TIME MACHINE--THE DYNAMIC WORKSHEET

William B. Nordgren

F&H Simulations, Inc.
P.O. Box 658
Orem, UT 84059-0658, U.S.A.

ABSTRACT

Time Machine is a menu-driven simulation package mainly used for process re-engineering. It is developed for the analysis and quantitative evaluation of processes especially those with a dynamic character. A lot of applications in different industries show that there is an increasing need for simulation tools for processes such as paper flows, staffing, and customer service. This paper will demonstrate the process of building, analyzing and presenting models of real world systems with Time Machine.

1 INTRODUCTION

Competitive companies spend a lot of time and money to obtain highest performance from their employees and resources. Besides expensive and complicated techniques, there are buzzwords like flexibility, BPR, lean production, etc. All these terms are based on the optimization of delivery, reliability, customer satisfaction, and costs. The problem faced by management is that it is often impossible to make a quantitative approach to these characteristics. Two factors are responsible. The first is complexity. With an increasing number of components being in relationship to each other, it becomes more and more difficult to describe the system mathematically. The second factor is uncertainty. When uncertainty is involved, even analytical methods fail. Uncertainties can be classified as breaks, varying process times and batch sizes, waste and reject, etc. Throughput times, queue sizes, the effects of resource allocation cannot be determined with conventional methods. Many managers have to resort to assumptions, experience and intuition, to solve problems. For these types of problems simulation can be a powerful tool to justify decisions or even prevent you from making wrong decisions.

Time Machine is a package for the simulation of discrete event systems. In general, you can simulate all kinds of systems in which discrete entities are to be processed, and stored (queuing systems).

Usually these entities are parts, paper, action items, people, etc. This shows that Time Machine is not limited to specific industries. Types of applications include processing of people, paper work, phone calls, staffing, harbors, airports, and administration.

Time Machine is a Dutch product, developed by F&H Simulations B.V. since 1993. The package is installed in more than 500 companies and educational institutes. In the middle of 1996, the package, now called Time Machine for Windows received a complete new structure and integrates all necessary functions for a simulation study. There is one platform for modeling simulation, animation, analysis and presentation. In the following all important functions will be described.

2 BUILDING A MODEL

Working with Time Machine usually starts with building a model. All model building is menu driven. A model represents a real world system which is to be studied. In practice, this representation is often simplified. The most important aspect when doing this is to build a model that emulates the system correctly while minimizing the details. The reason for this is to build an efficient, economical and objective-oriented way of working.

A model in Time Machine consists of four fundamental entities being related to each other: elements, jobs, routings and products. On each element, one operation can take place. The two basic operations are processing, and storage; in Time Machine they are called jobs. Jobs are characterized by a cycle time (cycle times for storage are naturally 0), which can be random. The entities using the jobs are called products. Products can be defined freely and represent parts, tools, paper, people, etc. They take place on an element and are sent to another element when the operation is finished.

Therefore, you need a description of how the products flow through a model. This description is stored in routings. Routings consist of a number of stages and can be placed as connections between elements graphically in the same manner as creating a flow chart.

2.1 Layout and Routings

Defining a layout is the first step when building a model. A layout contains a number of elements that you can position in different sizes, and in any place, on your screen. The following two element types are available in Time Machine: World and Element. Choosing a type depends on the function in the real world system. An element is the general purpose representation for any kind of operation or processing point, or queue location. World elements represent entries and exits (sink/sources) in a model. They generate and 'eat' products. Each element placed in the layout gets one job automatically.

Besides the cycle time, a job also describes how an operation is done concerning input batch, additional resources, etc.

By selecting the elements one after another you describe the path the products follow in the model. In most models the routing roughly reflects the flow of products just as in defining a flow chart. In some applications you have to handle a large number of product types all using different routings i.e. in a paper work model. In this case, Time Machine offers the modeler the ability to specify how each product type is routed through the model by using the select statement.

