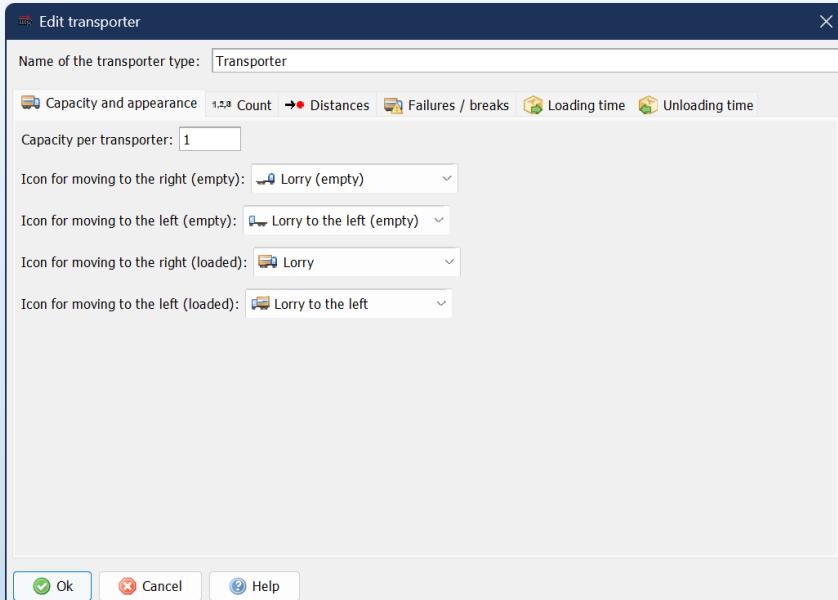
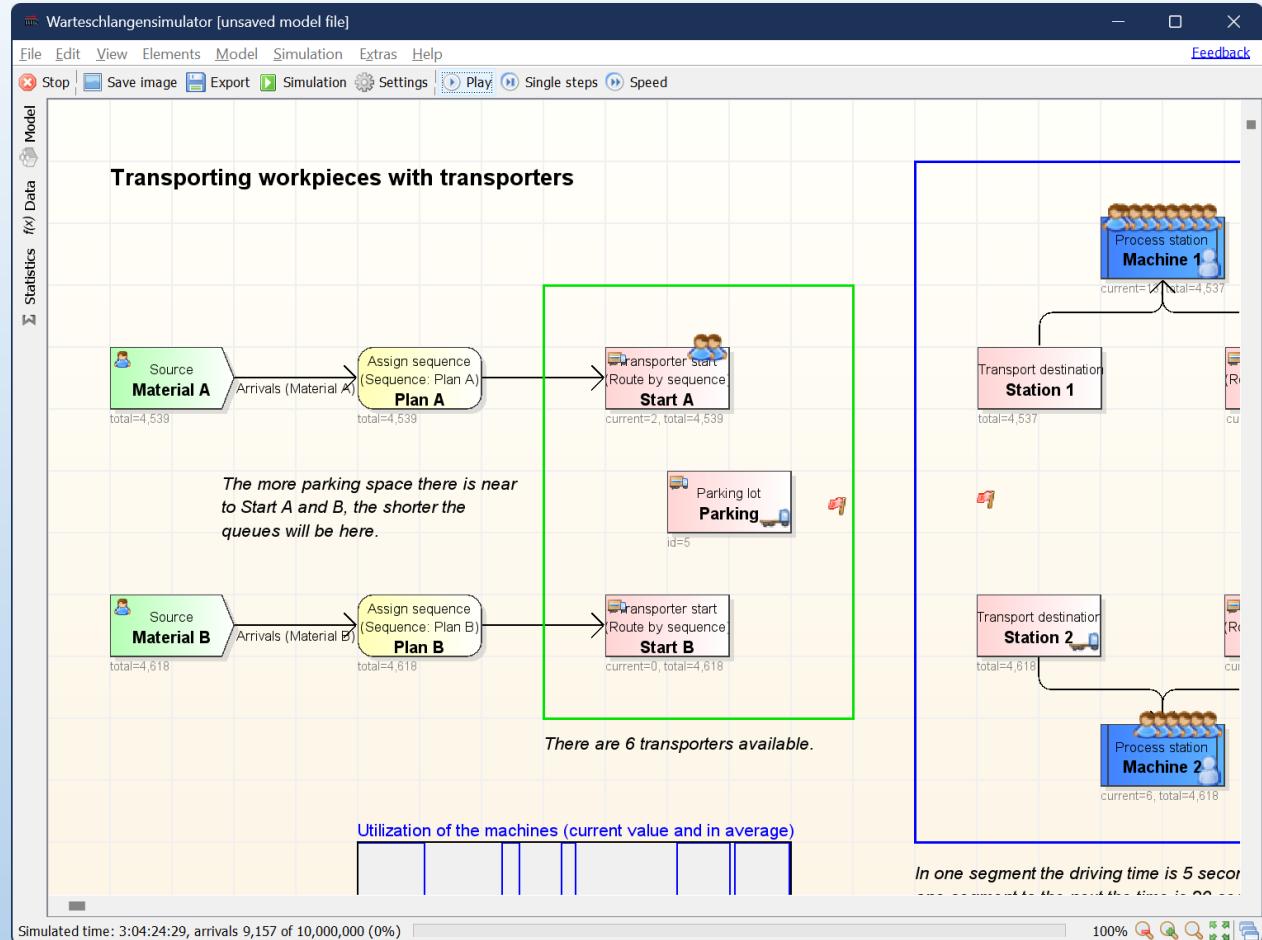


