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A TUTORIAL ON PROSIM™: A KNOWLEDGE-BASED SIMULATION MODEL DESIGN TOOL

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ABSTRACT

This paper introduces PROSIM, a knowledge-based simulation design tool that automatically generates simulation models from process models. Domain experts who are familiar with the various aspects of the system may be interviewed and process models can be developed based on the evidence collected using PROSIM. The built-in simulation design support environment of PROSIM enables building simulation models automatically from process models. A purchase order processing system example is described to demonstrate the utility of PROSIM.

1 INTRODUCTION

The increasing complexity of organized enterprises has enhanced the utility of simulation as a managerial problem-solving and analysis tool. While specific areas in simulation modeling technology have shown rapid advances in the recent past, there are a few areas which would benefit from further research. Specifically, current simulation practice 1) affords little support for the initial analysis and model design tasks which are largely qualitative in nature, 2) involves the unproductive use of both the domain expert's and the simulation analyst's time in the modeling process, and 3) suffers from lack of widespread acceptance by decision makers due to the relatively long lead times and sophisticated skills needed for the effective use of simulation modeling techniques. It is the purpose of this tutorial to introduce PROSIM, a knowledge-based simulation model design tool that automatically generates WITNESS™ simulation models from IDEF3-based process models, as a possible solution for the aforementioned shortcomings.

2 PROCESS MODEL GENERATION USING PROSIM

PROSIM enables a modeler to capture processes or situations as an ordered sequence of events or activities. It is designed to capture process descriptions of the precedence and causality relations between events/situations in a form that is natural to domain experts in an environment. One of the primary goals of the tool is to provide mechanisms for expressing a domain expert's knowledge about how a particular process works.

PROSIM uses "scenarios" as the basic organizing structure for establishing the focus and boundary conditions for the process description. This feature is motivated by the tendency of humans to describe what they know in terms of an ordered sequence of observed activities within the context of a given situation.

The basic syntactic unit of PROSIM graphical process descriptions within the context of a scenario, is the Unit Of Behavior (UOB) represented by a rectangular box. Each UOB represents a specific view of the world in terms of a perceived state of affairs or state of change relative to the given scenario. UOBs are connected to one another via junctions and links. Junctions provide the semantic facilities for expressing synchronous and asynchronous behavior among a network of UOBs. Links represent temporal precedence, object flow, and relations between UOBs. Each UOB can have associated with it both descriptions in terms of other UOBs (a decomposition of a parent UOB) and a set of participating objects and their relations (an elaboration).

Let us consider a situation of an analyst interviewing a purchase department manager to capture main activities involved in generating purchase orders at the company. The purchase department manager is mainly responsible for the processing of purchase request forms, finding existing suppliers for the part, inviting bids from potential suppliers, receiving bids, evaluating bids, placing purchase orders, and acquiring the material. First, the initiating department (typically design or process planning) formally requests the needed material. If the requested material has existing suppliers, a purchase order can be placed immediately. On the other hand, if the requested material is new, or the existing supplier no longer produces the part, then the purchase department has to invite bids from potential suppliers, receive the bids, evaluate the bids, and place a purchase order to the selected supplier. The process flow diagram that depicts the sequence of activities involved in the purchase order generation process can be captured using PROSIM and is shown in Figure 1.

