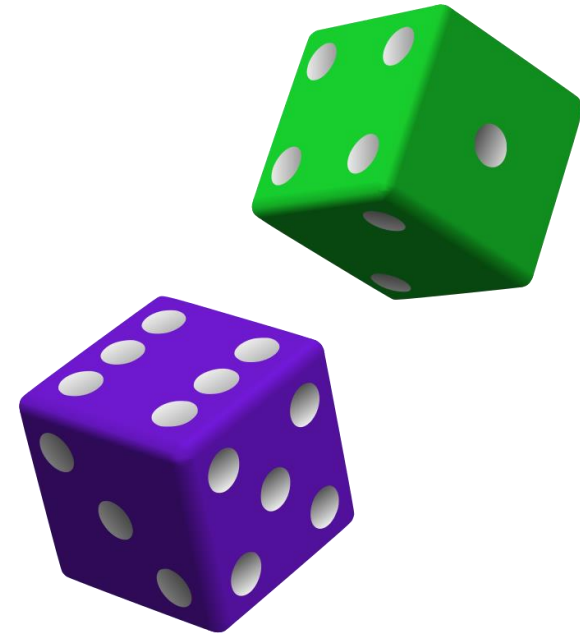


Module 3



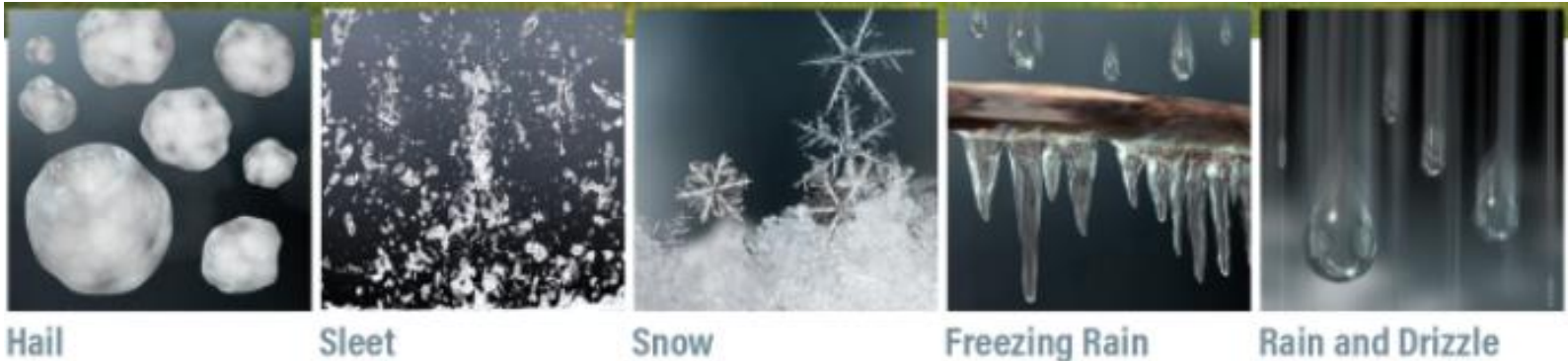
Random In – Random Out

- ▶ What is the value of a single trial?
- ▶ How many rolls of a dice pair is enough to determine the odds of rolling a 7?
- ▶ How confident are you betting on a 7 based on your “research” of 1 roll? 10 rolls? 100 rolls? 1000 rolls?
- ▶ How confident are you making a model recommendation based on 1 “replication”?
- ▶ Interactive results based on a single replication are generally not actionable. Instead use Experiments.



How do we make a good prediction?

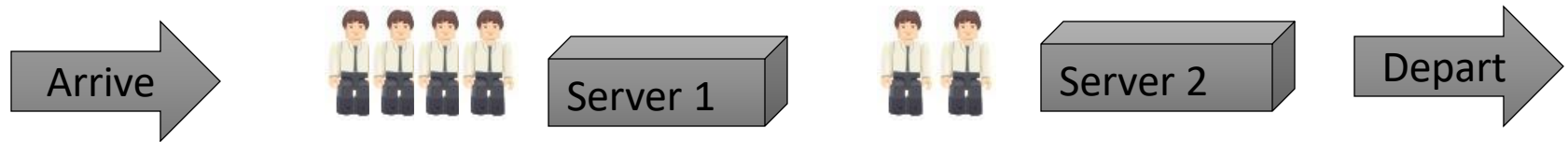
► Weather forecasts:



When creating the official forecast, meteorologists account for uncertainties by running a model several times. Each time, the model will give a slightly different result, but most results will be very similar. This ensemble of predictions is what becomes the official forecast.

► In Simio we do **experiments** with **replications** of **scenarios**, with proper **statistical analysis**

Simple Flow Line - Experiment



The screenshot shows the Simio software interface for setting up an experiment. The top menu bar includes File, Project Home, Design, and Support. The Design tab is active, showing a toolbar with icons for Run, Cancel, Reset, Add Response, Remove Response, Add Constraint, and Remove Constraint. The Starting Type is set to 5/13/2019 12:00:00 AM and the Ending Type is 24 Hours. The Experiment Setup section shows a table with the following data:

Scenario	Replications
<input checked="" type="checkbox"/> Name	Status
<input checked="" type="checkbox"/> Scenario 1	Idle
	Required
	Completed
	10
	0 of 10

The Properties: Experiment1 (Experiment) panel on the right shows the following settings:

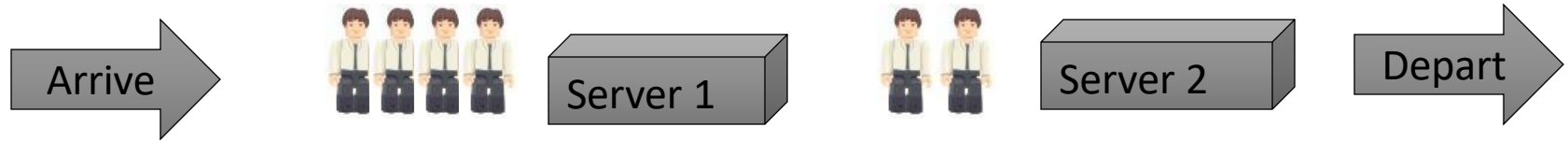
- Analysis**
 - Warm-up Period: 0
 - Default Replications: 10
 - Confidence Level: 95%
 - Upper Percentile: 75%
 - Lower Percentile: 25%
 - Primary Response
- Advanced Options**
- General**
 - Name: Experiment1

The status bar at the bottom indicates the experiment is "Stopped".

