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Decision making and knowledge management in inquiring organizations: toward a new decision-making paradigm for DSS

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Abstract

Organizational decisions of the future may include social, environmental, and economic concerns, and be much more "wicked" [Policy Sciences, 4 (1973) 155], complex and interconnected than those of the past. Organizations and their decision support systems must embrace procedures that can deal with this complexity and go beyond the technical orientation of previous DSS. Singerian inquiring organizations [Australian Journal of Information Systems, 6 (1) (1998) 3; http://www.cba.uh.edu/~parks/fis/fis.htm (1998); Proceedings of 3rd Americas Conference on Information Systems, Indianapolis, August 1997, p. 293; Proceedings of the 1999 Meeting of the America's Conference on Information Systems, Milwaukee, August 1999; Special Issue of Information Systems Frontiers on Philosophical Reasoning in Information Systems Research (in press)], based on Churchman's [The Design of Inquiring Systems: Basic Concepts of Systems and Organization, Basic Books, New York, NY, 1971] inquiring systems and Mitroff and Linstone's [The Unbounded Mind: Breaking the Chains of Traditional Business Thinking, Oxford Univ. Press, New York, 1993] unbounded systems thinking (UST), are designed to deal with wicked decision situations. This paper discusses DSS and knowledge management in Singerian organizations and calls for a new decision-making paradigm for DSS.

Keywords: Decision support systems; Knowledge management; Inquiring systems; Inquiring organizations; Wicked decisions

1. Introduction

In one of the most widely cited works in the MIS/DSS literature, Churchman [7] described the work of five influential western philosophers (Leibniz, Locke, Kant, Hegel and Singer) from the perspective of systems theory. These five inquiring systems constitute different approaches to the creation of knowledge. It has been proposed that Churchman's [7] inquiring systems serve as models for the development of "inquiring organizations" [9,18,22,34,35].

This paper describes decision making and knowledge management (KM) issues in inquiring organizations. Relying heavily on work by Mitroff and Linstone [27], it is argued that a new paradigm for decision making is needed within decision support systems. This paradigm must address decision-making in more complex contexts than have been attacked in the past by DSS research. It is suggested that the Singerian organizational model, and what

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Mitroff and Linstone [27] refer to as unbounded systems thinking (UST), provide a way for DSS research to begin addressing these more complex, "wicked" [36] situations. To date, DSS have tended to support the Leibnizian (analytical–deductive) and Lockean (inductive–consensual) styles, what Mitroff and Linstone [27] refer to as the technical perspective. They argue that UST requires consideration not only of the technical perspective, but also broad organizational and personal perspectives, and ethical and aesthetic issues, as well. This paper argues that future DSS should go well beyond support for Leibnizian and Lockean organizations, and provide support for decision-making in Kantian, Hegelian and especially Singerian organizational models. A new decision-making paradigm for DSS is proposed, based on the Singerian model, and Mitroff and Linstone's [27] UST concepts.

The paper begins with a brief review of the original DSS concept, and its emphasis on attacking semi-structured management problems. Next, the evolution of DSS thinking is reviewed, up to its present concern with knowledge management. Various perspectives on knowledge and knowledge management are discussed. Then Leibnizian, Lockean, Kantian, Hegelian and Singerian organizations are described, along with a discussion of decision making and knowledge management in each. The Singerian organization, which employs UST to sweep in the other four models and additional considerations, is emphasized. Finally, a new decision-making paradigm which encompasses UST is proposed, and its implications for DSS are considered.

2. Development of the DSS concept

This section will briefly describe the original DSS concept and its evolution to today's concern with managing knowledge required for effective organizational decisions. It will then be argued that, while organizational decision environments have always been complex and ill-structured, the environments of the near future will be even more so. This will set the stage for a discussion of a new DSS paradigm later in the paper.

2.1. The evolution of the DSS concept

Gorry and Scott Morton [14], who integrated Anthony's [2] categories of management activity and Simon's [39] description of decision types. Anthony [2] described management activities as consisting of strategic planning (executive decisions regarding overall mission and goals), management control (middle management guiding the organization to goals), and operational control (first line supervisors directing specific tasks). Simon [39] described decision problems as existing on a continuum from programmed (routine, repetitive, well-structured, easily solved) to non-programmed (new, novel, ill-structured, difficult to solve).

Gorry and Scott Morton [14] combined Anthony's [2] management activities and Simon's [39] description of decisions into a table similar to that in Fig. 1 (examples have been updated in some cases), and described decision problems as structured, unstructured, and semi-structured, rather than programmed and non-programmed (note that it is the decision *context* that is unstructured, not the DSS itself).

Simon [39] described the decision-making process as consisting of three phases: intelligence, design and choice. Intelligence is used in the military sense to mean searching the environment for problems, that is, the need to make a decision. Design involves the development of alternative ways of solving the problem, and choice consists of analyzing the alternatives

	Strategic Planning	Management Control	Operational Control
Unstructured	E-commerce	Career paths	Grievances
Semi-structured	Forecasting	Budgeting	Assignments
Structured	Dividends	Purchasing	Billing

Fig. 1. Examples of the Gorry and Scott Morton decision types.

and choosing one for implementation. Gorry and Scott Morton [14] defined a DSS as a computer system that dealt with a problem at least some stage of which was semi-structured or unstructured, or, in other words, as anything above the dashed line in Fig. 1. A computer system could be developed to deal with the structured portion of a DSS problem, but the judgment of the decision maker was brought to bear on the unstructured part, hence, constituting a human–machine system.

Gorry and Scott Morton [14] argued that the characteristics of both information needs and models differ in a DSS environment, as compared to most organizational information systems that were in use at that time. Management information systems, such as billing, other accounting systems, inventory control and the like, require current, accurate data that is derived primarily from sources internal to the organization. DSS applications, because many are strategic in their orientation, tend to require data from outside the organization, and this data may be in the form of trends or estimates. The ill-defined nature of information needs in DSS situations leads to the requirement for different kinds of databases than those for operational environments. Relational databases and flexible query languages are needed. Similarly, the ill-structured nature of the decision environment implied the need for flexible, interactive modeling systems, such as those in spreadsheet packages, and tools such as the Interactive Financial Planning System (IFPS), and later Lotus 1-2-3 and Excel came to be associated with DSS applications. It is interesting to note that such tools did not appear, actually *could not* appear, until direct access storage devices made interactive operating systems technically and economically viable. Keen and Wagner [18] especially emphasize how the interactivity and adaptability of IFPS models allowed managers to make much more timely decisions and to use models in a more intuitive manner as interaction provided immediate feedback, the ability to change models and assumptions quickly, and permitted the analysis of more options, and a wider variety of options.

Fig. 2 describes what probably came to be a more customarily used model of the decision-making process in a DSS environment. Here the emphasis came to be on model development and problem analysis. Once the problem is recognized, it is defined in terms that facilitate the creation of mathematical models. Alternative solutions are created, and models are then developed to analyze the various alternatives. The choice is then made and implemented as in Simon's [39] description. Of course, no decision process is this clear-cut in an ill-structured situation. Typically, the phases overlap and blend together, and there will be recycling to earlier stages, as more is

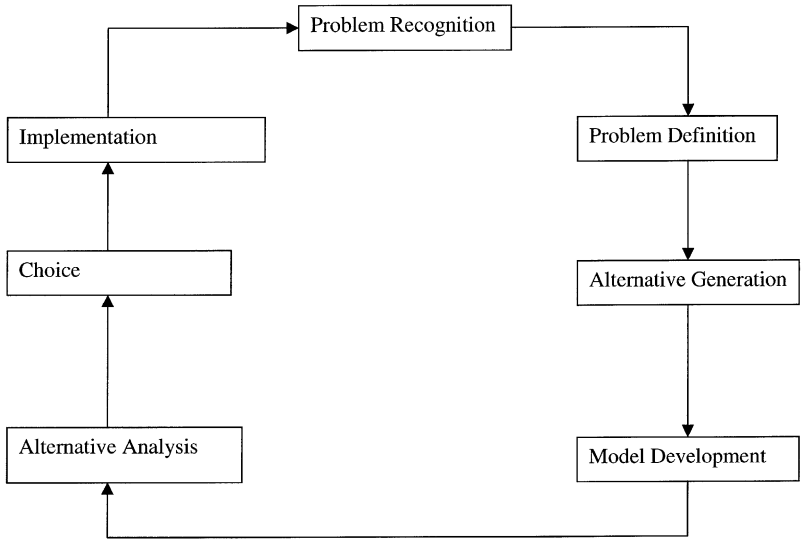

Fig. 2. The conventional DSS decision-making process.

learned about the problem, as solutions do not work out, and so forth.

