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ProModelPC TUTORIAL

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ABSTRACT

Typically, simulation packages for modeling manufacturing systems have been classified as either simulation languages or manufacturing simulators. There has been two reasons for this classification. Languages that offer flexibility require programming while simulators that offer ease-of-use lack flexibility. ProModel (PROduction MODELer) is a microcomputer based manufacturing simulation program that combines the flexibility of simulation languages and easy-to-use features of manufacturing simulators for rapid model development of complex systems. This tutorial presents an overview of ProModel, describes the elements that provide ProModel's modeling power and its ease-of-use, and highlights these elements with an example.

1. INTRODUCTION

In the past, manufacturing systems have been simulated primarily by programmers or simulation specialists rather than by the manufacturing or industrial engineers who design the systems. Typically, these simulations have been performed on mainframes with expensive software packages. Therefore, the use of simulation in manufacturing has yielded limited success until recently because of the lengthy programming efforts, miscommunication between the engineers and programmers, and expensive software and hardware.

Perhaps the most significant advancement in simulation software is the emergence of powerful and easy-to-use packages that run on microcomputers. While simulation purists cringe at the thought of what can happen when a sophisticated tool like simulation is put in the hands of inexperienced practitioners, there are three obvious benefits to be gained from this current trend:

1. Often, process or product design improvements suggest themselves in the very activity of building a simulation model. An engineer would never discover them if someone else is doing the model building. While an engineer may not be as proficient as a "simulation expert", the dividends in increased understanding of the system operation and acquired skill in conceptualizing system designs will pay off in the long run.

2. Realistic looking animation helps simulation to become a powerful communication vehicle between engineers and managers. A surprisingly large number of simulation models are now being constructed solely for the purpose of demonstrating Continuous Flow Manufacturing (CFM) concepts or presenting complexities of automated systems.

3. Menu-driven data input with manufacturing oriented, easy-to-understand modeling constructs tremendously reduce the model validation and verification time. Because all parties involved in the design process including managers, engineers, supervisors, and technicians can understand the simulation inputs, they are more likely to help insure model validity and to accept the results of the model.

In light of these major benefits, ProModel is designed for industrial and manufacturing engineers who have neither the time nor the interest to do programming and yet who have the need for a modeling tool that is powerful enough to simulate a wide range of production systems.

ProModel's design philosophy is also attractive to professors who are interested in teaching simulation modeling concepts rather than teaching how to do programming in Industrial Engineering, Manufacturing Engineering, Production Management, Operations Management courses.

2. OVERVIEW OF PROMODEL

ProModel is a powerful yet easy-to-use pc-based simulation tool for modeling all types of manufacturing systems ranging from small job shops and machining cells to large mass production and flexible manufacturing systems. ProModel is capable of simulating systems that operate under push or pull type production requirements.

ProModel's built-in constructs enable users to focus on manufacturing problems rather than programming problems. Particularly noteworthy are the powerful material handling constructs based on continuous part tracking. These constructs give you the ability to easily and realistically model complex operating characteristics and control logic of automated material handling systems including robots, AGVS (Automated Guided Vehicles), cranes, conveyors, and AS/RS (Automated Storage and Retrieval Systems).

While ProModel may appear at first glance to be just a simple parameterized simulator, it actually incorporates most of the features available in general purpose simulation languages. For special cases that cannot be modeled using ProModel's built-in constructs, ProModel provides a procedural language capability with attributes, global and state variables, user-defined distributions and functions, IF-THEN logic, etc. For extremely complex decisions or computations, ProModel provides hooks for user-written subroutines developed in low level programming languages such as C or PASCAL.

Use of ProModel requires only a brief orientation and no programming is required. ProModel's graphical and menu-driven input screens guide the user through a complete interactive model building process.

In addition to the interactive approach to model building, the user may also interact with the model during the simulation run to dynamically change resource availability, queue size, part availability, etc. This enables the user to have an active role in controlling the operation of a model.

To help visualize what is happening during the simulation, ProModel displays an animated picture of the factory operations. During the animation, the user can zoom and pan around the screen, freeze the simulation and review snapshot reports, and single-step through the events using traces.

After running the simulation, ProModel automatically generates a comprehensive report of the statistical results. Tabular and graphical reports are provided for each location, part, transporter, resource, etc. that is defined in your model.

ProModel runs on standard IBM PC XT, AT, PS/2 or equivalent computers with 640K memory and EGA or VGA video adapters. ProModel runs under DOS, OS/2 and WINDOWS.

Memory is dynamically allocated so that models size is restricted only by the amount of memory available on the computer. This gives users the capability to model very large systems with hundreds of operations and hundreds of thousands of active parts in the system at any time.

