What is Decision Support?

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ABSTRACT

This paper attempts to describe and clarify the meaning of the term Decision Support (DS). Based on a survey of DS-related WWW documents, and taking a broad view of DS, a classification of DS and related disciplines is presented. DS is put in the context of Decision Making, and some most important disciplines of DS are overviewed: Operations Research, Decision Analysis, Decision Support Systems, Data Warehousing and OLAP, and Group Decision Support.

1 INTRODUCTION

The term *Decision Support* (DS) is used often and in a variety of contexts related to decision making. Recently, for example, it is often mentioned in connection with Data Warehouses and On-Line Analytical Processing (OLAP) [1]. Another recent trend is to associate DS with Data Mining. This is the case in the project SolEuNet [2], which attempts to exploit these two approaches in a complementary way in order to support difficult real-life problem solving.

Unfortunately, although the term "Decision Support" seems rather intuitive and simple, it is in fact very loosely defined. It means different things to different people and in different contexts. Also, its meaning has shifted during the recent history. Nowadays, DS is probably most often associated with Data Warehouses and OLAP. A decade ago, it was coupled with Decision Support Systems (DSS). Still before that, there was a close link with Operations Research (OR) and Decision Analysis (DA). This causes a lot of confusion and misunderstanding, and provokes requests for clarification. The confusion is further exemplified by the multitude of related terms and acronyms that are either equal to, or start with "DS": Decision Support, Decision Sciences, Decision Systems, Decision Support Systems, etc.

This paper attempts to clarify these issues. We take the viewpoint that Decision Support is a broad, generic term that encompasses all aspects related to supporting people in making decisions. First, we present the results of a survey of WWW documents related to DS. On this basis, and on the basis of relevant literature and our previous experience in the field of DS, we provide a classification of DS and related disciplines. DS itself is given a role within Decision Making and Decision Sciences. Some most prominent DS disciplines are briefly overviewed: Operations Research, Decision Analysis, Decision Support Systems, Data Warehousing and OLAP, and Group Decision Support. The paper is concluded by presenting some other possible classifications of DS and discussing some recent trends of future DS development.

2 SURVEY

In April 2001, we conducted an ad-hoc survey of WWW documents related to DS. We used the AltaVista Search Engine [3]. In total, it found 262,377 documents containing the phrase "decision support". To narrow the search and identify documents that attempt to define the meaning of DS, AltaVista was requested to find documents that contained the exact phrase: "what is decision support". In this case, only 26 documents were found, among which about one fourth indeed contained definitions of DS. These were as follows:

1. "Looking at data from different angles to help in making a decision (Slicing and Dicing)" [4]
2. "Identifying all the data required to make a decision, gathering it together organized as meaningful information" [5]
3. "Structured, sometimes mathematically based, approaches to decision making: Kepner-Trego, Influence Diagrams, Analytical Hierarchy, Nominal Group Process, Ventana Group Collaborative Decision Making" [6]
4. "DS means helping you to make good decisions by understanding the effects of all the alternatives. It allows you to answer the question, 'What will happen if...?', for a whole range of scenarios." [7]
5. "Specialized type of data analysis developed to enhance the business decision process." [8]
6. "DS is utilizing computer-based systems that facilitate the use of data, models, and structured decision processes in decision making. Some key words associated with DSS are such as: Decision Theory, Decision Analysis, Operations Research, Management Science, and Artificial Intelligence. Or maybe this will help: Neural Networks, SAS Programming, and Expert Systems." [9]

Although far from exhaustive, these results clearly indicate that the term DS is used widely and in a number of contexts, but it is understood very differently; there is no commonly agreed definition. The actual definitions tend to be very narrow, taking into account only specific aspects of DS. The above definitions 1, 2, and (partially) 5, emphasize a data-centered approach, which is typical for Data Warehousing and Data Mining [10]. The definitions 3 and 4, on the other hand, are more focused to Modeling and Simulation, respectively. The last definition, although limited to computer-based DS Systems, is the broadest and mentions a multitude of related disciplines and techniques This is close to the viewpoint that we will take hereafter and consider DS broadly in the context of human decision-making.

