SIMULATION WITH ARENA

Simulation

- Simulation is a numerical technique for conducting experiments on a digital computer, which involves logical and mathematical relationships that interact to describe the behavior and structure of a complex real world system over extended periods of time [1].
- Simulation refers to a broad collection of methods and application to mimic the behaviour of real system usually on a computer with appropriate software.

What is being modelled

- A manufacturing plant
- A bank with different kinds of customers, servers, etc.
- A distribution network of plants, warehouses and transportation links
- An emergency facility in a hospital
- ……

Simulation languages

- GPSS, SIMSCRIPT, SLAM AND SIMAN
- Arena is based on the SIMAN simulation language
- Arena combines modules to build a fairly wide variety of simulation models.

Different kinds of simulations

- STATIC VS DYNAMIC –Time doesn't play a natural role in *static* model but does in *dynamic* models.
- Manufacturing system model describes dynamic model and Arena is primarily focus on such models.

Continuous vs Discrete

- In *Continuous* model state of the system can change continuously over time.
  E.g. Levels of a water reservoir falls due to evaporation occur.
- In a Discrete model change can occur only at separated points in time.
  E.g. A manufacturing system with parts arriving and leaving at specific time
- Arena is mostly focused in discrete models.

Deterministic vs stochastic

- Model that have no random input are *deterministic.*

E.g. Strict appointment-book with fixed service time

- *Stochastic* models operate with at least some inputs being random.

  E.g. A bank with randomly arriving customer requiring varying service times

General-Purpose Languages, Simulation Languages and High-Level Simulators

General-Purpose Languages:

- Highly customizable and flexible
- But painfully tedious and error prone

Simulation Languages:

- Provide much better framework
- Still have to invest a bit of time to learn about their features and how to use them effectively

High-Level Simulators:

- Very easy to use
- Operate by intuitive graphical user interface, menus and dialogs
- Select from available simulation-modelling constructs, connect them, and run the model
- Dynamic graphical animation of system components as they move around and change
- Domains of many simulators are rather restricted (like manufacturing or communication)
- Generally not flexible

Performance measures

- Total production
- Average waiting time in queue
- Maximum waiting time in queue
- Time-average number of parts waiting in the queue
- Maximum number of parts that were ever waiting in the queue
- Average and maximum total time in system
- Utilisation

PIECES OF A SIMULATION MODEL

Entities:

- The dynamic objects in the simulation that move around, change status, affect and are affected by other entities and the state of the system, and affect the output performance

- They usually are created, move around for a while and then are disposed (leave)

  E.g. parts to be processed, customers in a banking system, etc

Resources

- Entities often take the service from resources.
- An entity seizes a resource when available and releases it.

  E.g. Machines, Server

Attributes

- Attributes are generally attached to individual entities

  E.g. Part entities have attributes called due date, priority, colour, etc.

(Global) Variables

- A piece of information that reflects some characteristic of your system, regardless of how many or what kinds of entities might be around
- Many different variables are possible in a model
- In Arena there are two types of variables:
  - Built-in variables (number-in queue, number of busy servers, current simulation clock time, and so on)
  - User-defined variables (mean service time, travel time, current shift, and so on)

Statistical Accumulators

- To get the final output performance measures, it is necessary to keep track of the variables as the simulation progress and such variables are called statistical accumulators
- Arena take care of most of the statistical accumulation

Event

- Something that happen at an instant of time that might change attributes, variables or statistical accumulators

E.g. Arrival – A new part enters the system,

Departure – A part finishes its operations (service) and leaves the system

Queues

- When an entity can't move on (due to unavailability of resource) it needs a place to wait, which is the purpose of a queue.

Simulation Clock

- Current value of time in the simulation held in a variable is called the simulation clock
- Simulation clock and event calendar are the important pieces of any dynamic simulation

Starting and Stopping

- Starting and stopping conditions should be specified
- It is important to think about these conditions and make these conditions consistent with what you are modeling

- You may have to think about whether it should stop at a particular time or it should stop when something specific happens (like as soon as 100 finished parts produced when a production shop is simulated)

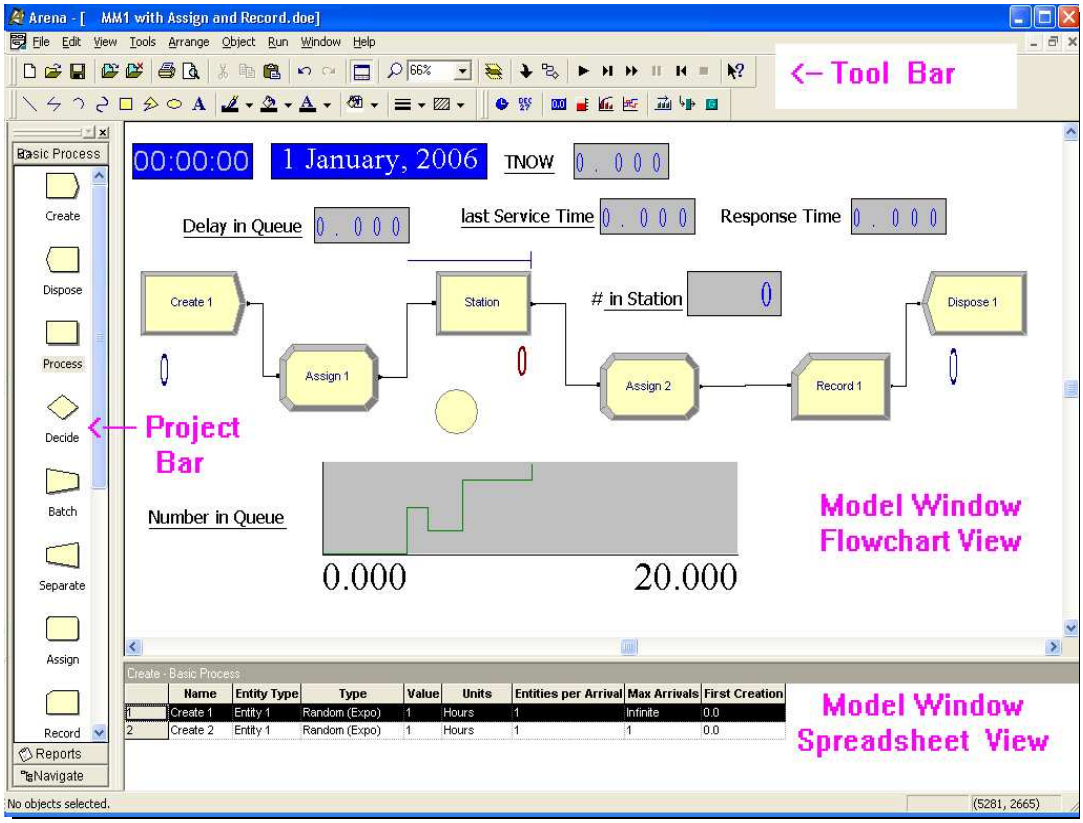
Replication

- Each run starts and stops according to the same rule and uses same input parameter setting (statistically identical) but use separate random numbers (independent)

