AnyLogic® 6

Advanced Applications of Systems Modeling & Simulation

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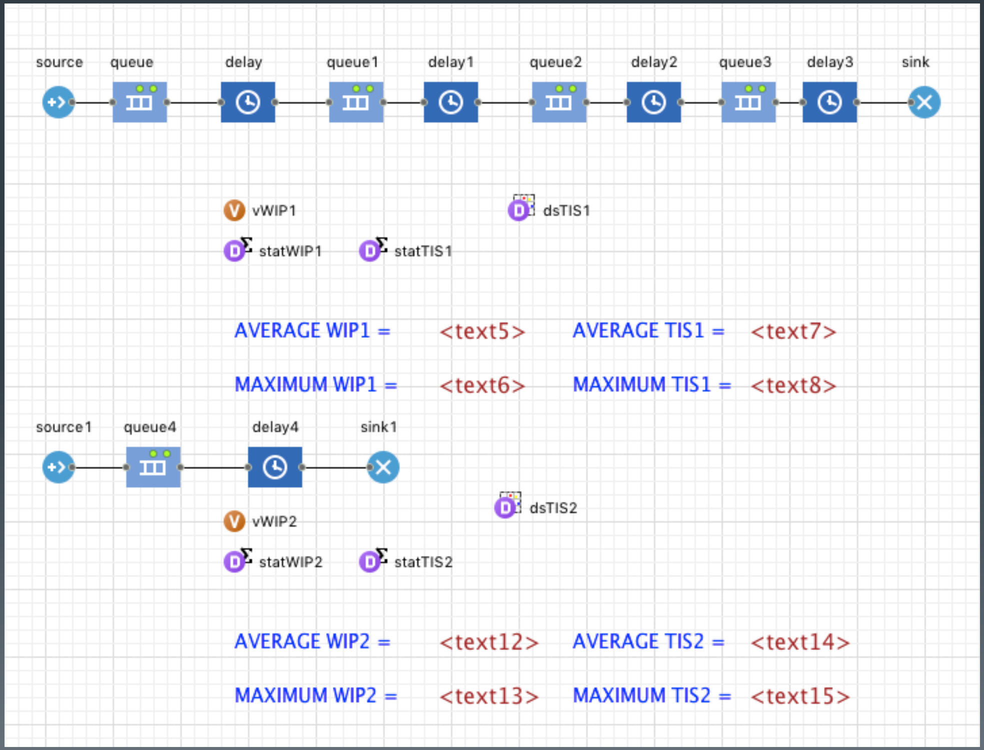
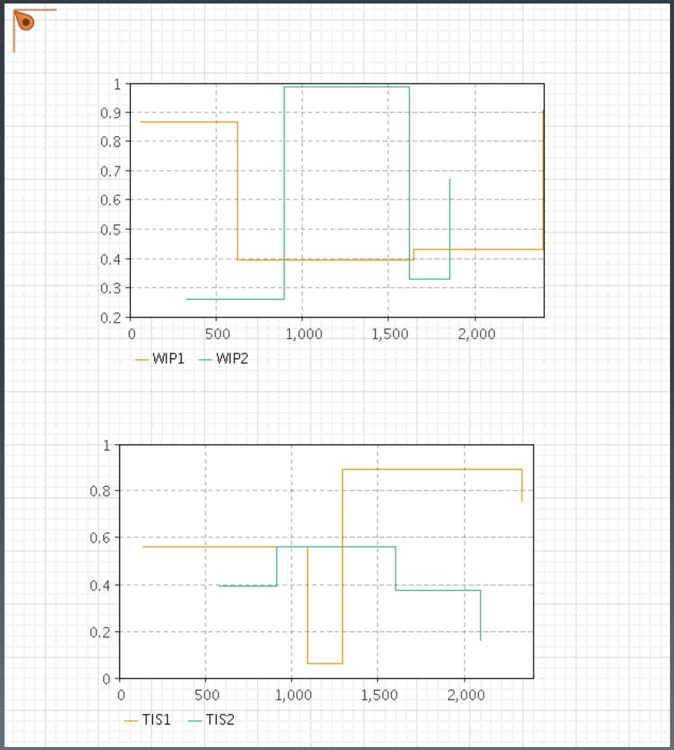
University of Tennessee, Knoxville

