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MI Systems Taxonomy

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Abstract

Systems theory is often used in MIS research and applications. It is frequently assumed that the underlying principles of system theory are shared by both the author and audience. However, as will be presented here, multiple variants of systems theory exist, with often conflicting basic tenets which can lead authors and audiences to misunderstanding. This paper offers a taxonomy of four systems theories. Brief suggestions for applications of each are made. The limitations of systems theories are presented.

Introduction

"The whole is more than the sum of the parts." Long a central tenant of systems theory, this principle is often cited to explain the recent phenomenal growth of the Internet and E commerce. Unfortunately indiscriminant use of "Systems Theory" and its principles can mislead. Often, references to systems theory assume that underlying principles are well accepted, that only one systems theory exists. However, as argued here, systems theory has at least four variations whose underlying assumptions about knowledge and philosophy are in conflict. Our understanding, explanation, and inquiry of systemic phenomena within MIS can be enhanced with a more complete understanding of systems theory and these variations.

The systems approach suggests that groups, collections, or organizations should be the unit of analysis (Klir, 1985; Meister, 1999), a framework long fundamental to MIS (Alter, 1999; Porra, 1999). The systems view is gaining support elsewhere in the social sciences as well as in the natural sciences where aspects of it are labeled chaos theory, complex systems, and non linear systems (Campbell, 1989). This integrative perspective has matured to a point that warrants an explicit taxonomy of its variants and a more detailed account of their assumptions, a concise tutorial.

To this end, this paper first briefly lays out key principles of systems theory in general. Then it describes four variations of systems theory. Our aim is to elucidate underlying principles that vary between the four.

To begin with an overview, systems theory is a philosophy to some, to others a science. The questions it poses often do not translate into the form of specific testable hypotheses common in traditional science. As a result, its language may appear fuzzy or vague; its appeal is as a different way to think about the world, not as a clear way to test it. The value of systems theory is to spur thought, suggest new dimensions for consideration, and alternative methods of inquiry. It can not compete with what traditional science has become over the centuries—a consistent, reliable, language and valid way of knowing. It is a relatively young philosophy and here is presented to complement traditional science in pursuit of like goals: more effective design and use of MIS.

Systems Principles

Systems are wholes; system science is both epistemology, where understanding emerges from the process of conceiving in wholes, and several distinct methodologies where phenomena are studied as wholes. Man has long recognized that wholes have qualities unrecognizable in their parts (Plato, 1954; Vickers, 1983). For example, economic and ecological phenomena, as well as evolutionary biology and chaotic structures are classically systemic, as are the immune system and central nervous system (Holland, 1995; Waldrop, 1992). Further, life, democracy, and cohesion are properties that emerge only in systems or wholes; they can not be inferred from any of their components. Understanding emerges from seeing wholes comprised of indeterminate interconnections and complex interactions (Gibson, 1979; Senge, 1990). The behavior of this system is more dependent on the interactions of the components than their individual actions. Holland (1995) uses an ecological example to argue for the usefulness of systems theory:

> Ecosystems exhibit overwhelming diversity, they are continually in flux and exhibit a wondrous panoply of interactions such as mutualism, parasitism, biological arms races, and mimicry. Matter, energy and information are shunted around in complex cycles. Once again the whole is more than the sum of the parts. Even when we have a catalog of the activities of most of the participating species, we are far from understanding the effects of changes in the ecosystem. (p. 3)

While recognizing the usefulness of wholeness is the philosophy of systems theory, the methodology of systems treats the object phenomenon as a whole and considers its relation to its environment, its exchanges with its environment, and how it adapts. Systems theory employs a variety of methods that are discussed in more detail later.

In contrast to systems theory, traditional science employs reductionism--addressing complexity by breaking it down into components, and conducting repeatable, scientific experiments on parts. Conclusions are based on linear extrapolations via the superposition principle (the whole *is* the sum of the parts), a method which has had great success in the natural sciences (Gell-Mann, 1994). Reductionism seeks to explain and predict the world by searching for regularities and causal relationships between elements or parts (Burrell and Morgan, 1979). Concomitant with reductionistic science is the philosophy of logical positivism: knowledge and understanding are accumulated, built up from understanding components. Facts are value free; the generation of knowledge is separate from the application of it (Jackson and Keyes, 1991).

