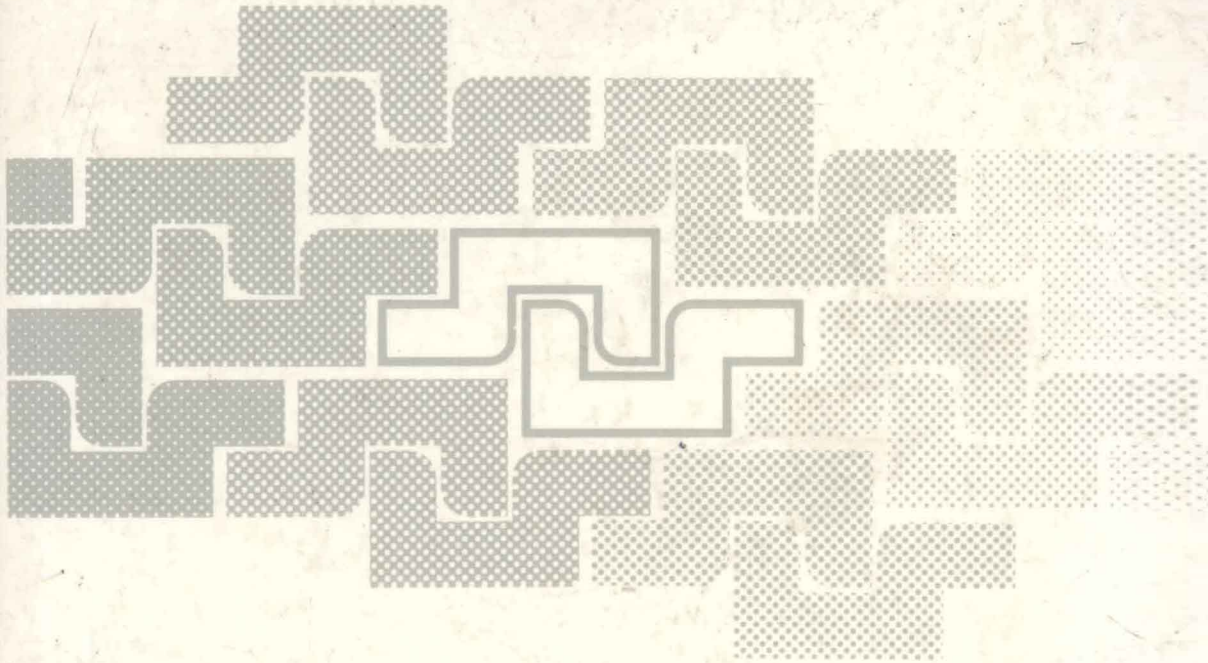

Decision Support Systems: Theory and Application

Edited by
Clyde W. Holsapple Andrew B. Whinston

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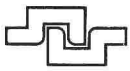

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PREFACE

This volume contains revised versions of papers presented at the N.A.T.O. Advanced Study Institute on Decision Support Systems Theory and Applications. This meeting took place in Maratea, Italy for a two week period in June 1985. The lecturers represented an international assortment of distinguished research centers in industry, government, and academia. Participants in the Institute represented eleven N.A.T.O. countries. Both participants and lecturers shared in the common goal of learning about emerging theoretical and applied developments in the decision support system (DSS) field.

Researchers and practitioners interested in current DSS issues and the shape of future decision support systems are the intended audience for this book. There is a particular, recurring emphasis on the adaptation of artificial intelligence techniques for use in the DSS world. The book's chapters are organized into two major sections, the first dealing with theoretical topics and the second with applications.

Although much progress has been made in understanding the foundations of decision support systems, there is clearly room for enlarging on basic concepts, frameworks, theories, and techniques. The seven papers contained in Section I are directed along these lines. In the initial chapter, Henk Sol identifies several paradoxes that can be observed in the DSS field. He argues that these are indicative of the need for a clearer delineation of the concept of DSS and, to this end, he introduces a framework for DSS-design environments. Chapter 2 descends from this global perspective to focus on the topic of model management. Here, Robert Blanning discusses the principal features of a relational theory of model management. In this view, a DSS's models are managed as a set of virtual relations. Expanding on this perspective, he suggests that relational data base management ideas can similarly be adapted to managing other kinds of knowledge in the context of a DSS. Dimitris Karagiannis and Hans-Jochen Schneider point out some limitations of relying on traditional relational data base management to handle a DSS's

descriptive knowledge. To help overcome these, they discuss an extension that allows rules to be used in conjunction with relational tables. Under this approach, a DSS can answer user requests by a combination of deduction on the rules and retrieval from the tables.

In Chapter 4, Amilcar and Cristina Sernadas point out the need for accommodating logical, structural, and procedural kinds of knowledge representation in decision support systems. As a possible basis for DSS development, they propose a framework for unified treatment of these three modes by means of parameterized theories. Michel Klein, Jean-Eloi Dussartre, and Francois Despoux discuss DSS development with the OPTRANS tool in Chapter 5. In particular, they explore extensions to the OPTRANS problem processor that allow it to make inferences using sets of rules in addition to its data management and model management capabilities.