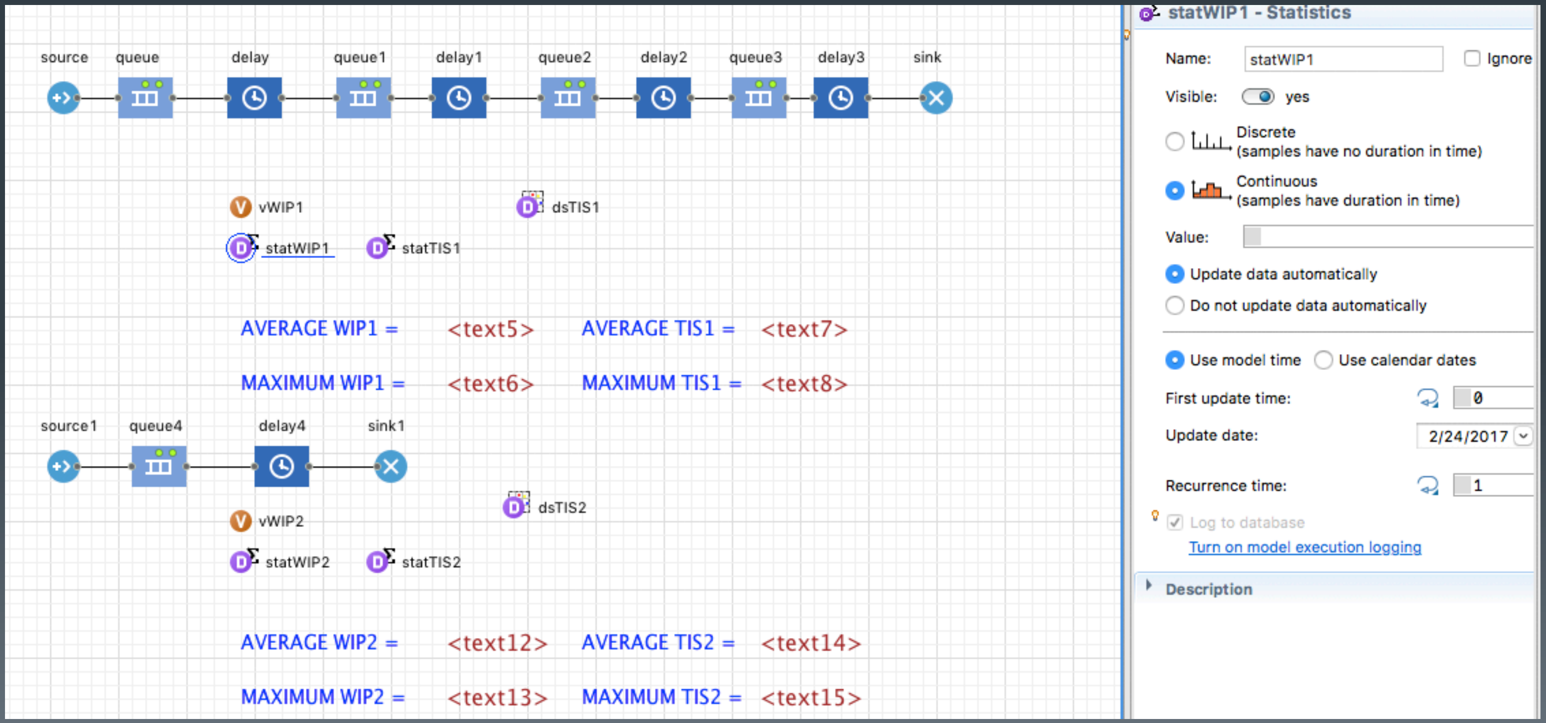
Case Study #3

- SP – PP System

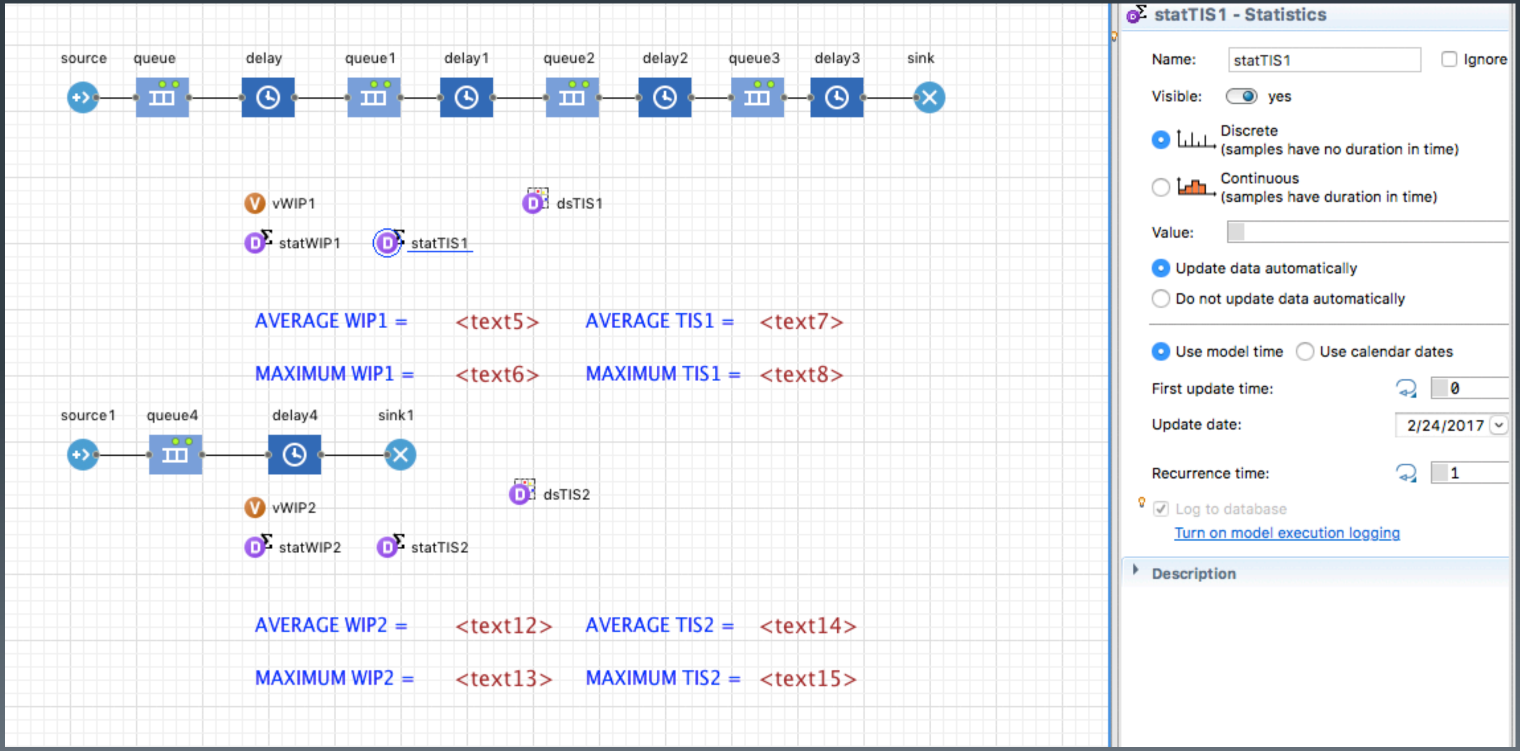

source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 = <text5>
AVERAGE TIS1 = <text7>
MAXIMUM WIP1 = <text6>
MAXIMUM TIS1 = <text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 = <text12>
AVERAGE TIS2 = <text14>
MAXIMUM WIP2 = <text13>
MAXIMUM TIS2 = <text15>

