Management Decision Making

A Network Simulation Approach

A. Alan B. Pritsker
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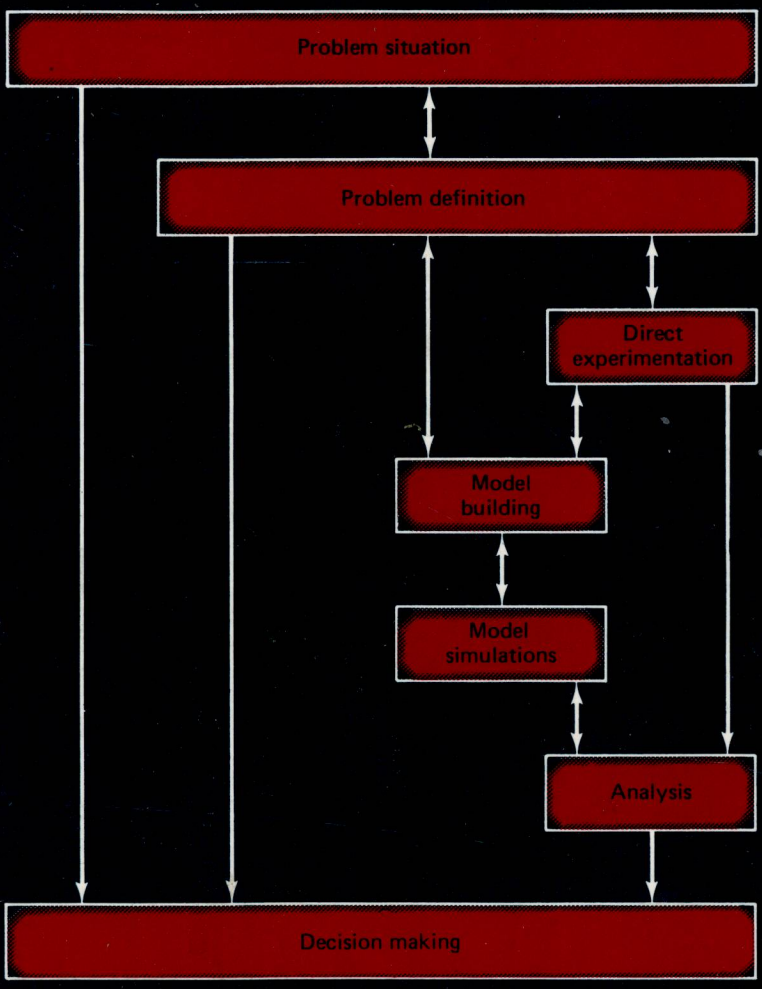

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DEDICATED TO:

Charles D. Hoyt, Jr., and Richard L. Smith,
friends and colleagues
who have helped to educate me (AABP)

My loving wife Ruth (CES)

Preface

Computer simulation has long been practiced by management scientists as a relatively inexpensive way to experiment with systems. Now, corporate and operations managers have found repeated successes for modeling and simulation in resolving manufacturing problems [199]. This book presents these findings and concentrates on the presentation of network models and their use.

Network simulation has truly come of age. Since the development of PERT and CPM in the mid-1950s, managers have benefited from using network diagrams as aids in decision making. Throughout the 1960s and 1970s, advanced simulation techniques permitted the refinement of computer approaches to decision analysis. Several network simulation packages were developed and applied to a wide variety of problems in management and engineering. Solutions too complex for analysis were obtained in unprecedented time frames. With this rapid development of technique, however, there coexisted a need for a single reference documenting the use of network modeling and simulation in the decision-making process. This book provides such documentation.

In order to focus clearly on the use of network simulation, we have used one particular network language throughout the text. The choice of the Q-GERT network language is based on its advanced capabilities, its ready availability, and its proven success in application.

A fundamental premise of this book is that networks can effectively be used in management decision making. Viewed in this perspec-

tive, the book presents a novel approach to management decision making. This approach involves obtaining an understanding of the problems and concerns related to the decision to be made. This includes a definition of the environment of the decision, a specification of the measures by which a good decision will be judged, and the building of a model that forecasts the measures of performance for each decision alternative.

A supplementary purpose of the book is to demonstrate that a single modeling vehicle can be used to portray a large class of problem situations that are of concern to management. Problem situations from the following areas are addressed: project planning, production scheduling, risk analysis, logistics analysis, and inventory planning. It is shown that Q-GERT networks are useful for describing, understanding, and communicating these problems at different levels of management. By providing a common modeling framework, decision makers can obtain a greater understanding of the modeling process and of models. Throughout the book, examples emphasize how the network simulation approach focuses on performance measures, key decision elements, and the use of computer simulation results to solve problems.

The modeling philosophy of Q-GERT leads to a systems approach to problem resolution that consists of four steps. First, a system is decomposed into its significant elements. Second, the elements are analyzed and described. Third, the elements are integrated in a network model of the system. Fourth, system performance is assessed through the simulation of the network model. The evaluation of the network model is accomplished through the use of a computer program called the Q-GERT Analysis Program or Q-GERT processor. The Q-GERT Analysis Program employs simulation procedures to obtain statistical estimates of the performance measures required for decision making. The Q-GERT Analysis Program is written in ANSI FORTRAN IV. It has been compiled and run on a wide class of computers and its portability has been demonstrated. The program is available from Pritsker & Associates, Inc., P.O. Box 2413, West Lafayette, Indiana 47906.

