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With a Forward by Richard O. Mason

ABSTRACT

Churchman [1971] defines inquiry as an activity that produces knowledge. He examines the epistemologies of five schools of philosophy from the perspective of general systems theory, asking the question as to whether each is suitable as the basis for the design of computer-based "inquiring systems." He considers systems design and design theory in some detail. We believe that Churchman's inquiring systems can form the basis for the design of knowledge management systems and that the IS research community has hardly tapped the potential of inquiring systems in that regard. Mason and Mitroff [1973] brought inquiring systems into the IS literature early on, essentially making the work endogenous to the field. We argue that building on inquiring systems can contribute to developing IS as a discipline by maintaining continuity in research and developing a theory that IS can call its own. We believe that the lack of use of Churchman's work may be due to its lack of visibility in recent years and attempt to remedy that by summarizing the basics of the inquirers in some detail, trying not to interpret, but to remain faithful to the original. The paper encourages readers to study the original and develop their own notion of how the inquirers might be used in knowledge management work. There are probably as many different perspectives on how inquiring systems could support KMS as there are IS researchers willing to study them. We would like to encourage a proliferation of such perspectives.

Keywords: systems theory, inquiring systems, knowledge management

FOREWORD

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The discipline of information systems (IS) has not until recently been very reflective about its most fundamental concepts. A clarion call was issued by Lynne Markus in 1999 when she asked, "What happens if the IS field as we know it goes away?" [Markus 1999] She raised a question of the field's identity and its lack of agreement on its most basic ideas. One rather quick response was for some leading researchers to call upon members of the field to concentrate more deeply on theory building and, in particular, to reach a more meaningful understanding of the "IT artifact." Wanda Orlikowski and Suzanne Iacono lobbed an initial salvo in "Desperately Seeking the 'IT' in IT Research: A Call to Theorizing the IT Artifact" [Orlikowski and Iacono 2001]. This was followed by a host of insightful articles, many of which have been collected by John King and Kalle Lyytinen and published in an informative book, *Information Systems: The State of the Field* [King and Lyytinen 2006]. These works stress the need for the field to address several crucial issues: to clarify its identity and legitimacy; to acknowledge the centrality of information technology (IT) in its research and teaching; to focus more diligently on theory and theory's crucial role in research; and to retain the intellectual diversity in perspectives, methods and topics that has thus far characterized its studies—all vital concerns.

Despite these efforts, the commentary to date is remarkably silent on the fundamental role that the underlying concepts of data, information, and knowledge play in IS practice, research and teaching. Should we also be "desperately seeking" the "I" in "IS"? I think we must and this paper by the team Jim Courtney has assembled helps address the need. Knowledge Management Systems (KMS) is currently a hot topic in the field; more and more organizations are implementing or flirting with them or renaming existing programs to say they have them, although few proponents appear to have any rigorous definition or profound understanding of KMS. "Knowledge" has become a term in good currency that is loosely attached to almost any application or system that can benefit public-relations-wise from the moniker. What most KMS initiatives lack, and the team seeks to rectify, is a reliance on "kernel theories" upon which to base their endeavors. The team roots its exploration for one of the field's core concepts in the writings of C. West Churchman and especially his *The Design of Inquiring Systems: Basic Concepts of Systems and Organization* [Churchman 1971].

"Inquiry" is the chief underlying concept. It refers to a process of searching for the truth, that is, for facts, information and knowledge. Churchman defines it straightforwardly as "an activity which produces knowledge" [p. 8]. This means that inquiry is the process that produces the "thing" —knowledge—that is the essence of KMS. So, it is a process we ought to be vitally interested in. The study of inquiry has a long history in philosophy, mostly discussed under the headings of epistemology, theories of evidence or, in a more restricted sense, the philosophy of science. Churchman delved deeply into this literature to develop a contemporary language and structure for understanding and applying modes of inquiry. The team has studied Churchman's efforts carefully and summarized them for IS researchers and professionals and demonstrates their application to KMS.

KMS, unfortunately, has become a kind of portmanteau concept, a set of diverse compartments into which various and sundry ideas and applications are thrown. Consequently, it will be helpful in understanding the team's analysis to settle on a common definition of KMS and its underlying concepts. This begins with an epistemic hierarchy: data $\Rightarrow$ information $\Rightarrow$ knowledge. Data refers to elementary observations and measurements of the attributes of entities in interest such as things, events, people, or places. Information is data that has been interpreted and given meaning. Knowledge is information that has in some manner been tested, validated, and codified and believed to be true. Churchman states that knowledge "can be considered as [either] a collection of information, as an activity, or as a potential" [Churchman 1971, p. 9]. Many KMS proponents conceive of knowledge as a collection, but Churchman argues that this view robs ". . .

the concept of all of its life. Knowledge is a vital force that makes an enormous difference in the world. . . . [It] resides in the user and not in the collection. It is how the user reacts to a collection of information that matters" [Churchman 1971, p. 10]. Thus, it is necessary to consider knowledge pragmatically as an activity or, importantly, as a potential involving a *user*. Fundamentally, "knowledge is an ability of some person to do something correctly" [Churchman 1971, p. 10]. Ultimately, Churchman concludes, "knowledge is a potential for a certain type of action, by which we mean that action would occur if certain tests are run" [Churchman 1971, p. 11]. Thus, knowledge is a means goal-seeking entities use to pursue their ends.

In *The Concept of Mind* Oxford philosopher Gilbert Ryle draws a distinction between "knowing how" and "knowing that" or "what" [Ryle 1949]. This suggests, in the most general sense, that there are at least two kinds of knowledge users employ to pursue our ends. "One is knowledge 'what' or *propositional* knowledge (that is to say, beliefs) about natural phenomena and regularities," according to economic historian Joel Mokyr, a devotee of Ryle's. This type of knowledge consists of an individual's true beliefs or what he or she is consciously aware of. The second kind is "knowledge 'how,' that is, instrumental or *prescriptive* knowledge we may call technique" [Mokyr 2002, p. 4]. This second kind of knowledge, Ackoff and Emery [1972] inform us, focuses on the "possession of a practical skill . . . . [that is] on knowing *how* to do something rather than on knowing *about* or knowing *of* something" [p. 46]. Frequently, "what" or propositional knowledge is used to produce or test "how" or prescriptive knowledge.

Inquiry may add increments to knowledge of both the "what" and "how" types. A new addition to propositional knowledge is called a *discovery* because it involves "the unearthing of a fact or natural law that existed all along but that was unknown to anyone in society." A new addition to the body of prescriptive knowledge is called an *invention* because it consists of "a set of instructions that, if executed, makes it possible to do something hitherto [thought to be] impossible" [Mokyr 2002, p. 12]. Many KMSs contain both discoveries and inventions; that is, they house both propositional knowledge and prescriptive or technique knowledge.

A key point about actionable knowledge is that a KMS that provides it should be conceived as a *relationship* between the knowledge base—a collection, usually accessible by computer, of various forms of knowledge relevant to a domain of interest—and a set of one or more users. A KMS's performance, consequently, should be measured in terms of the correct actions its users actually take or are capable of taking. In conclusion, a KMS may be defined as a knowledge-based system that supports the creation, organization, and dissemination of domain related knowledge to a specified set of users, which users intend to act effectively within a given domain of interest.

If effective action is our ultimate goal then the quality of the knowledge acted upon becomes a crucial, nay vital, factor. Significantly, the quality of knowledge available is a function of the activities used to produce it, namely, the inquiring system employed. Understanding this basic relationship is the task Churchman set for himself and, also, the one that the Courtney team implores us to apply to KMS. The team argues that inquiry is a fundament of KMS and then goes on quickly to acknowledge that multiple approaches to inquiry exist. In fact, the history of philosophy is replete with a host of proposed methods. How, the team, following Churchman, asks, is an IS researcher or a KMS designer to sort this out? What is the appropriate method of inquiry to use for a given problem? What are the *guarantors* of the truth of the knowledge and the strengths and weakness of any method used? Since users will base their professional and personal actions—the conduct of their lives—on the knowledge they acquire the answers to these questions are of the essence.

So, how to proceed? Churchman, taking an important clue from Edgar A. Singer Jr., his mentor and an illustrious student of William James at Harvard, addresses these questions by means of a "dialectic of the schools" [Singer 1959]. What Singer noted and Churchman elaborated on was that underlying all of the many different theories of inquiry lay a few pivotal assumptions, the differences among which could be used to place various philosophers' approaches into manageable categories. Following is my own reconstruction of the Singer, Churchman and Ian Mitroff approaches to this dialectic.

Assumptions are made about two essential components of knowledge: a priori laws that the inquirer assumes to be true at the outset and a posteriori facts that the inquirer will collect during the study. Modes of inquiry tend to place more emphasis on one or the other of these components. That is, an inquirer may assume that previously given laws, concepts and theories predominate (are more basic and controlling) or, alternatively, that subsequently observed empirical observations predominate. This notion leads to four propositions:

L	=	Knowledge of a priori law predominates knowledge of a posteriori fact.
~ L	=	Knowledge of a priori law does *not* predominate knowledge of a posteriori fact.
F	=	Knowledge of a posteriori fact predominates knowledge of a priori law.
~ F	=	Knowledge of a posteriori fact does *not* predominate knowledge of a priori law.

These propositions can then be used to develop a contingency matrix to reveal four fundamental modes of inquiry. The matrix below contains the name of the epistemological school, a philosopher classically identified with the school, and Mitroff's [1974] description of the school. This matrix may be used as a kind of road map for reading the Courtney team's exposition and application to KMS.

	L	~ L
F	Criticism Kantian Inquiry Synthetic Multi-model Systems	Empiricism Lockean Inquiry Experiential, Inductive, Consensual Systems
~F	Rationalism Leibnizian Inquiry Formal-Deductive Systems	Dialectic Hegelian Inquiry Conflictual, Synthetic Systems

The southwest cell of the matrix indicates that rationalist or Leibnizian inquiring systems begin with some given propositions, postulates, or axioms and use deductive logic to drive the process. Empirical facts are meaningful only in so far as they fit into or inform the logical scheme. Whereas, empiricism or Lockean inquiring systems in the northeast cell begin with elementary observations or facts which drive the process by becoming the raw material input for inductive generalizations. Laws are meaningful only in so far as they help explain the data. A Kantian inquiring system places laws and facts on equal footing and seeks to find the best model to fit the data often moving back and forth until an adequate synthesis is found. Finally, in the southeast cell the Hegelian inquiring system relegates both laws and facts to a secondary role and stresses the dialectical arguments that drive the process toward a synthesis.

Churchman develops these four schools of inquiry in depth and exposes their strengths and weaknesses. Powerful though each school is he nevertheless finds the quartet wanting primarily because each fails to deal adequately with the complexity of real world "whole systems." In his view, it is the whole system that forms the context in which users must draw on knowledge in order to act effectively. Again, Churchman returns to Singer to develop a fifth, more robust school of inquiry, one that draws on the strengths of each of the other schools where they are appropriate. It can be categorized as:

- Pragmatism
- Singerian-Churchmanian Inquiry
- Synthetic, Interdisciplinary, Holistic Systems

One characteristic of a Singerian inquirer is that it is restless. It never ends the process of questioning and, if necessary, revising every item of knowledge it develops. A Singerian inquirer forms a special relationship with its users. It presents knowledge to users in an imperative voice and tells them that they "ought" to accept this knowledge as true until further inquiry alters it. A Singerian inquirer does not make inalterable declarative statements that require users to accept the knowledge as given once and for all. The team's paper shows how this type of relationship is formed, describes the principles behind it, and reports on some applications to KMSs.

In summary, knowledge is one of the absolutely essential underlying concepts in information systems as well as a key component in KMS. It is important for us all to understand how knowledge is created; that is, to know about the processes involved in inquiry. The Courtney team has provided us with a readable and informative condensation of West Churchman's intensive treatment of inquiry, and in doing so they have laid the groundwork for future developments in inquiry for IS in general and in KMS in particular.