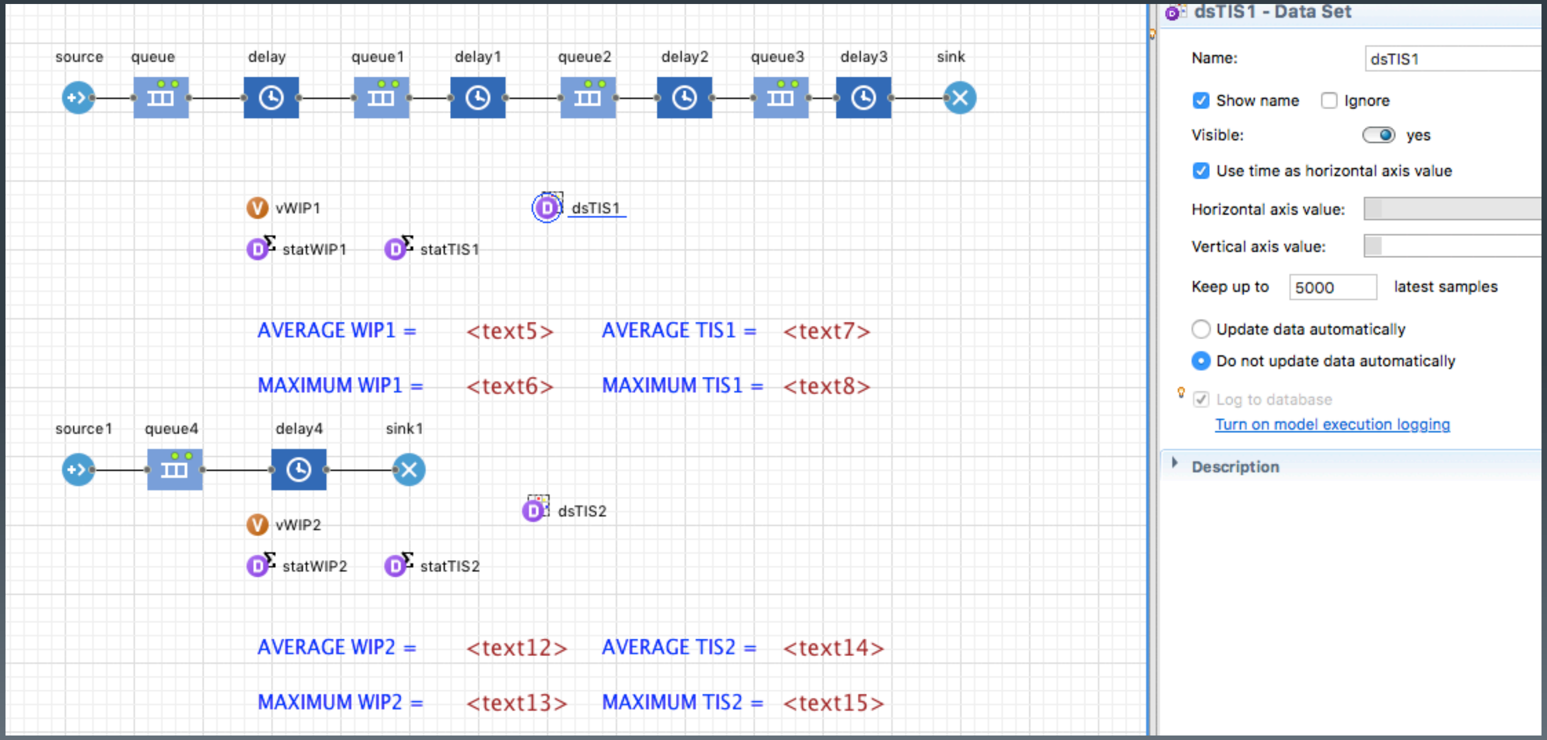


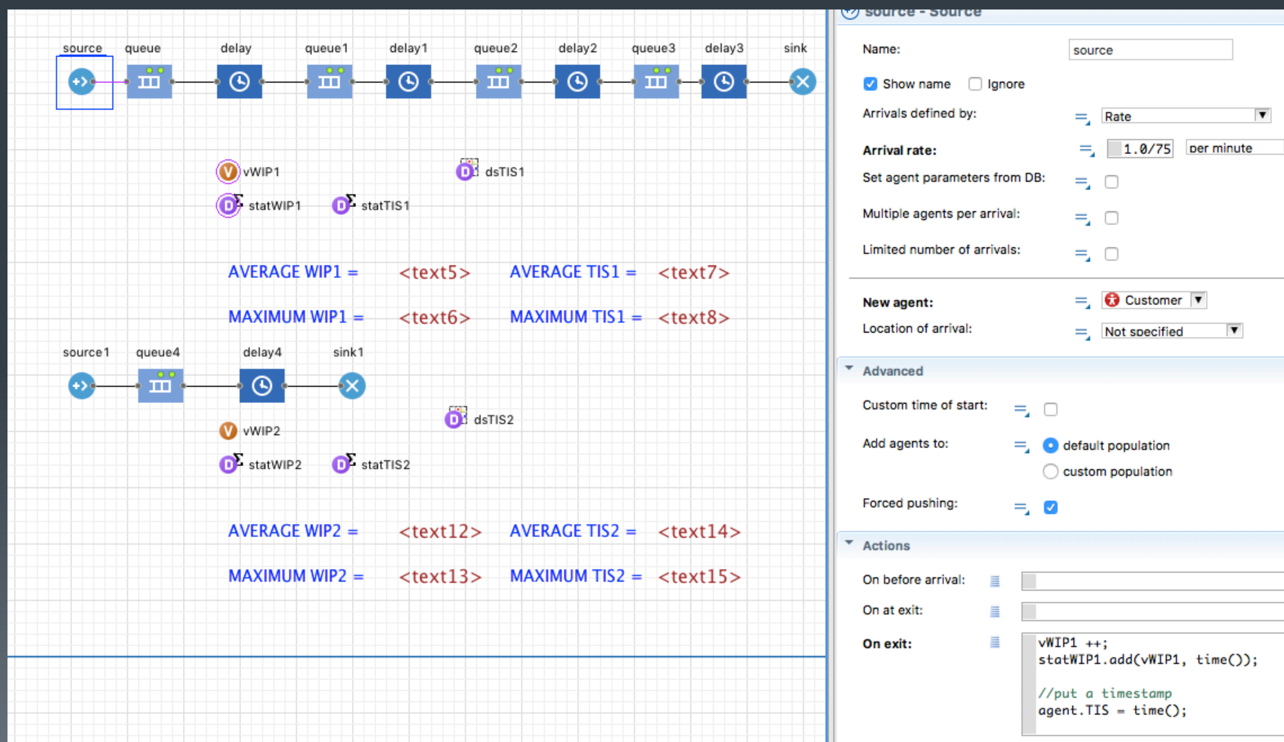
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
500
1,000
1,500
2,000
WIP1
WIP2
1
0.8
0.6
0.4
0.2
0
0
500
1,000
1,500
2,000
TIS1
TIS2

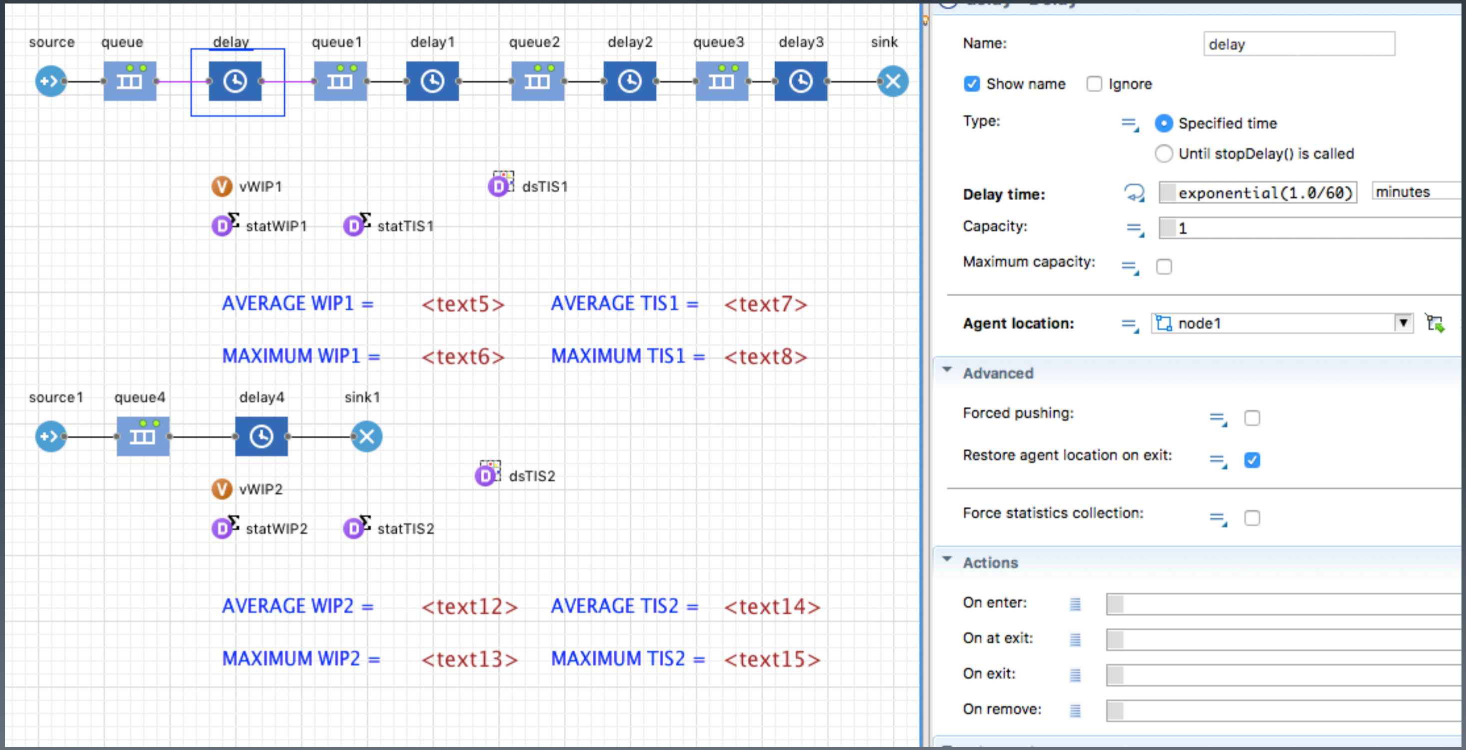


source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
statWIP1 - Statistics
Name: statWIP1
Ignore
Visible: yes
Discrete
(samples have no duration in time)
Continuous
(samples have duration in time)
Value:
Update data automatically
Do not update data automatically
Use model time
Use calendar dates
First update time: 0
Update date: 2/24/2017
Recurrence time: 1
Log to database
Turn on model execution logging
Description

