

Problem 11

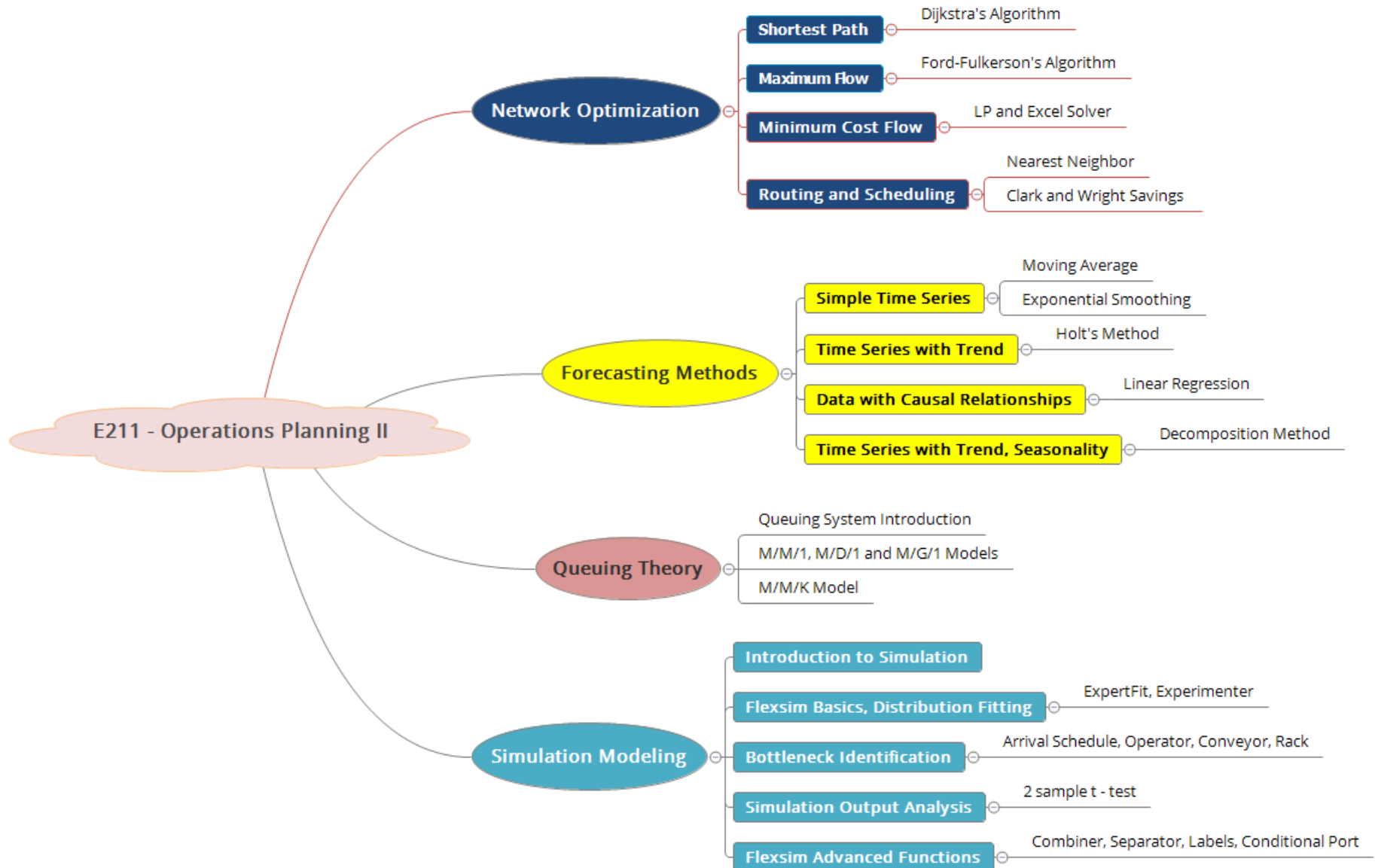
Is the Service Good?

E211 – Operations Planning II



SCHOOL OF
ENGINEERING

Module Coverage: E211 Topic Tree

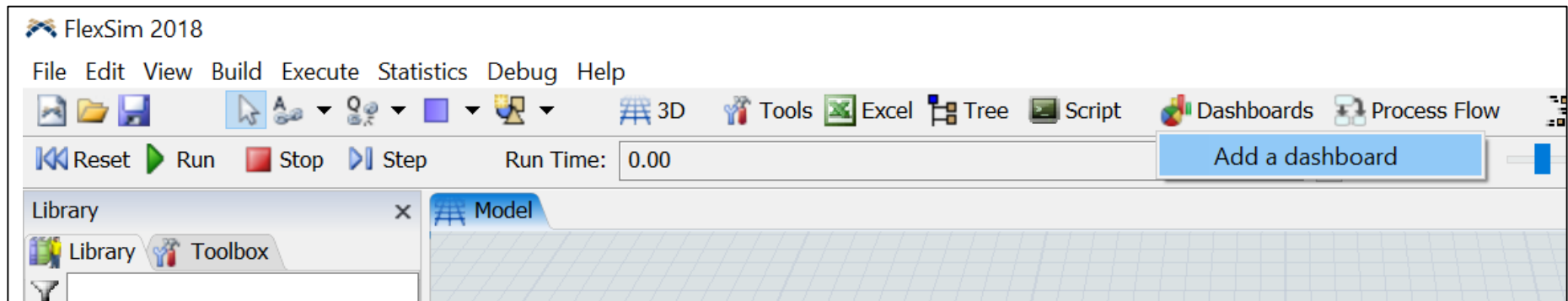


Exercise 4: Display the Simulation Output

Add Dashboard



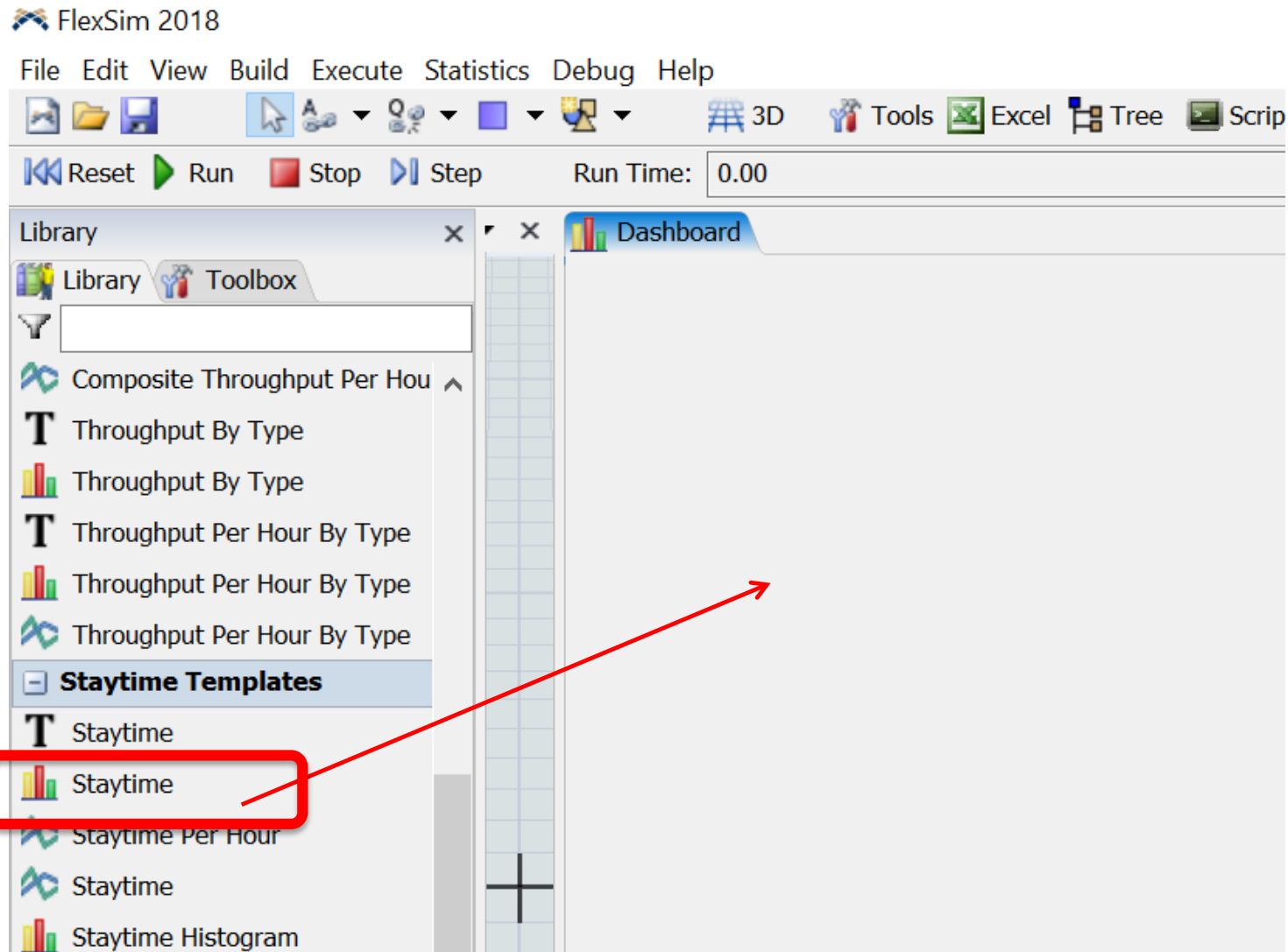
- Click Dashboards on the toolbar>Add a Dashboard



Exercise 4: Display the Simulation Output Dashboard-add statistic



- Click and drag the statistic (from the library on the left) to the open space.



