Learning Simio Lab Series

Overview of Lab Content

Module 1- Evaluating Potential Modifications to a Driver's License Facility

- Learn the basics of the Simio user-interface
- Learn the basics of modeling in Simio
- Using the Simio pivot grid
- Details

Module 2- Serial Manufacturing Systems Part 1

- Continue learning the basics of Simio modeling
- Understand the basics of symbols and the default object instance symbol list
- Learn about experiment responses
- Learn how to use SMORE plots
- Details

Module 3– Serial Manufacturing Systems – Part 2

- Continue learning basic Simio modeling
- Learn the event mode for the Source object
- Learn about buffer capacities for the Server Object
- Learn about reference properties
- Learn the basics of dynamic pie charts and status plots
- Details

Module 4– Simio Animation

- Continue learning basic Simio modeling
- Learn the details about Simio symbols, how to use them and how to create them
- Learn how to find and use 3D symbols from Trimble 3D warehouse
- Learn the (very) basics of using SketchUp to create 3D symbols
- Details

Module 5-Entity Routing

- Continue learning basic Simio modeling
- Learn the two different basic methods for entity routing - link selection weights and dynamic routing using node lists
- Details

Module 6-Routing with Sequences

- Continue learning basic Simio modeling
- Learn about free-space entity travel
- Lear about Routing entities with sequences
- Details

Module 7- Simio Processes and Add-on Processes

- Continue learning basic Simio modeling
- Learn about processes and add-on processes
- Learn how to use stations as detached queues for modeling entities
- Identification of version changes (5.87 to 5.91) – new commonly used properties checkbox
- [Details](#)

Module 8- Simio Tables and External Data

- Continue learning basic Simio modeling
- Earn how to use related tables and how to bind tables to external data sources
- Learn how to use rate tables for implementing non-stationary arrival process
- Learn the basics of resource schedules and arrival tables
- [Details](#)

Module 9- User Defined Statistics

- Continue learning basic Simio modeling
- Learn how to use Simio defined statistics (output, tally, state)
- Lear how to use add-on processes and resource lists to implement a customized secondary resource requirement
- [Details](#)

Module 10- Simulation-based Optimization

- Continue learning basic Simio modeling
- Learn to use Simio's simulation-based optimization tools; OptQuest, Subset Selection and KN procedure
- [Details](#)

Module 11- Vehicles and Conveyors

- Continue learning basic Simio modeling
- Learn to use Vehicle objects from the Standard Library
- Learn to use Conveyor objects from the Standard Library
- Develop a comprehensive model using conveyors and vehicles
- [Details](#)

Module 12- Defining and Using Custom Objects

- Continue learning basic Simio modeling
- Learn to create custom objects using the hierarchical method
- Learn to create custom objects using the processor object definition
- [Details](#)

Detecting and Resolving Model Errors

- Review of 3 types of model errors; syntax, runtime and logic errors
- [Details](#)

Discrepancies between videos and current Simio versions

The Simio software is constantly improving. Since the development of this spanned several months, the following changes are noted:

- Reference property default values are infinity and not 1
- Server symbols now include 5 instead of 2
- Object Properties are in different orders based on version
- "Show Commonly Used Properties" is not in older versions
- Some inherited properties which used to be visible are not
- Newer versions have more on the Results window (ex: display logs, dashboard report items)

Module 1 Details - Evaluating Potential Modifications to a Driver's License Facility

Video 2 – Initial Simio Model

- Modeling driver's license process
- Customers arrive, check in, take a written exam and checkout
- Performance metrics to be collected are =Server Utilization, Time in System, Number In System
- Use of Standard Simio library
  - Source = arrivals
  - Servers = check in, exam, checkout and process
  - Sink = departure process
  - Path = transfer between processes
- Overview of object hierarchy, definition, instance, run space
- Overview of object properties
- Overview of the Expression editor
- Overview of Run options (speed factor, run length, etc.)