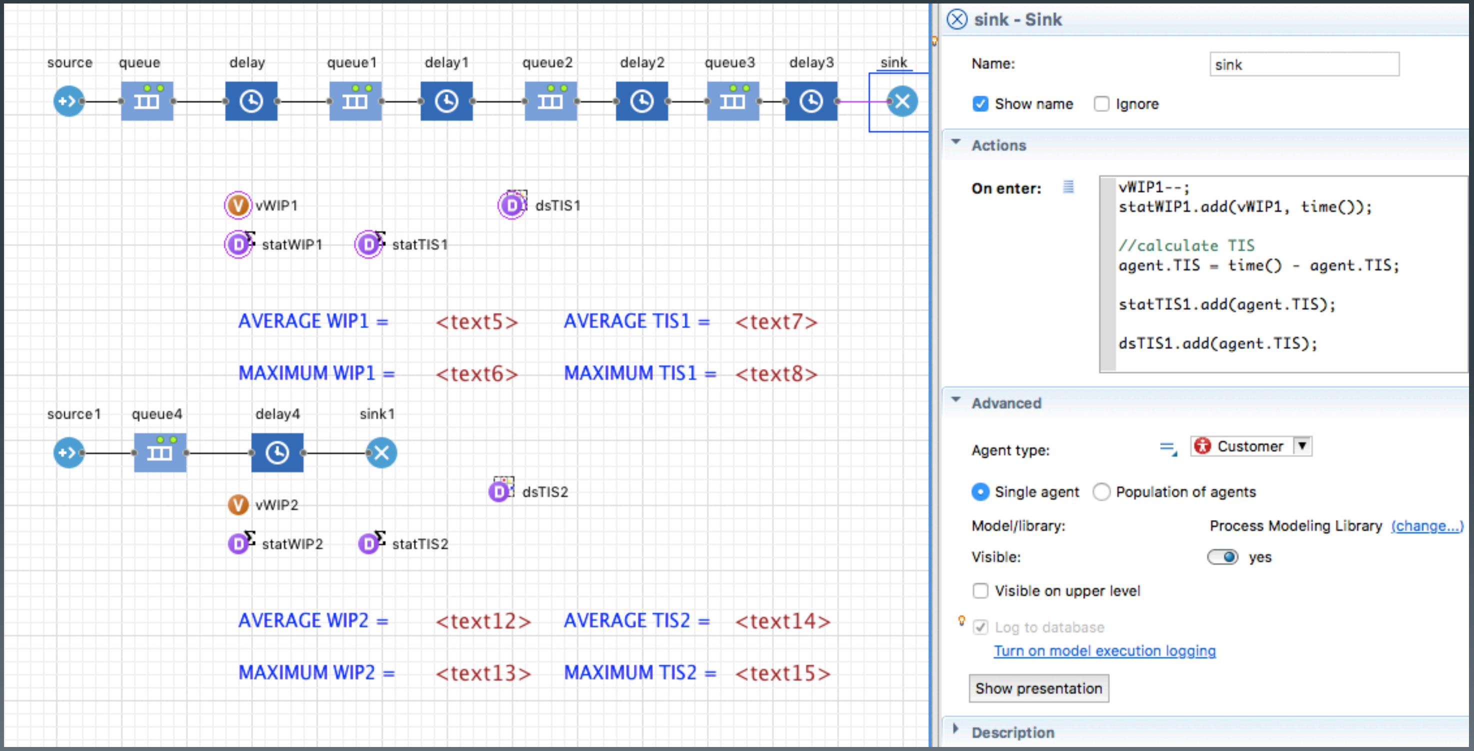

source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
statTIS1 - Statistics
Name: statTIS1
Ignore
Visible: yes
Discrete
(samples have no duration in time)
Continuous
(samples have duration in time)
Value:
Update data automatically
Do not update data automatically
Use model time
Use calendar dates
First update time: 0
Update date: 2/24/2017
Recurrence time: 1
Log to database
Turn on model execution logging
Description


source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
dsTIS1 - Data Set
Name:
dsTIS1
Show name
Ignore
Visible:
yes
Use time as horizontal axis value
Horizontal axis value:
Vertical axis value:
Keep up to
5000
latest samples
Update data automatically
Do not update data automatically
Log to database
Turn on model execution logging
Description

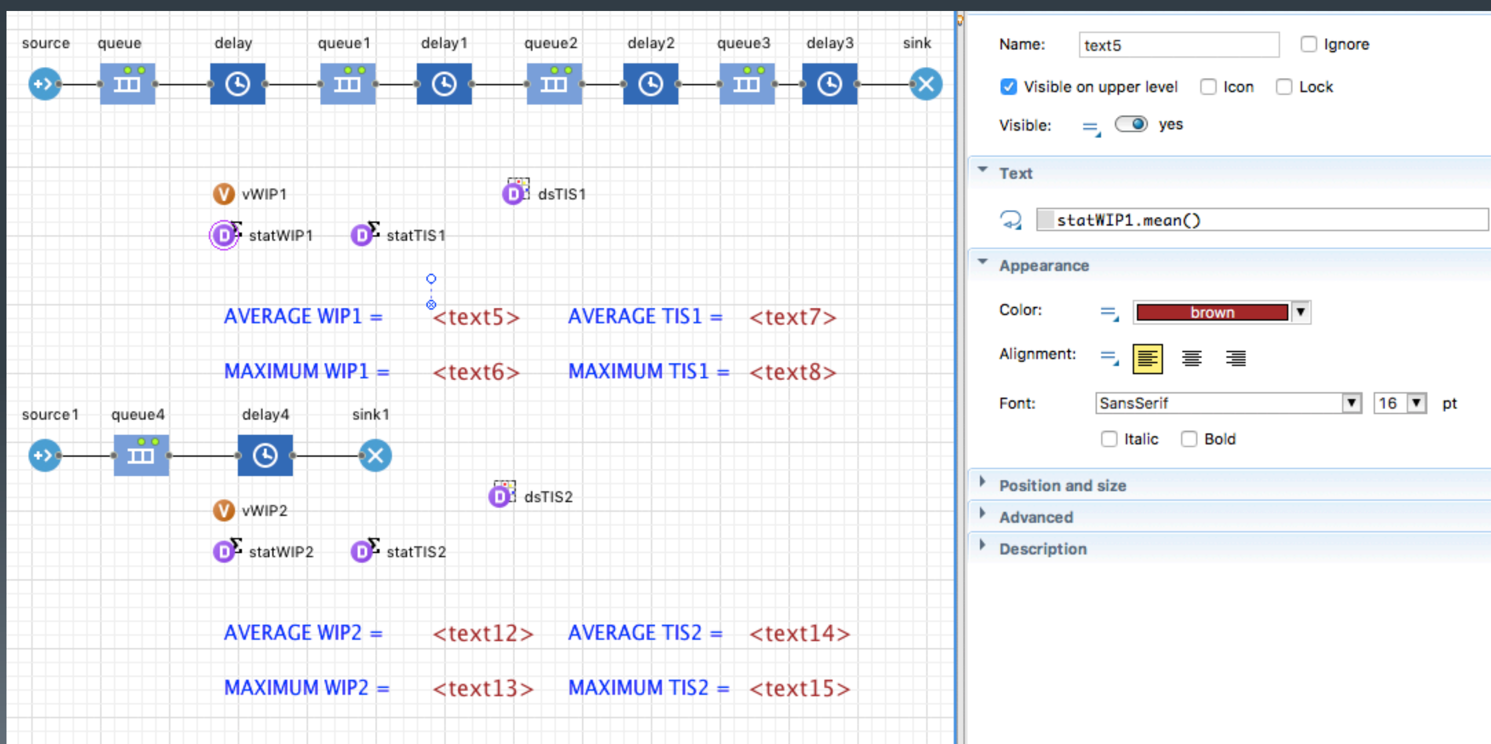

source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
Name:
source
Show name
Ignore
Arrivals defined by:
Rate
Arrival rate:
1.0/75
per minute
Set agent parameters from DB:
Multiple agents per arrival:
Limited number of arrivals:
New agent:
Customer
Location of arrival:
Not specified
Advanced
Custom time of start:
Add agents to:
default population
custom population
Forced pushing:
Actions
On before arrival:
On at exit:
On exit:
vWIP1 ++;
statWIP1.add(vWIP1, time());
//put a timestamp
agent.TIS = time();