ARENA

- General-purpose simulation package
- Process-oriented
- High-level (very easy to use by graphical user interfaces, menu and dialogues)
- Animation
- Model building
  - Drag-and-drop modules into model window
  - Connect them, so define flow of entities
  - Detail modules and entities in dialog boxes and in spreadsheet
- Run independent replications

ARENA WINDOW



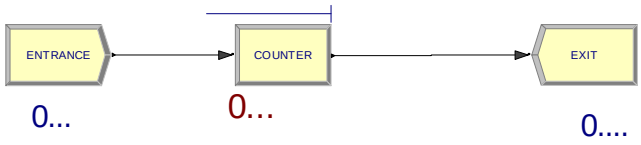
Models are described with ARENA version 11

SOME DETAILS FOR ARENA MODELLING

EXAMPLE: A SINGLE COUNTER TRANSACTION

- Customers arrive randomly: described by a distribution
- Transacts business: single counter
- Leaves
- E.g.: an ATM counter

Arena model



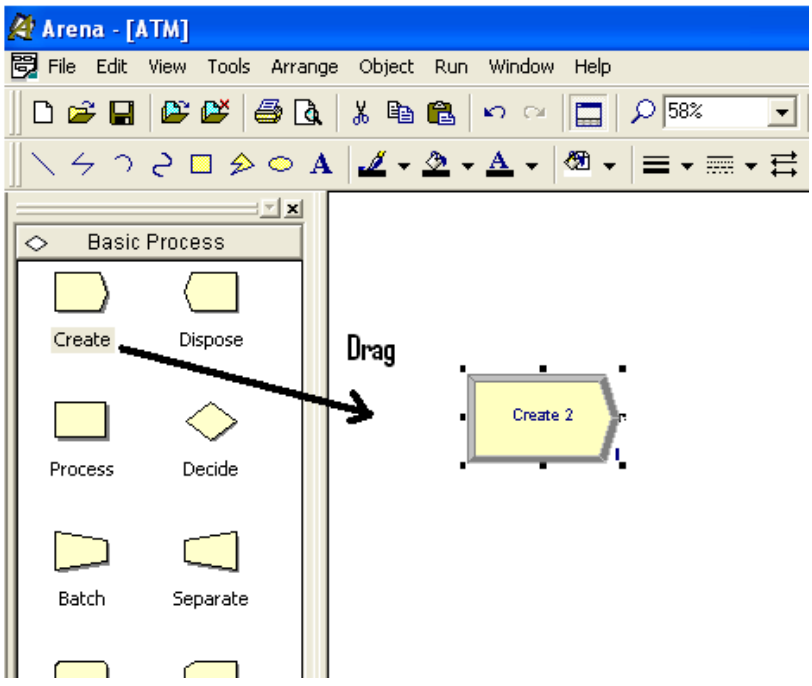
Play the 'ATM 2.exe' file to know the method of data inputting in this model.

Modules

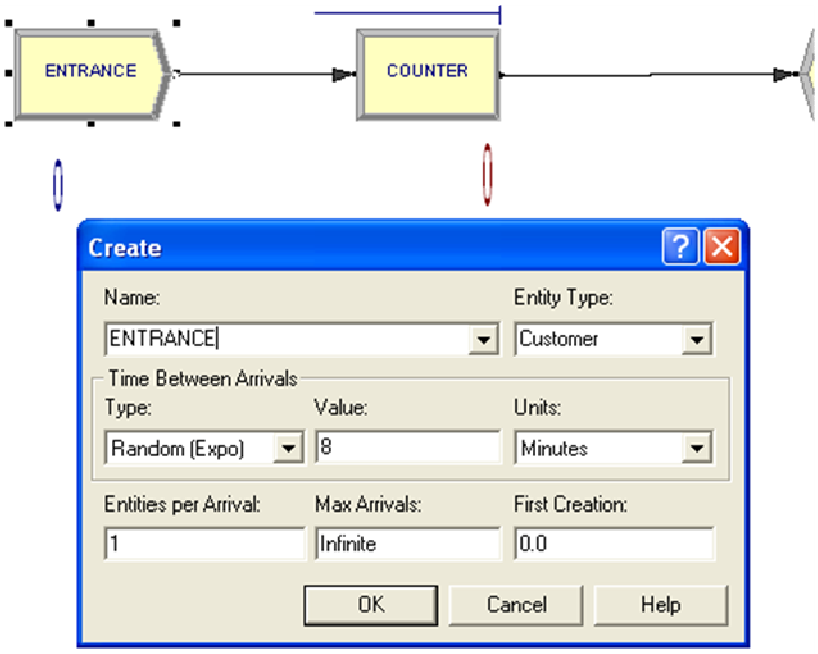
- Flow chart modules & Data modules
  - Basic modules
    - Create
    - Process
    - Dispose

Advanced modules

Model building

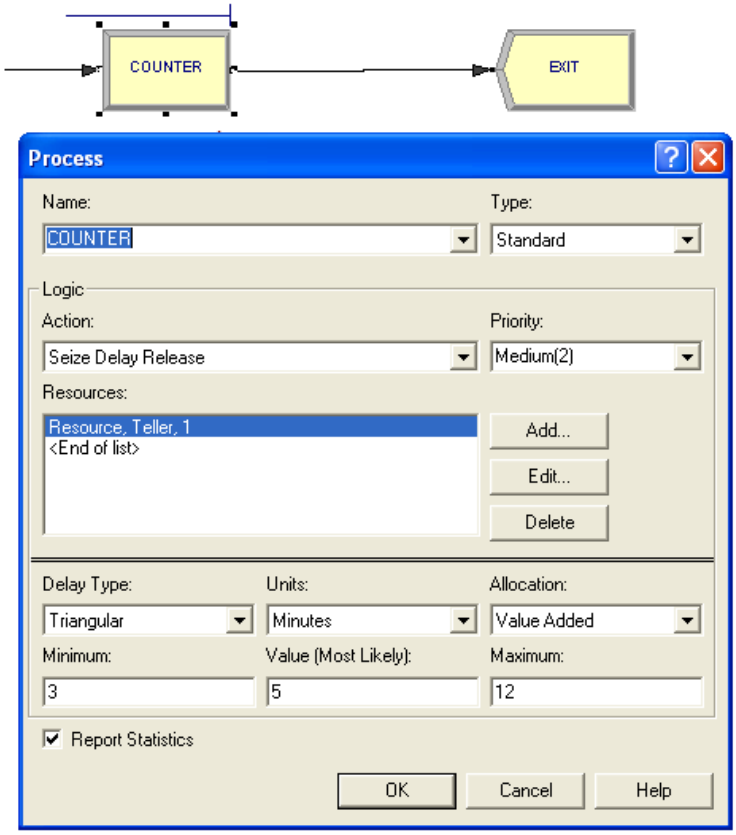


Create module



- **Name**
- **Entity type**
- **Time between arrivals**
- **Entities per arrival**

