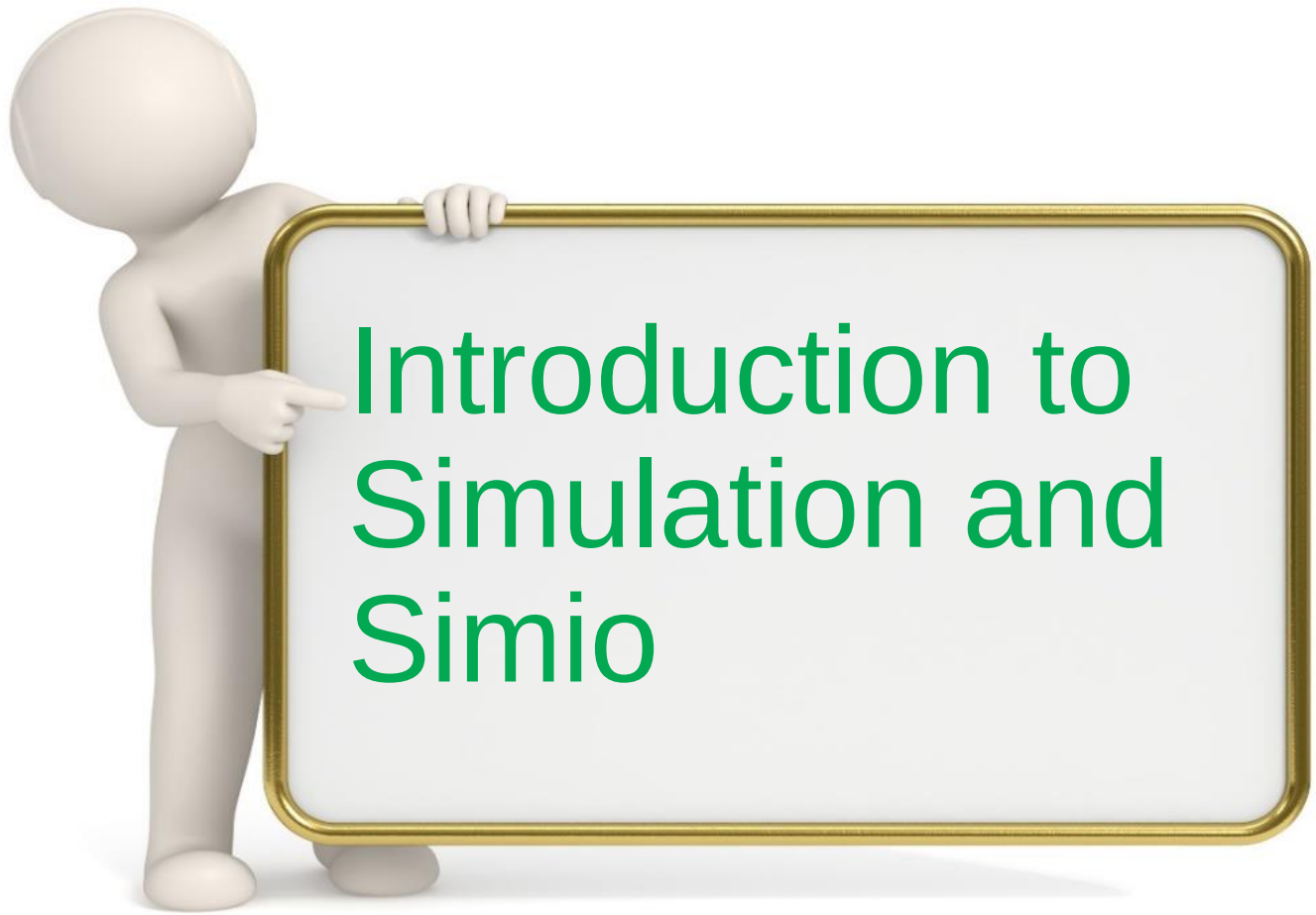
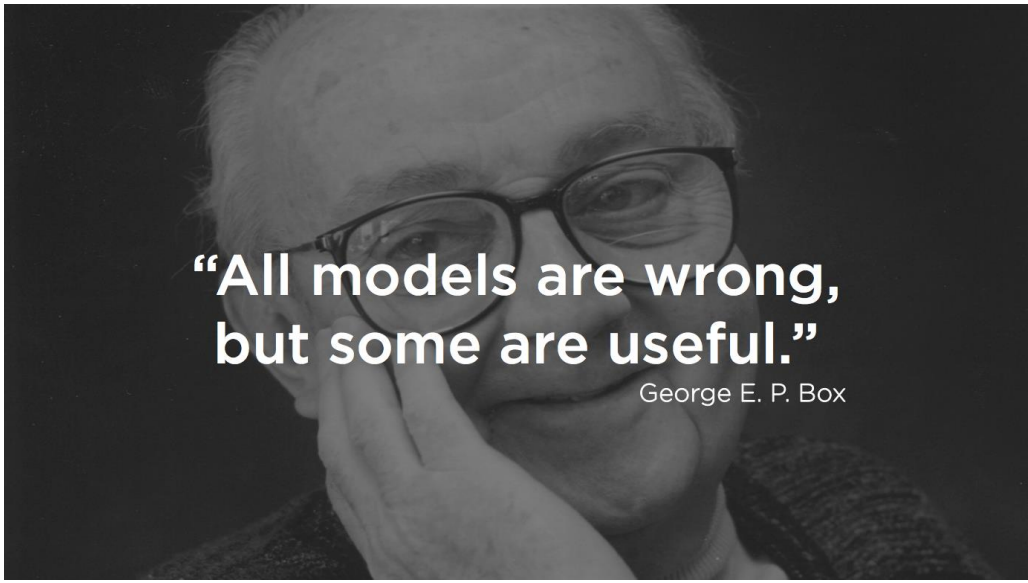
Module 2



What is Simulation?

