2 Decision Support Systems and decision-making processes

2.1 Introduction

Decision Support Systems (DSS) deal with semi-structured problems. Such problems arise when managers in organisations are faced with decisions where some but not all aspects of a task or procedure are known. To solve these problems and use the results for decision-making, requires judgement of the manager using the system. Typically such systems include models, data manipulation tools and the ability to handle uncertainty and risk. These systems involve information and decision technology (Forgionne, 2003). Many organisations are turning to DSS to improve decision-making (Turban *et al.*, 2004). This is a result of the conventional information systems (IS) not being sufficient to support an organisation's critical response activities – especially those requiring fast and/or complex decision-making. In general, DSS are a broad category of IS (Power, 2003).

A DSS is defined as "an interactive, flexible, and adaptable computer-based information system, specially developed for supporting the solution of a non-structured management problem for improved decision-making. It utilises data, it provides easy user interface, and it allows for the decision maker's own insights" (Turban, 1995). There is a growing trend to provide managers with IS that can assist them in their most important task – making decisions. All levels of management can benefit from the use of DSS capabilities. The highest level of support is usually for middle and upper management (Sprague and Watson, 1996). The question of how a DSS supports decision-making processes will be described in this chapter. This chapter is organised as follows: The background to decision-making is introduced. The main focus (of this chapter) describes the development of the DSS field. Some future trends for the DSS field are then suggested. Thereafter a conclusion is given.

2.2 Background to decision-making

H.A. Simon is considered a pioneer in the development of human decision-making models (Ahituv and Neumann, 1990). His individual work (Simon, 1960) and his joint research with A. Newell (Newell and Simon, 1972) established the foundation for human decision-making models. His basic model depicts human decision-making as a three-stage process. These stages are:

- **Intelligence**. The identification of a problem (or opportunity) that requires a decision and the collection of information relevant to the decision;
- **Design**. Creating, developing and analysing alternative courses of action; and
- **Choice**. Selecting a course of action from those available.

The decision-making process is generally considered to consist of a set of phases or steps which are carried out in the course of making a decision (Sprague and Watson, 1996). Decision-making can be categorised as:

- Independent;
- Sequential interdependent; or
- Pooled interdependent (Keen and Scott Morton, 1978).

Independent decision-making involves one decision-maker using a DSS to reach a decision without the need or assistance from other managers. This form of DSS use is found occasionally. Sprague and Watson (1996) contend that it is the exception because of the common need for collaboration with other managers. Sequential interdependent decisions involve decision-making at a decision point and are followed by a subsequent decision at another point. In this case the decision at one point serves as input to the decision at another point. A practical example is corporate planning and budgeting where a department formulates a plan which then serves as input to the development of the budget. Sprague and Watson (1996) indicate that DSS are frequently used in support of sequential dependent decision making but not as frequently as pooled interdependent decision-making.

Pooled interdependent decision-making is a joint, collaborative decision-making process whereby all managers work together on the task. A group of product marketing managers getting together to develop a marketing plan is an example of this type of decision. Specialised hardware, software and processes have been developed to support pooled interdependent decision-making but for the purposes of this study, these are not explored.

Problems and Decision-Making Processes

Ackoff (1981) cites three kinds of things that can be done about problems – they can be resolved, solved or dissolved:

- **Resolving**. This is to select a course of action that yields an outcome that is good enough that satisfices (satisfies and suffices);
- **Solving**. This is to select a course of action that is believed to yield the *best possible* outcome that optimises. It aspires to complete objectivity and this approach is used mostly by technologically oriented managers whose organisational objective tends to be *thrival* than mere survival; and
- **Dissolving**. This to change the nature and/or the environment of the entity in which it is embedded so as to remove the problem.

Sauter (1997) indicates that a DSS will not solve all the problems of any given organisation. The author adds, “however, it does *solve* some problems” (italics added by author).

In a structured problem, the procedures for obtaining the best (or worst) solution are known. Whether the problem involves finding an optimal inventory level or deciding on the appropriate marketing campaign, the objectives are clearly defined. Common business objectives are profit maximisation or cost minimisation. Whilst a manager can use the support of clerical, data processing or management science models, management support systems such as DSS and Expert System (ES) can be useful at times. One DSS vendor suggests that facts now supplement intuition as analysts, managers and executives use Oracle DSS® to make more informed and efficient decisions (Oracle Corporation, 1997).

