SIMULATION MODELING IN OPERATIONS MANAGEMENT:
A Sampling of Applications

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Abstract

Simulation modeling has become a promising technology for a variety of operations management applications. The modern software has made it easy for managers to initiate simulation projects to address various operational problems. The objective of this presentation is to review the latest applications of simulation projects addressing operations management issues.

Introduction

Computer-assisted simulation modeling has become more common as a method of inquiry for operations management and the service industry since the 1990's. Many technology driven managers now rely on extensive use of simulation to test new ideas and options before actual implementation of their ideas. Instead of building extensive mathematical models by experts, the readily available simulation software has made it possible to model and analyze the operation of a real system by managers who are not well versed in programming languages. Simulation allows the manager to both quantify and observe the system's behavior. Whether the system is a production line, a distribution network or a communications system, simulation can be used to study and compare alternative designs or troubleshoot existing operations. With simulation models, the manager can explicitly visualize how an existing operation might perform under varied inputs, and how a new or proposed operation might behave under same or different inputs [2,13]. The ability to easily construct and execute models and to generate statistics and animations about results has been the main attractions of simulation. The windows based simulation software such as ARENA, have made simulation modeling not only affordable but relatively easy for managers to initiate simulation studies of a variety of situations including operations and processes, feasibility studies, business processes, human resource deployment, call center staffing, capacity planning and others.

In manufacturing and service industries, companies are looking for ways to improve their systems performance and increase their competitiveness in order to survive in the market place. Simulation modeling is a practical tool that can be used by those companies to generate data and simulations to be used for better and faster decision-making and forecasts of their business models and approaches. Simulation also makes the task of "what-if" analysis very easy as most simulation software come equipped with scenario managers which are designed for the purposes of "what-if" analysis and can be run with minimal programming involved. "What-if" analysis includes the ability to show how a system would behave under varying input parameters and/or constraints [3].

Application areas for simulation are practically unlimited. Today simulation can be used for decision-support with supply chain management, workflow and throughput analysis, facility layout design, resource usage and allocation, resource management and process change. Whether contemplating a new office building, planning a new factory design, assessing predictive and reliability maintenance, anticipating new or radical procedures, deploying new staff, or planning a day's activities, simulation can play a crucial role in finding the right and timely solutions. The progressive and technology driven organizations, in pursuit of winning and/or maintaining their market share, have taken different approaches to their success. In their pursuit, some have focused on "customer service", many have embraced the "productivity" theme, and yet others have pursued the important issue of "quality and reliability". In recent times, simulation has been very successfully used as a modeling and analysis tool in the first two cases.

Customer Service

Customer service is the ability of an organization to constantly and consistently give the customer what they want and need. Customer service processes can be telephonic services (call centers), service factories (restaurants, copy centers), service shops (hospitals, repair shops) or retail stores. Today 64 of the fortune 100 companies are service companies. Customer services present a major area of applications for simulation because total waiting time may be as high as 95 percent of the total processing time in a typical service process, and as such, a natural area for simulation study and analysis [10].

Simulation of customer service processes demonstrates a unique challenge because both the flow objects and resources are humans. Humans have much more complex and unpredictable behavior than products, documents, equipment or vehicles. Time and money constraints on customer service processes have always been a big challenge for companies to achieve. Simulation modeling helps companies not only to find the best ways to improve customer satisfaction level without disrupting the current customer service processes but also it helps to see different aspects of customer service such as process flow, communication with customers, handling problems, and resolution of the problems and feedback.

Numerous enterprises around the world have adopted simulation as a modeling tool to enhance and improve their customer service components. For instance, Xerox, a manufacturer of a document imaging products, claims millions of dollars in potential savings and improved response time to customers by developing a flexible data driven model of the customer service teams policies using simulation modeling [12].

Coopers & Lybrand, one of the nation's largest mortgage investment firms achieved major changes in key service areas such as processing security by applying the SPARKS simulation modeling system. Simulation analysis yielded performance improvement recommendations, suggestions on new organizational structures and new job descriptions were developed [4].

