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The subSYSTEM Approach: A Framework for Analyzing Information Systems at Invention and Reinvention

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Abstract

Information Systems are often seen as useful artifacts that are designed objectively and thus represent reality "as is." This paper takes a different view, arguing that maximum utility cannot be reached unless systems theory is fused with the insight supplied by a philosophical foundation. The paper articulates within the context of the theory of ontology the classification of information systems into four unique information systems at the point of 'invention and reinvention' that must also be looked at as being embedded within other systems and subsystems. The four information systems can interact with each other and/or other environmental or social subsystems. Having clarified and organized the information system domain into a framework, using a subsystem approach this paper seeks to provide the conceptual organization that will assist information system researchers and designers in their professional activities.

Keywords: System theory, subsystems, socio-organizational perspective, socio-philosophical, inquiring systems, IS framework, system analysis

Introduction

In today's world, systems mystique has expanded to encompass business and social environments that use computers extensively. All people, businesses and organizations are developing systems and techno-hype has speculated and predicted what is needed to succeed in the information age. This techno-hype plays a central role in guiding the development and use of information systems. This article will filter out techno-hype and examine information systems and events that dramatically affect the system itself after development. The exploration is based on an understanding of functional information systems, complex social systems and a detailed analysis of the literature. More specifically, this paper will show that although there is a strong functional presence (techno-hype) that has influenced system development, that after initial implementation of the information system we have ignored the natural tendency of all systems towards disorder. This movement towards disorder comes from system changes, subsystems interaction, the need for adaptation and the natural evolution of all systems into a different and sometimes more complex system. Consequently, I will broaden the line of inquiry from 'invention through reinvention' and will discuss it within the common theme that all men are the designer of systems (Burrell et al. 1979; Churchman 1971), and each man is an element within many systems, incorporating some assumptions that require a philosophical line of analysis (Hirschheim et al. 1989).

Social and technical information systems are a few of the subsystems that make up the reality of our natural world. Consequently, their interaction helps define the world we live in. The purpose of this paper, therefore, is to undertake a formal analysis of systems that lead to the development of an information systems framework. Because systems are constructs that have been devised to perform different real-world phenomenon, it should be possible, therefore, to organize the information systems that exist in our natural world. Designers and researchers do not need to agree with this paper; they may have an alternate framework that serves a different objective much better. Clearly, a single conceptual framework might be impossible in a multidimensional world that is ever changing. However, this approach is valuable because an awareness of how the subsystems fit into the larger system 'as invented' or more importantly when people 'reinvent' them. In addition, how they interact with each other can be used to refine a systems impact on the reality of our natural world and thus extend its lifecycle of usefulness.

Theoretical Background

A system is a structure that has organized components (Churchman 1971) and can be simple or of increased complexity. A complex system could consist of many subsystems and processes. Consequently, system theory was developed to help us understand the way systems are organized and how they work. In systems theory the world is described in terms of inputs, which are transformed by processes to outputs, which achieve some goal. This goal is the systems reason for being; its overall purpose for existence or its desired outcome. A theoretical and methodological way of thinking called general systems theory is presented in its fullest and most persuasive form by Bertalanffy. This approach is an extension of the tenets of organismic biology and is credited for its attempt to provide a common methodological approach for all of the sciences. This approach is based upon the idea that systems of any kind, such as physical, biological, psychological, and social all operate in accordance with the same fundamental principles (Bertalanffy 1968). Ideally, it should be possible to deduce the principles of a particular sort of system from the more general ones and a particular sort of subsystem from the more general subsystems. Deriving from General Systems Theory, Living System Theory regards the universe as a concrete system composed of a hierarchy of levels of different types of smaller subsystems. Miller (1978) defines tangible and intangible subsystems as a set of interacting components with a relationship between them.

Churchman (1979) proposes a classification of systems, based on a conversation with five historical figures, Leibniz, Locke, Kant, Hegel, and Singer. Churchman (1979) reminds us that a system is a set of interacting subsystems and/or components that operate together to accomplish a purpose, which places them in the category of behavior called teleological. Teleology is the study of an action, event or thing with reference to its purpose or end. Attributions of purpose (teleology) appear frequently in system analysis. Not only do designers and analyst say that subsystems of information systems have a purpose with respect to the whole (organization), but some hold that we must remember that life itself is inherently purposive. Therefore, teleology is an important influence because information systems have typically been classified by their purposes.

