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ABSTRACT

This article defines an expanded conceptual framework for classifying and describing Decision Support Systems (DSS) that consists of one primary dimension and three secondary dimensions. The primary dimension is the dominant technology component or driver of decision support. The three secondary dimensions are the targeted users, the specific purpose of the system and the primary deployment or enabling technology.

Five generic DSS types are identified and defined based upon the dominant technology component, including Communications-driven, Data-driven, Document-driven, Knowledge-driven, and Model-driven Decision Support Systems. Specific targeted users like individuals, groups, or customers can use any of the five generic types of DSS. Also, a DSS can be created for a decision- specific or a more general purpose. Finally, in the framework, the DSS deployment and enabling technology may be a mainframe computer, a client/server LAN, a spreadsheet or a web-based technology architecture.

The goal in defining an expanded DSS framework is to help researchers better identify meaningful, homogeneous categories for research and to help Information Systems professionals describe and explain the various types of decision support systems.

Keywords: DSS, decision support, frameworks, decision-making support

I. INTRODUCTION

Decision-makers analyze, evaluate and receive information using many different tools and media, including traditional print reports and charts, group and inter-individual information exchanges, and computer-based information systems. Traditionally, the computer-based systems for supporting decision-makers are called Decision Support Systems (DSS), Management Decision Systems [Scott Morton, 1971], or Management Support Systems.

In the past few years, additional terms like analytical applications, business intelligence systems, data warehouses, document management systems, executive information systems (EIS), management expert systems, group DSS, knowledge management systems, knowledge-based DSS, and On-line Analytical Processing (OLAP) systems have been used to describe specific software and computer-based systems intended to support decision-makers. Many of these newer terms are imprecisely defined and some are subject to extensive marketing hyperbole from software vendors. This proliferation of ambiguous and overlapping terms for computer-based decision support systems that serve similar and related purposes create problems in conducting empirical DSS research and in communicating with decision-makers. One solution is to develop and define an expanded framework for categorizing, classifying and describing decision support systems.

The terms framework, taxonomy, conceptual model and typology are often used interchangeably. Taxonomies classify objects and typologies show how mutually exclusive types of things are related. Frameworks provide an organizing approach and a conceptual model shows how ideas are related. The general desire is to create a set of labels that help people organize and categorize information. Sprague and Watson [1996] argue typologies, frameworks, or conceptual models are "often crucial to the understanding of a new or complex subject." Decision support is not a new subject and a number of DSS taxonomies and frameworks have been discussed in the literature, but the domain of DSS is complex and evolving. Even though some disparage the development of frameworks, a good framework can show the parts of a subject area and how the parts interrelate [Sprague, 1980].

A widely recognized definition, proposed by Sprague [1980], is: "DSS comprise a class of information system that draws on transaction processing systems and interacts with the other parts of the overall information system to support the decision-making activities of managers and other knowledge workers in organizations (p. 6)". Although academic researchers proposed other narrower definitions of DSS, this article is conceptually anchored by Sprague's broad definition and framework and Alter's [1980] DSS framework.

In the following sections an expanded framework for classifying Decision Support Systems is summarized [Power, 2001; 2002a]. The goal is to stimulate debate about how DSS researchers should classify and describe various systems and technologies for supporting decision makers. The next section discusses the need for an expanded framework. Sprague's DSS component framework is briefly reviewed, then an expanded framework is defined that uses the dominant component of a DSS as the primary descriptive dimension (Section III). The final section presents conclusions associated with applying the framework.

II. NEED FOR AN EXPANDED FRAMEWORK

Both managers and DSS designers need to understand categories or types of decision support systems so they can communicate better about what needs to be accomplished in supporting decision-makers. Researchers need a framework for categorizing DSS so that hypotheses and theories can be tested meaningfully [Power, 2002b]. The DSS literature includes two major frameworks for categorizing computer-based systems for supporting decision-making developed by Alter [1977] and Sprague [1980]. Alter [1977, 1980] developed the broadest and most comprehensive process-oriented DSS framework more than 25 years ago. Sprague [1980] developed a framework of DSS technology components. A new, broader framework than Alter's [1980] of DSS types is however needed, because today's Decision Support Systems are much more diverse than when he conducted his research and proposed his taxonomy. Today some DSS focus on analyzing data, some on manipulating models, and some on supporting communications. DSS also differ in scope. Some DSS are intended for one primary user who works alone on specific analyses whereas other DSS are intended for ad hoc use by many users in an organization.

In 1980, Alter [pps. 73-93] explained his taxonomy in some detail. His taxonomy and analysis is still relevant for discussing some types of DSS, but it is not inclusive for classifying all contemporary Decision Support Systems. Alter's idea was that a Decision Support System could be categorized in terms of the generic operations it performs, independent of type of problem, functional area or decision perspective. His seven types of DSS are shown in Table 1.

