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USING ANIMATION TO ENHANCE A MARINE-TERMINAL MONTE CARLO SIMULATOR

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ABSTRACT

We built an animated simulator that runs on a PC. The animation helped with program debugging and was instrumental in 'selling' the simulator to a paying client.

The simulator models a collection of ship-docks, on-shore tankage and flow-rates, and a ship-channel with definable characteristics. The simulator collects statistics on terminal operation that can be used for planning terminal expansion and improvement, or for mothballing of unused facilities.

On-screen animation shows the movement of ships within the terminal and the levels of inventory in the tanks. On-screen histograms show selected port statistics, continuously updated as the simulation proceeds. Off-screen statistics include average time-in-port, average ship delays due to various causes, and excess waiting time (demurrage.)

This paper discusses the advantages of adding animation to a Monte Carlo simulation model. The talk also shows concrete examples.

1 INTRODUCTION

Monte-Carlo simulation is a method for modeling random systems that are too complicated to analyze mathematically. Although the method has been around for at least a century, it has become feasible only with the development of computers. Even so, the method has traditionally been associated with great cost, complexity, and time requirements for developing and using simulation models.

Because simulation is expensive, and because the abstract concept is difficult to explain to (and 'sell' to) those who can authorize such expenditures, the method is not often used, even where it might generate significant cost savings.

But powerful workstations and personal computers now make it possible to develop models quickly and cheaply. And animated graphical display of simulated activities offers a number of benefits:

- Animation helps explain the concept of Monte Carlo Simulation to upper-level managers, whose expertise lies in business management rather than abstract mathematics and statistics.

- Animation helps the manager and other prospective clients understand the workings of the systems being modeled.

- Animation demonstrates actual or potential problems with the system being modeled, that might be difficult to understand, or not even noticed, just by looking at long lists of numbers.

- Animation offers the possibility of interactive simulation—allowing the analyst to run the model and to make changes, on the fly.

- Animation reveals problems with the model itself—problems that would be difficult to discover otherwise—thus lowering the development cost.

We will exemplify each of these points with our actual experiences with marine terminal simulators.

ANIMATION HELPS 'SELL' THE MODEL

Except for a major client who funded a multi-year development project for a complex simulation model, we have had little success in marketing Monte Carlo Simulation within our rather large company. Although, in theory, managers see the value of developing a $100,000 model to possibly save a $10,000,000 capital expenditure, in practice, we have had a difficult time getting funding for developing such models. And this is not surprising. Frequently, a much less precise, but less expensive answer can be obtained by 'back of the envelope' approximations. And there is no certainty that the more accurate answer will actually lead to a better business decision.

So we decided to fund internally a small demonstration model that would be generally usable and easily customized. We achieved this cost reduction by intelligently simplifying the model specifications, moving the development effort from a mainframe-computer to a personal computer or workstation, and by using animation to help us find logic problems.

The demo modeled a real-world scenario involving importing crude oil to a terminal, whose berths were at the wrong end of a ship channel. Being very narrow, and having no nighttime navigational markers, the channel was usable only during daylight, and only by ships convoying in the same direction.

The demo showed the operation of the channel and the movement of ships. A sample screen, showing a simulation in progress, is shown in figure 1, below.

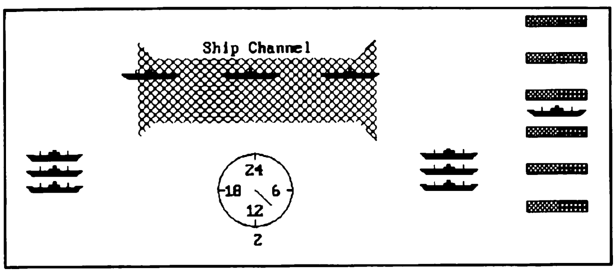

Figure 1

Although our shipping department had, for a long time, expressed a need for a generic marine terminal simulator, they had never before been able to get funding. They agreed to fund the development of a full-fledged model after seeing our demo.

ANIMATION AIDS UNDERSTANDING OF ACTUAL AND POTENTIAL PROBLEMS

In running the demo, we saw that the channel is a major bottleneck, with large queues of ships waiting to enter each end. To support the claim that something must be done about the channel, the demo also generated statistics about ship delays for various reasons, including waits to enter the channel. Our demo allowed an analyst and the client to play 'what-if' games with the simulation: 'What-if' the ship channel was open 24 hours a day ? 'What-if' ships could travel in both directions simultaneously ?

The demo and full-fledged model helped him play games with the simulated system, while trying out alternative solutions to the problem being modeled.

ANIMATION REVEALS UNEXPECTED BOTTLENECKS IN THE SYSTEM

The demo revealed the expected bottlenecks: waiting for berth, and waiting for channel. The possibility of these bottlenecks was the major reason for building the demo in the first place. But the animation also revealed a possible additional problem.

We found that the ship channel 'bunches' the ships. When it opens in the morning, as many as four or five ships will pass through and arrive at their berths nearly simultaneously. After they leave, the terminal might wait two or three days for the next bunch.

What does this say about storage tank requirements ?