Sociotechnical systems theory was originally developed to understand the relationships between new manufacturing information technologies and the service industries. In brief, sociotechnical systems theory treats an organization as a complex whole system composed of "two interdependent subsystems: a social system involving work groups, jobs, task interdependencies, work flow, and the like; and a technical system including, for example, electronic hardware, software, networks, applications, tools, and so on" (Bikson et al. 1996). A third interdependent subsystem is the environmental subsystem which involves the elements in the marketplace(Sena et al. 1999). A change in one of these systems intrinsically leads to change in the other, making them reciprocally influential. Mutually adaptive social and technical systems are required when changes occur (Bikson et al. 1996). Sociotechnical systems theory is helpful; but it is limited by its industrialized view of only traditional organizations.

The Critical Theory of Technology argues that the roots of the degradation of labor, education, and the environment are not the fault of technology in and of itself but in its design that encompasses the cultural values of society. A compelling argument for broader democratic participation in technological choices is given and a reminder that technique is always embedded in a larger framework of nontechnical human relations (Feenberg 1991). Dynamic socio-technical systems supporting people as part of every system on which they act and the "reintegration of object with context, primary with secondary qualities, subject with object, and leadership with group." (Feenberg 1991) Critical theory establishes a historically sound understanding of technology and recovers the lost contextual meaning, thus shattering the notion that technology is neutral (Feenberg 1991).

This paper is not about reopening these same discussions on systems, but to take up the challenge of outlining a framework for analyzing and classifying information systems that combines the lessons learned from established system theories fused with the insight supplied by a philosophical foundation. In addition, a look towards the social sciences offers relevant theories about information and organization. Sociology, in particular, offers a wide collection of theories, which can provide interesting insight. Some information systems researchers have used these theories to investigate the social aspects to information systems. Indeed, many have argued (Dhillon et al. 2001) that information systems are social systems (e.g. see Ulrich 1984; Stamper 1991; Lee and Liebenau 1996). Stamper (1973) argued an information system is comparable to an organization. In addition, organizations are considered social systems. Informal, formal and technical parts comprise an organization (Liebenau and Backhouse 1990). Moreover, Dhillon and Backhouse (1996) point out those computer-based systems are but just a small part of the technical component.

Hence, the goal of this paper is to develop a framework of the information systems domain. In addition to supplying categories, this framework strength will be its attempt to capture "an awareness" of the systems that the information system domain is embedded within, supplying a more comprehensive understanding of the natural world and a deeper and richer subsystem approach to understanding systems. This approach includes the fundamental concept that a system is `other than' and `greater

than' all components, subsystems and relationships (Germana 2000). Therefore, the subsystem approach shows how system and subsystems perform independently and dependently in parallel to each other. They are invented for a purpose and at times become reinvented for purposes 'other than' intended.

The Information Systems Framework

People have a social reality, an environment that consists of shared meaning in their social system. In another words, data is a by-product of our social reality. While information is a resource created from the data to serve a perceived social need. A collection of this information, or an activity, or as a potential can be considered knowledge (Churchman 1971). Although data and information are sometimes used interchangeably, it is better to view data as raw facts or observations, and information is the data that has been refined and organized by processing and applied in a meaningful context. The latter, applying to a meaningful context is crucial to the definition because people provide the purpose, the social reality and the conversion process that produces true information. What does "produces true information," mean? It means does it "make a difference in and of itself (Churchman 1971)." If the conversion process did not exist would the resulting social reality or environment be different?

Today, the ability to harness and manage data, information and knowledge has become an important factor that defines our social reality. To serve the information systems framework focus of this paper, I begin with a definition of an information system that allows us to understand information systems, society, the world, and our place in relation to it all.

> A system of functions concerning the acquisition and transfer of information, the carriers of which can be biological, personal, social or technical units. An information system is dedicated to a certain kind of information (topic), even if this may be a very broad one. It has always the purpose of providing information to a user or a group of users. In most cases, a storage device is part of an information system. (Hornung 2000)

Simply stated, information systems use the resources of data, people, hardware and software to transform data into useful information. The role of the computer is left out of this definition because an information system exists with or without a computer. For example, any record-keeping system such as an address book or a day planner *(technical units)* may be regarded as an information system. But it should be noted that information technology has significantly expanded the power and potential of most information systems. In addition, *biological, personal, social units, which include the individual people or groups,* can be information systems or subsystems within a system. For example, people can input data, process it and produce information and this person maybe part of a group of people that input data, process it and produce information. The resulting information from the group could be completely different from what the individual person would have produced.