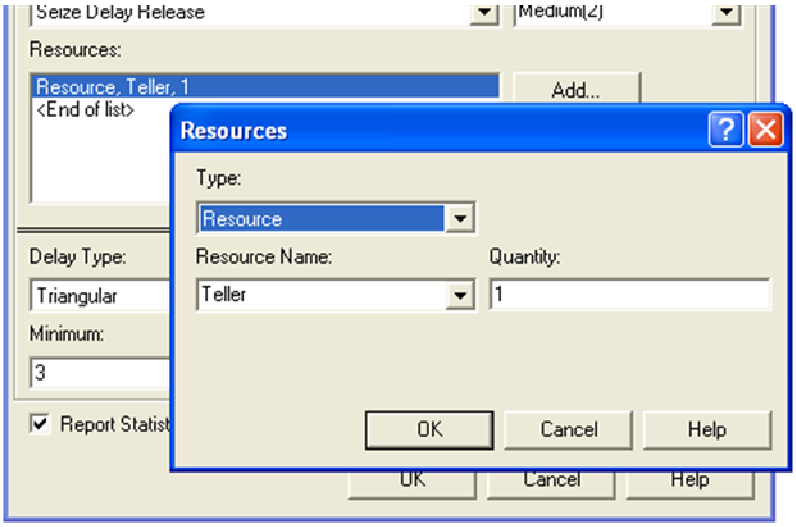
Process module



- **Name**
- **Action**
- **Resources**
  - **Add**
- **Delay type**

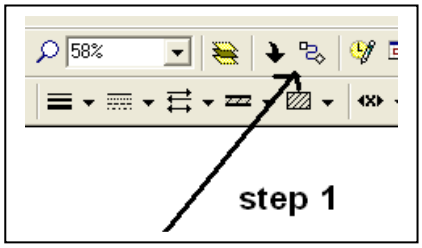
Adding resources

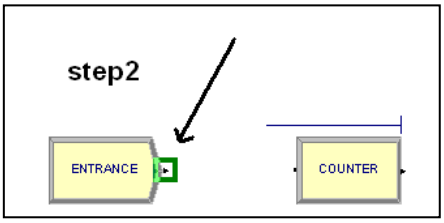
- Give the name of resource that do the processing
- Quantity: quantity of the above resource required to do the processing

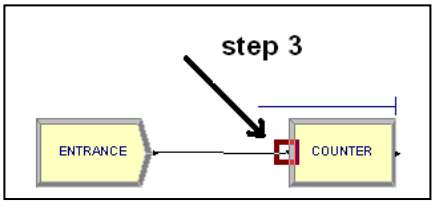


Caution: If same resource name is added in another process module, the same resource will have to do both processes