Over the last two decades or so, DSS research has evolved to include several additional concepts and views. Group decision support systems (GDSS), or just group support systems (GSS) provide brainstorming, idea evaluation and communications facilities to support team problem solving. Executive information systems have extended the scope of DSS from personal or small group use to the corporate level. Model management systems [13] and knowledge-based decision support systems [5], based on theories and techniques from artificial intelligence and expert systems, provided smarter support for the decision-maker. The latter began evolving into the concept of organizational knowledge management about a decade ago [30], and is now evolving into a broader notion of DSS serving as knowledge sources or connecting decision-makers with diverse sources [17].

2.2. DSS decision environments of the 21st century

As described previously, DSS have purported to attack semi-structured organizational problems, or at least the structured (modelable or tractable) portion of such problems. Many, although not all, semi-structured problems occur at the strategic planning level of the enterprise. Spreadsheets, group support systems and knowledge-based systems have been successfully used in many such situations. Strategic planning problems have always been messy and difficult because of the large number of factors involved, the uncertainty about relationships among factors, uncertainty about the future, and a host of other issues. Strategic planning promises to become even more complex in the future, as the Internet and telecommunications technology will allow more organizations to become global in nature, and suppliers, producers and customers will become more closely connected throughout the world. For example, Michael Dell, CEO of Dell Computing, now the largest seller of personal computers in the U.S and a player in global markets, says:

> All aspects of the relationship — such as real-time feeds from our manufacturing lines about quality, cost data, product roadmaps, inventory information, and order demand information — are included in valuechain@dell.com. This allows us to bring our suppliers inside our business and treat them as if they were part of our company. This is an illustration of the virtually integrated business, in which suppliers and customers are connected in real time. [11]

As globalization expands, the number of stakeholders affected by organizations will increase in size, and the widely disparate customs, laws, behaviors and environmental concerns of affected communities will further complicate strategic problems. The violent demonstrations that occurred at the 1999 meeting of the World Trade Organization in Seattle illustrate what can happen when people perceive that they are not being treated fairly. Business is responding to this need through initiatives on corporate social responsibility and "sustainable development," development that takes a long-term view, integrating social, environmental and economic concerns to avoid compromising the ability of future generations to fill their needs [16].

The World Business Council on Sustainable Development, which has firms from AT&T to Zurich Financial Services Group in its list of over 120 international members, recently issued a report on Corporate Social Responsibility, which it defines as:

> ...the commitment of business to contribute to sustainable economic development, working with employees, their families, the local community and society at large to improve their quality of life. [16, p. 10]

The report cites C. Michael Armstrong, chairman and CEO of AT&T as saying,

> AT&T understands the need for a global alliance of business, society and the environment. In the 21st century, the world won't tolerate businesses that don't take that partnership seriously, but it will eventually reward companies that do. [16, p. 1]

The WBCSD, the Global Reporting Initiative www.globalreporting.org), the Institute of Social and Ethical Accountability www.accountability.org.uk),

and SustainAbility www.sustainability.org.uk), among others, are working on proposed standards and reporting requirements that will greatly expand the complexity of organizational decision making. The WBCSD is developing a virtual university to teach sustainable development, business ethics and corporate social responsibility. Here is what the WBCSD says about its business ethics course:

> The most important message the participants should receive is that the level of complexity of BE [business ethics] issues is so high that it requires the involvement of key stakeholders, that there are no simple solutions, and even if there is a "right answer" it will be very much dependent on the interest of a particular stakeholder group. In other words, the emphasis is not so much on finding the "right answer" but on developing the capacity to address complex business problems in a much more effective and systematic way. (WBCSD, http://vu.foundation.no/ibt/seminar/be/ibt/description.html)

Other standards and guidelines these organizations are developing include "full cost accounting," which would comprise social costs and economic externalities in addition to conventional financial costs, and the "triple bottom line," which involves "the simultaneous pursuit of economic prosperity, environmental quality and social equity." (http://www.wbcsd.ch/aboutdfn.htm)

It seems clear that planning problems in these environments go beyond even what Gorry and Scott Morton [14] called unstructured problems in their original conception of DSS. Rittel and Webber [36] refer to such problems as being "wicked," and state that the classical rational paradigm of science and engineering are not applicable to problems in open social systems. They list 10 properties of wicked problems:

- There is no definitive formulation of a wicked problem — formulating the problem *is* the problem.
- Wicked problems have no stopping rule — planners stop, not because they have "the" answer, but because they are out of time, money, patience or because the answer is "good enough."
- Solutions to wicked problems are not true or false, but good or bad — values are inherently a large part of the problem and the values employed vary among stakeholders.
- There is no immediate or ultimate test of a solution to a wicked problem — solutions to wicked problems, because they are so inextricably bound to their environment, generate "waves of consequences over an extended — virtually unbounded — period of time." [36, p. 163]
- Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial and error, every attempt counts significantly — and consequentially, solutions cannot be undone.
- Wicked problems do not have a numerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan — there may be *no* solution.
- Every wicked problem is essentially unique — despite many similarities, each wicked problem also has distinguishing characteristics that make it unique.
- Every wicked problem can be considered to be a symptom of another problem — again, because of their connectedness to the environment and to other problems, "solving" a wicked problem may exacerbate other problems.
- The existence of a discrepancy [between actual and desired states of affair] can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution — the choice is the one most plausible to the decision-maker.
- The planner has no right to be wrong — scientists may formulate hypotheses that are later refuted, but planners seek to improve some aspect of the world. *"The planner who works with open systems is caught up in the ambiguity of their causal webs."* (Ref. [36], p. 167, emphasis added)

It would seem that globalization will lead to increasingly wicked planning problems for all kinds of organizations, both for profit and non-profit, and privately and publicly owned. This is a challenging environment for organizations, to say the least.

Methods are desperately needed to help with making effective decisions in such situations. Spreadsheets and other models and knowledge-based DSS, and especially GSS can help with such problems. But it seems that more powerful tools are required. Especially required is a broader perspective in terms of DSS research. However, before discussing the new perspective, the paper will digress somewhat and consider the nature of knowledge and knowledge management, and its relationship to decision making in organizations.

3. Knowledge and organizational knowledge management

To understand how knowledge may be managed in organizations, especially in a DSS context, it seems appropriate to discuss the nature of knowledge itself. Various authors have different perspectives, of course. Churchman [7,8] himself expresses his views, as do more recent students of the topic. This section begins with a review of Churchman's [7,8] perspective and goes on to contrast more recent views of his.

3.1. Churchman's view of knowledge

Churchman [7] describes knowledge from three different perspectives: knowledge as a collection, an activity, or a potential. When thought of as a collection, knowledge could be strings of symbols in some computer storage medium or sentences in a library (or a computer). But the library or computer has no reasonable way of assuring which symbol strings are meaningful and true. Consider, for example, the vast amount of misinformation available on the Internet. Churchman [7, p. 9] states that "We would have to say that the state of knowledge resides in the combined system consisting of the library and an astute and adept human user." Furthermore, "knowledge resides in the user, not in the collection." [7, p. 10] Some problems with the library perspective relate to whether the user and the library speak the same language, whether the user poses the question properly (in terms that can be understood by the library, and whether the library should estimate the quality and veracity of the information. It is interesting that Schultze [37], in an ethnographic study of knowledge work in a corporation, found precisely these problems occurring in its library system.

When viewed as an activity, "Knowledge is a vital force, which makes an enormous difference in the world" [7, p. 10]. It implies that the ability to act is pragmatic in the sense that it implies that someone knows how to do something correctly. Yet, a person does not have knowledge only when acting. A database analyst knows how to normalize a database even when she is asleep. Thus, knowledge can be viewed as the potential for action. Yet, "To be knowledgeable, one must be able to adjust behavior to changing circumstances" [7, p. 11]. Thus, being knowledgeable implies not only how to perform an act correctly, but also how to learn as circumstances change, clearly an essential ability in today's dynamic environments.