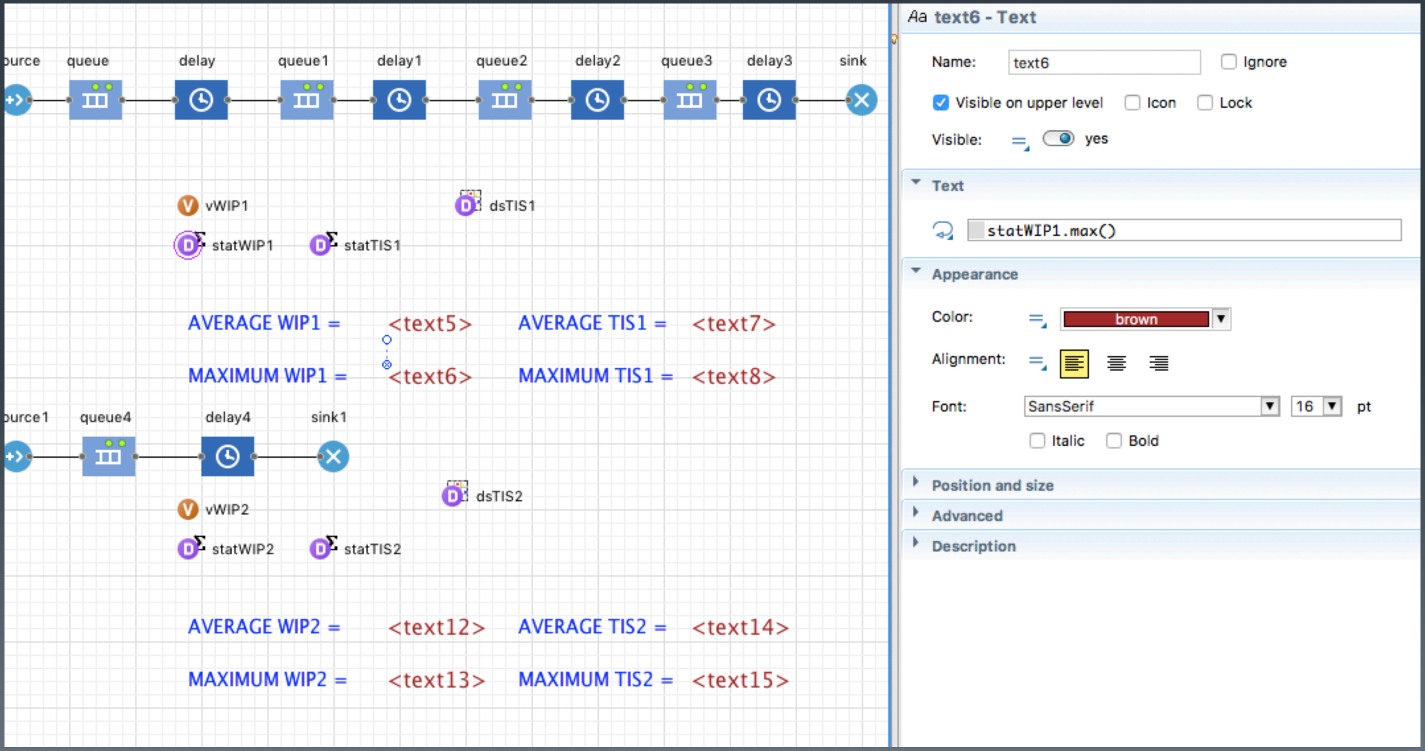


source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
Name:
delay
Show name
Ignore
Type:
Specified time
Until stopDelay() is called
Delay time:
exponential(1.0/60)
minutes
Capacity:
1
Maximum capacity:
Agent location:
node1
Advanced
Forced pushing:
Restore agent location on exit:
Force statistics collection:
Actions
On enter:
On at exit:
On exit:
On remove:

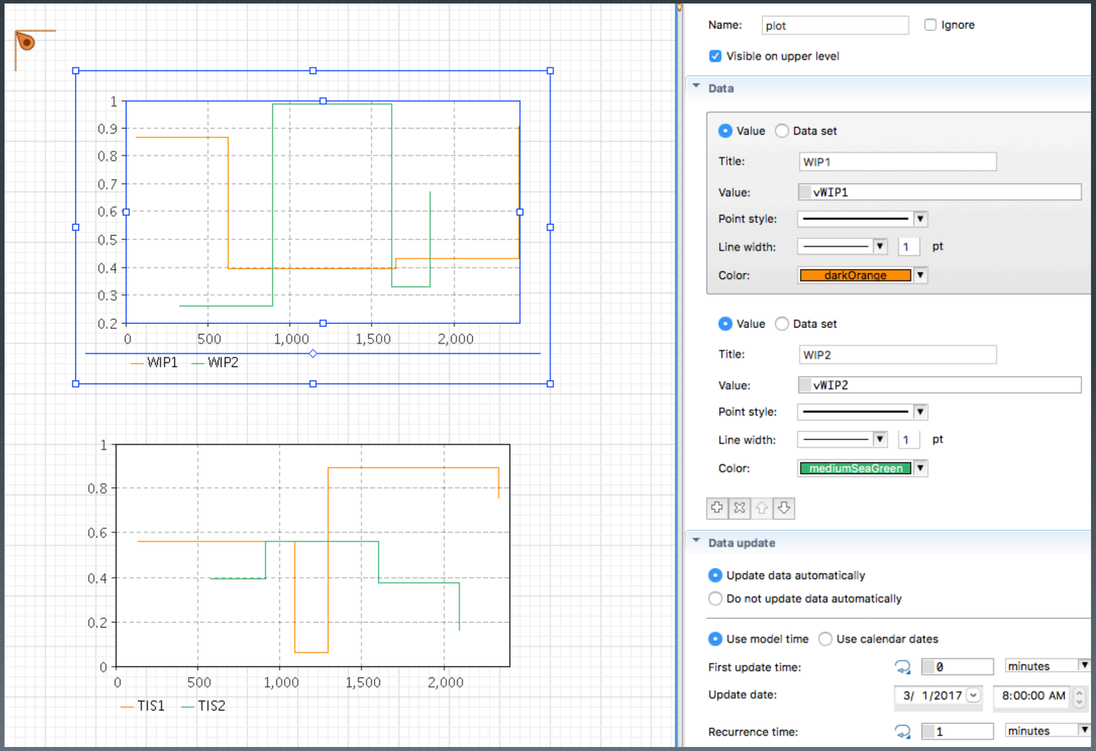


source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
sink - Sink
Name:
sink
Show name
Ignore
Actions
On enter:
vWIP1--;
statWIP1.add(vWIP1, time());
//calculate TIS
agent.TIS = time() - agent.TIS;
statTIS1.add(agent.TIS);
dsTIS1.add(agent.TIS);
Advanced
Agent type:
Customer
Single agent
Population of agents
Model/library:
Process Modeling Library
(change...)
Visible:
yes
Visible on upper level
Log to database
Turn on model execution logging
Show presentation
Description