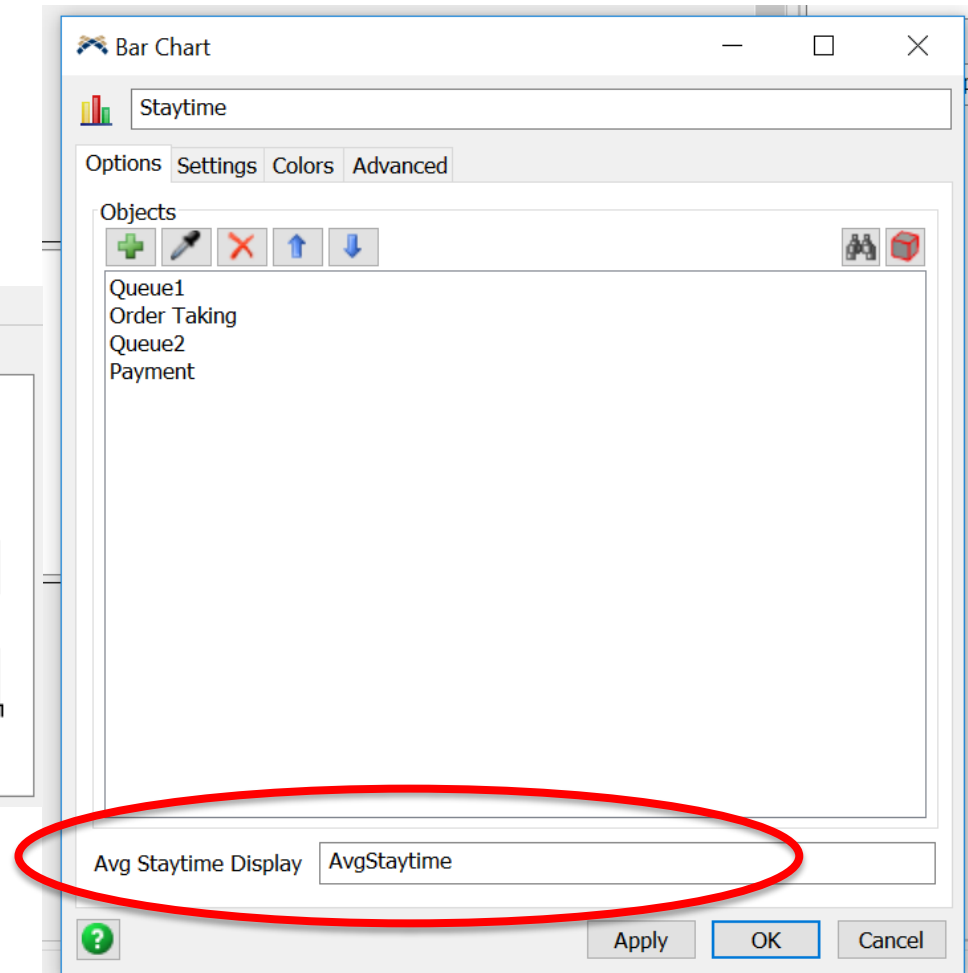
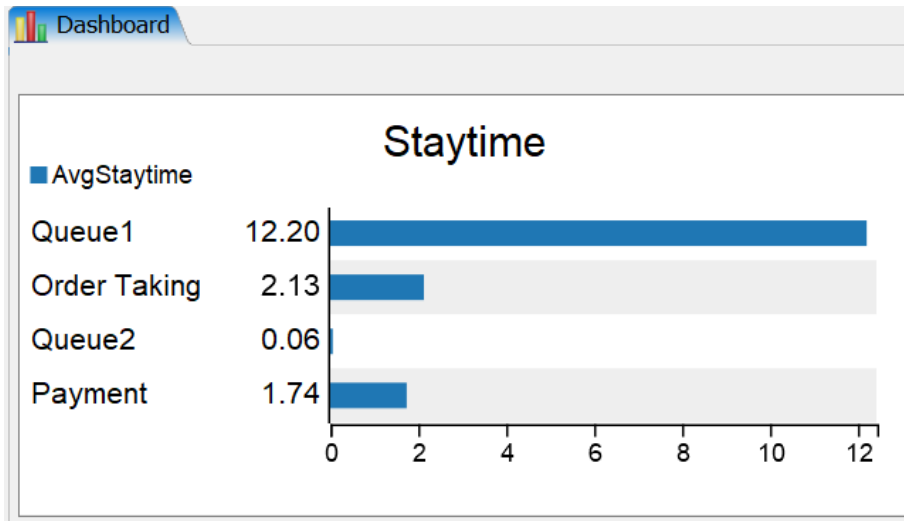
Exercise 4: Display the Simulation Output Dashboard-add objects



- Click “+”>Select Objects>Browse by tree, and select the object to show its statistics

The screenshot displays the Flexsim software interface. On the left, the 'Bar Chart' window is open, showing a chart titled 'Staytime'. Below the chart, there are tabs for 'Options', 'Settings', 'Colors', and 'Advanced'. Under the 'Options' tab, there is an 'Objects' section with a '+' icon, a selection tool, and a dropdown menu. The dropdown menu is open, showing options: 'Select Objects', 'Add Model's Selected Objects to Group', 'Set Group to Model's Selected Objects', and 'Groups'. A red arrow points from the '+' icon to the 'Select Objects' option. Another red arrow points from the 'Select Objects' option to the 'Browse by tree' icon in the 'Objects' panel on the right. The 'Objects' panel on the right shows a list of objects: 'FlexsimModelFloor', 'Source', 'Queue1', 'Order Taking', 'Queue2', 'Payment', 'Transaction Completed', and 'Balking Customers'. At the bottom of the 'Objects' panel, there are 'Clear' and 'Select' buttons.