Churchman [7] does consider another vastly different view of knowledge from that we see in most of the modern knowledge management literature. He believes this perspective was best expressed by Spinoza in *Ethics*. Men of Spinoza's age could not think of knowledge without also including moral and ethical considerations. To be knowledgeable was also to be moral and ethical. As Churchman [7, p. 12] puts it, "Nothing touches the true depth of the human spirit so much as the act of knowing." This, the spiritual, moral and ethical side of knowledge, seems to have been lost in modern decision science. Again quoting Churchman:

> If knowledge means the ability to pursue goals though the world about us changes, then perhaps an inquiring system that produces "science" does not produce knowledge. There seems to be sufficient evidence to make the [DSS] designer at least pause long enough to consider this issue. There is no way to consider it except to permit some breaking away from present practice; perhaps, as I have been hinting in resurrecting Spinoza, we need to turn to a reactionary policy. In any event, the [DSS] designer must let his feelings, as well as his common sense and thought processes, tell him some things. [7, p. 13]

Some authors, including Churchman [8], Merikangas [26] and Maxwell [25], believe that wisdom is

the result of integrating knowledge with moral concerns. As Merikangas [26, p. 69] says, "The call for a modern wisdom often takes the form of integrating knowledge and values." He goes on to define wisdom communities as:

> . . . those that seek to move ahead with the quest for truth and goodness, seeking what is really real. They want knowledge for right action, they want wise decisions and responsible decisions. They take knowing seriously and choices seriously. [26, p. 70]

Merikangas [26, p. 69] citing Maxwell [25] believes that "The central task of inquiry is to devote reason to the enhancement of wisdom."

Thus, one might say that knowledge involves the ability to act intelligently and to learn. Wisdom guides knowledgeable actions on the basis of moral and ethical values.

3.2. Current views on knowledge and knowledge management

Many contemporary authors distinguish among data, information, and knowledge (e.g. Refs. [4,10,12,40]). Typical definitions are that data are raw facts or simple observations about the state of the world; information is data in some context, or with some kind of human interpretation applied; and knowledge is information with guidance for action, that is, knowing how to act given the information.

There are also several different types of knowledge recognized in the literature: explicit vs. tacit, procedural vs. declarative, esoteric vs. exoteric, and shallow vs. deep. Tacit knowledge [28,29] is that which is contained within a person's head, and is difficult or impossible to express, write down and codify. Examples of tacit knowledge would be how to close a deal with a particular type of client, or how to develop an effective advertising campaign. Tacit knowledge is of great interest to organizations because it involves knowledge that leads to effective policies, practices and procedures. A good deal of the knowledge management literature deals with the creation of organizational policies and cultures that encourage sharing of tacit knowledge. Explicit knowledge, on the other hand, is that which can be readily articulated, written down, codified and shared. Standard operating procedures, and instructions how to bake quiche are examples of explicit knowledge.

The distinction between declarative and procedural knowledge comes from the expert systems literature [30]. Declarative knowledge, referred to as data or information in the knowledge management literature, consists of facts or observations about the state of the world, such as a patient's temperature, or a business firm's current ratio. Procedural knowledge is closer to what most authors would consider knowledge, as it involves "how to" do something, such as how to diagnose hepatitis B, or how to analyze a financial statement.

Esoteric knowledge is that which is highly specialized, formalized, and applicable to narrow domains, in short, that which is found in most scientific disciplines. Science is designed to produce knowledge of this variety. It is of limited value in solving unstructured, complex management problems. Exoteric knowledge [27] is applicable to broad domains, and in some cases, might be considered "common sense." It is applicable to complex, unstructured problems.

Deep knowledge and shallow knowledge are also distinguished in the expert systems literature [30]. Deep knowledge is usually related to relatively well-structured scientific and technical domains, and consists of formal theories of behavior of phenomena in those domains. Shallow knowledge is often that in social domains where theories and understanding are usually less well organized and codified than in scientific domains.

Schultze [38] describes three different perspectives on knowledge management: the functional, the interpretive, and the critical. The functional paradigm is that most often adopted by those in practice, especially in the software industry. Here knowledge management is defined as the way that organizations create, capture, store, re-use and protect knowledge to achieve organizational objectives [37]. This reflects a realist ontology, the belief that the world is factual, and that the facts can be known and captured. Facts and knowledge are "out there" waiting to be discovered. From this perspective, it is believed that knowledge can be captured, codified and shared. The most prevalent technology within the realm of

the functional paradigm is a repository of one form or another. Conventional databases, knowledge bases of best practices, or knowledge bases in expert systems are examples. Bock [4] recognizes three types of repositories: structured, consisting of databases and knowledge bases; unstructured, consisting of notes, documents, etc.; and the tacit repositories in people's minds.

Bock [4] also defines knowledge management as a process with four parts that comprise a loop (Fig. 3). Knowledge is created in the heads of people. It is captured. It is put on paper in a report, entered into a computer system, or some kind of library, or simply remembered. Knowledge is classified and modified. The classification can include the addition of keywords, or it may be indexing. Modification can add context, background or other things that make it easier to re-use later. The test of this step is how easily people in the organization will be able to find and use the knowledge when they need it. Knowledge is shared. When knowledge is shared and used, it is modified by those who use it. This takes us back to knowledge creation.

Nonaka [28] proposes a "spiral" model of organizational knowledge creation similar to, but more sophisticated, than Bock's [4]. The spiral model is based on the dynamic and continuous "entanglement" of four modes of knowledge conversion: (1) socialization, involving the conversion of tacit knowledge to tacit knowledge among individuals; (2) combination, involving the conversion of explicit knowledge to explicit knowledge; (3) externalization, involving the conversion of tacit knowledge to explicit knowledge; and (4) internalization, involving the conversion of explicit knowledge to tacit knowledge (learning). In Nonaka's [28] model, individuals

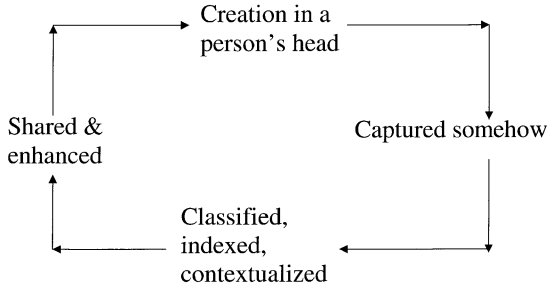

Fig. 3. Bock's knowledge creation cycle.

interact with others to create knowledge through these four modes. Knowledge "spirals" from individuals to small groups to the organization and perhaps to other organizations and society in general. The "hypertext" organization is designed to foster these modes of interaction and to promote organizational knowledge creation and sharing. Nonaka [28] suggests that this process, when properly instituted, results in more "humanistic" knowledge, as it fosters trust and caring among people. Later in this paper, a similar knowledge creation process will be discussed in the context of the Singerian organization.

The interpretive perspective [38] is founded on the belief that social reality is socially constructed, and attention is directed to interpretation, distributed cognition, communications, and social processes. Knowing and knowledge are inseparable from action, as in the Churchmanian view [7,8] described previously. Knowledge is viewed both as action and object; that is, as both procedural and declarative. Organizational knowledge is viewed as existing in a "collective mind," developed through interpretation, communication, and shared meanings. Organizational knowledge is in a constant state of flux as new experiences are evaluated and shared. Knowledge management in this environment consists of fostering communications between individuals, sharing and enriching interpretations, and coordinating actions. A collective culture must be created in such organizations to permit effective communication and sharing of knowledge.

The critical perspective is concerned primarily with social conflict and antagonistic relationships [38]. Various stakeholders and special interest groups take positions and form strategies that produce differences and conflict among them. Marxist labor processes, class struggles, and a radical humanist perspective are aspects of the critical perspective. Knowledge management in this perspective is viewed in a rather pejorative way as the exploitation of workers by owners, who seek to extract knowledge from them and commoditize it.

4. Inquiring organizations

Inquiring organizations are learning organizations patterned after Churchman's [7] inquiring systems.

There are five flavors of inquiring organizations: Leibnizian, Lockean, Kantian, Hegelian, and Singerian, each based on the philosophies of their respective namesakes. The organizations might be entire enterprises, or possibly even social systems, but more likely would be units within an enterprise. They could also be temporary groups or teams established specifically to resolve a decision problem.

