MEDMODEL® - HEALTHCARE SIMULATION SOFTWARE

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ABSTRACT

In response to the expressed needs of MedModel users, PROMODEL Corporation has made substantial improvements in its MedModel healthcare simulation software. Beginning with its inception in 1993, MedModel was specifically designed to be simple to use and tailorable to the needs of healthcare managers, engineers and clinicians. As such, it provides a basis for the comprehensive evaluation of large, complex problems which are representative of healthcare systems in general. This paper serves as a preliminary examination of some of MedModel's comprehensive features and capabilities. Special emphasis is placed on the new and modified features of MedModel 3.0. Preemption logic, pre and post shift logic, and new statements and functions have been carefully designed to solve unique hospital and healthcare specific simulation problems.

Accordingly, the analyst has usually made decisions relying on massive databases that record and correlate all manner of clinical and administrative information. Although accurate in recording information on workload, staffing, patient mix, capacity and policy as they relate to cost and quality, the database is often unable to provide the true correlation among these factors and the dynamic interaction of each upon the other is usually lost. Moreover, the database approach relies heavily on past performance and is less helpful for predicting the result of anticipated changes to the system.

Finding an analytical tool that can handle the exhibited complexities of healthcare systems has proven to be a daunting task. What has been needed is a tool which allows the investigator to quickly and efficiently model the gamut of healthcare activities from patient admission to disposition and one that would be as effective for modeling a single activity (clinic, emergency department, nursing unit, radiology) as it would for a linked network of activities (ambulatory care, surgical services, food services, etc.).

Moreover, the problem of finding such a tool actually extends beyond simulation itself since simulation long ago proved its value to the manufacturing sector and has been used to evaluate process problems in healthcare as well. However, pure manufacturing is anything but an accurate reflection of what occurs in a healthcare setting. And, as such, simulators and simulation languages designed with the manufacturing environment in mind rarely contain the constructs and algorithms necessary to handle unique healthcare issues.

2 THE DEVELOPMENTAL FOCUS

Analysis of the hospital environment leads to the recognition that there are five broad categories of
systems operating within its walls. Each has its own characteristics and each challenges the analyst attempting to develop a system model with its unique pattern of behaviors. These broad systems are: emergency departments, operating suites, nursing units, ambulatory patient care, and ancillary services. Using this knowledge, developmental activity was actually focused on two separate planes. First, there was the requirement to specifically understand the simulation needs and attributes of each of these broad hospital systems. Second was the focus on current and projected micro-computer and software technology that could be used to actually enhance the operational characteristics of the simulation itself.

2.1 Healthcare/Hospital Systems Needs

MedModel's genesis was prompted by the need for a simulation package that could adequately model each of these broad systems and yet be flexible enough to cross between them on models that link areas of more than one system. It needed to have constructs and algorithms that would assist the analyst in modeling healthcare and hospital systems. Based upon knowledge of the hospital and requests from scores of healthcare professionals, constructs and mechanisms that allowed for complex pathing, transparent relationships, multiple and repetitive activities and great operational variety were deemed crucial to a simulation software designed to solve even the most routine healthcare problems.

More importantly however, developmental concern went beyond simply capturing the essence of a healthcare system. Rather, it focused on ensuring that specific constructs represented precisely what was required to model the system of interest and did so with as much statistical validity as possible. For example, an initial concern for all five hospital systems surrounded the fact that patients and their records (doctor's notes, laboratory test results, etc.) often took different operational paths but they were, in fact, always linked to each other by the very fact that they were all a part of the patient's entire medical "persona". As such, one could not complete a process without the other being a part of the result. When the lab result is delayed, so is the patient's treatment and so on. Accordingly, specifically matching one with the other at various times in a simulation was often critical to the performance of a model.

Because these issues are often unique, how MedModel handles them is of specific interest.

2.1.1 Matching Entities

Since the treatment of a patient may well depend on the return of a lab or x-ray result and, conversely, the movement of the test result may depend on the availability of the patient, the ability to match patients and their supporting medical documents is a necessary capability. In the Acute Minor Illness Clinic shown as Figure 1, each patient has had a lab test done and waits in the patient waiting room for the results to be made available. Although one could assume that the longest waiting patient should be given the next available lab result, this is not necessarily the case. It has been shown that assuming that the longest waiting patient must be the next in the line for the next available lab result will yield waiting times that are significantly different statistically from those that correctly match an individual patient with his or her exact lab result.

![Figure 1: Acute Minor Illness Clinic with Lab Test](Image)

MedModel easily handles the requirement to keep identically "owned" entities together by using the built-in "matching" construct provided in the software. Shown below, the lab result is directly matched with its patient based upon a unique ID established early in the model and automatically transferred as an attribute to any entity "cloned" from the patient (Figure 2).
2.1.2 Preempting Locations and Resources

Emergency Department modeling requires, among other items, a sophisticated and versatile capability to preempt rooms that are currently occupied by less acute patients as well as take staff resources from the work they are currently doing and moving them to an acute patient requiring immediate treatment. Also essential is the ability for the staff member to “remember” where he or she was in the treatment of the first patient and pick up from that point upon return.

