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PRACTITIONERS' VIEWS ON SIMULATION

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The panelists are all actively engaged in applying simulation to a variety of systems. Their areas of application include manufacturing, electronics, steel, and health systems. The panel discussion will address issues relating to the practice of simulation and make recommendations for future consideration. The panelists' position statements follow.

KEN MUSSELMAN

I. NON-TECHNICAL EDUCATION

Over the years we have become very adept at teaching simulation modeling and analysis. In fact, graduates almost always become effective modelers within a very short period of time. However, while these graduates are often good modelers, they are seldom good practitioners. This is because we fail to teach the simulation modeling process in its entirety.

Most courses in simulation concentrate very heavily on modeling and analysis. This is very misleading, for it gives the impression that technical understanding leads to practical success. While technical understanding is unquestionably a key component, it does not, by itself, guarantee a successful project.

A simulation project is more of a journey than a model. It is a journey that will take many turns and demand a variety of skills. In the end, the client's impression of the project team members may be more lasting than the merits of the final recommendation. For this reason, a successful project requires more than just good modelers; it requires people skilled in the fundamentals of active listening, technical writing, public speaking, selling, negotiating, and managing. While our education system tends to emphasize simulation languages and output analysis techniques, successful simulation projects require people competent in the non-technical areas of simulation as well.

II. ANALYSIS AT THE DETAILED LEVEL

The dynamics inherent in a simulation model offer a wealth of information. Yet, little has been done to capitalize on it. In fact, the otherwise very prominent dynamic qualities of a simulation model are often purposely dampened for reasons of statistical convenience. Aggregated measures are used to draw conclusions about system performance, while the detailed dynamics of the system go virtually unnoticed.

A decision based solely on summary performance could lead to unacceptable results. Consider, for example, a model in which bottlenecks, of a stochastic nature, are occurring. The existence of these bottlenecks, while of obvious interest and importance to the client, could be concealed in summary statistics. To help prevent such oversights, balanced treatment should be given to the analysis of both the system's global performance measures and its detailed interactions.

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While statistical techniques allow us to make valid conclusions from a global standpoint, we have few techniques to help us evaluate the detailed dynamics of a process. Nevertheless, the client's acceptance of the final recommendation may well rest on the analyst's ability to properly communicate and evaluate the details of the system. Clients generally view a system at this finer level of detail and base many of their decisions on information gathered at this level. For this reason alone, it makes practical sense for us to learn how to properly amplify these details and to incorporate them into the evaluation process.

III. INTUITIVE OUTPUT

In most every simulation project, there is an element of risk associated with the result. Yet, as practitioners, we often fail to create an adequate setting for the client to truly understand this. Instead, the client is usually faced with an abstract statistical parlance that does little to help him comprehend the implications of his decision.

The simulation community has made significant progress in communicating how a given system has been modeled. Indeed, network and special purpose languages are good examples of this progress. However, equivalent progress has not been seen on the output side. Admittedly, some advances have been made (e.g., graphical output, animated traces), but clearly more should and could be done. Our ability to better convey the meaning of risk and uncertainty is central to this concern. As we continue to seek technical improvements in analyzing simulation output, let us not lose sight of the equally important need to make these techniques intuitively appealing as well.

BILL CLARK

I. EDUCATION OF PEOPLE WHO USE SIMULATION RESULTS

Computers have become faster, more powerful, less expensive and more available than ever before. Simulation languages have evolved to the point where the user has most of the routine bookkeeping, timing and statistics collection handled with a minimum of effort. Many languages provide a combination of network, discrete and continuous capability. All of these features are significant to the simulation modeler. However, the practitioner has much more work to do in the area of education of people who are using the results of a model. These users frequently do not understand concepts such as random variables and drawing from probability distributions. Users frequently want results but aren't interested in the details. This is a dangerous approach. The boundaries and underlying assumptions of a model should be clearly understood before trying to interpret output.

Many models are designed as tools for a study team. The education of this team is very important in the proper use of the model. Boundaries of the model, as well as required levels of detail, should be clearly established. Members of the study team should understand the tradeoffs between a very detailed model that requires many man-hours to develop and a less detailed model that can be put together quickly but only answer more basic questions. The study team must understand that as a model becomes more complex, more detailed input is required. The needs and constraints of the team must guide the modeler in establishing the level of detail required to answer the existing and potential questions of the team.

Often detailed models are developed that include complex code to "look ahead" and make decisions based on what is most likely to happen in the future. Extra code is often needed in a detailed model for handling the first and last piece of a batch of material being processed. Detailed delay information and routing sequences, along with system status checks may require additional complex coding. This type of model can be quite valuable to a study team. However, the team must understand that it can not change the system boundaries or the previously agreed upon basic operating characteristics of the system and expect model results an hour later. In addition the team must understand the need for defining their alternatives in detail. Questions such as "What is the effect of moving Facility A to the other end of the shop?" certainly does not provide enough information for a detailed model to work with. The simulation practitioner will need to know the exact new location, how that affects operating sequences, product schedules, facility schedules, material handling, etc. Once all of that information is obtained, then the simulation modeler can begin revising the model. This revision process takes time. The study team must realize that the more complicated the change, the more time will be required to revise both the model and the data.