Mitroff and Linstone [27] call the decision styles of the Leibnizian and Lockean "old thinking." They are somewhat more kind to the Kantian and Hegelian styles, labeling them "complex thinking." They argue for the need for "new thinking," as exhibited in Singerian organizations. This section briefly describes each type of organization and its decision making and knowledge management styles, and, in the spirit of Mitroff and Linstone [27], argues for a new decision style as exhibited by Singerian organizations and UST (see Table 1 for a summary of the features of each type of organization).

4.1. The Leibnizian organization

Churchman's [7] Leibnizian inquiring system (IS) is a closed, deductive system with a set of built-in elementary axioms that are used along with formal logic and analysis to generate more general fact nets or tautologies. The system generates sentences representing hypotheses, each new hypothesis being tested to ensure that it could be derived from, and is consistent with, the basic axioms. Once so verified, the hypothesis becomes a new fact within the system. The guarantor of the system is the internal consistency of the process.

The Leibnizian organization creates knowledge by using formal logic and mathematical analysis to make inferences about cause-and-effect relationships. A Leibnizian organization may incorporate the theory of autopoiesis, which comes from cell biology, and maintains that everything that the system needs for its reproduction is already within its boundaries [41].

Table 1
Summary of inquiring organization characteristics

	Leibniz	Locke	Kant	Hegel	Singer
Decision-making style	Formal	Open	Open	Conflictual	Teleological
	Analytical Bureaucratic	Communicative Consensual	Analytical Multi-model		Cooperative Ethical
Knowledge perspective/ mode	Functional	Interpretive	Functional	Critical	Interpretive-Critical
	Combination	Socialization	Combination	Socialization–Externalization	Socialization–Externalization
Knowledge creation process	Induction	Deduction	Mathematical analysis	Construct theses, antithesis	Strategy of disagreement
	Mathematical analysis	Observation	Multiple models	Dialectic	Sweeping-in
	Formal Logic	Classification	Choose best	Synthesis	Multiple perspectives
Information technology	Math models	Communication Repositories	Databases	Repositories	Groupware
	DSS	Groupware	Model managements systems	Negotiation systems	Networks
	Expert systems Document management	Networks			Repositories Document management

Leibnizian systems are created in a recursive, self-generating, closed and autonomous manner. As closed systems, they have access only to knowledge generated internally.

Decision-making procedures in Leibnizian organizations exhibit a strict, formal, bureaucratic, "by the book" approach. Missions, policies, goals, and standard operating procedures serve as Leibnizian axioms. "Truth" is determined in a procedural manner, with focus on structural concerns, and with error detection and correction being a direct consequence of comparing inputs with the accepted "axioms" of the system.

Decision problems in a Leibnizian organization are attacked in a formal, analytic style. Mathematical models, especially optimization models that attempt to get at the one "best" answer, would be widely utilized. A management science approach to decision making, and to a lesser extent a DSS approach, would be the hallmark of such organizations. Accounting departments within virtually any enterprise would be a prime example, with their emphasis on generally accepted accounting practices, and reliance on very well-defined systems and procedures. Budgets and forecasting models and the like are prevalent in these environments. They tend to be oriented towards getting *the* correct budget and forecast, looking for the one "best" solution. Well-organized manufacturing operations and military units would be other examples.

Mitroff and Linstone [27] call this the analytic–deductive approach to decision making, and argue that it is based on a metaphor of the organization and individuals as machines, a belief that the world can be reduced to formulas, and the assumption that each problem has one best answer. Such an approach to decision making is only suited to very well structured, simple problems. It has served science well in technical domains, but is entirely unsuited to the unstructured domains found in the DSS arena. Perhaps it is suited to a portion of an unstructured domain, but most likely, especially in the case of wicked problems, the structured part of which may be almost inconsequential.

Knowledge management in Leibnizian organizations adopts Schultze's [38] functional perspective, and exemplifies Nonaka's [28] combination mode of knowledge creation, as it focuses on manipulation of explicit knowledge. The knowledge to be managed consists of documents describing goals, plans, and especially standard operating procedures. Information technology most suited to this type of organization includes that related to models, decision support systems, and expert systems that instantiate the rules and procedures of the organization, and document management technology for describing policies and procedures. This is predominantly explicit knowledge. Tacit knowledge gets relatively little emphasis in the Leibnizian organization.

4.2. The Lockean organization

Mitroff and Linstone [27] refer to the Lockean IS as being inductive and consensual. Empirical information, gathered from external observations, is used inductively to build a representation of the world. The givens of the Lockean inquirer include a set of labels (or properties) which it assigns to the observations that constitute its inputs. The Lockean system is also capable of observing its own process by means of "reflection" and backwards tracing of labels to the most elementary labels. Communication and consensus are hallmarks of this approach, and agreement by the Lockean community on the labels to be assigned to an observation is the guarantor of the system.

A community of Lockean inquirers learns by observing the world, sharing observations, and creating a consensus about what has been observed. Organizational knowledge is created through observation, interpretation, communication, and the development of shared meaning. The organization's culture or subculture (a Lockean community) must be supportive of this type of environment. That is, organizational members must feel free to observe and express opinions. Moreover, they must have a common language and mindset, which permits effective communication. The decision style is clearly group-oriented and open. Input is sought from a variety of sources, communication is encouraged, and consensus is sought.

The Lockean organization clearly exemplifies the interpretative knowledge management paradigm, and socialization as the mode of knowledge creation. Organizational knowledge is socially constructed through observation and discussion.

The primary knowledge management tools in Lockean organizations are repositories, such as data warehouses, for storing observations, data mining for analyzing observations, and groupware tools, such as electronic meeting software and e-mail, for facilitating the communication process, and the development of shared meaning. These are all tools that come under the DSS umbrella. Their development was enabled primarily by developments in telecommunications and computer networking. Examples of Lockean organizations would be those having a close coupling to their environment, such as advertising firms and retailers who have to stay in close contact with customers.

4.3. The Hegelian organization

The Hegelian inquirer is based on the belief that the most effective way to create knowledge is by observing a debate between two diametrically opposed viewpoints about a topic [33]. The first party in the debate begins with a thesis to which it is passionately dedicated. Given information about the topic under debate, the first party develops a worldview that interprets the information in such a way as to maximize support for the thesis. The second party is equally dedicated to an antithesis, which is the "deadliest enemy" of the thesis. The second party interprets the same information in such a way as to maximize support for the antithesis. A third party, the "objective observer," analyzes the debate, and constructs a worldview that is a synthesis of the thesis and antithesis, and reflects the observer's belief about which aspects of the two are the most plausible.

The decision style of the Hegelian organization, then, is based on conflict. Decision makers encourage the development of opposing viewpoints on how to resolve a decision problem. Debate between parties holding the opposing views is encouraged. The decision is forged from the two views in such a way that the problem is not only solved, but also completely dissolved. Mason and Mitroff [23] have found this to be an effective approach to surfacing assumptions in strategic planning problems, leading to more effective plans. This is a more complex decision style, as it is based on the fact that there is more than one perspective on the problem, and it specifically relies on the two most diametrically opposed perspectives [27].

As they are based on antagonistic points of view, Hegelian organizations adopt Schultze's [37] critical perspective on knowledge management. The knowledge creation mode can be viewed as consisting of socialization and externalization, as the debate is somewhat of a social process, an extreme one, and through that process elements of the thesis and antithesis are externalized to the observer.

The knowledge to be managed in this environment consists of the information that the thesis and antithesis attempt to interpret, the thesis and antithesis themselves, the debate, and of course, the synthesis. Groupware designed to support negotiation and arbitration is well suited for this approach, along with repositories holding the data being debated, document management software, and analysis tools for developing points to support either the thesis or antithesis. An example application is contract negotiation. Hodges' [15] Dialectron exemplifies software in this arena.

4.4. The Kantian organization

The Kantian approach recognizes that there may be many different perspectives on a problem, or at least many different ways of modeling it. Provided with observations about a decision situation, the Kantian inquirer is capable of constructing various models which attempt to interpret and explain those observations. Each model has some "goodness of fit" measure, such as a standard error or variance. An executive routine is capable of invoking a particular type of modeling process, and observing its behavior. It can turn off models that are not performing well. It finally chooses the model which best explains the data.