# Visualizing simulation results as heatmaps

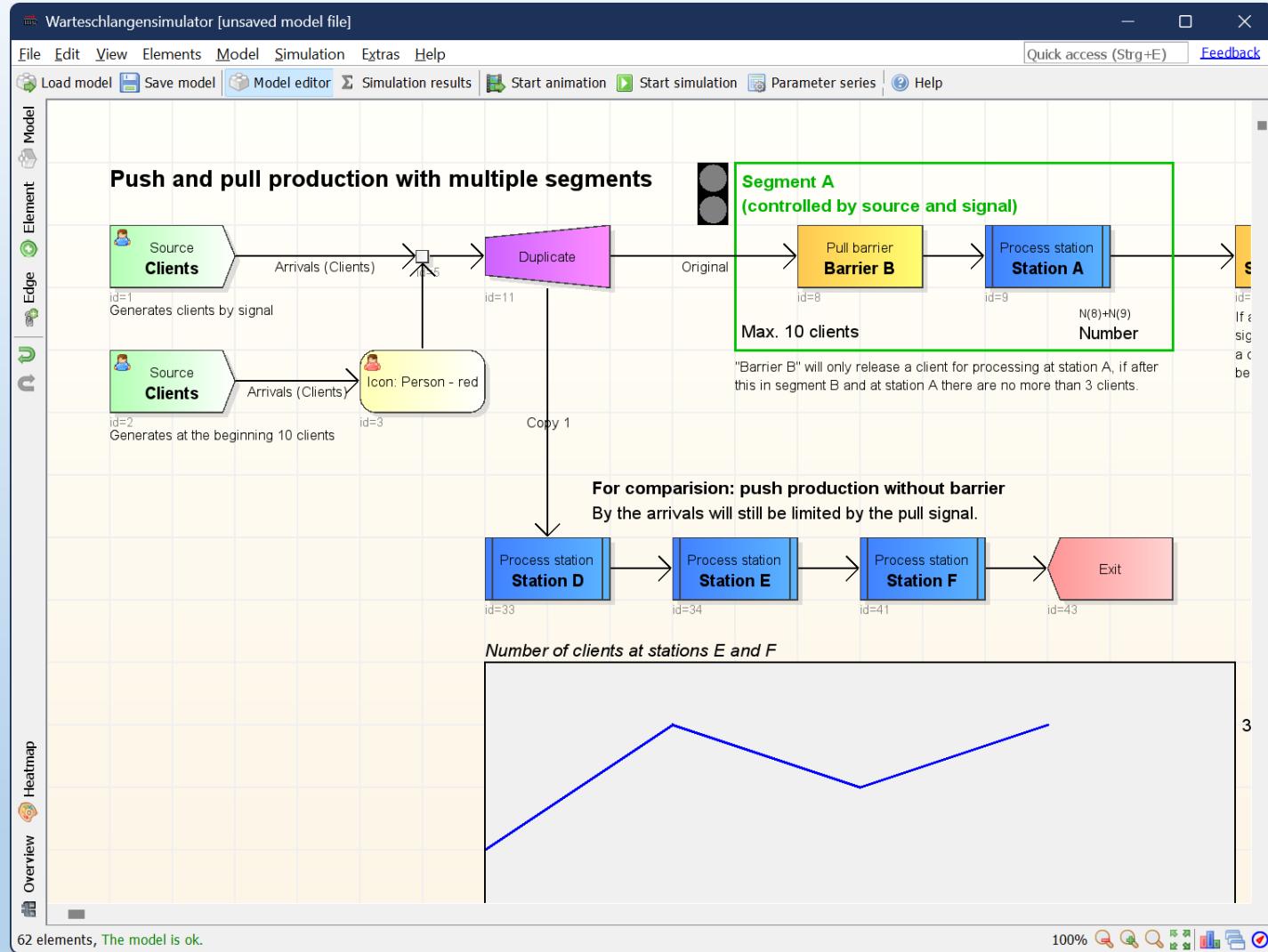




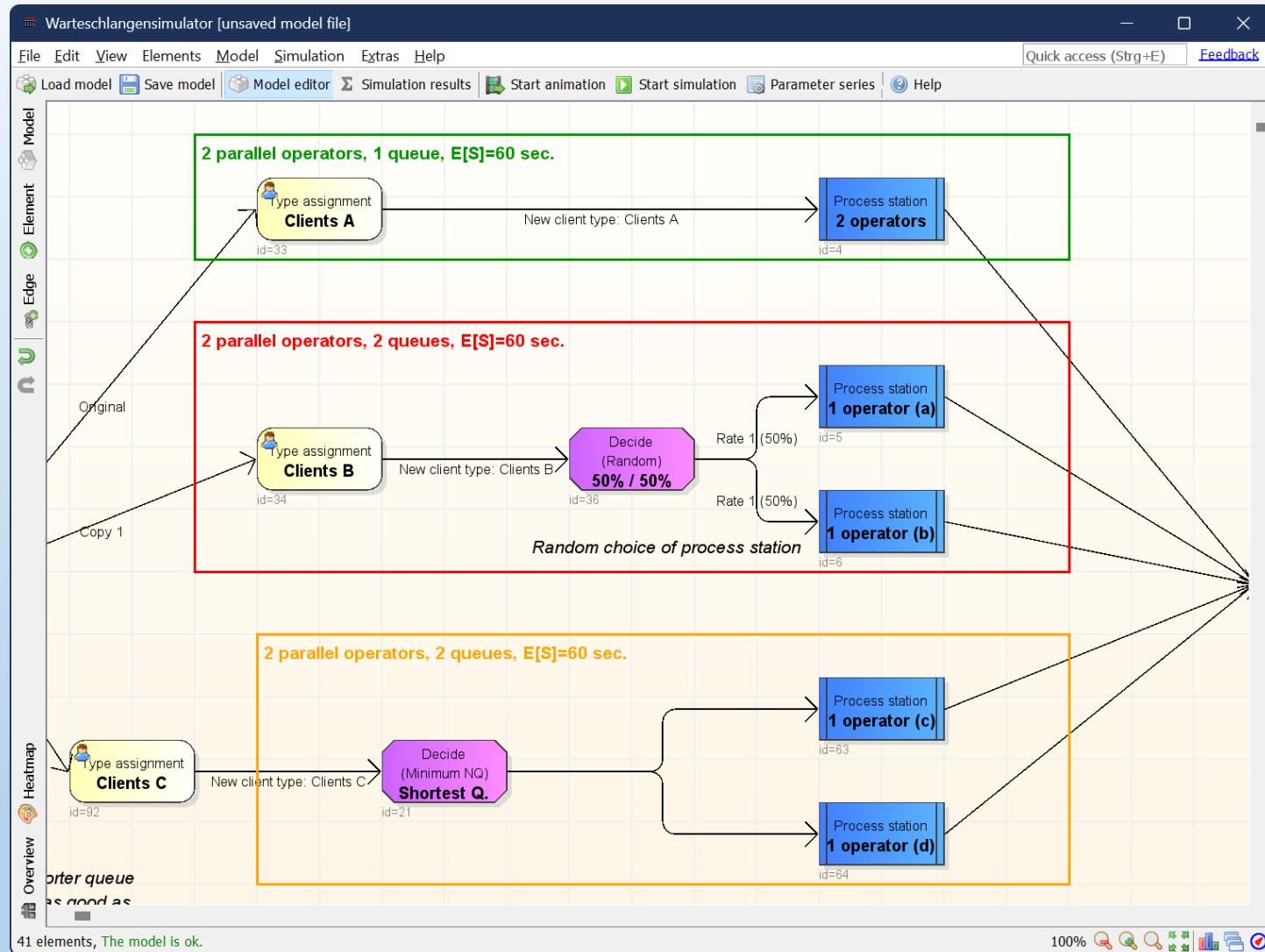
Simulation of temporary  
and permanent **batches**