Video 3 – Pivot Grids, Experiments, Verification of Model

- Looking at performance metrics Server Utilization, Time in System, Number In System - Simio tracks these automatically
- Overview of standard results on results tab and the pivot grid
- Discussion of various stats per object type, object name, data source category, data item, statistic
- How to manipulate the pivot grids
- Model verification based on expected values using a queuing network static model
- Overview of run length to ensure results are closest to expected values
- Add experiment to run multiple replications
- Use of Warm-up period to get to steady state
- Verification exercise

Video 4 – Add Computerized Exam

- Embellish model by adding a computer kiosk to replace a clerk. Kiosk can service 2 customers
- Customers choose between clerk or computer
- Embellish model to include failures
- Verify model against expected results

Video 5 – Assignments

- Compare 3 various proposed solutions in addition to the current module configurations by modifying exam times, changing the percentage of arrivals to the kiosk. Compare Server Utilization, Number in System, Time in System
- Implement failure logic. Determine maximum percentage of exam failures before system becomes unstable.
- Model a bank with an ATM and a teller. Determine Server Utilization, and Time in System for ATM, Teller and Manager

Module 2 Details - Serial Manufacturing Systems Part 1

Video 1 – 3-Stage Manufacturing System Model

- Build initial model. Parts arrive, are sent to a machining process and then a grinding process. Ten percent are deemed bad after grinding and disposed of. Good parts are sent to packaging.
- Verify model against a static queue model
- Creation and interpretation of model experiments

Video 2 – Intro to Symbols

- Review of Visibility Ribbon
- Changing the look of the entity (Parts) as they go through system)
- Review of Symbol ribbon and Symbol List
- Adding additional entity symbols, changing colors
- Use of animation property on objects to change entity symbols
- Same with server symbols (NOTE: additional server symbols included in 5.97)

Video 3 – Experiment Responses

- Definition of responses (expression that is evaluated at the end of a replication that can have units, objectives and upper and lower bounds)
- Develop responses for Server Utilization, Avg. Time in System and Avg Number in System for part entities
- Review of responses in experiment against pivot grid
- Review of SMORE plot of response values
- Increase replications to reduce confidence interval half width to in order to reduce sampling error

Video 4 – Assignments

- Embellish the model to include inspection steps where the percentage that requires rework will go through a rework process. Fifty percent of those are scrapped.
- Create responses for inspection and rework utilization as well as for Time in System for good and scrapped parts
- Use expression editor to create responses for the number of parts in the input buffer at packaging station

Module 3 Details - Serial Manufacturing Systems – Part 2

Video 1 – System Description and Initial Model
- Starting with a serial manufacturing line with 4 servers, perform capacity analysis. Determine impact of buffer size on capacity of system
- Assume infinite supply and demand of parts
- Change pictures of entities as they move through servers
- Change arrival mode to be On Event when an entity exits the output node of server 1
- Define experiment and standard responses (Utilization of servers, Number in System, Time in System). Run model for 200 hours with a warm-up of 100 hours.

Video 2 – Capacitated Buffers and Reference Properties
- Change buffer capacities using reference properties and compare results against various configurations
- Begin with buffers at 0 and 1, and then vary size
- 91 vs 97 difference - Controls group at bottom instead of top of property window
- 91 vs 97 difference - Default reference properties values of infinite in 97 and 1 in 91
- Compare throughput (total parts processed/runtime) based on buffer capacities
- Use of reference properties of buffer2, buffer3 and buffer4 as controls in experiment

Video 3 - Resource States, Pie Charts, Status Plots
- Create Dynamic plots in interactive mode
- How to use Simio help, general help discussion and examples
- Description of list states (auto generated)
- Create status pie charts for list states associated with resource, via Quick Create or Animation ribbon
- Create status plots for Average Number in System. Visualize effect of warm-up period on the graph

Video 4- Assignments
- Create experiment responses for Average Number of Parts in buffers between servers M1 and M2, M2 and M3 and M3 and M4.
- Create status plots showing Average Number of Parts in the same buffers
- Embellish model to vary processing times at servers with the maximum total buffers=20. Find the buffer allocation that maximizes part throughput
- Embellish the model with 5% failure rate. Determine if optimal buffers as a part of the failures

Module 4 Details - Simio Animation

Video 1- Symbols Revisited
- Review of Symbols for Entities, Queue States, Status Labels and Server Objects
- Add new entity symbols from Simio project symbols (ex: library\people) from Symbol Ribbon. Add additional symbols, change color, delete symbols
- Add Symbols that animate (ex: walk) – library\people\animated
- Change server symbol from project symbols
- Change entity picture upon leaving server using state assignments
- Animate queues (oriented point, adding vertex)
- Ass Status labels – attached and detached to objects (server and path)
- 91 vs 97 difference - Dynamic Label Text is a property in 97 and in 91 (as in video)
- 91 vs 97 difference – Additional animations of server object in 97

