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A TUTORIAL ON TESS: THE EXTENDED SIMULATION SYSTEM

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ABSTRACT

TESS™ for performing projects using models specified in the SLAM II®, MAP/1™ or GPSS/H™ simulation languages. Based on user specifications, TESS provides automatic collection of simulation results during runs in its database. Animations can be shown concurrently with simulations and after simulation runs. Business graphs and reports display variable values and statistical summaries. Statistical summaries can be computed after simulation runs from variable values collected during the simulation. For SLAM II, network models may be entered using a graphical builder. The TESS command language provides a single user interface to all TESS capabilities.

1. INTRODUCTION

The Extended Simulation System, TESS, provides a framework for problem solving using simulation. TESS integrates model building in SLAM II, MAP/1 and GPSS/H with the simulation of models, the statistical analysis of simulation results and the presentation of simulation results using reports, graphs and animations.

Figure 1 shows the TESS problem solving framework. The top half of the oval portrays the activities involved in problem solving using simulation: modeling, simulating models, analyzing and presenting results. TESS provides the mechanisms to jointly use a simulation language, database manager and graphics capabilities to support these problem solving activities. The relationship between these capabilities and the problem solving activities they support are indicated by the vertical arrows in Figure 1.

2. TESS CAPABILITIES

Specifically, TESS provides the following capabilities:

* A framework for problem solving using simulation.
* Separation of the analysis and presentation of simulation results from their generation in simulation runs.
* Integration of modeling and simulation execution with reporting, graphing analysis and animation capabilities.

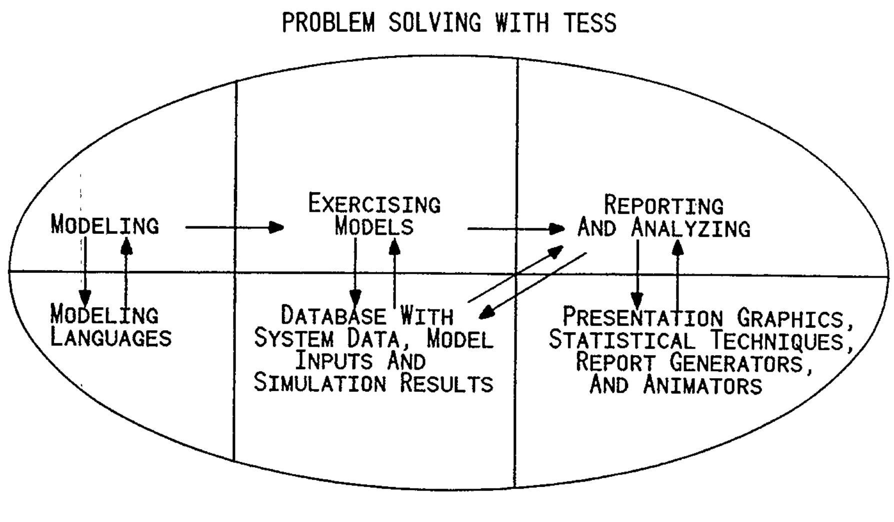

Figure 1: Conceptual View of TESS

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* A command language to access each capability used in problem solving.

* Creation and management of SLAM II network models.

* Independent specification of experimental conditions for controlling simulation runs (CONTROLS).

* Management of user defined simulation input data.

* A report generator for presenting simulation results and other data.

* Graphing of networks, simulation results and user defined data.

* Procedures for dynamically presenting the operation of a model, that is, the animation of simulation results both after and concurrently with simulation.

* Computation of frequency distributions and statistics as well as estimation of confidence intervals.

* Support for database management tasks.

Figure 2 shows how TESS is used to perform a simulation project. Models are descriptions of a system. TESS provides an interface to SLAM II, MAP/1 and GPSS/H models.

Independent of the development of a model, TESS allows an analyst to specify the controls required to simulate models. This specification includes initial conditions, run lengths and output values to collect. In addition, TESS recognizes that models often require significant amounts of problem specific input data. Therefore, procedures for the management of such model inputs are a part of TESS.

The combination of a model, a run control and input data forms a scenario. Typically, a scenario is used to evaluate a particular alternative. The simulation of a scenario produces observations of data values. These individual observations are used to construct basic statistics and frequency distributions referred to as summaries.

3. VARIABLE VALUES

Observations and summaries of the values are stored in the TESS database and can be analyzed and presented independently of simulation runs. Individual observations can be selected (filtered) and summarized into basic statistics and frequency distributions. Construction of summaries independently of the simulation has several advantages. All analyses of the observations need not be specified before simulations are run. Multiple analyses of the same observations, or perhaps involving different subsets, can be made. Furthermore, the computation of summaries need not be included in the simulation program, thus, making the program easier to debug, change and maintain.