The framework that is proposed is based on the notion that the information system domain is embedded in other systems (figure 1) and is comprised of interacting subsystems. An information system exists because people provide the social reality, the purpose, and the conversion process that produces true information. Social reality consists of the shared meaning obtained in social construction. Subsystems are components of a system, even though a subsystem can also be considered a system in its own right. If systems are taken out of context and the relationships are not considered then the approach is incomplete.

After careful analysis, this paper begins classifying information systems by positing that the fundamental construct needed to categorize a domain is a distinct representation of it as a system. Identifying the system and embedded subsystems in a domain is a prerequisite to our eliciting the attributes that are important. The interactions that exist among the subsystems and the system purpose are used to generate the social reality of the domain.

Epistemological and Ontological Assumptions of System Paradigms

Paradigms are traditions of scientific research that includes concepts, theories, standard procedures which define objects (Feenberg 1991; Kuhn 1962). In addition, a professional community that's members share similar perceptions and engage in commonly shared practices by adopting a fundamental set of assumptions is also called a "paradigm". "A paradigm consists of assumptions about knowledge and how to acquire it, and about the physical and social world" (Hirschheim et al. 1989; Hirschheim et al. 1995). The inclusion of assumptions is necessary to assess if the classification of the four information systems is complete. The system paradigms establish the foundation that is necessary for drawing and adapting appropriate system boundaries. Consequently, the

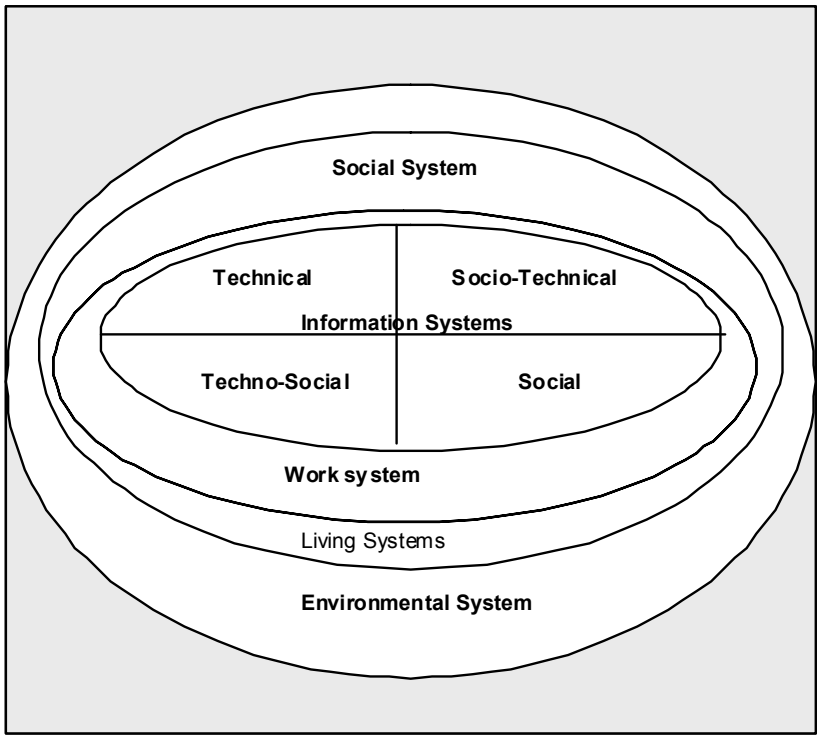

Figure 1. Social Reality and the Subsystem Approach

subsystem approach uses system theory and systems thinking to develop an understanding of the way information systems are organized and how they work; this is limited because it traditionally is only an understanding of the physical world. Living systems theory and Churchman (1979) supplies a theoretical foundation for the subsystem approach; Living Systems theory describes a concrete system composed of a hierarchy of levels of different types of smaller systems and Churchman reminds us that "a system is always embedded in a larger system." Additional concepts and theories such as critical theory and sociotechnical theory have been developed that promote the need to put systems in the context of their social world.