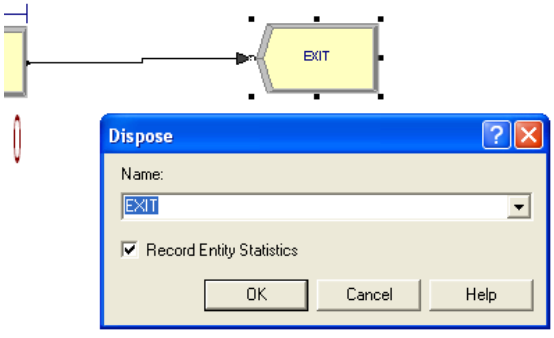
Connecting







Dispose module



Run Setup

- No. of replications
- Replication length
- Warm-up period

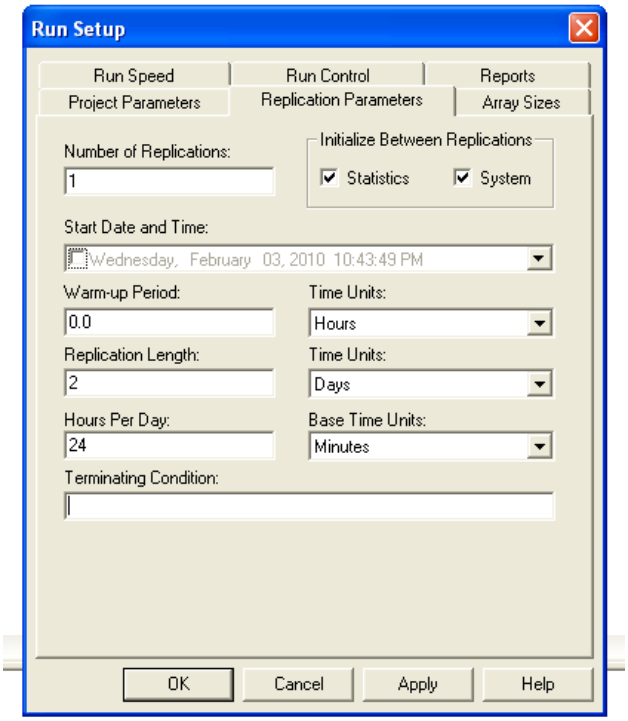
Run without animation

Tool bar

Run

Run control

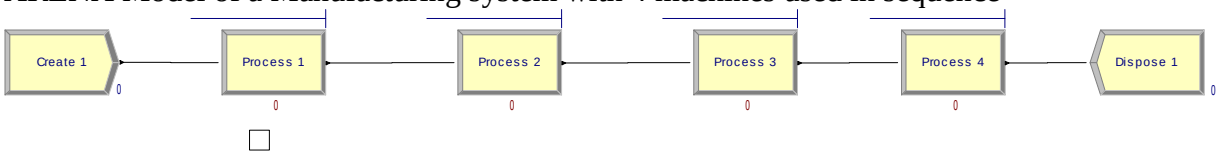
Batch run



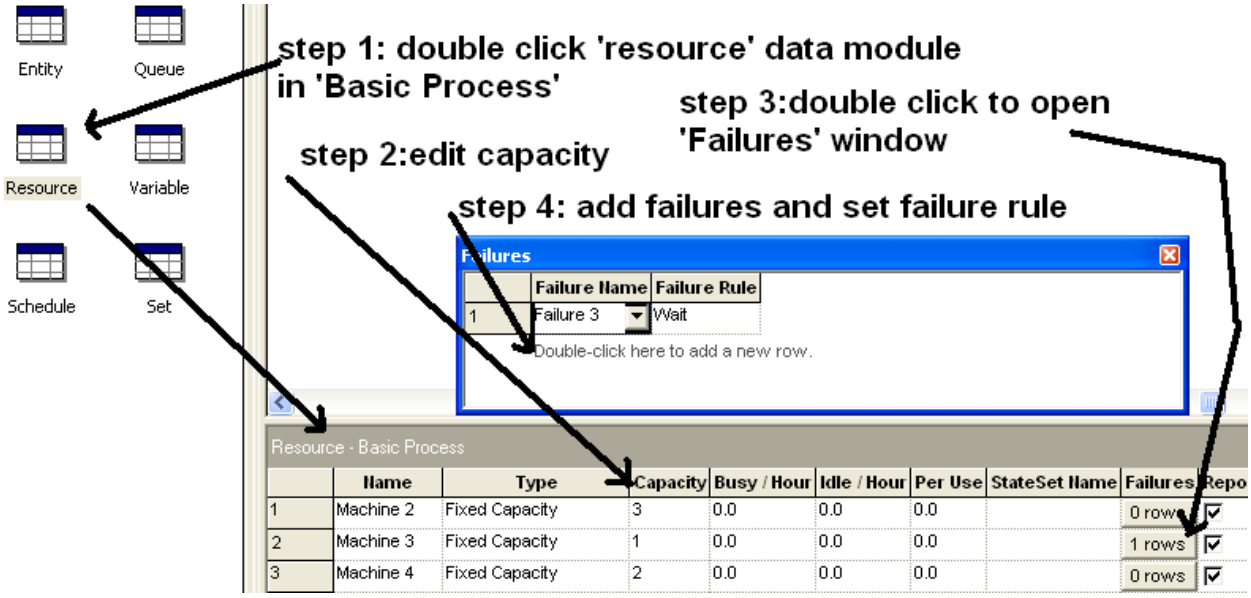
EXAMPLE 2: A MANUFACTURING SYSTEM

- Stations with multiple servers
- Machine failures defined
- Pictorial representation of machine state

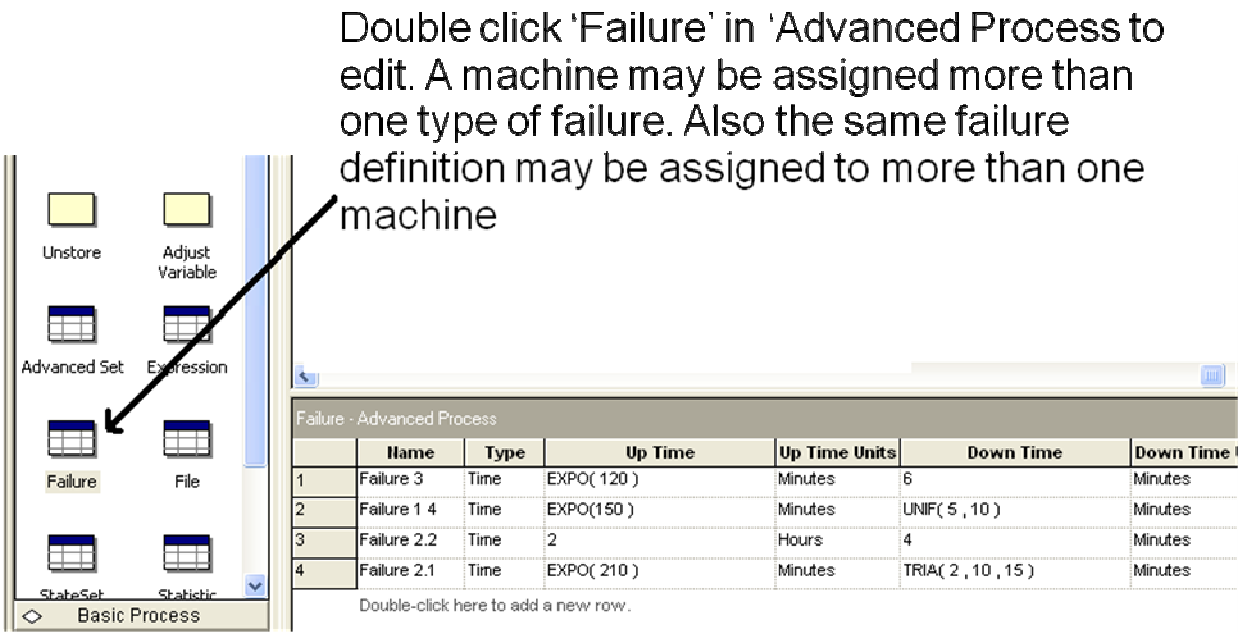
ARENA Model of a Manufacturing system with 4 machines used in sequence