The final two chapters in Section I are concerned with the evaluation of DSS development tools. In the first of these, Nasir Ghiaseddin identifies nine areas that a developer should consider when assessing DSS development tools. He derives these developer needs from an analysis of end user needs. Chapter 7 takes a narrower perspective by concentrating on tool characteristics that should be considered for the construction of artificially intelligent decision support systems. It focuses on the integration, representation, and processing of reasoning knowledge within decision support systems.

Section II contains ten papers presenting an interesting assortment of DSS applications. The application areas range from office automation and accounting to the support of strategic planning. In Chapters 8, G. Bracchi and B. Pernici argue that decision support systems can facilitate a variety of office activities. In discussing these activities, they survey the behaviors of relevant decision support systems and suggest several related research topics.

Chapters 9 through 11 examine DSS applications in the area of accounting. In the first of these, Eric Denna and William

McCarthy describe the implementation of an events accounting system that supports a variety of decisions in a manufacturing environment. The knowledge system for this DSS involves the integrated use of relational data bases, spreadsheets, procedural models and graphic images. The DSS development tool used for this system is the KnowledgeMan environment. In Chapter 10, Andrew Bailey et al. examine the applicability of decision support systems to financial auditing and describe an ongoing research project into DSS usage for evaluating internal accounting controls. Particular attention is given to the contributions expert system and other artificial intelligence techniques can make to these DSS applications. A general DSS environment intended specifically for auditors is proposed by James Gerlach in Chapter 11. It is conceived to provide not only a strong basis for general auditing support, but also to allow customization to reflect unique traits of an audit staff and audit engagements.

In Chapter 12, Leif Methlie examines the applicability of expert system techniques to building DSSs in the realm of financial management. In this vein he describes an experimental expert system for supporting bank loan evaluations. Three more DSS applications are reviewed by James Gantt and Donovan Young in Chapter 13. The three DSSs are designed to assist planners in the allocation of resources for purposes of project management, location allocation, and mobilization planning. Chapter 14 describes a large-scale energy management DSS that operates on a microcomputer. Norman Revell explains how this data-intensive system has been developed to support both operational and strategic decisions of an energy manager.

Chapter 15 explores the use of expert system techniques for supporting decisions about microeconomic systems. Elizabeth Hoffman et al. argue that rule and information flow structures of microeconomic systems are amenable to expert system modelling. This is illustrated with the example of an auction bidding mechanism and participating economic agents. They further propose an approach for testing resultant systems from a qualitative as well as quantitative perspective.

Section II closes with two papers concerning DSS applications in the area of strategic planning. In the first of these, Vicente Salas Fumás discusses the nature of strategic planning and points out the implications for building DSSs that address strategic planning problems. He emphasizes the issues of real-time strategic decision making and the use of competitive gaming models within the systems' modelling capabilities. In Chapter 17, Peter Mertens identifies various ways in which today's information technology can be used to enhance an organization's strategic position. He proceeds to explain how these techniques may improve strategic decision making.

In closing it is appropriate to acknowledge the support of the lecturers and participants in ensuring stimulating intellectual interchange as well as creating a friendly ambiance. Mr. Guzzardi and his staff of the Hotel Villa del Mare greatly enhanced this atmosphere. We would also like to express our appreciation of the N.A.T.O. Scientific Affairs Division, which was invaluable in providing financial support for many participants. We are particularly grateful to Dr. Craig Sinclair, Director, ASI Programme. Professors G. Bracchi, N. Revell and H. Schneider, members of the organizing committee, provided useful suggestions and contacts. Furthermore, the administrative and financial assistance provided by Professors Sergio de Julio and Manlio Gaudioso of CRAI (Consorzio per la Ricerca e le Applicazioni di Informatica) was very helpful during the meeting. Mrs. Barbara Kester of International Transfer of Science and Technology was helpful in the selection of Maratea as the site of the meeting. Finally, we are deeply indebted to Kathy Smith whose patient and diligent efforts in producing and editing this book's manuscript have significantly enhanced its value to all concerned.

Clyde W. Holsapple
Andrew B. Whinston

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SECTION I - CONCEPTS AND THEORY

1. PARADOXES AROUND DSS

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1. INTRODUCTION

Numerous researchers and practitioners have no hesitations in putting the label Decision Support Systems (DSS) to their work. It is remarkable that the term DSS is much used without a very strict definition of its content. Many writers seem to approach DSS as a philosophy to seek a useful complementarity between technological tools and human judgement and discretion. Klein and Hirschheim [1985] point out that 'there appears to be an implicit assumption on the part of DSS writers that DSS are beneficial to organizations and the DSS intervention process is not inherently polemic'. Gintzberg and Stohr [1982] remark that 'the basis for defining DSS has been migrating from an explicit statement of what a DSS does to some ideas about how the DSS objective can be accomplished (i.e., what components are required?, what usage pattern is appropriate?, what development process is necessary?)'. This migration during the years can be shown in the following descriptions of DSS:

