A Look Toward the Future: Decision Support Systems Research is Alive and Well

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Abstract

This commentary examines the historical importance of decision support to the information systems (IS) field from the viewpoint of four researchers whose work spans the several decades of decision support systems (DSS) research. Given this unique "generational" vantage point, we present the changes in and impact of DSS research as well as future considerations for decision support in the IS field. We argue that the DSS area has remained vital as technology has evolved and our understanding of decision-making processes has deepened. DSS work over the last several years has contributed both breadth and depth to decision-making research; the challenge now is to make sense of it all by placing it in an understandable context and by applying our analysis to the relevant issues looming in the future. One major outcome of this commentary is the identification of future trends in DSS research and what the users of these new DSS outlets can learn from the past. Trends include the increasing impact of social and mobile computing on DSS research, as well as knowledge management DSS and negotiation support systems that shift the focus to delivering more customer-centric and marketplace support.

***Keywords**: History of Decision Support Systems, Decision Making, Decision Models, DSS Future, DSS Research, Decision Levels, Decision Scope.*

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1. Introduction

Over the past four decades, decision support systems (DSSs) have been developed to facilitate better decision making for difficult and complex structured, semi-structured, and unstructured decisions. Using DSSs in structured decision-making tasks enables users to understand a large number of parameters and relationships that are stable but nevertheless limit the decision maker's ability to process all aspects of the decision. In semi-structured and unstructured decision tasks, DSSs still handle a large number of parameters and relationships but also attempt to alleviate the effect of some unknown or shifting parameters and relationships on the decision. Because of the longevity of DSSs as a research topic, we can view DSSs as a mature field in which many significant research questions have been answered. Thus, it has become an area in which it is difficult to publish. Indeed, Arnott and Pervan (2008) have questioned the vitality of DSSs research. We, the authors of this analysis, argue that DSSs research is alive and well the information systems (IS) research domain. We believe that DSSs is as relevant now, if not more so, than ever before. This commentary will examine the historical importance of decision support to the IS field from the viewpoint of four researchers whose work spans decades of DSSs research. Given this unique "generational" vantage point, we present the evolution and impact of DSSs research as well as future considerations for decision support research in the IS field.

DSSs has been a paradigm in IS research almost from the very conception of the IS field (Power, 2002). Many issues studied in the early days of DSSs, such as information structuring (e.g., Gorry & Scott-Morton, 1971) and user interfaces (e.g., Mason & Mitroff, 1973; Newell & Simon, 1972), are still with us today as we extend DSSs with data-driven forecasting, real-time analytics, and performance management tools made available by business intelligence and analytics systems (Watson, 2005). Providing a usable view of what the data contains (Gopal, Marsden, & Vanthienen, 2011; Pracht, 1986) and ensuring that decision makers can gain insights from their ad hoc questions (Bousequet, Fomin, & Drillion, 2011; Paradice & Courtney, 1987) are examples of decision support foci that have remained important and relevant in the IS field for years. In fact, the ubiquitous nature of decision support – from aiding online movie renters decide what to watch or directing online consumers to evaluate products that match their personal preferences – provides a wealth of problem spaces ripe for research. The goal of this paper is to situate these new uses of DSSs in the context of past DSSs research and identify trends for new DSSs research based on this analysis.

Today DSSs research has widened its focus to serve more and more reference disciplines. This can be seen in citations to the seminal paper by Shim et al. (2002) in the journal *Decision Support Systems and Electronic Commerce* that addresses the evolution and future of decision support technology. This paper has been referenced more than 500 times according to Google Scholar. These citations have occurred in a wide variety of journals including *Physics and Chemistry of the Earth*, *Environmental Modeling and Software*, *Environment and Planning*, the *European Journal of Operational Research*, the *International Journal of Mobile Communications*, *IEEE Transactions on Engineering Management*, *Communications Monographs*, *Electronic Markets*, *Automation in Construction*, *Mathematical and Computer Modeling*, *Informatics for Health and Social Care*, *MIS Quarterly,* and numerous others. The *DSS&EC* journal has been published since 1985 and currently produces four volumes a year that comprise some 50 or so papers. In their citation analysis of DSS journal articles from 1985 to 1993, Holsapple, Johnson, Manakyan, and Tanner (1995) describe *Decision Support Systems* (the original title of *DSS&EC*) as a journal that was well established (at that time in its 10th year of publication), among the top five journals in the business computing field, a leading venue of DSSs research, and one with an editorial policy focused on DSSs research (Holsapple et al., 1995; Chen, 2011). A quick search on Google Scholar shows that the term DSSs, or decision support systems, appeared in the academic literature 284 times in the 1970s, 5,190 times in the 1980s, 17,600 times in the last decade of the previous century, and 34,500 times in the first decade of this century. This clearly shows an increasing interest in the concept. While some of these papers might question the ongoing relevance of the DSSs concept, we suspect (without having read them all) that most of them do not raise this question. Given the breadth and depth of DSSs work that has occurred, the challenge is to make sense of it all by placing it in an understandable context, and then to apply the results of our analysis to the relevant issues looming for the future.

To best answer this challenge, we discuss the historical context of DSSs research in the second section of this paper. In the third section, we review the current state of DSSs and identify emerging trends of new DSSs research. Finally, we discuss future research directions for DSSs in context of what can be learned from the past.

2. An Historical Perspective on DSS

The critical role that decision making plays in management goes back at least to Herbert Simon's classic book *Administrative Behavior* (Simon, 1947). The importance that Simon attributed to decision making is illustrated in the introduction of *The New Science of Management Decision,* where he wrote: "I shall find it convenient to take mild liberties with the English language by using 'decision making' as though it were synonymous with 'managing'" (1960, p. 1).

Simon's intelligence-design-choice model of the decision-making process has been widely used in the DSSs literature (e.g., Abdolmohammadi, 1987; Courtney, 2001; Gorry & Scott-Morton, 1971; Hall & Paradice, 2005; Pomerol & Adam, 2005). He coined the terms "bounded rationality" (that decision makers may be rational but are limited in cognitive processing ability when confronted with complex problems) and "satisficing" (that even if the optimal decision is sought, bounded rationality and limited information may result in accepting a solution that is "good enough"). A great deal of DSSs research has been designed to overcome these limitations of human problem solvers.

The 1960s saw widespread use of mainframe computing; its primary application in business was to automate routine transaction processing. These computers were large, expensive, and had many specialized needs with respect to their maintenance. One of our authors remembers a room full of computing equipment running laboriously to tabulate data and present simple reports. The capacity of that computer was much less than the capacity of common mobile devices today. This was an age characterized by centralized decision making and batch processing. Computer models were difficult to develop. People needed specialized computer programming skills to write programs that would take input data, which itself had to be meticulously coded on paper cards or paper tape, process the data in a fixed way, and produce a fixed set of reports. Changes to any part of this process, whether it was the addition of a new data item, a new calculation, or a new item to report, required the intervention of the programming expert. Such changes took considerable time to implement so that the need for a change might not be realized in an actual change to the system for as much as a month. Once these routine processes were implemented, great efficiencies could be gained, but there was frustration around the inability to conduct "scenario analysis" in a timely fashion in an ever-increasingly dynamic business environment.

Minicomputers emerged in the early to mid-1970s. They were smaller, less expensive than mainframes, and had fewer specialized maintenance needs. As such, they could be purchased by individual departments within organizations, leading to distributed computing environments and ultimately to decentralized decision-making processes. At first, engineering and analytical-type functional areas (e.g., maintenance, research and development, and planning) purchased these computers because engineers and other specialists had the expertise to build their own specialized models to support their decision-making needs. Relatively quickly, however, other functional business areas within organizations were purchasing their own computing resource and beginning to develop their own systems to support their operations – and these operations were not necessarily well served by the older transaction processing-oriented systems executing on corporate mainframes.