Exercise 4: Display the Simulation Output



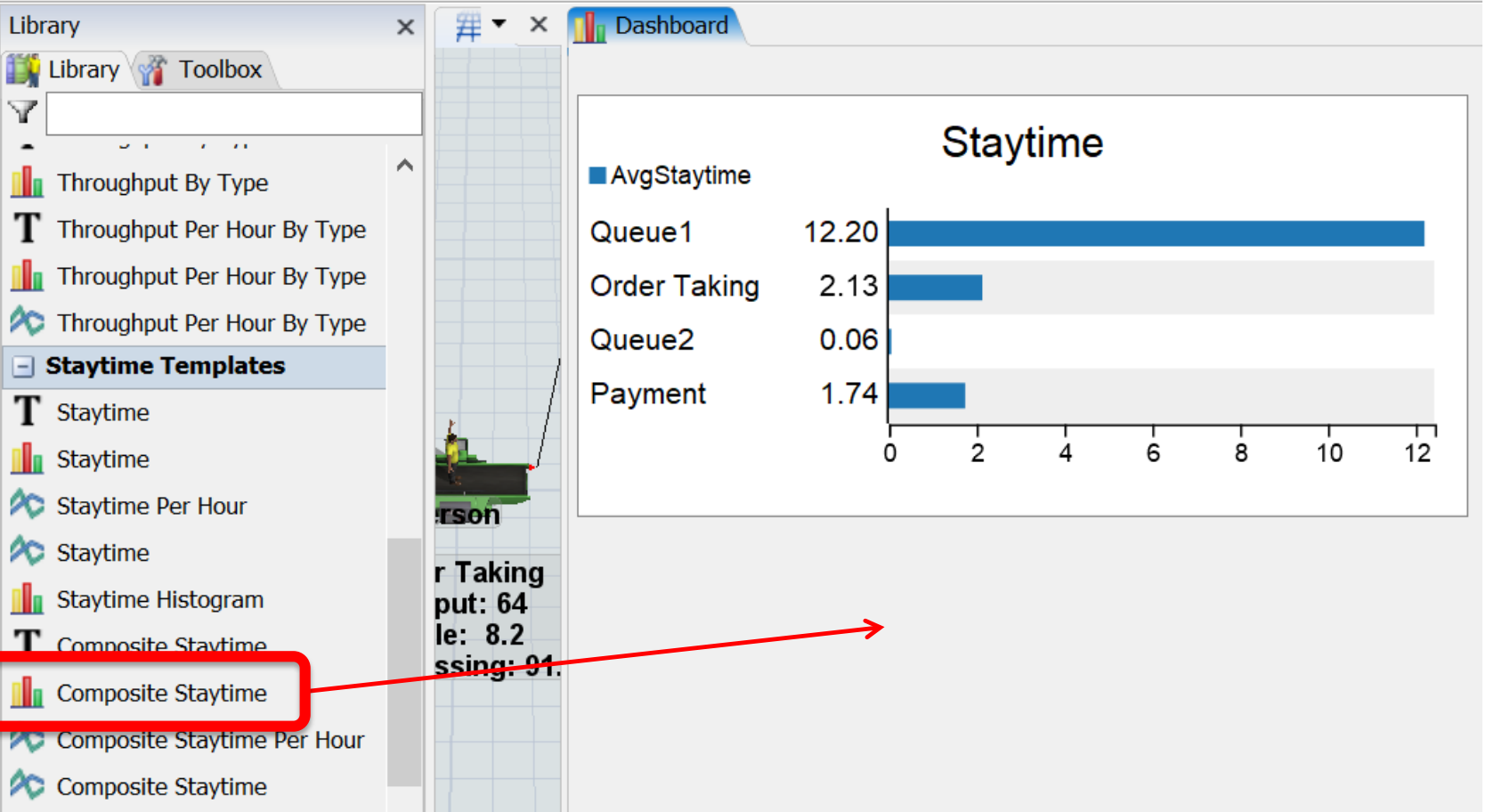
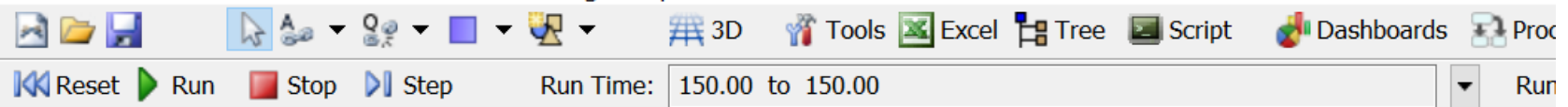
Exercise 5: Use Dashboard to Display a Customer's Total Stay Time in System



- Click and drag the statistic (Composite Staytime) from the library on the left to the open space.

FlexSim 2018 - E211_W11_2_Stage_2018.fsm

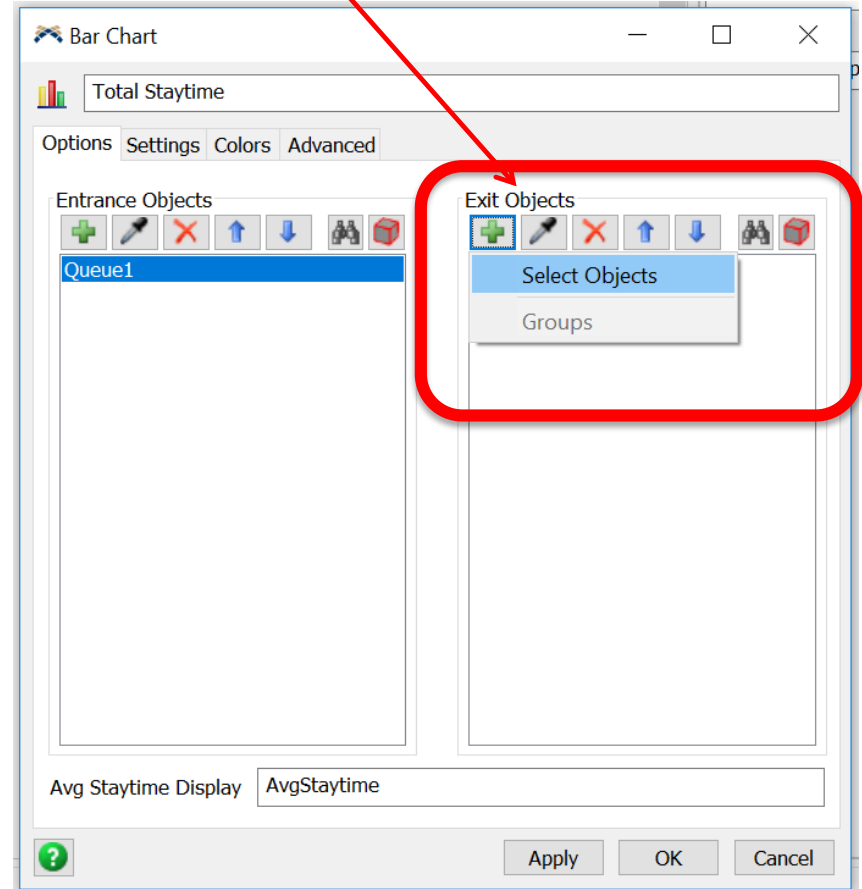
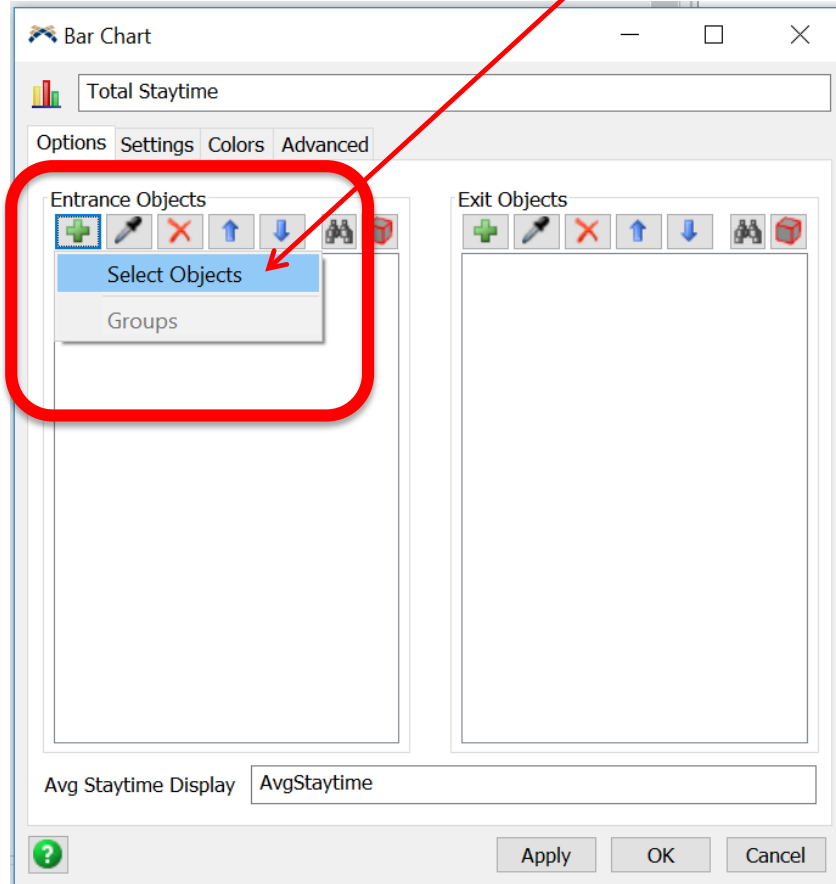
File Edit View Build Execute Statistics Debug Help



Exercise 5: Use Dashboard to Display a Customer's Total Stay Time in System



- Add and select the Entrance Objects and the Exit Objects to define a customer's total stay time in system.



Exercise 5: Use Dashboard to Display a Customer's Total Stay Time in System



- A Customer's Total Stay Time in System is defined as: the average time (of customers) from entering Queue 1 (queue for Order Taking) till exiting Payment.