- Our goal is to mimic the behavior over time of a real system with a model that behaves in a *similar* way.
- What are some applications you might encounter in your daily life?

We want
just enough fidelity
to achieve
project objectives.



Why Simulation?

- Objects can influence each other

- Every system has randomness
  Breakdowns, illness, late arrivals…

- The combination is complex.

- Simulation is uniquely capable of managing this complexity.

Traditional Uses of Simulation

- Design and Optimization
  - Visualize and understand the system.
  - Analyze system performance.
  - Evaluate alternatives.
  - Minimize risk of implementation.

Compelling Benefits

- See the future.
- Knowledgebase to document processes.
- Answer “what if”, analyze alternatives.
- Make mistakes early - and in the model.
- Visualize the process/ communicate.

Key Simulation Advantages

- Flexibility
  - Most real systems have unique characteristics that are critical constraints on performance.
- Variability
  - Most real systems have variations that have a critical impact on performance.
- Visualization
  - 3D animation can be a powerful tool for understanding and communication.

A Few Application Areas

- Manufacturing
- Logistics, supply chain, and distribution
- Construction engineering and project management
- Military operations
- Transportation modes and traffic
- Business processes
- Healthcare
- Pharmaceuticals
- Airports and mass transit systems

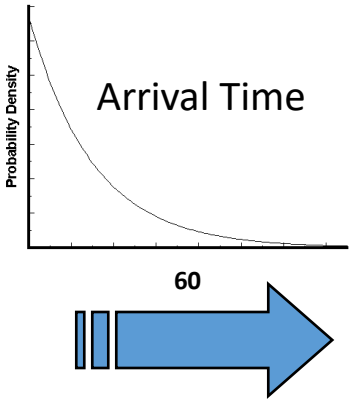
Impact of Variation

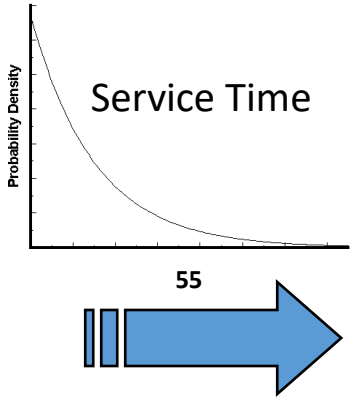
- Most systems exhibit variation.
  - Demand by customers, parts
  - Arrival times of customers, parts
  - Equipment/personnel failures
  - Shortages of materials/supplies.

- Variation is an important aspect of most systems.
- Static/Analytical tools are of limited value in analyzing random processes.

Why Variability Matters

2 Hour Photo Processing Example



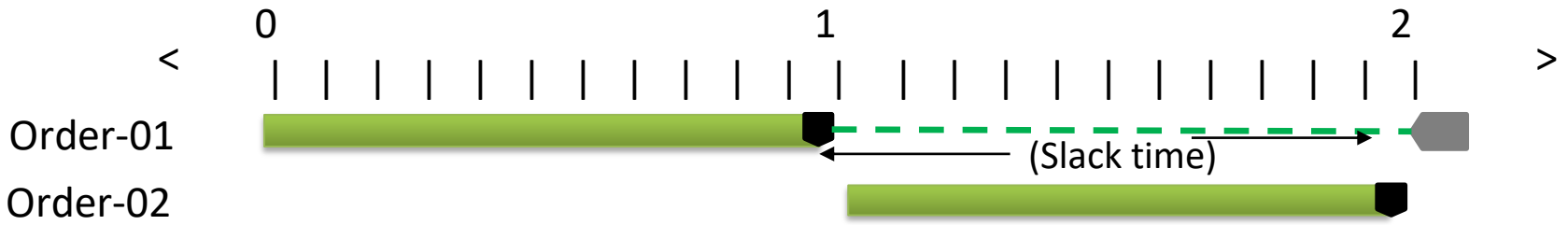


How will this system perform?
Average & Maximum "Time in System" when run 7 days for 24 hours/day?
How many orders will be completed?

Arrival Time	Service Time	Avg. Time in System?	Max. Time in System?	# Completed
Constant	Constant			
Random*	Constant			
Random*	Random*			

* Exponential Distribution

Why Variability Matters - Planning



- Plan is based on “expected” constant values (60 min arrival & 55 minute service time)
- 92% utilization
- Static process shows: ***No late orders***

➡ Variable process (exponential distribution) shows: **73% of the orders are late**

Managing Variation

- Must accurately account for variation in models.
- The degree of variation often has more impact on system behavior than the mean.