As corporations began to leverage such distributed computing resources, new areas of computer-aided decision-making research began to develop in academia. These more flexible and less expensive systems allowed researchers to address Simon's (1960) concept of non-programmed (novel) decisions as opposed to programmed (routine) problem. This formed the primary basis for Gorry and Scott Morton's (1971) paper in the *Sloan Management Review* that was the first to use the term "decision support system" and distinguished DSSs from management information systems. By their definition, DSSs dealt with semi-structured and unstructured problems, while IS was concerned with less critical, structured problems such as those supported by transaction processing systems. But as history has played out, DSSs can be seen still supporting decisions that may have once been unstructured and now, because of an increase in understanding, have become more structured.

In the 1970s, an emphasis on DSSs arose from the need for better decision-making support as difficult and complex semi-structured and unstructured decisions became a primary area of research in the IS field (Power, 2003). Gorry and Scott-Morton point out that, up until the time at which they wrote, IS research had largely been dealing with structured decisions: "The SDS [structured decision systems] area encompasses almost all of what has been called Management Information Systems (IS) in the literature—an area that has almost nothing to do with real managers or information" (1971, p. 61). Their unprecedented idea of using technology to interactively help solve problems and aid in decision making attracted researchers from traditional IS research and other fields to work on this new paradigm, requiring a shift in thinking about how IS were viewed and used.

Research in DSSs in the late 1970s was quite varied. One of the authors remembers working with a professor in industrial engineering to develop a DSS to support "Scrabble by mail" (written in APL) while also working with a professor in the business school on a system that business students could use to make better strategic decisions while participating in a class that used a business simulation game (written in FORTRAN).

Broadly speaking, engineering, operations research, and computer science researchers focused on technical and computational issues related to model building and data manipulation, while IS researchers in business schools focused on decision modeling and decision-maker efficacy. In the 1970s, DSSs came into existence as an idea, but further work needed to be done to develop a definition and framework for what Gorry and Scott-Morton (1971) described. A basic objective of early DSSs work was to integrate the advances being made in database management with those being made in management science and decision analysis to help managers analyze real decision problems. The early conceptual work on the emerging paradigm can be seen in the synthesis work of Alter (1977) and Sage (1981), the studies by Bonczek, Holsapple, and Whinston (1980), and the framework developed by Sprague (1980). Moreover, in additional work, Bonczek et al. (1981) provided a rigorous theoretical foundation for DSSs research based on formal logic and set theory. When combined, the work carried out by these researchers established a general framework and theoretical foundation that defined DSSs and gave future researchers a general paradigm through which to study decision support systems. This was a time that IS research actually led industry. Popular products such as IFPS (interactive financial planning systems), used in many MBA programs of that era, and SIMPLAN were developed by academics or in close collaboration with them. The work by Bonczek et al. (1981) provided a blueprint for the construction of real systems and was used by the development team of one of the earliest interactive decision support tools in the electric utility industry (Taylor et al., 1981). Still, in spite of these practical successes, Sprague acknowledged a crisis in DSSs at the time by pointing out the difficulty of defining DSS. He wrote: "A serious definitional problem is that the words have a certain 'intuitive validity'; any system that supports a decision, in any way, is a 'decision support system'" (1980, p. 2).

It was at this time that Sprague and Carlson (1982) provided a popular definition of DSSs as "*Interactive* computer-based systems to *help* decision makers use *data* and *models* to solve *unstructured* problems" (emphasis in original). The key words emphasized here are important for the following reasons. Most computer systems prior to the 1970s ran only in batch mode, meaning that users had to submit a program to a mainframe computer that ran to completion without any user intervention and interaction. Yet, the nature of DSSs has shifted to incorporate much more than traditional data and models, including business rules, images, documents, video, and much more (Power, 2002).

Interactivity was important in DSS advances because analysts and managers were now able to run models and "what if" analyses and analyze data in real time. This approach turned out to be vastly superior in problem solving because a decision maker could concentrate on a problem and explore it interactively. The decision maker was no longer forced to wait for hours or days to get back the results from a computer-based analysis, interpret those results, and then submit another analysis and wait hours or days again. The close interaction of the manager and software prompted Keen and Wagner (1979) to refer to tools such as IFPS as “executive mind support systems”.

The keyword “help” is important because DSSs researchers were only trying to assist managers in making decisions, not replace them, as was the case of expert systems in computer science. These systems were trying to mimic experts and make decisions as well as or better than they did.

The idea of integrating data and models is important because prior to the DSS movement, those working in management science were developing models for analyzing organizational problems, but they seldom actually had the data to use the models on real problems. However, the technology in the database arena was evolving, and computer science researchers were developing techniques to better organize and manipulate massive amounts of data. DSSs researchers focused on integrating database research that was occurring in computer science so that managerial decision makers could make better informed decisions.

In his work on DSSs in the late 1970s, Alter (1980) discussed what he found to be an unexpected effect of the DSSs studied: interpersonal communication. His studies showed that users adapted DSSs as either tools of persuasion or negotiation. From the persuasion perspective, the DSS was used to quantitatively demonstrate that a desired activity was beneficial (offensive) to an organization or that an unwanted activity was not beneficial (defensive). From a negotiation perspective, the DSS allowed an organization to standardize vocabulary and mechanics across functional areas. Simply reducing inconsistencies or misunderstandings allowed communications and negotiations to take place more effectively throughout an organization. While these uses seem quite normal today, we must realize that the DSSs under analysis at the time were for decision-making, not data analysis, purposes. The users who performed these tasks realized that the data available through the DSSs had other characteristics and uses and were able to adapt the DSSs to their needs.

Thus, the original concept in DSSs research and practice was tied to technology in the form of interactivity and communication, and to decision makers faced with what we will call ill-structured problems. DSSs researchers combined technological evolution in the forms of database systems, models, and distributed computing with a focus on the ill-structured problems decision makers actually face. In so doing, they helped managers analyze decision models in situations that Simon (1960) called non-programmed and that Gorry and Scott Morton (1971) called semi-structured or unstructured. As DSSs research has evolved over the decades, this thread of technology evolution combined with a growing understanding of decision-making processes and a need to cope with increasing uncertainty in problem structure occurs repeatedly and still appears to be the case today.

The DSSs research of the 1980s reflected yet another technological evolution combined with a growing understanding of decision-making processes. The introduction of the IBM PC in 1981 legitimized the microcomputer as a business computing resource. The “dumb” terminals that were connected to a mainframe computer or minicomputer were replaced with microcomputers capable of running programs independently of any larger corporate computing resource. An early software product was Lotus 1-2-3, a spreadsheet application, which was touted as a revolutionary decision support aid in the early 1980s. Combined with IBM’s Wordstar, a manager had the capability to interactively work with data and prepare reports without leaving his or her desk and without the intervention of programming specialists.

This combination of the microcomputer and the spreadsheet led to the development of small scale decision models that were used to support primarily individual and functional area decision making. Some DSSs researchers focused on the processes underlying model development (Paradice & Courtney, 1986), while others focused on model management issues (Blanning, 1986; Konsynski & Dolk, 1982).

In the corporate world, there was growing realization that these technological advances were creating a problem for decision-making processes at a corporate level. Distributed computing and the (relative) ease of model creation allowed different functional areas to build models of problem situations that reflected their perspective of the problem. Thus, decision makers were arriving at meetings with conflicting analyses of problem situations. Another technological evolution and additional research would be needed to address how best to support the group-oriented nature of many corporate decision-making processes. Thus, the focus of many researchers turned to the study of group decision-making processes. Researchers pursued group DSS (GDSS) research with vigor during this time, supported by several large grants from industry. They also explored the decision-making "war room" concept and learned much about the nuances of the group decision-making process.

