

Employing Operations Research at Universities to Build Management Systems

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Abstract—Operations research science (OR) deals with good success in developing and applying scientific methods for problem solving and decision-making. However, by using OR techniques, we can enhance the use of computer decision support systems to achieve optimal management for institutions. OR applies comprehensive analysis including all factors that effect on it and builds mathematical modeling to solve business or organizational problems. In addition, it improves decision-making and uses available resources efficiently. The adoption of OR by universities would definitely contributes to the development and enhancement of the performance of OR techniques. This paper provides an understanding of the structures, approaches and models of OR in problem solving and decision-making.

Keywords—Best candidates' method, decision making, decision support system, operations research.

I. INTRODUCTION

THE process of decision-making in the various administrative processes is the main objective, which aims to make optimal appropriate decisions for the development of the enterprise and solve any problems we may encounter. OR considered one of the most important applied sciences that used to solve complex problems and manage different systems in various fields. OR encompasses a wide range of problem-solving techniques and methods applied in the pursuit of improved decision-making and efficiency, such as simulation, mathematical optimization, queuing theory, Markov decision processes, economic methods, data analysis, statistics, neural networks, expert systems, and decision analysis. Nearly all of these techniques involve the construction of mathematical models that attempt to describe the system [1].

Because of the computational and statistical nature of most of these fields, OR also has strong ties to computer science. The importance of OR leads many universities in the world not only to teaches OR subject, but also introduce a department of operations research at their faculties of science and information technology. OR grew aware during World War II when the British military administration was entrusted to a team of scientists and researchers study important strategic and tactical problems for the defense of land and air. After encouraging results reached by the British teams, it motivated the United States military management to start similar activities. Following the war, the success of the military teams attracted the attention of industrial managers

who were seeking solutions to their problems. This has resulted in complex decision problems that ultimately have forced business organizations to seek the utilization of the effective tools of operations research. The impressive progress in the field of operations research is due in large part to the parallel development of the modern digital computer with its tremendous capabilities in computational speed and information storage and retrieval. Fig. 1 represents the components of computer information system that support decision making.



Fig. 1 Components of decision-making information system

Today, OR activities can be felt in many areas that gone beyond military and business applications to include hospitals, financial institutions, libraries, city planning, transportation systems, and even crime investigation [2].

II. OR STRUCTURE AND APPROACH TO PROBLEM SOLVING

The OR science structure based on the following steps:

- 1) The formation of a team of scientists having rehabilitation science and varied experiences rather than relying on one individual.
- 2) Uses the scientific method as the basis and methodology of research and study.
- 3) Supports building mathematical models for being clearer and more accurate and comprehensive, and help build a dynamic regularity easy to deal with any emerging variables in an integrated, fast and accurate and effective.
- 4) Target identification to assist management in optimal decision-making.

The scientific method to problem solving shown in Fig. 2, state a generally recognized ordered steps.

Operations research analysts, use advanced mathematical and analytical methods represented in Fig. 3, to help organizations investigate complex issues, identify and solve problems, and make better decisions [3].

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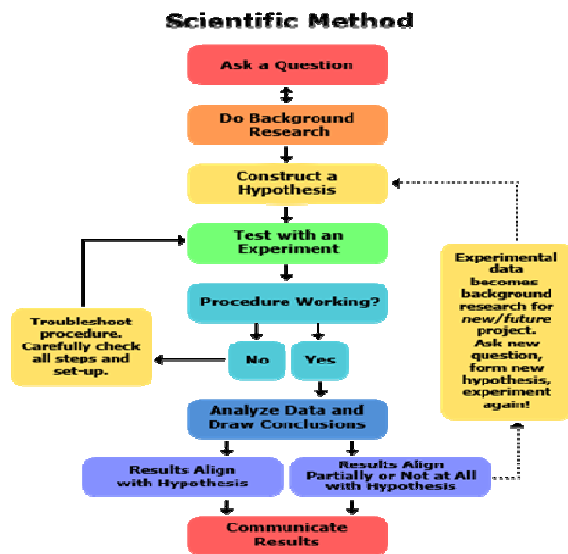


