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APPLICATIONS FOR ENTERPRISE SIMULATION

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ABSTRACT

The purpose of this paper is to describe several recent applications of enterprise simulation. An enterprise simulation is a simulation which is constructed with a top-down view of a business enterprise and which is intended to serve as a decision support tool for decision makers. Examples are taken from the domain areas of transportation, urban operations, supply chain management, entertainment, and manufacturing. The objective is to help clarify the meaning of the term enterprise simulation and to promote its use as an important management tool.

1 INTRODUCTION

This paper describes the application of computer simulation to a new and important problem area, enterprise simulation. Enterprise simulation refers to a dynamic model or simulation which is constructed with a top-down perspective and is intended to provide an overall conceptual view of the workings of the enterprise. Enterprise models often are constructed at the entity level. Entities interact with a synthetic representation of the real-world environment and with each other according to physically-based rules or accepted standards of behavior. The dynamic behavior of the system is captured as the record of this interaction over time. Enterprise simulation allows decision makers to ask 'what if' questions about the enterprise. The simulation computes the dynamic system response as a function of management decisions and policies so that managers can observe and better understand the cause and effect relationship between these decisions and system performance. Enterprise simulation provides the decision maker a virtual environment in which he can quickly, economically, and safely test and improve his understanding and expertise about the enterprise. It is a decision support tool, not a solution generator.

The Virginia Modeling, Analysis and Simulation Center (VMASC), a consortium of industry, universities and government lead by Old Dominion University, was established during summer 1997 to promote the commercial use of enterprise simulation. The Center (Mastaglio and Schultz 1997) also attempts to facilitate the transfer of simulation technology between the Department of Defense and civilian industry through a Cooperative Research and Development Agreement with the United States Atlantic Command. During the past two years, VMASC has identified domain areas where enterprise simulation could be of potential benefit. These domain areas include transportation, urban operations, disaster preparedness, manufacturing, supply chain management, entertainment, and training. The Center has recruited willing industrial partners in each of these areas to develop enterprise simulation demonstrations. These simulations are being used to encourage these partners to consider more fully embracing simulation technology as an important management tool, as well as being used as a marketing vehicle to interest additional companies in enterprise simulation.

The purpose of this paper is to describe briefly a representative enterprise simulation from several of the domain areas. It is hoped that this discussion will help clarify the meaning of the term enterprise simulation, and encourage additional interest in and demand for these important and powerful management tools.

2 TRANSPORTATION

Simulation has been used effectively as an essential design and analysis tool in the transportation industry for many years. However, the vast majority of these applications have been narrowly focused on specific problem areas of very limited geographic size. Simulation tools have been used to study the design of a new highway interchange or the re-engineering of a city intersection; there are few examples where simulation has been used to study an entire transportation enterprise. Modern commercial discrete event simulation packages are rapidly reaching the point where it is becoming possible, and in fact attractive, to model much larger- scale traffic systems.

VMASC currently is developing a transportation enterprise simulation for the Busch Gardens Theme Park located in Williamsburg, Virginia. The state of Virginia is constructing a new interstate highway interchange, called the Grove interchange, which will funnel traffic directly from interstate I-64 into the theme park. However, this interchange requires the construction of a new park toll plaza facility and access roads for entering the park, and totally reverses the traffic flow to the existing parking lot system. In the near term, the enterprise simulation tool will be used to assess and validate system design prior to the start of actual construction within the park. Longer term, the simulation tool will be used to assist in planning operating strategies for the parking system and to rehearse appropriate responses to unexpected events such as an in-park traffic accident or vehicle breakdown.

The Busch Gardens enterprise simulation is being constructed using a commercial discrete event simulation tool called Arena (Kelton, Sadowski and Sadowski 1998), made by Systems Modeling. The model is constructed on a 2D scale view of the theme park parking system. The model captures vehicle operating rules and constraints beginning at the interstate exits, continuing though the new park toll plaza, and extending to the seven system parking lot areas. Simulation entities represent different classes of vehicles including park-bound cars, recreational vehicles, motorcycles, buses, and service vehicles, and other non-park-bound vehicles. User adjustable parameters are used to specify input vehicle flow and mix from interstate I-64 as well as state Route 60. At the toll booth, provisions have been made for varying the number and schedule of open lanes, setting the individual booth service times, and for designating special-use lanes. The users are also given the ability to investigate different parking strategies. Parameters are available for setting the parking sequence for the seven lots, adjusting individually the lot opening and closing rules, specifying multiple simultaneously open lots, varying lot access times, and implementing various backup relief strategies. The simulation monitors important performance measures including traffic arrival profiles, traffic mix profiles, traffic backup locations and conditions, lot fill status and statistics, customer time to reach the toll plaza, and customer time to park as a function of source and destination. The simulation is automated to play from an Excel spreadsheet where input and output data are processed. This makes the use of the simulation extremely simple, even for those not familiar with discrete event simulation tools. The Busch Gardens simulation is shown in Figure 1.