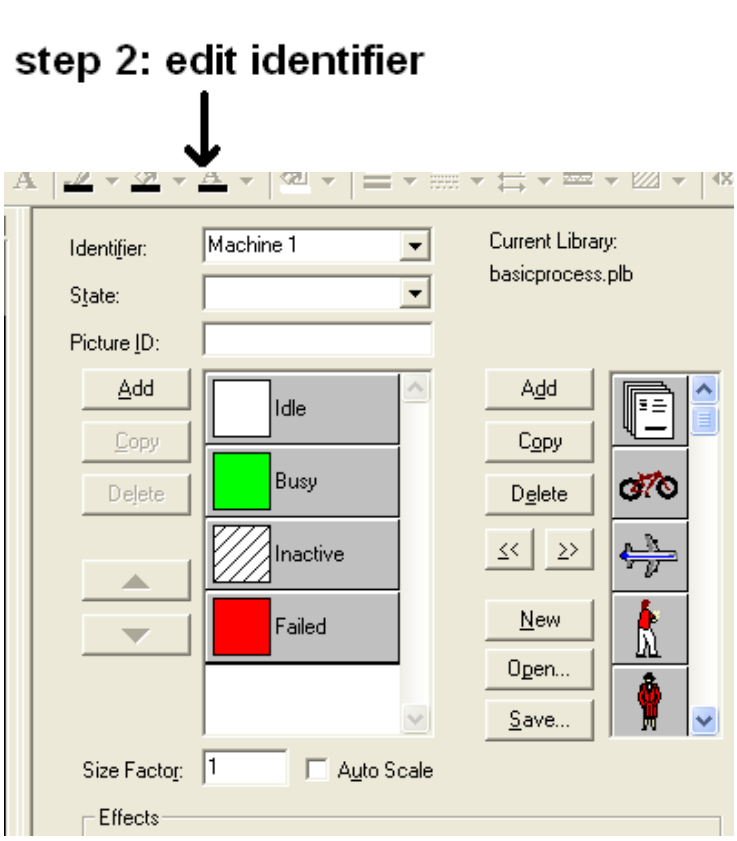
Setting capacities & assigning failures

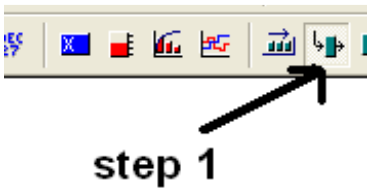


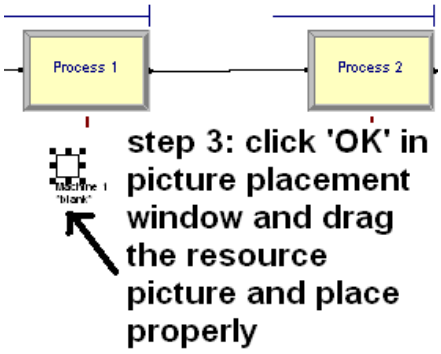
Failure definition



Machine state representation







Using schedules: for resources & arrivals

EXAMPLE 3: A BANK

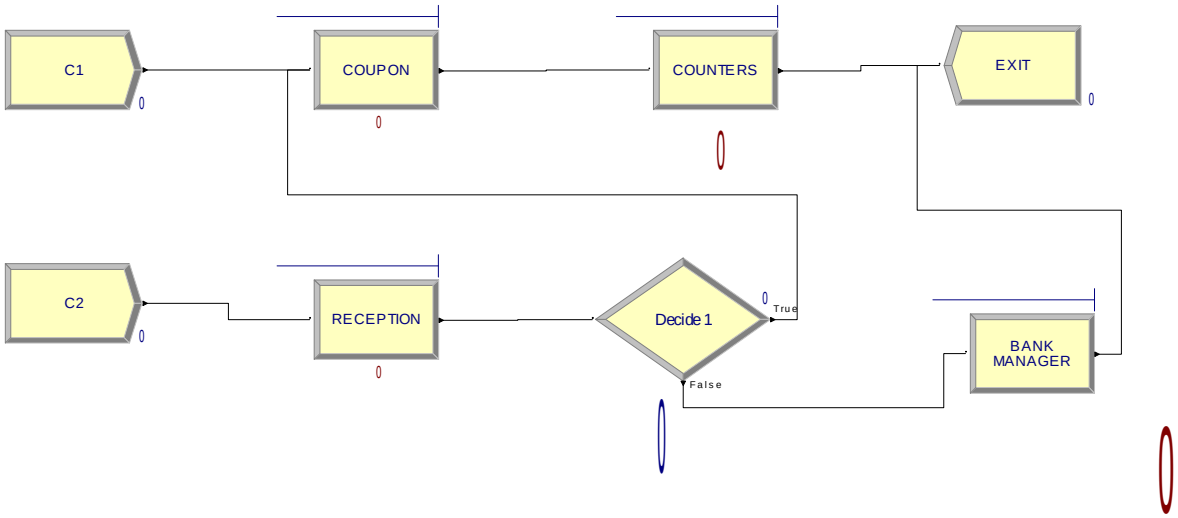
Tellers: no. of tellers vary during the day
- Calendar based
- Default value type: numeric

Manager: Availability based on time of day
- Calendar based
- Default value type: state

Arrival: Rate of arrival depends on time of day
- Duration based

Customer arrives to a bank; some of the customers collect coupon and proceed to a counter (teller) for processing. Another stream of customers directly goes to a receptionist and then proceeds either to the Bank manager or for coupon collection and then to the counter.