I. INTRODUCTION

Even though organizations are relying increasingly on information technology to assist in knowledge management (KM) efforts, Alavi and Leidner [2001] found that KM theory relates primarily to organizations themselves, rather than how IT can be used to support it. They call for theories to explain the process of knowledge management system (KMS) design and development.

Walls, Widmeyer, and El Sawy [1992; 2004] provide a general approach to the development of design theories. They suggest the use of "kernel theories" that might come from social or technical fields as the foundation for developing robust information systems design processes and products (artifacts). Walls and his colleagues [1992, p. 17] go on to suggest that ". . . there is a need for theory development based on paradigms endogenous to the area itself." We agree and would like to suggest that, for several reasons, Churchman's [1971] inquiring systems theories are especially well suited to serve as kernel theories for KMS design.

First, inquiring systems are designed to produce knowledge, one of the basic objectives of knowledge management systems. They are based on a long history of epistemology, the theory of knowledge, building upon some of the most well known philosophers of the ages. Churchman explores various branches of epistemology and chooses a particular philosopher from each school as the namesake for each approach. Hence he defines Leibnizian, Lockean, Hegelian, Kantian, and Singerian inquiring systems.

Moreover, Singerian inquiring systems are designed to generate what Churchman calls "exoteric" knowledge, or that which "goes out" to all people in all societies and is suitable for solving social and managerial problems such as those addressed in information systems (IS) research. It contrasts sharply to esoteric, scientific knowledge that becomes relevant to an increasingly smaller audience as it digs ever deeper into a narrow domain.

Thus, Churchman has already done a large part of our work for us, as he has viewed the epistemologies of five philosophers through the lens of systems theory. His thoughts on systems theory, and systems design in particular, remain among the foremost among general systems theorists. He has also suggested how information technology (albeit information technology circa 1971) might be used to support his inquirers.

Finally, we believe that the use of inquiring systems as the basis for KMS can contribute to the development of information systems as an academic discipline in that it addresses Keen's [1980] goals of continuity in IS research and the development of theory that IS can call its own. In their classic "program of research" article, Mason and Mitroff [1973] brought inquiring systems theory into the IS literature early on, effectively making it endogenous to the field. Since inquiring systems are considered to be part of the literature on information systems, this provides a theory that MIS can call its own, as opposed to being derived from a reference discipline. In addition, by continuing to rely upon and embellish inquiring systems theory, we naturally develop continuity in at least one of our research streams and strengthen our hold on inquiring systems theory as that of IS.

The Churchmanian inquirers have been used in several IS research projects, however only a few of these relate to knowledge management. At least two, however, involve KM's sister fields of organizational learning [Lee et al. 1992] and distributed cognition in organizations [Boland et al. 1994]. Boland et al.'s [1994] work on distributed cognition has been extended to KMS design through the integration of Habermas' theory of communicative action with Churchman's inquirers [Richardson 2005].

A class of learning organizations called "inquiring organizations" [Courtney et al. 1998] has been defined on the basis of Churchman's inquirers. Knowledge management in inquiring organizations has been considered [Courtney 2001] and examples of Singerian organizations have been described [Richardson et al. 2001]. Inquiring systems theory has also been used as the basis for the architecture of a learning-oriented knowledge management system [Hall et al. 2003] and for developing KMS design principles that were applied to a healthcare problem [Richardson et al. 2006]. Finally, an object-oriented representation of the inquirers has been developed [Parrish and Courtney, in press A].

Despite these developments, we agree with Mason and Mitroff [2005, p. vii] who wrote recently, "To say that Singerian and Churchmanian systems are underrepresented is putting it kindly. They are virtually nonexistent." We believe that there are at least three reasons for this. One is the inaccessibility of Churchman's book, which is out of print. And two, the book itself is admittedly not an easy read. Finally, while there remains a small cadre of IS researchers who have studied the work, it seems not to have the visibility it once held, despite the fact that Churchman was among the first three recipients of the prestigious Leo Award in 1999.

The purpose of this paper is to make Churchman's work on inquiring systems more visible to IS researchers so that it may inform work not only on knowledge management systems in particular, but information systems research in general. Even though we believe that inquiring systems theory is directly applicable to KMS design and development, we intentionally do not address that issue head on. Rather, we simply provide an extensive summary of the most salient chapters of Churchman's book. In doing that, we hope to inspire others to delve into this realm and use their own imagination to create unique ways in which inquiring systems concepts may be used to support information and knowledge management processes in organizations. In a luncheon address at the 1996 meeting of Americas Conference on Information Systems in Phoenix, Arizona, Churchman implored us to become the "information imagination association." Thus, we encourage you to use this work as an inspiration to your own imagination. And, as we shall see, the Churchmanian inquirer, in the Singerian form, puts great emphasis on moral and ethical issues, concerns that seem to have lost value in recent times. We also encourage you to include moral and ethical concerns in your imagination.

Before proceeding, we would like to point out what the paper is NOT. It is not intended to be a substitute for studying the original. Nor is it intended to be our interpretation of what Churchman is saying. We have tried to remain as faithful as possible to the original and have made liberal use of quotes from the book. As in the case of the Hegelian inquirer, we believe that there are many different possible interpretations and instantiations in the form of knowledge management systems. Again the objective is to raise the level of visibility of the work so that others may form their own ideas as to how it may inform KMS design. If that requires study of the original, so much the better. We realize the book is not an easy read, but we believe that many IS researchers are up to the challenge. We do describe some existing work that extends inquiring systems into the KM arena.

The remainder of the paper is simply organized. We proceed through the salient chapters in order, trying our best to be brief while replicating Churchman's logic. The chapters we consider cover general systems theory and systems design (chapters 1 and 3) and the basic inquirers themselves (chapters 2, 5, 6, 7 and 9). We conclude with some examples of how one might go about using the inquirers as the basis for KMS design. We regret that the paper is rather lengthy. While we want to raise the level of awareness of the work, we also feel compelled to capture the essence of Churchman's reasoning. If we err in the brevity versus comprehensiveness tradeoff, we have tended to do so on the side of the latter. In addition, we specifically want to avoid imposing our own interpretation on the reader as we feel that might unnecessarily constrain the imagination of others.

II. CHAPTER 1: DESIGN AND INQUIRY

In the first chapter, Churchman sets the philosophical tone for the design of inquiring systems. He discusses the definitions of design and inquiry and attempts to locate the unique creative processes that result in systems of actionable and communicable knowledge among people. The initial definitions are approximate and merely begin a discussion that rapidly narrows toward a focus on system design and implementation, and the resulting political and intellectual consequences. The philosophy initially appears voluntarist in epistemology and realist in ontology in the sense that he believes the whole system exists (a theme of *Challenge to Reason* [1968]); That is, he believes in the realism of systemic structures and our free ability to understand and create them in order to serve our purposes.

Design is initially defined as teleological (goal-seeking) *thinking* behavior that conceptually selects among alternative behavior patterns and tries to identify those that lead to desired outcomes. There are at least five characteristics of design [pp. 5 - 8]:

1. Design attempts to distinguish in thought between different sets of behavior patterns.
2. Design tries to estimate in thought how well each alternative set of behavior patterns will serve a specified set of goals.
3. The aim of design is to communicate its thoughts to other minds in such a manner that they can convert the thoughts into corresponding actions that will in fact serve the goals in the same manner as the designer thought they would.
4. Design pursues the goal of generality, also known by the name of methodology, whereby the designer strives to avoid the necessity of repeating the thought process when faced with a similar goal-attainment problem and therefore delineates the steps in the process of producing a design.
5. The system designer attempts to identify the whole relevant system and its components, defining the design alternatives in terms of the design of the components and their interrelationships.

The last characteristic refers to the process of defining boundaries for the system since ultimately the system of life (or self) can be virtually all encompassing, and it consists of subsystems or components. We need to understand the basic component level of our designs.

Inquiry is defined as an activity that produces knowledge. Production is deemed to have occurred when the absence of activity would have resulted in something different.

Defining knowledge is trickier. Churchman begins by defining it as a collection of information, or as an activity, or as a potential. A collection of information, such as a library, should contain meaningful and true symbols that can be retrieved by querying the collection in a certain manner. However, this by itself does not constitute knowledge. Conceptualizing knowledge as just a collection of information seems “to rob the concept of all its life” [p. 10]. The state of knowledge resides in the combined system of the collection of information and the ability of the astute and adept human user who can extract and use the information. ***Knowledge therefore resides in the user and not the collection.***

The action conception of knowledge is pragmatic, whereby knowledge is shown to be exhibited when a person has the ability to do something correctly. However, so as not to unduly restrict this definition, Churchman allows the *potential* for a certain type of action to constitute knowledge just as a database designer has knowledge of normalization even when he or she is not actually working.

Churchman hints at some of the moral implications of knowledge in discussing Spinoza’s poem, *Ethics.* Scientism, which is the attempt to reduce all matters of concern to science, has dropped the requirement for knowledge to be “good” or “bad” as would have been necessary in Spinoza’s era. Churchman states that for Spinoza, moral value was necessary to appreciate understanding and God was necessary to evaluate it. The question which arises for a designer of an inquiring system (or knowledge management system) is whether the knowledge-producing system considers goals that are beyond intellectual understanding, goals that have a moral worth or “ultimate intrinsic value” for humans. This is an issue that remains of great concern today, and extends into multiple areas of IS design, especially in decision support and expert systems and artificial intelligence.

Churchman also discusses the political and intellectual implications of implementing systems. Here he discusses resistance from the scientific community that tends to view change in only two ways, either as the type of change that will threaten their position or the type that will not. Suggestions for change which necessitate a change in outlook, such as a recommendation for spending time studying a particular subject matter, are resisted by scientists. One possibility for overcoming this type of resistance may be for the designer to focus on improving supporting activities for research. Suggestions for improved literature reviews, comparisons of concepts, mathematical modeling, computation, reporting, etc. are welcomed. These activities save time and improve channels of communication and do not threaten the role of a scientist. This is where computers can perhaps act as “intelligent technicians” to perform these supporting functions and permit scientists to allocate their creative energies toward designing better inquiring systems.

Churchman examines some historical reflective thinkers who have attempted to learn how people learn and how people justified their learning, in order to see “. . . how learning can be designed and how the design can be justified” [p. 17].

III. CHAPTER 2: LEIBNIZIAN INQUIRING SYSTEMS

Churchman begins chapter 2 by describing concepts related to design features of inquiring systems. Following Leibniz, the first concept states that the human mind learns the simplest and clearest things first and then learns about complex matters by “building up” from the base knowledge. A second concept asserts that the learning by an inquiring system begins with “input,” defined as the location in which control lies, either within the system or outside. Merging the two concepts results in four paths the designer may follow:

1. The system begins with elementary inputs that are clear and distinct.
2. The system begins with clear and distinct ideas that are not inputs.
3. The system begins with unclear inputs.
4. The system begins with unclear materials that are not inputs.

Churchman declares that the fourth path is the one taken by Leibniz. The materials are symbols or sentences. The question is whether or not a sentence is "true." Churchman considers Descartes' method of doubting as a way of "guaranteeing" the truth of a sentence, but dismisses it as not implementable. Next, he turns to consider God as the guarantor and the work of Spinoza.

SPINOZA'S INTUITION

Spinoza reflects about whether a system can be designed with intuition that accepts certain assertions as true and directly accepts that it knows those to be true. That is, "it knows and it knows that it knows." Churchman outlines Spinoza's own set of inquiring systems, which include four possible methods for inquiring and apprehending knowledge.

1. The "hearsay" method is based on the kind of knowledge a computer has when information is programmed into it and stored in memory (e.g. an encyclopedia). "There is nothing in the computer to guarantee that this information is accurate" [p. 25]. Wikipedia is a case in point.

