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PROMODEL TUTORIAL

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ABSTRACT

ProModel\WINDOWS is a microcomputer based, manufacturing simulation software that provides the flexibility of general purpose simulation languages while offering the convenience of data-driven simulators. ProModel\WINDOWS offers a powerful yet easy-to-use simulation environment for modeling all types of manufacturing systems ranging from small job shops and machining cells to large mass production and flexible manufacturing systems. This tutorial provides an overview of ProModel\WINDOWS and presents its modeling and analysis capabilities.

1 OVERVIEW OF PROMODEL\WINDOWS

ProModel\WINDOWS is designed to be used by novice simulation users, as well as simulation experts. Industrial and manufacturing engineers have neither the time nor the interest to do programming and yet they have the need for a modeling tool that is powerful enough to simulate a wide range of production systems. Because of its ease of use, it is also attractive to professors in engineering or business programs who are interested in teaching modeling and analysis concepts rather than teaching programming.

When simulating complex systems that require extensive analysis, usually a simulation expert with programming skills is involved in the modeling activity. In such situations, total modeling flexibility can only be achieved through additional programming. To satisfy this need, ProModel offers complete programming capability, which can be conveniently accessed without exiting from the program. In this respect, ProModel is powerful and convenient for systems analysts and simulation experts who are interested in ultimate flexibility.

Model development is completely graphical and object-oriented. To the extent possible, all input is provided graphically and information is grouped by objects for quick and intuitive access. For example, when you define a machine you can define its icon, capacity, downtime characteristics, input and output rules, desired output statistics, etc. ProModel is fully compliant with CUA standards which means that individuals familiar with other standard Windows programs such as word processing, spreadsheets will have no trouble learning how to use ProModel. This data input approach minimizes the learning curve for beginners and maximizes the efficiency for modifying large and complex models.

To help maximize model development ProModel provides model merging capabilities to allow several individuals to be working on a large model together. Additionally, a library of submodels can be constructed and easily be imported into models in multiple instances.

Powerful manufacturing constructs minimize model development time. Such manufacturing constructs as AGVs, conveyors, cranes, robots are not available in most general purpose languages. On the other hand, those simulators that claim to offer these constructs have rudimentary capabilities that oversimplify the actual hardware characteristics. ProModel offers realistic and flexible constructs for modeling complex manufacturing systems quickly.

Object oriented programming using C++ creates robust and portable software. One of the shortcomings of simulation software has been the difficulty in porting models across a variety of operating systems or hardware platforms. The main reason for these shortcomings is the underlying languages used such as FORTRAN. ProModel takes advantage of the portability and object orientation provided by C++. Furthermore, C++ produces very efficient code that is less prone to bugs and easy to add new features.

The latest advancements in operating systems technology are utilized. ProModel takes advantage of state of the art memory management techniques, syncronized windowing and dynamic data exchange capabilities offered by WINDOWS and OS/2. As a well behaved Windows application, ProModel allows multiple applications to run concurrently.

Model size is limited only by memory and execution speed is incredibly fast. Model size and execution speed have long been two significant concerns for simulation users on microcomputers. Although those simulation tools running under WINDOWS and OS/2 have eliminated the model size limits, they have done so by sacrificing model size for speed. Unlike other simulation software products, ProModel provides unlimited model size while offering comparably fast execution speed.

Graphics are realistic and easy-to-develop. Realistic looking animation helps simulation to become a powerful communication vehicle between engineers and managers. However, most engineers have neither the time to create 3-D graphics nor the easy access to special graphics terminals. ProModel offers a colorful and powerful 2-D graphics editor with scaling, rotating, etc. capabilities on standard hardware. This capability allows the user to develop quick and simple 2D layouts, or, with little extra effort, 3D perspective layouts. CAD drawings (e.g. AutoCAD), scanned pictures and drawings can be imported into ProModel for animation development.

Animation development is integrated with model definition. A major drawback of many simulation software products is that animation development is independent from simulation model development. This makes it time consuming and inconvenient for engineers to use animation as a validation\verification tool. ProModel integrates system definition and animation development into one function. While defining routing locations, conveyors, AGV paths, etc., you essentially develop the animation layout. The layout screen is a virtual screen which can be scaled to an actual factory layout.