- We can dramatically improve system performance by reducing variation.
  - Identify/explain variation.
  - Eliminate sources of variation.
  - Accurately model the variation.

Introduction to Simio

Quick Overview of Simio

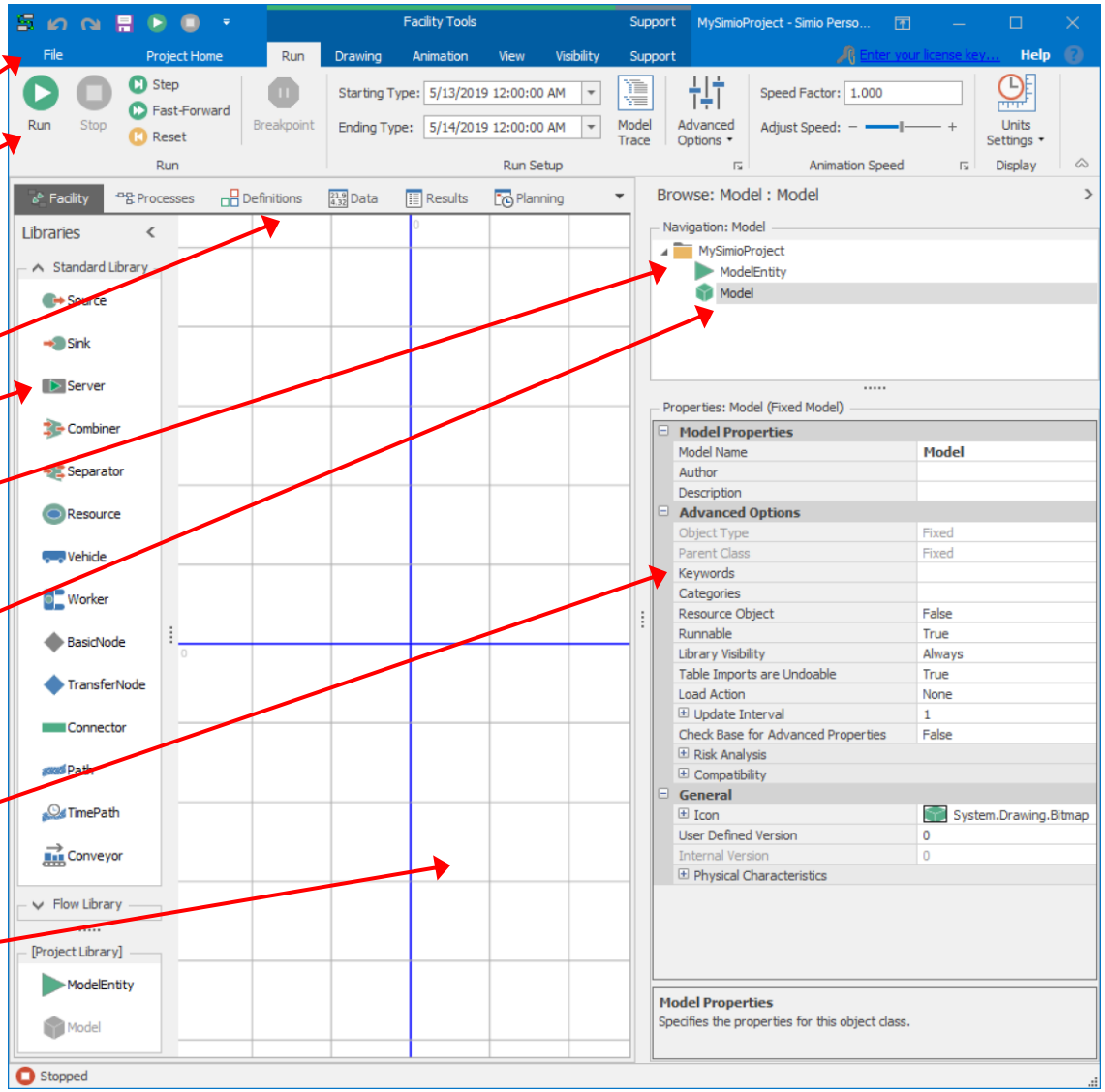
Building an Example Model

Expressions, Distributions, Results

Randomness

Simio User Interface

- Files Menu
- Ribbons
- Project Tabs
- Libraries
- Project
- Current Model
- Properties
- Facility View

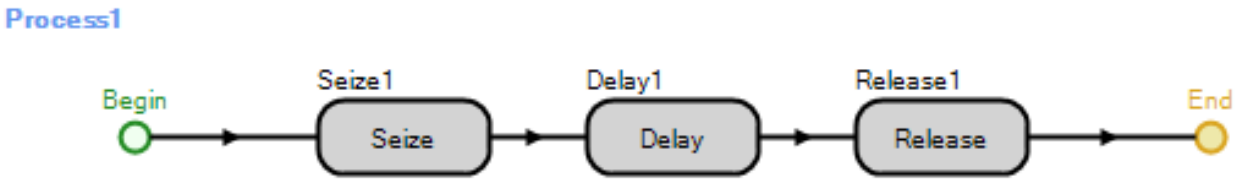


Key Simio Object Concepts

Object:	Defines data, logic, behavior, view, events, and interaction with other objects.
Model:	An object that is executable.
Project:	A collection of models/objects. A project can be loaded as a library.
Properties:	Static inputs to an object.
States:	Changeable values associated with an object
Events:	Supports communication between objects. Fired when key things happen.
Resource:	Constrains the system. Any object (even an entity) may be a resource.
Entity:	A dynamic object that may move through system
Transporter:	An entity that can “work on” or carry other entities. Vehicles and Workers are entities (and resources).