Fig. 2 Scientific method to problem solving

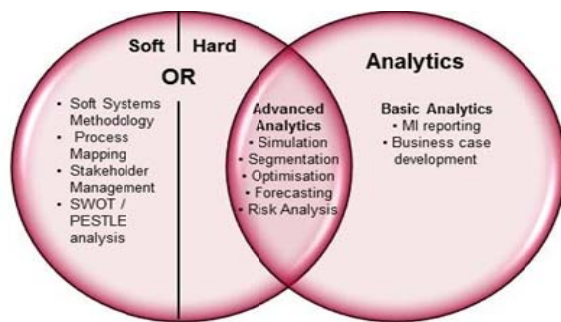


Fig. 3 Analytical approach in operations research

There are many different operations research approaches to problem solving. Here we introduce the process through three main phases' formulation, modeling, and implementation.

A. Formulation Phase

The formulation phase has the following steps:

1. Problem Definition

The operations research analysts explore available resources, determine goals, establish system inputs, and develop a statement of the problem.

2. Value System Design

The operations research analysts substitute the problem into sub problems and determine the objectives and criteria for each sub problem then organize objectives into a hierarchy or tree showing the relative importance of the objectives and the relationships between them.

3. Synthesis of Alternatives

As known for any problem solving there are many different alternatives are developed to reach the need objectives. The analysts determine and organize the alternatives using available Techniques such as (brainstorming, brain writing,

and dynamic confrontation), computer simulation, and others.

B. Modeling Phase

The main two steps in this phase are:

1. Systems Modeling and Analysis

In this step we must formulate the main model to analyze and to compare the various alternatives. There are many techniques that can be used in this step such as data analysis, probability theory, econometric modeling, regression, forecasting, mathematical programming (linear, nonlinear, integer, goal), queueing, networks, reliability analysis, and simulation.

2. Optimization of Alternatives

Here the analysts optimizes controllable parameters in each alternative system which is the effect measured through parametric sensitivity analysis.

C. Implementation Phase

The implementation phase has:

1. Decision Making

The analysts evaluate the alternatives to determine the optimal one and organize other selected alternatives.

2. Planning for Action

In this step the analyst must take all necessary procedures including actions to implement the results.

III. OPERATIONS RESEARCH MODELS

OR model is a collection of logical and mathematical relationships that represents aspects of the problem under study. Models describe important relationships between variables, constraints and objective functions, and also with other alternative solutions that are evaluated [4]. In the following, a description of various types of models used by operations research analysts:

A. Linear Programming

Linear programming (LP) is mathematical program define as a method or technique for the optimization of a linear objective function to achieve the optimal outcome (maximum profit or lowest cost), subject to linear equality and linear inequality constraints [5]. Moreover, many practical problems in OR can be expressed as linear programming problems such as linear assignment problems, transportation problems, network flow problems, and others. A number of algorithms used for solving LP problems which are based on different of special linear programming methods (such as best candidates' method, Minimum cost method, Genetic algorithm, Vogel's approximation method, and others) [6], [7].

B. Network Flow Programming

The network flow program is a type of LP model that describing the objective function and constraints. Whereby, the network flow programs used for Representation different Linear Programming Model of problems such as the transportation problem, the assignment problem, the shortest

path problem, the maximum flow problem, and the generalized minimum cost flow problem. It is an important type of models 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 [8].

C. Integer Programming

Integer programming problem is a mathematical optimization program where some or all of the variables are required to be integers. This type of models is very useful in cases that cannot be modeled by linear programming and easily handled by integer programming [9]. 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.

However, integer programming models of practical size still very difficult or impossible to solve, and the growing power of computers makes this an active area of interest in Operations Research.

D. Nonlinear Programming

Nonlinear programming (NP) is the mathematical problem to achieve minimizing or maximizing a nonlinear objective function subject to linear constraints, or nonlinear constraints, where the constraints can be inequalities or equalities. Moreover, the class of cases 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. Whereby, a nonlinear programming model is much more difficult to solve than a similarly sized linear programming model.

E. Dynamic Programming

Dynamic programming (DP) in general define as a method for solving complex problems by breaking them down into simpler sub problems, then combine the solutions of the sub problems to reach an overall solution. Moreover, DP model can be used to achieve the optimal solution and organize all alternative solutions. DP algorithms are used for optimization (for example, finding the shortest path between two points, or the fastest way to multiply many matrices).