3 SO, WHAT IS DECISION SUPPORT?

3.1 Decision Making

Inevitably, DS is a part of decision making processes. A *decision* is defined as the choice of one among a number of alternatives, and *Decision Making* refers to the whole *process* of making the choice, which includes:

- assessing the problem,
- collecting and verifying information,
- identifying alternatives,
- anticipating consequences of decisions,
- making the choice using sound and logical judgement based on available information,
- informing others of decision and rationale,
- evaluating decisions.

According to Simon [11], the decision making process consists of three main stages:

1. *Intelligence*: Fact finding, problem and opportunity sensing, analysis, and exploration.
2. *Design*: Formulation of solutions, generation of alternatives, modeling and simulation.
3. *Choice*: Goal maximization, alternative selection, decision making, and implementation.

3.2 Human vs. Machine Decision Making

The term DS contains the word "support", which refers to supporting *people* in making decisions. Thus, DS is concerned with *human* decision making. The definitions of DS rarely mention this characteristic and rather assume it implicitly. However, we have to be aware that there is a variety of artificial systems that also make decisions: switching circuits, computer programs, autonomous expert systems and software agents, robots, space probes, etc. Therefore, we explicitly differentiate between *machine* and *human* decision making and associate DS only with the latter (Figure 1). The two disciplines that closely correspond to this distinction are *Decision Systems*, which (primarily) deals with computer-based programs and technologies intended to make routine decisions, monitor and control processes [12], and *Decision Sciences*, a broad discipline concerned with human decision making.

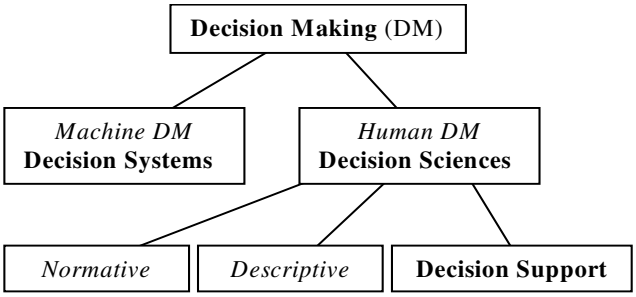

Figure 1: *The role of DS in Decision Making*.

3.3 Decision Sciences

A somewhat long, but very useful definition of *Decision Sciences* appears in [13], which we quote in its entirety, adding emphasis:

> "*Decision Sciences* is an interdisciplinary field that draws on economics, forecasting, statistical decision theory, and cognitive psychology. Broadly speaking, Decision Sciences addresses three fundamental and inter-related questions. *First,* how *should a 'rational' person make decisions*? This question is at the heart of economics, and often serves as a baseline for evaluating human decision making. *Second, how do people really make decisions*? Recent research has explored the ways in which people are 'boundedly rational,' and utilize rules-of-thumb and shortcuts to formulate judgements and to choose among alternatives. Often these shortcuts do well, but equally often they lead to systematic biases and serious errors. *Finally*, given what we know about rational decision making and actual behaviour, *how can we help people*, especially managers, *improve their decision making*? Decision researchers employ a variety of techniques to improve decision making, ranging from sharpening statistical intuition to quantitative decision analysis."

In other words, Decision Science covers three–possibly overlapping–aspects of human decision making (Figure 1):

1. *Normative*, which includes theoretical approaches such as Decision Theory, Multi-Attribute Utility Theory, Game Theory, Theory of Choice, and others;
2. *Descriptive*, which is closely linked with Cognitive Psychology, and Social and Behavioral Sciences; and
3. *Decision Support* itself.

In summary, we have identified DS as a discipline within Decision Sciences, which is concerned with human decision making, especially in terms of "helping people improving their decision making".

4 DECISION SUPPORT DISCIPLINES

The above broad definition of DS encompasses a number of more specialized disciplines; some most important ones are briefly overviewed in this section.

4.1 Operations Research

Operations Research (OR) is concerned with optimal decision making in, and modeling of, deterministic and probabilistic systems that originate from real life [14]. These applications, which occur in government, business,

engineering, economics, and the natural and social sciences, are characterized largely by the need to allocate limited resources. The contribution from OR stems primarily from:

- Structuring the real-life situation into a mathematical model, abstracting the essential elements so that a solution relevant to the decision maker's objectives can be sought. This involves looking at the problem in the context of the entire system.
- Exploring the structure of such solutions and developing systematic procedures for obtaining them.
- Developing a solution, including the mathematical theory, if necessary, that yields an optimal value of the system measure of desirability.

