Combining Simulation & Optimization for Improved Business Decisions

A White Paper from OptTek Systems, Inc.

October 16, 2000

Simulation is a powerful computer-based tool used by many decision-makers in business and industry to improve operating and organizational efficiency. The basic idea of simulation is to model a physical process on the computer, incorporating the uncertainties that are inherent in all real systems. The model is then "run" to simulate the effects of the physical process and to determine their consequences. For example, a factory can be modeled and simulated by incorporating the relationships among production times, demands, tolerances, and breakdowns, including provision for the uncertain nature of each. Such a simulation may model the flow of individual products through the factory over a period of hours, days, or even months. The analyst can then make virtual changes to the factory and product, to observe the impacts without ever changing a piece of real equipment or manufacturing a new product. Similarly, simulation models can be applied to analyze the consequences of alternative scenarios in financial planning and marketing strategy.

These uses of simulation have produced widespread benefits in industry, reducing costs and increasing profits through improved decisions. In spite of its acknowledged benefits, simulation has suffered a limitation that has prevented it from uncovering the best decisions in critical practical settings. This limitation arises out of an inability to evaluate more than a fraction of the immense range of options available. Practical problems in areas such as manufacturing, marketing, logistics and finance typically pose vast numbers of interconnected alternatives to consider. As a consequence, the decision making goal of identifying and evaluating the best (or near best) options has been impossible to achieve in many applications.

Theoretically, the issue of identifying best options falls within the realm of optimization. Until quite recently, however, the methods available for finding optimal decisions have been unable to cope with the complexities and uncertainties posed by many real world problems, particularly those approached by simulation. In fact, these complexities and uncertainties are the primary reason that simulation is chosen as a basis for handling such problems. Consequently, decision makers have been faced with a "Catch 22". Many important types of real world optimization problems can only be treated by the use a simulation model, but once they are submitted to simulation there are no optimization methods that can adequately organize the search for the best solutions. In short, there has not existed any type of search process capable of effectively integrating simulation and optimization. The same shortcoming is also encountered in settings outside of simulation where complex (realistic) models cannot be analyzed using traditional "closed form" optimization tools.

Recent developments are changing this picture. Advances in the field of metaheuristics- the domain of optimization that incorporates artificial intelligence and analogs to physical, biological or evolutionary processes -- have led to the creation of a new approach that successfully integrates simulation and optimization. This innovation, due to Professors Fred Glover, James P. Kelly, and Manuel Laguna, from the College of Business at the University of Colorado at Boulder, has been embedded in a computer software system called OptQuest®. The creators of this technology have also formed OptTek Systems, Inc., a company that develops and markets the OptQuest software system. The availability of this new system opens the door to handling decision-making problems in business and industry that could not be adequately approached in the past.

OptQuest Capabilities and Practical Implications

OptQuest replaces the inaccuracy of trial-and-error, which has been the only way previously available to search for effective options using simulation, or other computer based models for

evaluating proposed solutions, with a potent search engine that can pinpoint the best decisions that fall within the domain that the simulation or other evaluation model encompasses. Standard simulation packages give the decision- maker no help in identifying good alternatives to evaluate. More importantly, they offer no guidance or insight into the nature of alternatives that can yield the best decisions. To illustrate, the intelligent user of simulation and other business or industry evaluation models may want to know:

- What is the most effective factory layout?
- What is the safest equipment replacement policy?
- What is the most cost effective inventory policy?
- What is the best workforce allocation?
- What is the most productive operating schedule?
- What is the best investment portfolio?

The answers to such questions require a painstaking examination of multiple scenarios, where each scenario in turn requires the implementation of an appropriate simulation or evaluation model to determine the consequences for costs, profits and risks. The critical "missing component" is to disclose which decision scenarios are the ones that should be investigated -- and still more completely, to identify good scenarios automatically by a search process designed to find the best set of decisions. Traditional simulation and evaluation packages provide no means of fulfilling this critical function.

The OptQuest system fills the gap that exists in other systems, and gives the decision maker support when faced with the need to determine effective courses of action. OptQuest enables the decision maker to specify a variety of important relationships to control the determination of optimal decisions, such as:

- ranges of key parameters (technical or market based)
- budget limitations
- machine capacities
- minimum and maximum lot sizes
- limits on hours worked
- links between components or subsystems

OptQuest then determines the strategic options that are investigated under its guidance, and which it successively passes to the simulation package or technical model for evaluation. The resulting search isolates scenarios that yield the highest quality outcomes for profits, costs and risks, according to the criteria selected by the decision maker. Without the benefit of this search and analysis capability, the decision maker must contend with trying out different variations blindly -- with little hope of finding a competitive outcome from the vast number of possible decision combinations that arise in real world applications (even when the number of decision parameters is small). The relevance of this benefit comes from considerations identified below.

Features of Uncertainty
Most models are characterized by uncertainty and variability such as uncertain supplies, demands, and prices, or variable costs, flow rates, and queuing rates. OptQuest lets the user define the uncertainty for each value where this is needed.

Local solutions
Many real-world problems have nonlinear components that can create a solution space with many locally optimal solutions of poor quality. OptQuest is designed to find solutions of superior global quality for all types of objectives. Classical linear and nonlinear programming methods will get trapped in the first solution they find, whether it is a local solution or the true optimal solution. Integer programming methods, which are presumed to have a global solution capability, can not

handle important nonlinear relationships and are helpless to handle uncertainty. (In addition, in complex practical applications, integer programming methods can sometimes fail to find solutions that are feasible, let alone optimal.)

Solution Technology
The solution technology in OptQuest represents the outcome of over two decades of research. OptQuest integrates the metaheuristic procedures of Tabu Search, Neural Networks, and Scatter Search into a single composite method, and has demonstrated the power of this method in an extensive range of practical applications.

Decision Making Consequences - in Summary

The OptQuest system brings unprecedented intelligence to software for corporate decision-making, and gives a new dimension to optimization and simulation models in business and industry. OptQuest empowers decision makers to look beyond conventional decision-making approaches and actually pinpoint the most effective choices in uncertain situations. It is the first optimization technology to incorporate risk analysis, thus bringing corporate decision-making to a higher level of accuracy.
Illustrative applications of OptQuest involve the goals of finding:

- maximum return on funds allocated to different uses, given uncertain product demand, average selling price, market penetration and competition.
- optimal product prices to maximize revenue given uncertain demand at specific prices.
- most effective configuration of machines for production scheduling under variable conditions of demand and operation.
- most effective location of facilities for commercial distribution in the face of changing customer orders and distribution alternatives.

In these applications and many others, OptQuest provides decisions and scenarios that are beyond the capability of standard simulation or optimization packages to identify, and that are essential for effective planning in competitive and uncertain environments. The technology embodied in OptQuest represents a successful transfer of cutting-edge research to powerful and practical commercial software.

For additional information, please contact:

Dr. Fred Glover ,Dr. James P. Kelly or Jay April

OptTek Systems, Inc.
1919 Seventh St.
Boulder, CO 80302, USA

Tel. (303) 447-3255
Web: www.opttek.com
email: optinfo@opttek.com