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INTRODUCTION TO WITNESS AND LINKING TO PROCESS MAPPING TOOLS

W. Bruce Thompson

AT&T Istel, Inc.
60 Mall Road
Burlington, MA 01803, U.S.A.

ABSTRACT

The paper will describe AT&T Istel's WITNESS Visual Interactive simulator. Benefits of using WITNESS are described and illustrated by explaining the steps required to build any WITNESS model. Also described is the creation of WITNESS models from the ProSim process mapping tool.

1 INTRODUCTION

Witness is a comprehensive discrete event and continuous process simulator. It is designed to allow a person knowledgeable about the process under study to rapidly, incrementally, and accurately build, debug, validate, verify and exercise complex models. Model building time has been reduced by incorporating color coded status icons for each element, allowing portions or all of previously built models to be used (Sub-Models), user definable element library,(Designer Elements), the intelligent use of a graphical interface, form based modeling elements, pre-defined Input/Output rules, and built-in error checking. Modeling accuracy has been attained through the creation of an Action Language, a host of system and user-defined functions, user interactivity and Object Linking and Embedding (OLEII).

Because most simulation models start with a flow chart or process map of some sort, the ProSim© process mapping tool from Knowledge Based Systems Inc. will be employed to map the same example used for the WITNESS description and then output a file capable of being input to WITNESS. The obvious advantages of this link are verification that the process map actually represents the process under study and the savings in simulation model building time.

2 BUILDING A WITNESS MODEL

Using WITNESS' more advanced methods to construct a simulation model greatly reduces the simulation practioner's model building time. However, they do require a basic knowledge of how WITNESS works. WITNESS models are built in 3 steps:

1) Define the elements to be included in the model
2) Display the necessary elements
3) Detail the elements.

2.1 Defining Model Elements

In order to construct a simulation model, the user must first tell WITNESS what types of elements the model will contain. WITNESS contains 22 pre-defined elements that fall into 3 categories: 1) Physical, 2) Logical, and 3) Reporting. The user would enter the Define mode through a menu bar, select the element type to be defined, and provide a name and quantity required for the element.

2.1.1 Physical Elements

Table 1 lists the Physical elements that are available in both manufacturing and generic terms.

Table 1: WITNESS Physical Elements

Manufacturing	*Generic*
Parts	Entities
Machines	Activities
Module	Module
Labor	Resources
Tracks	Tracks
Vehicles	Vehicles
Buffers	Queues
Conveyors	Conveyors
Shifts	Shifts

Fluids	Items
Tanks	Store
Processors	Process
Pipes	Stream
Module	Module

2.1.2 Logical Elements

Table 2 lists the Logical elements. These elements provide the modeler greater control over execution of the model. Logical elements include:

Table 2: WITNESS Logical Elements

Variables	Attributes
Functions	Distributions
Files	Part Files

2.1.3 Reporting Elements

Table 3 lists the Reporting elements that allow user selected information to be graphically displayed while the model is running. Reporting elements include:

Table 3: WITNESS Reporting Elements

Histograms	Timeseries
Pie Charts	

In addition to these graphical reporting elements, the variables previously mentioned in the logical elements section can also be displayed.

2.2 Displaying Model Elements

Elements are displayed by clicking on the Display option from the menu bar and selecting the element to be displayed or, if the element is already displayed, the modeler may double-click on the required element, with the right mouse button, to bring up the Display form for that element. Once an element is selected, a sub-menu specific to the element type is presented. As an example, the sub-menu for a queue would contain selections for the Queue Name, Entity-in-the-Queue representation, and Icon graphic. The user would choose an option and place the chosen item accordingly. Should the initial placement of elements be unsatisfactory, a net is available to move an individual or group of elements to a new position.

2.3 Detailing Model Elements

Detailing a model involves the entering of cycle times, setup conditions, capacities, etc. Again, from the menu bar, a Detail option may be selected or, if the element is already displayed, the modeler may double-click on the required element, with the left mouse button, to bring up the Detail form for that element.

Each element type has a specific Detail form. The form for a Buffer/Queue would contain items such as the Name, Capacity, Delay Time (for black box analysis), Input Position, Output Position, as well as further conditions for Input and Output positions. The user would simply enter the relevant information into the appropriate field.

2.3.1 Input/Output Rules

WITNESS provides 8 pre-defined rules for Pushing or Pulling Parts/Entities through the model. At a basic level, elements such as Machines/Activities would either Pull from within the Input Rule editor or Push from within the Output Rule editor. At a more advanced level, IF/ELSEIF logic or User Defined Functions may be employed to move the Parts/Entities.

2.3.2 Action Language

Few, if any, models are straight forward enough to use only Push/Pull rules. More likely, movement of Parts/Entities would be contingent on conditions in some other part of the model. In addition, Parts/Entities are not always vanilla flavored. These items might also have lot sizes, specific routings or failure percentages, to name a few. WITNESS' Action Language allows these types of data to be added to the model at the beginning or end of each type of event. For example, a pass/fail determination needs to be made at the completion of a test. FOR/NEXT and WHILE/ENDWHILE constructs allow the user to change or monitor entity specific attributes or global variables thereby allowing greater control over model creation.