General system theory deduces that systems are generalizable. The weakness of this is that as the complexity of a system grows the more difficult it becomes to identify the "whole" relevant system and its components (Churchman 1971). Thus, living systems at the higher levels are more complex, open and dynamic in relation to the environment serve as great models for the man-designed information systems, which can also become very complex in design. Indeed, the complexity of the "whole" relevant system, the social reality, subsystems and its components are why we also need to include two types of assumptions for a more complete analysis: those associated with the way the research community acquires the knowledge needed to classify information systems (epistemological assumptions), and those that relate to the research communities view of the technical and social world that makes up an information system (ontological assumptions).

The assumptions of paradigms can be classified along two dimensions: a subjectivist – objectivist' dimension, and an 'order – conflict' dimension (Burrell et al. 1979; Hirschheim et al. 1989; Hirschheim et al. 1995). The natural world is a social world, made up of social systems that have smaller social systems and individual people embedded within them. This social world extends from the objective position of applying 'models and methods' that relate equally to the science of the natural and social worlds. At the opposite end of the spectrum, the subjective position is that seeks to understand the basis of human life by including the subjective experiences of individuals (Hirschheim et al. 1995). The second dimension, 'order – conflict' is a view that identifies the span from order and stability to change and conflict (Hirschheim et al. 1995). Although this dimension is important, research indicates that information systems are social inventions, whether physical or conceptual creations, thus a subsystem of a social system. They always have the purpose of directly or indirectly providing information to a user or a group of users. Therefore, when classifying existing information systems, the social dimension must be considered, specifically as related to an information systems social invention.

This papers second dimension will be, 'invention – reinvention' (Bikson et al. 1996). This is a view that identifies the span from development and creation to change and recreation and is very important because it offers a new vehicle for theorizing about nature, purpose and uses of information systems ***after*** development. In addition, the 'invention – reinvention' view is important because a strong functional presence influences system development, but that after initial implementation of the information system, all systems tend to have a natural movement towards disorder that evolves from the social systems and subsystems that interact with it. The natural world is a social world that uses information systems for some purpose or task. This extends the analysis within the common theme that all men are the designer of systems (Burrell et al. 1979; Churchman 1971), and each man is an element within many systems, incorporating assumptions that require a philosophical line of analysis (Hirschheim et al. 1989). Therefore, this movement towards disorder and interaction with social and technical subsystems, if left alone can and will in many cases cause changes. Some changes have no visible impact, some changes can be positive and some have a negative impact. All disorder, change and things that impact an information system are important and should be realized and explored. This perspective supplies a means to broaden and deepen an individual and a community of information systems researchers' contributions to normal science. Consequently, this view will extend from the invention position of continued use 'as created' for the purpose or tasks that it was designed. At the opposite end of the spectrum, the reinvention position is that a created system will be adapted and integrated into the other systems by a process that users work through for themselves about the nature and use of their tools (Bikson et al. 1996). The dimensions when mapped on to one another yield four paradigms (see figure 2):

- Technical information system (Objective – Invention)
- Techno-social information system (Objective – Reinvention)
- Social information system (Subjective – Reinvention)
- Socio-technical information system (Subjective – Invention)

This framework was chosen because it allows a simplified and yet philosophically grounded method to classify information systems at invention and when reinvented.

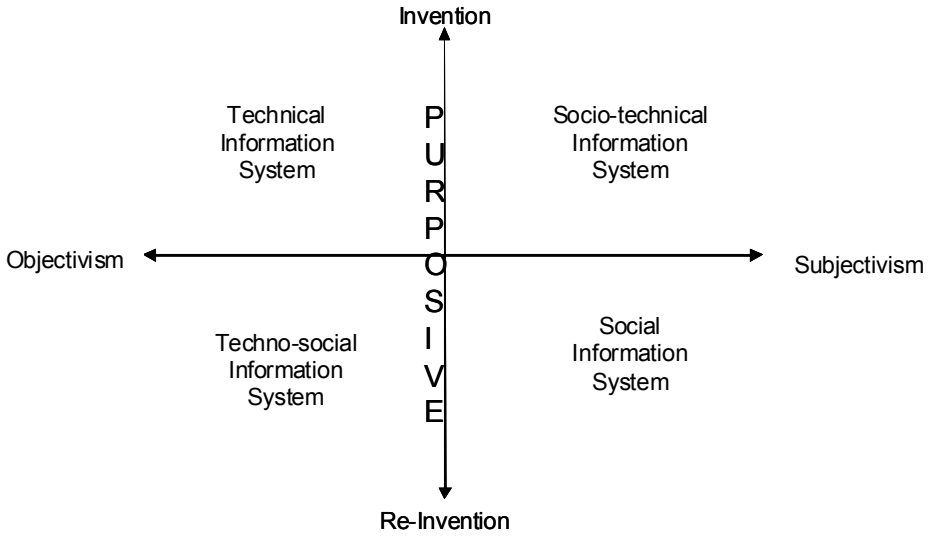

Figure 2. Information Systems Framework (Adapted from Burrell et al. 1979; Hirschheim et al. 1995)