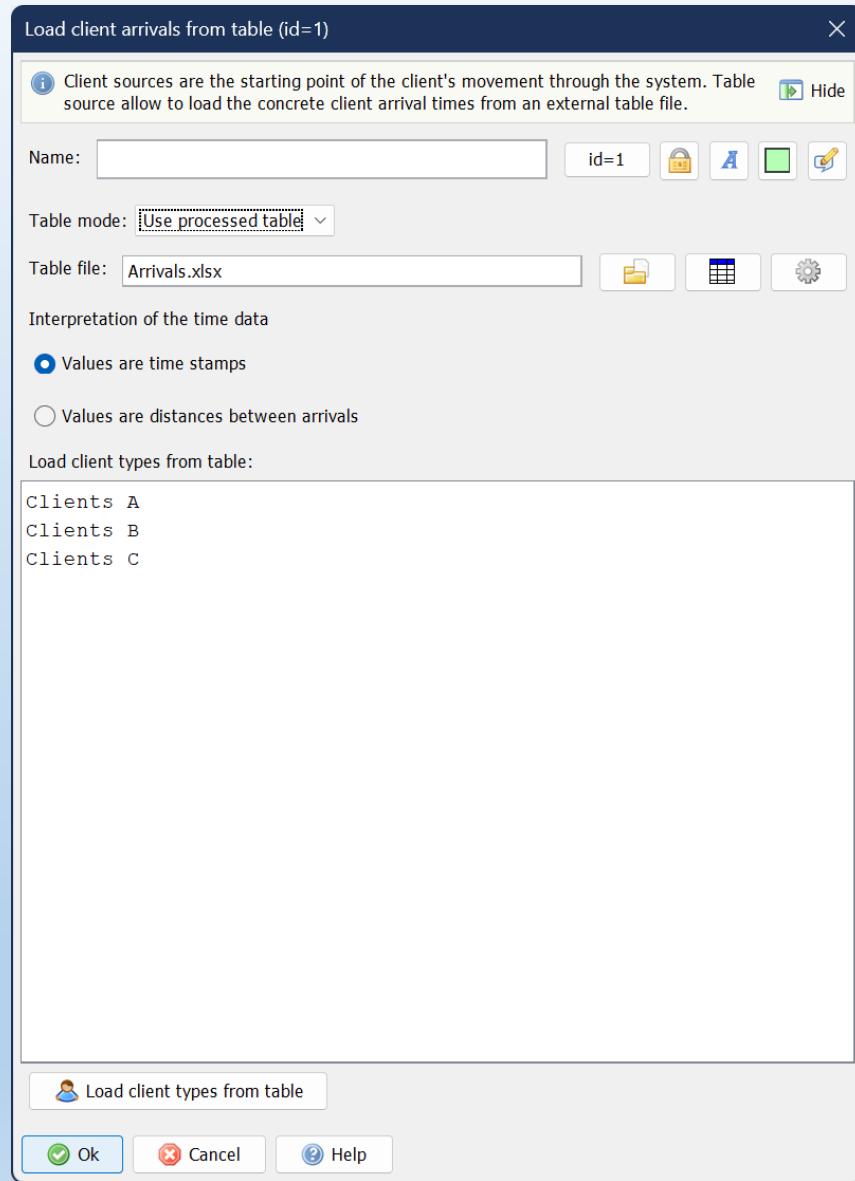
Simulation of transport processes using transporters



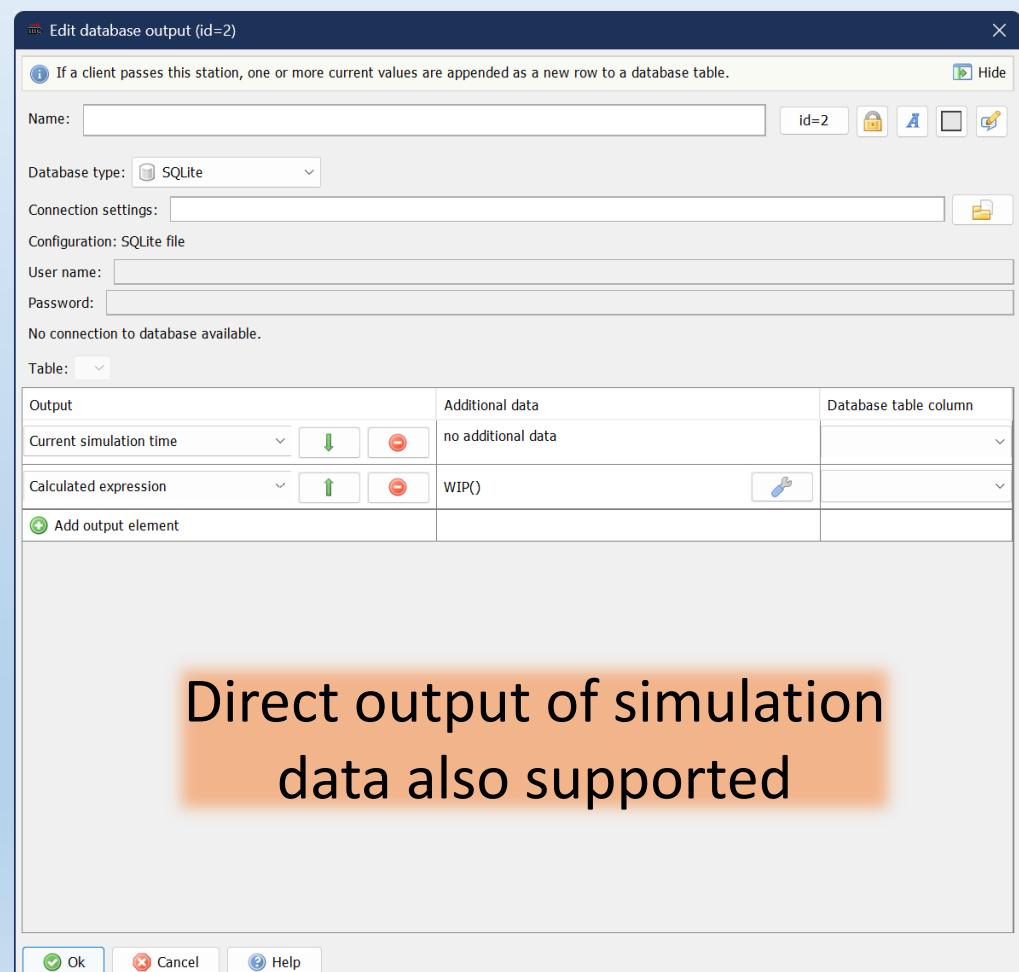
**Push/pull production – and any other kind of condition-based barriers, signals etc.**