2.2 Detailing the Model

The second step is to detail the model. This means that the modeler has to enter parameters describing the behavior of the model that differ from the default settings. Usually one only needs some of the parameters so that it is not necessary to detail before starting the model for the first time. Most of the parameters are related to the fundamental entities discussed above. Element parameters describe the behavior of the elements: what kind of element it is, stochastic (breakdowns) and deterministic (shifts, pauses), availability, how many products it can store, fixed and variable costs, how it selects its next task, etc. The job parameters are similar.

Many systems seem to be quite simple. When looking at details, one often finds different kinds of rules and strategies to make decisions. That is the reason why implementing these decision points takes most of the modeling time. An important aspect in this phase is the way a simulation tool supports the user. Two items have to be discussed: high flexibility for implementing

control logic and easy model verification. Besides special functions for verification the on-line animation in Time Machine plays a large part. When the layout and the routings are finished, animation is available immediately. All changes in the model can be seen on the screen at once. The user is able to detail and to test the model step-by-step until the model runs according to his desire.

Besides a number of default settings, Time Machine uses a macro language called TLI (Taylor Language Interface). Since Time Machine is a simulation program developed from Taylor II, models built in Time Machine will run in Taylor II. Therefore Time Machine utilizes the same macro language as Taylor II. TLI is an easy to use programming language that allows one to modify the model's behavior powerfully in combination with simulation-specific predefined and user-definable variables. TLI is used at element, job and routing level. TLI can be used interactively during a simulation run to make queries and updates. Typical situations in which the routines have to be modified are loops (i.e. rework), selecting elements as a result of a certain status, assembly, disassembly, etc. Time Machine can send products from each stage in the model to each other in any quantity. For this purpose the user has direct access to all addresses in a routing and replaces the (in most cases) fixed values by expressions of the following form:

select number *with* condition *from* list *order* expression *quantity* list *location* list

These so called 'select' statement are used for sending and receiving products. The italic parts in this structure can be values or other expressions. Selections can also be nested. This offers many possibilities for order picking, assembly and complex guiding and receiving strategies. Some examples:

select 1 from 3,4,5

One product will be sent to element 3, 4 or 5.

select 1 from 3,4,5 order - utilization [L]

The same as above, but the element with the lowest utilization has the highest priority.

select maximum[1,F] with queue[L]<5 from 3,4,5 quantity 4-queue[L]

An (express) order uses the maximum number of elements. Only elements with less than 5 products are taken into consideration.

Elements can be described by fixed acceptance rules for picking products or other TLI-user-definable rules and strategies for the entry and exit of products. Examples are:

TLI-entry condition: time|600<120

An element accepts products only for the first 120 seconds in a 600 second interval, (| stands for modulo). The expression is true for 120 seconds.

Product types are described by a code in combination with an icon. Sometimes it is necessary that products get individual information or signs. Information could be a delivery date, priority, state of work, etc. For this purpose, products are coupled with attributes. Attributes can also work as a pointer to a matrix in which i.e., cycletimes are stored. This enlarges the amount of possible information enormously. Querying and updating of the attributes are done at the jobs by evaluating triggers. A trigger is one (or more) simple lines of text with a TLI-expression. Triggers can be evaluated nearly every time an event is scheduled. They can influence products (with their attributes) or the model status itself. An example is:

Trigger on Entry: curcycle[J]:=itemcode2[C]

The cycle time of the order is stored in the second attribute and is assigned when the product enters the job.

Assume that a model is built with Time Machine. Now starts the actual simulation.

3 SIMULATION

In stochastic processes random numbers play an important role. Time Machine comes with different random number generators which normally work independently from each other. In some experiments you may want to study alternatives of a system. The models should run with identical conditions and for this purpose it could be necessary that all generators generate the same sequence of random numbers.

Time Machine is fully event-oriented. This means that the time between two events (i.e. beginning and ending of an operation) needs no CPU time. An internal event list makes sure that all changes in status are evaluated.

For every simulation run, the start situation is free to define. Products can be stored in any quantity at any place in the model. To reduce the warm-up period (moment of time that a model runs with stable status)

you can make a warmstart. For a number of various runs you can define a batch run.

During simulation you can zoom and pan, stop, make modifications and then continue. A model can be simulated during a certain period of time or until a special (user-defined) condition is met.