1. In the early 1970's DSS was described as 'a computer-based system to aid in decision making'. The starting point was found in the application of interactive technology to managerial tasks in order to use computers for better decision making. There was a strong cognitive focus in this DSS-concept, viz. that of a single decision maker.
2. In the mid to late 1970's the DSS-movement emphasized 'interactive computer-based systems which help decision makers utilize data bases and models to solve ill-structured problems'. The emphasis lies not so much on the decision process, but rather on the support for personal computing with tools for fast applications development and packages for financial planning.
3. In the later 1970's to early 1980's the DSS bandwagon

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provides systems 'using suitable and available technology to improve effectiveness of managerial and professional activities'. User-friendly software is produced almost unexceptionally under the label DSS. Disciplines like operations research and psychology are jumping on the bandwagon. Concepts like information center and prototyping are put forward in the same utterance as DSS.

4. By now we face a new technical base for DSS: the convergence on intelligent workstations. Telecommunication technology puts forward the issues of organizational versus personal computing and distributed DSS. We see new technologies emerging as expert systems and document-based systems. This is expressed by Elam et al. [1985] in the need for a new vision on DSS. They propose to confine the notion DSS to 'the exploitation of intellectual and computer-related technologies to improve creativity in decisions that really matter'.

We do not want to enter a new debate on definitions of DSS. Rather, we like to explore what new insights we gained from applying the DSS concept to improve organizational efficiency and effectiveness. In general, for a comparison of research contributions dealing with organizational decision making, one might wonder

- what problems are addressed,
- what paradigm or 'Weltanschauung' governs the process of problem conceptualization and problem specification,
- what construct-paradigm or model cycle is followed, expressing in broad terms the order of activities,
- what methodology, as an actual sequence of activities in view of a problem situation, is used, telling what to do in which activity, what project control is performed, during the activities,
- what theory is followed, contributing to the actualization of the model cycle and the methodology in terms of how the activity is to be performed, and especially, how alternative solutions are to be generated.

2. PARADOXAL OBSERVATIONS ON DSS

A useful framework for research on DSS is introduced in Sprague [1980]. He discusses the perspective of the end-user, the builder and the toolsmith from which a DSS can be viewed. In accordance with this distinction the concept of a DSS-generator is put forward to bridge the gap between general tools and specific DSS. Sprague distinguishes as the main components of a DSS a data base, a model base, and an intermediate software system which interfaces the DSS with the user.

Within the data base for decision support one can distinguish between external data from public data sources, administrative data produced by the transaction processing system, and internal data created by personal computing. The models in the model base as envisaged by Sprague are mostly of the 'equation' type: great number of so called corporate models or financial models consists of definition equations and behavioral equations. Econometric models also consist of equation models. Another category is formed by optimalization models based on linear, dynamic or stochastic programming.

A first generation of so-called DSS-generators focuses on equation models with data base and interactive facilities like data-, model- and text manipulation, cf. Klein and Manteau [1983] and Bergquist and McLean [1983]. By now, the integrated facilities are not only offered on mainframes, but also on microcomputers together with facilities for 'down-loading from and up-loading to central computer systems through data-communication'.

A less technological framework is put forward by Bonczek et al. [1981]. They replace the components mentioned by the concepts of a language system, a knowledge system and a problem processing system. The language system is the sum of all linguistic facilities made available to the decision maker by a DSS. A knowledge system is a DSS's body of knowledge about a problem domain. The problem processing system is the mediating mechanism between expressions of knowledge in the knowledge system and expressions of problems in the language system.

The framework put forward by Bonczek et al. makes it easy to relate the work in the field of artificial intelligence to DSS. We define an expert system as 'a computer system containing organized knowledge, both factual and heuristic, that contains some specific area of human expertise, and that is able to produce inferences for the user', see Chang, Melamud and Seabrook [1983].

When one looks upon an inference system as a special kind of problem processing system and upon the knowledge base as a special kind of knowledge system, then these expert systems fit neatly into the framework. Along this line, a school of researchers focuses on the representation of knowledge for decision support, cf. Fox [1984], Bonczek et al. [1983]. The relevance of epistemology to improve decision-making processes is addressed by e.g., Lee [1983], Stamper [1984].

The process of designing DSS is as yet not much addressed. Sprague and Carlson [1982] advocate an approach 'to systems analysis which is intended to identify requirements in each of the three major capability areas of DSS. The approach is based on a set of four user-oriented entities: Representations, Operations, Memory Aids and Control Mechanisms'. Humphreys et al. [1983] report empirical research on rounds and stages in the development paths and the roles played by various participants, as analyzed in several projects. Empirical research as presented e.g., in Fick and Sprague [1980], Ginzberg et al. [1982], Bennett [1983], Sol [1983], shows the variety of approaches undertaken by various researchers and practitioners to create systems for effective decision support.

It may be dangerous to draw conclusions from the available expertise on DSS. However, following the framework for evaluation outlined above it is possible to present some conclusions in the form of several paradoxes.

1. The paradox of understanding and designing.
   DSS are directed at ill-structured problem situations. It is striking, however, how little attention is paid to the process of problem solving. There are various frames to