Simulation has also been used in managing the health care operations in recent times. It is an especially ideal tool, as it will not disrupt the patient care process while analysis is being conducted. For example, Waukesha Memorial Hospital of Milwaukee faced a serious capacity problem in its surgical department facility. Management's preference was to redesign the existing facility since building an additional facility was not an option due to significant capital cost. Therefore, simulation modeling was used to study and verify the appropriateness of alternative designs of providing patient care within the existing facility. The modeling process revealed major inefficiencies in the way the inpatient and outpatient services were provided, and alternative superior procedures were identified [7]. In another study, the emergency department of a hospital, which handles over 40,000 patients annually, was simulated to create a test-bed for verifying various administrative, operational, and scheduling scenarios. Simulation proved to be a valuable tool for the analysis of the performance of the emergency department under different input without putting the patient care at risk [8].

Productivity

Productivity is formally defined as the ratio of output per unit of input. In real life situations, however, the diversity and complexity of inputs and outputs make productivity computation and analysis rather difficult and intractable. Depending on the situation, productivity can be measured by the ratio of revenue per employee, the return on assets, and at a more specific level, the number of products produced per hour at a given plant running with a given level of staffing, equipment, energy and other inputs. Productivity growth depends on finding better ways to produce goods and services. Given the diversity and complexity of inputs and outputs as well as the inherent computational difficulty, simulation becomes a more practical tool as compared to the traditional analytical approaches to productivity improvement studies. The superiority of simulation stems from the fact that simulation models are designed to mimic the process (or system) under study. Thus, the analyst has access to all variables and their values at any instant of time during the simulation. Some common approaches to productivity improvement are identification and removal of bottleneck in a process or operation, reducing inventory and work-in-process, and reducing cycle time [11].

Cleo Incorporated, a manufacturer of Christmas wrapping paper who delivers 30-40% of the world consumption, used business process simulation modeling to find ways to increase productivity and throughput, decrease cycle time, inventory and operating expenses, and to improve their capacity planning efforts. With the help of the Arena simulation software, they were able to reduce cycle time from five weeks to three days; to bring down overtime expenses, thus lowering operating expenses; and to increase on-time shipping performance from 70% to more than 95%. They identified and removed various interrelated bottlenecks. They also learned much about the effect of variations in production parameters, such as volume, on sales, which resulted in increase in sales of over $1 million dollars [5].

Textile Clothing Technology Corporation also used simulation in over twenty of their facilities to find ways to improve productivity. In one of the studies using the Arena software, which dealt with the description and analysis of a proposed 'team-sewing' production model, they were able to show improved productivity, smaller flow-times, and increased operators utilizations compared to the existing production model. The modeling effort showed that they

were able to decrease WIP by 55-80%, cycle time by 60-65%, and thus, increase productivity up to 25% [1].

J. B. Hunt Dedicated Contract Services (DCS), a division of J. B. Hunt Transport Services Inc. used simulation to create a visual model of their trucking operation showing how load volume varied from day-to-day and how it impacted overall operations [9].

Simulation modeling was used to study throughput, bottlenecks and system utilization at a high-speed liquid filling production line in a pharmaceutical industry. The study was a success as it helped to identify the processes that were susceptible to becoming bottlenecks, and to determine the appropriate settings, which increased throughput by 11% [6].

Summary

Advances in computing hardware and more importantly software have made simulation technology not only a viable but strategically vital tool in the field of production and operations management. Simulation software has become affordable and more sophisticated in their functionality and features. Today's software includes user-friendly interfaces for the development of the model and analysis of simulation results, animation capabilities for visualizing the system behavior, and enhanced computational capabilities for statistical analysis and decision-making. The modern simulation software is windows-based, requires no programming, and hence, much easier to be learned by operations and production managers, who could then use it for a variety of daily operational issues including feasibility studies, detecting bottlenecks and process improvement. Many questions of operations that used to go unanswered or at best contracted out to consultants may now be resolved in-house and rather quickly through the use of simulation technology at the managers' fingertips. The benefits and savings are substantial. The literature is filled with reports of cases and scenarios in operations and production management where simulation was used and how it benefited the organization.

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