Responses and SMORE Plots

- Experiment Responses
 - Existing Metrics
 - Computed Metrics
- SMORE Plots

Simple Flow Line – Responses



Software interface showing the 'Design' tab with a red box highlighting 'Add Response' and 'Remove Response' buttons. The 'Response Results' tab is active, displaying a table with columns: Scenario, Replications, Resp..., and UtilS1.

Scenario	Replications	Resp...	UtilS1
<input checked="" type="checkbox"/> Name	Status	Required	Completed
<input checked="" type="checkbox"/> Scenario1	Idle	10	0 of 10

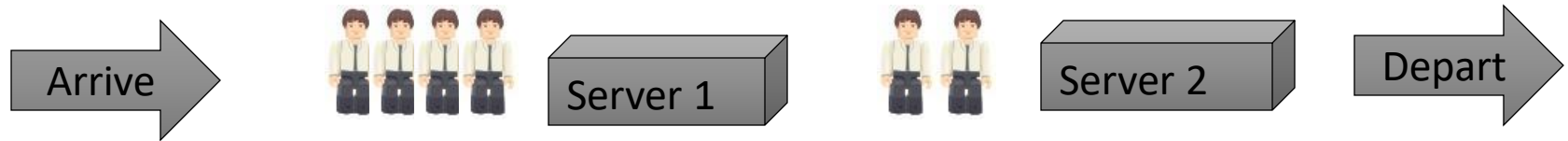
The 'Properties: UtilS1 (Response)' panel is also shown, with a red box highlighting the 'General' section:

General	
Name	UtilS1
Display Name	UtilS1
Expression	Server1.Capacity.ScheduledUtili...
Unit Type	Unspecified
Objective	None
Lower Bound	
Upper Bound	

The 'Expression' section below the properties panel states: 'The expression to be evaluated at the end of the simulation run.'

Stopped

Simple Flow Line – Throughput Response



Design | Response Results | Pivot Grid | Reports | Dashboard Reports | Input Analysis

Scenario			Replications		Responses				
✓	Name	Status	Required	Completed	UtilS1	UtilS2	NIS	TIS (Hours)	Throughput
✓	Scenario 1	Completed	100	100 of 100	82.9623	70.5956	6.97426	0.278431	24.715
*									

Experiment Experiment1_Copy, Scenario Scenario1, replication 91 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 93 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 92 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 94 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 95 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 96 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 97 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 98 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 99 completed at simulation time 24. Actual run time: 0.3 seconds.
Experiment Experiment1_Copy, Scenario Scenario1, replication 100 completed at simulation time 24. Actual run time: 0.4 seconds.

Run complete

The simulation diagram shows a flow line starting with an arrow entering a box labeled 'Server2'. From 'Server2', the flow continues through a series of arrows and diamonds, eventually leading to a box labeled 'Sink1'. A red dashed rectangle highlights the area around 'Sink1'. A red arrow points from the 'General' properties section on the right to 'Sink1'.

Browse: Model\Experiment1 : Throughput

Navigation: Model\Experiment1

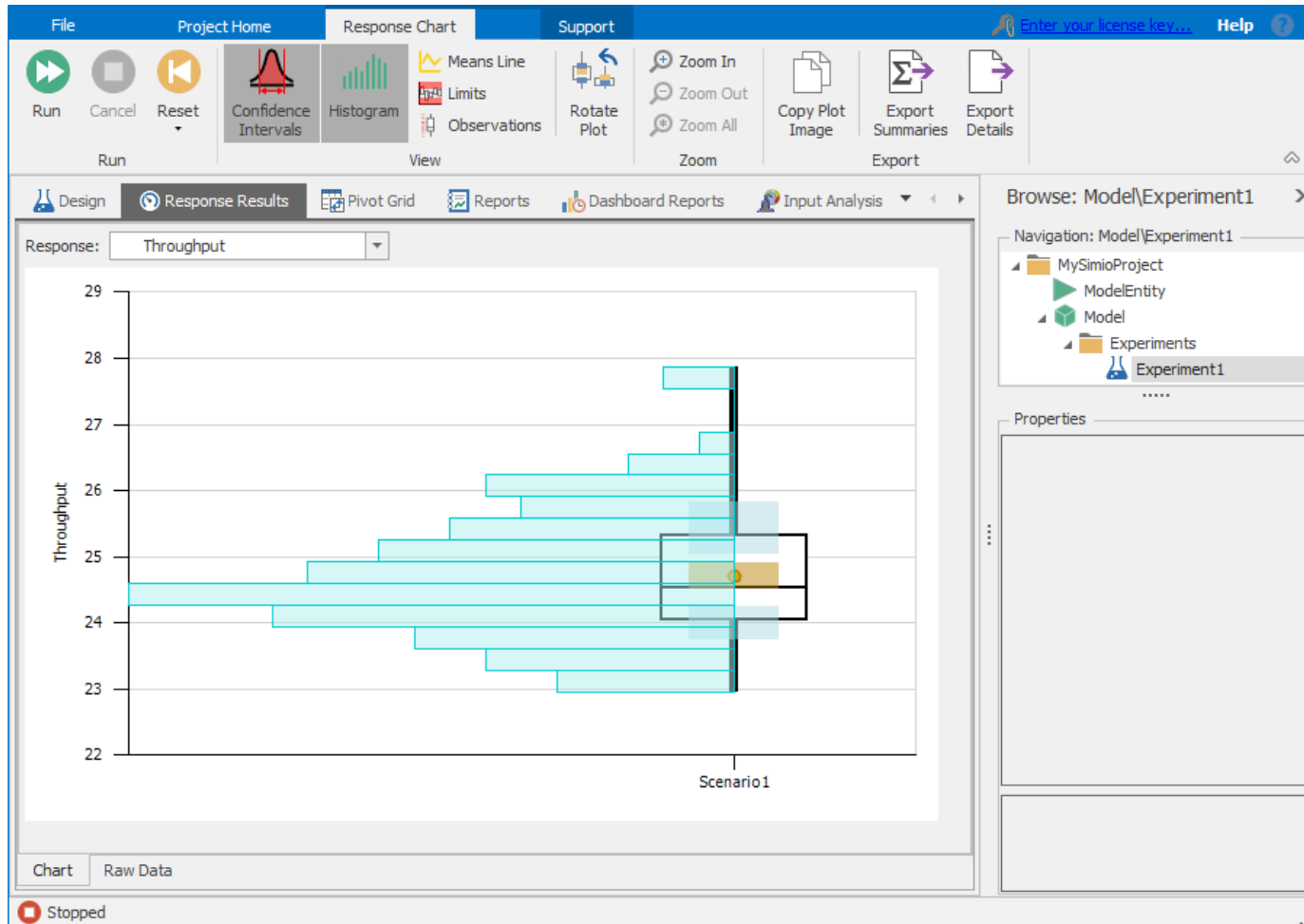
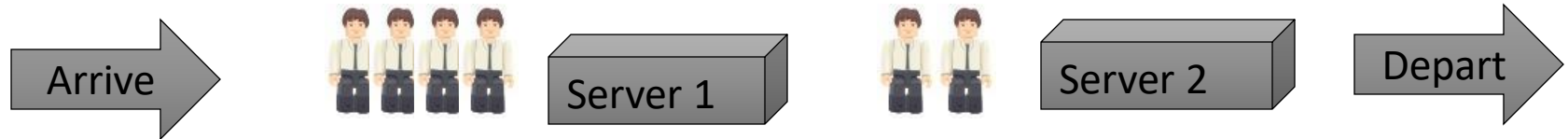
- MySimioProject
 - ModelEntity
 - Model
 - Experiments
 - Experiment1