Figure 1: Busch Gardens Simulation

3 URBAN OPERATIONS

Written and spoken language often are not adequate tools to describe highly complex or very detailed situations. First, it is difficult to accurately and fully describe such situations, and second, language descriptions can be interpreted and perceived differently by different individuals. In these cases, it is advantageous to construct an enterprise computer representation or visualization of the situation. An enterprise visualization can assist in developing a conceptual understanding because complexity and detail are more easily captured in a visual rendering of an object or process. An enterprise visualization is a useful tool to support collaboration because it can achieve greater uniformity of perception and interpretation among individuals. An enterprise visualization is also a useful analysis and planning tool because it facilitates discussion of alternatives and the formulation of ‘what if’ questions.

A surprising range and level of visualization capability is available today even using desktop PC hardware and low-to-moderately priced commercial software packages. A visualization may be as simple as a set of graphs and charts, but more commonly refers to a two-dimensional or three-dimensional rendering of a terrain background populated with a set of objects or entities. Often, animation is used to display the interaction which occurs between entities. A few animation tools support user interactivity. Thus, the user is able to modify the visualization and control entity movement during runtime. In addition, some software tools now provide the capability to deliver interactive simulations over the world wide web using a standard web browser as the user interface. Immersive visualization tools also are available, but still require more sophisticated and expensive hardware platforms and software tools. In most business enterprise visualizations, the added complexity and expense to achieve visual immersion is difficult to justify solely from a cost-benefit perspective.

VMASC recently completed the development of a web-deliverable, 3D, interactive enterprise visualization tool for the city of Portsmouth, Virginia. The tool is to be used as a conceptual planning and marketing tool for a planned commerce park; however, the same tool easily could be tailored to other specific visualization applications. The tool is constructed using Virtual Reality Modeling Language (VRML) (Special Issue on VRML 1999), a scene descriptive language that describes the geometry and behavior of a scene. VRML is an interpreted language written in UTF or ASCII text format which supports runtime object creation, identification, and management. The terrain model is obtained from a GIS or other appropriate database which is converted to a VRML file. Objects which populate the terrain are selected through a windows menu system and then created dynamically during runtime. The interface makes it easy to create, move, and modify objects with simple 'drag and drop' and 'point and click' mouse commands. In the commerce park visualization, users can place buildings, roads, parking lots, and landscaping on the actual site and then conduct a visual site tour. As actual business sites are constructed, the actual architectural plans will be used to add permanently these sites to the terrain model. A typical site model for the Portsmouth Commerce Park is shown in Figure 2.

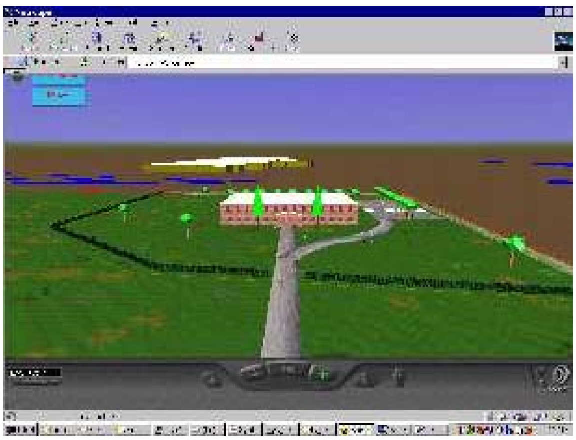

Figure 2: Portsmouth Commerce Park Visualization

A longer term objective is to use the commerce park visualization as the user interface to a more complete urban planning simulation tool. This tool would be used to plan the requirements and impact of placing a specific new customer in the commerce park. The tool could immediately calculate and assess the requirements for utilities, communication services, and transportation services. The new customer could be viewed in relation to the other potential tenants to determine the total impact on city infrastructure. The anticipated tax revenues from a new customer could even be calculated and used as a component of the decision-making process to compute incentive funding for encouraging companies to relocate to the commerce park.

4 SUPPLY CHAIN MANAGEMENT

Supply chain is a term used to describe the activities which comprise a manufacturing or service provider enterprise and usually includes the acquisition of raw materials, the production process, and then the moving, storing, and selling of the final product. Supply chain management refers to the integration and management of the business processes of the supply chain that provide product, service, and information which add value for the customer. The objective of supply chain management is to increase return on assets (ROA), defined as

ROA = (revenues – expenses)/(assets).