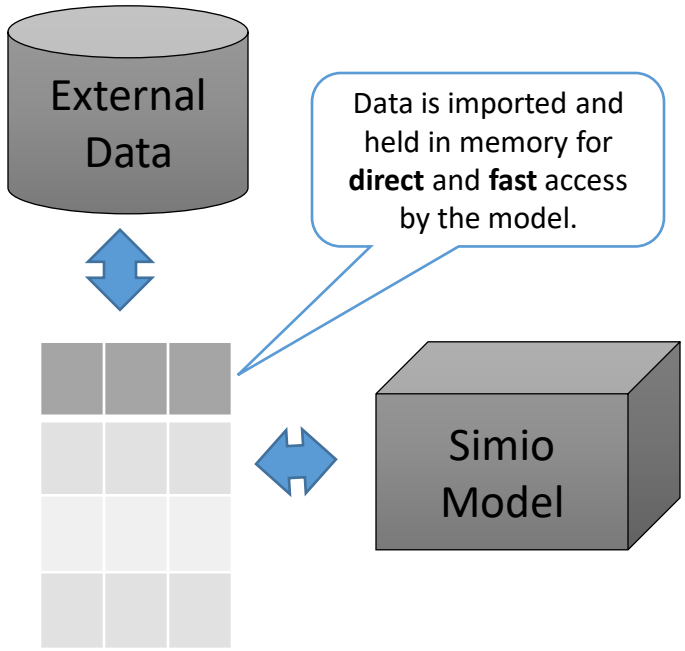
Processes

- A **process** is a set of actions that take place over time that may change the state of the system.
- All objects are built from a combination of processes and other objects.
- **Add-on Processes** provide a powerful mechanism to add model flexibility without programming.
- Steps perform actions such as:
  - Delay by a specified time.
  - Seize or release an object.
  - Fire an event or Wait for an event to occur.
  - Decide based on a probability or condition.
  - Transfer an entity into a station.
  - Search for an item or object …



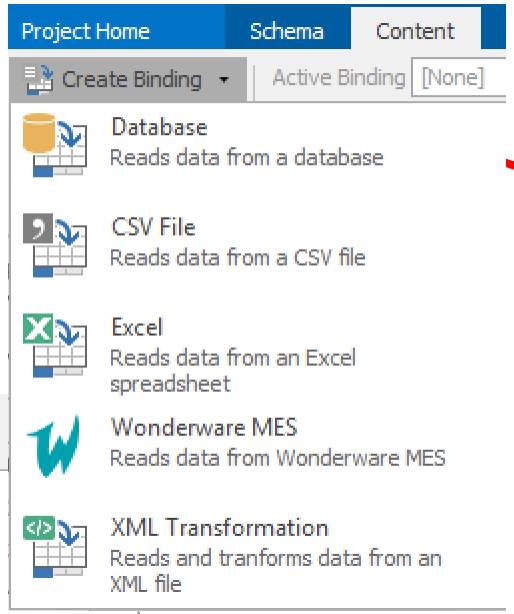
Model Data

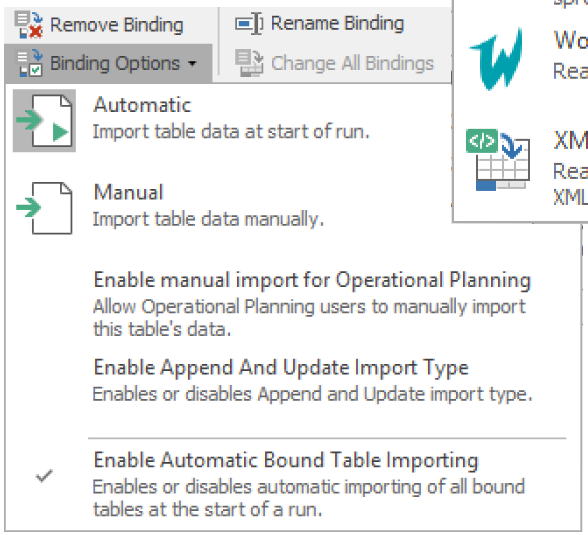
- Models often have large amounts of data that describe the different objects and Entities that move through the system.
- It is slow and inconvenient to repeatedly access the external data as the model is running. Simio brings the data into memory for fast access.
- Simio can represent data in simple tables or in complete data sets with multiple relations.
- The data schema for the tables are user-defined.