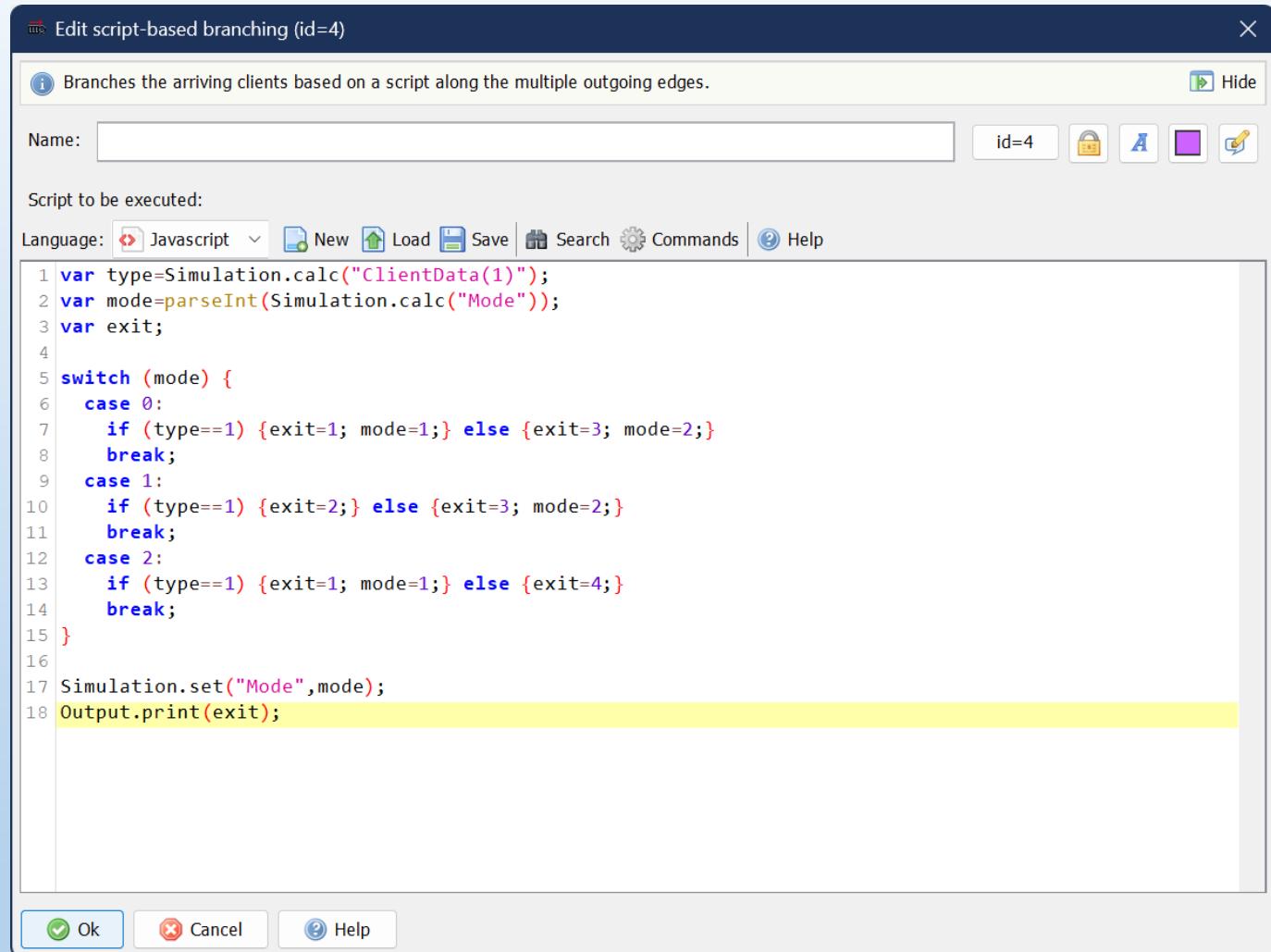
**Branching clients by conditions,  
by chance, script-based, etc.**



Using external data for client arrivals  
and parameters in simulation process



Direct output of simulation  
data also supported



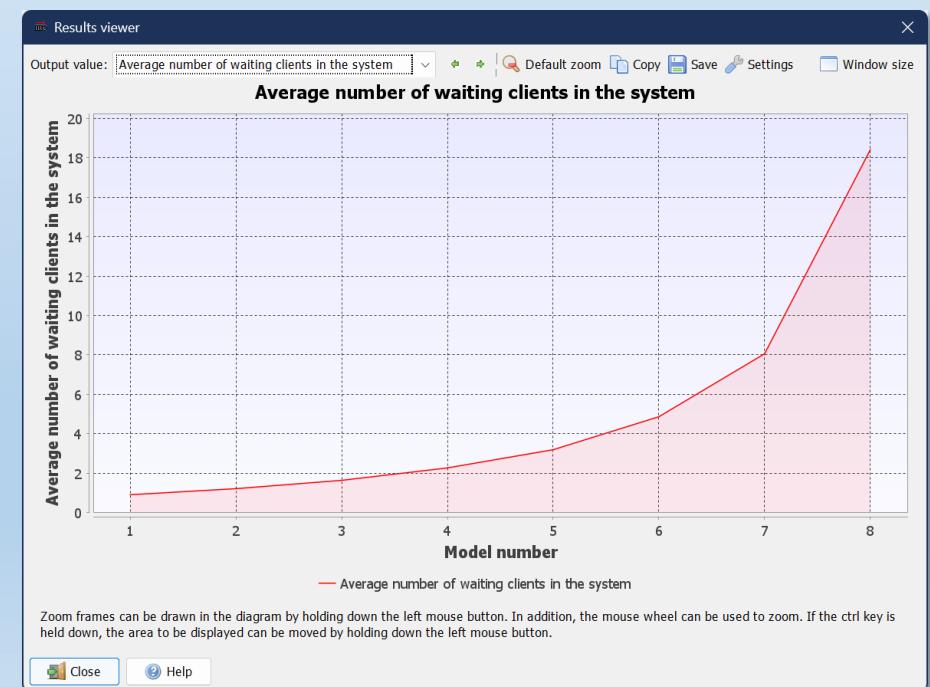
Scripts can be used for  
modelling complex  
control strategies