The decision style of the Kantian organization, then, is to encourage the development of multiple interpretations of a set of data. It is both empirical and theoretical in its approach. The perspectives tend to be very analytically based, however, somewhat akin to combining the Lockean and Leibnizian approaches, but relying heavily on analytical methods for interpreting the data. Mitroff and Linstone [27] believe this approach is suitable for problems of moderate complexity. Bonczek et al. [5], in what

remains the most profound theoretical work in the DSS literature, propose what could be considered a Kantian DSS, as it includes a problem processor with an executive that is capable of developing alternative models of a problem and choosing the best representative.

The knowledge management perspective of the Kantian approach is closest to that of the functional view, and its mode is combination, as it applies models to data to create new knowledge. It is based on the belief that problems can be modeled analytically. There is little or no emphasis placed on human interpretation of the problem, nor of human involvement. The problem is attacked strictly from a technical perspective. This approach requires knowledge management software capable of maintaining data about the problem, and supporting the development of alternative types of models that attempt to explain the data.

4.5. Singerian organizations

Churchman [7,8] elected to honor Singer with the notion of the broadest inquirer yet devised, but the concept, as does any notion really, rests on the shoulders of many. Churchman was a student of Singer, himself a member of the pragmatic school of philosophy, which includes William James and John Dewey, and Mitroff was a student of Churchman [7,8]. Thus, it seems that Mitroff and Linstone's [27] concept of UST is itself systemically entwined with this school of thought. It is difficult to extricate UST from the Singerian model and discuss it separately. As a matter of fact, such separability would violate the conventions of UST itself! Organizations using UST are Singerian in nature, and vice versa.

In describing the Singerian inquirer, Churchman [7, p. 200] says it "is above teleological, a grand teleology with an ethical base." Singerian inquirers seek a highly idealistic purpose, the creation of "exoteric" knowledge, or knowledge for "every man," as opposed to scientific, esoteric knowledge that, as it matures, becomes relevant to an increasingly smaller audience. It seeks this knowledge in such a way as to take human and environmental considerations into account. In other words, the Singerian inquirer seeks the ability to choose the right means for ethical purposes for a broad spectrum of society.

The Singerian inquirer views the world as a holistic system, in which everything is connected to everything else. From the Singerian perspective, problems and knowledge domains (disciplines) are highly non-separable. Complex social and managerial problems must be analyzed as wholes [27]. The artificial division of knowledge into disciplines and the reduction of complex problems into simple components inhibit the solution to social and management problems. Solving complex problems may require knowledge from *any* source and those knowledgeable in *any* discipline or profession.

The knowledge management perspective in the Singerian approach is a combination of functional, interpretive and critical views. Knowledge of all types must be supported in this environment, both tacit and explicit, both deep and shallow, both declarative and procedural, both exoteric and esoteric. Nonaka's [28] socialization and externalization modes are emphasized in this organizational style, as a discourse may involve many and varied perspectives on the problem. Every genre of software is required in the Singerian organization, but most appropriate are groupware and networks to support dialogue and communication, and repositories and document management systems to maintain the knowledge created.

As an example of thinking in a connected, unbounded fashion, Mitroff and Linstone [27] cite a speech given by Chief Seattle in 1854, as an assembly of tribes was preparing to sign a treaty with the U.S. government:

> This we know. The earth does not belong to man; man belongs to the earth. This we know. All things are connected like the blood which unites one family. All things are connected. Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself. [27, p. 163]

As an example of bounded thinking, we might refer again to Chief Seattle, who had his own notion of sustainability:

> We know that the white man does not understand our ways. One portion of land is the same to him

> as the next, for he is a stranger who comes in the night and takes from the land whatever he needs. The earth is not his brother, but his enemy, and when he has conquered it, he moves on. *He kidnaps the earth from his children.* [emphasis added] He treats his mother, the earth, and his brother, the sky, as things to be bought, plundered, sold like sheep or bright beads. His appetite will devour the earth and leave behind only a desert. [27, p. 162]

To deal with such connectedness as described by Chief Seattle, Singerian organizations must deploy UST to go well beyond the bounds of the other four organizational styles, by bringing in multiple *perspectives* or *worldviews* [20] and employing a holistic, systems approach in their thinking and decision-making processes. The Kantian approach uses multiple *models*, but these tend to be of the mechanistic, analytic variety, reducing all problems to a single number, and the results of the "best" model are chosen.

The multiple perspectives approach [19] is much broader. A synthesis of broad worldviews is developed, rather than adopting the limited view of a single perspective. The Singerian style and UST also recognize the connectedness of things in the universe, especially of complex social problems. The non-separability and irreducibility of elements in complex problems and issues is recognized. The development of multiple perspectives is the very core of UST. A critical aspect of developing multiple perspectives is open, honest, effective dialogue among all relevant stakeholders in the problem involved. Managers in such an environment must be careful to respect the rights and viewpoints of the parties involved, and be open and honest themselves in order to gain the trust of those who will be affected by the decision.

The Singerian approach and UST develop multiple perspectives in several ways. First, as Churchman [7] and Mitroff and Linstone [27] put it, the system "sweeps in" the other thinking styles, which means it uses any or all of them where appropriate in decision-making processes, and may include any knowledge as needed from any discipline or profession to assist in understanding the problem. Mitroff and Linstone [27] refer to the four non-Singerian models as reflecting a technical (T) perspective. All of these approaches are mechanistic and analytical in nature. None is preferred, except as one may be more suited to a particular decision problem than others. They are based on an industrial-age machine metaphor, and even view man from a mechanistic viewpoint. That is, man is viewed as a rational, objective, thinking machine. Personal and behavioral traits get short shrift in the non-Singerian perspectives.

To overcome the limitations of the technical perspective, UST sweeps in what Mitroff and Linstone [27, p. 99] call organizational and social (O), and personal and individual (P) perspectives. These perspectives "bring to the forefront human beings collectively and individually in all their complexity." They go on to say that:

> All complex problems — especially social ones — involve a multiplicity of actors, various scientific/technical disciplines, and various organizations and diverse individuals. In principle, each sees a problem differently and thus generates a distinct perspective on it. [27, p. 99]

Furthermore,

> In "real-life" situations, managing problems consists of at least three activities: (a) analyzing alternatives, (b) making decisions about which alternative to choose, and (c) successfully implementing the chosen alternative. The T perspective focuses most strongly on (a) and least on (c); hence the "gap" so often deplored between analysis and action. Successful implementation depends first and foremost on the use of human resources and this means that O and P become crucial as we move from (a) to (c). [27, pp. 101–102]

In developing organizational perspectives, parties in the decision-making process often fall into camps that advocate a preferred alternative, with each camp seeking to develop ammunition to support its position. Also, each camp tends to base its position on unstated assumptions which, if left uncovered, often lead to a circular debate that gets nowhere. For example, Mitroff and Linstone [27] give the example

of a pharmaceutical company that was trying to decide what to do about competition from a generic drug that was a substitute for its largest selling product. One camp argued that the price should be raised, the other that it should be lowered. Each was making an unstated assumption about the behavior of physicians. One believed that prescribing physicians would assume that the higher price meant higher quality and would prescribe the pharmaceutical companies' product. The other believed that physicians were cost conscious, and that the company had to compete on a cost basis. Surfacing such assumptions is a critical part of developing organizational perspectives. Mitroff and Linstone [27] suggest that assumptions can be surfaced by first identifying all stakeholders (anyone or group affected by the decision) and then simply asking each camp what they have to assume is 'true' of a particular stakeholder such that *starting from* that assumption that camp's preferred policy or actions would be supported. Of course, in complex, social decisions there will be many diverse stakeholders, some of which may have overlapping members, such as various special interest groups, taxpayers, governmental agencies, businesses and so forth. Surfacing assumptions about all these stakeholders may not be an easy task.

The personal perspective is perhaps not as well developed as the organizational. The personal perspective is based on individual experiences, intuition, personality factors, and attitudes about risk, among other things. Individuals are notoriously complex and varied in decision-making styles. In a complex scenario, given the same external information, no two people might reach the same conclusion, as their background, training, experience, values, ethics and mores may differ. Sweeping in as wide a variety of individual perspectives as feasible is thus necessary for unstructured decisions.

Kienholz [19] describes the Inquiry Mode Questionnaire (InQ), which measures an individual's propensity to use the different inquiring styles described by Churchman [7]. The Synthesist (Hegel) appreciates conflict, and is capable of integrating information from opposing views. The Idealist (Kant) employs multiple, but analytic, views, seeks ideal solutions, and values both data and theory. The Analyst (Leibniz) uses models, formulas and formal techniques to derive "optimal" answers. The Realist (Locke) is perceptive, preferring data and facts to theory, and seeks concrete results. The Pragmatist (Singer) is open to multiple perspectives, is innovative and adaptive, and is best in complex situations. Knowledge of thinking styles can be helpful in seeking input from individuals with different ways of looking at decision problems. This will help ensure that multiple personal viewpoints are represented, rather than getting input from several who think alike.

