Proceedings of the 1995 Winter Simulation Conference
ed. C. Alexopoulos, K. Kang, W. R. Lilegdon, and D. Goldsman

FUNDAMENTALS OF USING MICRO SAINT IN MANUFACTURING, HEALTH CARE, HUMAN FACTORS AND BUSINESS PROCESS REENGINEERING

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ABSTRACT

Computer simulation is becoming a common tool in the engineer's toolkit, but the move to simulation is slow in coming. There are still many people in Manufacturing, Health Care, Process Reengineering and Human Factors industries who are not using any sort of simulation software and see no advantage to using this powerful tool. Even in the information age of the 1990's it is still hard for the potential user of simulation to find the necessary facts to keep up with the changing market of computers and simulation software. In this paper we will focus on the changes in simulation software over the years, the ease of use of the 1990's simulation software, the broadening market for simulation software, along with a step by step approach to using Micro Saint Simulation software in several key areas.

1 INTRODUCTION

Discrete event simulation has been a standard technique in the analysis of manufacturing systems for the past 30 years. In the past 10 years other industries are seeing the advantage to using simulation software to analyze their systems. Today's rising costs and competitive pressure has led to an increased awareness of the value of simulation. This interest extends to other areas of industry as well. The adoption of total quality management (TQM) and process management techniques has created new challenges for managers and engineers. Process definition, quality measurement and control, process re-design, employee workload, safety and productivity are all areas where simulation is now being used to evaluate and improve efficiency.

Decision makers within organizations are applying simulation technology to a wider variety of problems. Consequently, the need for flexible, general purpose simulation tools capable of addressing all of these needs has increased. Micro Saint, a discrete-event simulation tool, is an efficient and cost-effective tool for simulating the complexities of systems within manufacturing, health care, retail, government, human factors, process reengineering and the service industry. The problems being analyzed range from process control and resource utilization to military maintenance procedures and human performance.

2 METHODOLOGY

Micro Saint was developed in 1985 specifically for modeling human-based in complex systems. The target users for the product were not simulation experts or computer programmers. Rather, we targeted individuals with little exposure to either simulation or computer science. This required a modeling approach that was much different from other simulation products that were available at the time. The engineers at Micro Analysis and Design, Inc. chose to develop Micro Saint implementing a methodology known as task network modeling. In task network model, activities are represented in a diagram as nodes, and the arrows between the nodes represent the sequence in which the activities are performed. A simple task network is shown in Figure 1.

This approach allowed users to develop models using the same techniques that they would use to define a flow diagram of the activity. Each activity, whether it be a human activity or machine activity, is defined using the same method. This minimizes the complexity of the user interface and eliminates the need for programming blocks specific to an application.

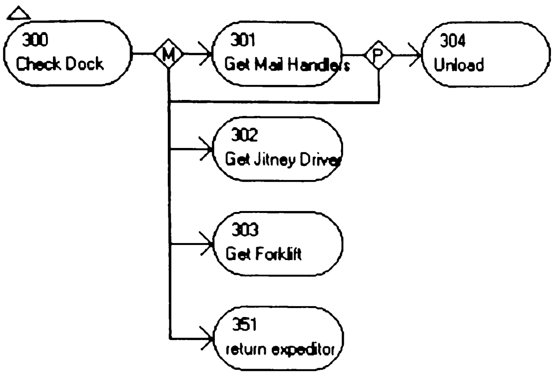

Figure 1: Sample Network Diagram

Over the years, the size and scope of the problems to which users wanted to apply Micro Saint has increased. This wider acceptance and use of Micro Saint in other application areas, including manufacturing and service industries, greatly influenced subsequent product development and enhancements. For example, there is rarely a need for defining queues when developing models of human performance, however, in order to remain competitive in the manufacturing market this capability to specify a queue and define parameters such as the exit order was critical.