ARENA Model

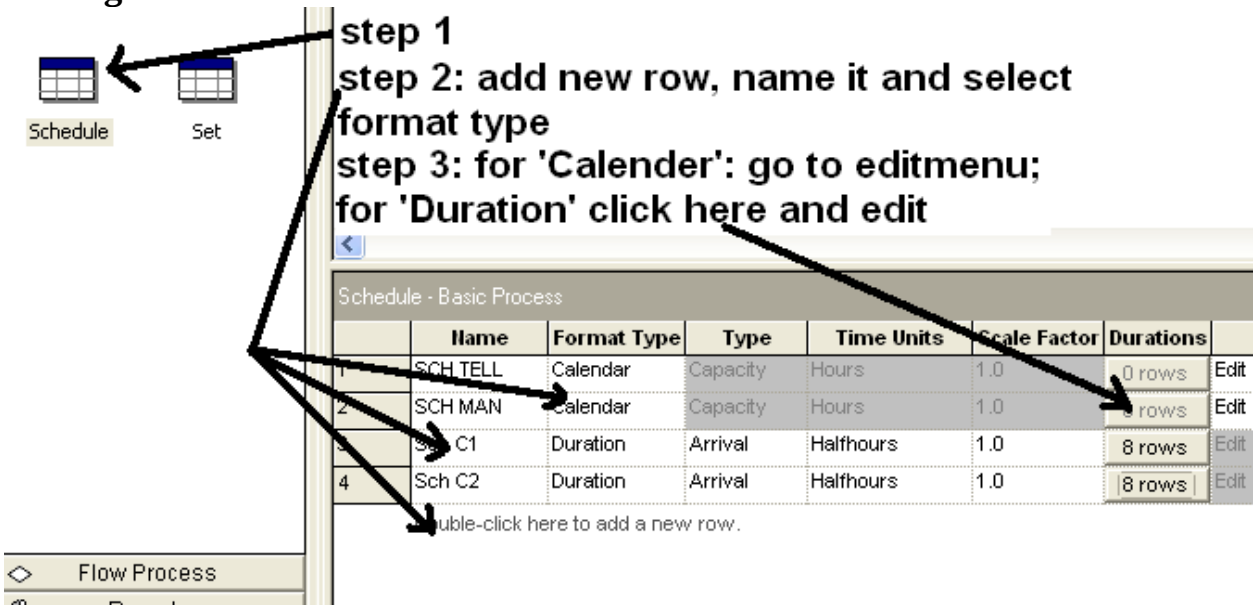


Creating schedules

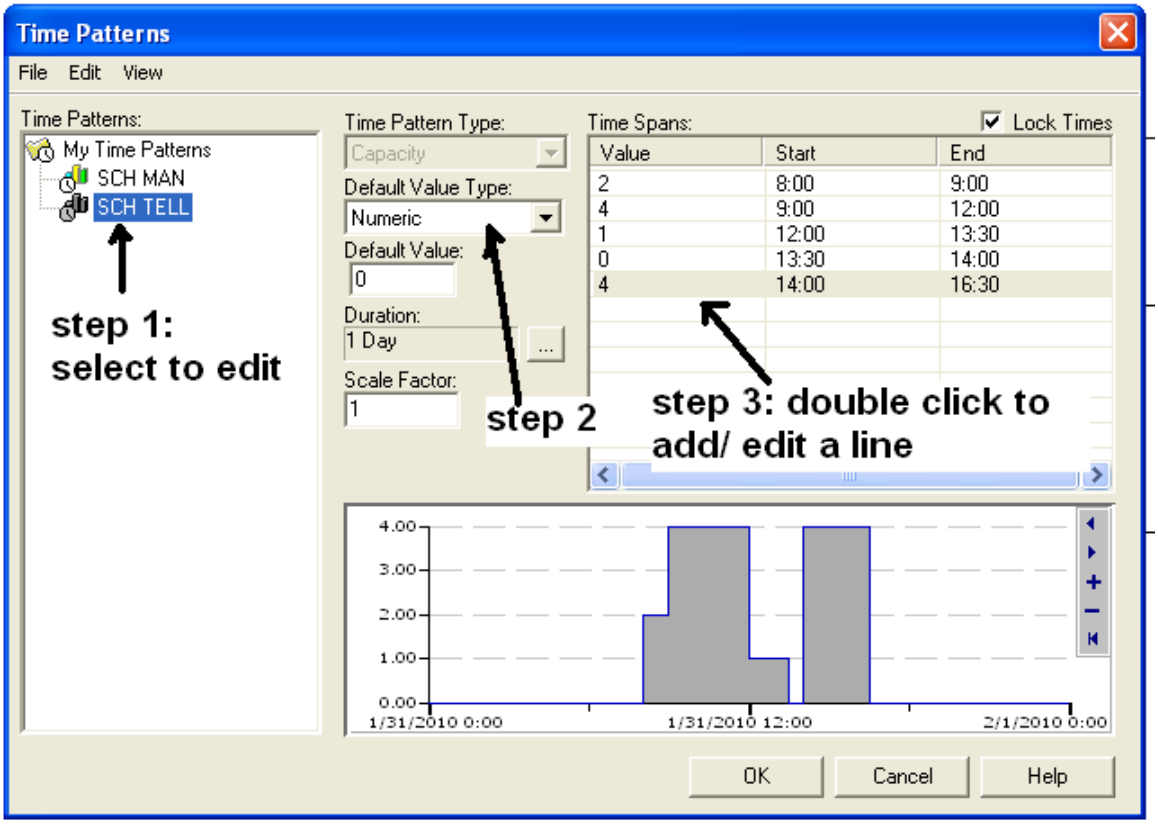
Click ‘Schedule’ in ‘Basic Process’
Add and name a new schedule
Select format type

- For calendar type
  - Go to: Edit – Calendar schedules- Time patterns: select the name & edit
- For duration type: click ‘durations’ in ‘schedule’ spread sheet itself & edit