2. The "vague" experience method relates to experience that is independent of the intellect. Pattern recognition machines are used as an example here, but Churchman says Spinoza would not apply the term "intellect" to them, as they do not have a way of explaining their findings [p. 26].

3. An inquirer with "knowledge that arises when the essence of a thing is deduced from another thing, but not adequately" [p. 26]. For example, problem-solving and game-playing systems are designed on the basis of axioms and postulates that are not built into the systems themselves. Thus they are inadequate in being able to trace back along a chain of explanation for an ultimate reason for their findings.

4. The fourth method is intuition and occurs when an inquirer obtains knowledge by perceiving a thing "through its essence alone." That is, the inquirer knows something and it knows why it knows; it "has a valid theory to explain why knowledge occurs" [p. 27].

Churchman focuses on the fourth method with the opinion that this method is useful in determining if a system can be designed to "conduct inquiry with a free executive rather than whether one can design a system to simulate the human mind" [p. 28]. The free executive can be thought of in terms of a programmer's use of an "executive routine" in a program, a heuristic routine that guides functions. Another example is an expert system that is capable of explaining its line of reasoning.

Spinoza's fourth method, intuition, must be conscious, with a completely free executive answering the questions: "Do I really know that this is so?" and "Is this so?" and to be able to explain why it is so [p. 28]. The implication for KMS is that they should have a theoretically based explanation facility.

Can a system be designed with intuition? Churchman states that Spinoza never addresses the question. However, Churchman states that human intuition can be faulty but would be beneficial to an inquiring system if it could be incorporated effectively.

THE LEIBNIZIAN INQUIRING SYSTEM

The essence of the Leibnizian inquiring system is that perceptions (streams of symbols) are generated **within the system** and thus are not inputs. The system identifies meaningful sentences in the stream or constructs sentences out of segments stored in memory through the use of a processor containing rules for "well-formed functions." Sentences not defined as tautologies (true by definition) or self-contradictions (false by definition) are termed "candidates" that become "contingent truths" or "contingent untruths" if they can be linked to some sentence in memory. Contingent truths and untruths can be derived from other contingent truths and untruths thus creating "fact nets" that grow. The system essentially starts with all the symbols that it will ever need and can construct all the sentences that are possible with those symbols. The Leibnizian inquiring system is a model builder.

Churchman lists the following as essential features of the Leibnizian inquiring system [pp. 34-35]:

1. Innate ideas i.e. no inputs
2. Capability of producing strings of symbols that can be broken down into recognizable units
3. Capability of classifying any unit as a tautology, self-contradiction, contingent truth or contingent untruth
4. Capability of forming nets of likely truths and untruths, both of which may be useful in decision making
5. Capability of ranking the nets based on a prescribed criterion
6. A method of processing symbols and building nets such that the system will ultimately arrive at the optimal net and know when it has reached that point

Examples of Leibnizian inquiring systems include algorithm machines, heuristic search machines, and theorem-proving and problem-solving machines.

Churchman notes the similarities between Leibnizian inquirers and the practice of science. Any given group of scientists pays more attention to new results linked to older findings, especially when the discipline is based on theory. The theory provides the foundation for linking the results into a "fact net." Similarly, results that can combine two unconnected nets will be readily accepted. However, results that lie outside the largest net will frequently be ignored. Consequently, when developing theory, scientists tend not to create absolute conditions but leave open the possibility for the existence of exceptions that do not force abandonment of the theory, seen here as a gigantic fact net.

Churchman points out aspects of Leibniz' thought worthy of further discussion. First, in order to optimally design part of a system, one needs knowledge of the whole system. This notion is attributed to all the rationalist inquirers. Second, one needs knowledge of the smallest unit of nature that can replicate all the complexity of nature. This is Leibniz's "monad" which can express potentially everything existing in nature. This is essentially the goal of general systems theory, the topic of the next chapter.

SUMMARY

Thus a Leibnizian system is based on the concept of monads, closed, deductive systems with everything they need to create "true" knowledge. Built into the Leibnizian system are all of the symbols it needs to create sentences as well as the logic operators it needs to determine the sentences' veracity. The rich description of this model-building system makes for easy identification of like knowledge management systems as well as the enterprise within scientific disciplines. The Leibnizian inquiring system, diagrammed in Figure 1, may be thought of as operating as follows:

1. A "sentence generator" combines symbols into sentences representing a potential statement of truth.
2. The sentence is passed to a logic processor that can determine if the statement is true, false, or contingent on other sentences.
3. If it is true or contingent, it is added to the fact net (knowledge base) of known truths.

4. If it is false, it is discarded or possibly stored in a base of "untruths."

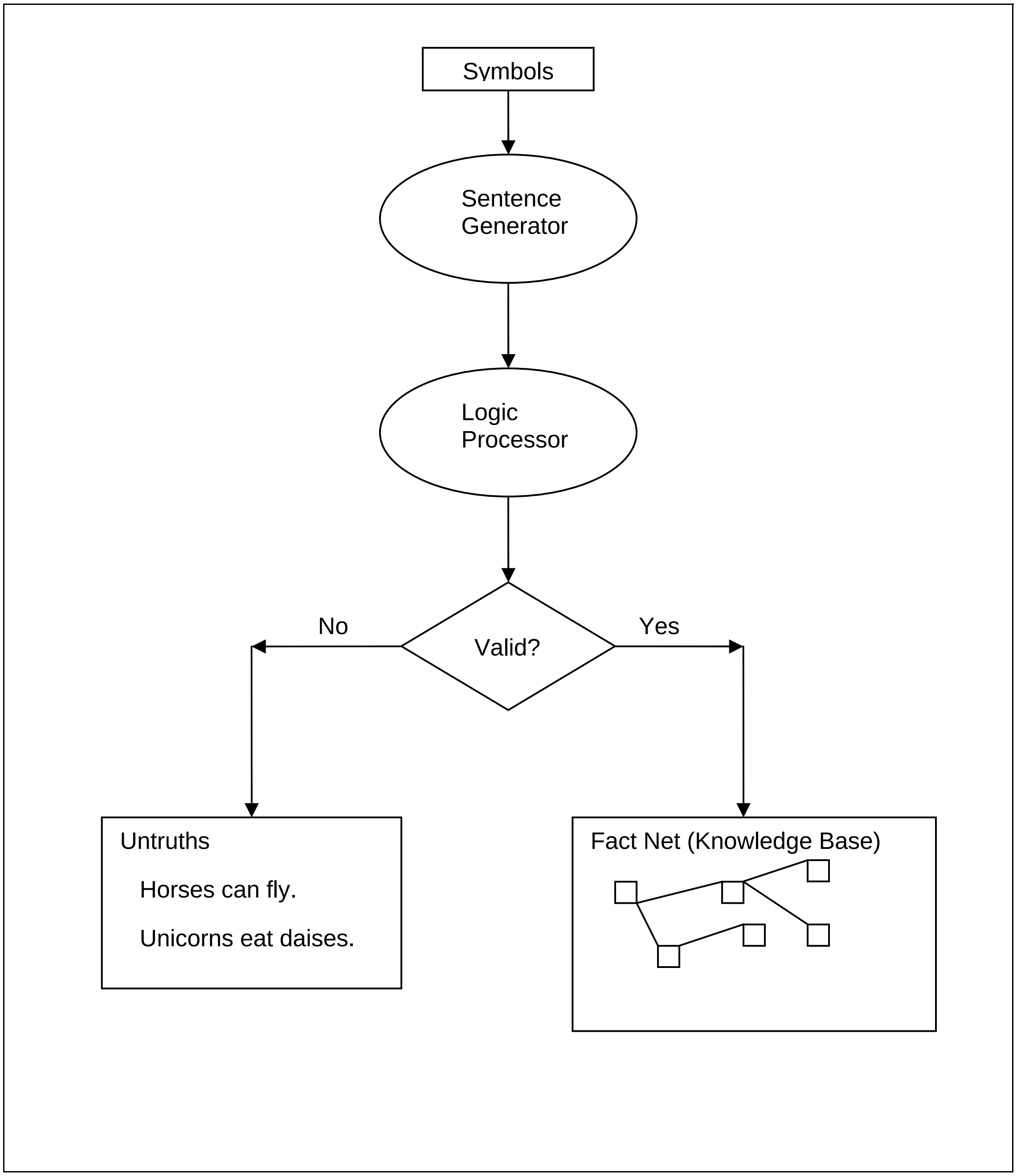

Figure 1. The Leibnizian Inquiring System

IV. CHAPTER 3: ANATOMY OF GOAL SEEKING

Chapter 3 relates back to the first chapter and Churchman's treatise on general systems theory, specifically as it relates to teleological (goal-seeking) systems and how goals are established and measured by the primary stakeholders involved in the process—the designer, the client and the decision maker. Because of the extraordinary complexity involved in the concept of teleological systems, a framework is needed to focus the discussion, and as such, Churchman postulates nine conditions that a goal-seeking system (S) possesses [p. 43]:

1. S is teleological.
2. S has a measure of performance.
3. There exists a client whose interests (values) are served by S in such a manner that the higher the measure of performance, the better the interests are served.
4. S has teleological components which co-produce its measure of performance.
5. S has an environment (defined either teleologically or ateleologically), which also co-produces its measure of performance.
6. There exists a decision maker who can take actions that produce changes in the measure of performance.
7. There exists a designer, who conceptualizes the nature of S in such a manner that the designer's concepts potentially produce actions in the decision maker.
8. The designer's intention is to change S so as to maximize S's value to the client.
9. S is "stable" with respect to the designer, in the sense that there is a built-in guarantee that the designer's intention is ultimately realizable.

THE CLIENT, DESIGNER, AND DECISION MAKER

Teleological systems are designed to accomplish, satisfy or meet one or more goals or objectives. Consequently, there must be one or more individuals who establish the system's goal(s). Churchman identifies three individuals who are involved in this process: the client, the designer, and the decision maker.

- The client is the person for whom the system is intended, is described in terms of a value structure, and is said to prefer one state of the system to others.
- The designer seeks to find the underlying principle behind the client's trade-offs by deriving performance measures that will allow the "objective" evaluation of the system's various states.
- The decision maker controls the resources of the system, thus determining the system's behavior and creating the "real future" [p. 48].

The possible futures of a given system can be described in terms of a set of properties called "goals" or "objectives." The "trade-off" principle tells us how much of one objective the client would be willing to give up for an increased amount of another objective. The designer seeks to find the underlying principle behind the client's trade-offs by estimating a "measure of performance" which enables the assignment of numerical values to possible futures. The designer also seeks a design strategy which appropriately attains both short- and long-range ethical goals.

The designer's intentions are in line with that of the client's, but the decision maker has a different relationship. The decision maker controls the resources and has personal trade-off principles that may not be identical to the client and designer. The designer is moral if he or she serves a client who has a legal or moral right to expect that the system will serve the client's interest and these interests themselves are legal or moral.

For example, the client may be investors, customers or society. Designers may be software engineers, architects, or industrial design professionals. Decision makers include business managers, politicians and health administrators. An example that views the roles together situates decision support system (DSS) and KMS designers trying to build systems that help managers examine trade-offs among potential alternative actions to determine the optimal choice for a constituency such as the citizens of a locality. The overall system is moral if all of the participants are moral.

TELEOLOGICAL COMPONENTS AND SEPERABLE SYSTEMS

"Not all teleological entities are systems" [p. 49]. Systems are different in that they can be reduced into parts that work together for the good of the entire system. Churchman writes, "What is of chief interest to the designer is the relationship of the parts to the whole system" [p.50]. It is imperative that the designer have the ability to identify the components of a system that the decision maker can change and to predict the effects that the change will have on overall system performance. Relationships between the component measures and the total system measures are of special interest.

