# Personalized Decision Support Systems



**Neal Shambaugh**
*West Virginia University, USA*

## INTRODUCTION

**Decision support systems** (DSS) are computerized systems that assist humans to make decisions. Early versions were designed for executives, but over time DSSs were designed for workers at any level in the organization (Keen & Morton, 1978; Rockart, 1979). Due to increasing costs in providing benefits and services, organizations are forcing workers and consumers to take increasing responsibility for insurance, health care, and financial planning decisions. Extreme events, such as terrorism, pandemics, and natural disasters will swamp the capacity of governmental agencies to serve their citizenry. Individuals in affected communities must turn to local agencies or ad hoc groups for assistance. **Personal decision support systems** (PDSS), consisting of databases, model-based expertise, and intelligent interfaces, along with wireless communications, Internet resources, and personal computing, provide sufficient resources to assist informed individuals and groups in solving problems.

This article reviews the typical components of a DSS and the different types of systems that have evolved. The article poses three types of problems facing individuals, including routine problem solving, immediate survival needs, and long-term evolutionary growth. Personal decision support issues of acquiring information, processing information, and dissemination are outlined. Future trends and research opportunities are discussed.

## BACKGROUND

DSS aid human thinking by accessing information, integrating this information in some way, structuring decisions, and optimizing decisions (Sprague & Carlson, 1982). These benefits are obtained using three major system features of a DSS, which include a database, which records knowledge; a model base, which models or represents expertise and problem-solving; and an interface, which provides a user with a means to interact with the other system components (Sprague, 1980).

Powers (2007) characterized DSS in terms of how the system provides assistance. Model-driven DSSs for individuals include spreadsheets. Data-driven DSS, such as **Executive Information Systems** (EIS), are used by organizations and institutions for strategic and tactical decisions. Communication-driven DSSs can be seen in groupware, video conferencing, and bulletin boards. A document-driven DSS, such as provided by search engines, facilitates document retrieval. A knowledge-driven DSS would be used to solve specialized problems and consist of knowledge represented in terms of rules, procedures, hierarchical frames, or networks. Most recently, web-based DSSs are found in browser searching, intranets, and portal use.

Decision support systems are based on the notion that human reasoning is a rational process, although this is not always the case particularly when humans are faced with complexity and stress (Druzdzel & Flynn, 2000). Experts' decisions in real settings have been shown to demonstrate less quality than linear models (Hastie & Dawes, 2001). Judgmental heuristics reduce cognitive load but decrease the quality of decisions. Characteristics of the DSS components vary in a PDSS in order to compensate for the type of problems faced by individuals. In general for a PDSS the data bases are customized, the model bases are organized along preferential outcomes (e.g., more or less, quantitative), decisions (e.g., lists and value ordering), and uncertainty (specific actions resulting in gain considering constraints and price).

## PERSONALIZED DECISION SUPPORT

This article summarizes three problem types facing individuals, including routine problem solving, extreme survival needs, and long-term change. The article outlines system architecture requirements in terms of acquiring and processing of information, interacting

with this information, and the dissemination of information and recommendations.

## PDSS Problem Types

The consumer of the 21st century faces numerous **routine problems**, such as career choice, self-improvement, volunteerism, financial planning, retirement, insurance, consumer purchases, health care physician, and personal health. PDSS applications can be seen in health care ranging from point-of-care use of personal data assistants (PDA) to helping patients make decisions on health care (Crawford, 1997; Pierce, 1998). Routine problems consist of complex options with short-term benefits and unknown long-term implications. However, individuals tend to discount the need to make decisions and/or the belief that institutions and governmental agencies will impose decisions on them.