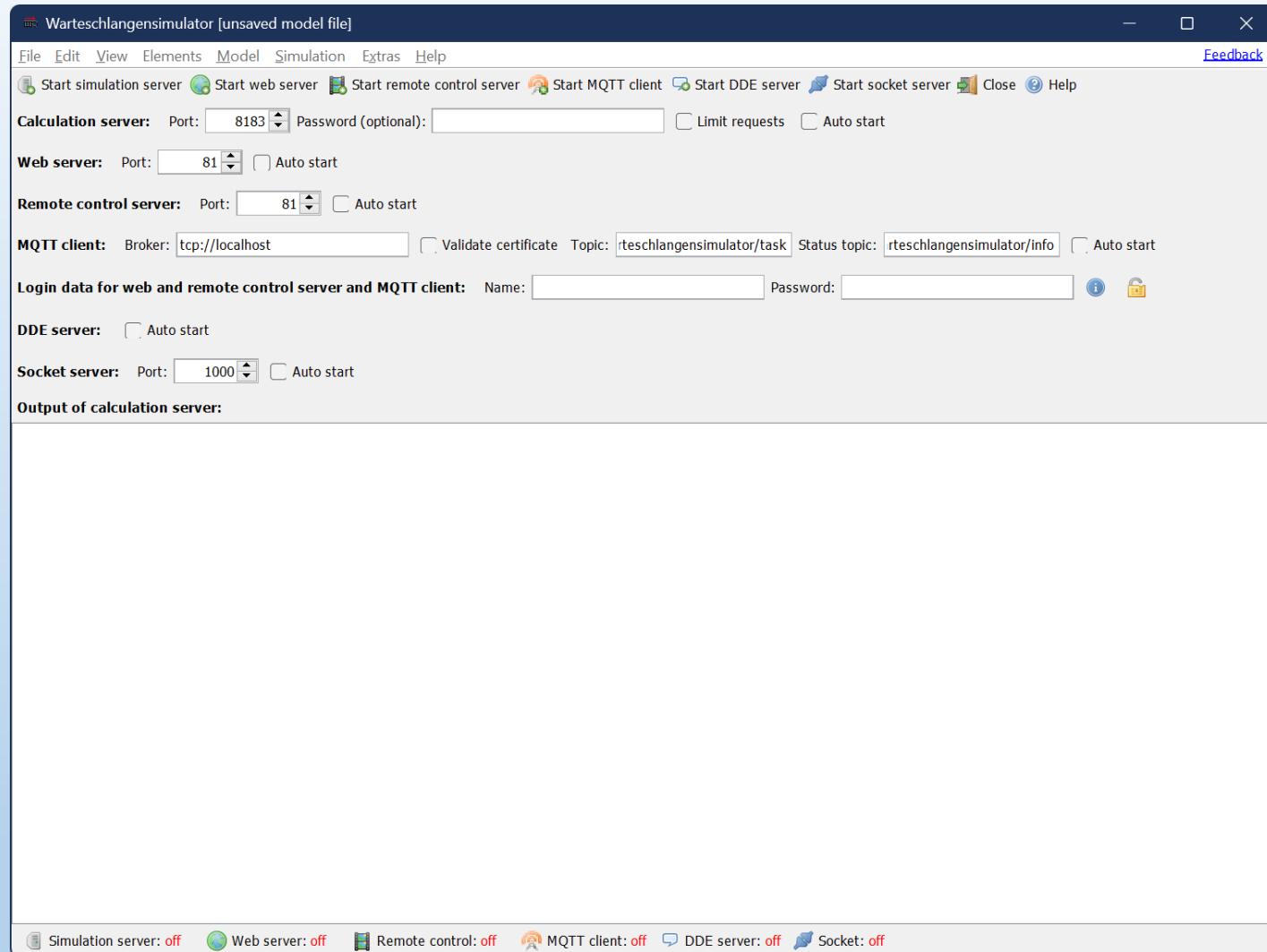
Supported languages:  
Javascript and Java

Model	Input parameter Average service time	Output value Average number of clients in the system	Output value Average number of waiting clients in the system	Output value Waiting time for all clients	Output value Process time for all clients	Output value Resource utilization - Operators group	Control
Parameter serie... 60	1.501	0.901	00:01:30	00:01:00	60.046%		
Parameter serie... 65	1.859	1.209	00:02:00.8	00:01:05	65.027%		
Parameter serie... 70	2.331	1.631	00:02:43.2	00:01:10	69.972%		
Parameter serie... 75	3.012	2.261	00:03:46	00:01:15	75.041%		
Parameter serie... 80	3.984	3.184	00:05:18.5	00:01:20	79.937%		
Parameter serie... 85	5.71	4.859	00:08:05.8	00:01:25	85.071%		
Parameter serie... 90	8.952	8.052	00:13:24.5	00:01:29.9	90.024%		
Parameter serie... 95	19.357	18.406	00:30:39	00:01:35	95.071%		