Properties: Throughput (Response)

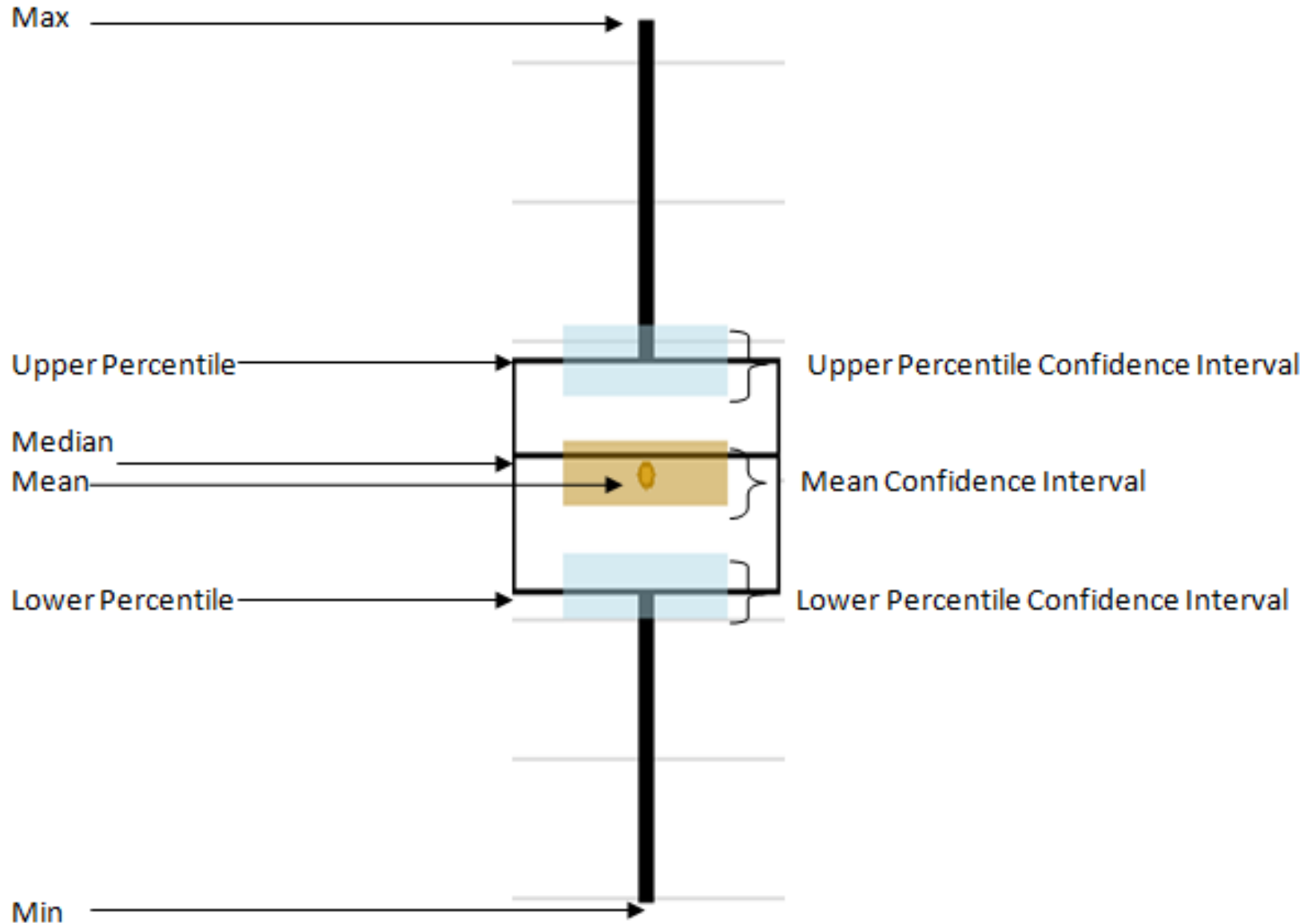
General	
Name	Throughput
Display N...	Throughput
Expression	<code>Sink1.InputBuffer.NumberEntered / TimeNow</code>
Unit Type	Unspecified
Objective	None
Lower Bo...	
Upper Bo...	