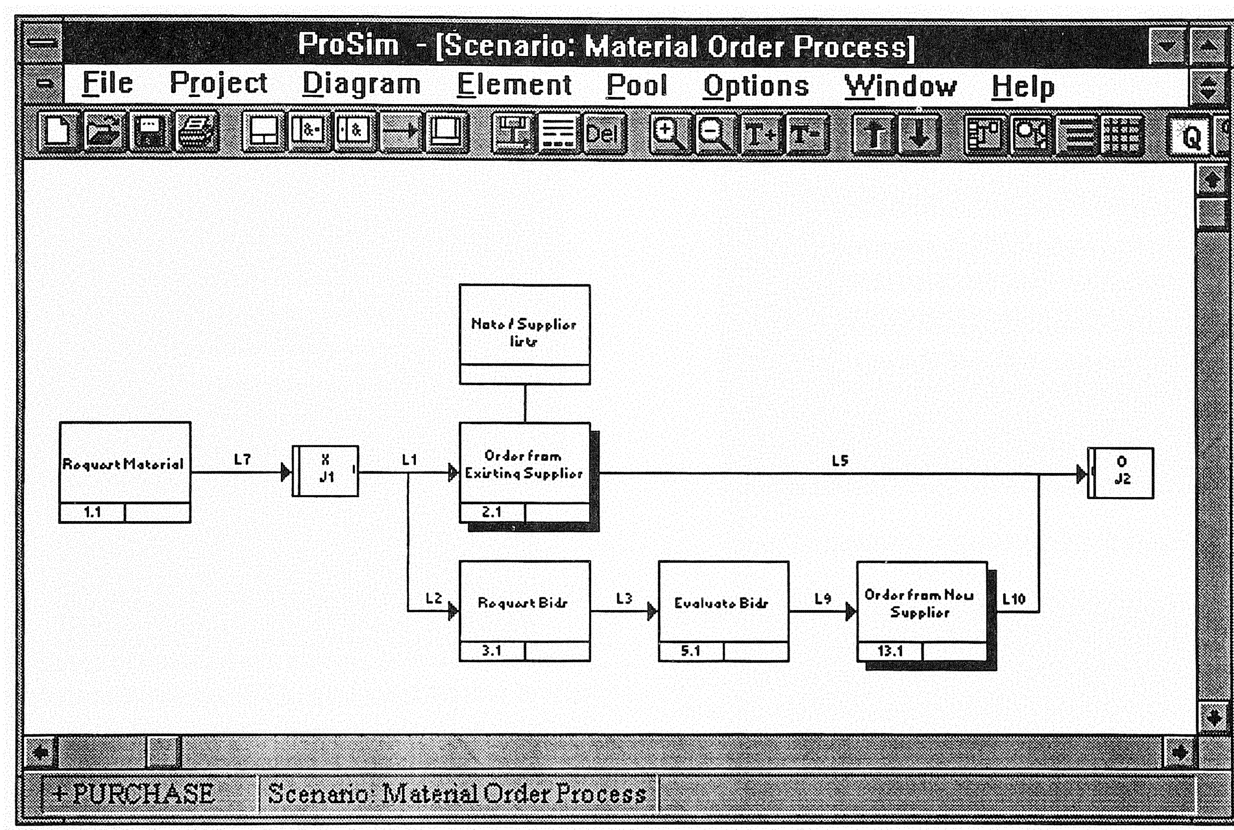

Figure 1: A Process Flow Diagram of the Purchase Order Process

3 GENERATING SIMULATION MODELS USING PROSIM

The intelligent support provided by PROSIM reduces the expertise required to design effective simulation models and perform simulation experiments. It provides an environment in which users can develop designs for discrete event simulation models from process descriptions and supports the conceptual modeling activities at various stages of the model design process. PROSIM can be used to support the analysis and design of manufacturing systems, business systems, logistics systems, command, control, communication, and intelligence systems, concurrent engineering systems, service systems, and information systems. It is a critical tool for realizing the monetary benefits of business process re-engineering and activity based costing.

PROSIM has a built-in simulation model design support environment. In other words, it has an expert system programmed to provide expertise at a level comparable to that of a simulation modeling expert. Process flow diagram constructs, UOBs, objects, and junctions, are required to be detailed within PROSIM in order to generate simulation model. Consider the *request for bids* UOB in the example process flow diagram in Figure 1. The real world objects that participate in the process of requesting bids are "Technical Package," "Purchase Department Manager," "Potential Supplier List," "Bid Package," and "Building 1." A "technical package" contains the technical data of the part to be ordered. The technical data of the part may include engineering specifications, tolerances, material to be used, special tools and jigs required to manufacture the part. A "Purchase Department Manager" requests bids by sending a technical package along with the bid package to potential suppliers. The "Potential Supplier List" consists of details of all the potential suppliers such as "supplier code," "supplier name," "supplier address," "supplier manufacturing capabilities." The "Bid Package" consists of information about the requirements of the bid responses, financial details, and other contractual details. This activity is performed in the location, "Building 1."

In ProSim, a dedicated resource is categorized as

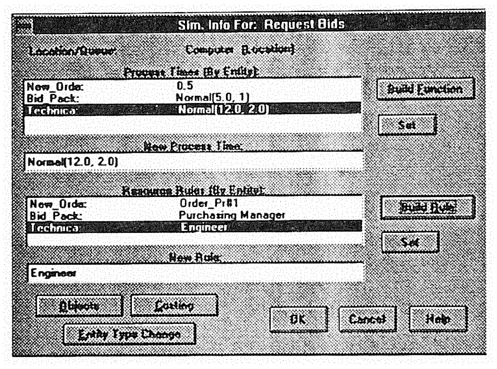

Figure 2: Dialog Box for Detailing a Unit of Behavior

either a *location* or a *queue*. The location label is provided whenever a non-waiting activity is represented by the UOB. If the UOB is used to represent a waiting activity, the dedicated resource is associated as a queue. Flow objects that participate in UOBs are called *entities*.