The multiple perspectives approach does not end with the technical, organizational, and personal perspectives. It also explicitly brings ethics and aesthetics into play. Many factors in the Industrial Age, the machine metaphor, the desire for "objectivity" and "rigor" in academic work, modeling social science research on "hard science" approaches, and the study of "rational man" to the neglect of our "spiritual" being, have all led to the demise of ethics, morality and aesthetics in decision making today. As we move into the Information Age, or perhaps the Knowledge Age, we seem to be stuck with this legacy of neglecting the factors that make us human. Churchman [7], Mason and Mitroff [23] and others have long called for much greater consideration of these factors in both our business and personal lives. The next section describes a new DSS paradigm for wicked decision problems, which embraces the Singerian model and UST.

5. A new DSS paradigm

UST and the multiple perspectives approach bring many new factors into the picture for organizational knowledge management and decision-making. One might even consider this to be an alternative decision-making paradigm, or at least a major overhaul of the conventional DSS view of decision making, which scarcely considers anything but the technical perspective. This paradigm is illustrated in Fig. 4. At the heart of the process is a mental model. Actually, this could be several mental models, or a collective model of some sort. As Churchman [7,8] and Mitroff and Linstone [27] point out, this model and the data selected by it (and hence the problems selected for solution) are strongly inseparable. Our mental model,

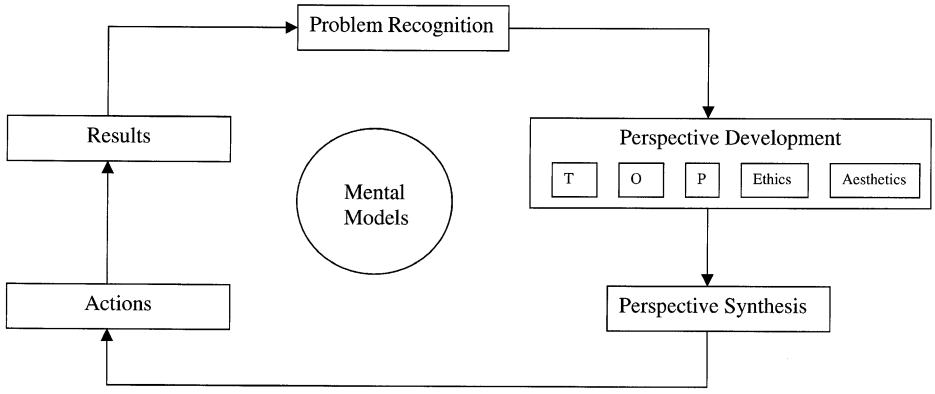

Fig. 4. A new decision-making paradigm for DSS.

either personally or collectively, determines what data and what perspectives we examine in a world of overabundant data sources and a plethora of ways of viewing that data. The mental models influence and are influenced by every step of the process. That is, the models determine what is examined and what perspectives are developed. As perspectives are developed, insight is gained, and the mental models are updated. That is, learning takes place. Tacit knowledge is created.

The decision process begins, of course, with the recognition that a problem exists; that is, a decision needs to be made. But rather than jumping simply into analysis (the technical perspective), the process consists of developing multiple perspectives of the various kinds described above. The various perspectives provide much greater insight into the nature of the problem and its possible solutions than the heavy reliance on the technical perspective that DSS has advocated in the past. It is suggested that diagramming tools such as cognitive maps [3], influence diagrams [32], entity–relationship diagrams [6], and object diagrams as expressed, for example, by the Unified Modeling Language [31] may be of great use both in showing the connectedness of elements in wicked systems, and in surfacing assumptions that people hold about wicked problems. For example, it has been shown that having groups draw cognitive maps leads to surfacing of differences in assumptions about variables and relationships in a problem and more effective communication during the decision-making process [21,24]. The next section presents an example of applying the proposed paradigm and diagramming tools to decisions related to the development of infrastructure, such as roads, streets, water supply and sewers, for an urban area.

5.1. An example: urban infrastructure planning and development

To illustrate the proposed new DSS paradigm, consider an analysis of how decisions are made about planning and constructing a city's infrastructure. To simplify matters somewhat, attention will be restricted to the development of new infrastructure for fresh water supply, wastewater and storm water processing, and roads and streets. The conventional DSS paradigm would concentrate on the engineering aspects of the decision-making process. Suppose an analyst is trying to understand this process and develops a diagram such as that in Fig. 5a, representing basic entities and relationships believed to exist in this problem. In this idealized situation, the planning department works with businesses, developers and contractors to develop general plans for new projects. Once plans have been approved, they are sent to either the Public Works Department, which handles water-related projects, or the Transportation Department, which is responsible for streets and roads. Public Works and Transportation use various mathematical models, decision support systems and so forth to develop detailed plans, specifications and

budget estimates for the proposed projects. From these estimates each department prepares a budget for the projects it proposes, and passes that to the Treasurer, who prepares a consolidated budget for all departments and submits that to the City Council for approval. The city council debates the merits of the projects, makes its adjustments and sends the approved budget back to the Treasurer and the other

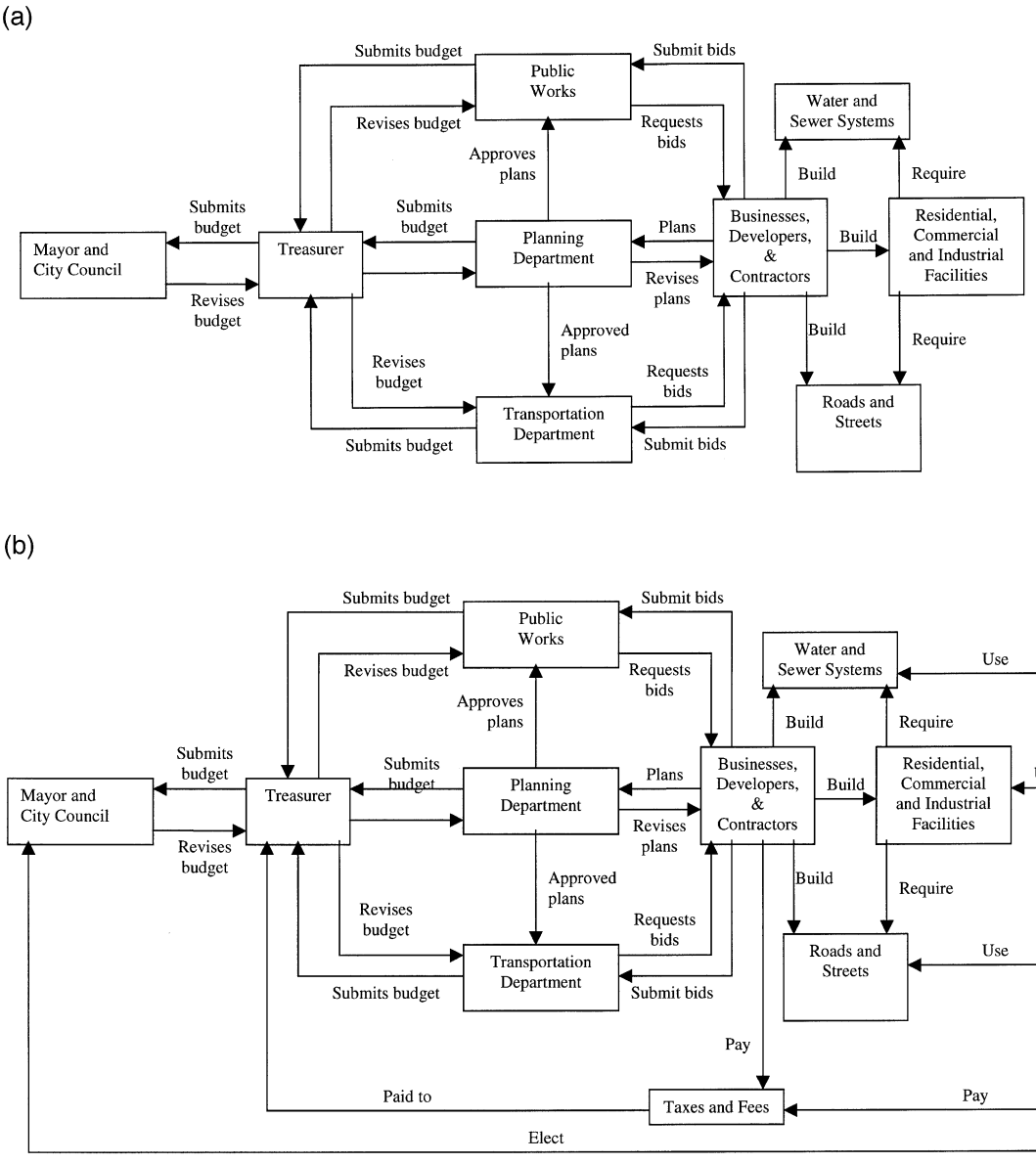

Fig. 5. (a) Planning and budgeting for urban infrastructure. (b) Planning and budgeting for urban infrastructure with citizens swept in. (c) Planning and budgeting for urban infrastructure with citizens and bonding and political concerns swept in. (d) Planning and budgeting for urban infrastructure with citizens, bonding, political concerns and quality of life swept in.