Early work on GDSSs revolved primarily around supporting co-located managers by providing computer support (e.g., spreadsheets, brainstorming support, idea generation support, and voting capabilities) during a traditional meeting. One of the earliest GDSS research environments was developed at SMU, and Gray et al. (1981) presented a paper on it at the first International Conference on Decision Support Systems in 1981. As technology evolved, co-location became unnecessary, and video conference-based GDSSs were developed (Gray, 2008). During this time, several Ph.D dissertations focused on IT-associated effects from GDSS use such as quality of decision making (e.g., Gallupe, 1985; Lewis, 2006), as well as on the group process itself, examining effects such as satisfaction (e.g., Applegate, 1986), leader behaviors (e.g., Zigurs, 1987), and group conflict (e.g., Gallupe, 1985). Established researchers began to craft frameworks for GDSSs research (e.g., Dennis, George, Jessup, Nunamaker, & Vogel, 1988; DeSanctis & Gallupe, 1987; Huber, 1984), and analyze its processes (e.g., Briggs, De Vreede, & Nunamaker, 2003; Nunamaker, Briggs, Mittleman, Vogel, & George, 1996; Nunamaker, Dennis, Valacich, Vogel, & George, 1991; Siegel, Dubrovsky, Kiesler, & McGuire, 1986).

Concurrent with the proliferation of micro-computing devices in organizations was the development of local area networks. Thus, yet another technological evolution unfolded hand-in-hand with a deeper understanding of the decision-making processes of groups. This time, the GDSS concept evolved into computer supported cooperative work (CSCW). In this way, researchers recognized that decision makers not only come together to make decisions (as supported in the decision war room context), but also often work collaboratively over time on projects and problems.

There has been some discussion in the literature as to whether group decision support systems (GDSSs), group support systems (GSSs), and computer supported collaborative work (CSCW) are the same. Coleman (1997) delineated GDSSs from CSCW by stating that the goal of GDSSs is to make a decision, whereas the goal of CSCW is to work toward a problem solution. The distinction between GDSSs and GSSs is more difficult; for example, Dennis, Wixom, & Vandenberg (2001) use the term in their work and reference other work as GSSs that was previously called GDSS. One reason suggested by Turban, Sharda, and Delen (2011) for the term GSSs is that GSSs go beyond decision support to include indirect support such as communications, planning activities, idea generation, discussion, negotiation, and other tasks necessary for a group to work together to effectively make a decision or solve a problem.

Regardless of such differences in concept and terminology, the plethora of research activity in this period gave rise to the need for specialized journals. In 1985, DSSs added another characteristic of becoming accepted as mainstream IS research by the introduction of its own specific journal, originally titled *Decision Support Systems*, but retitled in 1999 as *Decision Support Systems and Electronic Commerce*. This journal is still considered to be among the top IS research journals (Holsapple & O'Leary, 2009; Hu & Chen, 2011). By 1992, CSCW research was a cross-discipline research area with its own journal, *Computer Supported Cooperative Work*. With greater recognition that executive decisions have a strategic character that differs from middle management decisions that are more tactical, a new type of DSS was developed for complex executive decisions, called executive information systems (EISs). EISs were primarily developed to support individual executive-level decision making (Watson, Rainer, & Houdeshel, 1992) but were followed closely by technologies geared toward strategic enterprise-wide analytic capabilities. In the early 1990s, data warehouses became a new area of research within the study of DSSs (e.g., Codd, 1993; Inmon, 1992). According to Gray and Watson (1996), data warehouses were another area where the DSSs paradigm could be applied and developed. The Internet and Web explosion of the late 1990s and early 2000s further expanded the need for viable and flexible decision support. This technological evolution led to an expectation that business services would be available all day, every day. Now, consumers and lower level employees had more data available to analyze when making decisions and, thus, many of the decision-making responsibilities were often pushed downward in the organizational hierarchy or even outward to consumers and other stakeholders.

In the past decade, Shim et al. (2002) set forth an agenda for continued development of the DSSs paradigm, building on the tradition of Blanning's (1983) and Keen's (1987) work predicting the direction of DSSs research. Such papers show the continuing open-endedness of the field as technologies advance and the field continues to expand. Courtney (2001) points out that "more effective ways must be found to support the vast array of knowledge that will be required in these highly interconnected and wicked situations of the future" (p. 36). His call for a merger of DSSs and knowledge management systems creates new puzzles to be solved in the DSSs paradigm that may require continued research and development. Other acknowledgement of this stream of research is seen in the works of Benyon, Rasmequan, and Russ (2002) and Bolloju, Khalifa, and Turban (2002).

Arnott and Pervan (2005, 2008) trace the evolution of personal DSSs to group DSSs, which led to negotiation-based systems. According to their analysis, executive information systems emerged from GDSSs and led to data warehousing and online analytical processing, data mining, and business intelligence tools. Intelligent DSSs and knowledge-based systems grew from efforts to apply concepts from artificial intelligence and expert systems to DSSs problems. Power (2003) adds document-driven systems to this arena, appropriately pointing out that current information technology can manipulate text, graphics, audio, and video data almost as adroitly as it can handle numeric data and perform computations. On DSSResources.com, Power defines a DSS as "…an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions".

Although DSS has been primarily a successful concept that has been implemented in several forms over the last four decades, it does not always have a successful outcome. Many of the failures are due to poor design, lack of shareholder involvement, or poor implementation (Arnott & Dodson, 2008). If the failure is primarily from lack of use, improper implementation, or poor (or no) outcome, these, while annoying, may be of no particular consequence. In a study in the agricultural arena, researchers found that DSSs were not widely used among farmers and producers primarily because of either a lack of education or a misunderstanding about the DSS itself (Newman, Lynch, & Plummer, 2000). Therefore, the agriculturalists who have adopted the DSS see benefits, and those that don't, or do but do not use it appropriately, do not see benefits but suffer little perceived harm. On the other hand, when organizational members become dependent on an information system, particularly one that should be providing accurate, timely data on which to base decisions, poor outcomes may have far reaching, sometimes catastrophic consequences.

Additionally, the best DSS cannot overcome poor managerial decision making. The space shuttle Challenger disaster is one such event. In 1986, the Challenger exploded just after launch, killing all on board. Failure of the GDSS used between NASA and Thiokol (SRB "O" ring manufacturer), and the resultant decision to launch that was based on poor information, is largely blamed for the disaster (Report of the Presidential Commission, 1986). However, Richard Feynman, the Nobel award winning physicist on the Commission, pointed out that the management of NASA exaggerated "the reliability of its product, to the point of fantasy" (Feynman, 1999, p. 155). No system can overcome such an obstacle. As Feynman states in the last sentence of his report, "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled".

DSSs are also blamed for financial failures. Black Monday, which occurred on October 19, 1987, is blamed on portfolio insurance and programming trading, both automated tools that use stock index futures as a basis for trading (Young 1989). This scapegoating ignores the fact that human beings allowed these automated tools to dominate the trading floor and did not place restrictions on their use in critical situations or provide for human override capabilities.

We can conclude from this brief history that DSSs research and practice have evolved along with information technology. As Orlikowski (1992) points out, technology plays a dual role in both enabling and constraining human activity. Humans can only do what is feasible with technological resources. Thus, the concept of DSSs to support concentrated human problem solving was not really feasible until we could interact with computers. IT could not support groups until networking infrastructure was readily available. Knowledge-based DSSs were not feasible until AI and expert systems concepts were developed. As information technology seems to be expanding exponentially and becoming ubiquitous, we believe the opportunities for DSSs will become ever more extensive. To give a brief example, here are some excerpts from a joint press release from IBM and WellPoint, an independent licensee of the Blue Cross and Blue Shield Association and a major healthcare benefits provider, relating to IBM's Watson technology originally developed to play the popular television game Jeopardy.