Simulation results are easy to generate, meaningful and graphical. Many simulation software products require special commands to generate statistics that are difficult to interpret for non-simulationists. ProModel allows quick and convenient selection of reports and provides automatic tabular and graphical reports on all system performance measures. Output reports from several simulation runs can be compared on the same graph. The reports provide meaningful detailed statistics; thus eliminating special commands to generate useful information.

ProModel runs on any standard 386 computer. Most engineers, managers, and professors have easy access to IBM or compatible computers with VGA graphics capabilities. ProModel does not require any special graphics cards, special monitors, or a math coprocessor. This makes it convenient and cost effective for companies and academic institutions that have standard microcomputers. ProModel also runs on LANs (Local Area Networks) .

In ProModel\WINDOWS, a conversion facility is available to import any model ProModelPC models to ProModel\WINDOWS. This facility helps you convert your model data as well as your icons. For existing users of ProModelPC who wish to upgrade to ProModel\WINDOWS, this facility provides a convenient and productive way to convert their models.

2 MODELING FRAMEWORK

The modeling framework of ProModel provides the structure used for representing the physical and logical components of the system being modeled. Physical elements of the system such as parts, machines, or resources may be referenced either graphically or by name. Names of modeling elements may be any word containing up to 40 alphanumeric characters. Following is a brief description of each of these elements (see Figure 1).

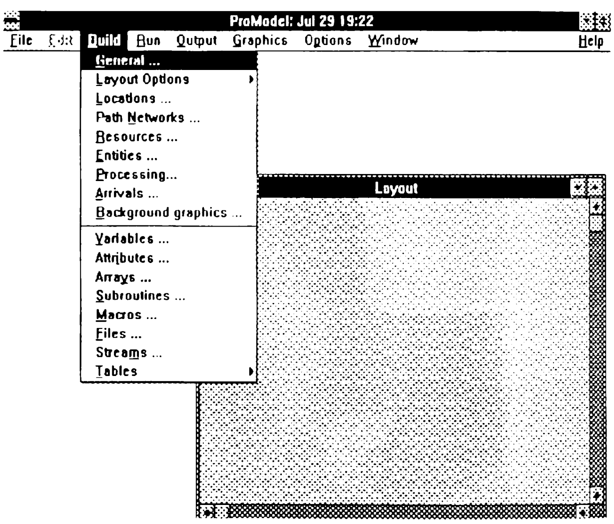

Figure 1 ProModel's Modeling Elements

2.1 Locations

Routing locations are fixed places in the system (e.g. machines, queues, storage areas, work stations, etc.) to where parts or entities are routed for processing, storage or simply to make some decision about further routing. Routing locations may be either single unit locations (e.g. a single machine) or multi-unit locations (e.g. a group of similar machines performing identical operations).

Routing locations may have a capacity greater than one and may have periodic downtimes as a function of clock time (e.g. shift changes), usage time (e.g. tool wear), usage frequency (e.g. change a dispenser after every n cycles), change of material (e.g. machine setup) or based on some user defined condition. Routing locations may be assigned input and output rules. Input rules are used for selecting what entity to process next while output rules are used for ranking entities (i.e. FIFO, LIFO, user-defined) in a multicapacity location.

2.2 Entities (or parts)

Parts or entities refer to the items being processed in the system. These include raw materials, piece parts, assemblies, loads, WIP, finished products, etc. Entities of the same type or of different types may be consolidated into a single entity, separated into two or more additional entities or converted to one or more new entity types.

Entities may be assigned attributes that can be tested in making decisions or for gathering specialized statistics. The graphic of an entity can be changed as a result of an operation to show the physical change during the animation.

2.3 Path Networks

Paths define the course of travel for entities and resources between routing locations. Movement along a path may be defined in terms of distance and speed or by time. Path networks consist of nodes connected by path segments. The nodes may be used as location interface points. Resources or entities may share common paths.

2.4 Resources

A resource may be a person, tool, vehicle or other device that is used either to transport material between routing locations, to perform an operation on material at a location, or to perform maintenance. Resources may be any one of the following types: 1) Static resources which are immediately accessible when not in use and have no special operating characteristics, 2) Mobile resources which have special operating characteristics to define their movement between tasks, 3) Robots which have an end of arm tool or gripper, and 4) Cranes (bridge or gantry) which are mounted overhead and move along multiple axes.