While Micro Saint has continued to evolve over the years, its origin in human-based systems modeling is still evident in the terminology that is associated with the product. A Micro Saint model may be composed of many networks, each a sequence of tasks to be performed by a human, a series of processes that define an organization, or a series of machines in a manufacturing plant. Networks are composed of either additional lower-level networks or "tasks." Although the identifier "task" has connotations of human activity, it is not restricted as such. Tasks represent the lowest level in the model and have specific parameters (timing information, conditions for execution, beginning and ending effects). An example of the window in Micro Saint for defining task information is presented in Figure 2. The following section explains the task parameters in more detail.

2.1 Task Timing Information

The task "mean time" is the average time that a task takes to complete. For example, if the task represents a human activity such as "transfer patient to recovery room," then the mean time to execute is the average time that it takes to transfer the patient. If the task represents a machine in a manufacturing process, then the mean time to execute is the average processing time for the machine. In many cases, the execution time is not constant. Rather, the elapsed time falls within a range of values that can be represented by a time distribution. Micro Saint supports more than 16 distribution types including normal, rectangular, exponential, gamma, Wiebull, Poisson, and others. In addition, users may enter parameters that control the spread of the distribution.

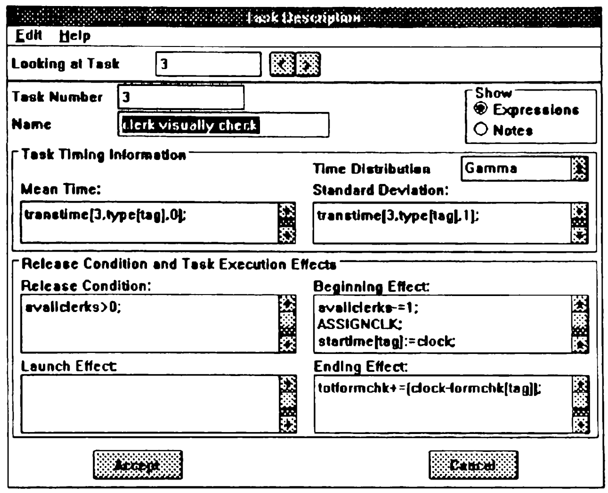

Figure 2: Task Description Window in Micro Saint

Alternatively, the mean time may be determined by the current state of the system or by an attribute of the process itself. In human performance modeling, the mean time to perform a task may be influenced by such conditions as how long the human has been working, the skill level of the human, or the current workload. In an insurance claim processing model, the time it takes to process a claim may be determined by the type of claim or the location of the client.

2.2 Conditions for Execution

Often, there are situations where a task cannot begin executing until certain conditions are met. A customer cannot make a transaction, even though the queue is empty, until a bank teller is available. A task may have resource requirements or other constraints (i.e., time of day, part type) that dictate when the task may begin executing. In Micro Saint, users enter a Boolean (logical) expression in the "release condition" field to control the execution of tasks. The release condition expression may be as simple as "teller <> 0", or it may be a complicated expression where several conditions are evaluated such as "(clock > 8 & clock < 16) & (clerk <> busy)." Entities moving through the network, whether they be patients, parts, or claim forms cannot be released into a task for processing until the release condition for the task evaluates to true.

2.3 Beginning and Ending Effects

The current state of the system may change when a task begins or ends. For example, when a machine begins processing a part it becomes "busy" and is not available to another part until it has finished. The user would define the following expressions in Micro Saint to define this condition:

Release Condition: busy == 0; (A test for logical equality is represented as "==" in Micro Saint.) This keeps an entity (part, patient, etc.) from moving into the task when the task is "busy" processing another entity.

Beginning Effect: busy := 1; (Assignment statements are represented as ":=" in Micro Saint.) This sets the busy flag to TRUE so that the next entity cannot enter the task. As long as the task is executing, the busy flag will remain equal to "1".

Ending Effect: busy := 0; When the task finishes executing, the ending effect is evaluated and the busy flag is set to 0. Now, when the release condition is evaluated, the condition will be true and the next entity can enter the task.

The relationship between the release condition and the beginning and ending effects provides a general, yet powerful mechanism for users to define complex behaviors within the system they are modeling. Users may define variables that are specific to their system and manipulate the value of the variables as needed so that they can accurately represent their system. They do not have to compromise the accuracy of their model by relying on pre-defined "blocks" within the modeling tool nor do they have to learn a complex programming language in order to obtain the level of control required.