Obviously, we needed to investigate storage capacity at the terminal. We could have done this on 'the back of the envelope'. But we decided to add storage tanks to the demo. This now allows the analyst to see which tanks fill up or empty out most frequently. Watching the demo, he can understand what other problems cause or are caused by inventory problems. Gleaning this information from model statistics would be nearly impossible.

A thoughful analyst would probably find this particular problem without the animation. But we can easily imagine more obscure bottlenecks that would be difficult to spot until they turned up in a real-world system.

Figure 2, below, shows the revised demo in progress.

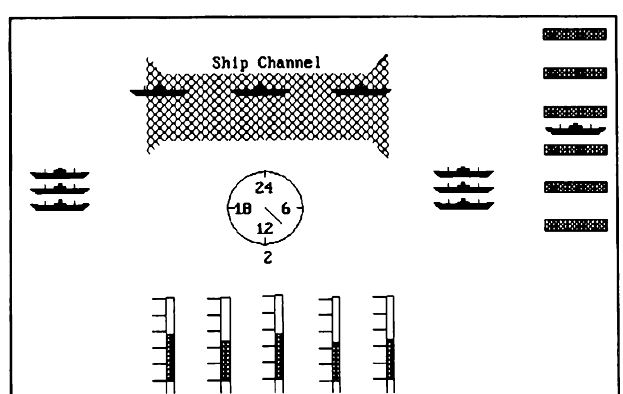

Figure 2

ANIMATION IS A WAY TO PROVIDE INTERACTIVE SIMULATION

In complex systems, we find that simulated system operation can be much worse than would occur in practice, because of our inability to simulate the 'human touch' in decision making. Operation of an existing facility involves heuristic decisionmaking based on years of experience. Although 'artificial intelligence' can model this type of experience, it cannot readily be built into a simulation model.

For example, in using the large model mentioned in the introduction, we found that the simulated facility would become jammed, not because it was necessarily overloaded, but because some human intelligence was needed at some point to work around a temporary problem. The facility was a large export terminal that received crude oil through a pipeline and exported it from the terminal. As the pipeline handled multiple types of crude, it was necessary to coordinate the arrival of crude batches in the pipeline with the arrival of ships to take the batches.

We tried developing an intelligent algorithm to choose ships from a queue of waiting ships based on what type of crude needed to be exported. But we were never able to develop sufficient intelligence to work under all possible scenarios.

One of our clients has proposed that we develop an interactive version of the model to run on a workstation. The new version will allow the analyst to interrupt the model and adjust the simulation parameters—in effect, telling it to do something unusual such as:

- Berth a recently arrived ship to alleviate an inventory problem
- Berth a multi-cargo ship to load only one of its cargos, or to load only a partial cargo, to alleviate an inventory problem.
- Re-dedicate a storage tank to a different type of crude
- Force the deberthing of a ship that, for whatever reason, is unable to load its cargo at the current time

Of course, allowing this capability in a simulation endangers the validity of the results. Unless the model maintains a history file of interactive adjustments that can be played back, it becomes impossible to repeat a run.

Our client wants this facility to further investigate simulation results that appear to justify, for example, the construction of an additional storage tank. The results might indicate that on a few days each year, the tanks for a particular product will become full, with unpleasant and expensive results. Yet, in practice, operational personnel would have worked around the problem, perhaps by switching tanks, perhaps by changing production rates. The interactive facility allowed the analyst to simulate the intervention of human intelligence into the operation of his marine terminal.

ANIMATION AIDS THE DEVELOPMENT EFFORT

Not only does the animation show what happens in the simulated system, but it shows what is happening in the simulation logic as well. We found that simply watching the movement of ships, the opening and closing of the channel, and the acquisition and freeing of berths, revealed bugs in the logic. Many times the bugs were only in the logic intended to display the movement of ships. So we carefully debugged this logic. Then we could presume that if a ship's movement was not what we expected, then the ship was, in fact, not doing what it should.

For example, the logic to operate the ship channel in the demo is quite complex. But even with massive amounts of optional trace output, we found it difficult to verify that ships were being handled correctly, without watching the demo. After observing a misbehaving ship, we could then inspect the trace output to see what went wrong.

But on our development workstation, a 486-PC clone, we found that running animated graphics slowed the simulation significantly. Obviously, a large proportion of the CPU's horsepower goes to displaying the graphics. Perhaps the speed could be increased by switching to one of the new, high-performance VGA cards, but we didn't try this. Instead we provided an option to switch off the graphics.

CONCLUSION

Although initially skeptical of adding animation to a Monte Carlo simulation, we found that the animation adds significant value to the model. It helps convey to a potential and actual client and model user an understanding of what actually happens during a simulation. And it offers the possibility of 'interactive simulation', giving decisionmaking power to the analyst as the simulation proceeds. These advantages more than outweigh the additional cost of developing the animation.

AUTHOR BIOGRAPHY

RODNEY W. CYR is a System Analyist for Chevron, working in a group that specializes in Operations Research and Statistics. He has written several very large simulation models now used in Saudi Arabia, and has used this experience to develop several PC-based simulators used at Chevron.