General
A response has an expression that is evaluated and recorded at the end of each replication of each scenario. The expression typically involves statistics recording during the run.

Simple Flow Line – SMORE Plots



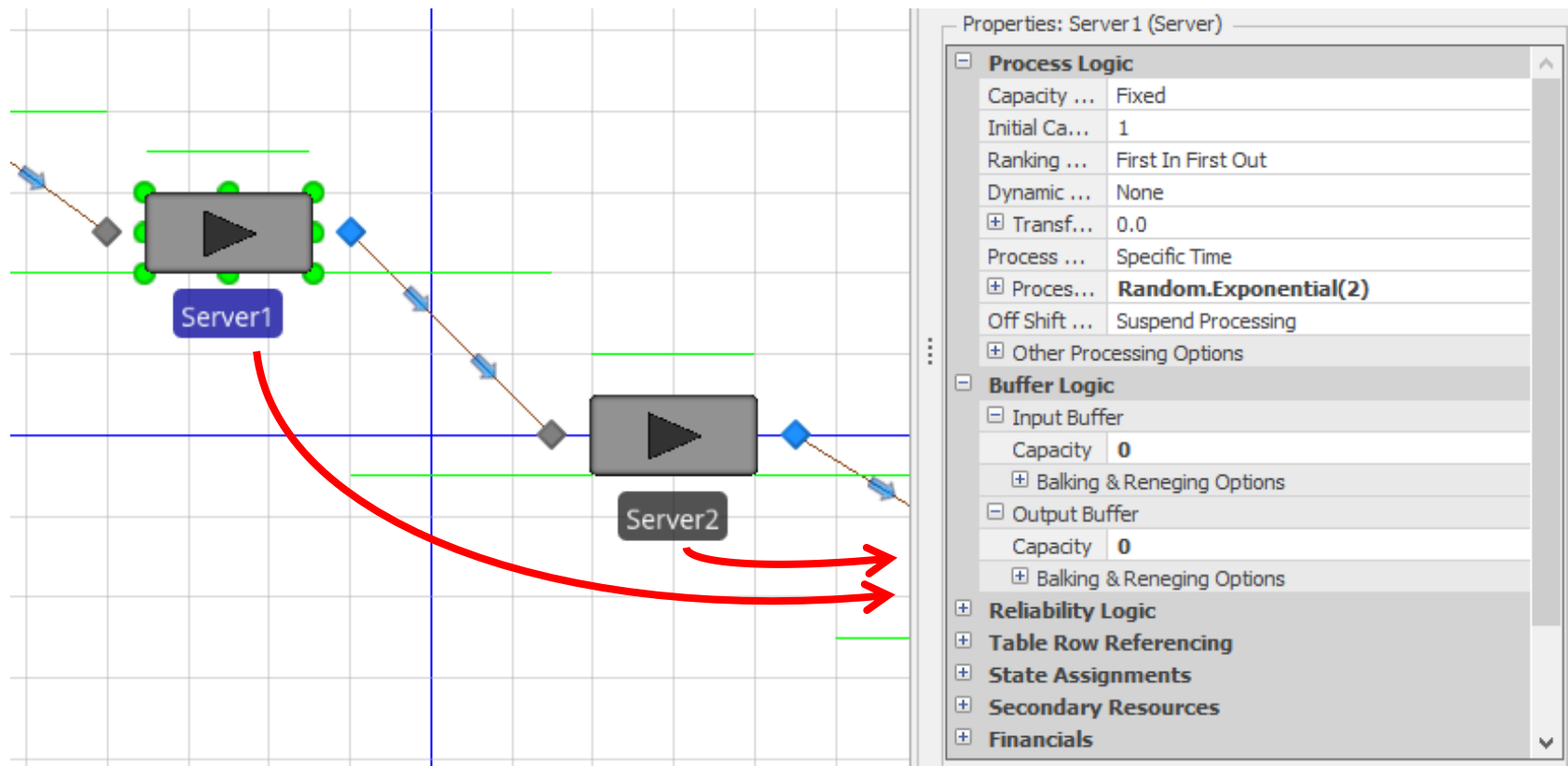
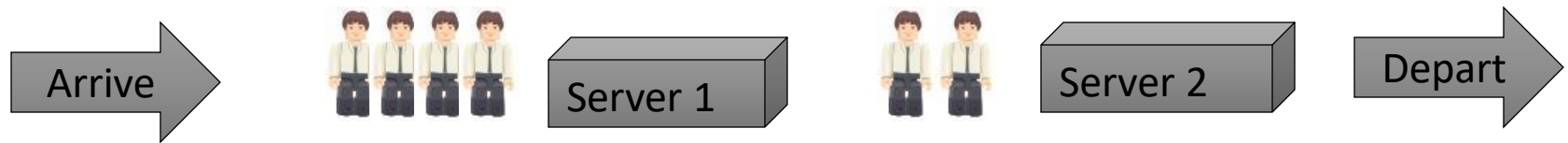
SMORE Plots