F. Stochastic Programming

Stochastic programs are mathematical programs where some of the data that available for the objective or constraints is uncertain. Uncertainty is usually characterized by a probability distribution on the parameters. Although the uncertainty is rigorously defined, in practice it can range in detail from a few scenarios (possible outcomes of the data) to specific and precise joint probability distributions. Stochastic programming explicitly recognizes uncertainty by using random variables for some aspects of the problem. With

probability distributions assigned to the random variables, an expression can be written for the expected value of the objective to be optimized. Then a variety of computational methods can be used to maximize or minimize the expected value. Whereby, the mathematical programming models, such as linear programming, network flow programming and integer programming generally neglect the effects of uncertainty and assume that the results of decisions are predictable and deterministic.

G. Combinatorial Optimization

This model is a mathematical optimization program that finding an optimal object from a finite set of objects. This model has important applications in several fields, including artificial intelligence, software engineering, machine learning mathematics and others. Some common problems involving combinatorial optimization are the traveling salesman problem and minimum spanning tree problems.

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.

H. Stochastic Processes

This type of models used in cases when the values 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 others.

I. Discrete Time Markov Chains

It used for a system with 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). Continuous time Markov chains: It used for a system when time is a continuous parameter. Here we consider a continuous time stochastic process in which the duration of all state changing activities is exponentially distributed. The process satisfies the Markovian property and is called a Continuous Time Markov Chain (CTMC).

J. Simulation

Simulation is a very general technique for estimating statistical measures of complex systems. When a situation is affected by random variables it is often difficult to obtain closed form equations that can be used for evaluation. 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.

As result from the mentioned above, Table I summarized the various techniques of Operations Research that used in business organizations. Moreover, the following points describe the advantages of using problem solving models:

- A problem solving model provides organized logical and systematic approach to the problem under study.
- It gives the analyst a base and availability to understand the problem and choosing the suitable methods of solving.
- It avoids unneeded and duplication work in solving the problem.
- It determines the constraints and scope of each activity.
- Models help the analysts to develop new methods of solving the problem.
- Models help analysts to substitute complex problem to be simpler.
- Models save used resources and time.
- Models reduce risk during experimental analysis.
- Models help analysts to achieve optimal solution and to organize all alternative solutions.
- Models help analysts to make meaningful simple description of the operation of the system they represent.

TABLE I
OPERATIONS RESEARCH TECHNIQUES

Categories	Techniques
❖ Linear Mathematical Programming Techniques	<ul style="list-style-type: none"> ▪ Linear Programming ▪ Transportation ▪ Assignment ▪ Integer Programming ▪ Goal Programming
❖ Probabilistic Techniques	<ul style="list-style-type: none"> ▪ Decision Analysis ▪ Game Theory ▪ Markov Analysis ▪ Queuing ▪ Simulation ▪ Forecasting
❖ Inventory Techniques	<ul style="list-style-type: none"> ▪ Inventory Models
❖ Network Techniques	<ul style="list-style-type: none"> ▪ Network Models (CPM/PERT)
❖ Non-linear Programming	<ul style="list-style-type: none"> ▪ Dynamic Programming ▪ Non-Linear Programming

IV. CONCLUSION

This study clearly shows the importance of operations research science and its essential implementation. The success of the evolution of OR relies on the formation of a scientist's team with different knowledge and experiences. Academic institutions are more fortunate in this area because of the large number of scientists with experience and different disciplines. Hence, a recommendation out of this work is to establish an operations research department under the faculty of scientific research. One duty for such department is developing a comprehensive computer information system for the university to achieve optimal decision-making. In addition, it follows up and updates the system dynamically with any changes or updates.

The foundation of such department can achieve optimal

management for the university and offer a great service to the community through the application of such computer systems in the management of small and large national institutions. Such computer system can be the initial seed for the basis of the construction of the following three consecutive computer systems:

- 1) Quality assurance
- 2) Monitoring
- 3) Simulation.

ACKNOWLEDGMENT

The author would like to thank Al Zaytoonah University of Jordan for supporting this study.

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