2.4 Basics Summary

So, in a nutshell, the steps necessary to create a simple model of an activity with an entity going through it would be to:

Define the entity: A
Define the activity: M1
Display the activity
Detail the activity

Input Rule: Pull A from World (Pre-defined WITNESS location)
Output Rule: Push to Ship (Pre-defined WITNESS location)
Cycle Time: 1

Click on Run on the menu bar and the model is running. Had we forgotten the Cycle Time, WITNESS would have displayed a screen prompting the user for the Cycle Time. Had we forgotten an Output Rule, WITNESS would have displayed M1 in a magenta color indicating the activity is blocked. This makes it very easy to get the model debugged and running. If we had different entities going through M1, each of which had a different Cycle Time, we could have defined an attribute for the entity called CYC_T. When the entity was created, we could have assigned a value to CYC_T and referenced the attribute directly in the Cycle Time field of M1's Detail screen, etc., etc. Oh, by the way, all this could have been performed without resetting the model back to zero. WITNESS' Interactiveness is built into the software.

3 ADVANCED MODEL BUILDING

The following sections describe the techniques used to rapidly build a complex, user friendly model.

3.1 Designer Element Libraries

The menu bar has a DESIGNER selection. Clicking on this selection brings up a Designer Window. Once in the window, the user Defines an element. WITNESS will use the first three characters to create a sequentially numbered name each time the element is used in the model. For instance, ACT might be the name I give an activity. When the activity is used in the model, WITNESS would append 001 to it making the activity name ACT001. Once defined, the element needs an icon representation and positions for Entities and Labor, if necessary.

As above, clicking on Display on the menu bar brings up the display sub-menu for the element. From there, the items would be displayed in the Designer window.

Finally, if there are any Details of the element that would be common when placed in the model, these Details would be filled in on the Detail form of the element. Once the Design of the element is complete, adding a new element of this type to the model requires only that the element be clicked on once in the Designer Window, at which point the cursor will turn into a crosshair, and the user clicks at the point in the model at which he wants the element to appear.

3.2 Sub-Models

Sub-Models are pieces of other models that the modeler might want to use over. Creating a Sub-Model requires clicking on File, Save, Sub-Model, from the menu bar and then selecting which elements will be included in the Sub-Model. Selection may be from a list of elements, by mouse or by placing a net around a group of elements. Once saved, any reference to elements not contained in the Sub-Model will be listed at the completion of the save. Using the Sub-Model requires clicking on File, Open, Sub-Model and selecting the appropriate Sub-Model file. The user would then be prompted for what to do in case an element name in the Sub-Model matches an element name in the model into which it is placed. Options are to Prompt, Change or Ignore. If Change is selected, further selections are Prompt, Replace the First Letter, or Add a First Letter.

3.3 Module Elements and Hierarchical Modeling

When bringing a Sub-model into the model proper, the user is asked if he/she wants it assigned to a Module element. Assuming the answer is yes, the elements in the Sub-model would be assigned to an icon. Once assigned, the Module can then be entered into the Designer Elements window and brought into the model by simply clicking. The beauty of this assignment is that the model being presented needs only show the Module icon. The detail associated with the specific module is in a different part of WITNESS' virtual screen. Double clicking on the Module icon will take the user to that part of the screen.

3.4 Object Linking and Embedding - OLEII

WITNESS is capable of acting as an OLEII server. This means it can be run from an OLEII controller application. Microsoft Excel 5.0, Microsoft Access and Microsoft Visual Basic are examples of OLEII controllers. What is so good about this?

First, many firms maintain process data in spreadsheets. It saves model building time to use this data directly. Secondly, many employees know how to use a spreadsheet. Not many employees in a line decision-making authority have the time or desire to go in to a simulation model and make changes to see how to handle changes to the process. By using Excel as a front end to the simulation, the user can change the entrees in the spreadsheet, run the model, and have the necessary results of the model reported back to Excel. To the user, the simulation proper is akin to an invisible calculator. In this way, the proven benefits of simulation can be brought to a larger user base, not to mention where the decisions need to be made. The details of employing OLEII in a simulation are beyond the scope of the tutorial

3.5 Experimentation

WITNESS has a built-in feature that allows the user to automatically change the random number streams and re-run the same model, or a number of different models, to statistically determine the model's performance. Creating an experiment requires defining a Situation/Scenario, determining the Warm-up period, Run Length, Continuous vs. Restart data collection, how the random numbers will be exercised, what the output file name will be, and running the experiment.

Defining the Situation/Scenario requires that the scenario be named and, if applicable, assign a model file to be run for that scenario. If the experiment will be running inside of the model, no model name would be required. For the Warm-up period, assume a Timeseries has been placed in the model to look at the number of shipments every hour. Assume also that number appears to level off after 2 hours of simulation time. Two hours would be used as the Warm-up. The Run Length will be 1 week with data collection occurring at the end of each replication. Exercising the random numbers requires a little background.