(c)

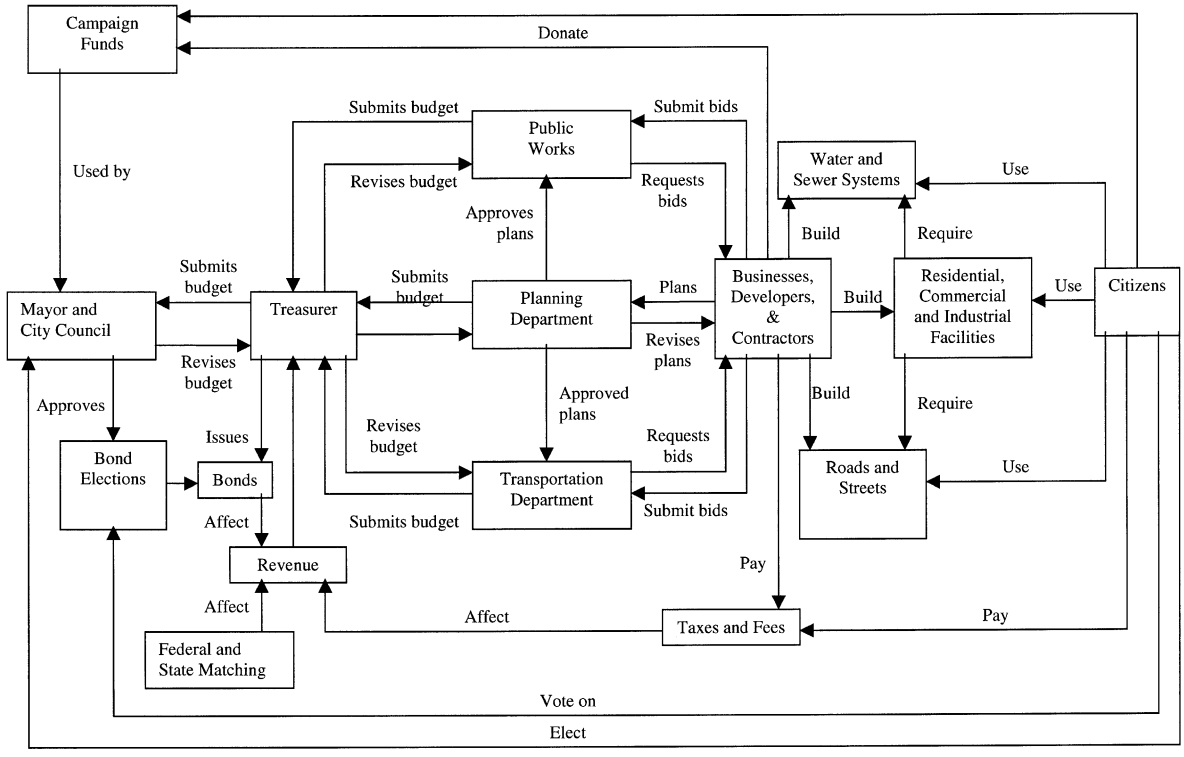

Fig. 5 (*continued*).

Departments. The departments prepare requests for bids for approved projects and contractors bid on those projects. Bids are analyzed, contracts are awarded to the winning bidder, and the work is undertaken. All seems reasonable, logical and rational.

As a first step towards considering the broader perspectives suggested in the new paradigm, examine Fig. 5b, which sweeps in the perspective of individual citizens of the city, that were perhaps glaringly omitted from the previous diagram. Residents use the facilities provided by businesses and developers, elect the mayor and city council, and pay taxes and fees, which partially fund infrastructure projects. Private sector firms also pay taxes and fees, but do not directly elect city representatives. Some models might be useful in the area of computing taxes and forecasting tax revenue for the city, but the process of electing city officials is exceedingly messy, and does not readily lend itself to mathematical analysis.

Fig. 5c sweeps in additional financial, political and organizational considerations. Here it is recognized that citizens and firms contribute to campaign funds for those running for public office, bringing a host of additional considerations into the picture. The possibility of ethical abuses is raised via the potential influence of contributions on the decision-making processes of elected officials. The decision process becomes murkier.

Fig. 5c also shows that the city issues bonds to pay for many infrastructure projects. Citizens must vote favorably in bond elections before the bonds can be issued. This is another public process that is only partially “rational.” Also swept in is revenue from state and federal programs that might provide

(d)

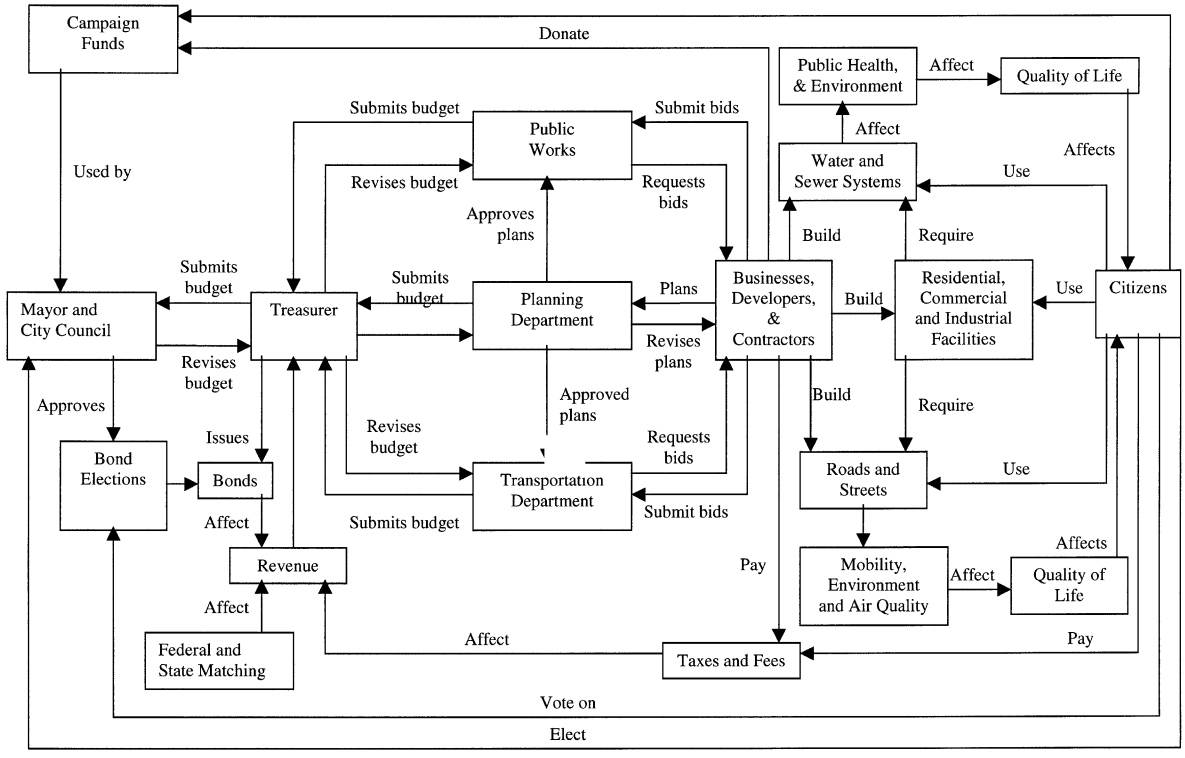

Fig. 5 (*continued*).

matching funds for infrastructure projects. Many of these programs have restrictions on the manner in which the funds can be used, thereby further muddying the waters, so to speak. The quantity of these funds is dependent on the coffers of the state and federal systems, of course, which are affected by the national economy, which is increasingly more affected by the global economy.