The crucial difference between traditional models and systems theory is in how they approach complexity, the overriding principle of the social environment (Senge, 1990). Complexity is also the mutually reinforcing impetus behind the growth in MIS. Traditional science assumes that breaking complexity down into components will not significantly distort the phenomenon being studied. It assumes that the components of the whole are the same when examined singly as when they are playing their part in the whole, or that the principles governing the assembly of the components into the whole are themselves straightforward. In contrast, systems theory holds that valid understanding and insight of complex systems accrue only at the level of the whole, that a whole can not be understood by any assembly of its parts (Campbell, 1989).

In a number of domains important to MIS, the systems approach has proven to be a robust framework, providing a foundation for a variety of very successful practice and research themes. It is often used as a foundational perspective in introductory MIS texts (e.g. Alter, 1999; Oz, 1998; O'Brien 1999; Zwass, 1998), as a source of ammunition for social MIS issues (e.g. Mitroff and Linstone, 1993; Porra, 1999), and as an explanation for the non-linear growth in network phenomena.

Clearly reductionism generates reliable knowledge when appropriately employed. If wholeness is a viable, useful framework, what patterns of specific and consistent insight does it reliably generate? One generally accepted property of systems is hierarchy (Checkland, 1981; Simon, 1969; Stein, 1989a). Systems are nested hierarchies of subsystems; each is more complex than the one below. Each level of system is characterized by unique emergent properties (Checkland, 1981).

A second fundamental tenet is adaptation. Systems, to remain viable, use control processes that lead to adaptation to environments. Control structures of human systems can typically be observed in communication (Beer, 1972; Simon, 1969).

Differences within Systems Theory

Systems theory is difficult to describe in general as it has at least four distinct forms (Jackson, 1991) each with implications for MIS. Table 1 shows how these four--hard, complex, soft and critical--differ. Each makes a number of philosophical assumptions in an attempt to be more coherent and useful than the general systems theory described to this point.

Table 1: Differences in Systems Theories

	Dominant Metaphor	Epistemology	Key Principle	Purpose	Methodology	Sociology	Domain
Hard	Mechanistic	Positivism	Goal Seeking	Predict Normative	Nomothetic/ Simulation	Regulation	Well Defined/ Organizational
Complex	Mechanistic	Positivism	Local Niche	Predict Normative	Nomothetic/ Simulation	Regulation	Natural Science
Soft	Organic	Interpretivism	Indeterminacy	Argue Descriptive	Ideographic	Regulation	Ambiguously Defined/ Organizational
Critical	Organic	Interpretivism	Power	Argue Descriptive	Ideographic Pluralistic	Radical Change	Poorly Defined/ Organizational

<u>Hard Systems</u>

Hard systems theory employs quantitative techniques from a positivist epistemology similar to the traditional sciences. What makes it different from traditional science is that its level of analysis is more holistic, the object of inquiry is typically large-scale systems in operation. Labeled systems management, management science, systems dynamics, and operations research, it assumes the existence of goal seeking behavior in purposeful systems (Ackoff, 1974; Checkland, 1981; Churchman, 1968; Forrester, 1971). The aim is to predict the behavior of the *system* within a framework of self-control, optimization and objectivity. The method of research is nomothetic (the study of cases or events as universals, with a view to formulating general laws), and entirely quantitative.

Complex Systems

Within the past 12 years, this school of thought has emerged sharing many of the same tenets with hard systems, but extending their common mechanistic, positivist-nomothetic, predictive, regulative approach to domains in the natural and artificial sciences (e.g. computer science, mathematics, logic, etc.). This group expanded out of organizational cybernetics (for examples see Beer, Forrester), proposing emergent property models for the immune system, evolutionary biology, spin glasses (magnetically charged glasses), computational physics, dynamical functions, and chaos theory (Devaney, 1990; Kauffman, 1993; McNaughton, 1989; Mitchell, 1995; Stein, 1989b; Zurek, 1990). This school is concerned with explanation and prediction via pattern recognition, modeling agent interaction, and understanding local goal seeking ("niching") rather than global optima. Further, complex systems behavior is thought to be highly dependent on initial conditions; small variations in these conditions have significant non-linear impacts on system performance. The complex school is critical of the hard systems approach as inadequately addressing complexity or emergent phenomena, overly relying on simplifying linear approximations, and unsuited to the inherently dynamic, iterative, interactive nature of complex systems. It attempts to quantitatively predict system-wide behavior by building mathematical, but non-linear models of the system's components. (Linear functions by contrast, predict model behavior based on weighted sums of input values.) The dominant method is simulation. Models of the system's components and their interaction are programmed. Initial conditions, input from random number generators, are varied, and the quantitative patterns or symmetries developed over the multiple iterated runs are evaluated.