Because simulation deals with stochastic systems, more than one run must be made to ensure that the value of a metric being reported upon is not caused by some strange combination of random events. As an example, if someone asked you how long it takes to get to work, you would probably answer with a range of values, perhaps 30 - 45 minutes. The exact number depends on the random events of weather, time of morning, time of year, etc. With simulation, these random events are represented by random number streams.

WITNESS has 999 unique random number streams numbered 1 through 999. Each model run would use a different set of random numbers. The easiest way of changing the numbers is with the Stream Offset. This option will use a random number stream that is a certain number higher than the one referenced in the model. For instance, assume I use the following distribution as a cycle time in a model:

LOGNORML (2, .15*2, 35)

The mean is 2, the standard deviation is 15% of the mean and the random number stream is 35. If I use a Stream Offset of 2 for this iteration of the experiment, the actual number stream being used would be 37. Exercising the model 6 times by simply changing the Offset is very convenient.

One thing remains. Where are the system statistics (i.e. Time in system, Total Throughput, etc.) going to go? Although there are 6 options, output from these iterations would normally go to a Comma Separated Values (CSV) file. This file format can be directly imported by a number of software programs for statistical analysis. For our purposes, a CSV file, call it WINSIM.CSV, will be used as it will be input to WITNESS' statistical analysis program XA. That's it. Now the user has to simply run the experiment and go home. The model will run 6 times and the output from each run will be placed in the output file WINSIM.CSV

4 XA

Packaged with WITNESS, although a separate program, is XA. XA will take a CSV output file from WITNESS, and calculate a Student's 't' statistic for each measurement over all runs of the experiment. It will also calculate 99%, 95%, and 90% confidence intervals using the 't' statistic. Measurements for which statistics are generated are user selectable. In addition, the format of the analyzed measurements is user definable.

5 OUTPUTTING PROCESS MAPS TO WITNESS

Before proceeding, some clarification on what a process map is and how it differs from a flow chart. For our purposes, a process map uses a structured methodology to capture information necessary to describe a process and keeps all the information in one place. The methodology used for the ProSim process mapping tool is IDEF3. IDEF3 is time based and readily lends itself to simulation. Does that mean the IDEF3 methodology must be used to create the output file for WITNESS? No. Information types such as description, elaboration, and process details to name a few, are available in ProSim. The choice of utilizing any or all is left to the user. However, entering the information necessary to create the simulation model is not optional. Specifically, routes for each of the entities, cycle times and entity types occurring at each activity must be entered. Additional items such as Timeseries, Histograms, and Pie Charts for important metrics can also be included in the model.

A process map also includes the ability to hierarchically represent a process. When explaining WITNESS' Module capabilities, only the Module was presented to the user. The decomposed or detail portion of the module was displayed elsewhere. Presenting process information in this way makes it easier to understand how the overall process functions as well as the detailed processes.

There are major advantages to using a process mapping tool. All but the simplest systems require some type of flow diagram to clarify how the steps in the process are connected. When building a simulation model, the same diagram is used. Unfortunately, it usually has to be re-entered since there hasn't been any way to get from a flow charting tool to a simulation tool. Additionally, the data supporting the process, cycle times, routings, etc., are held in another place, usually a spreadsheet. To add to the confusion, when going off interviewing people who know the process to see how everything is connected, interview notes are kept in another location, perhaps a word processor or text editor. The mapping tool keeps all of this information in one place. Now, what about outputting to WITNESS?

Once the ProSim map is complete, a menu bar selection allows the output of a WITNESS WCL file. A WCL file is a WITNESS batch file. When the WCL file is written to disk, the user enters the WITNESS application and simply reads in the WCL file. The same flow diagram that existed in ProSim will be re-constructed in WITNESS. Click on RUN and the model will start running. From here, the user can either restrict the use of the model to verifying the process map or further customize the simulation model to better represent the process.

6 SUMMARY

WITNESS is a discrete event, Visual, Interactive simulator. It has been designed to quickly and accurately create a simulation. Real-time color coded element status indications, combined with an extremely flexible graphic environment greatly reduce the time required to build a model

Basic models are built using a Define, Display, Detail cycle with pre-defined modeling elements and Input/Output rules. More complex models would incorporate IF/THEN/ELSEIF Input/Output rules, Object Linking and Embedding and the WITNESS Action Language. Modeling time can be significantly reduced by saving portions of previous simulations as Sub-Model for use in future simulations. In addition, elements common to the modeler's environment may be incorporated into a Designer library for quick Definition, Display and Detail.

Also described was how to set up experiments from within WITNESS and lastly, how to analyze the data from the experiments using the XA statistical analysis package.

The benefits of using a process mapping tool, in this case ProSim, to create WITNESS models was also described.

AUTHOR BIOGRAPHY

W. BRUCE THOMPSON is a Sr. Technical Consultant with AT&T Istel, Inc. He received his B.S. degree in Industrial Engineering from Northeastern University in 1981. His responsibilities for Istel include training, consulting, customer support and Editor of the company's worldwide newsletter, The Interactive Modeler.