Table 1. Alter's Seven Types of DSS

Data-Oriented Types	File drawer systems
	Data analysis systems
	Analysis information systems
Model Oriented Types	Accounting models
	Representational models
	Optimization models
	Suggestion models

Based on Figure 17 on page 76 of [Alter, 1980]

To keep the number of categories in an expanded framework manageable, one can and should consolidate Alter's typology into three broader types of Decision Support Systems. For a number of years, many researchers routinely combined Alter's first three types of DSS into a category called data-oriented, retrieval-oriented [Bonczek, Holsapple, and Whinston, 1981], or data-driven DSS [cf., Dhar and Stein, 1997]; the second three DSS types in Alter's taxonomy were combined into a category variously called model-oriented, model-based or quantitative DSS; and Alter's suggestion model DSS was termed model-oriented, management expert system and knowledge-based DSS [cf., Klein and Methlie, 1995; Holsapple and Whinston, 1996]. Systems variously called groupware, group DSS (GDSS), collaborative systems and document based systems also need to be included in an expanded DSS framework.

Traditionally, Information Systems academics and MIS staff discussed building Decision Support Systems in terms of Sprague's [1980] four major DSS technology components –

- dialog management,
- database management,
- model management, and
- DSS architecture [Power and Kaparthi, 1998].

This traditional list of components remains useful for understanding DSS and it can help identify similarities and differences among categories or types of DSS. The expanded DSS framework defined in this article is primarily based on the different emphases placed on DSS components when systems are actually built and developed.

Some DSS require specialized data base components, like a knowledge or document database to deliver decision support. Some structured DSS databases are large and the functionality of the DSS comes from rapid ad hoc queries. Some DSS use a simple flat-file database with fewer than 1,000 records; these DSS often derive functionality from a model. Some DSS use very simple models to calculate an average or sum. Other DSS derive their functionality more from a complex quantitative model or an optimization model. Despite the significant differences among DSS created by their specific purpose, the tasks supported and the scope of a specific DSS, all

Decision Support Systems use similar technology components with varying emphases placed upon them to provide functionality and to "drive" the decision support capability.

III. AN EXPANDED FRAMEWORK

An expanded organizing framework for classifying decision support systems was developed inductively from a "felt need" for increased clarity in discussing DSS. The framework focuses on one major dimension with five generic types of DSS and three secondary dimensions. The primary dimension is the dominant technology component or driver of the decision support system; the secondary dimensions are the targeted users, the specific purpose of the system, and the primary deployment and enabling technology. The expanded DSS framework has been used since 1999 as an organizing framework for the web-based knowledge repository called DSSResources.COM. The framework also strongly influenced the definition of the domain for the Association for Information Systems (AIS) Special Interest Group on Decision Support, Knowledge and Data Management Systems (SIGDSS). The author and others have used the framework to classify a large number of software packages and systems. Anecdotal reports indicate that people who use the framework to describe a proposed or existing DSS find it comprehensive, useful, and parsimonious. The framework helps classify and describe the most common Decision Support Systems currently in use.

PRIMARY DIMENSION – DOMINANT COMPONENT DRIVER

The primary dimension examines the dominant component that drives the DSS and provides its functionality. Five such components are identified:

- Data in Data-driven DSS
- Models in Model-driven DSS
- Knowledge in Knowledge-driven DSS
- Documents in Document-driven DSS
- Communications in Communication-driven DSS.

Data-Driven DSS

Data-driven DSS include file drawer and management reporting systems, data warehousing and analysis systems, Executive Information Systems (EIS) and data-driven spatial Decision Support Systems. Business Intelligence and OLAP systems are also examples of Data-driven DSS.

Data-driven DSS emphasize access to and manipulation of a large database of structured data, especially a static time-series of internal company data and, in some systems, external data. Simple file systems accessed by query and retrieval tools provide the most elementary level of functionality. Data warehouse systems that allow the manipulation of data by computerized tools tailored to a specific task and setting or by more general tools and operators provide additional functionality. Data-driven DSS with Online Analytical Processing (OLAP) provide the highest level of functionality and decision support that is linked to analysis of large collections of historical data [Dhar and Stein, 1997]. Dashboards, pivot tables, and drill-down capabilities enhance the user interface of data-driven DSS.

Model-Driven DSS

These systems use accounting and financial models, representational models, and optimization models. Model-driven DSS emphasize access to and manipulation of a model [Power, 2000].

Simple statistical and analytical tools provide the most elementary level of functionality. Analytical models are the major component of a Model-driven DSS. Because each Model-driven DSS is designed for a specific set of purposes, different models are needed and used. Choosing appropriate models is a key design issue. The software used to create specific models needs to manage needed data and the user interface. Model-driven DSS use data and parameters provided by decision-makers to aid them in analyzing a situation, but they are not usually data intensive. Very large databases are usually not needed for Model-driven DSS.