Bar Chart

Total Staytime

Options Settings Colors Advanced

Entrance Objects

Queue1

Exit Objects

Payment

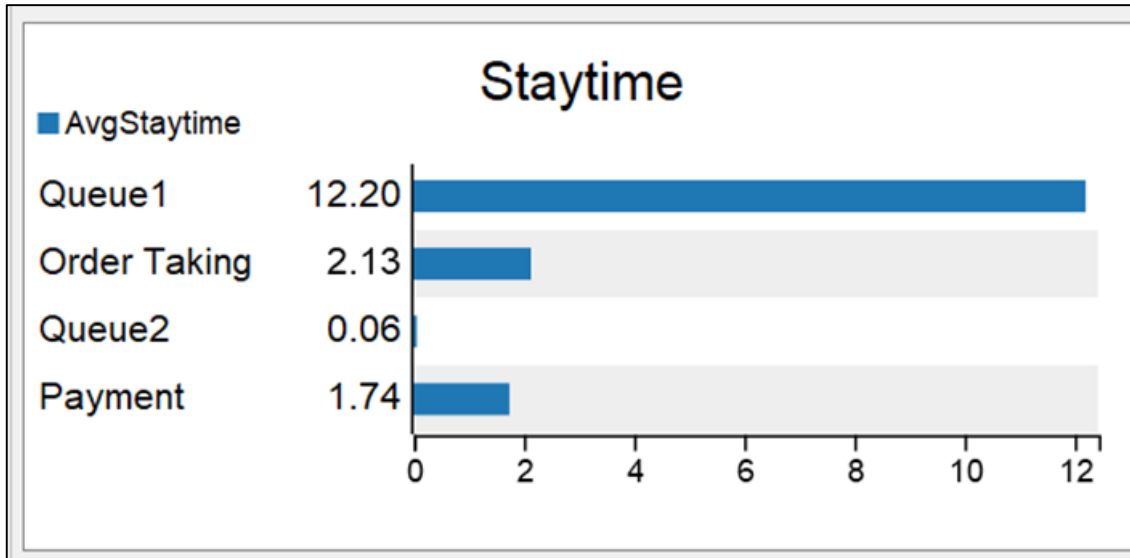
Avg Staytime Display AvgStaytime

Apply OK Cancel

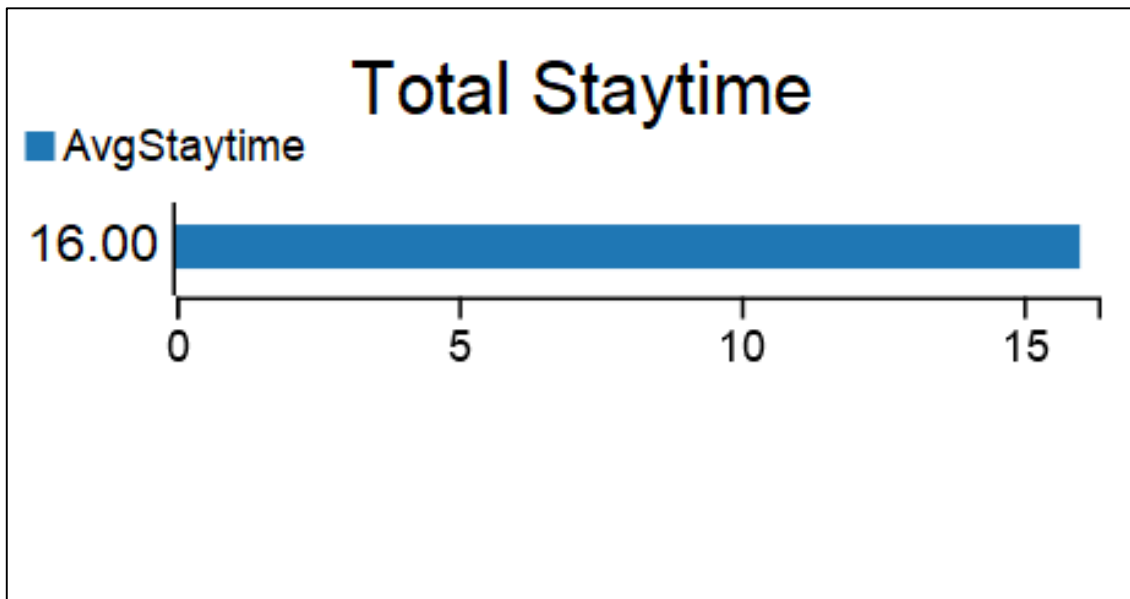
Exercise 5: Use Dashboard to Display a Customer's Total Stay Time in System



Stay time at each object of the system.



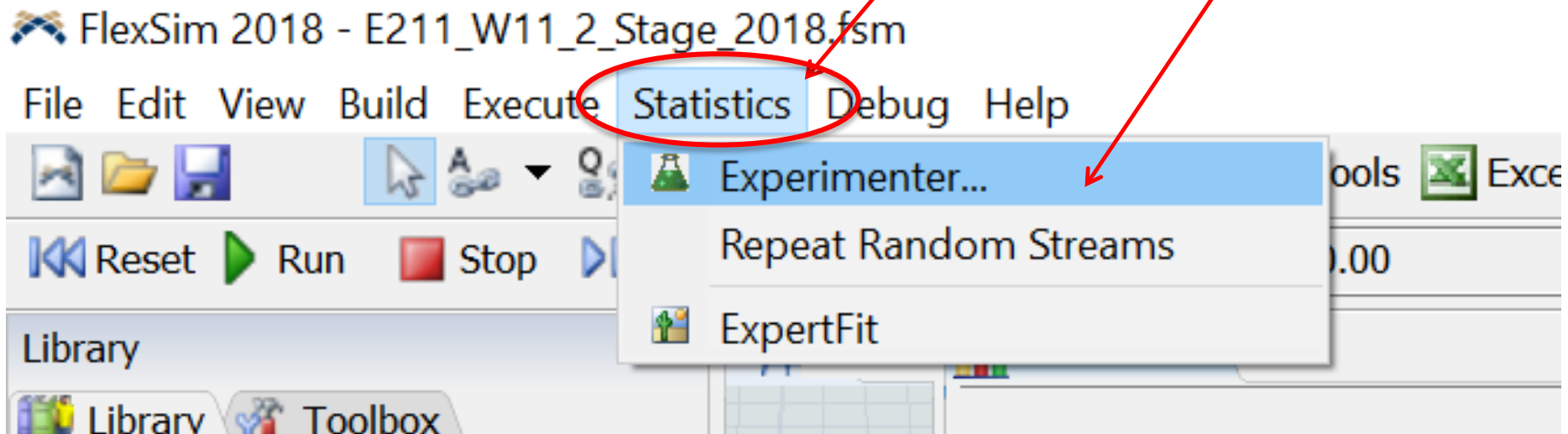
Total stay time in system.



Exercise 6: Use Experimenter to Generate Multiple Runs – Add an Experimenter



- To add an Experimenter, click Statistics->Experimenter



Exercise 6: Use Experimenter to Generate Multiple Runs – Add a “Standard Performance Measure”



- To add a performance measure (Example-Queue Length before Order Taking): click Performance Measures, then click “+”

The screenshot shows the 'Simulation Experiment Control' window. The 'Performance Measures' tab is selected and highlighted with a red rectangle. Below the tabs, there are four buttons: a green plus sign (+), a red minus sign (-), a blue up arrow, and a blue down arrow. The green plus sign button is circled in red. To the right of these buttons are three input fields labeled 'Name', 'Label for Y-axis', and 'Performance'. The 'Label for Y-axis' field contains the text 'Value'. A red arrow points from the text 'Add “Standard Performance Measure”' to the green plus sign button.

Scenarios	Performance Measures	Experiment Run	Optimizer Design	Optimizer Run	Optimizer Results	Advanced

Add “Standard Performance Measure”

Exercise 6: Use Experimenter to Generate Multiple Runs – Add a “Standard Performance Measure”



- To add a performance measure (Example-Queue Length before Order Taking):

Edit PFM1 to “Queue Length before Order Taking”

The screenshot shows the 'Simulation Experiment Control' window with the 'Performance Measures' tab selected. On the left, a list of performance measures includes 'PFM1'. The main area shows the configuration for 'PFM1':

Field	Value
Name	PFM1
Label for Y-axis	Value
Performance	Statistic by individual object

A red arrow points to the 'Name' field. A red circle highlights the dropdown menu for the 'Performance' field, which is open and shows the following options:

- Statistic by individual object (selected)
- Statistic by group
- State percentage by individual object
- State percentage by group
- Label by individual object
- Label by group
- Global table value

Exercise 6: Use Experimenter to Generate Multiple Runs – Add a “Standard Performance Measure”



- To add a performance measure (Example-Queue Length before Order Taking):

The screenshot shows the 'Simulation Experiment Control' window with the 'Performance Measures' tab selected. The left sidebar lists the performance measure 'Queue Length before Order Taking'. The main panel shows the configuration for this measure:

- Name:** Queue Length before Order Taking
- Label for Y-axis:** Value
- Performance:** Statistic by individual object

The 'Select an object and statistic' section shows:

- Object:** Operator1 (with a red circle around the '+' icon)
- Statistic:** Output

Below this, there are icons for different object types: VisualTools, Sources, Queues, Processors, and Sinks. The 'Queues' category is expanded, and 'Queue1' is highlighted with a red circle.

At the bottom, there are 'Clear' and 'Select' buttons.