The time representation is fully user-definable (i.e. week 8; tue; 8:30,2) and is displayed by an analog and digital clock. With the single-step-mode you can trace your model in detail or use the conditional single-step for watching a part of the model only.

While simulating, the screen output can be interactively changed, ranging from no information (as fast as possible), via statistics and simple animation to full animation. With full animation you see each product moving from stage to stage or queuing in the system. Time Machine automatically keeps track of a large number of common statistics like utilization, waiting times, etc. Default and user-defined statistics can be displayed as numbers or as dynamically changing graphs. Time Machine can also keep track of any kind of variables you want and display them after the simulation run.

4 ANALYSIS

For a correct description of a model, a number of input data is required like arrival times, cycletimes, breaks, etc. Often these data exist in protocols, databases, etc. But the question is: is there enough data to characterize a process well or are they only a part of reality? That means a detailed analysis with statistical methods should be done first. Taylor can read in datasets and analyze them. Two important parameters are the average value and the standard deviation. Another point is the statistical distribution which fits best. A built in routine automatically makes a distribution suggestion for the dataset and displays this distribution depending on the type, in continuous or discrete form on the screen.

Typical information you get from a simulation study is utilizations, throughput times, production per period and costs. The results are available in different ways:

Tabular reports: contents and form are predefined, but may be changed by the user.

TLI reports: containing a mixture of explanation, results and illustration or giving specific results.

Queries: all results can be queried with TLI interactively (including minimum, maximum, average and standard deviation).

Predefined graphs: wait time histogram, queue graph, status diagram, utilization pie, etc.

User-defined graphs: representation of any kind of data like throughput times, costs, etc.

Graphs can be displayed in over 10 types of general purpose representation: histograms, bar graphs, x-y plots, pie charts, etc. including averages (whole and cumulative), standard deviation and so on. All reports and graphs can be sent to screen, disk file and printer or you can export these data for use in other programs.

5 ANIMATION

In the past animation has been treated as a nice but more or less unnecessary extra. Time Machine has a built-in animation module.

There are several reasons. First, similar to the discussion in Section 2.2, the animation can be very useful (but generally not replace) for verifying a model. For this purpose the 2-D animation is available as soon as routing is created.

With the built-in paintbox you can define your own icon-sets or draw background illustrations. Background drawings are automatically translated into bitmaped easy access. Existing bitmaped drawings can be imported into backgrounds as well.

6 ADDITIONAL FEATURES

In addition to the points above there are some special functions useful (not essentially necessary) for the daily work. When simulating a lot of alternative models with different parameters and settings you could lose your overview. For this purpose, Time Machine generates a model documentation (text file) describing the whole model. Another important aid is the context-sensitive online help with index and page search facility.

Time Machine version 2.0 includes several new features that have been specially designed for windows 95. The Taylor Language Interface has been extended and with autofit you can curve fit your existing data to prepare data for use in your model

7 SUMMARY

Time Machine integrates all functions necessary for a simulation study and combines in a simple manner high flexibility with ease-of-use without making concessions to functionality. Many applications in different industries, manufacturing, fast foods, banking, and management, have benefited from simulation. Fast

modeling and online animation are the concept for the use not only by simulation experts. Time Machine is designed to be used by managers and is not more complicated to use that a good spreadsheet or flowcharting software.

Continuos customer feed back and our own consulting department enable F&H to keep improving Time Machine.

AUTHOR BIOGRAPHY

WILLIAM B. NORDGREN is President of F&H Simulations, Inc. U.S.A. He received his Master of Science in Computer Integrated Manufacturing (CIM), and Bachelor of Science in Manufacturing Engineering from Brigham Young University. Bill was co-founder of ProModel Corporation and served as Vice President of Customer Services and Training from 1988 until 1992. In 1993, Bill jointed F&H Simulations B.V. and founded F&H Simulations, Inc. U.S.A. Through this union Taylor II Simulation Software was introduced into the United States, Canada, Mexico and South America. He is listed in the 22nd, 23rd, 24th and 25th editions of Who's Who in the West. He has done simulation projects for several large corporations including Andersen Consulting, Black & Decker, Boeing, Eastman Kodak, IBM, Pillsbury, Thiokol, TRW and Whirlpool.