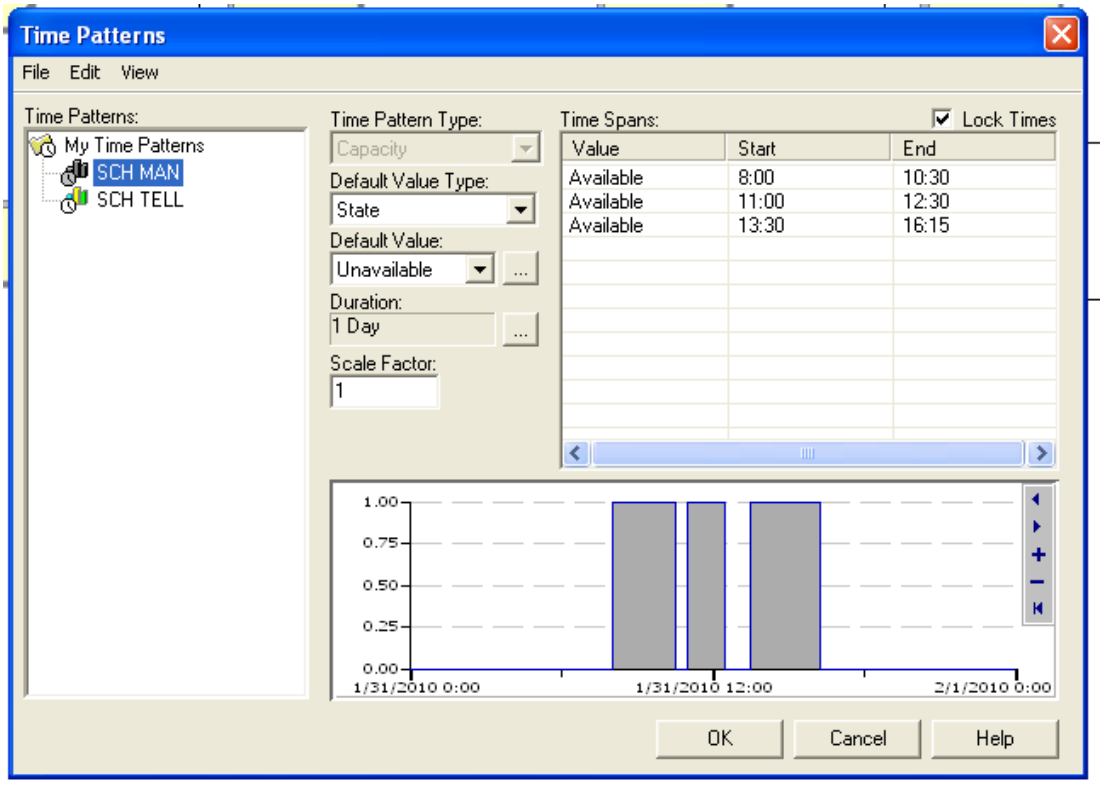
Editing schedule



Numeric value type



‘State’ type



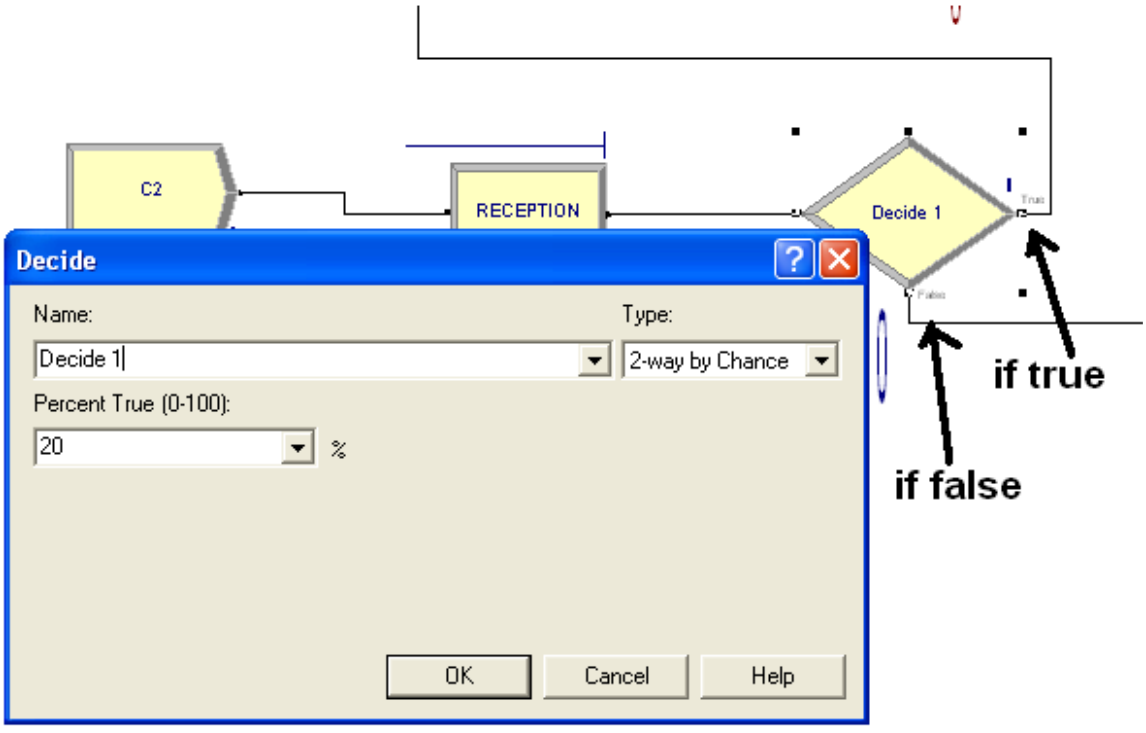
Assigning the schedule

- For resources
  - Go to ‘Resource’ spread sheet,
    - select the schedule name.
    - Schedule rule :preempt
- For schedule based arrivals:
  - Edit ‘Create’ module,
    - type of arrival : ‘schedule’
    - select schedule name

Decision module

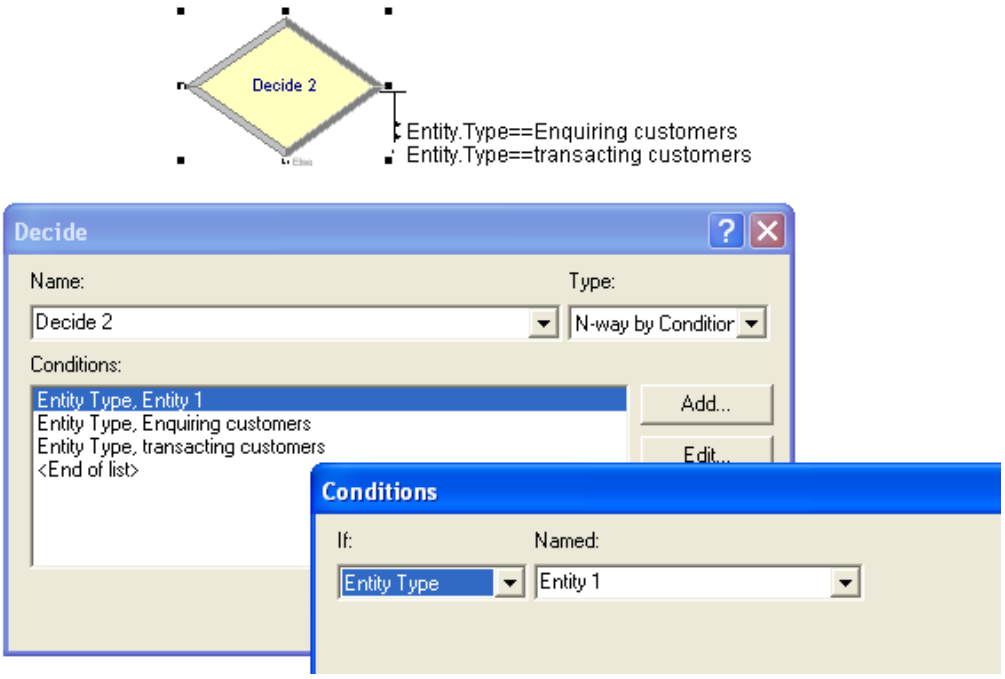
- 2- way by chance
- N- way by chance
- 2- way by condition
- N- way by condition

2-way by chance



N-way by condition

- Ex: different entity types can be diverted to different routes



Tips on self- learning

I. Use Arena Help
II. Use examples: (Default location:-C:\Program Files\Rockwell Software\Arena\Examples)
III. Use ARENA 'Smart Files' (C:\Program Files\Rockwell Software\Arena\Smarts)