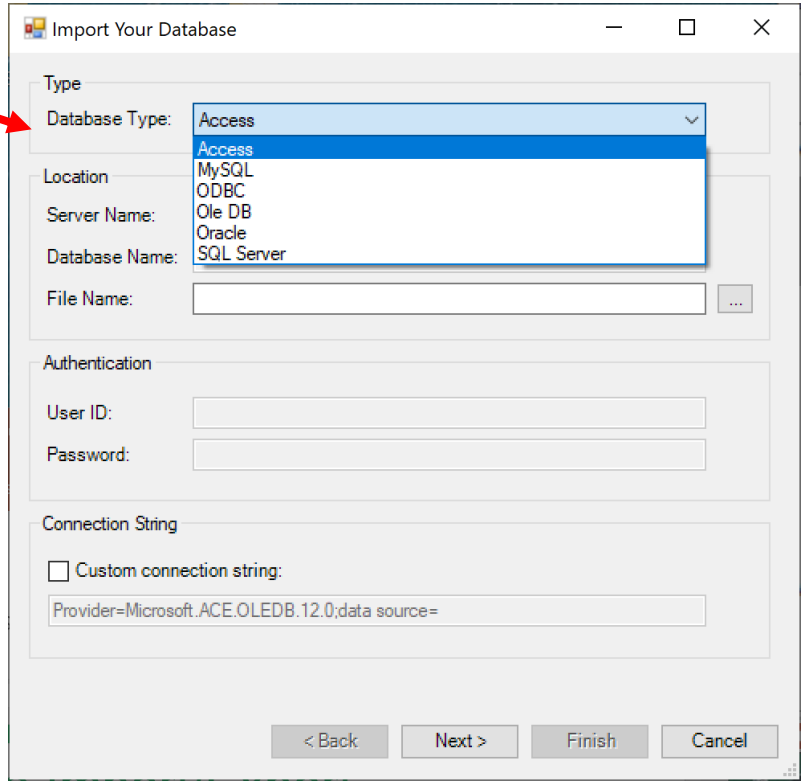


Data Table Import/Export

- Flexible import and export that supports many common data forms, databases, and flexible mapping.







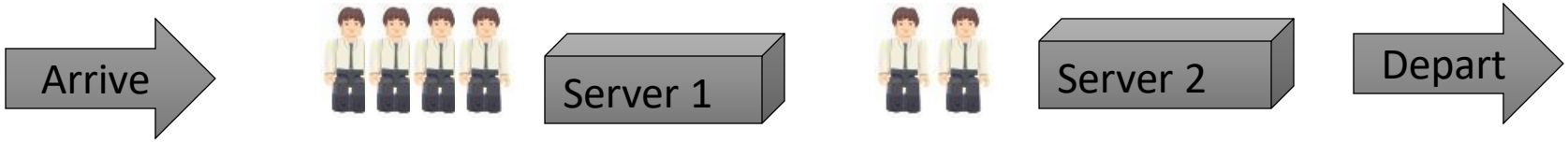
Standard Library

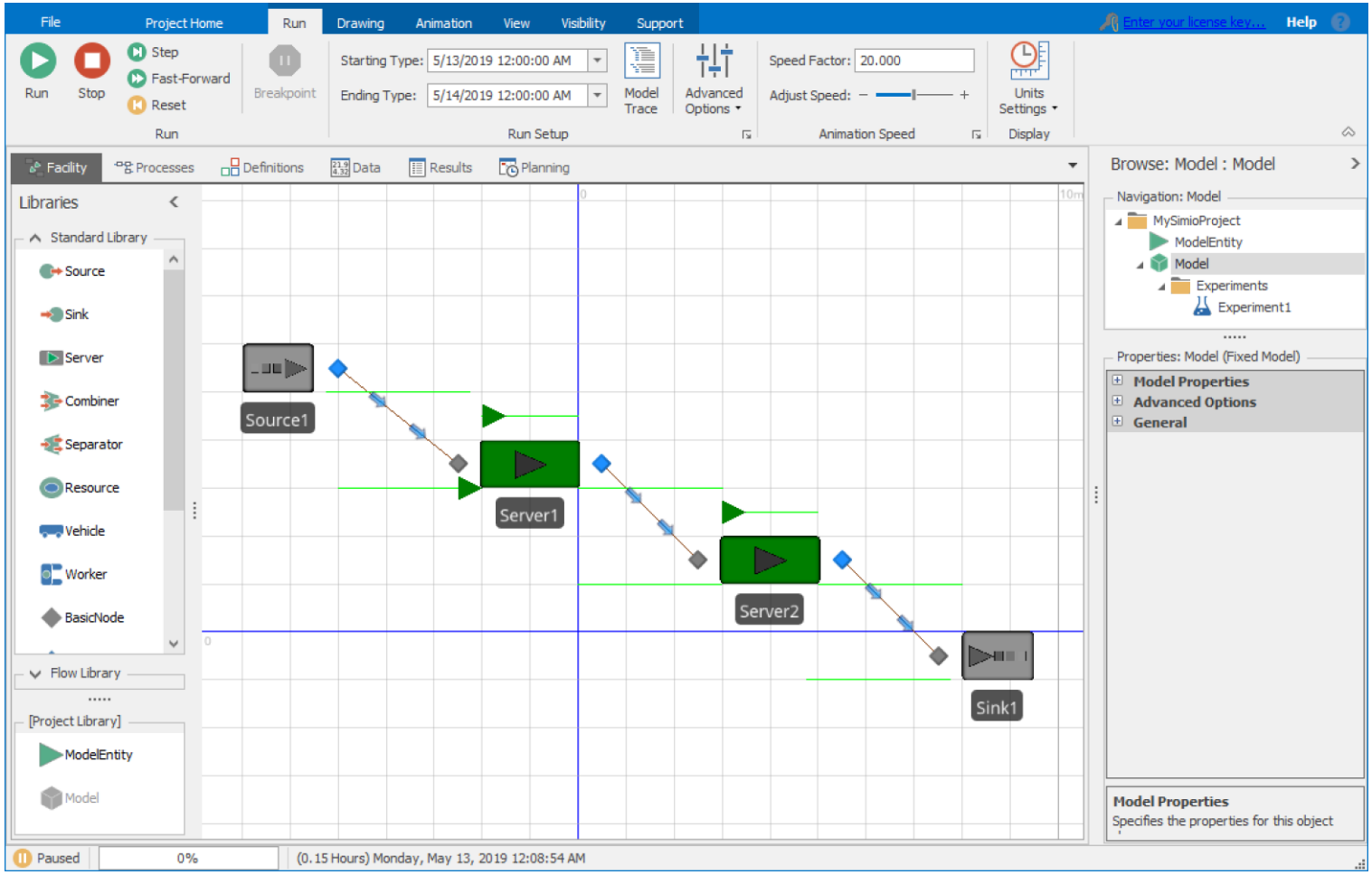
Source:	Generate entities of a specified type and arrival pattern.
Sink:	Destroy entities.
Server:	Capacitated process, such as a machine.
Combiner:	Batches entities with a parent entity (e.g., pallet).
Separator:	Splits batches or copies entities.
Resource:	Seized/Released by objects.
Vehicle:	Fixed route or on-demand pickups/drop-offs.
Worker:	Moveable resource, for stationary and non-stationary tasks.
BasicNode:	Simple intersection, fixed object input.
TransferNode:	Change destination/get rides, fixed object output.
Connector:	Zero travel time.
Path:	Entities independently move at their own speeds.
TimePath:	Entities complete travel in a specified time.
Conveyor:	Accumulating/non-accumulating conveyor devices.