Typical OR techniques include linear and nonlinear programming, network optimization models, combinatorial optimization, multi-objective decision making, and Markov analysis. Also, OR is often associated with *Management Sciences* and *Industrial Engineering*.

4.2 Decision Analysis

Decision Analysis (DA) in popularly known as "Applied Decision Theory". It provides a framework for analyzing decision problems by [15]:

- structuring and breaking them down into more manageable parts;
- explicitly considering the possible alternatives, available information, involved uncertainties, and relevant preferences;
- combining these to arrive at optimal or "sufficiently good" decisions.

The DA process usually proceeds by building models and using them to perform various analyses and simulations, such as "what-if" and sensitivity analysis, and Monte Carlo simulation. Typical modeling techniques include decision trees, influence diagrams, and multi-attribute utility models.

4.3 Decision Support Systems

Decision Support Systems (DSS) are defined as interactive computer-based systems intended to help decision makers utilize data and models in order to identify and solve problems and make decisions [12]. Their major characteristics are:

- DSS incorporate both data and models;
- they are designed to assist managers in semi-structured or unstructured decision-making processes;
- DSS support, rather than replace, managerial judgment;
- they are aimed at improving the effectiveness–rather than efficiency–of decisions.

DSS are further classified into four main categories: *data*, *model*, *process* and *communication oriented*. In addition, there are the so-called *DSS Generators*, which facilitate the development of dedicated DS Systems.

Specifically, the term DSS encompasses many types of information systems that support decision making. These typically include [16]: Executive Information Systems (EIS), Executive Support Systems (ESS), Geografic Information Systems (GIS), OLAP, Software Agents, Knowledge Discovery Systems, Group DSS, and some types of Expert Systems (ES) [17].

4.4 Data Warehousing

Data Warehouse is a repository of multiple heterogeneous data sources, organized under a unified schema in order to facilitate management decision making [10]. Data warehouse technology includes data cleansing, data integration, and OLAP, that is, analysis techniques with functionalities such as summarization, consolidation, and aggregation, as well as the ability to view information from different angles. In warehouses, data is typically represented in the form of decision cubes.

4.5 Group Decision Support

Group Decision Support Systems (GDSS) are interactive computer-based systems that facilitate the solution of unstructured problems by a set of decision-makers working together as a group. They aid groups, especially groups of managers, in analyzing problem situations and in performing group decision making tasks [12]. In addition to data and models of decision, GDSS must take into account the dynamics of the group decision-making process [17].

Software designed to support the work of a group is often referred to as *Groupware*. It provides mechanisms that help users coordinate and keep track of on-going projects, and allow people to work together thru computer-supported communication, collaboration, and coordination. Examples of groupware include Lotus Notes and Microsoft Exchange.

A closely related discipline is also *Computer-Supported Cooperative Work* (CSCW), which studies how people work together using computer technology. Typical applications include email, awareness and notification systems, videoconferencing, chat systems, multi-player games, and mediation systems.

4.6 Other DS Disciplines

In addition to the above major disciplines there is a number of others that can be considered a part of DS in its broadest sense. There are numerous tools and techniques that help people in organizing data and thoughts, starting with "pencil and paper", and including techniques such as brainstorming, Delphi, concept mapping and mind mapping. Another group of interesting DS-related techniques involves data storage, search and retrieval, such as the "query by example" technique (QBE). Especially in relation to DSS and data warehouses, there is a great emphasis on representation and visualization tools, such as report generators and charting tools. Visualization is also very important with data mining and expert modeling. Also, there are new developments that continuously provide new tools and techniques for DS: communication technology, multimedia, mediation systems, data mining, knowledge discovery, knowledge management systems, and many others.

5 OTHER CLASSIFICATIONS OF DS

In addition to the above classification of DS according to its major disciplines, there are other possible classifications. These have been studied in depth particularly in the context of DSS [17]. Some classification criteria are with respect to:

- *Decision type*: structured, semistructured, unstructured.
- *Organizational level*: operational, tactical, strategic.
- *Decision maker(s)*: individual, group, organization.
- *Prevailing DS element*: data, models, knowledge, communication.
- *Method*: reporting, visualization, modeling (qualitative or quantitative), simulation, optimization.