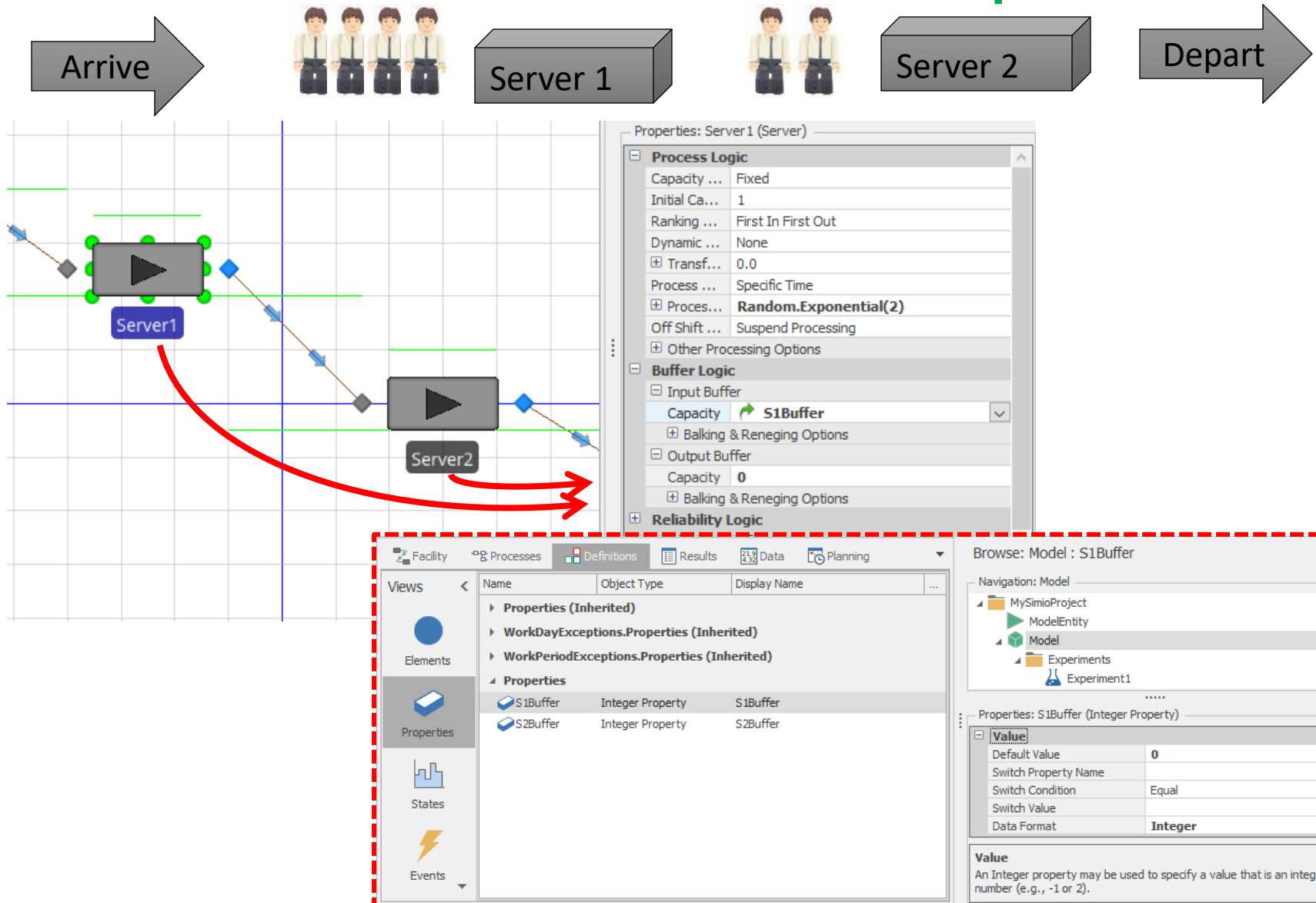
Referenced Properties

- Buffers
- Referenced Properties
- Workshop

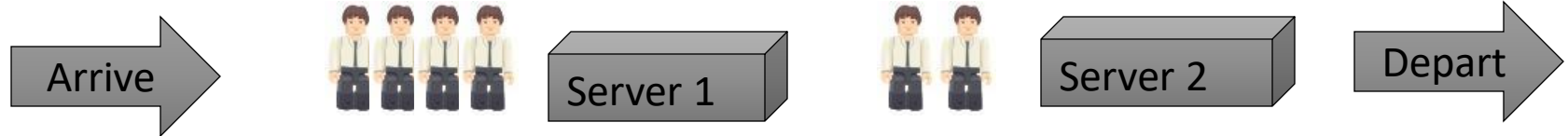
Buffers and Referenced Properties



Buffers and Referenced Properties



Buffers and Referenced Properties



File Project Home Design Support Enter your license key... Help

Run Cancel Reset Add Response Remove Response Add Constraint Remove Constraint Starting Type: 5/13/2019 12:00:00 AM Ending Type: 24 Hours Subset Selection Select Add-In Clear

Experiment Run Setup Analysis Add-Ins

Design Response Results Pivot Grid Reports Dashboard Reports Input Analysis

Scenario			Replications		Controls		Responses					
	Name	Status	Required	Completed	S1Buffer	S2Buffer	UtilS1	UtilS2	NIS	TIS (Hours)	Throughput	
✓	0x0	Completed	10	10 of 10	0	0	70.3692	61.4895	35.7826	1.47696	21.3583	
✓	1x1	Completed	10	10 of 10	1	1	78.948	66.2518	21.2623	0.848058	23.2	
✓	2x2	Completed	10	10 of 10	2	2	82.8647	68.646	13.6312	0.550681	24.2	
✓	3x3	Completed	10	10 of 10	3	3	82.101	70.6281	8.49843	0.338676	24.2875	
✓	3x1	Completed	10	10 of 10	3	1	78.948	66.2518	21.2623	0.848058	23.2	
✓	3x2	Completed	10	10 of 10	3	2	82.8647	68.646	13.6312	0.550681	24.2	

* [] Edit Filter

Experiment Experiment1, Scenario 3x3, replication 9 completed at simulation time 24. Actual run time: 0.4 seconds.
 Experiment Experiment1, Scenario 3x1, replication 9 completed at simulation time 24. Actual run time: 0.4 seconds.
 Experiment Experiment1, Scenario 2x2, replication 9 completed at simulation time 24. Actual run time: 0.5 seconds.
 Experiment Experiment1, Scenario 0x0, replication 10 completed at simulation time 24. Actual run time: 0.4 seconds.
 Experiment Experiment1, Scenario 3x2, replication 9 completed at simulation time 24. Actual run time: 0.5 seconds.
 Experiment Experiment1, Scenario 2x2, replication 10 completed at simulation time 24. Actual run time: 0.4 seconds.
 Experiment Experiment1, Scenario 1x1, replication 10 completed at simulation time 24. Actual run time: 0.4 seconds.
 Experiment Experiment1, Scenario 3x3, replication 10 completed at simulation time 24. Actual run time: 0.3 seconds.
 Experiment Experiment1, Scenario 3x1, replication 10 completed at simulation time 24. Actual run time: 0.3 seconds.

