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Beneficiaries of Operation Research and Simulation

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ABSTRACT

OPERATION RESEARCH AND SIMULATION:

An operation research (OR) is a discipline explicitly devoted to aiding decision makers. It may also be defined as the discipline of applying advanced analytical methods to help make better decisions. Simulation is a very general technique for estimating statistical measures of complex systems.

As we are industrial engineers, our mission is

- Help with the challenge of making complex decisions by:
  - Performing quantitative analysis that provides insight.
  - Providing sensible options and recommending courses of action.
  - Reducing risk.
  - Improving the quality of recurring decisions.
  - Have a dramatic, positive impact on a project's or organization's value.

The phenomenal growth of simulation throughout industry has led to a growing demand for simulation professionals to develop models and modeling tools, and to manage large and complex simulation-based projects. Lacking a source of simulation professionals, the traditional approach has been to re-train engineers, scientists or programmers in the specialized skills needed for a given modeling or software development effort.

So, here we try to present a paper on **OPERATION RESEACH AND SIMULATION** with **terminologies** involved in OR, SIMULATION, their **computer application tools**, their **benefits**, and with our **duties as industrial engineers**. Finally, we conclude with a case study in accordance with the conference theme that the advances are not restricted to academia, but have greatly benefited the policy makers, business and practitioners.

INTRODUCTION:

Most operations research studies involve the construction of a mathematical model. The model is a collection of logical and mathematical relationships that represents aspects of the situation under study. Models describe important relationships between variables, include an objective function with which alternative solutions are evaluated, and constraints that restrict solutions to feasible values.

Although the analyst would hope to study the broad implications of the problem using a systems approach, a model cannot include every aspect of a situation. A model is always an abstraction that is of necessity simpler than the real situation. Elements that are irrelevant or unimportant to the problem are to be ignored, hopefully leaving sufficient detail so that the solution obtained with the model has value with regard to the original problem.

Models must be both tractable, capable of being solved, and valid, representative of the original situation. These dual goals are often contradictory and are not always attainable. It is generally true that the most powerful solution methods can be applied to the simplest, or most abstract, model.

WHAT IS OPERATION RESEARCH?

An operation research (OR) is a discipline explicitly devoted to aiding decision makers. This section reviews the terminology of OR, a process for addressing practical decision problems.

TERMINOLOGIES IN OR:

LINEAR PROGRAMMING:

A typical mathematical program consists of a single objective function, representing either a profit to be maximized or a cost to be minimized, and a set of constraints that circumscribe the decision variables. In the case of a linear program (LP) the objective function and constraints are all linear functions of the decision variables. At first glance these restrictions would seem to limit the scope of the LP model, but this is hardly the case. Because of its simplicity, software has been developed that is capable of solving problems containing millions of variables and tens of thousands of constraints. Countless real-world applications have been successfully modeled and solved using linear programming techniques.

NETWORK FLOW PROGRAMMING:

The term network flow program describes a type of model that is a special case of the more general linear program. The class of network flow programs includes such problems as the transportation problem, the assignment problem, the shortest path problem, the maximum flow problem, the pure minimum cost flow problem, and the generalized minimum cost flow problem. It is an important class because many aspects of actual situations are readily recognized as networks and the representation of the model is much more compact than the general linear program. When a situation can be entirely modeled as a network, very efficient algorithms exist for the solution of the optimization problem, many times more efficient than linear programming in the utilization of computer time and space resources.

INTEGER PROGRAMMING:

Integer programming is concerned with optimization problems in which some of the variables are required to take on discrete values. Rather than allow a variable to assume all real values in a given range, only predetermined discrete values within the range are permitted. In most cases, these values are the integers, giving rise to the name of this class of models.

Models with integer variables are very useful. Situations that cannot be modeled by linear programming are easily handled by integer programming. Primary among these involve binary decisions such as yes-no, build-no build or invest-not invest. Although one can model a binary decision in linear programming with a variable that ranges between 0 and 1, there is nothing that keeps the solution from obtaining a fractional value such as 0.5, hardly acceptable to a decision maker. Integer programming requires such a variable to be either 0 or 1, but not in-between.

Unfortunately integer programming models of practical size are often very difficult or impossible to solve. Linear programming methods can solve problems orders of magnitude larger than integer programming methods. Still, many interesting problems are solvable, and the growing power of computers makes this an active area of interest in Operations Research.

NON-LINEAR PROGRAMMING:

When expressions defining the objective function or constraints of an optimization model are not linear, one has a nonlinear programming model. Again, the class of situations appropriate for nonlinear programming is much larger than the class for linear programming. Indeed it can be argued that all linear expressions are really approximations for nonlinear ones.

Since nonlinear functions can assume such a wide variety of functional forms, there are many different classes of nonlinear programming models. The specific form has much to do with how easily the problem is solve, but in general a nonlinear programming model is much more difficult to solve than a similarly sized linear programming model.

DYNAMIC PROGRAMMING:

Dynamic programming (DP) models are represented in a different way than other mathematical programming models. Rather than an objective function and constraints, a DP model describes a process in terms of states, decisions, transitions and returns. The process begins in some initial state where a decision is made. The decision causes a transition to a new state. Based on the starting state, ending state and decision a return is realized. The process continues through a sequence of states until finally a final state is reached. The problem is to find the sequence that maximizes the total return.

The models considered here are for discrete decision problems. Although traditional integer programming problems can be solved with DP, the models and methods are most appropriate for situations that are not easily modeled using the constructs of mathematical programming. Objectives with very general functional forms may be handled and a global optimal solution is always obtained. The price of this generality is computational effort. Solutions to practical problems are often stymied by the "curse of dimensionally" where the number of states grows exponentially with the number of dimensions of the problem.