Last and not least, for purposes of illustration, some environmental and health issues are swept in as shown in Fig. 5d. Water and sewer systems are designed to protect the public health, of course, but also impact the environment in many ways. Construction of the systems themselves has a tremendous environmental impact. It is well known that such projects can change ecosystems in unanticipated ways. For example, the City of Houston has long relied on fresh water from ground sources (wells) for its water supply. However, the volume of water removed, combined with the soft soil in the area, has resulted in subsidence which, as the land sinks, is damaging the very water lines designed to deliver the water pumped from below (not to mention the damage to streets and sewers). Houston is now in the process of converting to surface water sources.

Likewise, streets and roads provide mobility, but obviously have severe impacts on the environment as well. Again using Houston as an example, "transportation systems" are usually viewed in a very narrow sense as being those designed almost exclusively for private automobiles, as the "conventional wisdom" is that Texans will not use public conveyances. This, among other factors, has caused Houston to have the worst ozone problem of any U.S. city.

To be sure, Fig. 5 could be expanded ad infinitum. A vast array of federal and state agencies, and public and private organizations from trade groups to homeowner's associations enter into this process. It

is clearly a wicked situation, and one that almost defies analysis. Yet, it is an ongoing process that is vital to every city in the world. Problems such as these are not only worthy of the attention of DSS research, they really almost cry out for help, and our response will help determine the quality of life of the next century and beyond. A fundamental aspect of the proposed paradigm is the development of multiple perspectives on the problem at hand, and the synthesis of those perspectives into some sort of "solution." Attention is next turned to developing multiple perspectives.

5.2. Applying the multiple perspectives approach

Mitroff and Linstone [27, pp. 107–108] suggest some guidelines for applying the multiple perspective approach

(1) Strike for a balance among technical, organizational and personal perspectives.

(2) Use "good" judgment in selecting perspectives. Foster a dialectic among those holding various perspectives and draw out the most plausible elements of each.

(3) In obtaining information, recognize that organizational and personal perspectives require greatly different methods than the technical. One-on-one interviews are the best source of information, but the interviewers must be good listeners and sensitive to nuances and nonverbal communication.

(4) Pay attention to the mutual impact, interdependencies, and integration of perspectives. "We cannot reiterate enough that we are dealing with UST. There is no formula or pat procedure to assure or guarantee that all interactions are taken into account." [7, p. 108] Yet, this is a critical point, and the decision-maker must be careful to conceive of as many interactions as possible.

(5) Beware of thinking statically in dynamic environments. With the advent of globalization, the Internet and electronic commerce, business environments change rapidly. Decision-makers must stay abreast of changing situations.

These guidelines can only be applied effectively in an organizational environment conducive to the use of the Singerian, multiple perspective approach. Recall that Churchman [7,8] said that the environment the inquirer critically needs is one of cooperation. DSS analysts should be aware of the need for a cooperative environment and play a role in fostering that environment. Addleson [1] argues that the development of such an environment requires a shift from thinking of organizations as machines to be controlled to thinking of them as communities in which people learn from each other. He points out that the mechanical view is reflected in accounting systems in which people represent expenses to be minimized, not as assets to be nurtured and developed. Five axioms for the development of learning communities are listed below.

(1) Organization is about relationships and collaboration. Bureaucracies tend to create barriers that keep people apart, but organization and learning come about from the relationships among people. These must be fostered, not inhibited.

(2) People's attitudes, or orientation towards other people are at the heart of a learning organization. People are motivated more by their social circumstances and from a sense of commitment, obligation, responsibility, etc., towards other people. What is important is a widespread conviction and commitment to the community.

(3) Structure and strategic plans have little to do with getting things done. People tend to be self-motivated from ambitions, a work ethic and a responsibility toward others, not because the organization has a blueprint for instructing them in what to do.

(4) Organizational boundaries depend on people's relationships. Boundaries are represented by people's perceptions of relationships between them and others within and without the organization, as in Dell's case with its customers and suppliers, not by organizational charts.

(5) Managing — "organization building" — is situational, not functional. Managing is building an organization, which has little to do with functions and formal authority. Emphasis is on the importance of community and collaboration, but it is realized that people do not always get along. Conflict inevitably emerges in divisions, factions and rivalry, but it must be managed and dealt with, not ignored and shoved into the background.

The new decision-making environment in inquiring organizations calls for a greatly expanded view

of DSS and knowledge management. Support for the so-called "softer" aspects of the decision, the organizational, personal, ethical and aesthetic perspectives, must be provided. Much richer tools are needed for handling text, images, pictures, sounds, and video than are now available in DSS software. Computers will never be substitutes for humans in complex decision situations. But they can surely lend support to decision makers in helping us make more humane decisions than has often been the case in the past.

Technological developments have continually allowed the development of more effective DSS tools. Disk storage and interactive operating systems enabled spreadsheets, databases and flexible modeling tools. Networks and telecommunications enabled group support and executive information systems. Expert systems theory and technology enabled knowledge-based DSS. The Internet and the World Wide Web, while fostering the development of globally connected organizations and complicating organizational decision environments, may also enable Singeran-style decision systems that heretofore were not practical. Consider, for example, that organizations might use the Web to develop technical, organizational, personal, aesthetic and ethical perspectives by:

- Using e-mail, chat tools and discussion fora to conduct real-time or asynchronous dialogues with external and internal (employees, managers) stakeholders, almost regardless of where they are located on the planet.
- Publishing reports (possibly in multimedia format) on social responsibility efforts, including such things as full cost accounting disclosures, and triple bottom line reports.
- Gathering information about stakeholder concerns from their websites and newsgroups.
- Gathering information for decision-making from the vast array of sites online offering both technical and non-technical data.
- Using diagramming tools to represent the objects and relationships inherent in the broad domain of influence of the organization to communicate to all stakeholders the complexity of the situation.
- Developing mathematical models in Java or some other Web-compatible language or product and publishing it on the Web for stakeholders to run with their own assumptions, or perhaps to even modify locally and run.
- Organizing all of the above into searchable knowledge repositories and storing them on the organizational website.

As wireless access and bandwidth increase and as more Web-based meetingware becomes available, video and voice communications will make this an even more effective medium than it is today. Just as the Internet, especially the Web, is changing business-to-business and business–consumer relationships, they can also be used to broaden organizational decision-making and facilitate communications among a wide variety of stakeholders. DSS and knowledge management researchers should keep such factors in mind as we enter the 21st century.

6. Summary

The original DSS concept proposed by Gorry and Scott Morton [14] purported to attack semi- and unstructured problems, with the computer dealing with the structured portion and human decision makers dealing with the unstructured portion. Human judgment may be even more critical in the complex, globally connected organizational environments of the next century. As organizations increase in scope, the greater their ramifications for broad spectrums of societies and cultures become. More effective ways must be found to support the vast array of knowledge that will be required in these highly interconnected, wicked situations of the future. This would include support for Schultze's [38] functional, interpretive and critical perspectives on knowledge, and the technical, organizational, personal, ethical and aesthetic perspectives in Singerian organizations using Mitroff and Linstone's [27] UST.

A new decision-making model has been proposed to serve as the basis for such decision support systems. This model emphasizes the need to consider many perspectives beyond the technical and has suggested ways to develop those perspectives. The surface has only been scratched here, in what can

and should be done. Many new tools and techniques must be devised to help managers cope with the bewildering array of interconnected problems they will be facing. It is a great challenge to the ingenuity and creativity of DSS researchers to help create organizational environments and systems that are conducive to dealing with the wicked problems of tomorrow. We can expect many exciting developments in DSS and knowledge management scholarship as we enter the 21st century.

Acknowledgements

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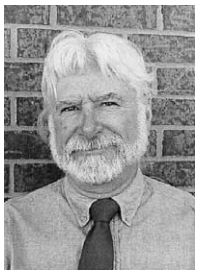

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