Soft Systems

Soft systems was developed to complement the hard systems approach, differing in epistemology, key principle, purpose, and method. It arose from a need to better address complex contemporary social issues (Flood and Jackson, 1991). Its interpretivist epistemology holds that knowledge is constructed by subjects or groups, as a result of selection pressures from the environment (Heylighten, 1996). Moreover, various stakeholders have unique and valid views of the problem space. Further, problem identification and selection are largely idiosyncratic:

> The social world is perceived (and constructed) by men according to the particular world-views. This is a cultural mechanism which maintains desired relationships and eludes undesired ones. The process is cyclic and operates like this: our previous experiences have created for us certain standards or norms, usually tacit; the standards, norms and values lead to readiness to notice only certain features of our situations; they determine what facts are relevant; the facts noticed are evaluated against the norms or standards, so that the future experiences will be evaluated differently. (Vickers, 1981; p. 17)

Another fundamental difference of soft systems is the idea that goals may be ambiguous, conflicting, non-quantifiable, and indeterminate. That is, ambiguity of problems is not a result of underdeveloped analysis tools; it is how things are. Thus, problems involve judgment, weighing moral issues and creation of form (Checkland, 1981). As a result, solutions do not emerge from one decision, but over time where action and refinement has a better chance of success. Direct cause and effect is rejected, a more indeterminate problem space is considered more realistic, and as a result, this approach is often described as organic. Therefore, social problems rich in complexity and change need to be managed rather than decided or solved, the predict and control framework of complex and hard systems yields to design and invention (Flood and Jackson, 1991).

The method or application of soft systems encourages participants to accept multiple realities, multiple world views of a problem. That is, participants are shown the idiosyncratic nature of their own world view and how this affects problem identification and solution. As a result, theory and practice are inseparable; practitioners attempt to help participants in social problems see themselves within the higher level system or context (Flood and Jackson, 1991).

Finally, validation in soft systems methodology is difficult if not impossible. External validity in an interpretivist epistemology depends on improved behavior of participants. But this opportunity for improvement assumes stakeholders are guaranteed free and open discussion about changes to be made. That may be unrealistic to assume. In reality, powerful participants in the process are unlikely to risk their dominant position and submit their privileges to the vagaries of others' ideal demands (Jackson, 1991). This critique leads to the critical systems position.

Critical Systems

The critical approach takes it name from the critical school of sociology. It is committed to the moral concepts of individual progress and emancipation from constraining paradigms and traditions. Sharing foundations of interpretivism, ideographic methodology and purpose with the soft approach, it views soft and hard systems as regulative approaches, unaware of their own conservativeness, and more generally the role of power in shaping social action and meaning. Hard systems explicitly, and soft implicitly--although it claims to be politically and ideologically neutral (Flood and Jackson, 199l)--take as a given organizational mission and needs. Problems are resolved to return the system to equilibrium.

According to Jackson (1991), Ulrich (1991), and Schecter (1991), the critical approach is founded on critique, emancipation, and plurality.

> Critique is a commitment to questioning the methods, practice, theory, non-native context and limits of rationality of all schools of thought. It requires a never-ending attempt to uncover hidden assumptions and conceptual traps. The commitment to emancipation is a commitment to human being and their potential for full development via free and equal participation in community with others. The commitment to pluralism insists that all systems approaches have a contribution to make and that no single approach is adequate to address the full range of problematic situations. (Schecter, 1991; p. 21 1)

One example of the critical school's methodology is presented in Ulrich (1991). He argues that problem selection and identification requires numerous boundary judgments of what is relevant beyond the control of logic or reason. Specifically, participant consensus on issues relevant to the problem should be motivated by considering "what should be" rather than "what is" to avoid overlooking hidden boundary judgments. Four general issues *should* be discussed, what *should* be sources of motivation, what *should be* sources of control, what *should be* sources of expertise, and what *should be* sources of legitimization in the domain of the problem space.

In general, critical theory attempts to question objectives toward which discussions are offered. It disagrees with the sociology of the soft approach that free and open debates are ever possible. It points to the weakness of soft systems theory's attempt to resolve plurality of ideas via exchange.

In the end, validation is possible,

> ... only via the social actors involved in the process. The analyst's success is measured by the extent to which the patient recognizes himself in the explanations offered and becomes an equal partner in the dialogue with the analyst. The actor in the social world very often suffers false-consciousness and does not truly comprehend his situation in that social world. It is incumbent, therefore, on the critical theorist to employ a social theory capable of explaining the alienated words and actions of oppressed groups in society. (Jackson, 1991; p. 133)

Applications to MIS

As mentioned, the imprimatur, “Systems Theory” is frequently employed without specification of assumptions. To show the value of the proposed taxonomy, the following section suggests placement of a number of ongoing MIS topics within the four variations framework.