## Optimizer also built-in

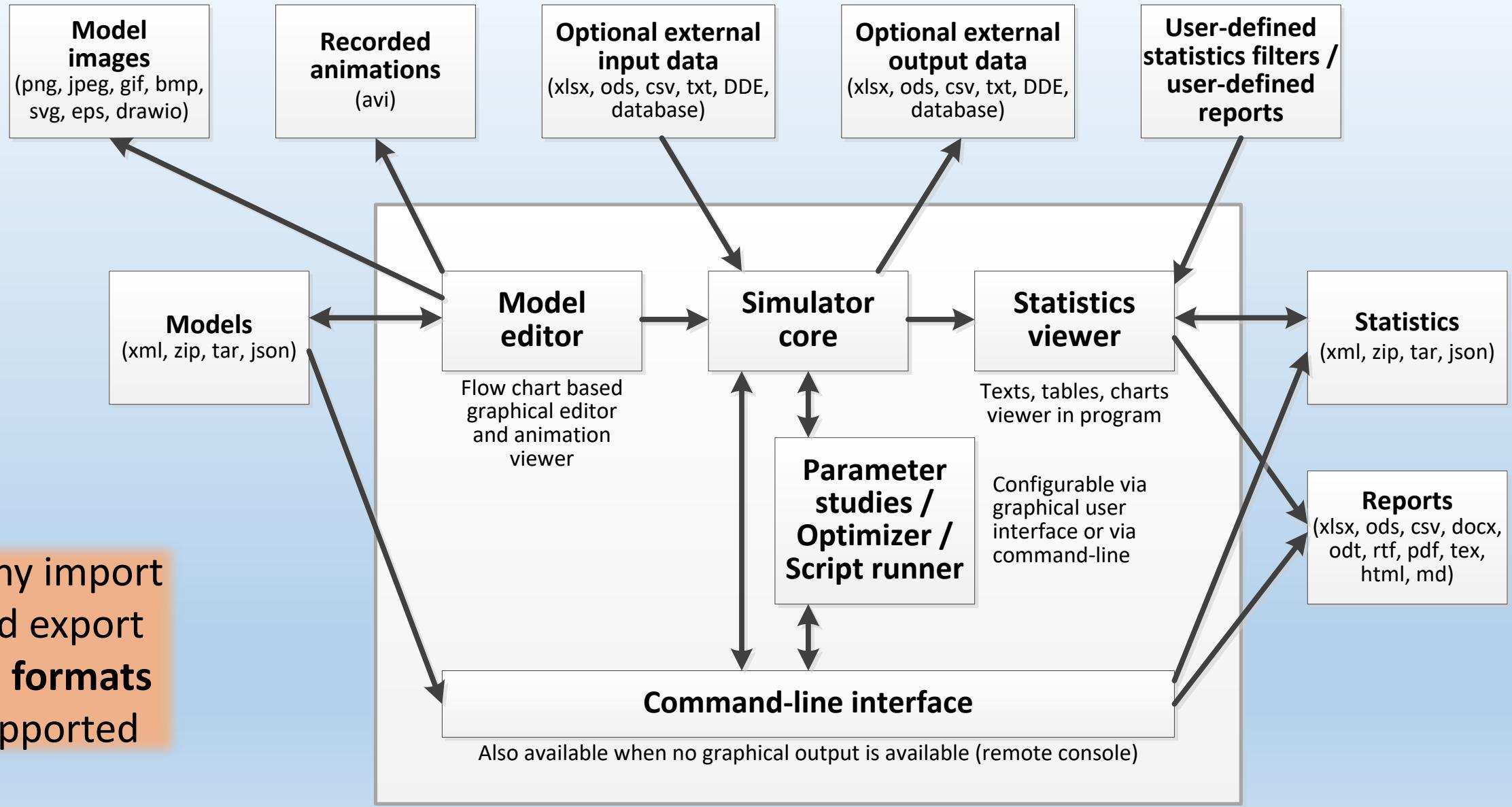
# Fast and easy creation of parameter studies





Command-line and  
server operation available

Simulator can be used on  
Linux-based HPC systems



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File Edit View Elements Model Simulation Extras Help

Quick access (Strg+E) Feedback

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### Simulation results

- Generate report
- Fast access
- Dashboard**
- 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)
  - Number of clients at the stations (by client)
  - Number of clients in the queues (Table)
  - Number of clients in the queues (by client)
  - Number of clients in service process (Table)
  - Number of clients in service process (by client)
  - Distributions by state
- Times of the clients**
  - Waiting, transfer and processing times of
  - Waiting, transfer and processing times of
  - Ratio of waiting to process times (Graphic)
  - Distributions by time
- Times at the stations**
  - Waiting, transfer and process times at the
  - Waiting, transfer and process times at the
  - Distributions by time
- Resource utilization**
  - Resource utilization (Text)
  - Resource utilization (Table)
  - Resource utilization and failures (Graphics)
  - Resource utilization and failures (Graphics)
- System data (Text)
- Arrivals per Thread
- Generate report

### System data

Copy Print Save Search Settings Window Word

**System data**

Used simulator version: 5.2.0  
 Run date of the simulation: 11/25/22, 7:38 PM  
 Threads: 24  
 Simulation computer: Windows 11 (amd64), OpenJDK 64-Bit Server VM (18.0.2)  
 Author of the model: Alexander Herzog  
 User (simulation run): Alexander Herzog

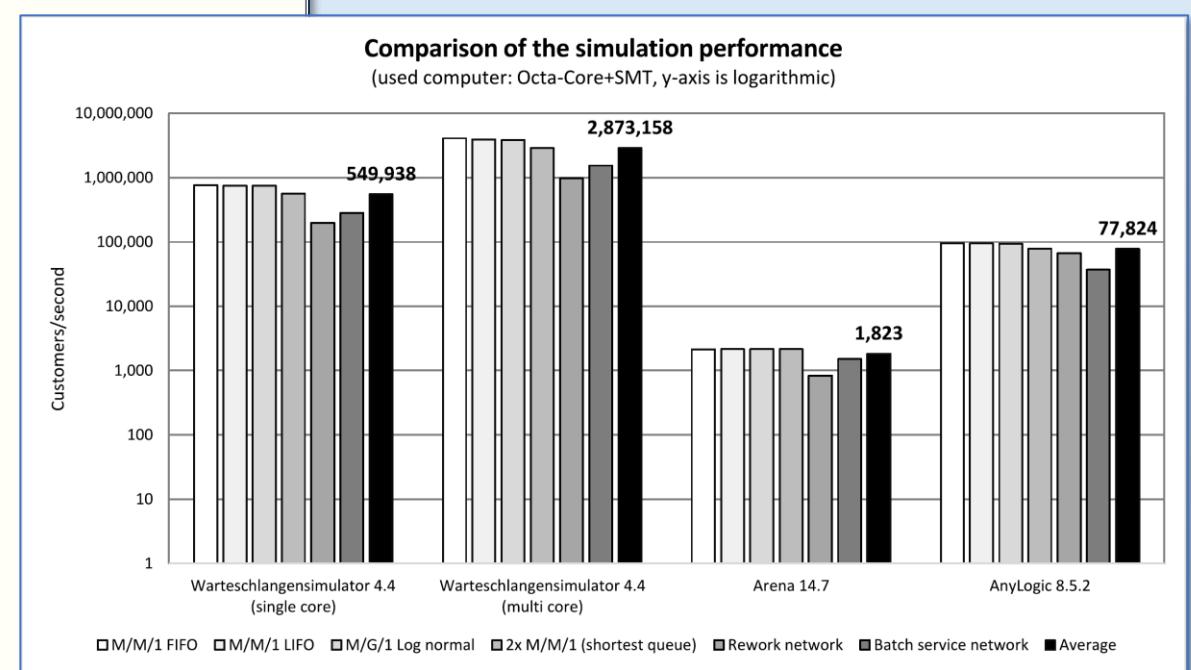
Needed simulation time: 519 ms  
 Relative runtime difference between fastest and slowest thread: 0.387%  
 Maximum relative difference in simulated clients between the threads: 9.121%  
 The simulation was ran in NUMA-aware memory mode.