Exercise 6: Use Experimenter to Generate Multiple Runs – Add a “Standard Performance Measure”



- To add a performance measure (Example-Queue Length before Order Taking):

Simulation Experiment Control

Scenarios Performance Measures Experiment Run Optimizer Design Optimizer Run Optimizer Results Advanced

Queue Length before Order Taking

Name Queue Length before Order Taking

Label for Y-axis Value

Performance Statistic by individual object

Select an object and statistic

Object /Queue1

Statistic

- Output
- Output
- Input
- Minimum Content
- Maximum Content
- Average Content
- Minimum Staytime
- Maximum Staytime
- Average Staytime
- Total Travel Distance

Exercise 6: Use Experimenter to Generate Multiple Runs – Add a “Standard Performance Measure”



- To add a performance measure (**Utilization rate of Order Taking counter**):

Simulation Experiment Control

Scenarios Performance Measures Experiment Run Optimizer Design Optimizer Run Optimizer Results Advanced

+ - ↑ ↓

Queue Length before Order Taking
Waiting Time before Order Taking
Total Staytime - AvgStaytime Average
Number of Customers Who Balked
Utilization - Order Taking

Name Utilization - Order Taking

Label for Y-axis Value

Performance State percentage by individual object

Select an object and state

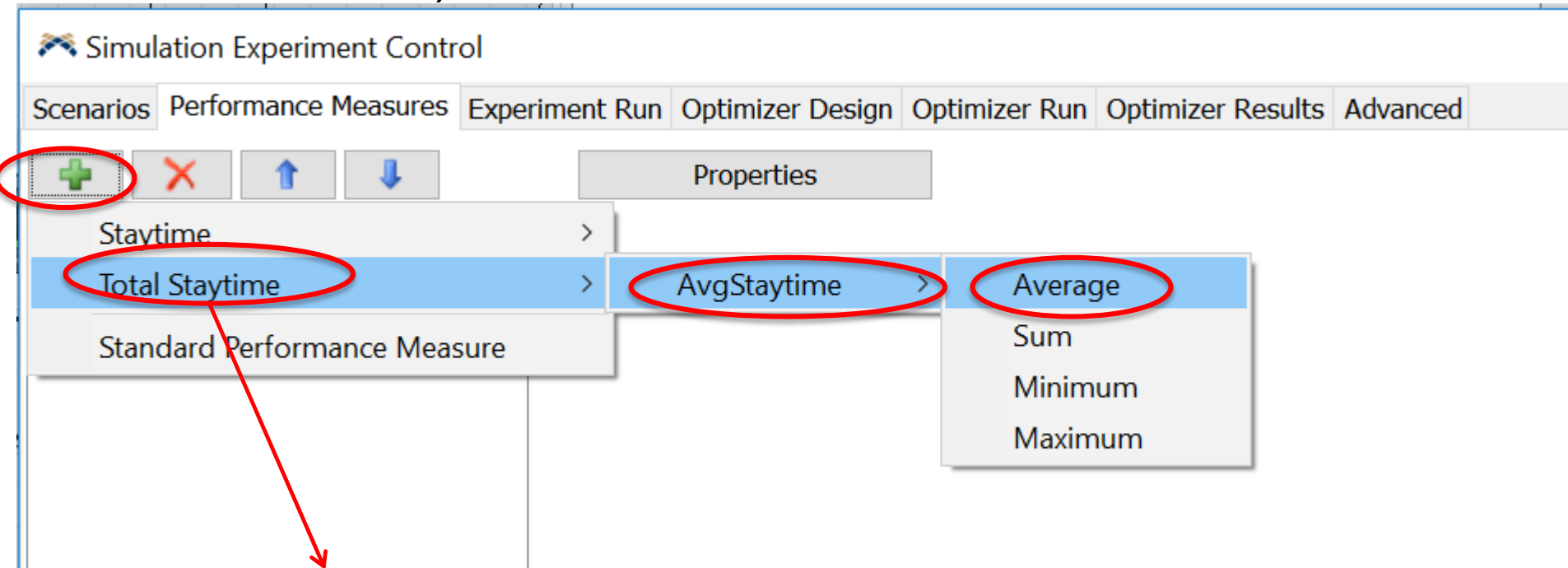
Object /Order Taking

State 2 - processing

Exercise 6: Use Experimenter to Generate Multiple Runs – Add Total Stay Time in System



- To add a performance measure defined **in the dashboard: Total stay time in system** (average of all customers)



Already defined in the dashboard

Exercise 6: Use Experimenter to Generate Multiple Runs – Set up for the “Experiment Run”



Simulation Experiment Control

Scenarios Performance Measures **Experiment Run** Optimizer Design Optimizer Run Optimizer Results Advanced

Run Experiment

Replications per Scenario 30.00

End Time 10:30:00 AM 15/ 1/2019 ☐ Save dashboard data for each replication

Run Time 150.00 Minutes ☐ Save state after each replication

Warmup 0.00 Minutes ☐ Restore original state after each replication

Experiment Status

View Results Export/Merge Results ☐ Export results after each replication

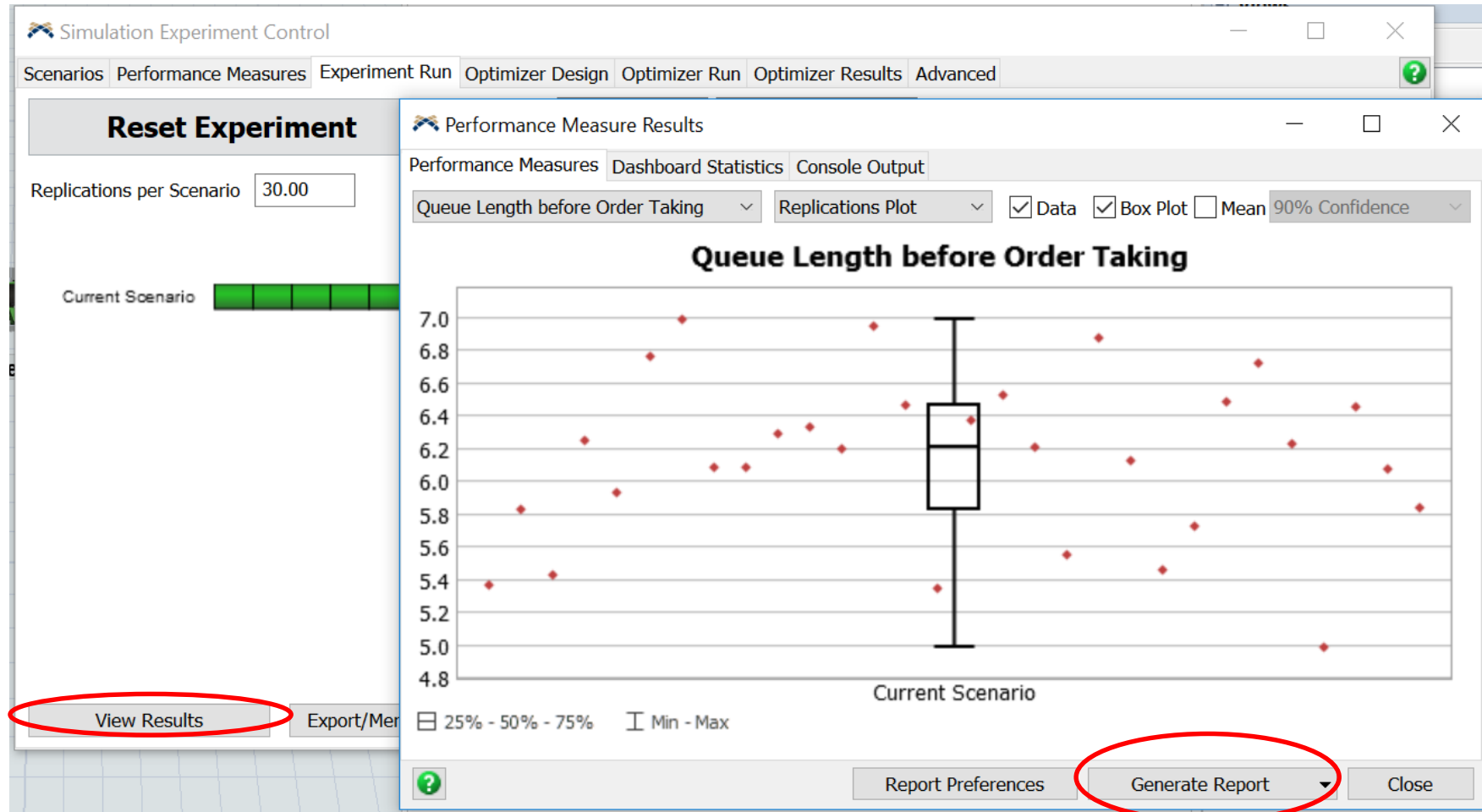
Indicate duration of simulation run and number of runs (replications)

Click to view results after experiment runs are completed

Exercise 6: Use Experimenter to Generate Multiple Runs - View Results and Generate Report