Stopped

Browse: Model\Experiment1 : Experiment1

Navigation: Model\Experiment1

- MySimioProject
 - ModelEntity
 - Model
 - Experiments
 - Experiment1

Properties: Experiment1 (Experiment)

Analysis

Warm-up Period	0
Default Replications	10
Confidence Level	95%
Upper Percentile	75%
Lower Percentile	25%
Primary Response	UtilS1

Advanced Options

General

Name	Experiment1
------	-------------

Analysis

Defining the “Best”

► Not so easy...

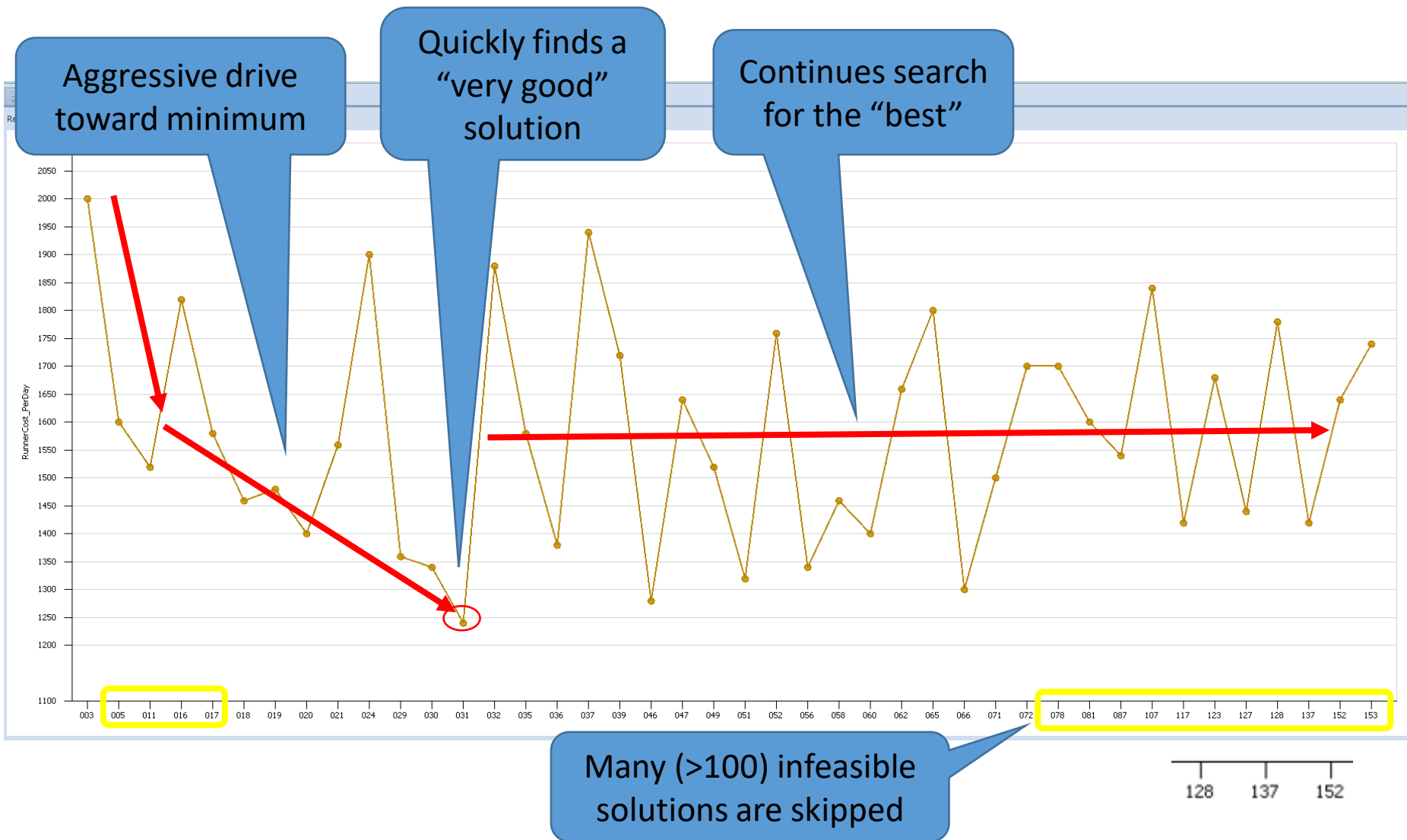


“Someone calling themselves a customer says they want something called service.”

OptQuest For Simio

- ▶ Replaces the inaccuracy of trial-and-error.
- ▶ Quickly determine which controls best meet objectives.
- ▶ Metaheuristics guide search algorithm toward better solutions.
 - Remembers which solutions worked well and recombines them into new, better solutions.
 - Does not get trapped in local solutions or get thrown off course by noisy model data.
- ▶ Combines Tabu search, scatter search, integer programming, and neural networks into a single composite search algorithm.
- ▶ Orders of magnitude faster than other approaches. According to experts in the field, it is the most reliable optimization software on the market today.