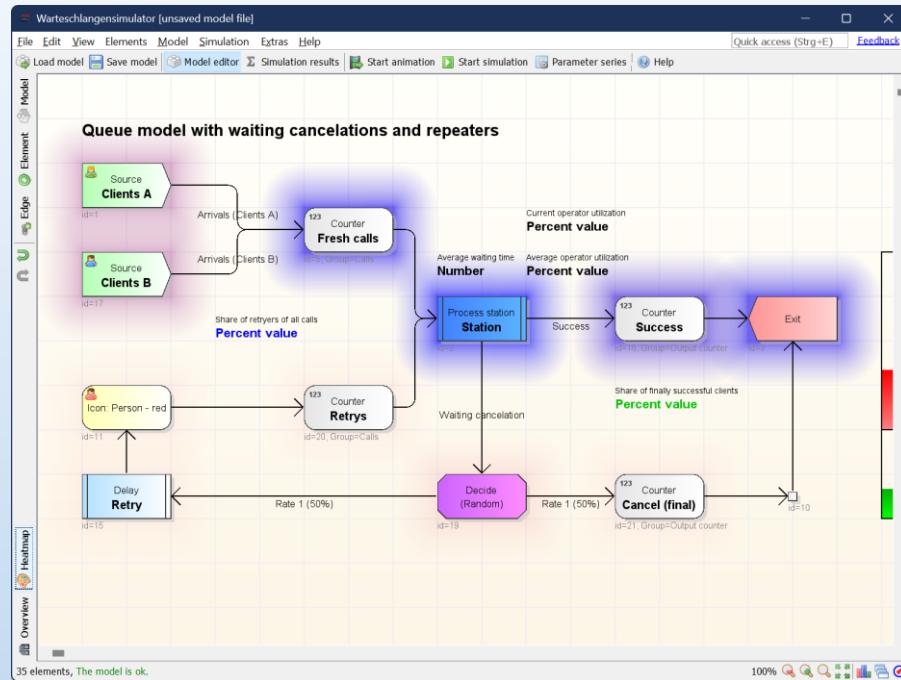
Simulated client arrivals (without warm-up phase): 5,000,089  
 Clients per second: 9,634,082  
 Needed calculation time per client (\*): 2.491  $\mu$ s

Simulated events: 18,600,137  
**Events per second: 35,838,414**  
 Needed calculation time per event (\*): 670 ns

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

Fast simulation  
supporting multi-core CPUs





**Model editor**

In the model editor, the queue model to be simulated can be defined. By using the **Element** toolbar button, components can be added to the drawing surface, and the **Edge** button can be used to insert connections edges between the components.

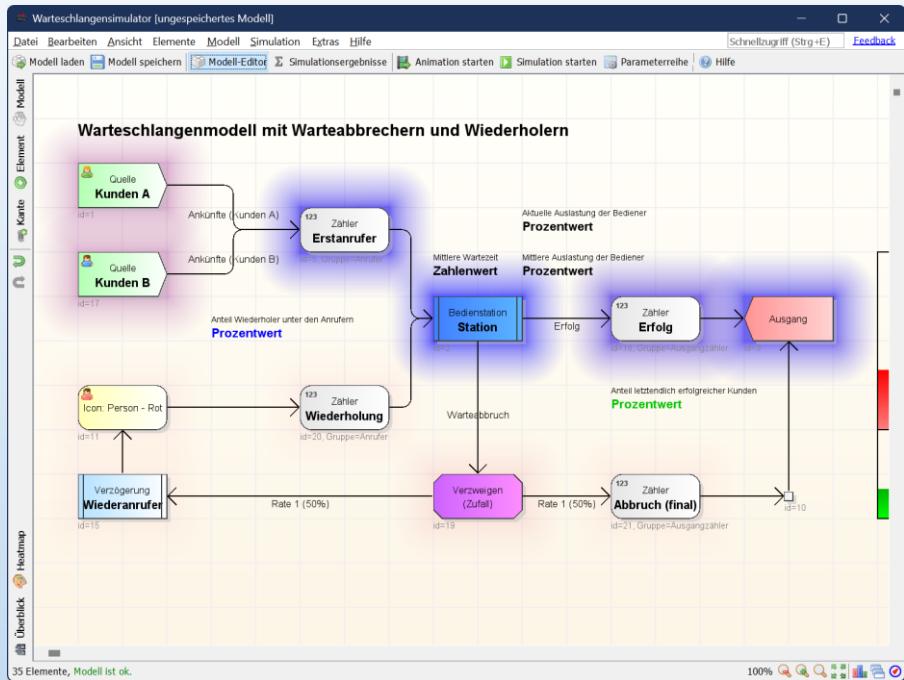
Elements can be selected individually (by holding down the **Shift** key if you want to select more than one element), or by area selection, and then moved groupwise by **drag&drop**. By right-clicking on an element, a context menu with additional command options can be called.

By **double-clicking** (or pressing the **Enter** key on a selected element) a properties dialog for configuring the selected component can be opened. The **Delete** key can be used to **remove** the selected elements. In addition to **drag&drop**, elements can also be **moved** by holding down the **Alt** keys and using the cursor keys. If the **Shift** key is pressed while dragging and dropping the elements or using the cursor keys to move them, the selected element can be moved pixel-wise, otherwise they are moved along a grid. If the **Ctrl** key is pressed while dragging and dropping an element, a copy is placed. The original element will not be changed. If the **Alt** key is pressed while dragging and dropping elements, the x or the y position is locked. The movement takes place along one axis only.

By using the **middle mouse button** the function for adding connection edges can be switched on or off without needing to click the Edge button.

An overview of all available **elements** can be found on the [help content](#) page.

# User-interface and full documentation available in English and German



**Modell-Editor**

Siehe auch Abschnitt Programmoberfläche im Lehrbuch.

In dem Modell-Editor kann das zu simulierte Warteschlangenmodell definiert werden. Über die Symbolleiste/Schaltfläche **Element** können Komponenten auf der Zeichenfläche hinzugefügt werden und über die Schaltfläche **Kante** Verbindungsketten zwischen den Komponenten eingefügt werden. Elemente können entweder einzeln per Anklicken (mit gedrückt gehaltener **Umschalt**-Taste, wenn mehrere Elemente selektiert werden sollen) oder per Bereichs-Selektion ausgewählt und dann gruppenweise per **Drag&Drop** verschoben werden. Über einen Rechtsklick auf einem Element kann ein **Kontextmenü** mit weiteren Befehlsoptionen aufrufen werden.