A feature that greatly increases Micro Saint's power is the "parser" that evaluates algebraic expressions. It provides the mathematical power of computer programming languages such as FORTRAN or C, but eliminates the need for compiling the model before running it. One of the biggest advantages of the parser is that it allows users to interactively change the value of model parameters while the model is executing. For example, the user can increase the number of resources available or change the execution time for a task while the model is executing to see what the overall effects on the system would be.

3 MODEL DEVELOPMENT

The process of building a Micro Saint model involves two separate but interrelated steps. First, the user must define the structure of the task network. This is done by selecting the appropriate tool from the tool palette and placing the object in the drawing space of the network diagram. The Micro Saint tool palette and drawing space is presented in Figure 3.

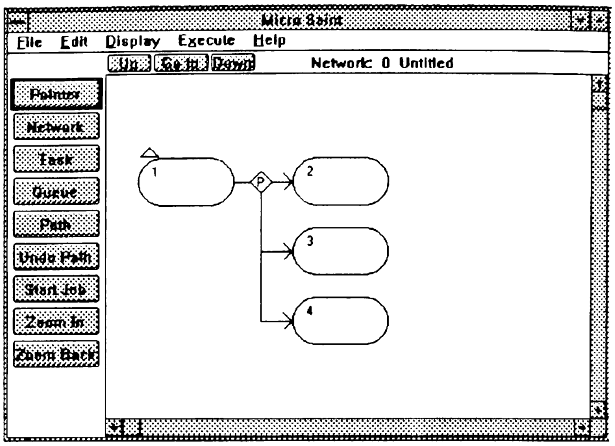

Figure 3: Micro Saint Tool Palette

Micro Saint uses a standard windows "point and click" approach to define the network objects. Using the mouse to "double-click" on an object will open it so that information specific to the object may be entered. Figure 2 above is an example of the Task Description window that is opened when the user double-clicks on a task (i.e., node in the network.).

Task sequencing is defined by clicking and dragging with the mouse from the first task to the following task(s). A diamond shaped "decision icon" appears on the network diagram when more than one following task is defined. Users must enter the conditions that control the branching when there is more than one following task. Micro Saint provides the following decision types to ensure that all real-world situations may be represented in the model:

Probabilistic - The following task conditions are evaluated and the next task to execute is determined by the relative probabilities of all tasks listed. Probabilistic decisions allow only one of the following tasks to execute.

Multiple - The following task conditions are evaluated and all of the tasks whose conditions evaluate to non-zero will execute.

Tactical - The following task conditions are evaluated and the next task to execute is the task whose condition evaluates to the highest value.

Variables and algebraic expressions can be used in the branching logic and the value of the variables can be changed by conditions in the model. This gives the user complete control and manipulation of the network flow.

Figure 4 is an example of a tactical decision that controls the flow of patients in an emergency room model through the network based on the seriousness of their injury.

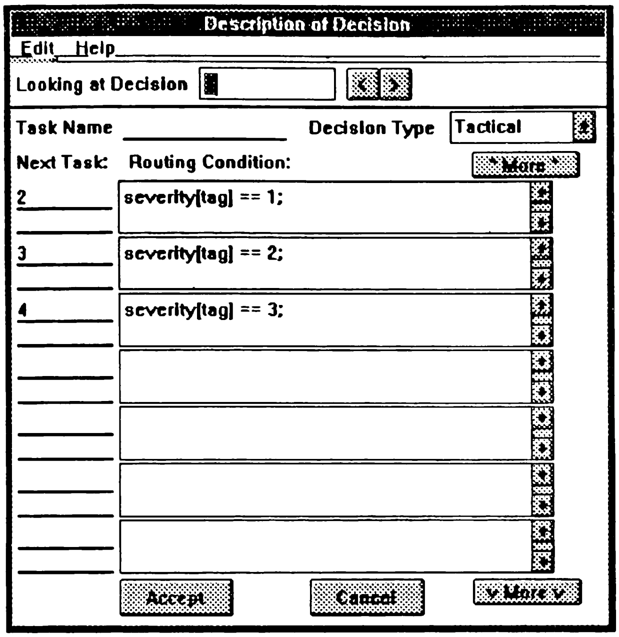

Figure 4: Micro Saint Tactical Decision

All of these features work to provide an environment for the model developer that is easy to learn and easy to use. Once the basic concepts are understood, any system or process can be modeled using Micro Saint. In addition, users can build models at any level of complexity. Some applications may require a very low-level, detailed definition while for others, a high-level definition is sufficient.