The users must also understand the difference in time requirements to change data versus change logic. Also, a common sense approach must be taken to analysis of alternatives. If previous runs allow the user or modeler to determine the results of another alternative without making any additional model runs, this can save man-hours as well as computer time.

Perhaps the most misunderstood item in simulation is optimization. Some models do include optimization modules or feedback loops to revise and try a different set of input. However, the user of a simulation model must understand that simulation itself does not automatically optimize. Normally, the results of a run are an evaluation of the logic and input data provided, and not an optimal way to run the operation. This is an extremely important point. In the field of Operations Research many models are optimization models. Users must clearly understand the capabilities of the model they are using.

In summary, simulation practitioners need to concentrate more energy in educating people outside this field with the basic concepts, capabilities and limitations of simulation. In order to accomplish this there must be good communications between simulation modelers and the users of the results. This communication is especially important before the simulation development effort begins. Documentation of system boundaries and logic, as well as data and sources of data, is required. Clearly designed output reports, using graphics when appropriate, can be very helpful in understanding the level of detail included in a model.

II. NETWORK MODELING CAPABILITY

Several languages now offer network, discrete and continuous modeling capabilities. The network features have resulted in decreased model development time and decreased time to learn a language. The development of a network capability is an important contribution to the field of simulation. From a practitioners viewpoint the strong arguments for using a network approach include:

1. A visual outline and a structured way of approaching a problem.
2. A faster way to develop and debug a model.
3. Easy interface to high level programming languages.
4. An easy way to teach and learn simulation without jumping in to all of the complications at once.
5. A good mechanism for the occasional user--it is easier to remember how to use network features than to code everything yourself.
6. Very rough documentation for the simulation practitioners.

These features are of great benefit to the simulation modeler. However, the modeler must understand what the network will not provide for him:

1. Networks are not flow diagrams that can be shown to operating personnel to help validate a model. A complicated network will only be understood by a simulation practitioner and, in many cases, only by the person who developed it unless additional documentation is provided.
2. Networks are not self-documenting. They are an aid to the development and use of a model but they still need complete documentation, Without documentation describing variables, attributes, resources, events and logic a network will be difficult to understand.
3. Networks do not include all of the features needed to develop a detailed model. Additional code will be necessary to handle real-life complications and logic.

As the network approach becomes more and more popular additional features will become available. Features such as "CONVEY" and "TRANSPORT" found in SIMAN™[1] and the Crane Module and Roller Line Module found in BETHSIM [2] are good examples of features that let the language handle items that, in the past, were coded in high level language. The network capability is a fantastic tool for the simulation practitioner. The next step should be to allow users to develop their own nodes and easily embed them within the simulation language.

III. NOTE

SIMAN is a trademark of Systems Modeling Corporation.

IV. REFERENCES

[1] Pegden, C. Dennis. Introduction to SIMAN (State College, PA, Systems Modeling Corporation, 1982).

[2] Clark, W.A. Jr. and Scriptunas, J.J. Jr. "Simulation Model to Evaluate Impact of Continuous Casting at Steelton," Iron and Steel Engineer, Vol. 60, No. 6 (June, 1983), p. 47.

STAN HENDRYX

From the viewpoint of a manufacturing manager in the electronics industry, simulation is a useful tool in gaining increased understanding of the complex interactions in a modern manufacturing facility, both during the design of the facility and later in its operation. Major benefits of simulation come by providing industrial engineers with insight into their factories, and managers with a better understanding of the consequences of policies and procedures they establish.

Although simulation is an expensive tool to use, particularly for the uninitiated, I believe its greatest benefits will come from staff people using simulators themselves. Since staff training time and the considerable time required to build and analyze models are major cost components in simulation, features of a simulator that make it easier to use and that make the staff more productive will generally be cost effective.

The need to improve the productivity of simulation tools in the hands of staff members with other responsibilities besides simulation suggests developing simulation technology in at least two directions;

I. Integration of simulation in the workplace.

II. Model architecture.

I. INTEGRATION OF SIMULATION IN THE WORKPLACE

A simulation tool has two principal interfaces:

1. Interface with the people in the workplace.
2. Interface with the data in the workplace.

1. Interface with People

So that operation of a simulator is as intuitive and straightforward as possible, human-factors principles should be employed in its design, as attending to this detail will pay dividends throughout the life of the simulator. Prompts and help features urgently needed by a beginner should be able to be muted by a more experienced user who finds them unnecessary, even undesirable; moving between branches of menu driven systems should be easy, as should editing and recovery from common errors.

Separate documents will better meet the needs of users for tutorial and reference material; attempting to make one document do the work of two is usually inadequate. To speed learning and promote self-teaching, minimizing instructor time, well designed on-line tutorial aids, such as might be achieved by invoking the simulator on a specially prepared help file, are helpful.

To help the modeler communicate with other people, the simulator should be able to produce readable documentation of the model, and its output should be available in presentation form, consisting of clearly annotated charts and tables.