TESS provides three basic mechanisms: reports, graphics and animation, for displaying simulation results and data inputs. Reports display information on

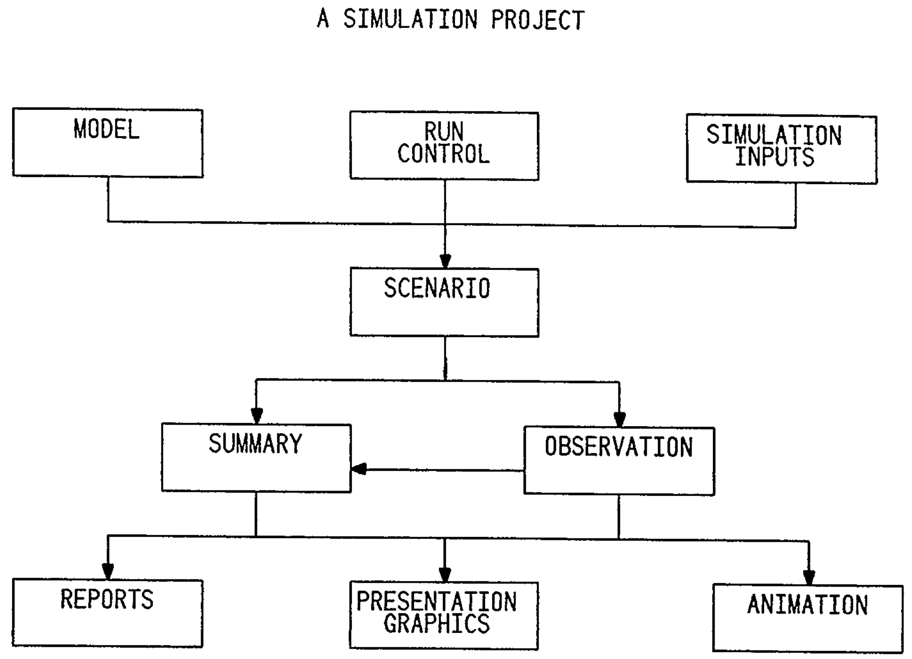

Figure 2: The TESS Framework for a Simulation Project

alphanumeric devices. Reports that can combine data inputs with simulation outputs can be used for validation purposes. Simulation outputs from many scenarios can be used for alternative evaluation purposes.

TESS provides for the graphical presentation of all simulation results. Graphics can be created at interactive terminals or on hard copy devices such as plotters or printers. Graphics for displaying statistics, frequency distributions and individual data values are included.

The animation capability in TESS shows the movement of entities and system status changes. Animation capabilities assist the analyst in communicating how a model represents a system. Both the elements of the system which were included in the model and the operating rules for these elements can be shown. The animation facility allows all members of a project team, both simulators and non-simulators, to participate in model verification and validation. They can see how the model operates by viewing the entity movement and the status changes. In this way, the decision rules that were employed in the model become evident.

4. THE ESSENTIAL REQUIREMENTS FOR SIMULATION SOFTWARE

TESS embodies six essential requirements which a simulation system must meet for maximum utility.

1. TESS supports all aspects of the simulation project. The comprehensive, integrated simulation framework of TESS reduces the amount of technical computer work simulation requires. So analysts with lesser computer skills will be able to use TESS. Analysts with computer sophistication will perform simulation projects more efficiently.

2. TESS tailors its simulation results to the needs of the decision makers. So decision makers can see the simulation, assist in its validation, and gain confidence in the results, TESS animates the model and provide graphical representations of all results, with supplementary reports. TESS can graph and report similar information from different scenarios to offer an easy means of comparing alternatives.

3. TESS takes a modular approach to simulation projects. Following the basic engineering strategy of "divide and conquer," TESS decomposes large problems into a series of smaller ones, or modules, which it solves one at a time. TESS provides specific capabilities to handle each module--model building, simulation execution, results analysis, and presentation--along with a mechanism to link all together.

4. TESS minimizes the need for technical computer knowledge. TESS keeps database operations transparent as much as possible. Analysts may perform entire simulation projects with no direct reference to the database. Using forms techniques and graphical procedures for model building, TESS provides non-programming interfaces for building networks and controls, entering data, and specifying the presentation of results.

   Because TESS is a fourth generation non-procedural language, analysts need only specify which operations they want performed, and TESS will figure out how to do them. For example, to graph a given result from each of three scenarios, the analyst simply names the result and the scenarios. TESS locates the results and specifies the method of joining and displaying the information.

5. TESS recognizes the differences between model builders and model users. Model users often need to use a simulation model as a black box--changing inputs, rerunning simulations, obtaining standard reports and graphs--without having to concern themselves with the internal details of the model. Builders, though have concern for details of construction, the gathering of inputs and results, and the nature of the presentation mechanisms. TESS supports both.