Revenues are increased by increasing customer demand through providing better service, and increasing the product production rate. Expenses are reduced by reducing inefficiencies of cost for labor, materials, marketing, etc.. Asset utilization is increased by reducing inventory and capital assets. Depending on focus, a supply chain could exist within a single company or could span multiple companies.

Engineering a supply chain usually involves two distinct activities, optimization and simulation. Optimization is used to improve or optimize components or activities of the supply chain: routing and scheduling; facility location and size; resource and labor allocation; transportation and inventory strategies; service levels and response times; and profitability. Optimization tools are normally applied to simplified, deterministic system models which capture only the most significant system features and constraints. The objective is to identify potentially good operational or procedural alternatives that satisfy fundamental operating conditions. Simulation is then used to investigate how the good alternatives, identified using optimization, perform when real-world uncertainty and anticipated variability are added. Thus, simulation tools are applied to a more detailed, stochastic representation of the system and are used to identify the one or two best solutions for effective supply chain management.

VMASC currently is conducting a supply chain management study for the Virginian Pilot Newspaper. The focus of the study is the examination and possible re-engineering of the single-copy distribution system for southeastern Virginia and northeastern North Carolina. The present distribution system utilizes 34 different truck routes and makes deliveries to approximately 2,200 sites. Each truck can haul no more than 2,000 newspapers (1,500 on Sundays) and can service only a single route. Paper availability can occur as late as 3:00am and all delivery locations must be served by 5:00am; thus, one-way truck routes can be no longer than 2 hours. CAPS Logistics Route Pro is being used to investigate (optimize) the route selection. When this is completed, a discrete event simulation tool will be used to determine the effects of uncertainty on system performance. The short term objective is to identify a more efficient single-paper distribution system for the existing delivery stations. It is estimated that annual savings of up to $200,000 are possible. The route model for the Virginian Pilot is shown in Figure 3. The longer term objective of the project is to provide the newspaper with a tool which can be used to re-organize the distribution system as new distribution points are added, demand increases, or supply constraints change over time.

Figure 3: Virginian Pilot Route Model

5 ENTERTAINMENT

The entertainment industry has been at the forefront in embracing simulation technology in the production of special effects and animation for movies and electronic gaming. Surprisingly, the industry as a whole has been slow to adopt simulation as a management tool. Therefore, VMASC was very pleased to have the opportunity to work with a local theme park, Water Country USA, to develop an enterprise management tool to help support park operations.

Water Country USA, located in Williamsburg, Virginia and operated in conjunction with Busch Gardens-Williamsburg by Anheuser-Busch, is a typical example of a small to medium-sized theme park. The park consists of sixteen major attractions, locker rooms and dressing areas, dining and concession facilities, customer parking area, pool and sunbathing areas, and functional areas for staff parking, office space, maintenance shops, and equipment storage. On a typical busy July day, the park will serve approximately 11,000 guests with a peak in-park load of nearly 7,000 customers. The park is staffed by a relatively small full-time staff to provide year-around management and technical functions, and several hundred seasonal employees to provide operational and customer support services during the operating season.

Park management requested a simulation tool to support 'what if' questions concerning how park operating strategies affect the quality of experience of park customers. Customer quality of experience is measured primarily by how long a customer must wait in a queue to gain access to desired attractions and services. Management decisions which impact quality of experience include staffing level, staff deployment, attraction and service facility operating schedules and levels, attraction cycle time, and service facility service times.

An enterprise simulation of customer flow through the entire theme park (Mielke, Zahralddin, Padam and Mastaglio 1998) was developed using the discrete event simulation package called Service Model (Bateman, Bowden, Gogg, Harrell and Mott 1997) made by ProModel, Incorporated. Customers are represented as entities, attractions and service facilities are modeled as servers, and management decisions are used to define characteristics associated with the servers. Average customer waiting time measured as a percentage of total visit time is calculated by managing entity attributes. Visitor count, as well as visitor arrival and departure profiles, also can be controlled so that different operating scenarios can be investigated. This enterprise simulation provides park management the ability to review, and possibly modify, daily park operating strategies for any anticipated customer level. The user interface for the Water Country USA simulation is shown in Figure 4.

Figure 4: Water Country USA Simulation

6 MANUFACTURING

Manufacturing firms have used simulation successfully as a planning tool for many years. However, the predominance of these applications focus on a specific trouble spot or problem area, and the simulation is designed to provide a point solution to the problem. It is only recently that manufacturing companies have started to recognize simulation as an important enterprise management tool. VMASC recently completed an enterprise simulation project with Howmet, Incorporated.