In the case of the ED below (Figure 3), patients are placed in one of many exam rooms or may be placed in a trauma or cardiac room if their condition or lack of other space requires. But if a more serious trauma/cardiac patient should arrive, the room must be made immediately available to the arriving patient.

to preempt locations from the currently occupying patient (Figure 4) and take resources from another patient when the new patient’s condition requires immediate assistance (Figure 5). MedModel can even set up an entire system of preempting levels so that a patient with an acuity level of 1 will be preempted by a patient of acuity 2, an acuity 3 will preempt the acuity level 2 patient and so on. By merely filling in the priority level for the capturing of a location or resource, and applying the preemption hierarchy levels, MedModel will automatically preempt from one patient to another and remember where in the course of treatment the clinician left the patient. MedModel 3.0 adds preemption process logic to allow you to completely control what happens to the preempted patient rather than limiting you to program defaults. A preemption process record can be defined to postpone the actual preemption of a location or resource until the current entity explicitly releases it or to route the preempted entity to an alternate location (Figure 6).

Figure 3: Emergency Department

To handle this situation, MedModel has an entire hierarchy of preemption constructs that have the ability
2.1.3 Multi-Use Subroutines and Macros

Healthcare in general and hospital systems in particular are characterized by many locations capable of having the same activity performed in each area. Examples such as non-specialized operating room suites, clinic exam rooms and inpatient rooms are but a few examples. A quick and effective way to model like activities at different locations is essential to any simulation software professing to accurately emulate healthcare activities. Not only must they be quick to use but they too, must be able to recall repetitive activities. In the nursing unit model depicted in Figure 7, all the patient rooms are identical and can house any of the patients assigned to the unit. Therefore, similar activities such as medication administration, meal serving, etc. can be handled as the same set of process logic.

2.1.4 Shifts

Certainly not the least of the problems handled deftly by MedModel is that concerning the management of resources and their accurate arrival and departure times. Nearly all healthcare workers are assigned to recurring shifts. Activity planning is often accomplished based on the knowledge of who will be at work during certain hours of the day. In fact, task responsibility is often changed from one hospital worker to another when certain shifts do not have a particular type of resource assigned. MedModel allows you to create any number of shifts of any length or days of the week along with break periods to represent breaks or meals (Figure 9). Single or multiple resources may be assigned to any shift. Locations may also be assigned to shifts which facilitates closing certain areas of the hospital during certain hours of the day. In MedModel 3.0, we have now added the ability to change shift assignments as the model runs. For example, a resource may work the day shift one week and the night shift the following week (Figure 10). In addition, logic can now be used to control whether a resource goes on break or off-shift (Figure 11). This solves one of the problems previously encountered of resources going off-shift when the clinic still had patients remaining in the clinic.
object oriented programming using C++ and runs entirely under Microsoft Windows (including Windows 3.1, Windows for Workgroups 3.11, Windows 95, and Windows NT). In addition, MedModel is a true 32-bit program thereby eliminating nearly all size and memory constraints. This means that a model's size is limited only by the amount of memory available in your hardware and that MedModel takes full advantage of synchronized windowing capability, as well as dynamic data exchange offered by Windows. Naturally, larger and faster machines produce ever more dramatic results when building and running models. In fact, although any standard 486DX machine with VGA graphics and 8 Megabytes of RAM should suffice, a Pentium machine with Super VGA and 16-32MB RAM will show a dramatic speed-up of work.

But there is more to "technology" than the operating system itself. Use of software features available through existing programs that emphasize the capability to make full use of system capacity is also essential. Accordingly, MedModel avails itself of this technology by being nested in Microsoft Windows.

What makes MedModel unique then are the features that it calls on to make healthcare system modeling in general and hospital modeling specifically far easier. Coupled with responsive and versatile animation, MedModel provides a basis not only for rapid model building but ease of validation as well. The use of animation, or being able to "see" what's going on as the model progresses through its run-time, significantly enhances the modeler's ability to recognize whether the modeled system is operating correctly.

2.2.2 Custom Icons

To facilitate ease of use while simultaneously capturing extremely large-scale models, MedModel is based on
MedModel also comes with an impressive library of colorful, pre-designed healthcare system icons representing everything from hospital-specific patients, staff members, material and treatment fixtures to instruments, used surgical trays, baby bassinets and the like. MedModel is also accompanied by an icon editor that enables the modeler to design any manner of icon desired using an almost limitless array of colors and shapes. This enables you to use the icons provided in the library or draw new icons in the graphic editor, MedModel allows for the import of Windows metafiles or .PCX clipart to be used as graphics too. The value of this capability transcends simple esthetics and allows the modeler to represent, as accurately as possible, specifically what is occurring in the hospital environment.

2.2.3 Automatic Processing and Path Entries

Unlike the majority of simulation software packages, MedModel presents the modeler with the capability to design and construct a model using nothing much more than the mouse. This is especially useful when identifying movement and processing steps. In this case, the modeler need only click on the succession of locations to which a patient may move and the required movement entries are made automatically. This holds true for both resource (i.e. doctor, nurse, technician, etc.) movement as well as processing. To create the required pathing for a clinical patient for example, the modeler need only draw a line from the clinic entry to the different locations the patient might go. In this manner, people can be made to walk down hospital corridors, through doors, up stairs and the like. Paths may be bi- or uni-directional. MedModel automatically enters all distances required to complete pathing and calculates correct movement times based on the distance and speed of the moving entity or resource.

3 CONCLUSIONS

MedModel is one of the most powerful tools available to use in analyzing the healthcare environment. It represents an opportunity for all elements of the healthcare sector to get involved with analytical tools that are far simpler, easier to use and yet more powerful than those previously available. Of greater significance however, is the fact that because of the comprehensive nature of the tool, assumptions and short-cuts that have routinely characterized healthcare and hospital simulations, are no longer necessary. Rather, it is now possible to model complex healthcare systems accurately and with confidence in the results.

AUTHOR BIOGRAPHY

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