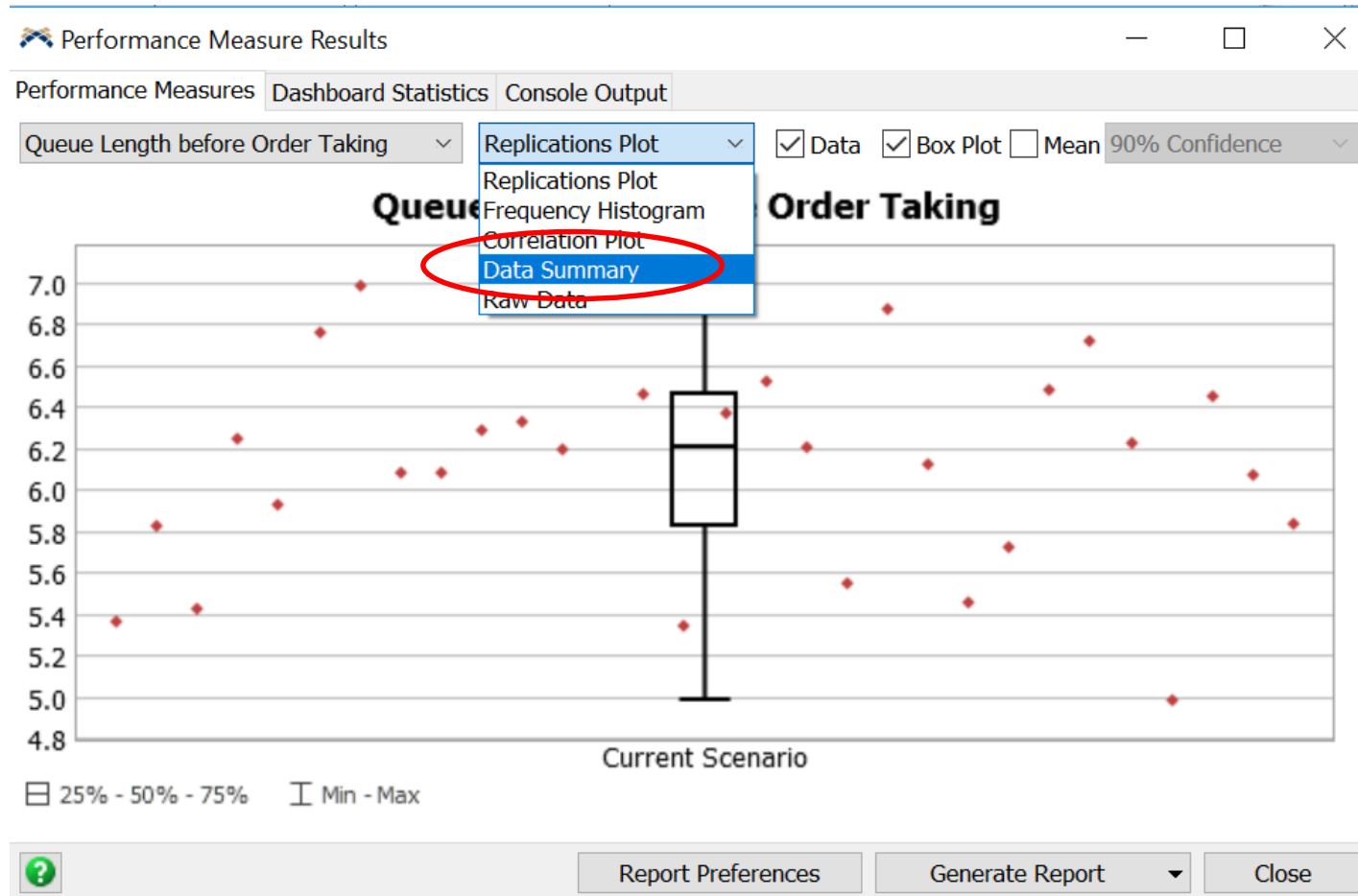
- After Running the Experimenter, View Results and Generate Report.



Exercise 6: Use Experimenter to Generate Multiple Runs - View Results and Generate Report



- Obtain data summary of the performance measures.



Exercise 6: Use Experimenter to Generate Multiple Runs - Summary of Performance Measures



Performance Measure	Mean	90% Confidence Interval of Mean	Range
Queue Length before Order Taking	6.13	5.97 – 6.29	4.99 – 6.98
Waiting Time before Order Taking (min)	12.92	12.57 – 13.28	9.97 – 15.03
Total Staytime - Average Stay Time (min)	16.23	15.85 – 16.61	13.00 – 18.00
Number of Customers Who Balked	26.20	23.00 – 29.50	9.00 – 50.00
Utilization – Order Taking (%)	98.29	97.76 – 98.82	91.82 – 99.90
Utilization – Payment (%)	73.29	72.47 – 74.11	69.16 – 78.95

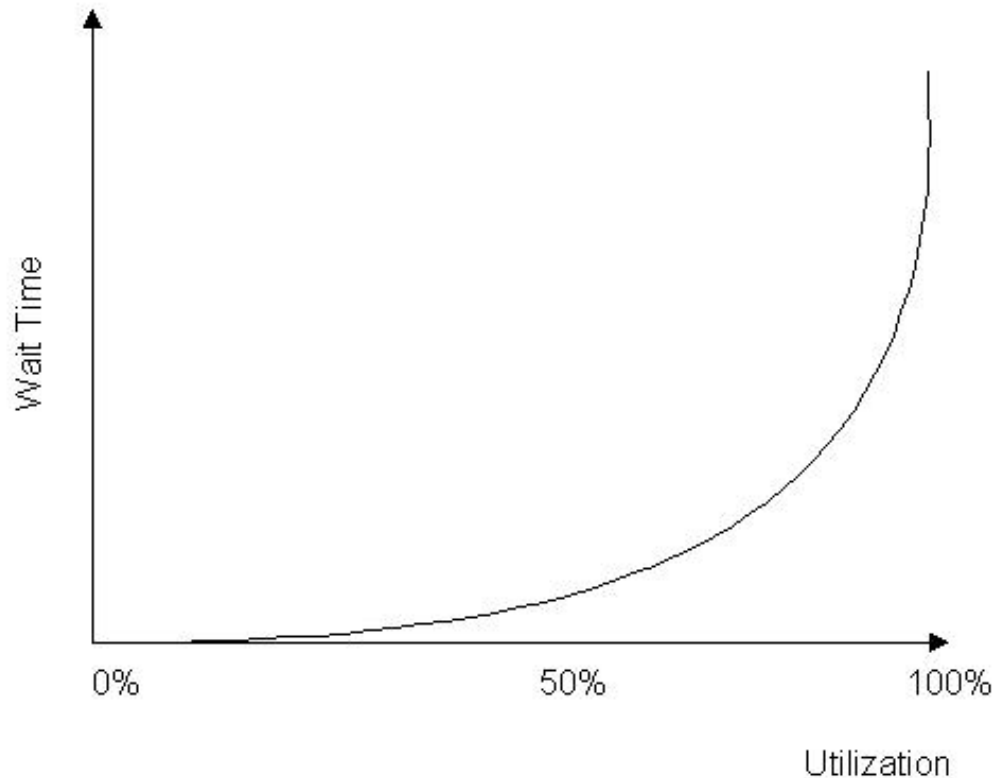
Problem 11

Suggested Solution
(for the 4 stage service system)

Waiting Time Vs Utilization



- In a service system e.g. clinic, bank, post office, the busier the server, the longer is the waiting time. What causes this phenomenon?



General Concepts of “Queuing Theory”



- Waiting time is caused by variability in customer arrivals and service times, and/or not enough service capacity.
- Every service system contains waiting time. As the customer arrival rate increases, load (utilization) of the system will increase and average waiting time will increase in a non-linear fashion.
- Totally eliminating waiting time is impossible due to uncertainties in the system. A good system should be designed such that the cost of waiting times is minimized.