Per **Doppelklick** (oder per **Enter**-Tastendruck) kann ein Eigenschafts-Dialog zur Konfiguration der jeweils gewählten Komponente aufrufen werden. Über die **Entfernen**-Taste kann das oder können die selektierten Elemente **entfernt** werden. Außerdem per **Drag&Drop** können Elemente auch mit gedrückter **Alt**-Taste mit den Cursortasten **verschoben** werden. Wird beim Verschieben per **Drag&Drop** oder per Tastatur zusätzlich die die **Umschalt**-Taste gedrückt gehalten, so kann das jeweils gewählte Element pixelgenau verschoben werden, ansonsten wird es entlang einem Raster verschoben. Wird beim Verschieben per **Drag&Drop** die **Strg**-Taste gedrückt gehalten, so wird eine Kopie erstellt und neu platziert. Das Originalelement bleibt unverändert an seiner Position. Wird beim Verschieben per **Drag&Drop** die **Alt**-Taste gedrückt gehalten, wird die x- oder die y-Position beibehalten. Die Verschiebung erfolgt nur entlang einer Achse.

Über die **mittlere Maustaste** kann die Funktion zum Einfügen von Verbindungsketten jederzeit eingeschaltet werden, ohne dass dafür zuvor die Schaltfläche **Kante** angeklickt werden müsste.

Eine Übersicht über alle auf der Zeichenfläche verwendbaren **Elemente** finden Sie auf [Hilfe-Inhalt-Seite](#).

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- Commercial use
- Distribution
- Modification
- Patent use
- Private use

### Conditions

- License and copyright notice
- State changes

### Limitations

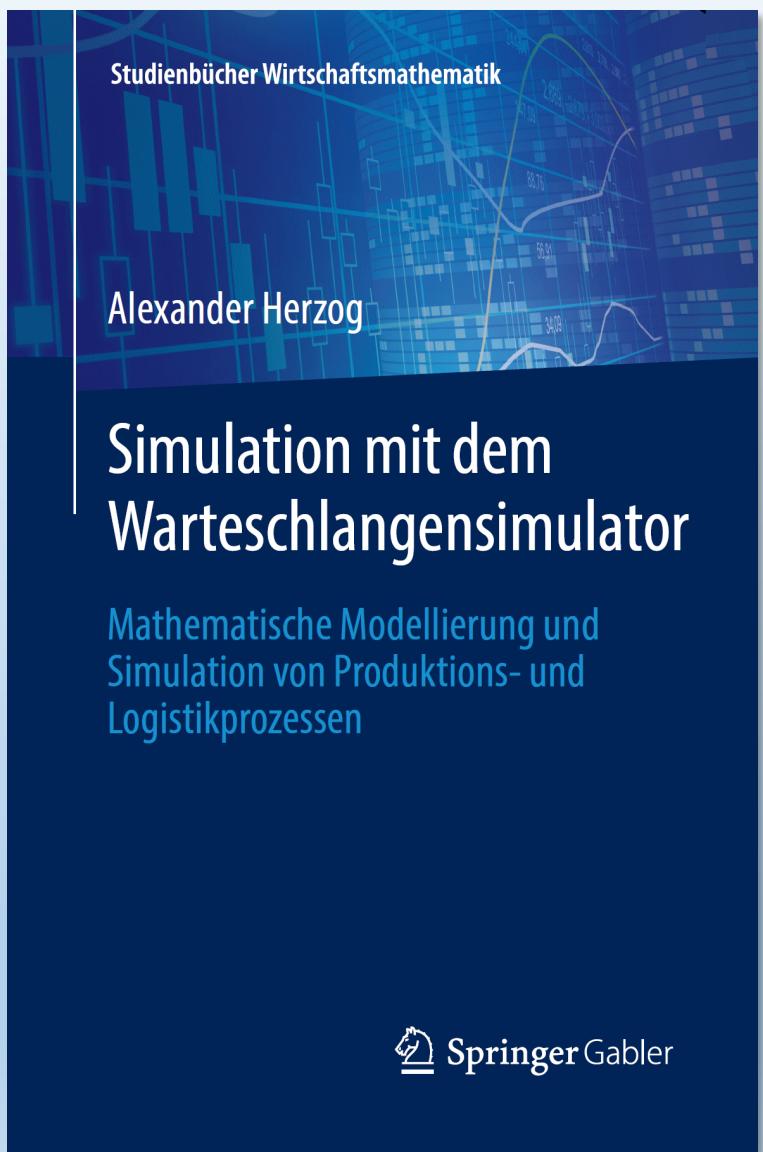
- Liability
- Trademark use
- Warranty

Available as Opensource  
on GitHub

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

The screenshot shows the GitHub repository page for 'A-Herzog / Warteschlangensimulator'. The page includes a navigation bar with links for Product, Team, Enterprise, Explore, Marketplace, Pricing, Search, Sign in, and Sign up. Below the navigation is a header for 'A-herzog / Warteschlangensimulator' with options for Code, Issues, Pull requests, Actions, Wiki, Security, and Insights. A 'Releases / 5.1.0' section is shown, featuring a release note for Version 5.1. The note mentions 102 commits since the previous release and lists three assets: 'Installer for Windows', 'Zip archive for Linux and MacOS and for portable use', and 'Linux AppImage'. It also notes that a Java runtime environment version 8 or higher is required. The 'Assets' section lists six files: Simulator.zip, SimulatorSetup.exe, SimulatorSetup.sig, Warteschlangensimulator-glibc2.3-x86\_64.AppImage, Source code (zip), and Source code (tar.gz). All assets were updated on March 7, 2022.

Asset	Size	Last Updated
Simulator.zip	120 MB	07 Mar 2022
SimulatorSetup.exe	120 MB	07 Mar 2022
SimulatorSetup.sig	512 Bytes	07 Mar 2022
Warteschlangensimulator-glibc2.3-x86_64.AppImage	119 MB	07 Mar 2022
Source code (zip)		07 Mar 2022
Source code (tar.gz)		07 Mar 2022



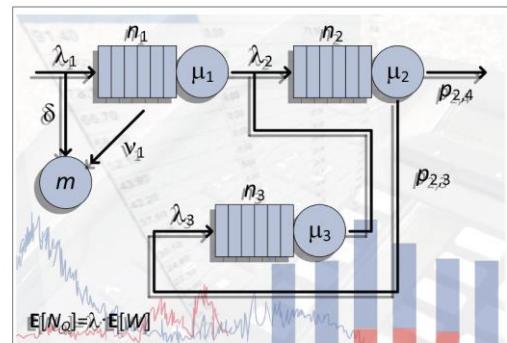
## Textbook

(in German language)

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

Short introduction to  
Warteschlangensimulator

ALEXANDER HERZOG (alexander.herzog@tu-clausthal.de)



This tutorial refers to version 5.1.0 of Warteschlangensimulator.  
Download address: <https://github.com/A-Herzog/Warteschlangensimulator/>