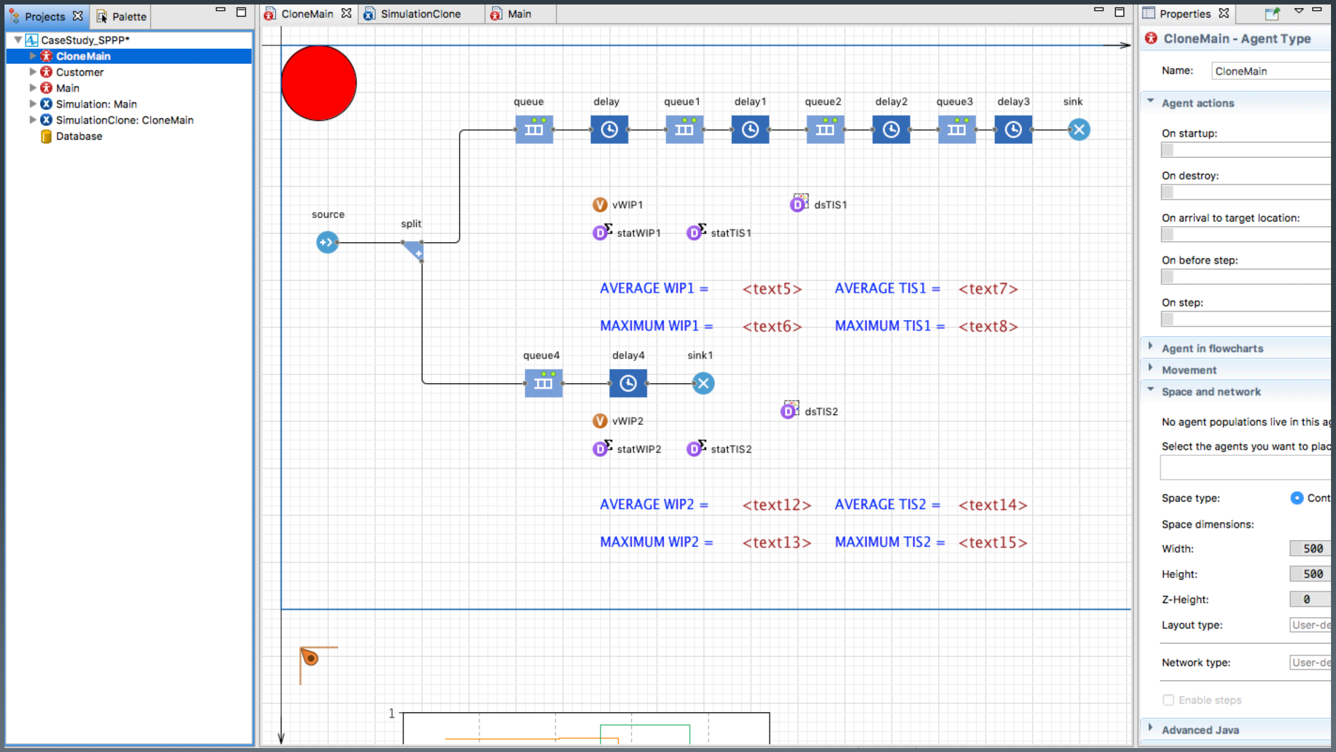

source
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
source1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
Name:
text5
Ignore
Visible on upper level
Icon
Lock
Visible:
yes
Text
statWIP1.mean()
Appearance
Color:
brown
Alignment:
Font:
SansSerif
16
pt
Italic
Bold
Position and size
Advanced
Description



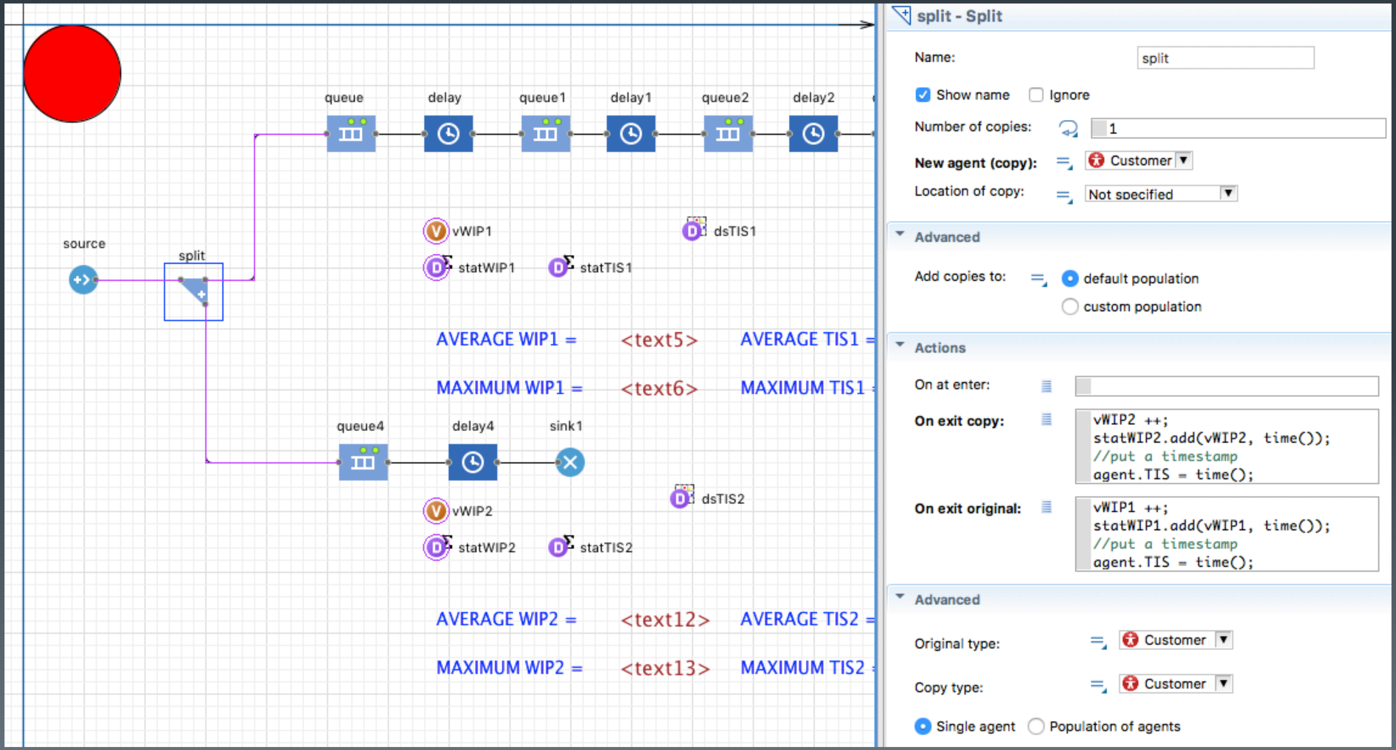
ource
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
vWIP1
dsTIS1
statWIP1
statTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
ource1
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
Aa text6 - Text
Name: text6
Ignore
Visible on upper level
Icon
Lock
Visible: yes
Text
statWIP1.max()
Appearance
Color: brown
Alignment:
Font: SansSerif 16 pt
Italic
Bold
Position and size
Advanced
Description



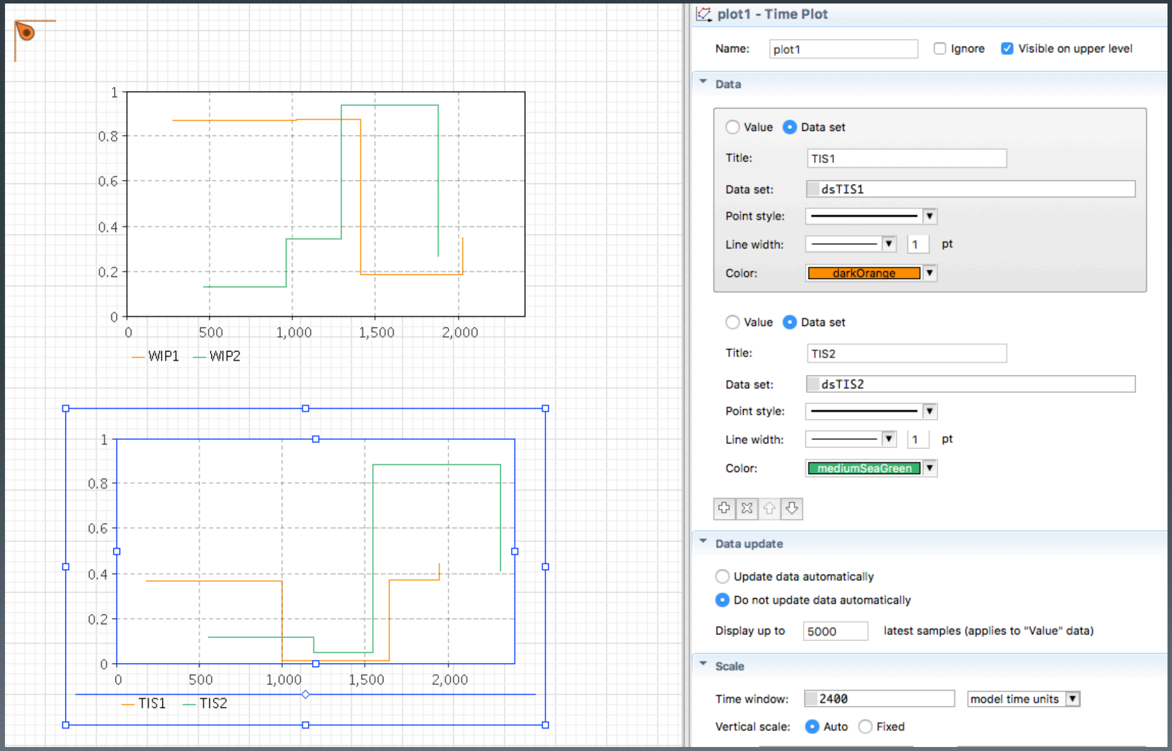
WIP1
WIP2
TIS1
TIS2
Name: plot
Ignore
Visible on upper level
Data
Value
Data set
Title: WIP1
Value: vWIP1
Point style:
Line width: 1 pt
Color: darkOrange
Value
Data set
Title: WIP2
Value: vWIP2
Point style:
Line width: 1 pt
Color: mediumSeaGreen
Data update
Update data automatically
Do not update data automatically
Use model time
Use calendar dates
First update time: 0 minutes
Update date: 3/ 1/2017 8:00:00 AM
Recurrence time: 1 minutes