> *INDIANAPOLIS and ARMONK, N.Y., - 12 Sep 2011: WellPoint, Inc. (NYSE: WLP), and IBM (NYSE: IBM) announced an agreement today to create the first commercial applications of the IBM Watson technology. Under the agreement, WellPoint will develop and launch Watson-based solutions to help improve patient care through the delivery of up-to-date, evidence-based health care for millions of Americans. IBM will develop the base Watson healthcare technology on which WellPoint's solution will run.*
>
> *Watson's ability to analyze the meaning and context of human language, and quickly process vast amounts of information to suggest options targeted to a patient's circumstances,* can assist decision makers, such as physicians and nurses*, in identifying the most likely diagnosis and treatment options for their patients," IBM and WellPoint said ("WellPoint and IBM", 2011, emphasis added).*

One might ask how does advancing technology such as Watson combine with the longevity of the DSS research paradigm to affect a rapidly changing field like IS? The next section examines where the current state of DSSs research fits in current IS research and focuses on elaborating what DSSs really encompasses.

3. Current State and Future Directions of DSS Research

During its evolution, the area of DSSs has migrated from a purely technological perspective to one that incorporates the full range of information and knowledge (Courtney, 2001). As Courtney states, simply understanding that information and knowledge must be acknowledged in a system is not the same as understanding how to do so.

Since this work, others have proposed systems that incorporate decision support in a variety of arenas outside of technologically based disciplines. The list is extensive and only a few are listed here for purposes of illustration: water resource management (Kolkman, Kok, & van der Veen, 2005; Mysiak, Guipponi, & Rosato, 2005), environmental science (Mcintosh, Jeffrey, Lemon, & Winder, 2005), emergency management (Vaught et al., 2006; Wickramasinghe, Bali, & Naguib, 2006; Wickramasinghe & Bali, 2008), and medicine (Richardson, Courtney, & Haynes, 2006). It is difficult to even begin to track all of the areas into which DSSs research has now spread, so our intent is to show examples of some reference disciplines that are now actively researching DSSs and illustrate how future research trends could draw on the history of DSSs research in the IS field.

DSSs, for example, have most commonly focused on ill-structured decisions, and this trend continues today. While we have better and faster technology, the amount of data and information to be processed has increased at a rate that at the very least maintains a level of "unstructuredness" that is on par with historical decisions. Decision making in this context is further muddled by the speed with which decisions must be made; instead of having weeks or days, businesses and organizations may have minutes or seconds.

Arnott and Pervan (2005) provide a solid starting point for analyzing DSSs research in this context in their comprehensive analysis of the current state of DSSs research through the midpoint of the last decade. They build a history of the theoretical foundations of DSSs, identifying seven subfields, three of which are most active in the last decade (Figure 1). We now integrate current trends and future possibilities of DSSs study into their tapestry of DSSs research (Figure 1).

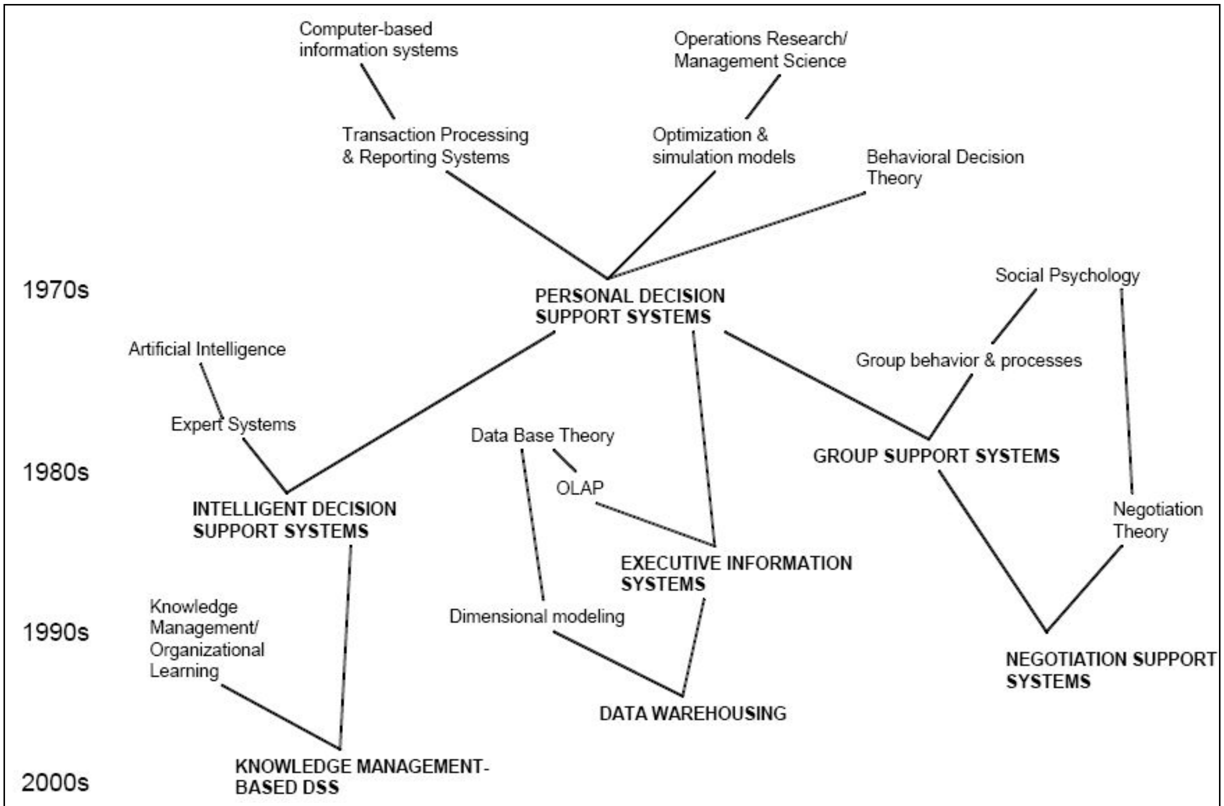

Figure 1. Arnott and Pervan (2005) DSSs Timeline

3.1. Current Research Examples

As Figure 1 notes, three main areas stem from the 1990s: knowledge management-based DSSs, data warehousing, and negotiation support systems. In the sections below, we provide examples of work since 2005 to show that DSSs is, indeed, alive and well up to the present time.

Knowledge management-based DSSs (KMDSSs) are systems that facilitate decision making throughout and between organizations with the added component of knowledge management functions. Such functions include storage, manipulation, retrieval, transfer, and use of knowledge such that individuals and organizational memory benefit (Arnott & Pervan, 2008). Given that one emphasis is on distributed decision-maker support, these systems may also include group support and or collaborative functions. However, the research emphasis is not on the group, but rather on the knowledge function of these systems (Arnott & Pervan, 2005).

Around the time of Arnott and Pervan’s (2005) framework, Nemati, Steiger, Iyer, & Herschel (2002) developed the concept of a knowledge warehouse. Recognizing that decision support is a critical operational need for an organization, and that knowledge workers need data support to make informed decisions, they developed an architecture that combined aspects of knowledge management, decision support, artificial intelligence, and data warehousing. Closely thereafter, Cil, Alpturk, and Yazgan (2005) proposed a framework based on Courtney’s (2001) proposed extension of DSSs with enhanced knowledge and inquiring capabilities. Their system differed from that of

Nemati et al. (2002) in that the focus was on the decision process of developing knowledge through multiple perspective interpretation rather than on facilitating access to knowledge.

By 2006, the concept of knowledge-based DSSs was moving beyond academic foundations and toward practical application. *OR/MS Today* suggested that practitioners should consider moving away from traditional DSSs toward knowledge-based DSSs that allow active knowledge capture that not only improves decision-making capability but allows forward-looking views for strategic decisions (Lewis, 2006). Clark, Jones, and Armstrong (2007) put forth a conceptual model for a management support system (MSS) designed to broadly support both decision making and managerial support systems. This model sought to maximize the potential of evolving technology by incorporating knowledge management, decision support, executive information systems, and business intelligence. Recently, such research has continued with emphases in different contexts. For example, Zavadskas, Kaklauskas, Raslanas, and Galiniene (2008) capture and share both tacit and explicit knowledge in a web-based intelligent DSS designed for the real estate industry. Saad and Chakhar (2009) developed a knowledge-based DSS to support Simon's decision-making process for ill-structured problems in the automobile industry. Knowledge discovery databases (KDD) have been used with DSSs to illustrate the importance of both developer-based and user-based development approaches in the context of the healthcare industry (Ayed, Ltifi, Kolski, & Alimi, 2010). Most recently, applications of the use of unstructured narratives in narrative-based reasoning for social services organizations (Wang & Cheung, 2011) and advances in knowledge transfer and benchmarking in the agriculture industry (van Leeuwen et al., 2011) have been published.