Video 2 - Shop Floor Model Part 1
- Use of floor layouts and Trimble 3D warehouse
- Import jpg layouts. How to position and resize
- Download existing 3d objects from Trimble 3D warehouse. How to resize. How to change entity and server symbols (change to wood, table saw, drill bit, etc..)
- Placement of processing areas and queues around imported objects so they make sense
- Symbol of shelf for queue, how to make it look like parts are on a shelf

Video 3 - Shop Floor Model Part 2
- Review status labels. How to attach status labels to entities
- Floating label – label remains upright in 3D
- Floor Label – moves as though it's part of the floor. More edit options and expression options
- Basic drawing tools (rectangle, polygon, etc…). How to make walls, how to draw in 3D
- Creating your own symbols that can be used anywhere in the model
- How to use Google SketchUp. NOTE: SketchUp 2013 file formats not compatible with Simio. Must save in a previous SketchUp version.

Video 4 – Assignments
- Use given office layout and create an animated model for the office
- Use a service type model where people are animated entities. Use several server objects with symbols created of from Trimble 3D warehouse

Module 5 Details - Entity Routing

Video 1 - Using Selection Weights for Routing

- Basic use of selection weights. Calculation is weight of a link divided by sum of all weights (ex: doesn't have to add to 1)
- Use of selection weights on paths
- Use standard queuing metrics. Compare to static queuing model
- Additional use of response results, increasing replications
- Additional use of SMORE plots
- Use reference properties to compare two scenarios – the difference in processing times between an exponential and uniform distribution

Video 2 - Conditional Routing Using Selection Weights

- Use of conditional routing based on the number of part failures. Tacking number of failures via the entity state
- Verify entity state assignments by adding a tallies on the sinks
- Add the number and maximum failures to the design responses
- Change entity color to reflect number of failures
- **91 vs 97 difference**
  - In Simio 91, if an object's Current Symbol Index value was 'out of range' based on the value assigned and symbols defined, a large warning would appear and temporarily halt the simulation model. We have now changed this behavior such that if an object's animation symbol index is not within the defined range, an animated exclamation point, as shown below, is shown over the symbol with a warning displayed when the animation is paused and mouse hovered over the object. After several user's feedback on the original method, we have changed this warning to be less obtrusive and hopefully more suitable to all users.
- Add condition logic on paths to not allow more than 3 failures on an entity

Video 3 - Dynamic Routing Using Node Lists

- 3 servers have varying processing times
- Entities select a server based on which one will be available first (not necessarily shorted processing time)
- Using routing logic, select entity destination on the output nodes
- How to create and use a node list
- Use of preferred order selection for routing
- Use of smallest value selection goal (associated station overload) as well as number in queue + in process

Video 4 – Assignments

- Embellish model to immediately reject part after 3rd failure. Create reference properties for the max number of failures allowed and compare with configuration values of 1, 2,3,4,5,100.
- Use dynamic routing model from 3rd video and develop an experiment with 25 replications of run length of 500 hours and 250 hour warm-up.
- Create responses for 3 server utilizations, time in system, number in system; compare the 5 performance metrics using a various routing alternatives such as probabilistic using selection weights, preferred order, associated station overload and shortest queue length

Module 6 Details - Routing with Sequences

Video 1 – System Description and Initial Model

- Model of a Healthcare Clinic with stations/offices (registration, triage, treatment, lab, etc…) and patient types (walk in, lab only, etc..)
- Patient routing sequences by patient type
- Validate against typical queue model
- Use Entity sequences to define sequence of station visits
- Overview of Data tab and adding a sequence table
- Define which sequence entities follow (entity destination = by sequence)
- Overview of free space travel. No connectors required

Video 2 –Initial Model (continued)

- Add arrival rates for entities and processing times for stations
- Set up experiment to compare actual results to expected results and review in pivot grid
- Create view in pivot grid
- Discovery of an error in a value. Emphasize the need for the verification process

Video 3 –Using a single sequence table and source

- Adding a Data table (patient types) where the object reference column= patient type. Patient Type column as key.
- Define patient type sequence in the single sequence table where patient type=foreign key.
- Use a single source to use the patient type table. Identity the patient type and routing sequence using given probabilities for individual patient types
- Add a new property to patient type table called mix which stores the patient type probability
- On source object, use the table reference assignment to connect to the patient type table. Before the entity is created, look at mix in table to determine patient type.