Howmet is a worldwide manufacturer of cast metal machine components. The Hampton, Virginia facility makes titanium and super alloy components for jet engines and gas turbines using a process called lost-wax casting. In this process, a wax replica of the desired component is made and then used to construct a casting mold by repetitively dipping the wax replica in a series of ceramic slurries. When the mold hardens, the wax is removed, first by melting the wax and then using a mechanical and chemical treatment to remove any wax residue. The mold is then inspected, repaired if necessary, and sent to a staging area. In the staging area, molds corresponding to parts having similar characteristics are batched, sent through preheat ovens to raise the mold temperature, and then finally are moved to the casting area where the molten alloy is poured to create the actual cast metal part.

The facility manufactures 84 part types using 7 different alloys on 6 preheat/casting work cells. As batched parts move through the preheat ovens, temperature is controlled to within $\pm$5 degrees, and the temperature for succeeding batches must continually increase. When the maximum oven temperature is reached, production is stopped to cool the oven and the cycle is then repeated. The molten alloy is poured from a crucible. Each crucible can be used for only one alloy type, the alloy melt-line in the crucible must decrease with each use, and a single crucible can only be used between 10 and 20 times before it must be replaced. Crucible replacement requires a production delay of approximately 3 hours in that work cell. Because of these physical operating constraints, it is apparent that part cycle time and in-process inventory depend strongly on the manner in which molds are batched in the staging area and the order with which parts are submitted to the wax work cell.

At Howmet, the ordering of parts at the input to the wax work cell is made by the facility master scheduler, and the batching decisions are made by the casting supervisor. Each of these individuals has considerable flexibility with their respective decisions. The objective, then, was to produce an enterprise simulation that allows the master scheduler and the casting supervisor to investigate how to best use this flexibility. The goal is to identify decision strategies or rules which lead to a decrease in part cycle times and a decrease in in-process inventory. The simulation was developed using the Arena discrete event simulation package. Part ordering is controlled from an Excel spread sheet linked to the simulation through a VBA interface. Batching decisions are made at runtime through an interactive dialog box which appears each time a new batching decision must be implemented. Part cycle time and in-process inventory are monitored though manipulation of entity attributes. The simulation provides the capability for management to conduct operating rehearsals for the anticipated new part orders. The Howmet simulation is shown in Figure 5.

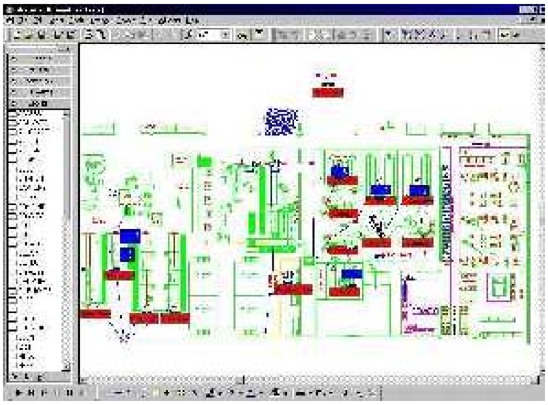

Figure 5: Howmet Simulation

7 CONCLUSION

An enterprise simulation is a simulation which is constructed with a top-down view of a business enterprise and which is intended to serve as a decision support tool for decision makers. The purpose of this paper is to describe several enterprise simulation projects conducted recently at VMASC. Examples are taken from the domain areas of transportation, urban operations, supply chain management, entertainment, and manufacturing.

Having worked on a number of enterprise simulation projects over the past two years, I would like to offer two observations. First, promoting the use of enterprise simulations is still a marketing challenge. Many companies are just learning to deal successfully with computerized information gathering and reporting. On top of that, they are focused on the Y2K problem. They have not discovered yet that they are not taking full advantage of the power that having this information offers. Consequently, there is a need for more domain specific demonstrations of successful applications of enterprise simulation that tell a convincing cost-benefit story to motivate investment in these tools.

Second, there is a need to reduce the cost of developing enterprise simulations. Of course, the cost of the hardware and software tools required for enterprise simulation continue to decrease while their capabilities increase, and this is a welcomed trend. However, the most significant costs associated with building and using enterprise simulations are the costs of construction labor and of training endpoint users. Construction costs can be lowered by developing new ways to reuse models and by finding ways to more easily integrate separately constructed models of enterprise subsystems. User training costs can be reduced by further development of friendly and intelligent interfaces which allow simulations to be configured and run from more familiar office automation tools such as spreadsheets and database tools. These areas represent important and exciting research opportunities for the simulation application community.

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