The next stem in Figure 1 is data warehousing. Note that one of the research items from above, that of Nemati et al. (2002), was specifically based on data warehouses. In fact, many of the databases/data stores/knowledge bases involved in KMDSSs research revolve around large data stores that are, or at least approach, data warehouses. As defined by Arnott and Pervan (2005, 2008), data warehouses are systems that provide infrastructure to provide data to decision makers. Because data warehouse research is somewhat older, today much of the research is oriented toward practical application. For example, a DSS based on a data warehouse for building site selection was developed by Ahmad, Azhar, and Lukauskis (2004), and a system for healthcare planning decisions benefitted from additional data warehouse tools (OLAP) (Tremblay, Fuller, Berndt, & Studnicki, 2007). Researchers have examined bioterrorism surveillance (Berndt et al., 2007) and modern and traditional healing method data warehouses (Lin, Lin, Lin, & Yang, 2009; Zhou et al., 2010), as well as fund dispatching decisions (Wang & Kuo, 2010) and logistics (Ehmke, Grosshans, Mattfeld, & Smith, 2011). However, some foundational research is still being done. Mazon and Trujillo (2008) investigated a model-driven architectural framework for data warehouse development, while Ariyachandra and Watson (2010) investigated which organizational factors drive the data warehouse architecture selection decision. Issues that organizations consider when making a data warehouse decision were analyzed by Ramamurthy, Sen, and Sinha (2008), and the question of how to rank facts retrieved from a warehouse was considered by Perez, Berlanga, and Aramburu (2009).

The third stem of Arnott and Pervan's (2005) model is negotiation support systems (NSSs). NSSs are group systems where the primary focus is the facilitation of negotiation (Arnott & Pervan, 2005, 2008). NSSs, which builds on expert systems research, has a decades-long history that can be seen in the work of authors such as Kersten (Kersten & Lo, 2003; Kersten & Noronha, 1993; Matwin, Szpakowicz, Koperczak, Kersten, & Michalowski, 1989) or Bui (Bui & Gachet, 2005; Bui & Shakun, 1996) and their co-authors. Research in this area stems from research older than either KMDSS or data warehouse research. Current research is primarily oriented toward improving the process or the application, or developing its use in new contexts, and much of it is situated in agent technology. Kuula and Stam (2008) developed an NSS using an algorithm that differs from the traditional Pareto frontier algorithm typically used in these systems. Rios and Insua (2009) suggested the use of influence diagrams to structure a decision problem (although both sides do not necessarily agree on preferences and beliefs). Li and Sheng (2011) developed a model for training software agents to reason under uncertainty during price negotiations within expert systems. Another branch of this research examines not the technology, but the human side of negotiating and/or interaction. For example, Lee and Kwon (2010) looked at what causes a user to accept a negotiation system.

This short review of research from 2005 indicates that the lines between the stems are blurring. There is a clear overlap of KMDSS and data warehouse research; negotiation support, while its research is somewhat focused in the realm of artificial intelligence, also needs to draw on the data and knowledge within an organization for its efficacy. Moving into the future, these stems are changing.

3.2. Back to the Future

Arnott and Pervan's (2005) model provides a basis for understanding DSSs research as it stands currently. However, we believe that looking forward without remaining cognizant of the past may cause us to miss salient and interesting points. We made the point earlier that many of the key issues in early DSS research (e.g., information representation, user challenges) are still with us today. Looking backward in order to gain perspective, we chose to draw on Alter's work as a basis of key issues emerging from the first decade of DSSs research. A passage written by series editors Peter Keen and Charles Stabell, from the foreword of Alter's book, *Decision support systems: Current practice and continuing challenges* (1980), is of particular interest. Speaking of the series label of decision support, they say: "The term serves to highlight the need for concepts and methodologies to exploit *any available technology*" (Alter, 1980, p. ix, emphasis added).

What are abiding issues in DSSs? Over the last several years, research has waxed and waned between the behavioral aspect of decision support and the technical side. Emphasis on simulation, modeling, automated decision processing, and the like often remove the organizational member from consideration in the process and support the idea that a decision support system is a technological, rather than an organizational, concept. This changing emphasis may be part of the reason behind the inconsistencies in term usage in the popular press, with such terms as business intelligence, decision support system, and business analytics being used. Alter (2004) addresses this point when he states: "Decision support is not about tools per se, but rather, about making better decisions within work systems in organizations" (p. 320). He suggests that most work systems include an element of support for decision making and, therefore, adopting the term "decision support within a work system" (p. 326) may be more useful.

Ultimately, for research to continue to produce meaningful ideas for organizations, researchers of the future must strive to integrate technology evolution into the concept of organizational decision support while understanding that technology, decision-making processes, and organizational support are different foci of the research. As we move into the next decade of DSSs research, the categories drawn from Alter's research (1980) are still relevant. There are still data and model-oriented systems; file drawer systems (mechanized "file cabinets") are still a primary data storage and retrieval means. Whether data is stored in a database, data warehouse, knowledge base, or a yet to be defined storage type, it is the facilitation of the interaction with the data that has been, is now, and will be of importance. In this sense the issues of the past are still driving the future of DSSs, but each new age of DSSs research deals with newer technologies and greater understanding of decision-making processes. Alter (2004) later suggested nine broad categories of potential future research under his work system support suggestion. These include the business process, participants, information, technology, products and services, customers, infrastructure, environment, and strategy. These categories have been investigated, and will continue to be investigated as DSSs research evolves. Rather than investigate local customers, technology now allows us to investigate global customers. Decision makers that were located in the same room can now be located anywhere in the world. Mainframe and terminal infrastructures have given way to cloud computing. In each case, any available technology is being used; the facilitation of the decision support process is what is of interest moving into the future.

In his book, Alter (1980) speaks of future trends. Predictably, among the trends are the development of hardware and software. Like Alter in 1980, it is difficult for us to predict where the confluence of hardware and software will be in the coming decades. On the brink of the personal computer revolution at the time of his book, Alter notes that such a development may well change DSSs. It did, of course, bringing the concept of DSSs closer to the user, with more information, more powerful analytics, better graphics, more useable interfaces, and quicker responses. Now we are on the edge of the next revolution, a full move to mobile and cloud computing. Unlike the move to personal computers, however, these new technologies and associated software packages are changing where we interact with data. A salesperson can now run sales analytics sitting in a client's storeroom, yet the data appears no different from when it was running on a PC in the salesperson's office. It may come from multiple sources in "the cloud" and be "mashed-up" using a range of technologies to accommodate a new range of data types, such as news items, blogs, wiki entries, and/or video. In fact, the speed could be somewhat less because of the nature of mobile technology, but it may still be fast enough to support the decision-making process. Technology has allowed business models to change, and leveled some playing fields, but ultimately the complexity of decisions and what is needed to support them has been increased, not decreased, by those advances.

In 1980, Alter also noted some future trends with respect to organizational members. One was that individuals were (at that time) becoming more comfortable with computers, thus reducing the uncertainty that came with DSSs in organizations. The second was that students were coming (at that time) into organizations having had an education that included computing at some level, thus bringing not only comfort and understanding of computers with them, but occasionally a skill set in computing. Most individuals entering the workforce today do not remember an era in which a computer was not part of a daily routine; many are well versed in the art of smart phones and social media. While this does not necessarily make the concept of DSS more difficult, it does make design and implementation of systems to support decision making more difficult, as multiple venues for delivery must be considered. Indeed, many employees now bring their personal technology into the workplace (i.e., iPads) to support their decision-making processes. Future DSSs research must incorporate personal as well as institutional decision support tools.