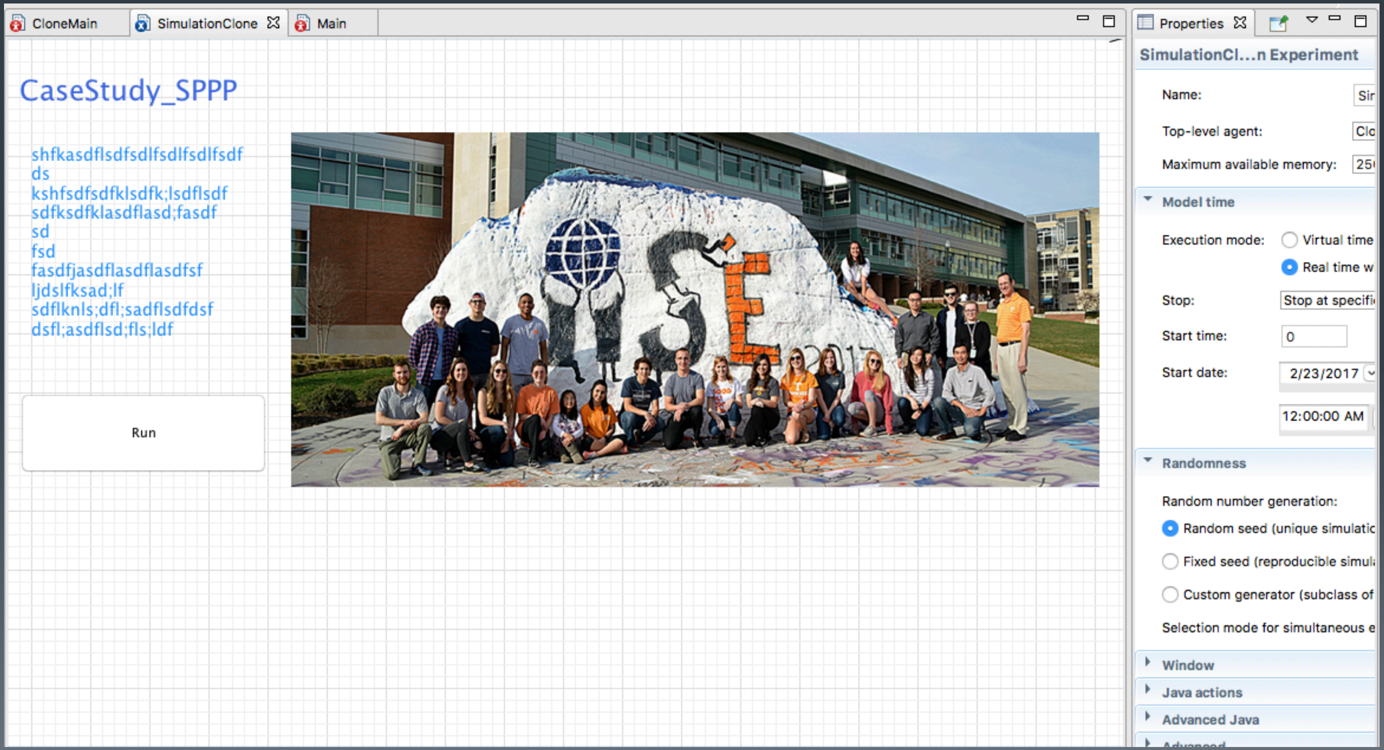
Projects
Palette
CaseStudy_SPPP*
CloneMain
Customer
Main
Simulation: Main
SimulationClone: CloneMain
Database
CloneMain
SimulationClone
Main
queue
delay
queue1
delay1
queue2
delay2
queue3
delay3
sink
source
split
vWIP1
statWIP1
statTIS1
dsTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
<text7>
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1 =
<text8>
queue4
delay4
sink1
dsTIS2
vWIP2
statWIP2
statTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
<text14>
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2 =
<text15>
Properties
CloneMain - Agent Type
Name:
CloneMain
Agent actions
On startup:
On destroy:
On arrival to target location:
On before step:
On step:
Agent in flowcharts
Movement
Space and network
Space type:
Space dimensions:
Width:
500
Height:
500
Z-Height:
0
Layout type:
Network type:
Enable steps
Advanced Java



queue
delay
queue1
delay1
queue2
delay2
source
split
vWIP1
statWIP1
statTIS1
dsTIS1
AVERAGE WIP1 =
<text5>
AVERAGE TIS1 =
MAXIMUM WIP1 =
<text6>
MAXIMUM TIS1
queue4
delay4
sink1
vWIP2
statWIP2
statTIS2
dsTIS2
AVERAGE WIP2 =
<text12>
AVERAGE TIS2 =
MAXIMUM WIP2 =
<text13>
MAXIMUM TIS2
split - Split
Name:
split
Show name
Ignore
Number of copies:
1
New agent (copy):
Customer
Location of copy:
Not specified
Advanced
Add copies to:
default population
custom population
Actions
On at enter:
On exit copy:
vWIP2 ++;
statWIP2.add(vWIP2, time());
//put a timestamp
agent.TIS = time();
On exit original:
vWIP1 ++;
statWIP1.add(vWIP1, time());
//put a timestamp
agent.TIS = time();
Advanced
Original type:
Customer
Copy type:
Customer
Single agent
Population of agents



WIP1
WIP2
TIS1
TIS2
plot1 - Time Plot
Name: plot1
Ignore
Visible on upper level
Data
Value
Data set
Title: TIS1
Data set: dsTIS1
Point style:
Line width: 1 pt
Color: darkOrange
Title: TIS2
Data set: dsTIS2
Color: mediumSeaGreen
Data update
Update data automatically
Do not update data automatically
Display up to 5000 latest samples (applies to "Value" data)
Scale
Time window: 2400 model time units
Vertical scale: Auto Fixed


CloneMain
SimulationClone
Main
CaseStudy_SPPP
shfkasdflsdfsdlfsdlfsdlfsdf
ds
kshfsdfsdfklsdfk;lsdflsdf
sdfksdfklasdflasd;fasdf
sd
fsd
fasdfjasdflasdflasdfsf
ljdslfksad;lf
sdflknls;dfl;sadflsdfdsf
dsfl;asdflsd;fls;ldf
Run
Properties
SimulationCl...n Experiment
Name:
Top-level agent:
Maximum available memory:
Model time
Execution mode:
Virtual time
Real time w
Stop:
Stop at specifi
Start time:
0
Start date:
2/23/2017
12:00:00 AM
Randomness
Random number generation:
Random seed (unique simulatic
Fixed seed (reproducible simul
Custom generator (subclass of
Selection mode for simultaneous e
Window
Java actions
Advanced Java

How many runs are needed??

Half Width, Number of Replications

- Prefer smaller confidence intervals — *precision*
- Notation:

$$n = \text{no. replications}$$
$$\overline{X} = \text{sample mean}$$
$$s = \text{sample standard deviation}$$
$$t_{n-1,1-\alpha/2} = \text{critical value from } t \text{ tables}$$

- Confidence interval:

$$\overline{X} \pm t_{n-1,1-\alpha/2} \frac{s}{\sqrt{n}}$$

- Half-width = $t_{n-1,1-\alpha/2} \frac{s}{\sqrt{n}}$

Want this to be "small," say $\leq h$ where h is prespecified

- Can't control t or s
- Must increase n — how much?