<u>Applications of Hard Systems</u>

Many fields of MIS share a quantitative, large scale, regulative, positivistic approach with operations research/hard systems. Applications within both frequently employ the input/ value added /output systemic model. Optimization of network control, telecommunication, and database management indexing and hashing algorithms share common assumptions with the hard systems variation. More specifically, recent MIS research using a hard systems design includes inventory/supply chain efficiency (Kumar and Christiaanse, 1999; Salam, Rao, Bhattacharjee, 1999), information retrieval/knowledge management (Abraham and De, 1999; Zhu, Ramsey, Chen, Hauck, Ng, and Schatz, 1999), genetic algorithms (Fan, Gordon, and Pathak; 1999), and accounting and rational decision making (Hilmer and Dennis, 1999).

<u>Applications of Complex Systems</u>

Applications of complex systems in MIS include virus protection, E commerce, taxation policy, trust, and value determination. Each assumes quantitative, regulative, positivism. In addition, for each, local niching, adaptation, and small change are key rather than large scale optimization of hard systems. Many advances in MIS adoption by users share a common attention to local adaptation. Recent research under this framework includes auction (Mbarika, 1999), group decision making (Srite and Ayers, 1999), and pattern matching/search engine (Glezer and Yadav 1999).

<u>Applications of Soft Systems</u>

The essential assumptions of soft systems theory are indeterminacy and interpretivism. These principles are useful when interpreting Internet phenomena. No one has an omniscient view of the web, E commerce, or telecommunications. Recognizing the limitations of our perception improves understanding, precludes over generalizations, enhances cognitive flexibility, helps see a client’s perspective, and forces illumination of assumptions (Walsham, 1995). Research on ethical issues (McManus, 1999), trust (Stewart, 1999), marketing, and inquiring organizations (Courtney, Croasdell, and Paradice, 1998) are current exemplars of the soft systems approach.

<u>Applications of Critical Systems</u>

Critical systems suggests that MIS can be viewed as an exceptionally powerful control mechanism. This perspective also argues the purpose of an MIS is often regulatory, a controlling mechanism whose stifling power is unnoticed by those in authority. Colonial systems (Porra, 1999), teledemocracy (Lee 1999), and Singerian inquiring systems (Courtney, Croasdell, and Paradice, 1998) are prime examples of using the tenets of critical systems theory to argue for change in a poorly defined social environment. In addition, current work in privacy and copyright law are applications of this form of systems theory.

Summary

Systems theory is not a panacea; a useful understanding demands consideration of its limits. It is difficult to test hypotheses in a conventional sense. With traditional science, assessment has been well developed. With soft and complex systems theories, validity is determined only by each user, making standardization, training, and regulation difficult. Systems theory, a language without a sentence, pays for its generality with validity. It's maddeningly broad and vague, generating curious and intriguing insights that disappear like a Cheshire cat when examined in the light of traditional science. Further, systems theory has been criticized for not addressing what it is that makes the whole more than the sum of its parts, that is, what is the central intuition of wholeness (Fuenmayor, 1991; Varela and Goguen, 1978). In the absence of such a theory it is difficult for this paradigm to grow methodologically or establish a foundation for validation.

Finally, soft and critical systems theory are most useful in messy environments with conflicting or ambiguous objectives. However, a number of MIS domains have clear objectives. Therefore if the ends are predetermined, widely understood and accepted; there is no need for a paradigm based on a better way to understand and argue.

These limits are not taken lightly or dismissed. Rather they serve as a warning of what not to do with systems theory. What then should we to do with systems theory? To that end, this paper, using a soft systems perspective suggests systems theory can provide insight on stress, and life long learning. Using a critical perspective, systems theory can provide viable views on power, and culture.

In addition to these specific topics, systems theory is helpful in messy, organic domains that are difficult to quantify or measure such as communication and control. Communication and control, two vital aspects of MIS, are well modeled by the systems language. Further, it is argued here that systems can give an alternative or complementary model of understanding. Unhinging long-held and unquestioned epistemological views can lead to closer scrutiny of thinking processes, and to stimulating communication that establishes better understanding and research. And on those criteria systems theory and this manuscript are offered: to question, stimulate, and enhance the ongoing effort to make MIS more productive. If however, established criteria of traditional science—completeness, detail, and validity—are unassailable, systems theory will be of little utility.

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