Variability Propagates through System

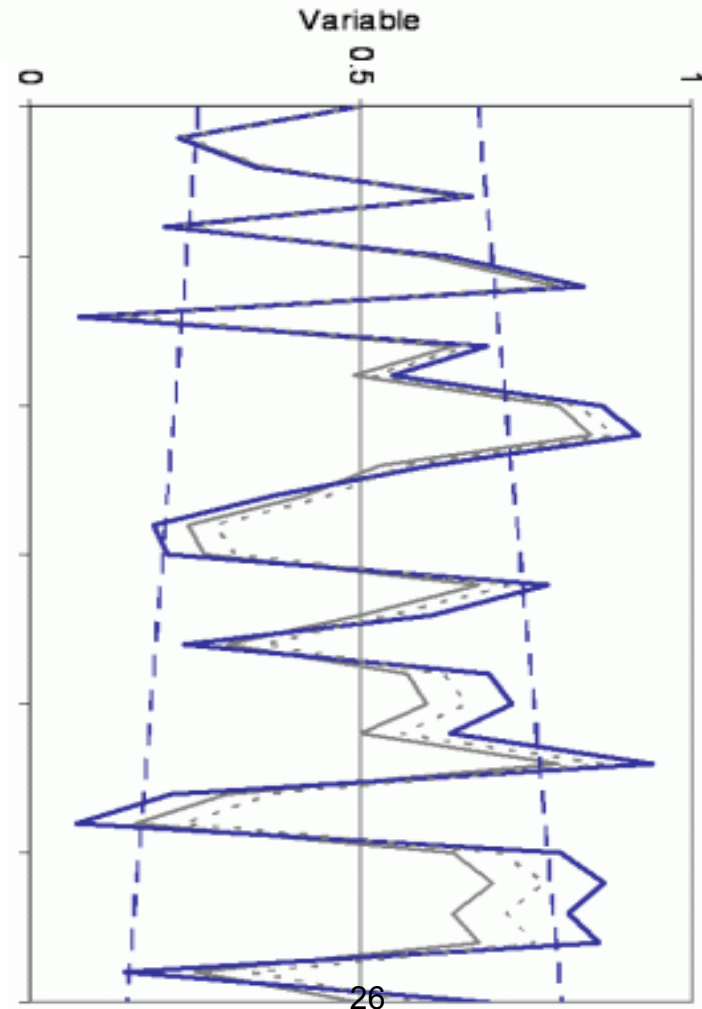


Congestion effects multiply!

Flow in system with multiple stages



Total system variability



Negative Influence of Variability



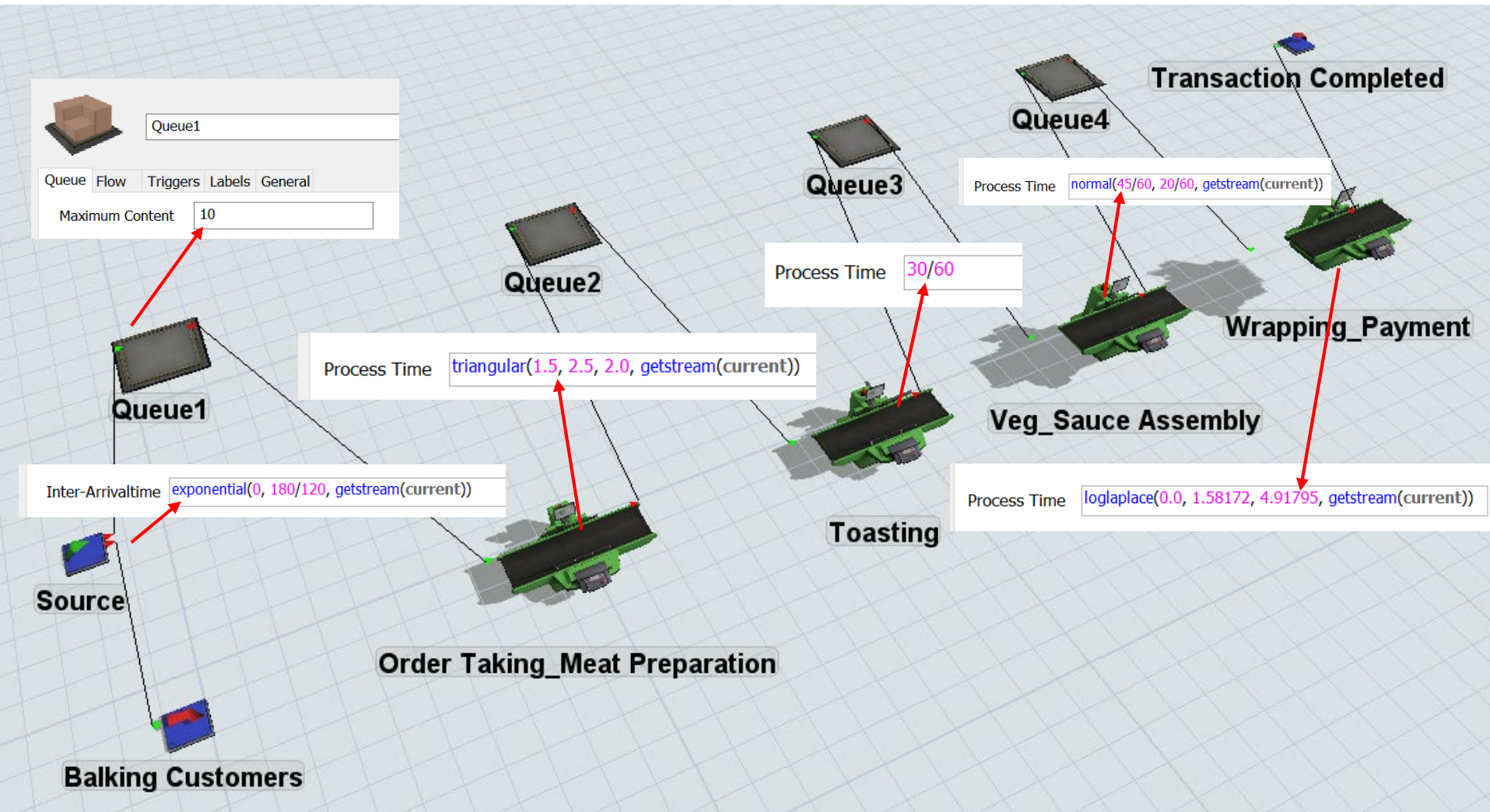
- Large variability in system together with inadequate capacity results in:
 - ✓ Long waiting times
 - ✓ Large number in queue
 - ✓ Increased total time in system
 - ✓ Under-utilized capacity
 - ✓ Reduced customer service (unhappy, balking customers)
- Systems with variability must be buffered by some combination of:
 - ✓ Inventory (e.g. pre-order → preparation)
 - ✓ Capacity (e.g. additional manpower, space)
 - ✓ Time (e.g. managing waiting time expectation)
- Simulation is an appropriate tool to study systems with large and propagating variability

Performance Measures



- Number of customers who left without joining queue
 - unhappy customers who balk (lost revenue)
 - ✓ What is the acceptable queue length?
- Time in queue
 - ✓ What is the acceptable waiting time before ordering?
- Total time in the system
 - ✓ What is the acceptable 'time in system' for the customer before he gets his food?
- Utilization
 - ✓ What is the desired average utilization of staff?

Exercise 7: The Simulation Model



Exercise 7: Fit Distribution to Data for “Wrapping and Payment”



Automated-Fitting Results

Relative Evaluation of Candidate Models

Model	Relative Score	Parameters	
1 - Log-Laplace	91.13	Location	0.00000
		Scale	1.58172
		Shape	4.91795
2 - Log-Laplace(E)	89.52	Location	2.74419 e -4
		Scale	1.58145
		Shape	4.91707
3 - Log-Logistic	84.68	Location	0.00000
		Scale	1.54725
		Shape	6.66102

32 models are defined with scores between 0.81 and 91.13

Absolute Evaluation of Model 1 - Log-Laplace

Evaluation: Good

Suggestion: Additional evaluations using Comparisons Tab might be informative.

See Help for more information.

Log-Laplace distribution best represents Wrapping and Payment timings.

Parameters of the recommended distribution.

Anderson-Darling Test

Anderson-Darling Test with Model 1 - Log-Laplace

Sample size 20
Test statistic 0.30001

Note: The following critical values are exact.

Sample Size	Critical Values for Level of Significance (alpha)				
	0.200	0.150	0.100	0.050	0.010
20	0.592	0.658	0.758	0.919	1.264
Reject?	No				

Goodness-of-fit test indicates that there is no strong evidence to reject the null hypothesis: The data set follows Log-Laplace Distribution with the given parameters.

Exercise 7: Using Experimenter to Set Up Multiple Runs



Simulation Experiment Control

Scenarios Performance Measures Experiment Run Optimizer Design Optimizer Run Optimizer Results Advanced

+ - ↑ ↓

Queue Length before Order Taking	Name	Queue Length before Order Taking
Waiting Time before Order Taking	Label for Y-axis	Value
Total Staytime - AvgStaytime Average	Performance	Statistic by individual object
Number of Customers Who Balked		
Utilization – Order with Bread and Meat Preparation		
Utilization – Toaster		
Utilization – Veg and Sauce Assembly		
Utilization – Wrapping and Payment		

Define performance measures

Watch the e-learning video in the link below for a demonstration on how to set up Experimenter to collect performance measures.