This book has been written to be self-contained, and only minimal prerequisites are required of the reader. The material in the book is primarily at the junior–senior college level. It can be used to introduce the concepts of decision making, modeling, and simulation. Alternatively, the material in the book can be used at the graduate level to integrate and explain problem solving, industrial engineering, management science, and operations research techniques.

The book is organized into six parts. Part I introduces management decision making and the role that can be played by network modeling in the decision-making process. Part II contains a summary of the Q-GERT network language. The four chapters included in Part II

contain information on network symbols, support routines, input procedures, and output reports. Procedures for storing the outputs in a data base for future use are detailed in Chapter 5.

Part III deals with decision making and model building related to production planning. The first chapter in Part III, Chapter 6, presents the basic concepts of production planning, including performance measures and their use, and basic procedures for modeling production systems to obtain the planning performance measures. Chapter 7 describes how network models can be developed to evaluate scheduling and sequencing procedures. Models for evaluating material handling systems are described in Chapter 8. Material handling systems considered are conveyors, pipelines, and overhead cranes. Special topics related to production planning are detailed in Chapter 9. These include labor-limited queueing situations, maintenance and inspection processes, and order routing. Five applications of Q-GERT network models that have been used for decision making within a production planning context are presented in Chapter 10.

Part IV is concerned with logistics and inventory control. The terminology and modeling requirements associated with logistics systems analysis are presented in Chapter 11. This chapter presents modeling concepts for integrating reliability, maintainability, supply, transportation, personnel and training, and support equipment and facilities into a single system study. An example of decision making for a logistics system at an Air Force depot is presented. Chapter 12 defines reliability and quality control concepts in terms of Q-GERT network models. The chapter makes explicit the concepts involved in these areas and can be used for explaining such concepts to management. Chapters 13 and 14 address the central questions of inventory control: when to place orders and how much to order. Q-GERT models for periodic review and transaction reporting (continuous review) inventory control procedures are developed. The modeling of back orders and lost sales is also included. Diverse methods for characterizing the demand for units in inventory are presented, and a consideration of how to model multi-commodity inventory systems is considered.

Part V provides a detailed presentation of risk analysis and project planning. In Chapter 15, the concepts and procedures associated with decision trees, decision networks, risk assessment, and shortest-route problems are presented. Q-GERT network models for these areas are described, and the procedures for using such network models in management decision making are explored.

Chapters 16 through 19 are devoted to project planning with the basic concepts, terminology, and performance measures contained in Chapter 16. Procedures are provided for estimating project completion-time distributions, activity start times, activity criticality indices, and

project cost for network models of the PERT/CPM variety. Chapter 17 combines the concepts of risk and decision making into project planning, and it illustrates how Q-GERT network models can be employed for decision making in a project planning context when increased uncertainty due risk and failure are included. Chapter 18 presents information on the scheduling of activities in a project planning context. Procedures for making the scheduling computations, including estimates of activity slack, are given. In addition, analyses of project plans under the condition of limited resources are made. Applications of Q-GERT network modeling for decision making in project planning are presented in Chapter 19.

Part VI is concerned with network graphics. Procedures for using advanced graphic capabilities for building models, portraying the operation of systems, and for displaying performance measures are described. The potential impact of computer graphics on management decision making is portrayed. The combined use of computer graphics and network modeling will provide the foundation for new organizational and behavioral procedures for management decision making.

The material in this book covers a wide spectrum of applications, network models, and statistical developments. We have drawn on the research and contributions of many people. Several of the applications and analysis projects of Larry Moore, Ed Clayton, and Chuck Taylor have been used directly. Gary Whitehouse reviewed the manuscript, and we have used material from his book on decision and risk analysis. The material on nuclear fusion forecasts is taken from the work of John Vanston. Charlie Standridge, Ken Musselman, and Steve Duket provided detailed comments on the manuscript that significantly improved its readability. The material that describes the use of simulation data languages in conjunction with network languages is based on research by Charlie Standridge.

Chapter 11 is based on the work of Lt. Col. Robert Mortenson and Capt. Victor Auterio. The material included in Chapter 20 on statistical analysis of probability distributions and the study of McClellan Air Force Base is derived from the work of Ken Musselman, Bob Hannan, Bill Penick, and Bob Mortenson. Obtaining graphical outputs from network simulation languages was developed based on the work of Steve Duket and Jerry Sabuda. The material on Q-GRAF for interactively building Q-GERT models and for displaying output traces is based on the developments of Jerry Sabuda.

Insights into production and scheduling applications have been obtained through discussions with Jim Wilson, Randy Sadowski, Richard L. Smith, and Bill Stewart. Throughout the years, we have received support from many individuals interested in the development of a network language for describing management decisions. Our discussions with Ed Clayton, Steve Duket, Salah Elmaghraby, Hank Grant, Larry Moore,

Charlie Standridge, Gary Whitehouse, Jim Wilson, Phil Wolfe, and Dave Wortman have been significant. We gratefully acknowledge the contributions of all the individuals named above and thank them for their contributions, assistance, and encouragement.

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