The nature of the system depends on the instability of the environment and how the system responds to changes in the environment. The designer can simplify his or her role by concentrating on one part at a time, making it better and then moving on to other parts, which brings us to considering the separability of system components.

Churchman stresses that the designer should strive to make the system "separable," wherein one part is virtually independent of the state of the other parts. No matter what happens to a given part, the contributions of other parts remain invariant. In designing the system, the designer needs to strive for such separable systems. Churchman writes, "A system designed to solve problems in a formal framework may be separable; the optimal method of solution of one problem may not depend on how the other problems are solved" [p.54]. He later points out however, that such separability is for practical purposes only in that the designer of a system of any great magnitude cannot cope with the whole system simultaneously, but systems themselves are not separable in a pure sense.

Churchman illustrates separability in a system by considering basic research, an example which may make it easier to see how the concepts could be adapted to KMS. A community of scientists pursues knowledge in an objective fashion with a freedom of inquiry, yet the components can be viewed together as a system creating a more subjective collective. In the face of performance measures such as "payoff" of applied technology and the influential constraints of political bodies such as governments that provide grants, the boundaries that encompass the system's components become large and the designer must optimize for political and other problems. Where is the borderline and on what basis is it to be drawn?

When scaled down to the level of a single research project, the question becomes whether the thinking and observing activities are separable from the other parts of the system. Churchman points out that "the positivist position is that it is possible to do the best one can with some acts of thinking or observing without having to be concerned about the uses to which one's thoughts and observations are put or the way in which they are communicated to others" [p. 60-61]. Leibniz claims otherwise. Churchman follows Leibniz and points out several poorly designed communications subsystems in science, concluding that all systems are design nonseparable.

Churchman asks: "What kind of guarantee must the designer have that the design activities are meaningful relative to the system objectives, given that evidence for the improvement of a part depends on knowledge of the "whole" system?" [p.62] The rationalists believe that the design system is an integral part of the system. To solve this problem, "The designer temporarily assumes separability in order to improve a part" [p. 63]. The parts are virtually separated. After focusing effort on the individual parts, the system is put back together when separability is no longer feasible.

THE NONSEPARABILTY AND DECOMPOSITION PRINCIPLES

The conception of temporary separability can be cancelled by any of a multiple set of fixed assertions. Churchman says that Leibniz would argue that the satisfactory performance of a system part is dependent on some concept of the satisfactory performance of the entire system. Thus, he presents the concept of nonseparability which states that one can only determine instability in a system by examining the entire system in addition to each part.

The decomposition principle is a related concept dealing with components and the whole. In the decomposition principle, each part of the system makes its own requests for resources to attain its design goals and then forwards them to a central point that evaluates the requests on an entire system level. If certain resources are requested by multiple parts then the cost of that resource goes up and the information is communicated back to the parts. The parts are then redesigned in light of the new information and requests for resources are resubmitted. The process continues until the "optimal" overall system design is reached [p.67].

These principles and their ramifications may inform the exploratory thinking about the design of KMS. For example, Churchman points out that although a system may satisfy the requirements of the Leibnizian inquirer, there has been no attempt on a scale larger than a corporation or federal agency because of the lack of a central entity that could feasibly compare the plans, calculate costs, and develop measures of performance.

MONISM

The previous subsections have highlighted a difference in the views of systems. Churchman describes the different views as an intellectual battle between Pluralism, championed by those who prefer to design their systems in pieces, and Monism, championed by those who prefer to design the system as a whole.

Pluralists are problem solvers, empiricists, individualists, and instrumentalists. Monists are people that hold to the following principles: the whole system exists, is unique, is optimal, and the proof of the existence of the whole system and its properties meets the requirements of scientific proof.

To the monist, pluralism is irrational. For example, the empiricist never accepts more than is strictly warranted by sensory evidence. The monist looks to rationalism to address the difficulty with this answer. Churchman writes "If the empiricist is designing inquiring systems, then we must ask whether or not the kind of parsimony he requires is desirable. The answer to this question depends on the manner in which the inquiring system gathers its evidence, i.e. on the design of the whole inquiring system" [p.72]. That is the design of all science.

SUMMARY

This chapter has thus devolved somewhat to consider the nature of systems and their design systems in more detail than in chapter 1. After starting with a list of nine conditions that a goal-seeking system (S) possesses, Churchman explores these conditions under the umbrella theme of whole systems.

Chapter 4 uses mass spectrometry and organic chemistry to illustrate the Leibnizian inquirer. The expert system DENDRAL is given as the example. It was the first such system for scientific hypothesis formation [Kindsay, et al., 1993]. However, we suspect that this application is not of great interest to readers of this paper and we omit the chapter and proceed to a discussion of the Lockean inquirer in chapter 5.

V. CHAPTER 5: LOCKEAN INQUIRING SYSTEMS

"The Leibnizian inquiring system provides a framework for an elaboration of the vague purpose of science to create a 'storehouse' of knowledge. The storehouse is a set of fact nets, gradually expanding sets of contingent truths interlinked by appropriate relationships" [p.95]. Most scientists believe that they have an accurate image of man and that they are seeking to improve the accuracy of man's image of nature through fact and theory. Churchman warns however, that, "Much needs to be done to specify more how we are to plot the course of the approximation, lest we waste time exploring fact nets that lead nowhere" [p.95]. This chapter attempts to limit the amount of contingent truths that exist due to the human mind's ability to concoct wild contingent truths, such as great myths of many cultures. This chapter describes the knowledge validation method of consensus and other characteristics of the Lockean inquirer.

SIMPLE INPUTS AND PROPERTY LABELS

One way of stating the problem of a Leibnizian inquiring system (from the previous chapter) "is to ask for a system capable of distinguishing between reality and nonreality" [p.97]. It is assumed that the realistic fact nets will continue to exist as the unrealistic ones wither away. The Liebnizian inquirer has no filtering method for eliminating obviously irrelevant information. If one is building a KMS for an auto manufacturer, the knowledge that manatees are mammals may be true but not particularly relevant. The inquiring system needs "to pay attention to the relevant" [p. 98]. But the designer needs to incorporate more than the just a concept of attention, into the inquiring system. The designer needs to design a feature which provides assurance that the system is not filtering out relevant items and is filtering out irrelevant items and not acquiring them.

The design begins where the expert or knowledge broker is removed and the inquirer learns by paying attention. The class of information which is first suggested to be relevant and reliable to the inquirer is direct sensory data. These designs however, have a central difficulty, as Churchman points out, the problem of guaranteeing that a simple sensation constitutes reliable information.

To begin with, the design of the Lockean inquirer is clearly different from the Leibnizian system because the Lockean inquirer can accept inputs. When the Lockean receives information, a process occurs wherein properties from a basic, built-in list are attached to the information. Properties relate to the five senses and include items such as green, silent, soft, pungent, and tart. The Lockean system may also process information by labeling compound properties using Boolean operators. The Lockean system is also capable of reflection; it can label its own labeling processes. For example, the system may have one process for labeling animals and another for labeling knowledge. However, it seems unlikely that a process for labeling knowledge would be based on sensory input, but more likely on labels such as true or false, tacit or implicit, deep or shallow and so forth. Libraries are given as an example of a system that can receive inputs (publications), label them consistently, store them and retrieve them on request.

Churchman realizes that there is some question as to whether the Lockean system is doing anything significant. By this description, imagining a KMS based on this model, the system would appear primitive, a mere filing system that can grow its own categories. However, the Lockean inquiring system appears more interesting when the focus turns to the nature of the labeling process and how the labels are validated. For this Churchman calls upon the designer to bring together a community of inquirers that have the same basic labels and this community becomes the basis of judging whether a particular inquirer within the community is assigning labels correctly. An example is a community of inquirers that determine whether an e-mail should be labeled as spam or not and can learn to sort e-mail into various folders based on subject lines or contents.

Another example can be found in the Google image labeling application that uses human sensory inputs to provide keywords for images that can be searched for on the Google image search Web site. In this application, humans are paired together to assign meaningful labels to random images in the Google database. The humans assign labels to the image until they reach consensus on a particular label, which is then assigned to the image.

GENERALIZATION IN LOCKEAN INQUIRERS

The design of a Lockean inquirer requires a community of inquiring systems in which virtually all "agree that an input is simple or not simple" [p. 105]. If there is disagreement, the input is re-presented to the community until there is a consensus. Further still, Churchman states "the community of Lockean inquirers is to be designed so as to develop a learning process, in which they attempt to generalize their experience" [p. 108]. They do this by means of induction from their agreements about specific observations. Lockean inquirers have some logic built into them, capable of recognizing contradictions.

The problem of generalization facing the Lockean inquiring system is not different from the problem of "fact nets," with the exception of the goals of the networks. "In the Leibnizian system, the goal is to create a network of sentences that will take precedence over all competing networks" [p. 111]. In contrast, the Lockean system's goal is to create the largest, most elegant network possible based only on empirical data.

To achieve agreement, some Lockean systems have measures of confidence designed into them to make the generalizing sector behave more precisely. While it might seem obvious to apply confidence measures to all situations, it is regarded by Churchman as an important design feature. The domain may include a generating system, like a number generating system, in which "no veto power should be allowed to the generalizer" [p.112].

Another design issue for the generalizing sector is that of "the inducer which can direct where the next observation is to be made" [p. 112]. Churchman cautions, "The generalizing sector may turn the attention of the Lockean inquiring system to various aspects of nature in order to increase its confidence in certain generalizations or to modify generalizations already held" [p. 113].

There are many hypotheses governing human life in which the full generalization "all *a* is *b*" is not valid, but one may arrive at a well-substantiated assertion of the form "in *p* percent of the cases, *a*'s are also *b*'s" [p.113]. A language of doubt may be constructed whether simply using a "D" for doubt or getting into the language of statistics. Although there is some question about the statistical language, because it does not enable the inquirer to designate what actions are appropriate.

"Some might want to say that the problem of Lockean design is not to determine how to use information for action, but rather to produce information which describes the world. Even so, what guarantees the validity of the descriptions?" [p. 115]. The implications for KMS design are that we may wish to include a "language of doubt" or statistical estimate of the validity of an assertion and we may wish to include information on relevant actions given a valid assertion. In an earlier work, *Prediction and Optimal Decision,* Churchman [1961, p. 335] pointed out that managers might take a page from the scientist, who "does not take it as a confession of failure that there is positive, probable error in his measurements." Whereas managers seem to want their accounting data to "exact," expert systems and other KMS should have some means of expressing the confidence associated with the accuracy of their inputs and outputs.

SUMMARY

The Lockean inquiring system receives simple inputs, labels properties, and validates knowledge through a strategy of induction powered by community protocols for reaching consensus (Figure 2). Here Churchman explores several ideas of inquiry which may stimulate refreshed thinking about contemporary KMS design.