Alter's (1980) study primarily found efficiencies through automation of clerical tasks (thereby freeing time for an individual) and through problem-solving expedition. Particularly, faster turnaround of tasks was enabled, accuracy and consistency were increased, and the DSS provided an advantage in problem structuring. In today's economy any problem is fraught with uncertainty. Even a routine problem from a year ago, such as what inventory to stock for a holiday period, has uncertainty when consumer confidence rises and falls in an uncertain economic environment. Developing problem structures will continue to be a problem for future DSSs researchers. In the early DSSs days, the data on which the DSS drew was primarily organizational. Now, however, DSSs and their counterparts must draw data from a vastly larger pool of information. Not only is there the technical aspect of how to find, extract, transform, clean, and load the data into the system, but there are the more practical matters of what data to seek and to collect, how often to obtain it, how to gauge its accuracy and relevancy, and how to protect the organization's systems during these processes.

While much research indicates that both breadth and depth of information is necessary for good decision outcomes (e.g., Kim, Hahn, & Hahn, 2000), there is also a need to structure the information available to the decision maker in a way that supports the process without resulting in information overload. Hall and Davis (2005) propose a perspective-based decision-making model that develops and synthesizes perspectives. The model not only affects the current decision context, but grows organizational memory, and expands the organization's shared mental model. This feeds into knowledge and databases, providing necessary information for data warehouse support of decisions and negotiations.

Clearly, DSSs is alive and well and its future is bright. There is yet much to do, and, as it has in the past, the field will continue to ebb and flow with the evolution of technology. The task in the immediate future is to understand the pervasiveness of technology in the lives of organizational members and fully understand how best to design processes that use the capabilities of technology to promote enhanced organizational outcomes. We believe that the future holds a number of potentialities, a theme that we elaborate next.

4. Future Trends

Taylor, Dillon, and Van Wingen (2010) suggest that IS research from 1985 through 2005 indicates an evolution that moves forward in six ways: inter-business system research, IS strategy, Internet applications, IS thematic research, qualitative methods research, and, most important from our perspective, group work and decision support research. They note that the continuity of research during the 30 years reviewed indicates that its place is strong as a specialized subfield of the IS discipline. We contend that this is true because it is difficult, if not impossible, to separate the process of decision making from the process of managing. Indeed, we see DSSs today still supporting Mintzberg's (1971, 1973) four decisional roles of management: entrepreneur, disturbance handler, resource allocator, and negotiator.

Holsapple and Whinston (1996) assert that the classical functional views of management (e.g., Fayol, 1949; Urwick, 1943) do not prominently feature decision making or necessary knowledge handling. Despite this, the functions (e.g., coordinating, organizing, commanding, planning, etc.) are certainly knowledge-based activities that require not one but a series of oftentimes interconnected decisions. Although managerial functions may not have changed since early management research (Fayol's research first appeared in 1916), the technology available to support it has. Project management software, exception reporting software, collaboration/coordination systems, and others have freed managers from the technical aspect of these functions, allowing them to focus on the more challenging knowledge acquisition, analysis, and decision-making functions inherent in each.

In this final section we discuss future trends by extending the Arnott and Pervan (2005) model and by incorporating current movements and trends in technology. There is a continued shift from building systems to configuring solutions delivered out of the box or a mash-up of services and streams of data pulled together to address a pressing need, personal or organizational, across all of the trends.

4.1. KMDSS and Data Warehousing

We predict that the research streams of KMDSSs and data warehousing will merge, and the focus will incorporate better ways to allow organizational members to interact with available information, wherever and whenever it is available. This is likely to be the most active area of research, as it is the most comprehensive. It is evident in the current research discussed above that such a trend is already underway. As the complexities of decision making increase and the availability of information increases, there will be a need for larger and more analytically based data infrastructures to be aligned with knowledge and decision-supporting technologies. Our contention is that such a merging of trends is already occurring and is supported by the use of tools by firms such as Netflix, Amazon, and Google (ranked, best fit algorithms), all of whom hope to increase revenue through providing a customer experience that leverages data to help customers make informed, knowledgeable decisions.

Much of the data that these organizations manage, such as films, satellite images, spatial information, and data in social media, do not fit well into the highly structured requirements of relational databases. Research on "NoSQL" (not only SQL) databases may provide much more flexible ways of storing and accessing data than have been available in the past. Indeed, Amazon and Google already have such databases in place (Leavitt, 2010), and Oracle recently announced the release of a NoSQL package (Jackson, 2011). This infrastructure will enable the integration of vastly varied kinds of information within knowledge management systems built on data warehouses.

The merging of data warehousing with knowledge management DSSs shows a synthesis of efforts that is customer centric (Alter, 2007) and designed to deliver timely information for real-time decisions based on the speed that evolving technologies now demand. In the past developing a data warehouse/business intelligence solution could take years, but with today's appliance bundles, an entire organization can have a wealth of knowledge at its fingertips in seconds. This customer centric view of decision making is closely tied to the use of social networking and how it factors into a person's decision making. Consumers now consider how many Facebook "likes" a product or service may have or the current tweets about a show or restaurant before making a decision about a product or service.

Customer decision making is further fueled by the ability of mobile technologies to provide quick information on a variety of topics almost anywhere, instantly. In fact, one local organization that one of the authors has encountered offers iPads as part of the in-store shopping experience so that customers can compare competitor prices. Figure 2 summarizes our extensions to Arnott and Pervan (2005), adding the context of social and mobile computing that now must be considered across DSSs research.