3. MODELING ELEMENTS

3.1 Parts

Parts refer to items that are processed in a production system. These include raw materials, piece parts, assemblies, loads, WIP, finished products, etc. Each unique part type is defined with alphanumeric characters (part names or part numbers) and has its own defined routing. Parts can be put into temporary or permanent batches, and they can be assembled or disassembled. Parts may be assigned attributes that can be used for complex routing logic or for customized reporting.

3.2 Resources

Resources refer to items that are used for producing parts. These include routing locations (i.e. machines, storage areas, queues, etc.) where parts are routed and some operation may be performed, or general resources (i.e. operators, tools, fixtures, etc.) which may be used during an operation or part movement. Resources may be assigned priorities and downtimes.

Resources must be assigned capacities. The capacity of a resource is the maximum number of parts that can independently use the resource at any given time. For a storage or queueing location, it is the maximum number of parts that can simultaneously occupy that location. For a machining location or a general resource, it is the number of resources available to perform identical operations.

3.3 Transporters

Transporters refer to mobile resources that are used for moving parts. These include AGVs, robots cranes, operators, forktrucks, etc. Transporters have specific paths (uni-directional or bi-directional), a defined control logic for movement and allocation.

3.4 Conveyors

Conveyors refer to synchronous or asynchronous material movement systems that are used for moving parts. These include accumulating conveyors and non-accumulating conveyors that may be configured with transfers, recirculation loops, sortation, accumulation and distribution capabilities. Bi-directional conveyors can be modeled.

3.5 Routing

The routing defines the part flow logic including location and operation sequences, operation times, part input-output relationships such as assembly or disassembly, routing conditions, move times, etc. Parts can be routed conditionally (built-in or user-defined), probabilistically, or deterministically. Operation times and move times can be defined using built-in statistical distributions, user-defined distributions or functions, user variables, attributes or subroutines.

3.6 Downtimes

Downtimes refer to the five built-in routines that are used for representing resource interruptions such as planned maintenance, tool wear, random equipment failures, lunch breaks, product changeover, etc. These include clock based, usage based, cycle based, set-up based, and shift based downtimes. Like operation times in the routing, downtime duration and frequency can be defined using various built-in or user-defined options. A resource may have multiple downtimes. Furthermore, a downtime may be assigned to several resources.

3.7 Part Scheduling

Part Scheduling refers to the mechanism for introducing parts to the production system. Raw materials, purchased parts, sub assemblies, or WIP can be scheduled into the system using Part Scheduling. Scheduling can be done randomly, deterministically, or cyclically. The necessary data for scheduling parts include part name, location where the parts enter the system, batch size, arrival frequency, number of arrivals, and the starting time for the first arrival. Scheduling data can be imported into ProModel from an external manufacturing database.

4. GENERAL SIMULATION CAPABILITIES

The general simulation features are what give ProModel its power and flexibility necessary for modeling complex manufacturing and material handling systems. A brief summary of these features are presented below:

Part attributes (999 per part type)
Integer and Real User Variables (999)
System Variables
Discrete and Continuous User-defined distributions (999)
User-defined functions (100)
User-defined Subroutines (No practical limit)
Expressions (Arithmetic, Relational, Logical)
Built-in Statistical Probability Distributions
(Exponential, Normal, Uniform, Triangular, Beta, Gamma, Erlang, Weibull, Lognormal)

5. SPECIAL FEATURES

In addition to general simulation capabilities, ProModel has some special features that completely distinguish it from other simulation software.

5.1 Scheduling Optimization

This built-in feature is designed to help manufacturing supervisors to optimize a daily or weekly production schedule. Given a simulation model with a set of jobs for production, ProModel executes simulations of all possible combinations of job sequences and finds the best order release (Shortest throughput time and highest throughput).

5.2 Merging Multiple Models

This built-in feature is designed to help modelers to tackle large simulation projects effectively by developing independent models of portions of a system and later combining these models (simulation and animation) with the push of a button. For example, while one engineer models the fabrication operations in a factory, another engineer models the assembly operations. Using ProModel's Merge capability the two models can be combined where the outputs of the fabrication model become the inputs to the assembly model.

6. USING PROMODEL

Much of the ease in using ProModel comes from the simple and straightforward way in which the models are defined and results are obtained. A model is defined the same way in which a manufacturing engineer would naturally describe a production system using the same familiar terminology. On-line, context sensitive help screens provide useful hints for data input.

Models may be defined graphically or textually. To define a model graphically, you begin by placing locations on your layout screen (see example in Figure 1). A location may be a machine, work station, queue, a department, a position on a conveyor or transporter path. You may choose a location symbol from ProModel's rich library of icons or you may create your own icon using the pixel-based graphics editor.