Building a Sample Model

- Build a Sample Simio Model – Simple Flow Line
- Simio Object Hierarchy
- Expressions and Editing Object Properties

Simple Flow Line





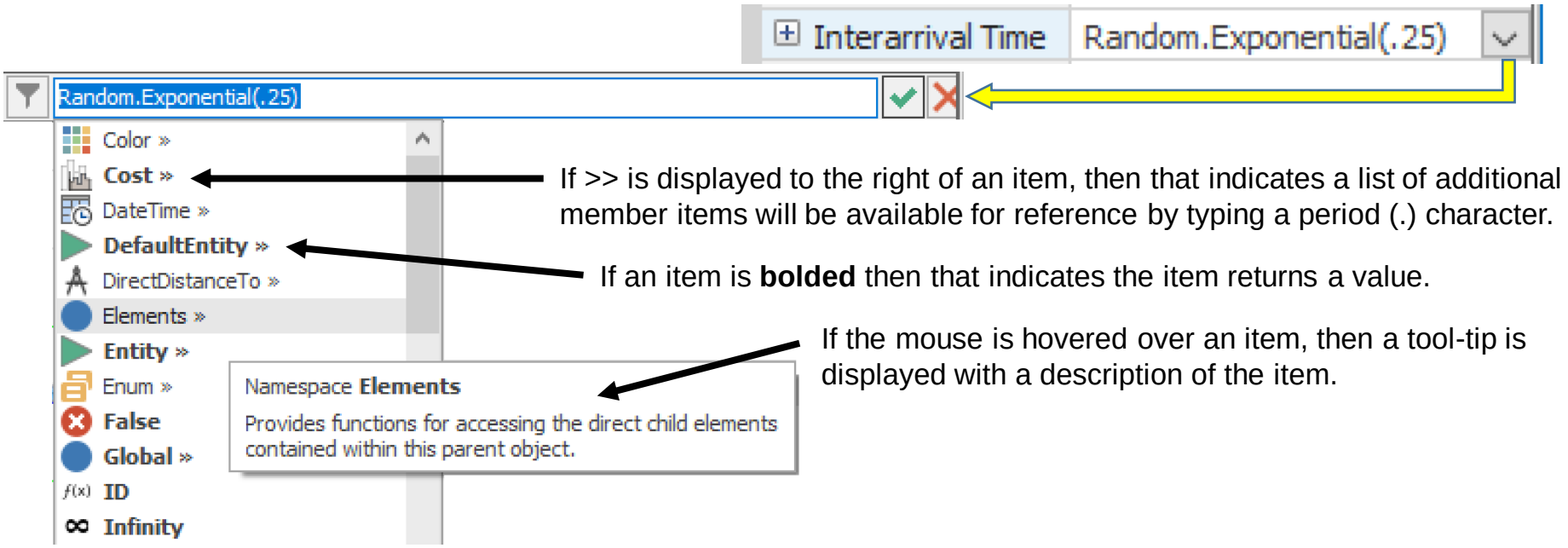
Simio “dot” Notation

- Simio uses a “dot" notation for addressing an object's data such as it’s properties and states.
- The general form is “xxx.yyy" where yyy is a component of xxx.
- **Server1.Capacity.Allocated.Average** provides the average allocated capacity for Server1.