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<https://drive.google.com/file/d/0B9sGwZfXz0MkcVBVcm91Y1I1c3M/view?usp=sharing>

Exercise 7: Using Experimenter to Set Up Multiple Runs



Simulation Experiment Control

Scenarios Performance Measures Experiment Run Optimizer Design Optimizer Run Optimizer Results Advanced

Run Experiment

End Time 11:00:00 AM 15/ 1/2019 ☐ Save dashboard data for each replication

Run Time 180.00 Minutes ☐ Save state after each replication

Replications per Scenario 30.00 Warmup 0.00 Minutes ☐ Restore original state after each replication

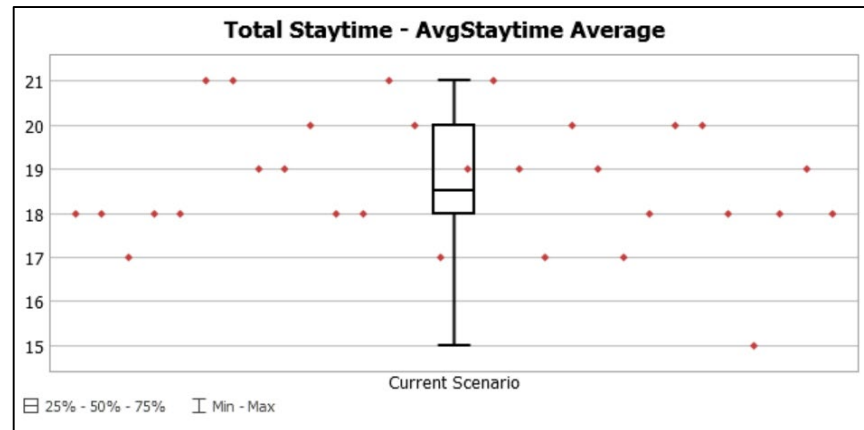
Experiment Status

View Results Export/Merge Results ☐ Export results after each replication

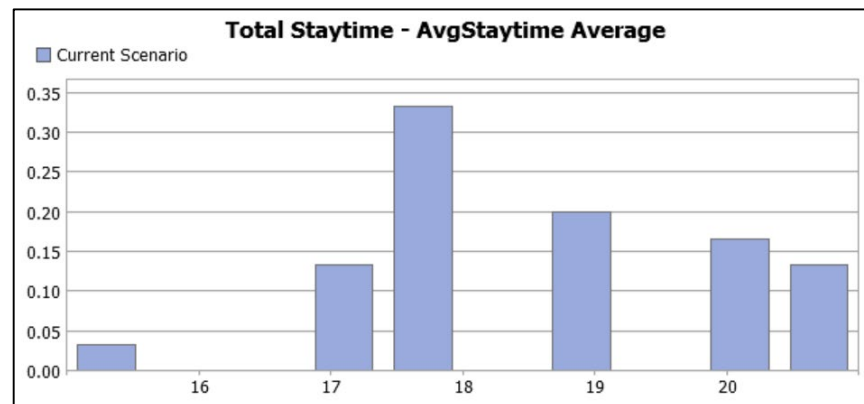
Indicate duration of simulation run and number of runs (replications)

Click to view results after experiment runs are completed

Exercise 7: Example of Simulation Output – Replication Results for Time in System



Individual replication outputs shown in scatterplot



Frequency graph

Total Staytime - AvgStaytime Average

	Mean (90% Confidence)			Sample Std Dev	Min	Max
Current Scenario	18.25	< 18.70	< 19.15	1.44	15.00	21.00

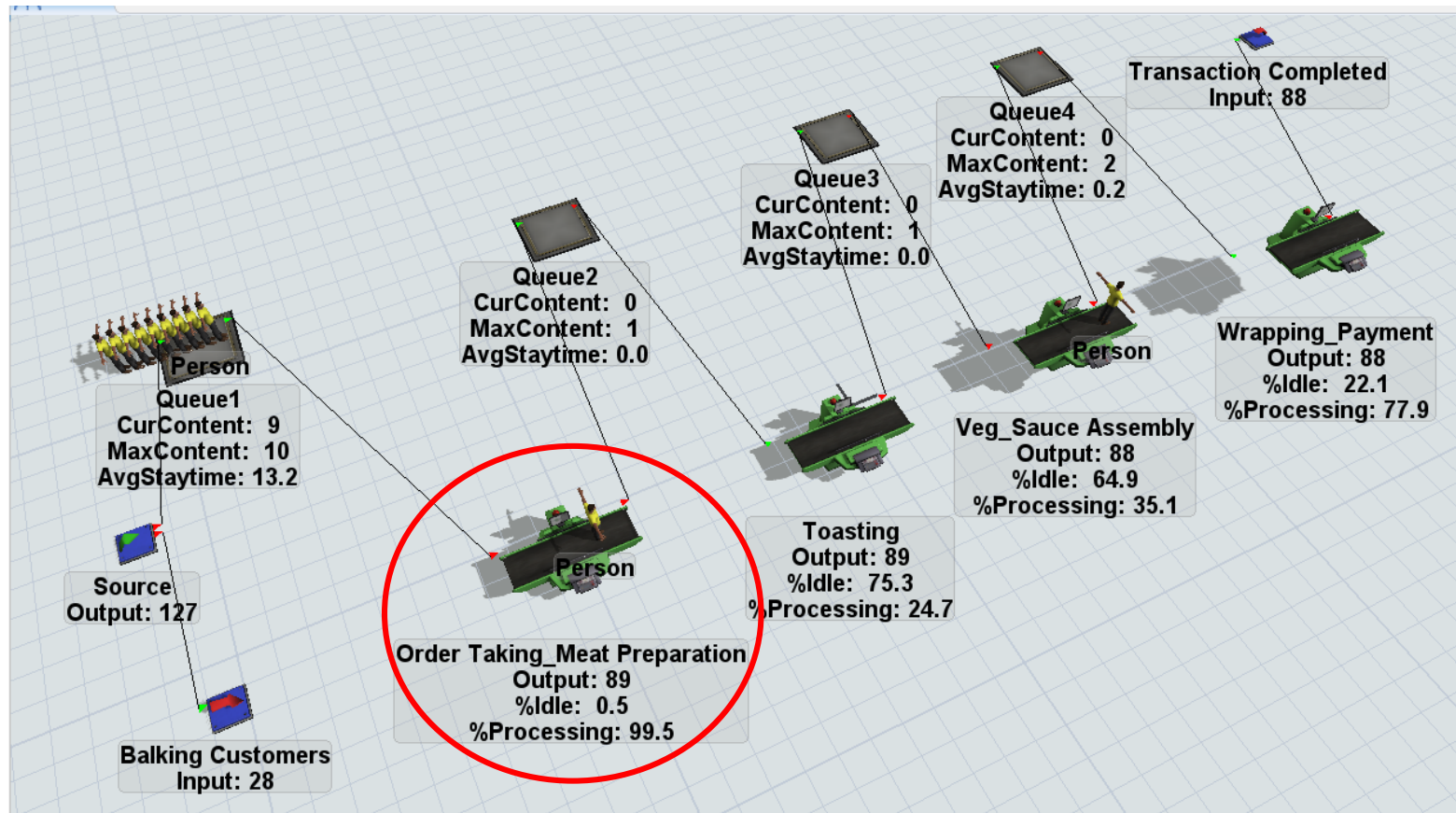
90% confidence interval of mean time in system

Exercise 7: Summary of Performance Measures of Existing System Based on 30 Replications



Performance Measure	Mean	90% Confidence Interval of Mean	Range
Queue Length before Order Taking	7.42	7.21 – 7.63	5.93 – 8.71
Waiting Time before Order Taking (min)	14.17	13.77 – 14.57	11.19 – 16.62
Total Staytime - Average Stay Time (min)	18.70	18.25 – 19.15	15.00 – 21.00
Number of Customers Who Balked	22.90	19.60 – 26.20	2.00 – 49.00
Utilization – Order with Bread and Meat Preparation (%)	98.38	97.89 – 98.86	93.15 - 99.92
Utilization – Toaster (%)	24.38	24.24 - 24.52	23.06 - 25.00
Utilization – Veg and Sauce Assembly (%)	36.59	35.93 – 37.24	32.39 – 40.66
Utilization – Wrapping and Payment (%)	79.55	78.62 – 80.47	72.51 – 86.49

Bottleneck of the 4-stage Service Process



From running the simulation model, we observe that “Order Taking_Meat Preparation” is the **bottleneck** of the 4-stage service process.

- A long queue in front of this bottleneck process
- Utilization rate of this processor (%Processing: 99.5) is the highest among all processors.

How to Improve Customer Service Level?



To reduce customer balking, first determine the acceptable queue length and waiting time by conducting customer survey.

Suggestions to improve service level:

- Assign one more staff for the order taking stage. This will reduce queue length and waiting time.
- Modify work processes such that less busy staff help out their busier colleagues. E.g. cashier to assist the simple food preparation at order taking stage. This will reduce overall time in system.
- Introduce new order process. E.g. allow self service order and payment to reduce queue length. See:
<http://www.youtube.com/watch?v=vf8JQSB8-so>

Learning Objectives



- Construct a simulation model for a multi-stage service system.
- Generate performance measures of service system including waiting time, time in system and queue length from simulation model.
- Discuss measures to improve service system performance bearing in mind inherent variability and cost implications for service systems.

Overview of E211 Operations Planning II Module