Video 4 –Assignments

- Increase patent arrival rate by 5% and asses if system can handle the increase. Try 7% and 10%. Compare patient wait times by patient type
- Add another patient type and can system handle new patient type. If not, recommend changes.
- Replace free space movement with path and clinic layout. Use reasonable distances between stations and develop an animation

Module 7 Details - Simio Processes and Add-on Processes

Video 1 –Using Add-on process: TV Adjust/Inspect model revisited
- Review of a detached queue; a queue not connected to an object
- Definition of processes (flow charts). Actions that can change the state of a system (seize object, delay for specific time, etc…)
- Definition of tokens, which execute processes. Tokens carry references to parent and associated objects
- Various Process definitions (standard, add-on and event-triggered)
- Replacement of a tally statistic (number of failures) with a process
- Created 3 add-on processes to 1) replicate state assignment, 2) replicate tally assignment and 3) calculate a selection weight

Video 2 –Using Stations with Add-on process
- Key concepts – stations, add-on processes, search step, user defined events
- Station definition peer Simio
- Created add-on processes that define detached queues and movement of entities from station 1 to station 2 at specified time.
- Add user defined event to move entities from station 1 to station 2
- Add source-sink logic to move entities from station 1 to station 2
- Add source-sink logic to move from station 2 to server 1
- Pull from detached queues on specified events

Video 3 –Building a "Process Model"
- Build a single server queuing model out of processes – no library objects
- Define a timer. The timer triggers the process of seize-delay-release
- No entities – only tokens
- Create process to collect time in system – use special token add assign and tally to process
- Create process to collect number in system – add integer state to track work-in-progress, piggyback on assign step
- No source, entity or server objects used. Resource object used for automatic statistic collection
- Advantages over standard library – flexibility (ex: can add balking rules, etc...)

Video 4 – Assignments
- Embellish model from video 2 to add 5% fail inspection rate. Record the count of rejects and destroy entity in the add-on process. Animate model.
- Embellish model from video 3 to model an amusement park ride. Interested in average group size per ride, load process utilization, ride process utilization and waiting time when load process starts. Run for 10 reps length of 160 hours

Module 8 Details - Simio Tables and External Data

Video 1 –Related Tables and Binding to External Data Sources

- Create a part type data table. Create sequences table for routing
- Bind data to external data source; export part sequences table to csv file
- Bind Part Sequences table to an external worksheet. Binding options are automatic (import data at start of a run) or manually

Video 2 –Rate Tables

- Development of a model of a hot dog stand. Open 9am-3pm, 210 arrivals per day. Arrival rates vary over time (non-stationary arrival process).
- Input data from Excel as a rate table. Note rates are in arrivals per hour
- Tell source object to use rate tables for customer arrival rates
- Create responses to measure server utilization, number in system, time in system
- Plot maximum number in system to visualize arrival patterns

Video 3 – Schedules and Arrival Tables

- Change in capacity in previous vide based on arrival rates. Arrival table=read external data that specifies arrivals to system
- Add work schedule to change server capacity based on arrival pattern
- Review of writing data to an external data file

Video 4 – Assignments

- Embellish model so hot dog stand is open 9am-9pm. Add dinner rush arrivals and extend arrival process. Develop experiment responses for average server utilization, average and maximum time in system and average and maximum number in system
- Embellish model in video 1 to support orders arriving on a schedule. Data is in an Excel workbook. Assume arrivals can deviate from schedule + or - 10 min. Create an experiment with responses for average time in system for all parts and number parts completed.

Module 9 Details - User Defined Statistics

Video 1 – Emergency Department Model
- Use of resource objects to identify which types of resources (doctors and nurses). Initial capacities are reference properties
- Use of Add-On process triggers before and after processing to determine the secondary resource requirement.
- Use of Preferred Order of lists (Doctor or Nurse or Nurse or Doctor)

Video 2 – Adding User Defined Statistics
- Want to track waiting time between arrival until patients have exam room as well as when a doctor/nurse gets there
- User defined statistic = Wait time = time to get exam room +time to see doctor/nurse.
- Waiting Time = TimeNow –ModelEntity.TimeCreated

Video 3 – Adding User Defined Statistics (cont.)
- Want to track number of patients in system at any given time
- Add integer state variable (from Definitions) called NumPatients. Increment when a patient arrives (on Source) and decrement when patient leaves (on Sink)
- Add output statistic to calculate total cost (total patient waiting hours + resource capacity costs)

Video 4 – Assignments
- Add a new user defined statistic to track number of non-urgent patients
- Add new user defined statistic to measure patient throughput. Use statistic to determine if system is stable
- Add new user defined statistic for patient satisfaction (wait time <= .5 hours)
- Create experiment to find best resource capacities (in terms of cost) subject to patient satisfaction of at least 80%. Demonstrate stability