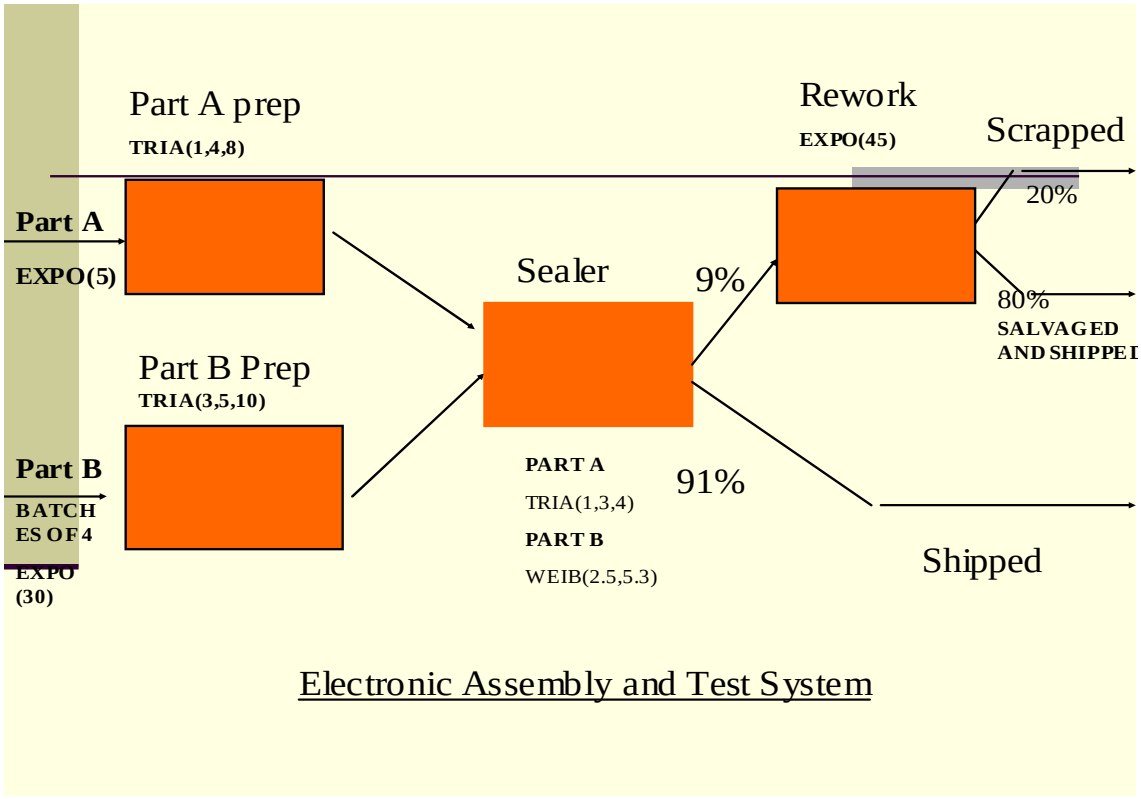
Smart files are code-named . Index is
given in :Help- Arena SMART Files

SMART Files

Ex: for entity pictures

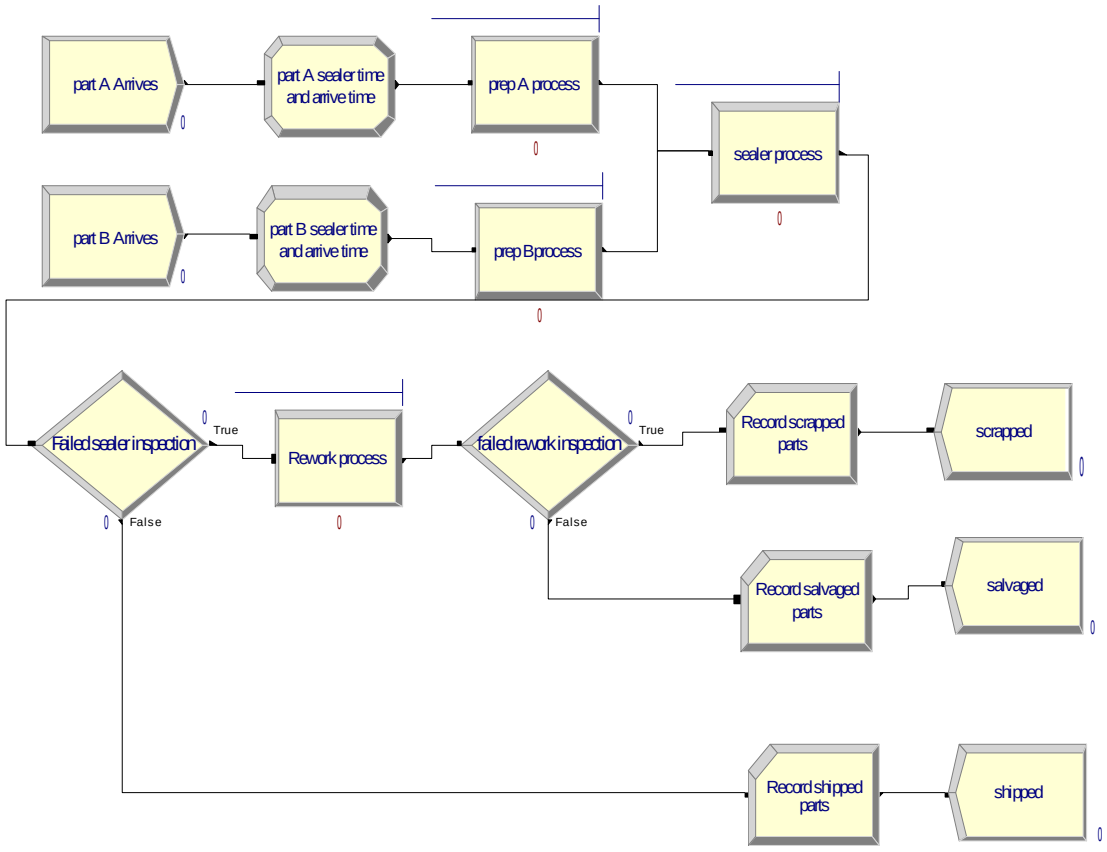
- Help: Arena SMART Files: Animation: Animating entities:Smarts023
- Open 'Smarts023' form 'Smarts' folder

EXAMPLE 4: ELECTRONIC ASSEMBLY AND TEST SYSTEM



Electronic Assembly and Test System

ARENA MODEL OF THE ABOVE EXAMPLE



Play the ‘electronic 2.exe’ file to know the data inputting in this model.

REFERENCE MATERIAL

[1]. Ravindran A., Philips, D. T. and Solberg, J. J., (1987) Operations Research: Principles and Practices, Second edition, John Wiley & Sons, New York

[2]. Book: Kelton, W.D., Sadowski, R.P., and Sturrock, D.T: Simulation with Arena, Fourth Edition, 2007, McGraw Hill (with limited student edition of Arena on CD-Rom).

[3]. In a computer where Arena installed, use the following path:

Start/Programs/Rockwell Software/Arena/Online Books

Very useful examples are available when you opened Arena in a computer and use the help. You can use Arena help and Arena SMART files from the help menu