4 ANALYSIS AND RESULTS

People build models to provide insight to, or answer specific questions about, a system or process. Some information can be gained by watching the Micro Saint model run. Micro Saint's symbolic animation capability provides an animated view of the network diagram as the model is running. Users can watch as entities flow through the network or wait in queues before being processed. This type of animation is particularly useful in debugging the model. An example of an animated network is shown in Figure 5. Micro Saint also provides an iconic animation capability called ActionView (see Figure 6) that allows users to build a realistic "picture" of their model.

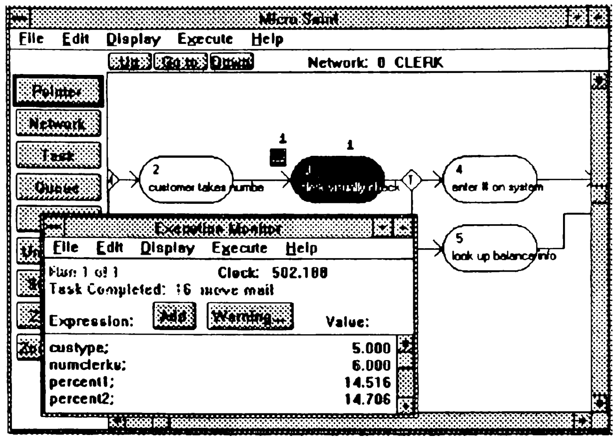

Figure 5: Micro Saint Symbolic Animation

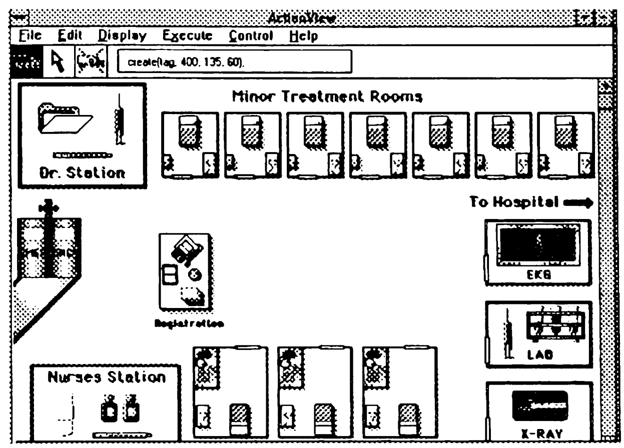

Figure 6: Micro Saint ActionView Animation

In addition, data can be collected at any time during the model run. Sometimes it is sufficient to save the state of the system at the end of the run. However, in order to gain insight into the dynamic aspects of the system users can "take snapshots" of the model variables any time during run. These "snapshots" of data can be analyzed using the graphing capabilities within Micro Saint (see Figure 7) or imported into another statistical analysis package. Through the results of the simulation analysis and the insights gained, users can assess the relative merits of alternative solutions as well as predict their impact that leads to a better understanding of the costs and benefits.