Knowledge-Driven DSS

Sometimes it may seem appropriate to use Alter's original term, suggestion model DSS, or a narrower term management expert system, or knowledge-based DSS. Adding the modifier “driven” to the word knowledge maintains a parallelism in the expanded framework and focuses on the dominant Artificial Intelligence (AI) knowledge base component that is a specialized database management component. Knowledge-driven DSS can suggest or recommend actions to decision makers. These DSS are software applications with specialized problem-solving expertise. The "expertise" consists of knowledge about a particular domain, understanding of problems within that domain, and "skill" at solving some of these problems. Knowledge-driven DSS use special heuristic models called inference engines for processing rules.

Document-Driven DSS

Document-driven DSS (also called Document-based system [Swanson and Culnan, 1978]), are evolving to help managers retrieve and manage unstructured documents and web pages. A Document-driven DSS integrates a variety of storage and processing technologies to provide complete document retrieval and analysis. The web provides access to large document databases including databases of hypertext documents, images, sound. and video. Examples of documents that would be accessed by a Document-driven DSS are policies and procedures, product specifications, catalogs, and corporate historical documents, including minutes of meetings, corporate records, and important correspondence. A search engine is a powerful decision-aiding tool associated with a Document-driven DSS [Fedorowicz, 1993, pp. 125-136].

Communications-Driven DSS

Group Decision Support Systems (GDSS), developed in the early 1980s, exploited expanded communications capabilities that became available in the computing architecture**.** They were the first examples of a broad category of DSS. This type of Decision Support System includes communication and collaboration decision support technologies that do not fit conveniently within three DSS types identified by Alter. The dominant component is the DSS architecture. Advances in networking technologies in the past 20 years made this type of multi-participant decision support much more common and more powerful. Therefore, we need to identify these systems as a specific category of DSS. Groupware supports electronic communication, scheduling, and other group productivity and decision-support-enhancing activities. A number of technologies and capabilities are included in this category in the framework: some group DSS, two-way interactive video, electronic white boards, computer-based Bulletin Boards, distributed collaborative environments, chat tools, and email.

SECONDARY DIMENSION – TARGETED USERS

Inter-Organizational and Intra-Organizational DSS

Targeted users of DSS can include individuals, groups, and functional departments. A relatively new targeted user group for DSS is customers and suppliers. We can call a DSS targeted to external users an Inter-Organizational DSS**.** The public Internet is creating communication links for many types of Inter-Organizational systems, including DSS. An Inter-Organizational DSS provides stakeholders with access to another company’s Intranet connections and authority or privileges to use specific DSS capabilities. Companies can make a Data-driven DSS available to suppliers or a Model-driven DSS available to customers to design a product or choose a product. Most DSS, however, are Intra-Organizational DSS that are designed for use by individuals within a company as stand-alone DSS or for use by a group of managers in a company as a Group DSS or Enterprise-wide DSS [Power, 1997].

SECONDARY DIMENSION – PURPOSE

Function-Specific DSS

Many DSS are designed to support specific business functions or types of businesses and industries. We can call such a Decision Support System a function-specific or industry-specific DSS. A function-specific DSS that supports a function such as marketing or finance (e.g., a budgeting system) may be purchased from a vendor or customized in-house using a more general-purpose development package.

Task-Specific DSS

Some DSS products are designed to support decision tasks in a specific industry like a crew scheduling DSS for an airline. A task-specific DSS is used to solve a routine or recurring decision task.

Function or task-specific DSS can be further classified and understood in terms of the dominant DSS component, that is as a Model-driven, Data-driven, or Knowledge-driven DSS.

General-Purpose DSS

General-purpose DSS software helps support broad tasks like project management, decision analysis, or business planning. The most general purpose Decision Support Systems are often called DSS generators because they can be used to develop or “generate” more specific DSS [Sprague and Carlson, 1982].

SECONDARY DIMENSION – DEPLOYMENT AND ENABLING TECHNOLOGY

Web-Based DSS

DSS also differ in terms of the technology used for building and deploying the decision support capability. The deployment or enabling technology may be a mainframe computer, a client/server LAN, a PC-based spreadsheet, or a Web-based architecture. All five of the generic types of DSS can be deployed using Web technologies and we can collectively call these systems built and deployed using such technologies Web-based DSS. A Web-based DSS is a computerized system that delivers decision support information or decision support tools to a manager or business analyst using a "thin-client" Web browser like Netscape Navigator or Internet Explorer. The computer server that is hosting the DSS application is linked to the user's computer by a network with the TCP/IP protocol. In many companies, a Web-Based DSS is synonymous with an intranet or Enterprise-Wide DSS. A company intranet supports a large group of managers using Web browsers in a networked environment [Power, 1998]. Managers increasingly are provided Web access to a data warehouse and analytical tools. Also, Web technologies are the primary tools used to create Inter-Organizational DSS that support the decision-making of customers and suppliers. Although a Web-enabled DSS includes a Web interface and is accessible using a web browser, a legacy database or optimization model provides the functionality for the DSS.

