WHITE PAPER

Optimization vs. Simulation

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Understanding advantages of optimization in general business operations

Quite often the terms *simulation* and *optimization* are misused. In some cases, they are interchanged. However there is clear distinction between them. Each of these methods must be applied appropriately based on the type of problem one is dealing with and the type of IT solution one will acquire.

In general, simulation and optimization require different software for their implementation. Therefore understanding the nature and underlying structure of the problem is truly essential so that the methods are deployed accordingly to achieve the desired objective.

Both simulation and optimization have been used in many industries such as energy, finance, manufacturing, transportation, and medical. They can be used effectively to support strategic, tactical operational decision-making processes. Today scientific advancement and high power computing capabilities allow these methods to play a crucial role in managing various aspects. Industries seek to deploy these two methods to help establish long- and short- term policies.

Optimization is a scientific approach in a decision-making process to find an optimal, or the absolutely most efficient, way to achieve an objective while simultaneously satisfying all constraints associated with achieving this objective. Typically the objective is maximization or minimization of an analytical mathematical expression with a large amount of variables. Quite often, the objective function is a mathematical expression of the revenue or cost function. Constraints are the mathematical expression representing the limitations of resources such as financial, labor / human, technological, transportation, etc. Optimization methods can be applied in planning, flow network/transportation flow, inventory management, resource management, scheduling / work force assignment, or financial investment – and thus provide the most proficient results available given the objective and constraints.

Simulation is the evaluation of a large number of alternatives under different realistic scenarios identified by decision-makers. It is essential to understand that simulation supports decision-making by evaluating predefined options, but it does not generate the best possible strategies. Simulation models can be used to measure the performance of alternatives under considerable flexibility and a high degree of realism supplied by decision-makers. This method requires decision-makers to have comprehensive knowledge of the topic to ensure the correct selection of a single option from a potential field of thousands, in order to arrive at the best possible outcome. Simulation furthers the understanding of the outcome of certain events and behavior of a certain system. It also provides a virtual experience of real world operations and empirical data using a variety of realistic conditions.

A Closer Look at Optimization

Many different optimization techniques can be used to support decision-making processes. They can result in sophisticated and quality operational solutions. Optimization can be used effectively for forming long-term strategies. In fact, rapid advancements in mathematical programming and stochastic programming make optimization an extremely effective tool for long-term planning. Over a longer period of time, uncertainties play a greater role and the defined problem becomes indeterministic. In that case, stochastic optimization or sensitivity analysis is more effective.

For shorter-term decisions pertaining to tactical operations, an equally effective method can be deployed. Several powerful optimization methods and software can efficiently solve deterministic optimization problems. Benefits include a high degree of accuracy and less costly computation compared to stochastic techniques. A disadvantage is the possibility of oversimplifying the problem with the assumptions made during the modeling stage.

Simulation in Detail

Certain behaviors, processes, and events in a practical world cannot be accurately described analytically or in a closed mathematical expression. Simulation is preferred over optimization when the problem contains a large number of parameters with a high degree of uncertainty or when the structure of the problem is too random or too difficult to accurately translate into an analytical expression. Simulation can manage indeterministic problems, so the method can be implemented very effectively as a long-term decision-making tool. Decision-makers however cannot expect to obtain an optimal solution from simulation. Simulation techniques only point to the best possible solution from a set of predetermined scenarios, which may be subject to implicit biases. Therefore the solution is considered as *local optimal*. It may be substantially lesser quality compared a *global optimal* solution identified by the optimization method.

Conclusion

In many cases, the ideal approach uses both simulation and optimization to guide decision-making. Simulation provides valuable insights and information about the outcomes of certain events and certain operations. Combined with statistical analysis, this information can now be incorporated with optimization to obtain the truly best available results.

Summary of Optimization vs. Simulation

	Optimization	Simulation
Advantages	produces high quality analytical solutions	manages highly practical scenarios with minimal assumptions
	provides powerful tactical and strategic solutions for countless applications	manages parameters of uncertainty and produces a long-term strategy
Disadvantages	can oversimplify the problem during the modeling stage	difficult process to obtain high-quality solutions
	less effective as the degree of parameters of uncertainty increase	high costs associated with data sets and the modeling process

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