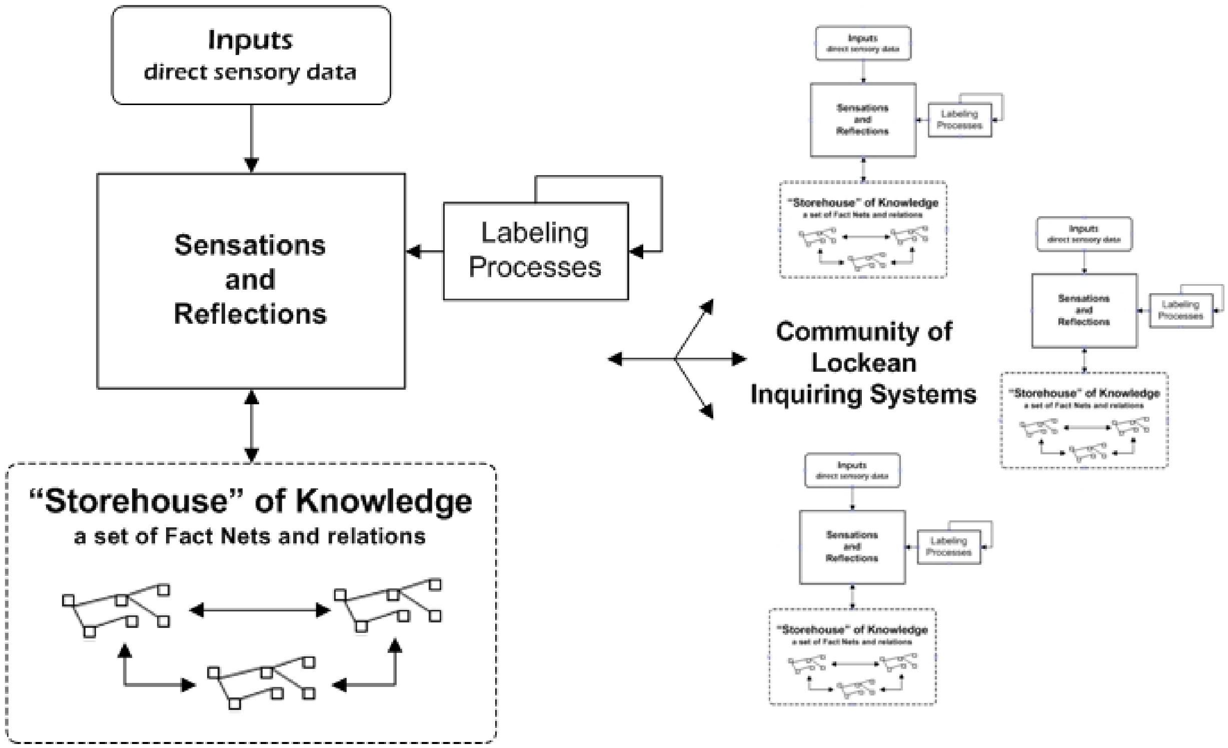

Figure 2. The Lockean Inquiring System and a Lockean Community

A world of cheap sensors, positioned with GPS or freeze-framed while in motion with RFID suggests that the thinking of simple inputs is not without some basis in reality. Seemingly simple policy issues regarding whether or not to attach confidence intervals to forecasts of climate change published by globally public agencies (the UN) appear as contemporary example consistent with Churchman's views. Churchman even provides in this chapter a way to view the labeling process of libraries in a differing manner, still relevant after dramatic changes since the book was written.

The design questions that have been raised concern innate ideas, communication, community and induction. In Leibniz, ideas (sentences) come from within the system; in Locke observations come from outside. Leibniz emphasizes the lone researcher; Locke the scientific community. The chapter assumed there is one "basic" way to describe the world regardless of language or viewpoint. One of Kant's basic observations is that there are multiple ways to view the world, which leads us to the next chapter.

VI. CHAPTER 6: KANTIAN INQUIRING SYSTEMS

Churchman begins by analyzing Kant's *Critique of Pure Reason* stating "For Kant . . . the existence of an input system capable of receiving data implied that the inquiring system had built into it certain a priori sciences" [p. 128]. Kant seems to believe that the inquirer is not capable of receiving inputs without the basic axioms of a priori science, axioms such as elementary geometry, arithmetic, and kinematics.

Churchman illustrates this point again using a library as a rough metaphor. If the librarians and catalogers are considered part of the input device, one could conclude that the input device has a priori axioms in the form of elementary numbering theory for coding and three-dimensional geometry for storing and locating materials. How then does the inquiring system validate these a priori axioms? Furthermore, once the a priori axioms are deemed necessary, as Kant believed, how does the inquiring system decide which are necessary? Churchman believes the answer is implied by Kant, that to validate the a priori axioms an inquiring system must also be capable of a process of self-examination by which it can discover its own methodology for receiving inputs.

He next explores the ability of the inquirer to validate its number theory and a space-time framework. Churchman questions how the self-examination of the inquirer determines the correct or optimal a priori alternative since the system cannot learn from experience but must receive experience within the framework of a priori science. This leads to two basic design problems [p. 130]:

1. How does the a priori structure influence the decisions of the inquiring system's generalizing sector?

2. How can one determine the appropriate a priori structure such that the inquirer can "validate" the a priori axioms?

These two questions direct Churchman's analysis in this chapter.

THE A PRIORI SECTOR AND THE GENERALIZING SECTOR

According to Churchman, there are two opposing design philosophies concerning inquiring systems and the proper relationship between the a priori sector and generalizing sector. This philosophy separates the two sectors and treats them independently. One philosophy prefers a simple approach, allowing each sector to be judged on its own performance. The other regards the sectors as nonseparable. The designer in this case aims for a performance increase gained from a combined capability, but sacrifices simplicity as the whole becomes more complex.

Kant's approach most resembles the first (simple) in that he attempts to identify only the key assertions necessary for an inquiring system to receive inputs. Churchman initially questions this approach by providing an example of a clock. An experiment may require the use of a clock (a prior axiom) to track the events of a particular test (generalizing sector). The simple philosophy assumes the clock behaves appropriately. How does the inquiring system know that this is true? Churchman presses the issue of the simple design by asking *qui custodiet custodium,* or, in terms of the example, what guarantees that the clock is working properly?

This leads to a paradox. How can the inquirer prove the axioms needed to validate the clock by experience? To solve this, Churchman points to a mathematical method called *reductio ad absurdum* that states "assuming a proposition X to prove that X is false." Assuming a negation and deducing a contradiction is common for formal assumptions. However, with empirical a priori, is it so easy to discard unexplainable events because it clashes with an axiom? Churchman further mentions that no alternative a priori need be chosen because one alternative can be translated into another with some differences. For example, Newtonian mechanics could be translated into a special case of Einstein's special theory of relativity. The question of guaranteeing a set of axioms has led Churchman to question whether the mode in which information is expressed even has consequences beyond the fact that one mode is a simple way of handling data (e.g. special theory of relativity) and one mode is a complex way of handling data (e.g. Newtonian kinematics).

Under the simple approach, the best a priori method of structuring information will be the one that is most efficient in collecting, transmitting, and interpreting information. The ease of interpretation is utilized by the generalizing sector to determine the adequacy of information. What many would regard as a scratch on a photographic plate is interpreted by a physicist to be the paths of electrons. Churchman raises the question, "How is the sector to determine whether it has been successful?" [p. 137]. With this query, Churchman moves to the chapter's second question which asks, "What is the appropriate a priori structure?"

PROBLEM SOLUTION AND THE A PRIORI

Churchman identifies two important aspects of problem solving. In the first, the problem solver searches for a pathway that leads to a solution. Any successful path is acceptable. In the second, the problem solver searches for the easiest path to find to the solution. Churchman states that formal science has not been particularly successful in identifying paths from the second perspective.

The second approach, in which the problem solver seeks the minimal pathway, may not always provide the most value. For example, the incremental decrease in cost from a cost reduction strategy may be less than the marginal gain. Therefore, the designer may want to maximize the influence of the inquiring system's a priori on the representation of information to facilitate problem solution.

A maximal a priori inquirer is then presented. This inquirer is similar to the Lockean inquirer, with the ability to receive inputs and label properties, but in addition to these abilities the inquirer has a stored set of models. Churchman then adds to this inquirer an "executive" that "examines whether a given input is appropriately interpreted by a given model" [p. 142]. This inquirer is capable of assessing whether the representation of an input by a particular model is valid, and then if deemed so, continues "to look upon the world through the 'spectacles' provided by the model" [p. 142]. If the executive determines that a given model is not converging, it may turn the model off.

Churchman identifies at least five critical design problems of this particular inquiring system [pp. 142-144].

1. What input should the inquiring system process? Given a potentially infinite set of inputs, is there a desired design economy in filtering inputs?

2. How should an input be translated within the language of a model? In terms of an analogy, can a creative process be analyzed much less designed?

3. How does the executive decide to judge whether the translated inputs provide a good basis for solution? There must be some criterion function to determine if the model is performing well, as in step-wise regression, for example.

4. How is the executive to judge whether a solution has occurred? Churchman notes that everyday problems often have no way to determine if a solution has even occurred.

5. Is the whole idea of a maximal a priori appropriate? If a system works on the basis of the maximal a priori then a good deal of control over the inputs is given up, and perhaps the inquirer might be better conceived with more control over inputs.

To Kant, experience contains information (an input stream) that is "given" and the inquirer cannot change it. Kant deemed the irreconcilable differences between the Leibnizian and Locke-Kantian theories of design as antinomy. The core thesis of Leibniz is predicated upon the fact that input streams are under the control of the executive. The antithesis developed by Locke and Kant states that some aspects of the input stream are not under the control of the executive.

Churchman asks "How did the designer decide what in fact to give the inquirer to solve?" [p. 146]. Understanding the problem concoctor may reveal the answers to the five questions Churchman poses above related to maximal a priori models. To the KMS designer, this translates to:

- What problems should the KMS address?

- What models are appropriate for addressing these problems?

- What is the problem statement language of the model and how can problems be stated in that language?

- What is the degree of fit of the model to the problem?
- How do we know when a solution has been obtained?

SUMMARY

Like the Lockean system, a Kantian inquiring system can accept inputs. It contains a set of models that can translate the inputs into their own terms for processing and a criterion function that is a measure of how “satisfactory” the model is performing. A Kantian system has an executive that can accept problems, turn models on or off based on the model’s performance, and decide when the problem is solved. As an example, Paradice and Courtney [1987] used the Kantian approach as the basis for a knowledge-based managerial advisory system that was capable of producing multiple models in response to user requests for assistance in decision making.

Another example of a Kantian inquiring system is the set of models that the National Hurricane Center uses to project the paths of tropical disturbances (http://www.nco.ncep.noaa.gov/). Several different models have been developed to predict where storms will go. Additionally, more credence is given to the predictions of models that have proven to be more accurate during past hurricane seasons or to those that seem to be making similar predictions for the same storm. The use of these models has an enormous impact in potentially saving lives and property, as it is possible to evacuate areas where storms are expected to strike.

Another example is Allison’s (1969) analysis of the Cuban missile crisis in which he views this event through the lens of three different theories (rational actor, organizational process, and bureaucratic politics). He is able to derive useful and varied insights into the problem with each model.

Finally, Churchman states that Locke and Kant had difficulty describing their interpretation of the information “given” to inquiring systems. The given to one system is the problem of another inquiring system observing the first in its own problem-solving activities. This section leads into the next chapter and the concept of the Hegelian over-observer.

VII. CHAPTER 7: THE HEGELIAN INQUIRING SYSTEMS

Churchman’s Hegelian inquiring systems continue the ongoing discussion of inquirers and how knowledge is verified, focusing on several related concepts, including observation, objectivity, subjectivity, and importantly, the dialectic. There are two ways for an observer to be observed [p. 150]:

1. He may observe himself directly.
2. He may be observed “inferentially” by another observer.

This brings us to the “The Subjectivity Syndrome,” the assertion, “I and I alone can know the inner states of my mind and can only infer the states of other minds” [p. 151]. Given this, there is not a way to compare one person's feelings directly with another person's feelings because there is no real unit of measurement.

This line of thought continues from the subjectivist’s viewpoint. It is difficult to see how an inquiring system can observe the internal workings of others. However, the internal data that an inquiring system generates from the observing can be regarded as knowledge without the same scrutiny. This creates two classes, personal knowledge and community knowledge.

The Lockean inquiring system is recognizable in the community knowledge class, where the community shares the methods by which the knowledge was achieved. However, this method leaves no room for the designer; community knowledge has too much weight. Furthermore, an individual may seek to preserve his or her own subjective view. A conflict arises over the location of control of observing knowledge. For example, instead of giving internal observations more importance, perhaps the system should give internal observations the same status as observing outside objects. However, what if the sensation is a toothache? Churchman guides in such a fashion to suggest that there is no easy answer. He writes, "Inquirer A's information about inquirer's B's internal states may be as reliable as B's own reflections about his internal states" [p. 156].