A second problem type can be classified as **survival**. Three examples include natural disasters, terrorism, and pandemics. Natural disasters, such as hurricanes, tornadoes, floods, drought, volcanic eruptions, earthquakes, and meteorite impacts, can also include gradual changes brought about by global warming. Radical changes could involve results of nuclear winter, the shift of the moon's orbit, or pole shifting of the earth's magnetic field. PDSS applications involve disaster management and attempts to connect satellite mapping technology with government agencies (Hegde, Srivastava & Manikiam, 2004). Terrorism provides a more recent survival problem brought about by racial cleansing, violence between religious groups, undermining of governments through corruption and assassination, chemical warfare, and destruction of neighbourhoods and infrastructure. PDSS applications for this problem type has emerged for counter-terrorism applications (Alward, 2004). Pandemics have always occurred throughout human history but have taken on serious implications given technological developments in genetics. Survival problems cannot be predicted, fully characterized, and their impact overwhelms the capacity of a DSS. The value of a PDSS is its proactive potential by identifying national, state, and local resources, recommending action, and triggering the development of institutional support and awareness that did not exist before.

A third problem type is evolutionary or long-term change brought about by a realization that existing decision paths may lead to significant consequences. Awareness of **change problems** signal a need for people to make long-term proactive decisions in light of multiple paths or scenarios (Schellnhuber, Crutzen, Clark, Clausssen, & Held, 2004). Proactive decision-making enables humans to become aware of and address serious consequences of prior decisions by individuals, groups, institutions, and governments, as well as the impact of technological innovations. However, change problems tend to be low priority, require significant resources, and they resist consensus due to their apparent intractability. Simulations and virtual environments may be needed to help citizens interact with potential paths (Stanney, 2002).

## Personal Decision Support Architecture

Early views defined a personal DSS as one which focused on a discrete task or decision (Rockart & Bullen, 1986). Examples frequently involved group support, such as Morton's (1971) DSS which involved both marketing and production planning. Keen and Hackathorn (1986) identified three main parts of a personal DSS to include the interface between machine and user, relevant operators (i.e., action verbs, such as "help"), and a database. Development of a personal DSS requires attention to dialogue, refinement of the vocabulary-operators, and evolution of the data structure of the database.

PDSS, as described here, would involve both individual and social needs, and thus would be hybrid versions of several DSS types (Powers, 2007). A PDSS would include mathematical and statistical tools (model-driven) to calculate and make inferences on numerical data. They would retrieve forms and information (document-driven) to support decision-making. They would use information and data as input to address specialized needs (knowledge-driven), such as health care, insurance, career options, and travel planning, among others. The PDSS would consist of both localized (personal computer system) resources and distributed (web-driven) sources where information and computing may be conducted at other sites.

The major systems of a PDSS include databases, reasoning models, interface, and communication options. Each of these four systems can be equated to acquiring information, processing this information in ways that make it amenable to specialized decision modules (e.g., insurance, health-care, travel planning), interacting with the information visually, and com-

*Figure 1. PDSS system features*

| Acquiring | Processing | Interacting | Disseminating |
|---|---|---|---|
| Databases | Model bases | Dialogue-Interface | Communication |
| • Local, personalized<br>• Remote, browsing<br>• Remote, integrated | • Expertise<br>• Specialized functions<br>• Heuristic patterns<br>• Context objects | • Desktop metaphor<br>• Personal metaphor<br>• Task-specific<br>• Just-in-time | • Wireless<br>• Internet posting<br>• Internet feedback<br>• Portals<br>• Collaboration |

municating or sharing decisions or information with others (see Figure 1).

## Acquiring Information

Databases provide a repository for information within any DSS. A personalized version of a DSS would combine local databases, which are developed individually for specific needs, with remote integrated databases. These databases would consist of inconsistent structures, while in the long term some standardization of database structure would be required to develop a personalized integrated database. In addition, ad hoc browsing tends to characterize individual information needs with little regard for organizing this information over the long term.