In an unstructured problem, human intuition is often the basis for decision-making. Typical unstructured problems include the planning of a new service to be offered or choosing a set of research and development projects for the next year. The semi-structured problems fall between the structured and the unstructured which involves a combination of both standard solution procedures and individual judgment. Keen and Scott Morton (1978) give the following examples of semi-structured problems: (USA) trading bonds, setting marketing budgets for consumer products and performing capital acquisition analysis. Here a DSS can improve the quality of the information on which the decision is based (and consequently the quality of the decision) by providing not only a single solution but a range of alternatives. These capabilities allow managers to better understand the nature of the problems so that they can make better decisions.

Before defining the specific management support technology of DSS, it will be useful to present a classical framework for decision support. This framework will assist in discussing the relationship among the technologies and the evolution of computerised systems. The framework, see Figure 1, was proposed by Gorry and Scott Morton (1971) who combined the work of Simon (1960) and Anthony (1965).

	Type of Control			
Type of Decision	**Operational Control**	**Managerial Control**	**Strategic Planning**	**Support Needed**
Structured	1 Accounts receivable, order entry	2 Budget analysis, short-term forecasting, personnel reports, make-or-buy analysis	3 Financial management (investment), warehouse location, distribution systems	MIS, Management science models, Transaction processing
Semi-structured	4 Production scheduling, inventory control	5 Credit evaluation, budget preparation, plant layout, project scheduling, reward systems design	6 Building new plant, mergers and acquisitions, new product planning, compensation planning, quality assurance planning	DSS
Unstructured	7 Selecting a cover for a magazine, buying software, approving loans	8 Negotiating, recruiting an executive, buying hardware, lobbying	9 R & D planning, new technology development, social responsibility planning	DSS ES Neural Networks
Support Needed	MIS, Management science	Management science, DSS,	EIS, ES, Neural Networks	

Figure 1: Decision support framework
Technology is used to support the decisions shown in the column at the far right and in the bottom row
(Source: Adapted from Turban *et al.*, 1999: 394)

The details of this framework are:
The left-hand side of the table is based on Simon's notion that decision-making processes fall along a continuum that ranges from highly structured (sometimes referred to as programmed) to highly unstructured (non programmed) decisions. Structured processes refer to routine and repetitive problems for which standard solutions already exist. Unstructured processes are "fuzzy" for which no cut and dried solutions exist. Decisions where some (but not all) of the phases are structured are referred to as **semi-structured** by Gorry and Scott Morton (1971).

The second half of this framework (upper half of Figure 1) is based on Anthony's (1965) taxonomy which defines three broad categories that encompass all managerial activities:

- **Strategic Planning**. The long-range goals and the policies for resource allocation;
- **Management Control**. The acquisition and efficient utilisation of resources in the accomplishment of organisational goals; and
- **Operational Control**. The efficient and effective execution of specific tasks.

Anthony and Simon's taxonomies are combined in a nine-cell decision support framework in Figure 1. The right-hand column and the bottom row indicate the technologies needed to support the various decisions. For example, Gorry and Scott Morton (1971) suggest that for semi-structured and unstructured decisions, conventional management science approaches are insufficient. They proposed the use of a supportive information system, which they labelled a **Decision Support System** (DSS). ES, which were only introduced several years later, are most suitable for tasks requiring expertise.

The more structured and operational control-oriented tasks (cells 1, 2 and 4) are performed by low level managers. The tasks in cells 6, 8 and 9 are the responsibility of top executives. This means that DSS, Executive Information Systems (EIS), neural computing and ES are more often applicable for top executives and professionals tackling specialised, complex problems.

The true test of a DSS is its ability to support the design phase of decision-making as the real core of any DSS is the model base which has been built to analyse a problem or decision. In the design phase, the decision-maker develops a specific and precise model that can be used to systematically examine the discovered problem or opportunity (Forgionne, 2003). The primary value to a decision-maker of a DSS is the ability of the decision-maker and the DSS to explore the models interactively as a means of identifying and evaluating alternative courses of action. This is of tremendous value to the decision maker and represents the DSS's capability to support the design phase (Sprague and Watson, 1996). For the DSS choice phase, the most prevalent support is through "what if" analysis and goal seeking.

In terms of support from DSS, the choice phase of decision-making is the most variable. Traditionally, as DSS were not designed to make a decision but rather to show the impact of a defined scenario, choice has been supported only occasionally by a DSS. A practical example is where a DSS uses models which identify a best choice (*e.g.* linear programming) but generally they are not the rule.

2.3 Development of the DSS Field

According to Sprague and Watson (1996), DSS evolved as a 'field' of study and practice during the 1980s. This section discusses the principles of a theory for SS. During the early development of DSS, several principles evolved. Eventually, these principles became a widely accepted "structural theory" or framework – see Sprague and Carlson (1982). The four most important of these principles are now summarised.