Then, to determine if the inquirer's personal knowledge is "objective," consider the classification of what is being observed with a classification of a physical description of the "inner states" of the observer. If they are the same then, the inquiring is objective. Objectivity, therefore, is a property of an observer of a subject.

THE EXPERIENCE OF BEING OBJECTIVE IS SUBJECTIVE

The problem remains that the experience of being objective is subjective and, therefore, self-reflection is not enough. What if the observer is wrong about what is being observed of the manner of the subject? Or, using the metaphor, who sees the whole "elephant" for the community of inquirers?

Churchman explores this problem by discussing the Mechanist theory of objectivity. Information is the stored set of reactions that the inquirer has to the inputs from a subject. The information is said to dominate the observed because the observed is powerless to change the information and must react to it as programmed.

Churchman discusses how statisticians, semanticists, and information theory mathematicians take the information as given and assume that it truly represents objects. In this way, information becomes the master and conquering lord and the subjects are often willing slaves. Why do people accept "facts?" Because they come from experts? Because controls are in place? Because it is a popular belief?

Churchman states, "The designer of inquiring systems is less interested in whether the master is the expert, the auditor, or the collective mind than he is in the basic design principle that justifies each of these choices" [p. 162]. One way to see the problems that arise is to consider how problematic it is to accept "facts" when they deal with value judgments.

One approach to information that emphasizes purpose (means and ends) is the teleological approach. Alienation disappears if the subject, for example a manager, gets to decide the observer of the subject, the expert. The facts are proven to be worthy by virtue of the policy of soliciting the assistance of the expert. Similarly, using the teleological approach, a designer can go beyond simply accepting a fact, which is the "Is it indeed?" approach and determine whether or not a fact is appropriate by asking, "So what?"

The mechanical inquirer uses the information when it is from an authorized source. However, the purposeful inquirer only uses the information when it fits in the design. Here the purposeful inquirer takes into consideration not only the information, but how the source views the information, i.e., the inquirer is self-reflective about the context of the information. So, in this sense, one could consider a design of a mechanical, simple, observing system embedded inside a purposeful, reacting system.

THE HEGELIAN DIALECTIC

The inquirer in the Hegelian inquiring system performs the following acts:

1. Gets experience;

2. Starts by believing in a **thesis;**

3. Asks "So What?" about the thesis, creating the **antithesis,** which is the "deadliest enemy" of the thesis;

4. Creates a new observer of the subject that observes the conflict in the form of a debate between ardent proponents of the thesis and equally ardent proponents of the antithesis;

5. Forms a **synthesis** that ideally absorbs the thesis and antithesis in such a way as to dissolve the problem, the conflict is nullified as by the mother who solves the problem of two squabbling children by saying "Let's go to the park and play."

The system actually contains several world view models. In constructing the thesis and antithesis, the designer does not design using the "data-to-model-to-optimal methodology" as does the Kantian inquirer, but instead uses the "optimal-policy-to-relevant-and-irrelevant-data methodology." Given a policy (thesis), what is the interpretation of the data (world view) that maximizes belief in that policy? Similarly, the antithesis is the interpretation of the data that maximizes belief in a diametrically opposed policy. From these, a synthesis is created by the over-observer. The synthesis is a new thesis of a higher order. Ideally, the apparent differences in the thesis and antithesis are "dissolved" and the problem vanishes. The process is reminiscent of a two-party political system in which each party attempts to interpret the same data in terms of its world view. It may be somewhat optimistic to believe that a synthesis can be obtained that dissolves the differences.

"The inquirer can also work on the data bank, either expanding it or making it more precise, and search for the optimal change in the data bank that will maximize the irrelevance of the thesis and antithesis and maximize the credence in the synthesis" [p. 175]. In other words, the inquirer picks the view of reality that maximizes the information value of the data. It does NOT distort the data to, for example, justify making a certain decision. Rather, it tries to improve the quality and relevance of the data.

SUMMARY

The Hegelian inquirer may be summarized roughly using the following example [p. 179]. Start with a set of data, a set of world views, a set of interpretive operators that map elements of the data for a given world view into an information set, and a set of theses about the world.

Suppose that our data consists of the fact that a two-quart beaker contains one quart of oil. The Democratic interpreter says the glass is half empty, the Independent interpreter says it is half full, and the Republican interpreter says the oil is mine, don't tax it. In other words, the interpretation is the information produced by applying a particular world view to the data set. All interpretations are applied to the same data set.

Suppose also that we have a set of theses T containing statements about the world, such as "Minimal government is good." Let C be a function that expresses a "degree of credence" in each thesis given the information sets (interpretations of the data) produced by the various world views. For example, the function might compute to 0.5; indicating we are 50 percent sure that minimal government is good, given a two-quart beaker with one quart of oil.

The "thesis" A is the element of T with maximal credence. The "antithesis" B is the element of T with the highest credence other than A, say for example, "Maximal government is good."

The set of world views, the set of data, and the set of theses are each mapped into an expanded set. The synthesis is now the new thesis with maximal credence from the expanded set of theses, a thesis which in turn minimizes the credence in both the thesis and antithesis. For example, "Democracy is good, irrespective of the size of government and the amount of oil in the beaker."

While both the Kantian and Hegelian inquirers have multiple models that are applied to the inputs, the Hegelian selects the two that are most opposing and the over-observer constructs a synthesis on the basis of those. These concepts are useful in KMS designs that anticipate contentious situations or where the context of an information policy shifts depending upon the perspective. For example, who controls the debate on a given online discussion forum, the people posting comments, the programmer of the software, the administrator who monitors it, the advertisers who generate income, or the emergent synthesis of all of the above? Elgarah, et al. [2002] have developed a multi-perspective, dialectical system design methodology based partially on the Hegelian inquirer. This process and an application of it in developing a multi-perspective, knowledge-based system for supporting urban zoning decisions is given later in the paper.

As shown next, the Singerian approach invokes any of the other inquirers as appropriate to arrive at problem solutions.

VIII. CHAPTER 9: THE SINGERIAN INQUIRING SYSTEM

Singer chose metrology, the science of measurement, as his starting point. Philosophically, it is concerned with the operational design of measurement, i.e. the steps that take place to produce measurements and the justification that the readings accurately measure some aspect of reality.

To an inquiring system that measures, two things must be decided: the unit and the standard. Churchman gives two examples to illustrate his point: the measurement of a desk and the measurement of his income for tax purposes. From these examples the shape of the measuring system emerges. The set of components for the system must include the following:

- A rule-generating system, to specify the steps to be followed
- A visual system capable of following the specified rules
- A second visual system capable of checking the first

The design is based on a Lockean community. The main design component for measurement in the Lockean community is the "standard," which will resolve any disagreements arising in the community. If there is a disagreement among the members of the community, then they would go to another entity whose measurement system would conform to "standards." If the disagreement continues the parties take their dispute to other members until they reach the member that the community has agreed to be the ultimate check on any disagreements; for example, the U.S. Bureau of Standards.

A MEASURE OF PERFORMANCE OF THE MEASURING SYSTEM

The measure of performance of a measurement system is the degree to which all of the members of the Lockean community are taken into account in the design of the measurement system. The measure of performance of all measurement systems is the "fundamental" measurement of utility, which means that it is not a very high standard. Churchman states that despite this, "it seems absurd to say that there is a serious question about our ability to measure length" [p. 190].

An important aspect of any measurement system is the ability to replicate, or go through the same set of operations several times and get the same result. It also seems reasonable to say that if the process is replicated, the readings should be in "sufficient" agreement. If the readings are not in agreement, then we can assume that the measurement system is not accurately describing reality.

However, if the converse is true, then we cannot necessarily infer that the system is working properly. There are conditions that would cause the readings to change and possibly not to agree. Therefore the system must behave differently in differing conditions, or have a Hegelian over-observer. Churchman asks, "How can the over-observer be created? " [p. 191].

We might be tempted to say that two or more readings are inconsistent if they are not exactly alike. Churchman states that this is the error of naïve empiricism. Instead the readings can be considered in agreement if they are within an *acceptable level of refinement.*

FROM REFINEMENT TO THE PROCESS OF REVISION

Churchman writes, “To Singer the lesson seemed clear: when the readings are identical, then the inquiring system must shift to a higher level of refinement” [p. 192]. In this instance, the inquiring system accepts the idea that every meaningful descriptor of natural objects can be partitioned into meaningful subsets on the basis of some measure.

“The ontological assumption of partitioning is often expressed in terms of ‘quantification’ because the number system provides a very convenient way of satisfying the four stipulations” of partitioning. [p. 192]. The Singerian IS will partition whenever complete agreement occurs until the system reaches a level of refinement where all readings do not agree. This creates “a new dimension of the Lockean community, which in effect creates disagreements in order to attain a higher level of agreement” [p. 193].

However, Churchman asks, does the partitioning gain us anything? The answer depends on a whole system judgment. Churchman states, “in its simplest form, the assumption says that if two contrary hypotheses are both consistent with a set of adjusted readings at a specified level of refinement, then there exists some higher level where one (or both) will fail to be consistent” [p. 193].

The problem of revision is when and how to revise — use the a priori of Kant, or the world view of Hegel, or Singer’s natural image. The design problem depends on the answer to the question: Why revise? This, in turn, depends on the purpose and measure of performance of the system.

“Most philosophers of science during Singer’s time were devoting their energies to a ‘logical reconstruction’ using symbolic logic” [p. 195]. Churchman writes, “They were trying to determine how science had been designed” [p. 195]. They believed that they could cull the essence of science by sorting out the inconsistencies through logical analysis. But they could only tell *how* problems ought to be solved, not *what* problems ought to be solved.

Singer saw the error in logical reconstruction as using only one discipline of inquiry to reconstruct the inquiring system. Singer believed that the whole scope of inquiry was necessary to aid in the design task. Revisions erroneously assume that there is some sort of authority in the system, that a component can observe and correct the system. “Singerian inquiring systems have no such component” [p. 196]. “Authority and control are pervasive throughout the system, but no component is the controller” [p. 196]. There is no executive.

THE “SWEEPING-IN” PROCESS

This process is one of revision wherein the measurers can “sweep-in” variables into their laws that will allow them to adjust readings. We can see that Singer’s idea is one more way of building Leibnizian fact nets, and that one may view the history of the design of inquiring systems as the elaboration of the basic design features of the Leibnizian inquirer.

The recent (circa 1971) cry for interdisciplinary research might be a response to the collective unconscious realization that human knowledge does not come in pieces; “to understand an aspect of nature is to see it through ‘all’ the ways of imagery,” not simply one of a particular science or another or a single perspective [p. 198].

THE STRATEGY OF AGREEMENT REVISITED

Churchman has shown that a departure from the process of a Lockean inquirer occurs when all the readings are alike. Singer built his theories on the Hegelian dialectic so when data and hypothesis are mutually compatible, that is the time to “rock the boat” or “upset the apple cart” [p.

199]. This is also a dialectical process where both forces (thesis and antithesis) are at work in the inquiring system.

Churchman at the end of chapter 7 considers the real and the ideal. The idealist sees evil in complacency. The realist accuses the idealist's restlessness as precluding positive action. The Singerian inquiring system seeks not to resolve this debate but to intensify it in its search for the "truth."