Half Width, Number of Replications
(cont'd.)

- Set half-width = h, solve for $$n = t^2_{n-1,1-\alpha/2}\frac{s^2}{h^2}$$
- Not really solved for n (t, s depend on n)
- Approximation:
  - Replace t by z, corresponding normal critical value
  - Pretend that current s will hold for larger samples
  - Get

$$n \cong z^2_{1-\alpha/2}\frac{s^2}{h^2}$$

s = sample standard deviation from "initial" number n_0 of replications

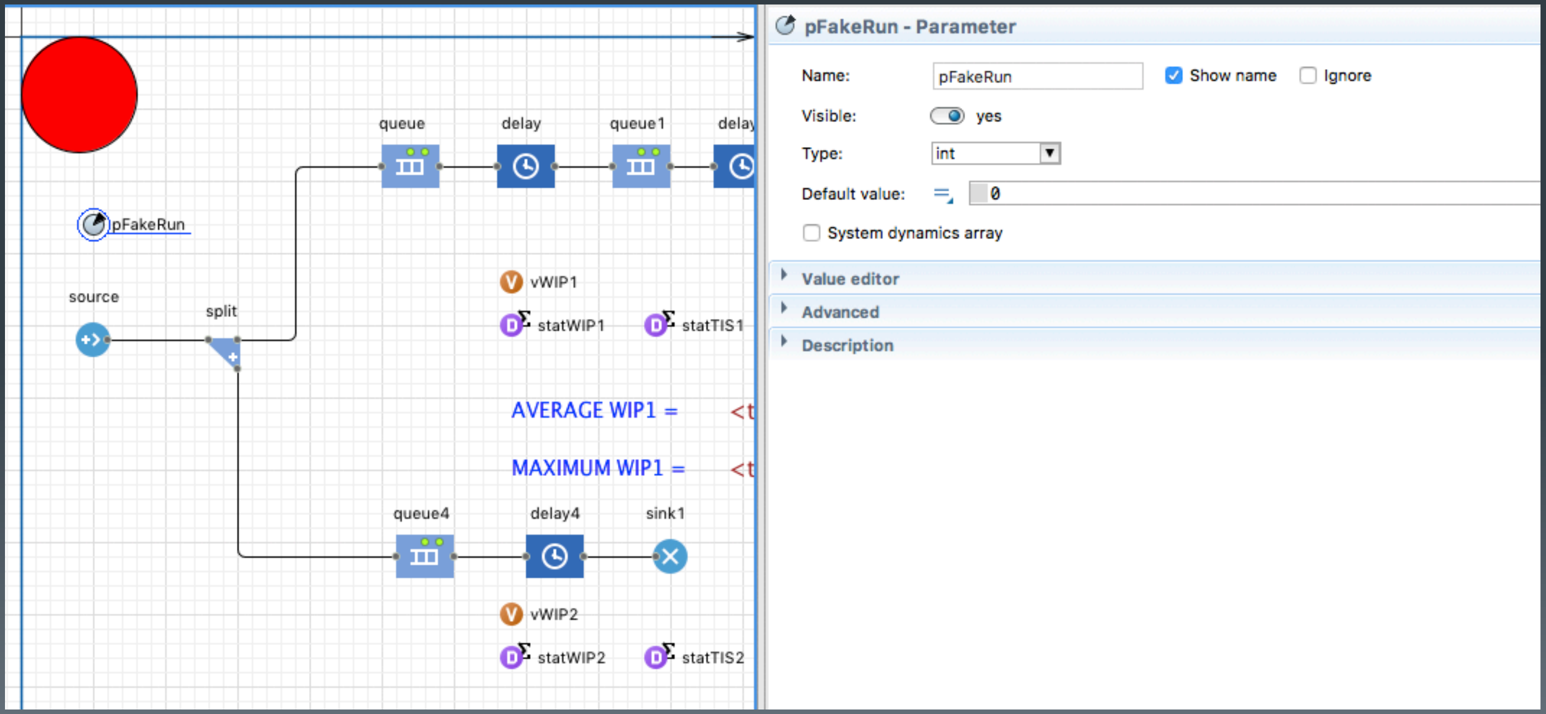
n grows quadratically as h decreases

- Easier but different approximation:

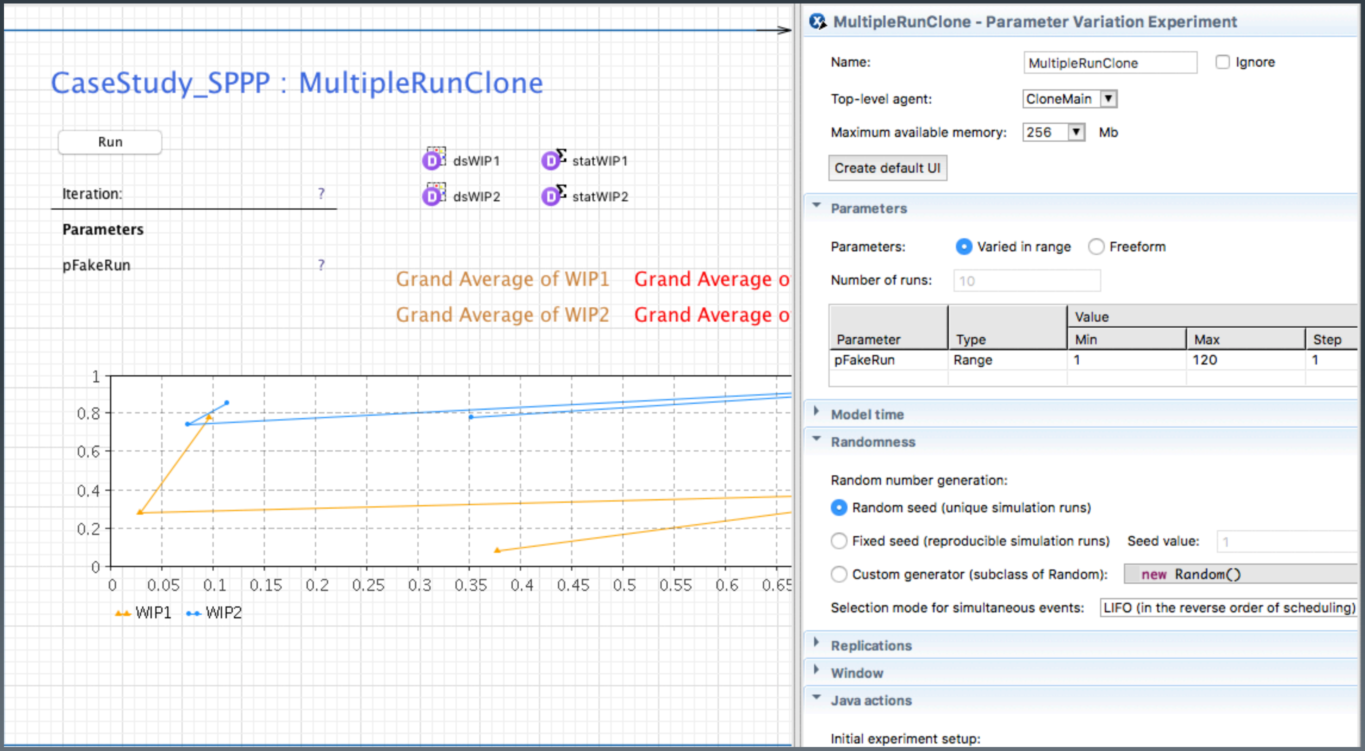
$$n \cong n_0\frac{h_0^2}{h^2}$$

h_0 = half width from "initial" number n_0 of replications

E.G. SP-PP Project::
1) Define a parameter



2) Create a Parameter Variation experiment



3) Collect data etc.