Mobile resources move along paths that are graphically defined. Mobile resources can carry parts or other resources. Built-in decision rules can be used for allocation of resources and for prioritization of part pick-up and delivery. Motion characteristics of resources such as empty and full speed, acceleration, deceleration, pickup-up and delivery time can also be specified.

2.5 Conveyors

A conveyor is a continuous movement device along which entities are conveyed. Conveyors are accumulating or non accumulating and may be segmented or non-segmented. Conveyors have operating characteristics such as speed and material spacing and may also have downtime characteristics. Conveyors may be configured with transfers, recirculation loops, sortation, accumulation and distribution capabilities. Bi-directional conveyors and complex conveyor networks can be modeled.

2.6 Processing (or Routing)

This element defines the processing sequence and flow logic of entities between routing locations. The operation or service times at locations, resource requirements, processing logic, input/output relationship, routing conditions, and move times or requirements can be described using the Processing element.

Operation times can be defined by constants, distributions, functions, attributes, subroutines, etc. or an expression containing any combination of these. Operation logic can include IF THEN ELSE statements, loops, nested statement blocks and subroutine calls. Resource related statements such as GET, USE, GET JOINTLY with boolean expressions and built-in operation statements such as ACCUM, JOIN, GROUP greatly simplify otherwise complex logic in describing the processing requirements. Built-in and user-defined routing rules provide flexibility for modeling all types of routing conditions.

2.7 Arrivals (or Schedule)

Deterministic, conditional or stochastic arrivals can be modeled using this element. External files including production schedules or arrival data can be read into ProModel in the Arrivals element. Built-in or user defined distributions or spreadsheet created data can be used to define inter arrival times and quantities.

2.8 Background Graphics

This facility provides a flexible way to develop static icons, labels etc. By using primitives (i.e. square, polygon, circle, etc.), you can draw complex icons, by using the color palette paint the icons, and save them to libraries. These icons can be rotated, labeled or sized. In addition, this facility allows importing of CAD drawings, scanned pictures, or any bit maps as background graphics for the animation layout.

3 LANGUAGE ELEMENTS

3.1 Variables

Variables are used for decision making and statistical reporting. Variables may hold integer or real values and can have names with up to 40 characters.

3.2 Attributes

Attributes for entities and locations can be defined. Attributes can have any name assigned by the user. They can take on real or integer values.

3.3 Arrays

An array is a matrix of variables representing multiple values. An array may be one dimensional or multi dimensional.

3.4 Subroutines

A subroutine is a user defined statement block that can be called to perform certain logic and return a value that can be used to define an operation time, inter arrival rate, etc. Subroutines may have arguments (i.e. numeric expressions) which are optionally passed to subroutines.

3.5 Macros

A macro is a complex expression that can be defined once and used multiple times as part of a logic statement (i.e. processing, scheduling, downtime logic). Macros can be helpful in situations where the same expression is repeated in many places in the model.

3.6 Files

One of the powerful features of ProModel\WINDOWS is the ability to read data from external text or spreadsheet files or write data to external files. For example, operation times (even in the form of expressions) from an EXCEL spreadsheet file can be read into ProModel using this element.

3.7 Tables

Tables are used to define table functions, user distributions or arrival patterns. For example, a user defined distribution which returns an operation time of 5 minutes thirty percent of the time and an operation time of 8 minutes seventy percent of the time can be expressed in the Tables element.

3.8 System Functions

System functions provide information on the current state of the systems such as the available capacity of a location, etc.

3.9 Logic and Action Statements

To perform special testing and provide specific instructions within a model, ProModel enables the user to enter logic and action statements. While some statements are related specifically to entities and resources, other statements are general programming statements providing the complete flexibility of a programming language including if-then statements, switch or case statements, loops, complex boolean expressions and file I/O statements. Statement nesting and even subroutines are supported. These statements can be used to define processing logic, downtime logic, arrival logic, transportation logic, etc.

3.9 Expression Builder

A unique feature in ProModel is the ability to bring up a pop-up menu depending on the current context that prompts the user in defining any statement or expression. This enables any expression or statement to be entered using only the mouse.