6 TRENDS

Currently, there are several prolific areas which are expected to importantly contribute to DS in the future: data warehousing and OLAP, data mining, qualitative modeling, artificial intelligence, and various communication and networking approaches. Some considerations include:

1. Enhancing data warehouse and OLAP systems with data analysis, visualization and modeling tools and languages [10].
2. Integration of DS and data mining (DM) [2]. The idea is to supplement data mining with DS modeling approaches in cases where there is insufficient data available for developing an appropriate model with DM alone. The two possible ways of combining DS and DM are *parallel*, where a DS model is developed separately based on expert knowledge, and *sequential*, where DS is used to enhance a DM-developed model.
3. Qualitative modeling. In addition to the currently prevailing quantitative modeling, simulation and optimization methods, qualitative methods will become increasingly important for exploring symbolic, qualitative aspects of the decision process: experience, intuition, judgment, and specialist expertise. Ideally, the new approaches would provide a seamless integration of qualitative and quantitative modeling.
4. Introduction of advanced technologies such as Artificial Intelligence, Expert Systems and Machine Learning. to the DSS This will add rule-based features, the use of heuristics and "soft" reasoning, allowing the DSS–especially GDSS–to actually "learn" and become proficient in making decisions that supplement the decision process.

Also, a lot is expected from emerging communication and network-based approaches, particularly in the areas of Distributed DSS, GDSS, GIS, and mediation systems.

7 SUMMARY

Decision Support (DS) is a broad field concerned with supporting people in making decisions. It is a part of Decision Sciences, which it shares with normative and descriptive approaches to decision making.

DS encompasses a number of disciplines, including operations research, decision analysis, decision support systems, data warehousing, and group decision support.
The major future contributions to DS are expected in relation with data warehouses, integration with data mining, developments in qualitative modeling and "soft" computing, and networking.

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References

[1] H.J. Watson: *Decision Support in the Data Warehouse*. Prentice-Hall, 1998.

[2] SolEuNet: *Data Mining and Decision Support for Business Competitiveness: A European Virtual Enterprise*. EU co-founded project IST-1999-11495. http://soleunet.ijs.si/website/html/euproject.html. 2001.

[3] AltaVista®, WWW Search Engine. AltaVista Company, http://www.altavista.digital.com/, 2001.

[4] L. Barry: Using the Data Warehouse for Decision Support. http://www-act.ucsd.edu/dw/forum9806/index.htm. 1998.

[5] J.G. Morrison, R.A. Moore: Design Evaluation and Technology Transition: Moving Ideas from the drawing board to the Fleet. http://www-tadmus.spawar.navy.mil/Slides/JGMC2Conf/index.htm. 1999.

[6] L. Gilfillan: Project Management and Evaluation. http://lga-inc.com/ut/syllabus/Session7and8/index.htm.1997.

[7] SRI On-Line: Maths & Decision Systems Group, Silsoe Research Institute. http://www.sri.bbsrc.ac.uk/scigrps/sg9.htm. 2001.

[8] IMOS, Inc.: Decision Support Primer. http://www.imos.com/whatis.htm. 1997.

[9] A. Srivastava: Model Management. http://www.gsu.edu/~gs01cpl/ModelManagement.htm. 2001.

[10] J. Han, M. Kamber: *Data Mining: Concepts and Techniques*. Morgan Kaufman, 2001.

[11] A.H. Simon: *The New Science of Management Decision*, Prentice-Hall, 1977.

[12] D.J. Power: Decision Support Systems Glossary. http://DSSResources.COM/glossary/, 1999.

[13] INSEAD: Decision Sciences. PhD Program Description. http://www.insead.fr/phd/decisions.htm, 2001.

[14] F.S. Hillier, G.J. Lieberman: *Introduction to Operation Research*. McGraw Hill, 2000.

[15] R.T. Clemen: *Making Hard Decisions: An Introduction to Decision Analysis*. Duxbury Press, 1996.

[16] D.J. Power: What is a DSS? *DSstar* 1(3), http://dssresources.com/papers/whatisadss/index.html. 1997.

[17] E.G. Mallach: *Understanding Decision Support and Expert Systems*. Irwin, 1994.