Tip: Read expression from right to left

Editing Object Properties

- Displayed in Properties Window
- Defined by object builder
- Integers, Booleans, rules, expressions, …
- **Expression editor** (down arrow at right)
- Results are filtered by default



Enhancing our Sample Model

- Expressions
- Common Probability Distributions
- Continue with the Flow Line Model
  - Expressions
  - Viewing Results
  - Resource Utilization

“Top 10” Expressions

- *X* (a number – integer or real)

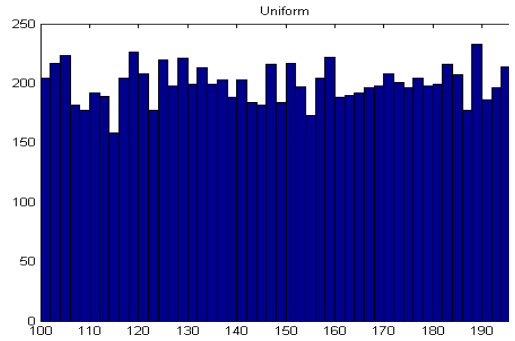
- RANDOM.*{Lots of choices, next slide}*
- MATH.*{Lots of choices, chap 5}*
- DATETIME.*{Lots of choices, chap 5}*

Key
KEYWORD
Object Name
Station Name

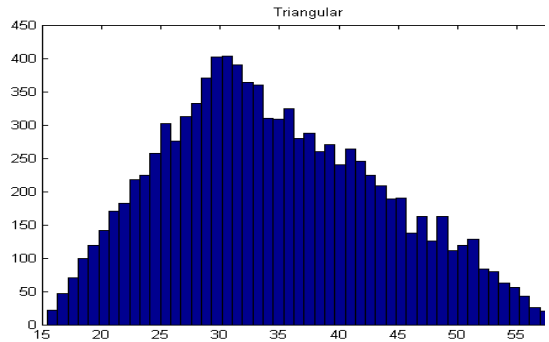
- *ServerName*.CAPACITY.ScheduledUtilization
- *ServerName*.InputBuffer.Contents
- *DefaultEntity*.POPULATION.TimeInSystem.Average
- *DefaultEntity*.POPULATION.NumberInSystem.Average
- *SinkName*.InputBuffer.NumberEntered
- *SinkName*.TimeInSystem.Average

Commonly used Random Expressions

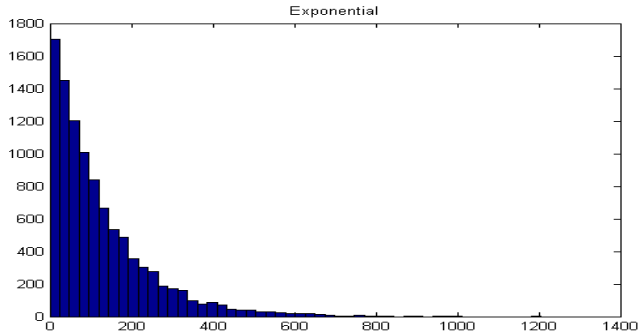
- RANDOM.Exponential(*mean*)
- RANDOM.Triangular(*min*, *mode*, *max*)
- RANDOM.Uniform(*min*, *max*)