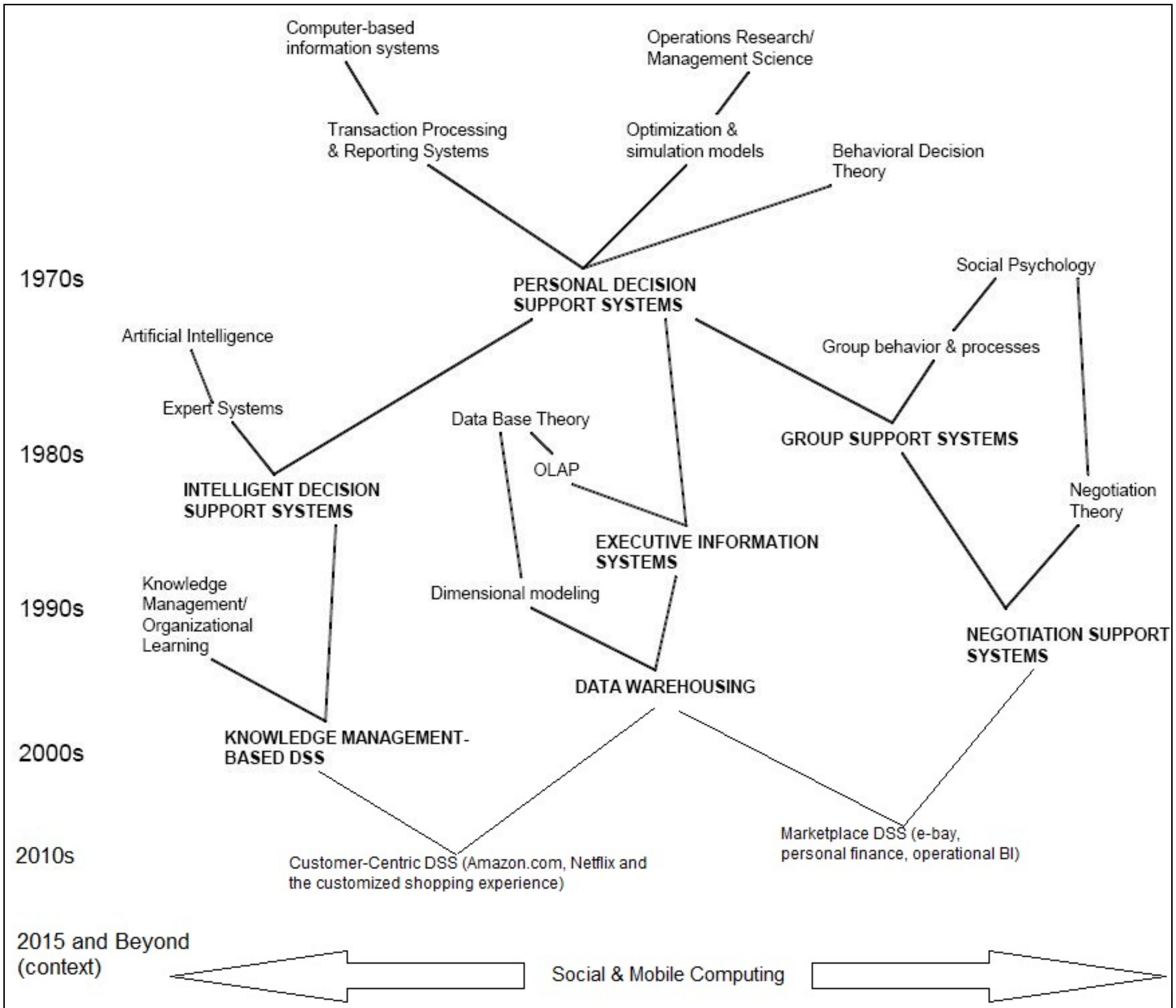

Figure 2. Updated and Extended Arnott and Pervan (2005) Timeline

Increasing information available to KMDSSs through data warehouse capabilities may be useful to the security industry. While information systems generally can be used to detect intrusions, a DSS has been developed for the purpose of information security planning. El-Gayar and Fritz (2010) have developed a system that approaches the problem of information security planning using the methodology of multiple criteria decision making, an approach that requires large amounts of information that is both factual and contextual. Their system uses the philosophy of multiple perspectives for decision support as first developed by Churchman (1971) and extended by Courtney (2001) and Hall and Paradice (2005). A DSS has also been developed that helps calculate which countermeasures are most effective during an attack. This DSS helps users by analyzing measures that reduce the levels of uncertainty threat rate, countermeasure cost, and asset loss (Rees, Deane, Rakes, & Baker, 2011). Other DSSs help a business determine whether obtaining customer information is a valuable investment given the volatile nature of the asset (Lee, Kauffman, & Sougstaf, 2011). Genetic programming can be used to improve intrusion detection (Hansen, Lowry, Meservy, & McDonald, 2007). Thus, the increasing concern with all aspects of data security is well situated for novel DSSs research.

One could continue nearly indefinitely with new uses for data and knowledge-enhanced DSSs. As has been the case for four decades, DSSs has been on the forefront not only of new technologies, but of new ways to address existing business problems and processes. For example, a DSS was recently developed for rural housing architects in Iran (Habib, Sartipipour, Garakani, & Rahimbakhsh, 2011). DSS have also been developed and used for some time to help investors develop and maintain profitable investment portfolios, beginning with the interactive financial planning system launched in 1978 (Weber, 2008). Generally, DSSs moderate the tradeoff between risk and reward in a portfolio transaction (e.g., Dong, Du, Lai, & Wang, 2004) by examining data and performing calculations or simulations quickly and accurately. Recently, particularly with the rise of individual investors needing support, conceptualization of mobile financial applications has begun. Burstein and Holsapple (2008) review the approaches available for such an application, developing a prototypical mobile accounts manager called iAccountsMgr. This concept blends the needs of the savvy financial investor (such as real-time data and quality of decision information) with the mobile needs of today's busy executives. A quick scan of news services in October 2011 shows development of a DSS for drilling rig selection (www.worldoil.com), a support system designed for marketers to better understand Facebook users (www.microstrategy.com), and a rail yard management system (www.ubisense.net). The nature of DSSs is to continuously improve the decision-making processes that, in turn, improve the efficiencies of organizations.

Data and knowledge-enhanced DSSs will continue to be a main stream of research well into the future. Future research opportunities include better understanding the complexities of decision making in today's highly uncertain environments, how to best balance the speed and breadth of available information against the cognitive limitations of the human processor, application of DSSs in new contexts, and refinement of existing frameworks and algorithms. Given that much of the research in data warehousing is technically oriented, there is room to explore enhanced algorithms for data retrieval/sorting/manipulation, ranking, the extraction/transformation/load (ETL) process, and other technical innovations to improve efficiencies in the warehouse, as well as the interaction of the warehouse with other facilities such as DSSs, KM, and collaborative systems.

4.2. Social Media Decision Support

Our second future trend is that of social media as a means of decision support. We separate this domain because it is unique, "cutting edge", and, therefore, will likely dominate the next decade. Additionally, it is primarily a behavioral, not a technical domain. Social networking plausibly extends group support systems, but rather than brainstorming organizational requirements, users may brainstorm more socially-oriented entities such as movie or restaurant popularity. This is often done through the voting process or the process of liking a page in Facebook or a publicly posted comment. Negotiations may take place in, or be supported by, social media, such as in a number of games within Facebook where players must barter for products and services.

However, social media is not only a pastime. Social media can be and are used in the organizational arena to help consumers make informed product or service decisions; this is a relatively new business model that has not been adequately explored. Social media also provides a basis for organizational decision making using idea generation and ranking tools such as those provided by Spigot (www.spigot.com). Notably, social networking applications are beginning to be seen in critical decision-making fields. For example, social networking has been discussed as a tool to support pilot decision making (Scott, 2011) or decision making in healthcare (Griffin & de Leastar, 2009). One of the authors currently has a graduate student working on a system to integrate live feeds from Twitter and Facebook to provide current information to emergency response teams. These systems use a combination of the algorithms and structured data that traditionally make up a DSS but adds the evolving technology of Geographical Information Systems and social media to the models and information that aids decision making.

The Weather Channel (www.weather.com) captures social media feeds online so that people can quickly see what the weather trends are across the country. Recent research has explored the relationships among gender, age, and a social networking site member's propensity to be affected by advertising through that venue (Taylor, Lewin, & Strutton, 2011). Each of these examples shows that social media is a pervasive technology that has been accepted by organizations as a viable platform; exactly what its potential and limitations are is something that future research can explore.

One area of research that has been a continuing theme throughout DSSs (and organizational) research that will have particular importance to social media is that of trust. Researchers have long investigated the relationship between trust and information systems. Of importance to social media is a development of trust measures for e-commerce conducted by McKnight, Choudhury, and Kacmar (2002). However, recent research indicates that what we thought we knew about trust in information systems artifacts may not hold true for social media. People tend to attach social characteristics to IS artifacts (Al-Natour, Benbasat, & Cenfetelli, 2011). Because many social media users communicate primarily with individuals through the network of people whom they know personally (e.g., Ellison, Steinfield, & Lampe, 2007), the idea of trusting social media itself (that is, the artifact) may not be as important to the member as is trust in the member's friends. Kolek and Saunders (2008) found that very few Facebook users (11 percent) restrict access to their profiles, and Tow, Dell, and Venable (2010) found that most Australian Facebook users divulged private information. This indicates that future researchers should investigate what types of trust will influence decision makers in the social media arena, and, as a side stream given Tow's research, how to increase privacy and security in the face of seemingly nonchalant users.

Another area of social media is that of virtual worlds/communities. Second Life and other such communities are used not only by individuals as pastime games, but also by businesses as test beds and as training tools (e.g., Condic, 2009). The military has considered it for both training and recruiting (Cacas, 2010). The popularity of these sites is unquestioned, but whether they create true business value is less clear. The role of identity in decision making in these environments comes into play, as does the question of whether people make different decisions (and need different types of decision support) as avatars that are not accurate representations of themselves. Another area of concern is how to get people to engage in these communities. Porter, Donthu, MacElroy, and Wydra (2011) suggest that both embeddedness and empowerment are necessary to elicit cooperative, engaging behavior from community members. Interestingly, trust played a large part in these findings.