COMBINATIONAL OPTIMIZATION:

The most general type of optimization problem and one that is applicable to most spreadsheet models is the combinatorial optimization problem. Many spreadsheet models contain variables and compute measures of effectiveness. The spreadsheet user often changes the variables in an unstructured way to look for the solution that obtains the greatest or least of the measure. In the words of OR, the analyst is searching for the solution that optimizes an objective function, the measure of effectiveness. Combinatorial optimization provides tools for automating the search for good solutions and can be of great value for spreadsheet applications.

STOCHASTIC PROCESS:

In many practical situations the attributes of a system randomly change over time. Examples include the number of customers in a checkout line, congestion on a highway, the number of items in a warehouse, and the price of a financial security, to name a few. When aspects of the process are governed by probability theory, we have a stochastic process.

The model is described in part by enumerating the states in which the system can be found. The state is like a snapshot of the system at a point in time that describes the attributes of the system. The example for this section is an Automated Teller Machine (ATM) system and the state is the number of customers at or waiting for the machine. Time is the linear measure through which the system moves. Events occur that change the state of the system. For the ATM example the events are arrivals and departures.

In this section we describe the basic ideas associated with modeling a stochastic process that are useful for both Discrete and Continuous Time Markov Chains.

DISCRETE TIME MARKOV CHAIN:

Say a system is observed at regular intervals such as every day or every week. Then the stochastic process can be described by a matrix which gives the probabilities of moving to each state from every other state in one time interval. Assuming this matrix is unchanging with time, the process is called a Discrete Time Markov Chain (DTMC). Computational techniques are available to compute a variety of system measures that can be used to analyze and evaluate a DTMC model.

CONTINUOUS TIME MARKOV CHAIN:

Here we consider a continuous time stochastic process in which the duration of all state changing activities are exponentially distributed. Time is a continuous parameter. The process satisfies the Markovian property and is called a Continuous Time Markov Chain (CTMC). The process is entirely described by a matrix showing the rate of transition from each state to every other state. The rates are the parameters of the associated exponential distributions. The analytical results are very similar to those of a DTMC. The ATM example is continued with illustrations of the elements of the model and the statistical measures that can be obtained from it.

SIMULATION:

When a situation is affected by random variables it is often difficult to obtain closed form equations that can be used for evaluation. Simulation is a very general technique for estimating statistical measures of complex systems. A system is modeled as if the random variables were known. Then values for the variables are drawn randomly from their known probability distributions. Each replication gives one observation of the system response. By simulating a system in this fashion for many replications and recording the responses, one can compute statistics concerning the results. The statistics are used for evaluation and design.

COMPUTER APPLICATION TOOLS OF OR AND SIMULATION:

Some of the computer application tools of OR are

- TORA
- LINDO
- LINGO

Some of the computer application tools of SIMULATION are

- GPSS
- ARENA
- AWESIM

BENEFITS OF OR AND SIMULATION:

- The phenomenal growth of simulation throughout industry and particularly within the Department of Defense (DOD) has led to a growing demand for simulation professionals to develop models and modeling tools, and to manage large and complex simulation-based projects.
- In the case of manufacturing and service fields where discrete-event simulation is the predominant approach, many of these skills could be obtained as part of a degree program in operations research, management science or industrial engineering.
- In a similar manner, expertise in communications or radar simulation might be developed by recruiting and retraining generalists from physics or electrical engineering.

DUTIES OF INDUSTRIAL ENGINEERS:

Designing, operating and improving the performance of systems of people, material, and equipment. IEs use their skills in mathematical, physical and social sciences together with their special knowledge in computer modeling and manufacturing.

IE's regularly interact with people on projects and teams to solve industrial problems. They often have opportunities to quickly move into management positions.

THEME OF THEINTERNATIONAL CONFERENCE ON GLOBAL BUSINESS AND POLICY MODELLING (GBPM 2006):

The statistical and econometric advancement not only help to bridge the gap between the theory and data, but also enable researchers to gain a deeper insight into complex behavior of economy of financial markets. More importantly, these advances are not restricted to academia, but have greatly benefited the policy makers, business and practioners.

CASE STUDY:

The blockbuster movie "The Matrix" and its recent sequel "The Matrix Reloaded" portray an interactive simulation environment so realistic that the participants remain ignorant that their "reality" is only a simulation, and only the hacker heroes such as Neo (Keanu Reeves) know the truth. It is a simulation so engaging that participants can convince themselves that they are dead! The pervasiveness of simulation and of role-playing games is great enough that the concept is easily accepted and imagined. Increasingly, simulations are being used for visualization, exploration and training, taking advantage of advances in animation and computer processing to make this possible. Of course, we are used to thinking about simulation as a powerful tool for letting us imagine new systems and allowing us to both quantify and observe their behavior. Whether the system is a production line, a distribution network or communications system, simulation can be used to study and compare alternative designs or to troubleshoot existing systems. With simulation models we are free to imagine how an existing system might perform if altered, or imagine and explicitly visualize how a new system might behave before the prototype is even completed. The ability to easily construct and execute models and to generate statistics and animations about results has always been one of the main attractions of simulation software.

CONCLUSION:

The need for simulation professionals appears to be outstripping the supply that can be provided through the traditional approach. Simulation application far transcends the methods favored by individual disciplines, such as operations research. In fact, application areas and their disparate simulation approaches have sub-divided simulation, but there is an increasing sense that modeling and simulation may constitute a discipline in itself.