4 GRAPHICS EDITOR

The built-in graphics editor provides an extremely flexible way to develop user defined icons for locations, resources, and entities. By using primitives (i.e. square, polygon, circle, etc.), you can draw complex icons, by using the color palette paint the icons, and save them to libraries. These icons can be rotated, labeled or sized. See Figure 2 for an icon developed by using the Graphics Editor.

5 RUNNING THE SIMULATION & ANIMATION

You can run your simulation models with or without animation. The animation is very smooth and it maintains great resolution at any zoom factor. During the animation, you can get snapshots and traces. The status lights for locations change colors to help you see various states such as busy, idle, down, etc. The animation screen is a virtual screen which means the animation layout is limited by memory in your computer. By turning off the animation, you can speed up the simulation, run for a while and turn the animation back on. The simulation clock resolution can be expressed in terms of hours, minutes, or seconds with a clock resolution of .00001 a second.

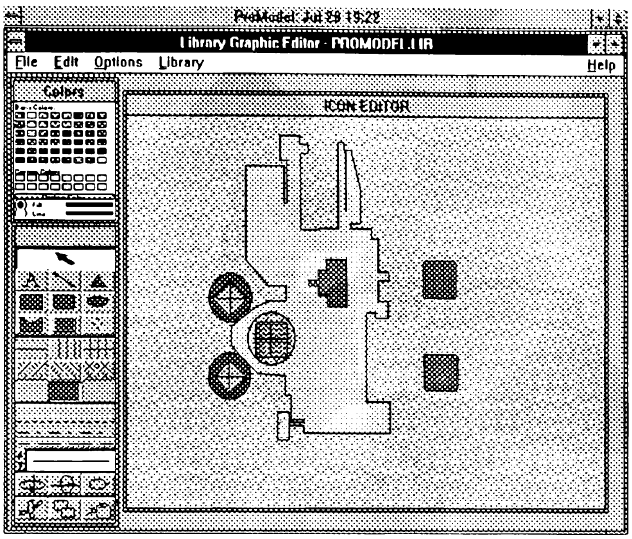

Figure 2 A Sample Icon Developed in ProModel

6 OUTPUT REPORTS

By choosing the statistics for resources, locations, entities, variables, etc., users can customize the output reports. The statistics are written to ASCII output files which can be exported to spreadsheets. Additionally, graphical reports of the outputs can be displayed, printed or plotted. These graphs can be individual or comparative pie charts, histograms, time-series plots, etc. See Figure 3 for a sample location state graph.

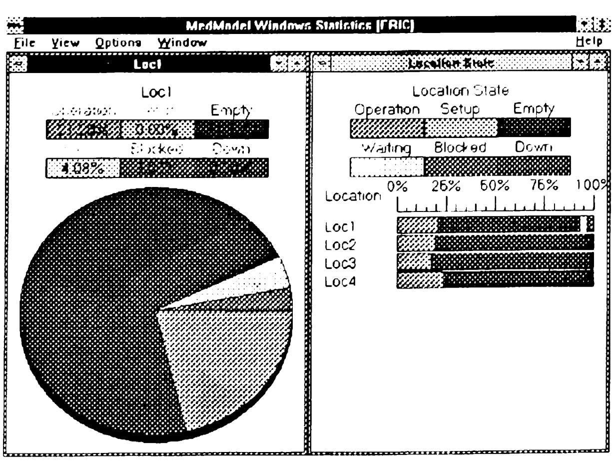

Figure 3 A Location State Graph

7 OPTIONS

One of the most powerful aspects of ProModel\WINDOWS is that it provides maximum flexibility for the user. Under the options menu, you can zoom in or out, display a grid, define default fonts and sizes for text, set default names for modeling elements, set default directories for model files, icon library files, or model output files. You can set and save default settings (i.e. window sizes, appearance). ProModel also allows you to choose either a beginner or an advanced user setting for model development. While the novice user benefits from the prompts and added explanations provided by the beginner setting , the expert user benefits from the convenient, advanced user setting.

8 CONCLUSIONS

Until recently, manufacturing companies have not fully benefited from simulation in making continuous improvements because of the time, programming expertise, and cost involved in getting useful results. ProModel is designed for manufacturing companies to fully achieve the benefits of simulation technology at an affordable price. ProModel is directed toward making simulation a standard tool in the hands of engineers, managers and systems analysts just as spreadsheet software is in the hands of accountants and financial analysts.

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