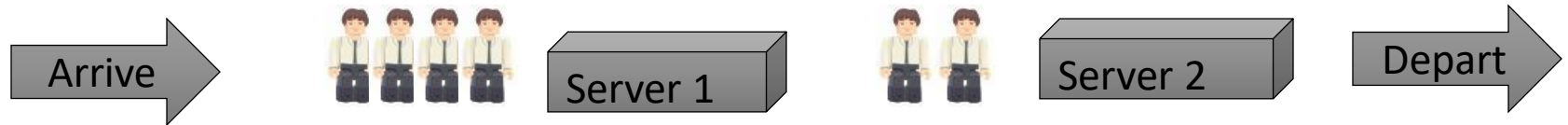
OptQuest Search for Minimum



OptQuest For Simio

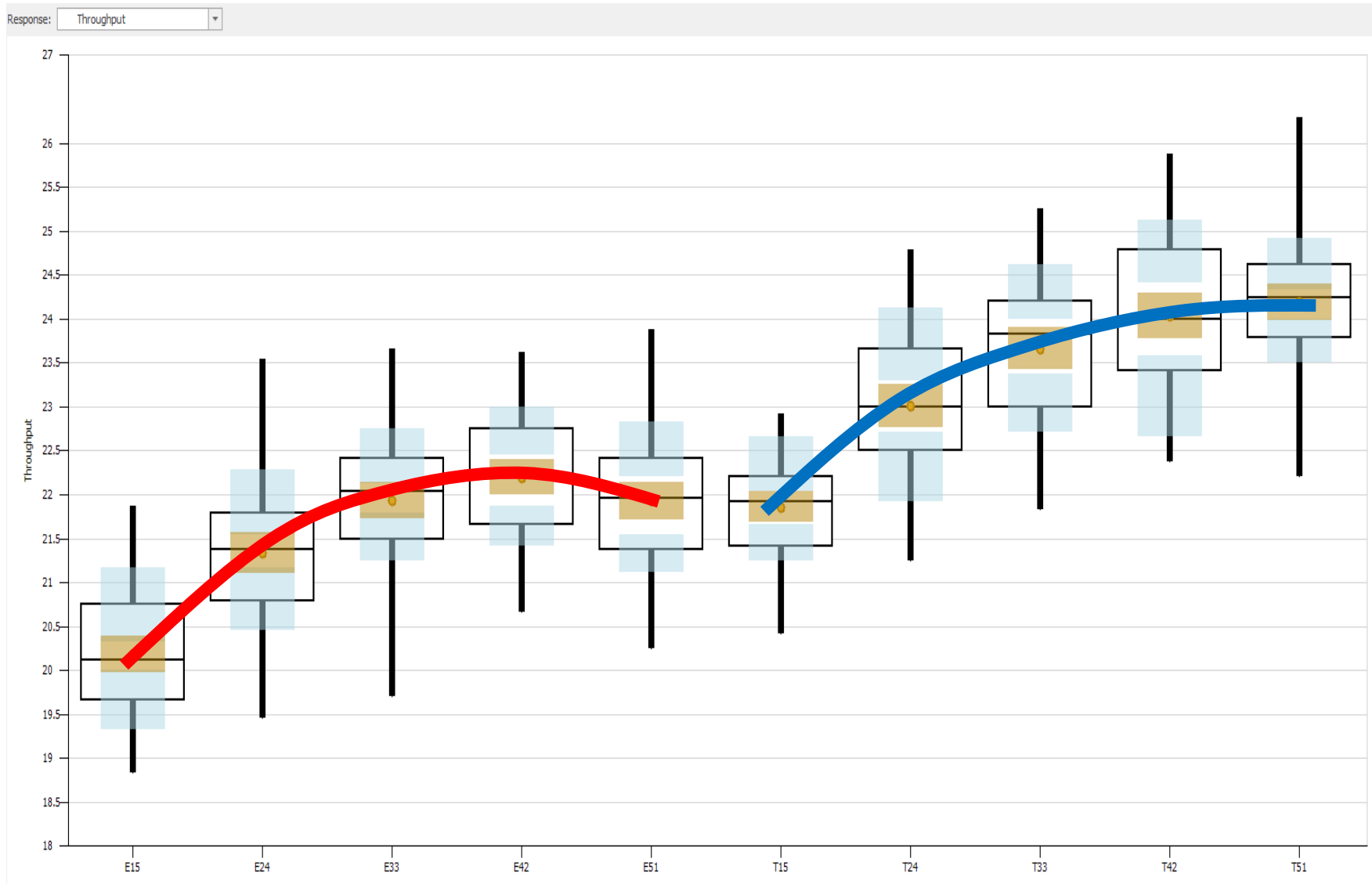
- ▶ OptQuest sets **Control** (referenced property) values, starts replications, and retrieves results.
- ▶ The Add-In adds parameters to all Controls that allow the user to define how OptQuest moves between input values
- ▶ **Constraints** can limit the input values even further and guide the algorithm to the optimal solution
 - For example, $\text{Input1} + \text{Input2} + \text{Input3} < 10$
- ▶ The experiment can have several **Response** columns which define the **Objective Function**:
 - **Single Objective** (Minimize or maximize Primary Response).
 - **Multiple Objective Weighted**
 - **Pattern Frontier**
- ▶ OptQuest will then intelligently create **Scenarios** to close in on the optimal solution quickly and easily
 - OptQuest does all the work!

Workshop/Lab



- ▶ Create the model (if you weren't following along 😊).
- ▶ Find the buffer configuration that maximizes the throughput where you only have 7 buffer slots (total) available, including exactly 1 at Source
- ▶ Retain Source1 Interarrival Time: ***Random.Exponential(2.4)***
- ▶ Update the processing times at the two stations as follows:
 - Server1: ***Random.Triangular(0.5, 2, 3.5)***
 - Server2: ***Random.Uniform(1, 2.4)***
- ▶ Re-run the experiment and note the differences in throughput vs. buffer sizes compared to the exponential case.
- ▶ **Challenge:** Use additional controls to display one experiment with original and revised service times.

Workshop Results



Success Tips

Stakeholder Objectives

- ▶ *Stakeholder* – Someone who commissions, funds, uses, or is affected by a simulation project
 - Conflicting objectives between different stakeholders are not uncommon
- ▶ There is no “single simulation model” for a system – the “right” model depends on a combination of the system and the *study objectives*:
 - What do you want to evaluate, learn, or hope to prove?
 - What’s the scope of the project?
 - What data are available or can be collected?
 - In what form do you want the results?