## Processing Information

One of the powerful features of a DSS is its model base. Modeling allows knowledge to be applied across problems and facilitates analysis, explanations, and advocacy (Druzdzel & Flynn, 2000). A model base would include one or more models or representations of expertise ranging from highly specialized (e.g., resale home value) to more general (e.g., model of a learner). Model bases might become object-oriented and incorporated into a PDSS like a software plug-in as needed. Generic versions of a PDSS might include a range of common model components for financial, employment, travel, and health needs and provide simulations to help a user see the implications of decisions. Integrating model bases, as with databases, will require some standardization of model structure along some common categories. Personal patterns of reasoning may also be archived to provide speed and options for new problems.

The most important and the most challenging to archive and characterize would be context information, an example of unstructured data. A top-down version of a system that would increase the structure of the context-data would be to categorize specific routine contexts, such as financial, health, college selection. Extreme survival categories could include natural disaster and other types of emergencies, crime and terrorism, and pandemics. A bottom-up version of a context representation system would be to identify patterns of information using semantic webs (Hädrich & Priebe (2005), and over time a context-map would be built to characterize particular categories of context.

## Interacting with Information

Human dialogue with databases and model bases has used a visual interface, which has typically featured a desktop metaphor. To date users have relied on the metaphor presented to them. A customized interface could still use a desktop metaphor to organize individual problem needs. Other options could be available and custom-developed, which might still rely on an inventory of choices or through some metaphor of choice. Specialized interfaces could be used depending on the problem type (routine, survival, change) to facilitate decision-making. Survival needs require that a user not be presented with too many choices, but rather accurate options to meet an immediate need. These just-in-time visual views present just the information and advice as needed (Lieberman, 2002).

## Disseminating Information

The dissemination function, involving the communication and sharing of information and decision options with others, represents a critical system component of a PDSS. While routine problems relate to an individual, problems of survival and change require collaboration. Multi-point sharing of information facilitates decision-making. As wireless becomes a standard feature in many technological devices, dissemination and communication increases for more people. Wireless may become an antiquated term as it becomes transparent and common. Information can be posted for everyone or particular audiences and can be edited or linked to other sources. Much of this information and collaboration may become routed through **personal portals** which structure the information for other users (Shambaugh, 2007).

# FUTURE TRENDS

## Future Design Metaphor

One feature of a DSS includes the retrieval of information so that decisions can be made based on this information and other sources. Decisions are then based on existing data or data from the past. Goals of profit and cost reduction rely on what-if scenarios and simulations based on assumptions. The focus of individuals, however, is rarely on the past but on the present and the near future. Although the future cannot be predicted, trends based on past and current data provide a picture of where we are in our business, career, or personal life. Making decisions on what we want our life to be for ourselves, our families, and our communities, and even "what business are we in?" necessitates a different view that of **future design**, which is not about predicting the future but rather working towards a future based on our intent to continually cycle through rethinking, designing, and improving.

## Government and Community

Responsibility for daily life has always been the domain of the individual and the family. However, the historical reality is that daily life has been continuously constrained by institutions and governments, and by the unseen consequences of technological innovation. Much of daily life requires navigating these constraints and impacts. However, these tensions can be ameliorated with a move towards taking advantage of personal insight and motivation, a belief in taking responsibility for our lives and our communities, and designing our technological tools for where we want to go, all features of a future design stance.

## Research Opportunities

One avenue for research is to add more structure to unstructured data, including information from remote sources, locally-developed databases, and context information. How might these different sources of information be integrated and generalized for use by others? How might context be characterized in terms of re-usable objects?

Modeling expertise has been a long-standing challenge in AI. Modeling decisions for routine problems, those that can be characterized by rules or procedures, and use static domain models, have been the most successful. But a bigger question beyond *What do we know?* becomes *How does the model update itself*?

Decision-making in survival situations will require customized model bases developed specifically for categories of extreme survival. In these type of situations problems are unique and tools will need to be developed see how users' beliefs about uncertainty and preferences on different outcomes can be visualized (Howard & Matheson, 1984). Evolutionary decision-making, decisions that impact long-term change, will require that model bases evolve from new data. Continually re-defining expertise provides opportunities to analyze what people do on a daily basis (Gigerenzer, Todd, & ABC Research Group, 1999) and how daily, routine expertise becomes critical for individuals and groups of individuals.