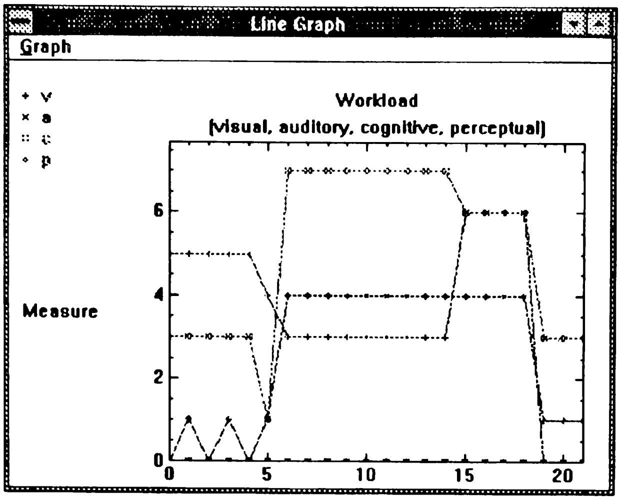

Figure 7: Micro Saint Line Graph

5 MANUFACTURING

Micro Saint is used in the manufacturing industry to look at throughput, cycle time, the optimal schedules and in new factory layout. Major companies have found Micro Saint is easy to use and very flexible making it a choice for companies that need a simulation tool to use in different departments such as the work cell analysis and the reengineering of the accounting department.

In one example, a Fortune 100 company had a cellular manufacturing layout that they felt could be made more efficient. They were about to make substantial capital improvements in manufacturing system equipment and wanted to make sure the new equipment was integrated with the old equipment in the best possible way. The company used Micro Saint to model their manufacturing system and reach their goals of finding a cellular layout that would meet their production goals. This study required a sophisticated model because the production goals were spread across 40 different product types , and capacity for inventory was limited, indicating a need for a JIT design. The study was limited to three weeks in length.

In the process of building the model, the customer gained an understanding of the system that showed them many areas for potential improvement. The project did not attempt to discover the "optimal design" for the cell rather it only identified one of an entire family of solutions that would work. More models were built in order to simulation the other production line cells. These models allowed the customer to consider tradeoffs based on operator utilization balanced against the cost of the equipment, operator training, installation requirements and process time.

The bottom line was the manufacturer was able to increase production by 71% and increase profit per unit by 142%. This resulted in an increase in the annual profits of the company by over 400% on that single production line. The company reduced costs and improved quality with a small investment in simulation.

6 HEALTH CARE

In the health care industry, Micro Saint has been used to look at emergency room flow, ambulatory services, OBGYN units, pharmaceutical processes and patient file flow. Customers often choose health care facilities on the basis of the quality of service they receive. Every hospital or health care organization must answer questions about cost and quality. One way hospitals are able to look at cost versus quality is by using simulation. In one instance, an Ambulatory Surgery Department, the department that cares for patients both pre-operatively and post-operatively, had run out of space. The question was to build a new facility or redesign the existing space without changing the surgery schedule. Micro Saint was used to simulate the flow of patients from ambulatory surgery to surgery to recovery and back to ambulatory surgery. A management engineer simulated the effects on many different alternatives for routing patients through the system and maximized the utilization of the facilities.

The hospital staff was so pleased with the recommendations for the ambulatory surgery facilities that the management engineer was asked to help evaluate the surgery schedule on a daily basis. The changes recommended as a result of the simulation models allowed the hospital to increase the number of patients that can be scheduled for ambulatory surgery, therefore increasing profits while improving the quality of service being offered to patients.

This is just one example of how Micro Saint can help improve the patient care while reducing costs at a hospital.

7 HUMAN FACTORS AND ERGONOMICS

The use of simulation to analyze human factors and ergonomics is a relatively new application of simulation. However, we at Micro Analysis and Design have found simulation to be extremely useful in evaluating decisions such as "how many crewmembers do we need to fly an airplane?" and "what will the availability of trucks be for a given number of maintainers of given skill types?" Additionally, we have developed simulation techniques to answer these questions as a function of equipment design factors.

For example, during the early design phases of the Army Comanche helicopter, one of the key objectives was that the aircraft be piloted and operated entirely by one human. Central to that objective was the question, "Can one person do it all?" We were called upon to examine this issue with respect to four alternative helicopter cockpit designs. Specifically, the purpose of this project was to determine whether a one-person cockpit design would cause the operator's workload to reach unacceptable levels during the mission.