The DDM Paradigm

The technology for DSS must consist of three sets of capabilities in the areas of dialog, data and modelling and what Sprague and Carlson call the DDM paradigm. The researchers make the point that a good DSS should have *balance* among the three capabilities. It should be *easy to use* to allow non-technical decision-makers to interact fully with the system. It should have access to a *wide variety of data* and it should provide *analysis and modelling* in a variety of ways. Sprague and Watson (1996) contend that many early systems adopted the name DSS when they were strong in only one area and weak in the other. Figure 2 shows the relationship between these components in more detail and it should be noted that the models in the model base are linked with the data in the database. Models can draw coefficients, parameters and variables from the database and enter results of the model's computation in the database. These results can then be used by other models later in the decision-making process.

Figure 2 also shows the three components of the dialog function wherein the database management system (DBMS) and the model base management system (MBMS) contain the necessary functions to manage the data base and model base respectively. The dialog generation and management system (DGMS) manages the interface between the user and the rest of the system.

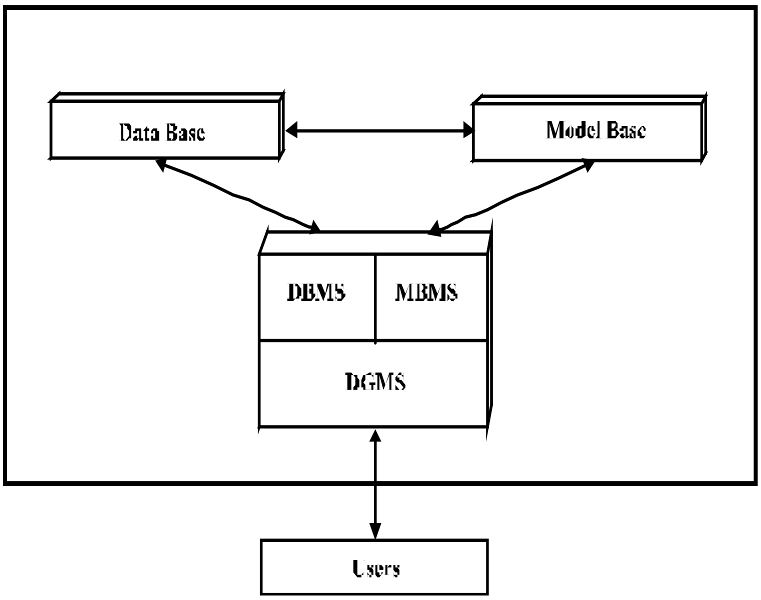

Figure 2: Components of DSS
(Source: Adapted from Sprague and Watson, 1996)

Even though the DDM paradigm eventually evolved into the dominant architecture for DSS, for the purposes of this chapter, none of the technical aspects is explored any further.

Levels of Technology

Three levels of technology are useful in developing DSS and this concept illustrates the usefulness of configuring *DSS tools* into a *DSS generator* which can be used to develop a variety of *specific DSS* quickly and easily to aid decision-makers. See Figure 3. The system which actually accomplishes the work is known as the *specific DSS*, shown as the circles at the top of the diagram. It is the software/hardware that allow a specific decision-maker to deal with a set of related problems. The second level of technology is known as the *DSS generator*. This is a package of related hardware and software which provides a set of capabilities to quickly and easily build a specific DSS. The third level of technology is *DSS tools* which facilitate the development of either a DSS generator or a specific DSS.

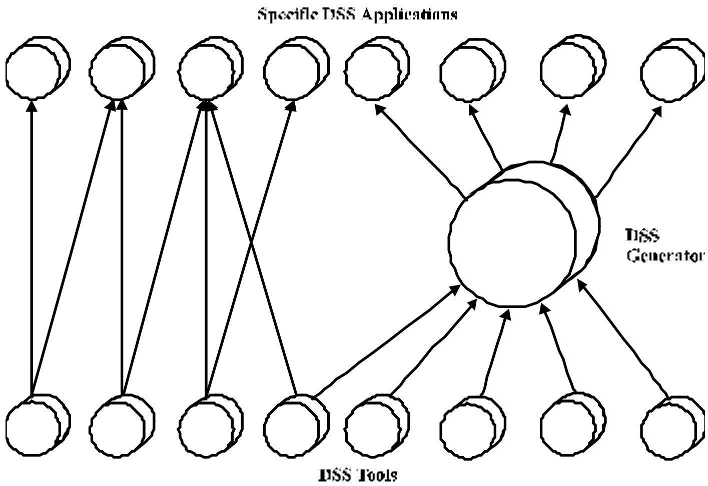

Figure 3: Three Levels of DSS Technology
(Source: Adapted from Sprague and Watson, 1996)

DSS tools can be used to develop a specific DSS application strictly as indicated on the left-hand side of the diagram. This is the same approach used to develop most traditional applications with tools such as general purpose languages, subroutine packages and data access software. The difficulty of the approach for developing DSS is the constant change and flexibility which characterises them. The development and use of DSS generators create a "platform" or staging area from which specific DSS can be constantly developed and modified with the co-operation of the user and with minimal time and effort.