2. Interface with Data

A simulation model is only as good as the data used in its preparation. Access by a model to on-line shop floor data such as inventory records, process routings, and production schedules is necessary to simulate a factory efficiently. Ability to select, transfer and reformat this data from the host data base and use it in simulation should be a feature of simulators used in managing factories.

Simulation is but one tool used by the manufacturing staff. Ability to run other programs as subroutines during execution of a model could greatly expand the capability of simulators, and reduce model complexity. For example, take the job of testing by simulation an improved shop scheduling algorithm that recomputes the priorities for each work station each shift. Testing could be simplified if the simulator could call on the new scheduling program to recompute the ranking of the work-in-process queues at the end of each simulated shift. Using the algorithm under development and the current contents of the simulator queues, whose initial contents were loaded from the on-line shop inventory, queue ranking would be determined for continuing the simulation. The capability described would allow testing the algorithm against a model of shop floor activity, starting with real inventory data, without having to include explicitly the algorithm in the model, or even having to use the whole model if only part of the shop was involved.

Note that in the above example, the link between model and scheduling program would also be useful in studying proposed changes on the shop floor that are reflected in the model.

II. MODEL ARCHITECTURE

Breaking a problem into small parts and building piece by piece from the parts is a time-honored method of enhancing productivity. This method permits many people to work on a project, makes it possible to deal with complex systems, and frequently reduces total effort by using some parts repeatedly. A modular hierarchical model architecture could bring these benefits to simulation.

Modular means breaking a model into parts or modules that may be run like subroutines and used repeatedly in different places in the model. Hierarchical means that instances of modules in a model of a complex system are related in a tree-like structure.

There is a difference between breaking a large model into pieces, and making the model to be modular and hierarchical. In the first case, the model is simply broken up and the pieces related to each other. Similar pieces, differing only in variable names or parameter values, are explicitly repeated in each instance, and the entire model must be simulated together. In the case of modular hierarchical model architecture, a module can be called repeatedly like a subroutine, having different arguments or parameters passed to it each time it is called. Main programs that relate the modules in a particular analysis could be used to exercise a module alone or with other modules.

A modular hierarchical model architecture would support developing models of complex systems from small, top level models into complete models having considerable detail. Adding detail only as required, and permitting modules to be run separately or in small groups, modular hierarchical model architecture would permit useful results to be obtained early on in the modeling process. A large model, existing as a library of compatible modules, may possibly never be run as an entity. Modules in the model library could be linked together for simulation in a fashion analogous to using a link editor to combine program modules for execution. Input entity streams or initial queue contents required to run a module independently could be obtained from data files arising from the execution of other modules or from outside sources.

A modular and hierarchical model architecture would promote orderly development of models of large or evolving systems by several people working together. Such an architecture would improve the productivity of the modeler by enabling him to build onto his own work and onto the work of others. That such a model, or some modules of it, could be used beneficially for purposes not initially intended or expected, would not be surprising.

With simulation tools available having features like those described here, simulation will have come of age. The people responsible for the factory could then build and maintain a factory simulation facility as the factory itself is built and maintained, and could use it to help run the factory effectively. Simulation will then become a standard tool used by manufacturing staffs to help them understand and control the increasingly complex environment in which they work.

DON SEGAL

Several issues come to my mind as important and that are worth significant attention by the "Simulation Practitioner."

How much detail is enough? The level of detail of a Simulated System is critical both as far as the adequacy of the results and the timeliness of the conclusion. Often you see good devoted analysts consuming 178 days out of 180 days time frame in constructing a model but having only 2 days to really run it and analyze the data. Figure 1 is a simplified graph reflecting the relationships between the decision variables.

Estimating the optimum model detail level for the situation is, therefore, not as easy as it appears. Some more rigorous techniques are suggested particularly in the preparation stages of system development.

Results Presentation

As we all know this is the most critical part of a project. Regardless of the adequacy of the model if the decision maker is not convinced, or if the owner of the system that is being simulated is skeptical, the project is surely going to fail. The question is, "What level of effort is required to familiarize an unknowledgeable executive to understand the results in terms of accuracy and risk?" It is suggested that a simulation project should be a participative process in which various managers are involved at various depths throughout the process; from data collection to model flow building.

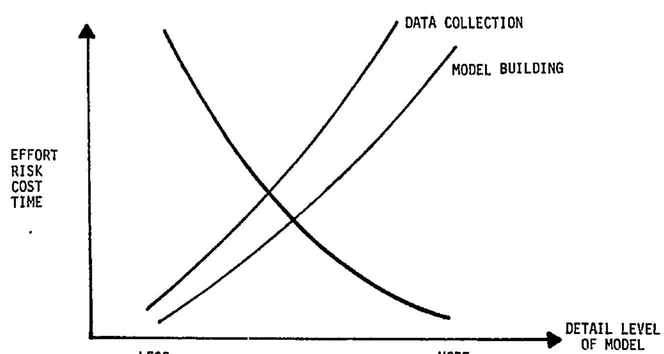

FIGURE 1