3.1 UOB Detailing

The dialog box shown in Figure 2 is used to record the process times for the *Request Bids* UOB. Process times are recorded for the entities that participate in the process. The names of the entity objects that participate in this UOB are New Material Request Form (labeled "New Order"), "Bid Package," and "Technical Package." The process time for "New Order" is a constant of 0.5 days. The process time for "Bid Package" is a normal random variable with a mean of 5 days and a standard deviation of 1 day. The process time for "Technical Package" is a normal random variable with a mean of 12 days and a standard deviation of 2 days. The Objects such as "computers," "personnel manager" are categorized as *resources* in ProSim. Resource objects, as well as other objects, can be shared between different UOBs in a ProSim model.

3.2 Entity Detailing

Entities flow between UOBs in a scenario. The inter-arrival time distribution is an item of information required to simulate the behavior of entities in a system. Figure 3 displays how the details of "New Material Request Form" are recorded in a ProSim model. Observe that the inter-arrival time for this entity is a negative exponential random variable with a mean of 10.0 time units. The arrival point is the first process visited by the entity as it flows through the scenario.

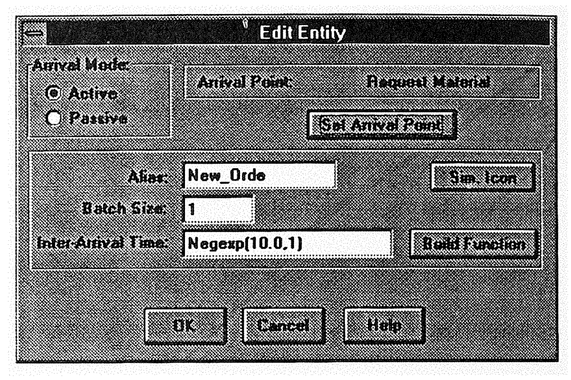

Figure 3: Entity Detailing

3.3 Decision Logic Specification

Junctions in ProSim provide a mechanism to specify the logic of process branching. Different junction types are supported in ProSim to aid in capturing the semantics of branching in real-world processes. Junctions support the description of 1) a process that splits into two or more process paths, or 2) two or more process paths converge into a single process. Junctions are classified in three different ways. First, they are classified according to the logical semantics involved: *AND* (&), *OR* (O), and *exclusive OR* (X). Junctions are further classified as either *fan-in* or *fan-out*, based on whether they represent a *convergence* or a *divergence* in the logic of the process description. They are also classified based on the coordination of the timing of the associated UOBs as either *synchronous* or *asynchronous* (KBSI 1992a).

An exclusive OR (X) junction is used to model decision logic. In our purchase order processing example, an exclusive OR junction is used to represent the logic that activity "request material" is followed exactly by one of the following two activities: 1) "order from an existing supplier", or 2) "request bids from new suppliers" with probabilities of 0.8 and 0.2, respectively (Figure 1).

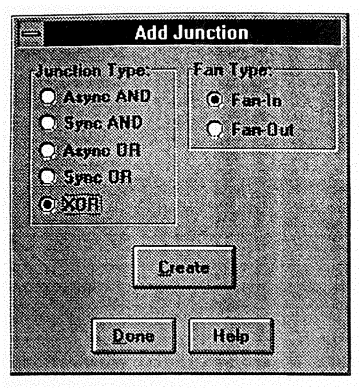

Figure 4: Adding a Junction

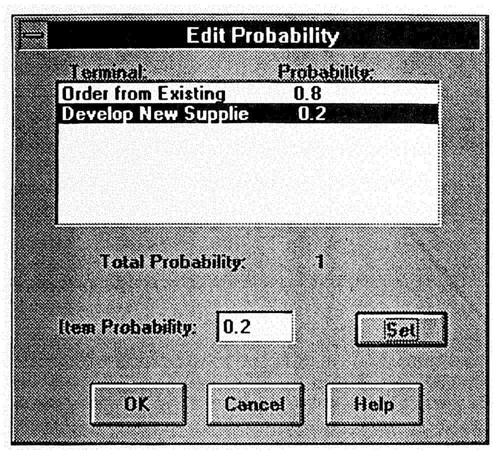

Figure 5: Junction Detailing

3.4 Performance Metric Specification

The goal in designing a simulation model is to generate data to answer a set of questions. Examples of questions include, "What is the total process time?", "What is the resource utilization?". PROSIM provides support for designing instrumentation to help answer these questions. In other words, PROSIM helps you select appropriate performance metrics that will automate the generation of output data to answer the questions. For example, the performance metric used to answer the first question is *Process Time* for the UOBs "preparation of bid package," "preparation of technical package," "filling in new material request form," and "filling in the repeat material request form." The PROSIM dialog boxes used to specify these performance metrics are shown in Figures 6 and 7.