THE TELEOLOGY OF INQUIRY

"The Singerian inquiring system is above all teleological, a grand teleology with an ethical base" [p. 200]. The nine characteristics of Singerian systems are:

1. "The system has the purpose of creating knowledge, which means creating the capability of choosing the right means for one's desired ends" [p. 200].
2. The system's measure of performance is the "level" of scientific and educational excellence of all society.
3. The client is humankind, i.e., all human teleological beings.
4. The components of the system have traditionally been "disciplines;" this is incorrect if the goal is "exoteric" knowledge, or knowledge that is relevant to everyone in every society.
5. The system has a cooperative environment, with "fuzzy" boundaries necessary for cooperation.
6. The decision makers are everyone — in the ideal; the most important of which are the "heroes."
7. The designers are everyone — in the ideal. Progress can be measured in terms of the degree to which the client, decision maker, and designer are the same.
8. The designer's intention is to change the system so as to maximize its value to the client (everyone).
9. There is a built-in guarantor that gives a sense of optimism.

Singer's theory of progress is on one side the production-science-optimism trilogy of 19th-century optimism. Although the lessons of history tell us that when cooperation falls out of the equation, society becomes fragmented and only some people reap the benefits.

"The measure of progress must include cooperation, which cannot be separated from production-science. Refining our measures and producing more effective machines is not progress if thereby more conflict occurs" [pp. 202-203]. In other words, progress is a very complicated nonlinear relationship between production, science, and cooperation. That is all very well, but it is the scientist who is speaking. Even if the scientists create more and more knowledge, are we making progress? Why not say making knowledge is like any other form of life: "It happens and is neither good nor bad" [p. 203].

THE HEROIC MOOD

Churchman believed that a charge to the scientific community was based on "a complex of emotions that arise from man's ancestry" [p. 203]. This is called the "heroic mood." Singer could have used Jung's work on the "collective unconscious" had it been available at the time he wrote, rather he found his clue in the heroic mood [p. 203]. "[T]he heroic mood is often suppressed by other emotions and thoughts; to free it in every [person] is an ideal, the ideal of a unified decision maker, client, and designer" [p. 204].

This chapter asks the question: "Is there progress, or merely process?" [p. 204]. This question is the same as the thematic question of the book: Does the inquiring system generate knowledge of reality or its own form of illusion?

The response is that "It depends on where you are" [p. 204]. If you are in the status quo, there is a kind of quiet progress that incrementally makes things better. If you are on the road [in the heroic mood], then there is no progress, just change. If you are fighting the battle, "you are risking your soul for something overwhelmingly important" [p. 204]. "Progress is no longer diffuse, but here and now in your actions" [p. 204].

Can the heroic mood be designed? In Jung's book, *The Undiscovered Self*, we see two views of the human psyche. "In one, man is counted and classified" [p. 204]. Diversity is the wonder, but out of it comes the need to regulate. "The other world view is the unique individual and his relation to something more wondrous than himself" [p. 204].

Churchman uses the example of man's relationship with God to illustrate one form of a hero's quest. He states that this cannot be "designed" by any of the typical methods of design, but design is young. "What would design have to be like" to design a unique relationship with God or a heroic mood? He does not "know any sensible response to this question" [p. 205].

SUMMARY

Unfortunately Churchman does not provide much help in summarizing the Singerian model other than the nine characteristics listed previously. In the mode of "normal science," the process works roughly as follows:

1. The system consists of Lockean communities that attempt to build Leibnizian fact nets, whose teleology is the creation of exoteric knowledge, "a grand teleology with an ethical base" [p. 200].

2. The communities have measurement systems and instruments that can be used to compare observations and findings.

3. If measurements are in agreement, the instruments are refined until disagreements in readings occur. In essence, members of the community agree to disagree.

4. Variables are swept into models to explain the discrepancies. A Hegelian debate occurs between a thesis and antithesis constructed over the revised models.

5. Members of the communities are the observers of the debate as well as the participants and a synthesis is formed and the process reiterates.

6. Overall progress is measured by the extent to which the client, decision maker and designer become the same, that is, involves all of humanity, perhaps even those humans who are no longer living or are yet to be born.

Hall and her colleagues [2003; 2005] describe the architecture of a learning-oriented knowledge management system that was developed by integrating Churchman's inquirers with Simon's decision-making model (Figure 3). This is a tightly integrated system and it may be difficult to envision exactly how the inquirers fit into this design. Briefly, the hypothesis generating module is a DENDRAL-like creator of hypotheses based on the Leibnizian inquirer. The time/space assessor is derived from the Kantian system, as is the best fit analyzer in the knowledge creation unit. The guarantors in this unit are derived from all five of the systems. Unfortunately, the extensiveness of the system prevents further description. For more details, see the Hall papers. Also, Richardson, et al. [2006] provide design principles for knowledge management systems based on an integration of Singerian inquiring systems with Habermas's theory of communicative action.

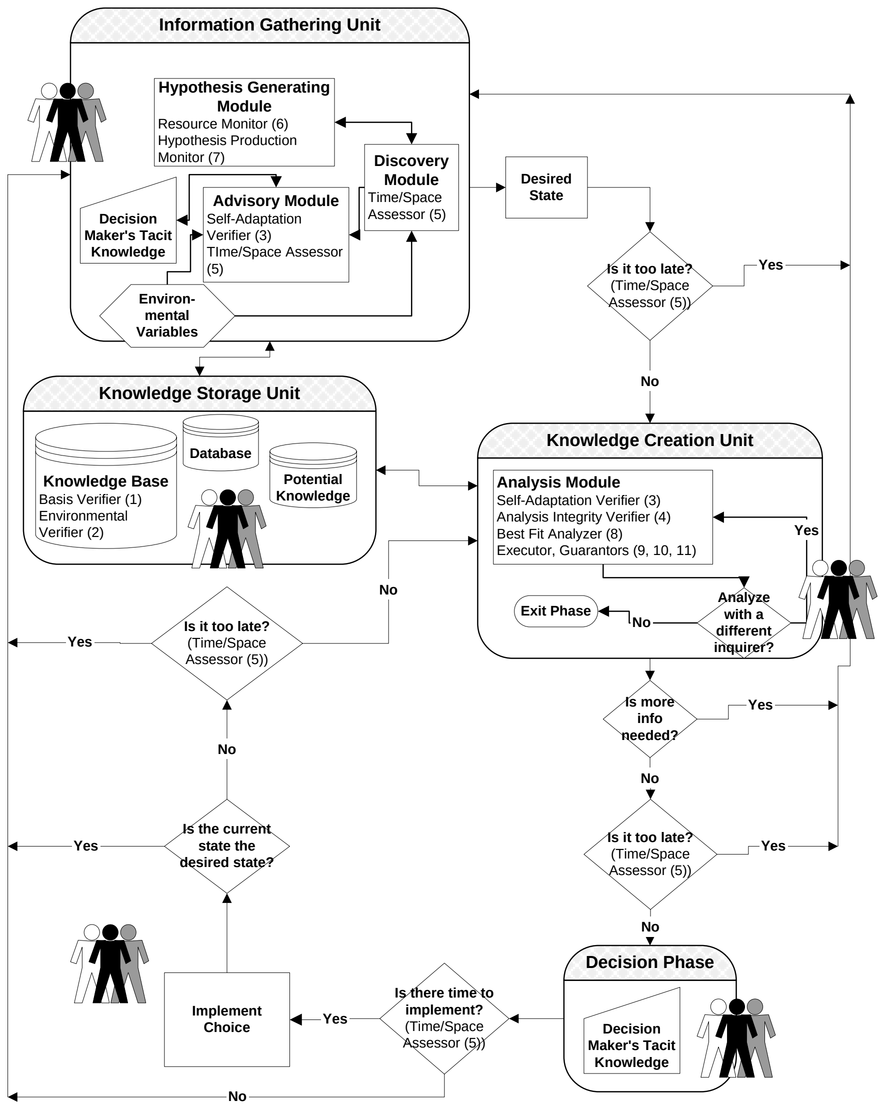

Figure 3. A Churchmanian Learning-Oriented Knowledge Management System [Hall et al. 2003].

If the system is in the heroic mood, we have even less to go on. "The approach is circumambulatory, a marvelously long word for confusion," Churchman writes. "So in the remainder of this book I'll walk around the issue of a meaning of design which could encompass the heroic mood and other aspects of the creative" [p. 206]. That is when things really begin to get interesting.

Next, we illustrate use of the Hegelian inquirer as the basis for a dialectical, knowledge-based system design methodology and its use in designing a system to support zoning decisions in county in Central Florida.

IX. A HEGELIAN APPROACH TO KNOWLEDGE-BASED SYSTEM DESIGN

Churchman's Hegelian inquirer has been used as the basis for the development and validation of a systems design theory for wicked situations [Elgarah, et al. 2002]. Organizational environments are becoming increasingly complex, changing radically and discontinuously. In this environment, organizations must consider a vast array of increasingly vocal stakeholders, ranging from consumer groups to environmental activists, governmental agencies, the media, and even terrorists. It is essential that organizational decision-making processes include greater consideration of social, political, environmental, ethical, and other factors [Mitroff and Linstone 1993]. Environments such as the ones mentioned are decidedly "wicked" [Rittel and Webber 1973], in that they have no definitive problem formulation, in fact, formulating the problem *is* the problem. Wicked situations are characterized by the multiplicity of stakeholders involved, the pervasive nature of conflicts among their perspectives, the lack of firm criteria for determining an optimal answer and the complex interconnectedness of numerous problem elements.

Courtney [2001] has proposed a decision-making paradigm based on the Singerian model and the Mitroff and Linstone multiple perspective approach. This model (Figure 4) includes multiple stakeholders and augments Mitroff and Linstone's [1993] technical (T), organizational (O) and personal (P) perspectives with ethical (E) and aesthetic (A) considerations and synthesizes them into an integrated whole (the TOPEA model). The process is driven by mental models, which lie at the heart of the framework.

The multiple perspective, dialectic process (MPDP) is based on the multiple perspective approach advocated by Mitroff and Linstone [1993], the TOPEA model [2001] and Churchman's view of the Hegelian dialectic process [1971]. This approach is well suited to capturing knowledge related to complex decisions. It calls for the synthesis of knowledge from different perspectives including the technical, organizational, personal, ethical and aesthetic knowledge of multiple stakeholders involved in a management process.

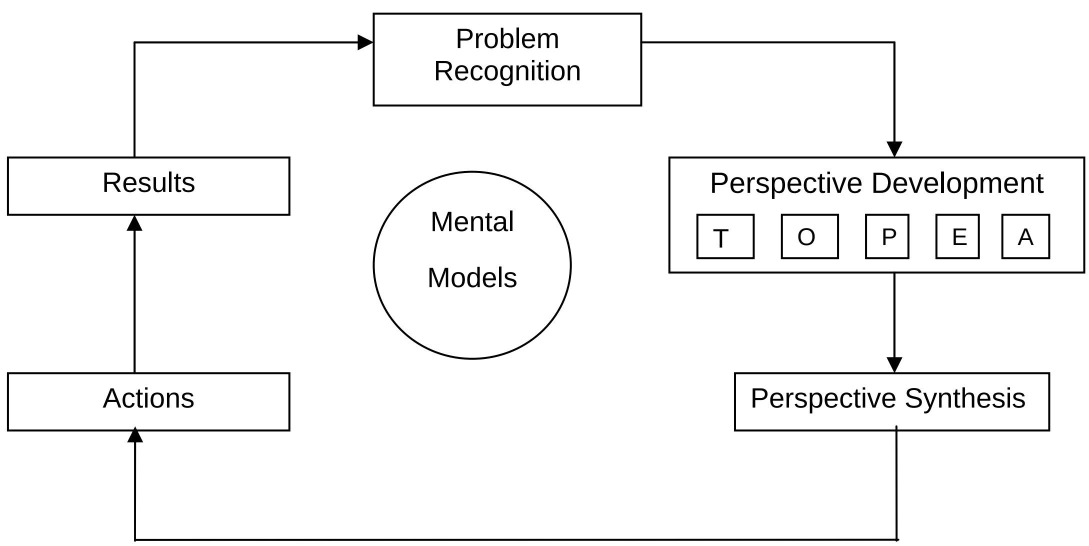

Figure 4. The TOPEA Model [Courtney 2001]

The design process (Figure 5) consists of seven steps: (1) identifying relevant stakeholders; (2) representing their respective world views in cognitive maps; (3) identifying conflicts in these world views regarding the importance of various factors involved in the process; (4) developing a prototype design (thesis) and "counter design" (antithesis) for the most diametrically opposed world views; (5) conducting a debate concerning the merits of the two designs; (6) developing a synthesized design; and finally (7) evaluating the synthesized design.