Micro Saint computer models were developed for each of the cockpit alternatives considered. Variables and modeling constructs were included in these models to track operator workload demands in the visual, auditory, cognitive, and psychomotor aspects of the operator's tasks. Using these models, simulation experiments were conducted under several experimental conditions corresponding to different cockpit designs. For each design, operator workload was predicted and the tasks driving workload were identified. The advantages of each of the alternatives were identified. The report we prepared discussed the relative advantages and disadvantages of each design as well as the projected technological requirements that would be required to support a one-person cockpit. Ultimately, we recommended that a one-person cockpit was not feasible within the technical and other design constraints.

This is one of many examples of human engineering questions we have addressed with Micro Saint.

8 BUSINESS PROCESS REENGINEERING

Business Process Reengineering is a term that, in effect, applies to all the areas previously discussed. In many cases the process the way it is today is looked at critically and in depth, the reengineering project is defined, objectives are set and a team is assembled. Then questions are asked by a team as to why a certain process is done in a certain way. The phrase, "because it has always been done that way" is a clue that closer scrutiny is warranted. To be competitive in today's environment one has to look beyond the limited scope of the same four walls. In evaluating the process many hard questions unfold. How many people needed to get the job done? Is there any cross training going on so one person can be more productive?

At this point in most BPR analyses, a process map is built. The process map is in turn used to identify the data requirements for what is the heart of the understanding phase, the process model. The process model is, essentially, a task network. When the data requirements are defined and the sources of the required data have been identified, a task analysis is conducted to verify the process map and begin the development of a process simulation model of the current process. In this case, the simulation takes an additional role - the means of process model verification and validation.

For example, in a hospital model, we gathered all the information for an obstetric unit, built a model and validated the model -- only then did we find out the process that was given to us by doctors was not the actual way the nurses went about their tasks! If we had not validated the model with simulation, the model would have been incomplete.

The final phase of the process reengineering methodology is the solution phase. Given the insights that were obtained from the process modeling effort, and the reengineering objectives, this phase searches for opportunities for radical improvement in cost savings, cycle time, service and quality. During the final phase we continue to look for ways to make the new process easier. The final phase also allows the Micro Saint user to play "what if" with the potential process modifications and test our initial hypotheses about how to reengineer the process. The decision to implement an identified reengineering solution is done by looking at the results of the process models and process objectives.

Business Process Reengineering takes on many different approaches. A Fortune 500 company has recently used Micro Saint to look at their underwriting process. The process was studied and modeled. In the modeling process the modelers found the claims were stacking up in the mailroom and sometimes up to a week before getting to the underwriter. After modeling the process flow and building a working model, the insurance company found the time it takes for a claim to be filed until the customer receives the check could be cut from 10 days to 5. They could accomplish this goal by using an express mail service. The net result is happy customers.

9 SUMMARY

In this paper, we have focused on the Micro Saint methodology and the underlying principles of modeling with Micro Saint in a variety of different industries. We have not attempted to cover all of the software features for building models, controlling a simulation, and generating and analyzing data. If you would like to know more, please contact Micro Analysis and Design.

What we have shown is that Micro Saint is a powerful tool for evaluating the dynamic aspects of systems within a wide variety of application areas. Micro Saint's primary strength is that it has an intuitive, graphical interface that allows users to quickly develop models that accurately represent their system. Users are then able to play "what if" with a variety of inputs to evaluate alternative solutions. Simulation technology has been used by industrial engineers in a manufacturing context since the 1960's but only recently has been applied to more "white collar" applications. Regardless of the application area, the results are the same: better decisions can be made, money can be saved, productivity can be increased, and customers can receive a higher level of service.

AUTHOR BIOGRAPHIES

CATHERINE E. DRURY is the Marketing Director of Micro Analysis and Design, Inc. She has a Bachelor's of Science in Marketing from Miami University of Ohio. Currently, she is working towards her M.B.A. at the University of Colorado at Boulder.

K. RONALD LAUGHERY JR., received his Ph.D. in Industrial Engineering from the State University of New York at Buffalo. He established Micro Analysis and Design in 1981, managing contracts for the development of computer modeling and simulation languages, the design and evaluation of training simulators, the development of supporting technologies for constructive and distributed simulations, and the development of tools for the Army MANPRINT program. Additionally, he participates in developing a number of simulation models for the Army, Air Force, and private industry.