Furthermore, inquiry could be conducted on how informed citizens create new societies, **epistemic cultures** that are themselves creating new bodies of knowledge (Cetina, 1999). These new societies could be a block of families, an online community of individuals, or physical neighbourhoods, cities, or countries, or geographic regions. The idea of a PDSS does not limit itself to an individual but to personalizing human life as tools to help individuals, neighborhoods, and cities grow (Longworth, 2006). The conundrum for researchers and designers is realizing that in designing systems that are less logical and more approximations

of the messiness of real life they may be helping humans come to understand what it means to be human (Johnson, 2005).

Another research avenue would study how users might determine the user interface, based on personal metaphors or specific needs, rather than reacting to a standardized metaphor. The study of mental models and how humans project meaning from their experience to a new experience might provide a new means to think and act beyond old rules (Fauconnier & Turner, 2002). Not all problems and situations require the same interface, particularly as the severity of the problem may require a design focused on immediacy and limited choice. Continued collaboration between AI researchers who study representation and reasoning, and those in Human-Computer Interaction (HCI), in which interaction is addressed, may lead to intelligent interfaces with flexible planning, incorporation of human constraint issues (e.g., time, patience, attention, motivation, cognitive demands), and relevance of context (Lieberman & Selker, 2000). Such intelligent interfaces may find themselves first in wireless devices, such as PDAs.

## CONCLUSION

Specific skills and responsibilities for living in the 21st century have been pushed down to consumers by organizations and governmental agencies. Individuals now require more time to make important decisions related to their personal and professional lives. These personal decisions add to the growing complexity of human living and require time and resources. Technological developments in computing, networking, and communication provide humans with the capacity for making informed decisions. With the prospect of survival threats and long-term change, informed groups of citizens can initiate proactive priorities in their national, state, and local governments to address these potential problems. A PDSS with features that enable communication and collaboration creates a tool to help individuals take responsibility for decision-making rather than relying on government and institutions. Personalized decision support, characterized by access to Internet resources, integrated knowledge bases, and personal computing and wireless communication, can provide humans with information and recommendations to solve problems, address emergencies, and enhance life.

## REFERENCES

Alward, R. (2004). *Personal decision support aids for special operations, Report of Syndicate One*. Retrieved on August 30, 2007 from http://handle.dtic.mil/100.2/ADA427997.

Cetina, K. K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.

Crawford, P. (1997). Computer-assisted decision support in health care. *Annual Meeting of the International Society of Technology Assess Health Care Meeting, 13*, 170.

Druzdzel, M. J., & Flynn, R. R. (2000). Decision support systems in A. Kent (Ed.). *Encyclopedia of library and information science*, *67*, Suppl. 30 (pp. 120-133). New York: Marcel Dekker.

Fauconnier, G., & Turner, M. (2002). *The way we think: Conceptual blending and the mind's hidden complexities*. New York: Basic Books.

Gigerenzer, G., Todd, P. M., & ABC Research Group. (1999). *Simple heuristics that make us smart*. New York: Oxford University Press.

Hädrich, T., & Priebe, T. (2005), A context-based approach for supporting knowledge work with semantic portals. *International Journal of Semantic Web and Information Systems, 1*(3), pp. 64-88.

Hastie, R., & Dawes, R. M. (2001). *Rational choice in an uncertain world: The psychology of judgement and decision making* (2nd Rev. Ed.). Thousand Oaks, CA: Sage.

Hegde, V. S., Srivastava, S. K., & Manikiam, B. (2004). *Space resources, operational services, and future plans.* India-United States Conference on Space Science, Applications and Commerce. Retrieved on August 30, 2007 from http://www.aiaa.org/indiaus2004/Disaster-management.pdf.