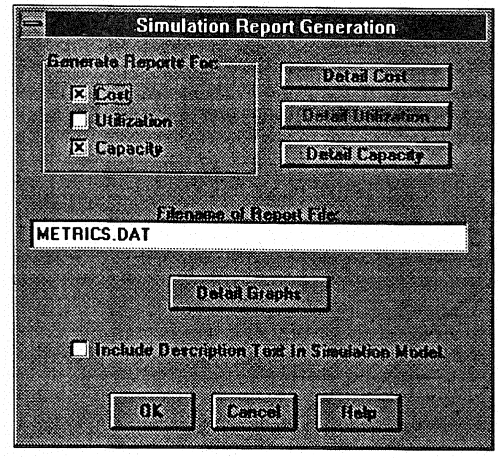

Figure 6: Simulation Performance Metrics Specification

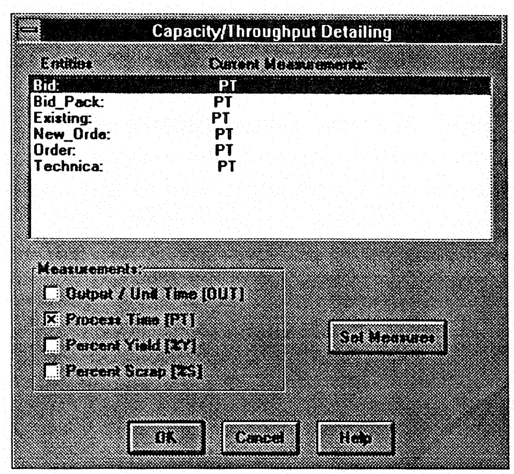

Figure 7: Metrics to Compute Process Time

3.5 Model Verification

In the context of PROSIM, model verification is defined as the process of ensuring that the minimum amount of information required to generate a WITNESS simulation model exists in the process model. Model verification is performed using the *Model Verification* option in the Diagram menu in PROSIM. A more detailed description is given in the *PROSIM User's Manual and Reference Guide* (1995).

3.6 Simulation Model Generation

PROSIM simulation model design specifications are now transformed to an equivalent representation in the WITNESS Input Command Language. This is done by using the *Build Simulation Model* option in the PROSIM

File menu. After the model has been generated, the next step is to open the application and load the model using the *Read Commands* option in the Model menu (see AT&T ISTEL 1992). After the WITNESS model has been loaded, the user can run the model and generate the desired performance metrics. WITNESS provides state-of-the-art capabilities for simulation-based analysis and experimentation.

4 POTENTIAL BENEFITS OF USING PROSIM

PROSIM has the following potential benefits: 1) it enables novice simulation modelers to develop and use complex simulation models, 2) it encourages and promotes the use of simulation as a decision support tool among a wide group of users from a variety of application domains, 3) it substantially reduces time and effort needed to develop simulation models, and 4) it facilitates the capture and retention of simulation model design rationale.

5 SUMMARY

This paper described salient features of PROSIM, a simulation model design tool. An example of purchase order processing system is provided to demonstrate the procedure of building process models from domain experts' descriptions and then generating a simulation model from this process model.

REFERENCES

AT&T ISTEL Limited. 1992. *WITNESS user manual*, Release 4.0, Cleveland, OH.

Knowledge Based Systems, Inc. (KBSI). 1992a. IDEF3 method report. Prepared for the U.S. Air Force Human Resources Laboratory, Contract No. F33615-C-90-0012.

Knowledge Based Systems, Inc. (KBSI). 1992b. Issues in knowledge-based assistance for simulation model design from IDEF3 descriptions. Technical Report for NSF SBIR Phase II Grant No. III-9123380.

Knowledge Based Systems, Inc. (KBSI). 1995. *PROSIM user's manual and reference guide*, Version 2.1, College Station, TX.

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