Web or Internet technologies are the leading edge for building DSS, but some Intra-Organizational DSS will continue to be built using traditional programming languages, fourth generation languages, “thick-client” application development tools, or mainframe technologies.

A Data-driven DSS database is a collection of current and historical structured data from a number of sources, organized for easy access and analysis. It may be deployed using a relational or multidimensional database. Developers are expanding the database component to include unstructured documents in Document-driven DSS and "knowledge" in the form of rules or frames in Knowledge-driven DSS.

The DSS architecture component refers to how hardware is organized, what software is used, how software and data are distributed in the system, and how components of the system are integrated and connected. The network and communications architecture is the key driver of a Communications-Driven DSS. Various technologies are used to deploy these DSS.

FRAMEWORK SUMMARY

Table 2 is a summary of the expanded, multi-attribute DSS classification framework. The far left column lists the five generic categories of Decision Support Systems that differ in terms of the dominant DSS technology component, including (in alphabetical order) Communications-driven DSS, Data-driven DSS, Document-driven DSS, Knowledge-driven DSS and Model-driven DSS. The next three columns provide examples of the secondary attributes: target users, purpose, and deployment technology.

Table 2. An Expanded DSS Framework

Dominant DSS Component	Target Users	Purpose	Deployment/ Enabling Technology
Communications **Communications-driven DSS**	Internal teams, now expanding to external partners	Conduct a meeting or Help users collaborate	Web or Client/ Server
Database **Data-driven DSS**	Managers, staff, expanding to suppliers	Query a data warehouse, Monitor performance indicators	Mainframe, Client/Server, Web
Document base **Document-driven DSS**	Internal users, but the user group is expanding	Search Web pages or Find documents	Web or Client/ Server
Knowledge base **Knowledge-driven DSS**	Internal users, expanding to customers	Management advice or Help structure decision processes	Client/Server, Web, Stand-alone PC
Models **Model-driven DSS**	Managers and staff, expanding to customers	Crew scheduling, Financial planning or Decision analysis	Stand-alone PC , Client/Server or Web

When the target users are customers and other external users, the label Inter-Organizational seems an appropriate descriptor. When all of the users are internal to the company that owns the DSS, then intra-organizational serves as a descriptor. Also as noted, Decision Support Systems can be categorized by the purpose of the DSS. Many DSS are narrow, focused, specific purpose rather than general purpose. Finally, DSS can be described by the basic deployment technology. The Web is an important new development arena for DSS so it is crucial to examine and understand Web-Based DSS.

We can use dominant DSS component, target users, purpose and deployment technology to categorize a specific system. For example, a manager may want to build a Model-driven, Inter-Organizational, product design, Web-based DSS. In another situation, a manager may want a Data-driven, enterprise-wide, performance management, Web-based DSS.

IV. CONCLUSIONS

The field of Decision Support Systems suffers, in many ways, from the broad, ambiguous use of the term DSS. Informing and communicating with others involves using shared concepts. That has not been the case in discussing and investigating Decision Support Systems. Even though some might try to limit the term DSS to model-driven DSS or even abandon the term DSS and substitute business intelligence or knowledge management to describe these systems, the intuitive and descriptive appeal of the term coupled with its historical importance should encourage researchers to differentiate more clearly what type of DSS is being studied or built. Every Decision Support System is not the same and both researchers and managers need a meaningful framework for discussing what is being done to support decision-making using information technologies. This article is a modest attempt to provide such a framework.

Integrated or comprehensive DSS now on the market can "blur" some of the distinctions in the expanded framework in Table 2 unless specific decision support subsystems are identified. For example, some analytic application packages include a knowledge-driven decision support capability that helps a user choose an appropriate analysis technique. It is common to include communications-driven decision support in integrated transaction processing and decision support systems. In addition, Web-based portals can provide access to many different DSS that a manager needs or wants to use. DSS are fast becoming truly interactive computer-based systems and subsystems intended to help decision makers use communications technologies, data, documents, knowledge and/or models to complete decision process tasks successfully.

The expanded DSS framework builds upon both Alter's [1977] empirically-derived framework and Sprague's [1980] normative framework. Also, the framework integrates more recent software and technology developments and provides a more consistent naming convention for computer-based DSS.

In an attempt to improve how researchers and practitioners discriminate among and describe DSS, this article defines an expanded framework for labeling, describing and classifying systems intended to support decision-making. In general, a specific Decision Support System should be discussed and explained in terms of four descriptors: the dominant technology component or driver of decision support, the targeted users, the specific purpose of the system, and the primary deployment and enabling technology.

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