Module 10 Details - Simulation-based Optimization

Video 1 – Simulation-based Optimization
- Starting with project created in Module 3.
- Want to select the "best" allocation of 10 buffer slots using best (max) throughput measure
- Use OptQuest to identify possible scenarios of buffer space based on constraint
- Use Subset Selection analysis to identify candidates. Ranking and selection routine on active scenarios based on best of the possible configurations. Need to have at least 10 replications
- Use of KN procedure to identify the best alternative. Model runs until it identifies the best alternative or the maximum number of replications have been exceeded

Video 2 – Emergency Department Model Revisited
- Review of ED model and modifications to add-on processes
- Calculate number of satisfied and unsatisfied patients for all patient types. Added logic in the add-on processes.
- Add output statistic to calculate the satisfaction value. Also add a response for the satisfaction value

Video 3 – Emergency Department Model Revisited (cont)
- Use model from previous video
- Want to minimize cost and maximize patient satisfaction
- Limiting capacities (constraints) and meet satisfaction level (requirements)
- Use OptQuest to determine potential solutions and highlight those that do not meet requirements
- Use Subset Selection and KN to further identify potential optimal scenarios

Video 4 – Assignment
- Embellish model by creating reference properties for patient satisfaction threshold, nurses cost, exam room cost and wait time cost
- Create an experiment to test the above configurations. Run OptQuest optimization on the various configurations

Module 11 Details - Vehicles and Conveyors

Video 1 – Vehicles

- Vehicle object basics; initial node, initial speed
- Review of Transfer Nodes and Ride On Transporter property
- Use of spurs and bi-directional movement
- Increase vehicle capacity by 1) increasing initial ride capacity, 2) use population parameter on vehicle to make additional copies of vehicle and 3) creating a second vehicle instance – can mix and match
- Use of transporter lists

Video 2 – Conveyors

- Conveyor basics - accumulating, non-accumulating, speeds, paths and path decorators
- Creation of a simple model with multiple sources, conveyors of varying speeds, merge points and varying buffer capacities

Video 3 – Assignment

- Create a model of a packaging line with 3 arrivals via conveyors then go to a merge point. They then move onto a labeler, palletizer and then shrink wrap. A forklift (vehicle) takes the packages to shipping
- Model above given a set of buffer capacities, processing times, conveyor speeds, load/unload of forklift
- Animate model and modify model changing the number of forklifts required and the number of pallets a forklift can carry

Module 12 Details - Defining and Using Custom Objects

Video 1 – Building Hierarchical Objects

- Create tandem model out of 2 connected servers. Define reference properties for processing times and identify where they appear in the properties list
- Review of inherited properties and if they are visible or not
- Review of external view (what user sees)
- Define external nodes and map to input node server 1 and output node server 2. Add queues and processing buffers to view. Add status label to display the number exiting the tandem model
- View statistics of tandem that come via standard objects

Video 2 – Building Hierarchical Objects (cont)

- Start with tandem object from previous video
- Creation of models within models
- Create a library of objects
- Develop logic from standard or custom libraries
- Define external view
- Add external nodes where appropriate
- Save project as a file to be loaded as a library

Video 3 – Using the Processor Object Definition

- Building a Processor object (or building model from scratch)
- Adding a processor model, by default, adds an input node, output node and station.
- Object designer must incorporate the logic
- Add a Delay to the processing logic

Video 4 – Assignments

- Create a project with 2 custom objects – one using hierarchical method and other using processor

Detecting and Resolving Model Errors

- 3 classes of model errors; Syntax, Runtime and Logic
- Syntax Errors - incorrect use of the language or constructs such as misspelling of keywords, use of reserved words or referencing undefined states, statistics, etc.
- Generally easy to find and fix once you understand the rules of Simio
- Runtime Errors – program errors during simulation a run even though the model is syntactically correct (ex: missing paths, exceeding maximum number of entities)
- Runtime error messages generally provide enough information to resolve the error
- Logic errors – simulation runs but is not reflective of the system you are modeling
- Simio has tools to help resolve logic errors
    - Carefully watch animation
    - Enhance animation with debugging and messages
    - Watch – ability to view the values of an object's states, functions and elements during the run
    - Breakpoints - causes the execution of the model to pause when an entity or a transporter arrives to the specified object, node or link or when a token arrives to the specified step.
    - Model Trace - allows you to see exactly what is occurring during the simulation run with each step that occurs.
    - Subclass object – allows you to break down an object in a library so you can see at the process level how an object works
    - Notify Step - used to output a user defined trace or warning message