The design theory (MPDP) was developed using the process proposed by Walls et al. [1992; 2004]. Action research and design science research methods were used to validate and test the design theory. The action research project was implemented in the planning department of a county in Central Florida, where a prototype of a knowledge-based system for the county's zoning process was developed using the MPDP design theory. Five stakeholder groups were identified, consisting of the planning and zoning department staff, developers who often ask for parcels to be rezoned, environmental groups, citizens affected by the decision (represented by neighborhood organizations) and elected officials who vote on zoning changes. This application involved all dimensions of the TOPEA model. The technical perspective was represented primarily by the planning and zoning staff. Organizational perspectives were represented by neighborhood associations, elected officials and environmental groups. Each participant had a personal perspective, of course. Ethical issues were involved in that attempts were made to treat all stakeholders equitably, and even aesthetic issues were included in the sense that zoning classifications had to be harmonious with surrounding properties and compatible with the comprehensive plan for the county.

Representatives from each of the five groups were identified and customized interview guides for knowledge acquisition were developed for each group. Cognitive maps were developed to represent the knowledge structures of each group. The method and software developed by Markoczy and Goldberg [1995] were used to compare cognitive maps of the different stakeholder groups. The most diametrically opposed maps were those of the zoning staff and neighborhood groups.

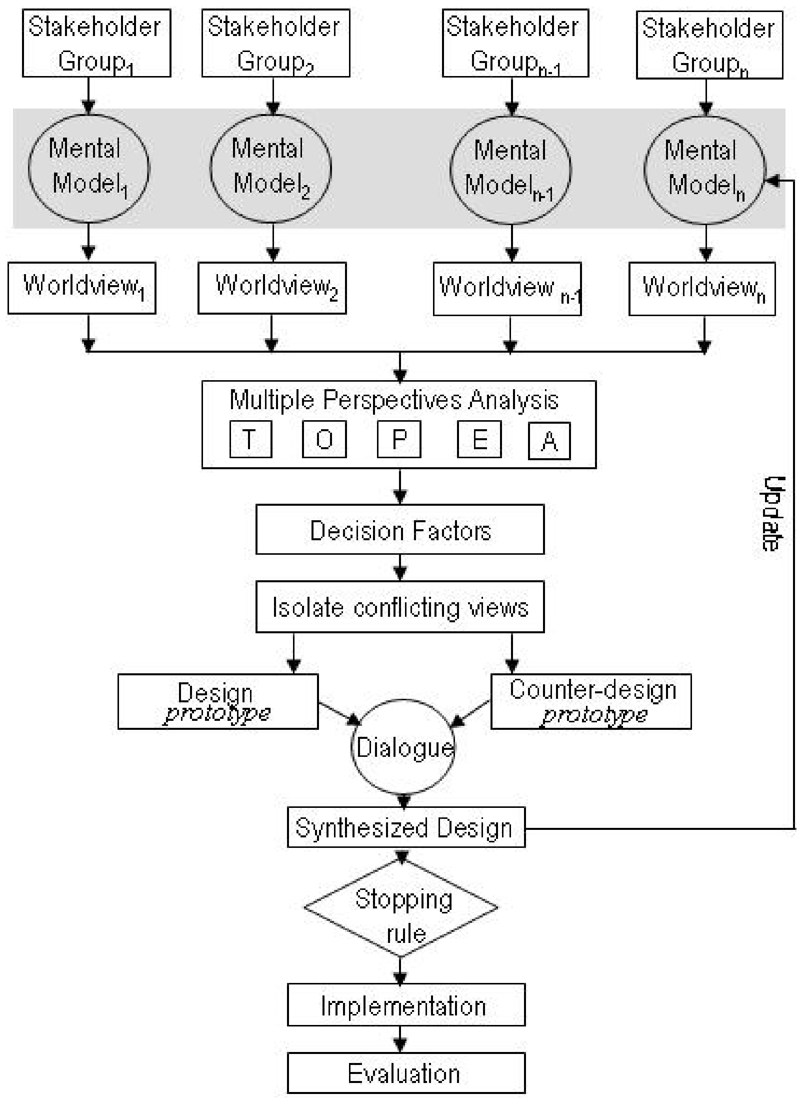

Figure 5. A Hegelian System Design Process [Elgarah, et al. 2002]

Initial prototypes were developed for the two most opposing viewpoints and three vignettes of representative zoning decisions were created and tailored to each prototype. The prototypes were used to present the vignettes to each of the five stakeholder groups and a dialogue ensued regarding the efficacy of the two in supporting the zoning process. Responses to the initial prototypes were used to develop a synthesized model that was well accepted by the planning department staff and the different stakeholder groups involved in the action research project.

Three new vignettes were developed for the prototype and the semi-structured interview process was repeated for the synthesized system. As an illustration of response to the final prototype, the director of IT stated: “This application would be a great add-on to the Zoning Analyst [an application they were implementing in the planning department]. This looks good and this is definitely something we can use.” One staff member praised the synthesized system pointing out that: “It has more information than our current report.”

Following Mason [1969], an open-ended questionnaire was developed to evaluate the MPDP design process. As for the process itself, one respondent commented, “It is great to involve all stakeholders.”

Another said, “What I like about your design is that it does not take for granted or make the assumption that one person has got to have all the answers. It really tries to include perspectives from all the experts and parties that have something to say about this. We can’t all look at this from the same direction.”

The iterative process of the methodology was also appreciated by two respondents; one stated that, “This gives you the opportunity to re-look at the situation without having to say yeah or nay! This is really good.” One respondent related that this process “is very difficult to implement.” Another pointed out that it was very time-consuming.

Overall, these comments seemed to indicate that the design theory proposed is feasible and applicable to the development of knowledge-based systems to help with complex problems such as zoning decisions. Details of the MPDP design methodology can be found in Elgarah et al. [2002], Elgarah [2005] and Elgarah and Courtney [2007].

X. CONCLUSION

We have tried to capture the essence of Churchman’s inquirers by reviewing the chapters that we believe are relevant to knowledge management system design and implementation. We apologize for any errors, misjudgments, or misunderstandings that may arise, but we must accept responsibility for those. We conclude with a short summary of each inquirer and suggestions on conditions under which each may be suitable as the kernel theory for a KMS (See Table 1).

Briefly, the Leibnizian inquirer, in its strictest form, uses only internally generated sentences and formal logic to deduce fact nets of tautologies and contingent “truths.” Mitroff and Linstone [1993] call this the *analytic-deductive approach* and state that it is more useful in well-defined, machine-like situations where problems can be reduced to logical, mathematical or algorithmic approaches. Thus, it is suitable for situations where mathematical models or rule-based expert systems might be used. An example would be in computerized physician order entry systems (CPOE) which may include a component that checks medication dosages recommended by physicians [Wilson, et al.,1997]. Pharmaceutical companies provide stringent guidelines for dosing based on age, weight, gender, or other medical conditions the patient may exhibit, other drugs the patient is taking, allergies, and so forth. It is a relatively straightforward matter to implement these guidelines in CPOE and warn physicians if a dosage appears to be incorrect.

In sharp contrast, the Lockean community accepts inputs, has a labeling procedure, and is able to communicate with other Lockean inquirers about what has been observed. This approach is inductive and consensual and is appropriate when observations (data) are an input to the system and sense must be made of that input via discussion and consensus. Sales data for a firm or data on general economic conditions and what they mean for the future of the economy are examples. The data, which could be textual, may be contained in repositories such as data warehouses with data mining tools applied to search for patterns. Communication tools such as discussion forums, e-mail, mobile devices and so forth would be necessary for sharing interpretations about what has been observed. Disagreements are resolved via a consensus-seeking process. The approach is suitable for relatively ill-structured problems [Mitroff and Linstone 1993].

The Kantian inquirer adds a space-time framework and goes beyond the one-minded approach of Leibniz and employs multiple perspectives on knowledge issues. The Kantian approach is suitable when multiple models of a situation may be developed and no one model is best in all situations. Mitroff and Linstone [1993] suggest that this approach is suitable for problems of moderate complexity, that can be modeled relatively well, but not with complete precision. Again, hurricane forecasting models come to mind, as suggested earlier.

Table 1. Summary of Inquiring Systems (Adapted from Parrish and Courtney, in press B)

	Leibniz	**Locke**	**Kant**	**Hegel**	**Singer**
Input	• None	• Elementary Observations	• Some empirical	• Some empirical	• Units and standards •
Given	• Built-in axioms	• Built-in labels (properties)	• Space-time Framework • Theories	• Theories	• System of measurement
Process	• Formal Logic • Sentence generator	• Assign labels to Inputs • Communication	• Construct models from theories • Interpret data • Choose best	• Construct theses, antithesis • Dialectic	• Strategy of agreement • Sweeping-in • Rock the boat
Output	• Fact nets • Tautologies • Contingent truths	• Taxonomy	• Fact Nets	• Synthesis	• New standard • Exoteric knowledge • Simplistic optimism
Guarantor	• Internal consistency	• Consensus	• Fit between data and • model	• Objective over-observer	• Replicability • Hegelian over-observer
IT Support	• DSS models • Expert Systems	• Databases • Communication technology • Groupware • Ontologies	• Knowledge repositories • Model bases • Problem processors	• GSS • Dialectical systems • Negotiation systems	• Internet & WWW • Intranets and portals • Modeling & visualization tools • Mobile devices
Applicable Situations	• Well-structured situations • Tractable • Relatively well understood	• Moderate or ill structure • Taxonomy available or can be developed • Community of observers	• Moderate structure • Tractable • Multiple • models feasible • Cooperative environment	• Relatively ill structured • Conflict present • Open debate encouraged • Common database	• Ill structured • Metrics available • Cooperative, ethical environment

The Hegelian system also incorporates multiple world views but seeks to create knowledge via synthesis by an over-observer witnessing a debate between a thesis and its deadliest enemy, an antithesis. While Mason [1969] used this approach early on in strategic planning, it is also well suited to situations such as those in government and politics where open debate is actively encouraged. All participants should have access to the same information, but need not process that information in the same way. It is suitable for relatively complex problems and may use textual, numeric data or other forms of information such as images.

The Singerian inquirer applies measures to readings and may resolve differences in readings by a dialectical process. If readings agree, the measurement system is refined (observations are partitioned more finely on the basis of measurements) until readings disagree, then the dialectical process is again used to reach a synthesis. But when the situation is "normal" and things are proceeding calmly, that is the time to rock the boat, produce discontinuity and enter the heroic mood — try to produce a paradigm shift.

The Singerian approach places great emphasis on ethical issues and cooperation. The dialectic is used more in the sense of an open discourse than in the sense of a debate. The Singerian inquirer is the most sophisticated of all the five and is suitable for complex, wicked problems [Mitroff and Linstone 1993; Courtney 2001]

We believe that the Churchmanian inquirers can be used as kernel theories on which to base knowledge management systems design. Some examples of this already appear in the literature [see Mason 1969; Paradice and Courtney 1987; Lee, et al. 1992; Boland, et al. 1994; Courtney 2001; Hall et al. 2003; Richardson, et al. 2006, for example]. We leave it to the reader to invent, devise, and create such KMS, and encourage the consideration of systems "with a grand teleology and an ethical base" [p. 200]. In so doing, IS researchers can establish a discipline with continuity, built on an endogenous base, and a theory that IS can claim as its own.

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