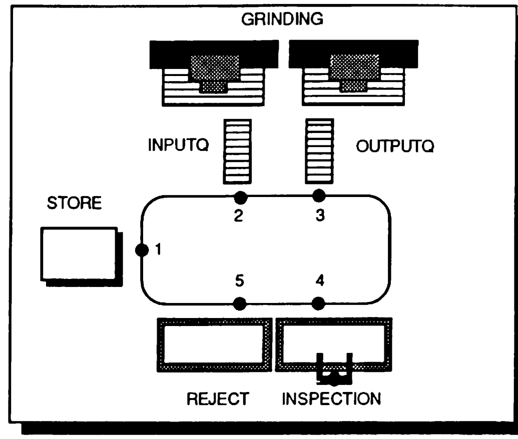

Figure 1. An Example of Layout Screen

After laying out your locations, you define the flow of parts through the system by clicking on the locations where parts are routed. On each location, you specify what operations, if any are performed, what resources are required, what downtimes are applied, how parts are moved between locations, etc.

Once you define the routing, you can utilize ProModel's "Automatic Model Build" mode which guides you step-by-step through the rest of the menus and helps you complete your model. Each of these steps is performed using easy-to-complete menus that are automatically invoked based on information supplied in a previously completed menu. This unique feature of ProModel insures data integrity and saves valuable engineering time.

All model data is written to an ASCII file which can be quickly edited or saved for documentation purposes (see example in Figure 2). This also allows experienced simulation users to bypass the menus and develop models using a text editor.

ROUTING

Part	Location	Operation (min)	Output part	Next location	Condition	Qty	Move time (min)
LOAD	STORAGE	0	LOAD	INPUTQ	0	1	AGV
LOAD	INPUTQ	.05	PLATE	GRINDING	0	10	.05
PLATE	GRINDING	.8	PLATE	OUTPUTQ	0	1	.05
PLATE	OUTPUTQ	.05	PLATE	INSPECT	0	1	AGV
PLATE	INSPECT	USE INSP .5	PLATE	EXIT	800	1	0
			BAD	REJECT	200	0	.05
BAD	REJECT	ACCUM 10	BAD	INPUTQ,1	0	1	AGV
BAD	INPUTQ	.05	BAD	GRINDING	0	10	.05
BAD	GRINDING	.4	PLATE	OUTPUTQ	0	1	.05

Figure 2. An Example of Routing Data

After completing your model, you can save it and run a simulation. At this time, if there are any errors or inconsistencies in model input that could not be detected during model definition time, ProModel provides detailed error message and points out the elements that may have caused the error. If model input is free of errors, ProModel begins executing the simulation.

Simulations can be run with or without animation. If the animation option is selected, the layout screen becomes your animation screen. This screen is a virtual screen and can include as much detail as the user wishes. During the animation, counters of user variables such as WIP level and throughput can be displayed for meaningful presentations. Animation screens can be printed on dot matrix or laser printers.

Simulations can be run in batch or interactive mode. Multiple simulations can be executed one after another for scenario comparison. An automatic replication capability is also available for making multiple replications of a simulation run. Using a multitasking operating environment, users can simulate and animate multiple simulation models simultaneously.

After the simulation, you can view the output reports to analyze the system performance measures. Unlike most simulation software, ProModel's output reports are automatic. The automatic graphical results permit quick output analysis without resorting to spreadsheet analysis software. However, if you wish to customize your reports, you can export ProModel's ASCII output file to spreadsheet programs (see example in Figure 3).

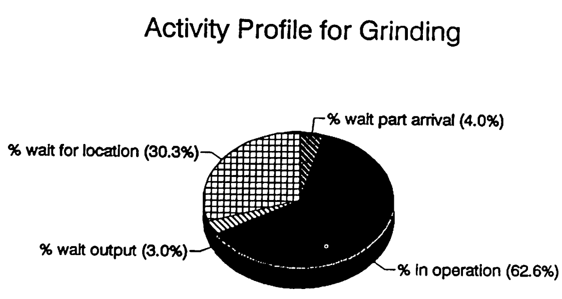

Figure 3. An Example of Graphical Output

7. CONCLUSIONS

One of the major obstacles to successful use of simulation in manufacturing applications in the past has been the difficulty in getting results in a timely, understandable and cost-effective fashion. ProModel eliminates this obstacle by providing an easy-to-use, flexible, portable, quick and affordable environment for engineers.

Future developments and enhancements to ProModel are directed toward making ProModel a standard tool in the hands of manufacturing and industrial engineers just as spreadsheet software is in the hands of accountants and financial analysts.

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