Howard, R. A., & Matheson, J. E. (1984). Influence diagrams. In R. Howard & J. Matheson (Eds.). *The principles and applications of decision analysis*, 719-762, Menlo Park, CA: Strategic Decisions Group.

Johnson, M. (2005). Swamped by the updates: Expert systems, semiclasm, and apeironic education. In S.

Franchi & G. Guzeldere (Eds.). *Mechanical bodies, computational binds: Artificial intelligence from automata to cyborgs* (pp. 365-388). Cambridge, MA: MIT Press.

Keen, P. G. W., & Scott Morton, M. S. (1978). *Decision support systems: An organizational perspective*. Reading, MA: Addison-Wesley.

Keen, P. G. W., & Hackathorn, R. D. (1986). Decision support systems and personal computing. In J. F. Rockart & C. V. Bullen (Eds.). *The rise of managerial computing: The best of the Center for Information Systems Research, Sloan School of Management, MIT*. Homewood, Ill: Dow Jones-Irwin.

Lieberman, H. (2002). Interfaces that give and take advice. In J. M. Carroll (Ed.). *Human-computer interaction in the new millennium* (pp. 475-486). Boston, MA: Addison-Wesley.

Lieberman, H., & Selker, T. (2000). Out of context: Computer systems that adapt to, and learn from, context. *IBM Systems Journal, 39*(3 & 4), 617-631.

Longworth, N. (2006). *Learning cities, learning regions, learning communities: Lifelong learning and local government*. New York: Routledge.

Morton, S. (1971). *Management decision systems: Computer-based support for decision making*. Cambridge, MA: Division of Research, Harvard Business School.

Pierce, P. F. (1998). *Choices: An interactive decision support program for breast cancer treatment.* Retrieved on August 30, 2007 from http://handle.dtic.mil/100.2/ADA369255.

Powers, D. J. (2007). *A brief history of decision support systems*. DSS. Resources.COM, retrieved on March 10, 2007 from http://DSSResources.COM/history/dsshistory.html.

Rockart, J. F. (1979). Chief executives define their own data needs. *Harvard Business Review, 67*(2), 81-93.

Rockart, J. F. & Bullen, C. V. (1986). *The rise of managerial computing: The best of the Center for Information Systems Research, Sloan School of Management, MIT*. Homewood, Ill: Dow Jones-Irwin.

Schellnhuber, H. J., Crutzen, P. J., Clark, W. C., Claussen, M., & Held, H. (2004). *Earth system analysis for sustainability*. Cambridge, MA: MIT Press.

Shambaugh, N. (2007). Personal portals. In A. Tatnall (Ed.). *Encyclopedia of portal technologies and applications*. Hershey, PA: IGI Global.

Sprague, R. H., Jr. (1980). A framework for the development of decision support systems. *Management Information Systems Quarterly, 4*(4), 1-26.

Stanney, K. M. (2002). *Handbook of virtual environments: Design, implementation, and applications*. Mahwah, NJ: Lawrence Erlbaum Associates.

## KEY TERMS

**Change Problems:** A type of problem with long-term consequences.

**Decision Support System (DSS):** A computerized system which assists humans to make decisions.

**Epistemic Cultures:** Bodies of knowledge developed by individuals with a common need.

**Executive Information System (EIS):** A decision support system that directly supports management decisions.

**Future Design:** A means of looking and working towards the future rather than predicting the future.

**Personal Decision Support System (PDSS):** A computerized decision support system which acquires information and organizes the information so that models of reasoning can produce recommendations for further information, resources, or action. Another feature of PDSS is its capacity to openly communicate organized information or decisions to others.

**Personal Portals:** A computerized site which provides a gateway other sites of individual interest.

**Routine Problems:** A type of problem faced by individuals involving complexity of choices as well as short-term and long-term implications.

**Survival Problems:** A type of problem characterized by extreme impacts on individuals and communities.