Functional Specification

*“If you don’t know where you’re going,
how will you know when you get there?”*

Carpenter’s advice: “Measure twice. Cut once.”

- ▶ *Functional specification* – a document describing exactly what will be delivered, when, how, and by whom
- ▶ How long will this project take?

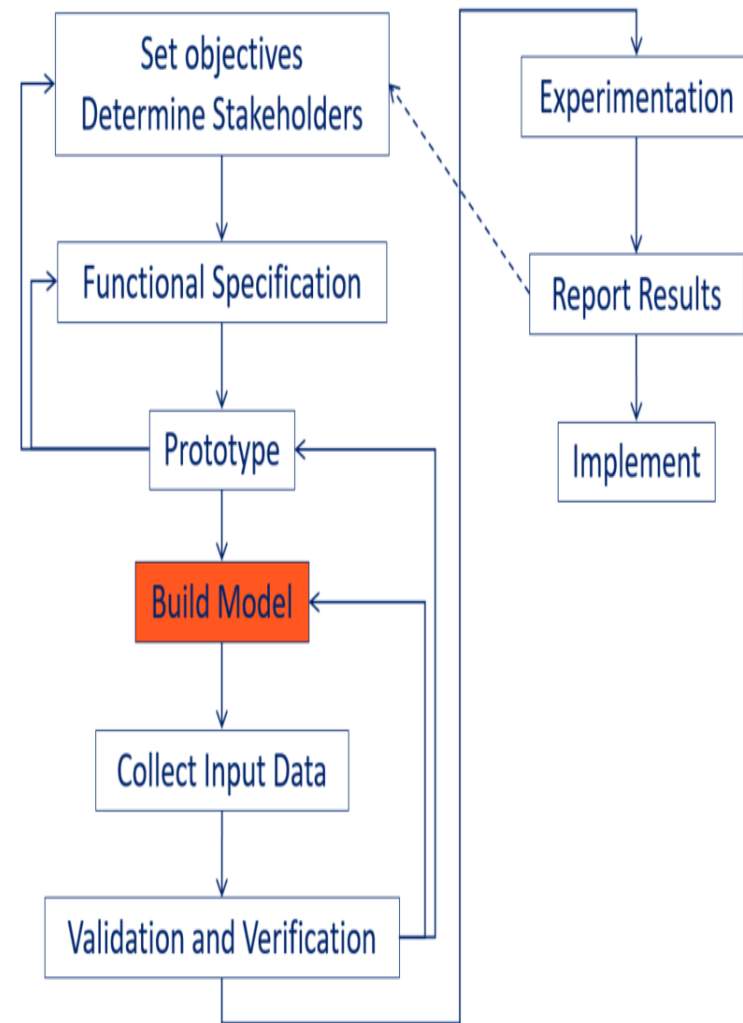


Functional Specification

- ▶ For most models:
 - Objectives
 - System description and modeling approach
 - Input data required
 - Expected experimentation
 - Deliverables
- ▶ From practical experience, approximately **5-10%** of a project's total time should be spent on developing the objectives and functional specification.
- ▶ This is NOT extra time, but rather moving *selected* important work to the **beginning** of the project where it can be used in planning and estimating the work.

The Simulation Project

- ▶ Define the objective of the study.
- ▶ Understand the system.
- ▶ Determine the modeling scope and level of detail.
- ▶ Data collection
- ▶ Build the model (iterative).
- ▶ Verify the model logic and data.
- ▶ Validate the results.
- ▶ Design and execute experiments.
- ▶ Analyze and interpret the results.
- ▶ Document and present the results.



Project Iterations

- ▶ Simulation novices often start modeling and keep adding to the model until it's "complete," and only then run the model.

Don't do that!

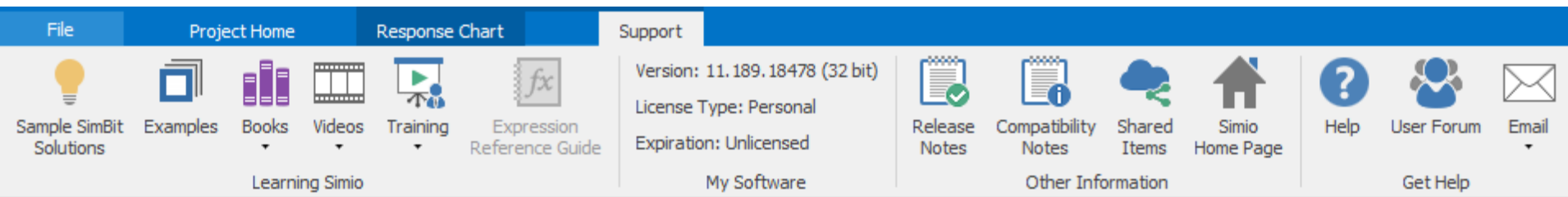
- ▶ Use an iterative model-building process
 - Add features/model components
 - Run/Test
 - Repeat
- ▶ "Save early, save often!"

What are common pitfalls?

- ▶ Not understanding the purpose upfront.
- ▶ Too big/complex.
- ▶ Not fully accounting for variability.
- ▶ Obtaining the necessary data.
- ▶ Failure to verify/validate the model.
- ▶ Incorrectly interpreting random results.
- ▶ Untimely results.

How to Learn More about Simio

Learning Resources



Support Ribbon

- ▶ SimBits
- ▶ Examples
- ▶ E-books
- ▶ Multiple Video Sets and hundreds of YouTube videos
- ▶ Release Notes
- ▶ Shared Items
- ▶ User Forum

More Formal Training Materials

► Choice of Books:

- E-books &
- Printed
- Eight+ languages

► Simio University

- Learning Simio Fundamentals
- Advanced Course
- Fundamentals of RPS
- Learning Simio Suite (all of above)

► Free videos

- 13 Lab Series with 60 explanatory videos
- Flexible Manufacturing Video Series (11 videos)
- Hundreds of YouTube Videos