4.3. Mobile Computing

Our third area that we see as a future trend is mobile computing. This is a more technical area and incorporates all of the previous forms of DSSs research. Mobile computing is a facilitator that provides the means for the user to interact with existing systems, regardless of the location of either the user or the system. Like social media, mobile computing is becoming pervasive as a technology and is often embedded in the user's environment. For example, GPS units placed in transportation vehicles constantly monitor the position of the vehicle and often broadcast that position to a monitoring station so that companies can track their fleet, or so lost or stolen vehicles can be located. These units not only relay information such as location, but can record information as the vehicle travels, such as distance, speed, stop time, and so forth. Over time, the organization can develop averages for routes that can be used for predicting needs and standardizing deliveries.

Mobile devices provide a new platform for DSSs that challenges traditional approaches to DSSs. The size, speed, and reach of data combined with continuously available support introduces a substantial technological advantage to decision making. Mobile devices capture image data and allow for real-time monitoring or updating of data from the field, which, in turn, can be fed back into the decision loop.

Mobile computing has complexities that will require some foundational work, however. Although the technology exists, building the bridges that will connect users to resources can be difficult. Thus, there will be some interest in evolving both the technology and the use of the technology. Neyem, Ochoa, and Pino (2011) developed a system to coordinate collaborative systems designed specifically for mobile applications. Their design overcomes the difficulty that a centralized system used by non-mobile applications presents to mobile applications.

Others are looking for ways to use mobile technology to make consumer or organizational members' lives more enhanced. Sense Networks (www.sensenetworks.com) is a company that makes use of reality mining (a subset of data mining) to use location indicators such as those emitted by GPS to aggregate activity. Businesses can track customer activity (macrosense), or individuals can join groups that frequent the same locations (Citysense). In the same vein, Path Intelligence (www.pathintelligence.com) creates databases of pedestrians.

4.4. Negotiation Support Systems

We see negotiation support as increasingly important. Holsapple and Whinston (1996) also defined NSSs as those that, regardless of other features, are designed with the primary intention of negotiation facilitation. Far from simply providing and ordering information, or facilitating communication or coordination, negotiation is a complex context with a multitude of issues. Among them are the issues of the negotiation, participants, group or organizational, negotiation strategies, rules, whether the negotiation is expected to be discordant or harmonious, and so forth. These NSSs are, then, a mixture of technical and psychological characteristics. Technical aspects such as risk analysis may be used to overcome psychological aspects such as uncertainty aversion.

Thus, building on the Holsapple and Whinston (1996) definition of NSS, we propose a trend merging data warehousing with NSSs as currently seen in Ebay for personal negotiations or line workers using business intelligence in day-to-day transactions (i.e., insurance call centers providing quotes). New areas of DSSs research can develop around social network technologies and the increasing use of mobile technologies to access data for business and personal use.

4.5. Historical Realization

This expansion into new areas of consumer and market place decision support as well as personal decision support may well be the realization of the "human" decision support system proposed by Holsapple and Whinston (1996), who compare what a DSS should be able to do with what a person who supports a decision maker can do. Referred to at one time as a human decision support system (HDSS) (Huber, 1980), this person supports a decision maker by responding to requests, processing information, summarizing reports, storing, retrieving, and transferring knowledge, and so on. These systems make the point that machines and humans differ on two primary levels. First, humans are capable of learning, both through training and experience, whereas the machines in that era learned through programming. Second, humans are capable of speech, which carries with it nuances, inflection, and semantics not available to machines of that age. These systems also make the point that technology may close those gaps through, among other things, the use of artificial intelligence to emulate human behavior. The evolution of technology to the point of Watson, discussed earlier, shows that the development of an "electronic HDSS" could well be in the future for DSSs research. As we respond to meeting requests in our calendar software or beeping reminders for this or that, it does seem that we are incorporating more "human-aide" elements into our daily lives, especially as speech recognition software rises in use (e.g., Apple's iPhone 4S), this trend of support will only continue to grow.

4.6. Trending Summary

Holsapple and Whinston (1996) discuss how decision context influences decision making. Examples include the management level of the decision maker, whether the setting is established or emergent, and the design of the organization. They conclude that the type of support that the decision maker has available (i.e., the DSS) is in itself a context. Given our contention that technology has evolved to include those that allow organizational members to interact with organizational data from anywhere (mobile computing) and extends beyond the traditional boundaries of organizations (social media), this last point is as important today as when it was written in 1996. Furthermore, it supports our contention that DSSs research will evolve less along technological lines, but more along the lines of how the existing technology, in all of its forms, can best be positioned in the support of knowledge management and decision support.

Figure 2 adumbrates our extensions to the DSSs timeline, but also adds the context shift that mobile and social computing have introduced across all aspects of DSSs. Moving DSSs research into the future will require that researchers begin to work toward integrating the complex processes of human thought and human behavior with business needs and technological support. While simple to state, learning to "unthink" in order to move forward is itself a difficult task. As we move forward in DSSs research, adoption of new technologies is but a small part of the process. Use of new and creative methodologies, borrowing frameworks from other disciplines, and stepping far enough back to see the whole picture is required. Paraphrasing the words of Churchman (1971), we must challenge existing knowledge of what a DSS is and its place in decision making, and work to refine the measures by which we have defined DSSs.

5. Conclusion

This historical commentary is less prescriptive than other works; it highlights the plethora of DSS research and collaboration opportunities that currently exist or are within our reach in the near future given the trends identified and shown in Figure 2.

While we agree with the assessment of Arnott and Pervan (2005, 2008) that there has been a decrease in the number of publications in the field, our analysis shows that DSSs maintains a vitality that is readily evident in the citations of DSSs research and a continued growth of use in industry. It could also be argued that a decrease in DSSs research publication could be attributed to the branching nature of the DSSs field. As research drills into specialized topics, such as data warehousing or knowledge management, decision making and decision support may not be explicitly mentioned. Yet, the research in this specialized topic, upon further review, could be distilled to systems that are supporting some form of decision making.

Thus, we suggest that the model proposed by Arnott and Pervan (2005, 2008) can be expanded to include social media, web applications that help consumers make decisions, and mobile services that provide real-time data, among other areas. These new branches of DSSs show the increasing ubiquity of decision support in personal and organizational outlets outside of IS. Any perceived decline in DSSs research interest in IS results from a narrower focus on DSSs embedded as an older conceptualization of traditional developing "from scratch" systems to support decision making, rather than capturing the broader range of DSSs research that has spread to reference fields as "bolt-on" services, functions, or widgets that now support decision making.

Based on this assessment of the current state of DSSs research, IS researchers can use this focus on specific areas of support to design and test holistic systems that incorporate all categories. Given the variety of decisions that confront users on a daily basis, the research opportunities to understand the human-technical interaction outlined in the trends above are almost limitless. Coupled with the need for increasing flexibility in systems to handle rapidly changing user preferences and environmental factors, the range of DSSs research can cover social-behavioral to very technical research.The pervasiveness of decision-making needs across research disciplines is evident, as well. The continued need to pair traditional IS approaches to DSSs with new fields that require decision support is imperative. This pairing further establishes the IS field as a reference discipline and illustrates the need for IS research collaboration outside of the field.

However, this model is not only appropriate for DSSs researchers. Anyone with an interest in supporting the process of decision making can use the same categories to focus on complexities not only of technological support, but also behavioral and procedural support. Those in business can use it to extend their understanding of the complex nature of decision making in the organization and to allocate resources appropriately to provide support for creative and innovative decision making.

DSSs research must continue to evolve and is undoubtedly viable for many years to come; however, we must not forget the past and the importance of past research that can inform future DSS innovations. This brief history provides a unique multi-generational perspective designed to stimulate new IS research and growth and serves to remind us to occasionally look at the past to potentially see some benefit for the future.

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