Iterative Design

The nature of DSS requires a different design and development techniques from traditional batch and online systems. Instead of the traditional development process, DSS require a form of iterative development which allows them to evolve and change as the problem or decision situation changes. They need to be built with short, rapid feedback from users thereby ensuring that development is proceeding correctly. In essence they must be developed to permit change quickly and easily.

Organisational Environment

The effective development of DSS requires an organisational strategy to build an environment within which such systems can originate and evolve. The environment includes a group of people with interacting roles, a set of software and hardware technology, a set of data sources and a set of analysis models.

DSS: Past and Present

Van Schaik (1988) refers to the early 1970s as the era of the DSS concept because in this period the concept of DSS was introduced. DSS was a new philosophy of how computers could be used to support managerial decision-making. This philosophy embodied unique and exciting ideas for the design and implementation of such systems. There has been confusion and controversy over the interpretation of the notion decision support system and the origin of this notion is clear:

- **Decision** emphasises the primary focus on decision-making in a problem situation rather than the subordinate activities of simple information retrieval, processing or reporting;
- **Support** clarifies the computer's role in aiding rather than replacing the decision-maker; and
- **System** highlights the integrated nature of the overall approach, suggesting the wider context of machine, user and decision environment.

Sprague and Watson (1996) note that initially there were different conceptualisations about DSS. Some organisations and scholars began to develop and research DSS which became characterised as *interactive* computer based systems which *help* decision-makers utilise *data* and *models* to solve *unstructured* problems. According to Sprague and Watson (1974), the unique contribution of DSS resulted from these key words. They contend that the definition proved restrictive enough that few actual systems completely satisfied it. They believe that some authors have recently extended the definition of DSS to include any system that makes some contribution to decision-making; in this way the term can be applied to all but transaction processing. However, a serious definitional problem arises in that the words have certain 'intuitive validity'; any system that supports a decision (in any way) is a "Decision Support System". As Sprague and Watson (1996) indicate, the term had such an instant intuitive appeal that it quickly became a 'buzz word'. Clearly neither the restrictive nor the broad definition help much as they do not provide guidance for understanding the value, the technical requirements or the approach for developing a DSS.

A further complicating factor is that people from different backgrounds and contexts view a DSS quite differently: a computer scientist and a manager seldom see things in the same way. Turban (1995) supports this stance as DSS is a content-free expression whereby it means different things to different people. He states that there is no universally accepted definition of DSS and that it is even sometimes used to describe any computerised system. It appears that the basis for defining DSS has been developed from the perceptions of what a DSS does (*e.g.* support decision-making in unstructured problems) and from ideas about how the DSS's objectives can be accomplished (*e.g.* the components required and the necessary development processes).

2.4 Future trends

New technology continues to affect the dialog, data and models components. Differences in data, knowledge and model structures may necessitate the development of new technologies for model retrieval tasks (Forgionne, 2003). Relational database technology and object-oriented databases and data warehousing are influencing how data is stored, updated and retrieved. Drawing from artificial intelligence advances, there is the potential for representing and using models in new and different ways.

Decision support technology has also broadened to include monitoring, tracking and communication tools to support the overall process of ill-structured problem solving. DSS implemented on a corporate Intranet provides a means to deploy decision support applications in organisations with geographically distributed sites. Clearly these technologies and other emerging Web-based technologies will continue to expand the component parts of a DSS domain. An area of rapid growth is Web-based DSS. Even though Web-based technologies are the leading edge for building DSS, traditional programming languages or fourth generation languages are still used to build DSS (Power, 2003).

2.5 Conclusion

Moving from the early DSS concept era to almost 35 years later, DSS still comprise a class of IS intended to support the decision-making activities of managers in organisations. The concept has been buffeted by the hyperbole of marketing people and technologies have improved or changed (Power, 2003). While some major conceptual problems may be found with the current terms associated with computerised decision support (and which has been catalysed by marketing hype), the basic underlying concept of supporting decision-makers in their decision-making processes still remains important.

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