6. TESS requires the analyst to concentrate on only one form of the model. Using SLAM II network features as a modeling language, TESS allows analysts to build network models at an interactive graphics terminal and to update and change the model with the same mechanism. TESS creates and maintains all other forms transparently. TESS eliminates the need for analysts to translate models from symbolic to statement or textual form. This procedure eliminates discrepancies that rise over time from changing the statement model directly.

5. THE FUNCTION--ELEMENT STRATEGY

TESS is comprised of 3 functions which act on 9 elements. Elements encompass the entities which make-up a simulation project. The functions are manipulations of the entities required to perform the project. Figure 3 shows the TESS framework. Data elements are classified into three categories: modeling, simulation and analysis, and presentation.

5.1 Modeling Elements

Modeling elements are networks, definitions, ICONs and facilities. Networks are SLAM II networks. Networks are built and modified graphically using the TESS network builder. Plots of networks can be generated.

DATA ELEMENTS

		MODELING			SIMULATION & ANALYSIS				PRESENTATION	
		NETWORK	DEFINITION	FACILITY	CONTROL	SCENARIO	DATA	SUMMARY	FORMAT	RULE
FUNCTIONS	BUILD	X	X	X	X	X	X	X	X	X
	REPORT		X		X		X	X	X	X
	GRAPH	X		X			X	X	X	

Figure 3: The Function - Data Element Strategy

Definitions are specifications of the attributes of variables to be stored in the TESS database. Definitions are given implicitly when simulation results are automatically collected or explicitly in the TESS language.

A facility is a descriptive model of a system. A facility is used in two ways: as an informal model of a system for discussion purposes and as a tool for displaying an animation of a simulation. TESS provides a facility builder for selecting, locating and specifying the parameters of a set of symbols to describe a system. To show different aspects or levels of detail in a system, there may be many facility diagrams for one system or one model of a system. This allows many different animations for one simulation run.

5.2 Simulation and Analysis Elements

A control is a set of statements which tells how to run a simulation. Control statements specify results to be automatically collected, initial conditions and simulation operational parameters. The TESS control builder may be used to build or edit SLAM II controls. Forms for each control statement are provided.

A scenario is a set of conditions under which data are generated. One such set of conditions is a simulation run. However, under this definition, no distinction is made between simulation results and other data. Thus, all data are processed by TESS in the same way.

Data are variable values. Data may be simulation input, simulation results or any other information of interest.

Summaries, derived from data, consist of basic statistics or frequency distributions. Summaries may be automatically collected during simulation runs, computed in user-written code, or computed using TESS language statements.

5.3 Presentation Elements

Two elements assist the analyst in presenting simulation results. The first of these is format. A format specifies the parameters by which TESS should draw a graph or print a report. TESS supplies default parameters for all reports and graphs so that the analyst need not specify any formatting information. There is a type of format for each graph; range chart, histogram, bar chart, pie chart, spike plot, discrete plot, and continuous plot; for graphing networks; generating reports; placing annotation on graphs; and for text only graphs called word charts. Formats are created or modified using the TESS format builder. The format builder uses a series of forms to display parameters of the format. The analyst can change the parameters by inserting new values on the form. A particular format is associated with a particular graph or report only at the time the graph or report is generated.

The final TESS element is a rule. A rule is a mapping between the events that can occur in a simulation run and actions to be taken on a facility to portray an animation. For example, in SLAM II, events can be categorized as: 1. the beginning of an activity, 2. the completion of an activity, or 3. a time, discrete, or a state event. Actions taken during an animation that can correspond to events include: changing color of symbols to show changes in status, changes in counters to show changes in the number of entities grouped together, movement of ICONs to show movement of entities in a simulation, flows to show continuous movement of entities such as fluids, entry and exit of ICONs from queue, and tanks to show variable values by changing the length of colored bars. A rule is a set of statements that relates events during a simulation to actions to be taken during the animation. These statements are built using the TESS rule builder. In the rule builder, the analyst completes a form for each statement in the rule.

5.4 TESS Functions

Three TESS functions manipulate the elements in the database. The BUILD function is used to create or modify occurrences of elements. The REPORT function displays occurrences on an alphanumeric device such as a line printer or alphanumeric terminal. The GRAPH function displays occurrences on a graphics device such as a interactive graphics terminal or a hard copy device such as a plotter or printer. The GRAPH function activates animations as well. Animations can be run either concurrently with the simulation or after the simulation is run.

Some combinations of functions and elements are not allowed. The permissible combinations form 20 TESS statements which were indicated by an X in Figure 3. These 20 statements are the foundation of the TESS language.

6. SUMMARY

TESS initiates a fourth generation of simulation software. TESS contains a framework for organizing simulation projects and provides software support for all simulation project activities. TESS operationalizes its simulation project framework as a set of functions operating on a set of elements. TESS is implemented with an integrated architecture combining database management and graphics capabilities with a simulation language.

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