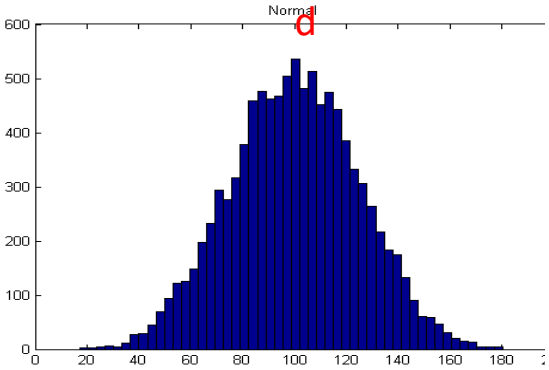
Uniform(Min, Max),Bounded



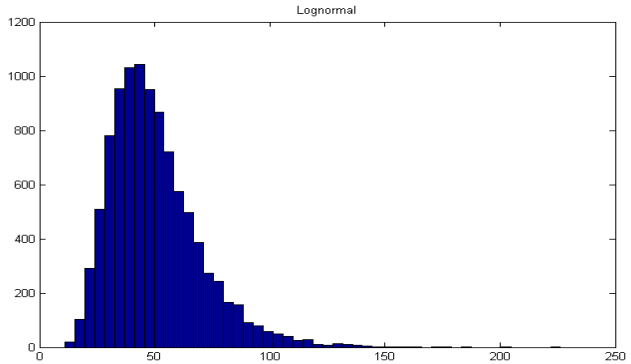
Triangular(Min,Mode,Max),Bounde



Exponential (Mean),Unbounded upper



Normal(Mean,StdDev)
Unbounded



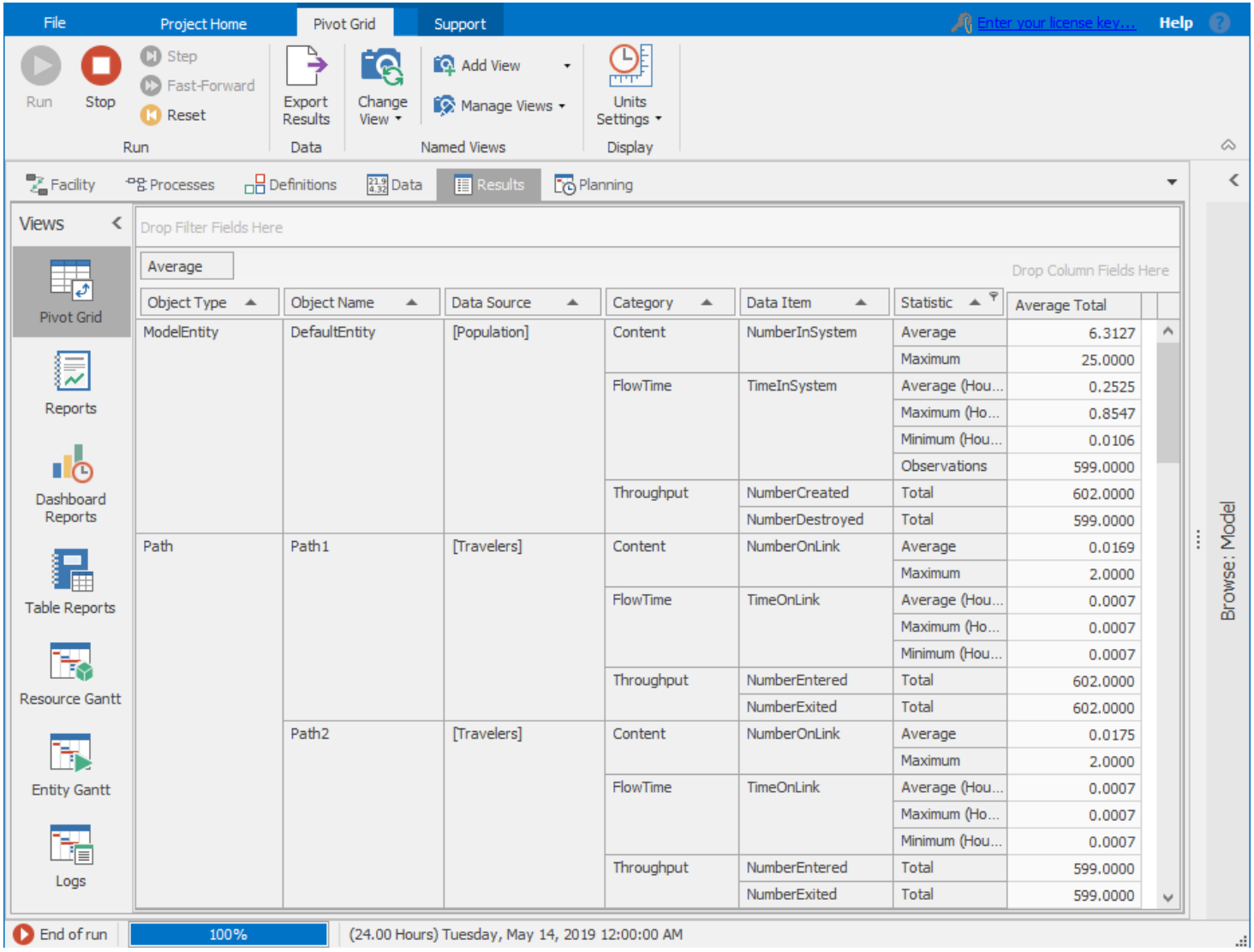
Lognormal(Mean,StdDev)
Unbounded

Simple Flow Line – Expressions

- Source1
  - Interarrival Time: Random.Exponential(2.4)
- Server1
  - Processing Time: Random.Exponential(2)
- Server2
  - Processing Time: Random.Exponential(1.71)

*Times in Minutes

Sample Pivot Table



Object Type	Object Name	Data Source	Category	Data Item	Statistic	Average Total
ModelEntity	DefaultEntity	[Population]	Content	NumberInSystem	Average	6.3127
					Maximum	25.0000
			FlowTime	TimeInSystem	Average (Hou...	0.2525
					Maximum (Ho...	0.8547
					Minimum (Hou...	0.0106
					Observations	599.0000
			Throughput	NumberCreated	Total	602.0000
				NumberDestroyed	Total	599.0000
Path	Path1	[Travelers]	Content	NumberOnLink	Average	0.0169
					Maximum	2.0000
			FlowTime	TimeOnLink	Average (Hou...	0.0007
					Maximum (Ho...	0.0007
					Minimum (Hou...	0.0007
			Throughput	NumberEntered	Total	602.0000
				NumberExited	Total	602.0000
	Path2	[Travelers]	Content	NumberOnLink	Average	0.0175
					Maximum	2.0000
			FlowTime	TimeOnLink	Average (Hou...	0.0007
					Maximum (Ho...	0.0007
					Minimum (Hou...	0.0007
			Throughput	NumberEntered	Total	599.0000
				NumberExited	Total	599.0000

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.