Classification of Four Information Systems

Technical Information System

The Technical information system is concerned with 'Objective – Invention'. A technical subsystem applies 'models and methods' that relate equally to the science of the natural and social worlds and is still 'as invented' for the purpose or task that it was designed. The elements used in defining the technical information system are people, hardware, rules and procedures as physical or formal, objective entities, which is consistent with the functionalist paradigm (Hirschheim et al. 1989). For example, most everyone understands how a day planner works. It could be a simple paper day planner or an electronic day planner (i.e.,

Global Inc.'s Visual Day Planner 7.1) where we enter appointments that we need to remember. Each day we review the day planner. When the day and time comes, we are reminded that it is time for the appointment. Now let's go through this example and connect it to this category

Input – people, hardware (paper or an electronic day planner), rules and procedures
Output – planning
Feedback - when the day and time arrive, we are reminded; after the day and time past we no longer review those entries.

A technical information system serves an objective function concerning the acquisition and transfer of information, the carrier of which is a technical unit. An electronic day planner is dedicated to a certain kind of information (appointments). It has the purpose of providing information (planning) to a user. A day planner is a systematic method of managing time. It relates equally to the science of the natural and social worlds. The elements used in this technical information system are people, hardware, rules and procedures. A day planner is a physical, objective entity that is being used 'as invented' for the purpose or task that it was designed.

Techno-Social Information System

The techno-social information system is concerned with 'Objective – Reinvention'. A techno-social subsystem applies 'models and methods' that relate equally to the science of the natural and social worlds and includes the adaptations and integrations that users work through for themselves about the nature and use of their information systems. The elements used in defining the techno-social subsystem are people, hardware, rules and procedures that achieve reciprocal adaptation with the social system that it is embedded within. For example, let us continue with the simple paper day planner or electronic day planner as an illustration of a very simple information system, but now let us include the adaptations and integration that a user worked through for himself about the nature and use of the day planner. We enter events that we need to document for weekly reporting purposes. Each week we review the day planner. When the report is being written, we are reminded of the time and day that certain events that have taken place. In addition, important comments can be captured. Now let's go through this example and connect it to this category

Input – people, hardware (paper or an electronic day planner), rules and procedures
Output – report documentation
Feedback - when the time for writing the report arrives, we are reminded of day and time of events and comments; after that week we no longer review those entries.

A techno-social information system serves an objective function concerning the acquisition and transfer of information, the carrier of which is a technical unit. Any day planner is dedicated to a certain kind of information (time and day of events and comments). It has the purpose of providing information (report documentation) to a user and group of users. A day planner is a systematic method of managing time but is adapted and integrated into the report writing process. It relates equally to the science of the natural and social worlds. The elements used in this technical information system are people, hardware, rules and procedures. A day planner becomes a physical, objective entity that is being used 'as reinvented' by its user for a new purpose or task.

Socio-Technical Information System

The socio-technical information system is concerned with 'Subjective – Invention'. A Social-technical subsystem seeks to understand the basis of human life by including the subjective experiences of individuals, but is still 'as created' for the purpose or tasks that it was designed. The elements used in defining the techno-social subsystem are people, hardware, rules and procedures that's formal, social entities do not need to achieve reciprocal adaptation with the social organization. For example, most everyone understands how a team works; it may or may not be virtual. We volunteer or are assigned to a team. Teams are created for a purpose and have activities, rules and procedure, even if they are informal. Now let's go through this example and connect it to this category.

Input – people, hardware, rules and procedures
Output – an organization
Feedback – An organization defines its purpose, they have activities, follow rules and procedures, even when they are informal.

A socio-technical information system serves a subjective function concerning the acquisition and transfer of information, the carrier of which is social units. An organization is dedicated to a certain kind of information (depending on the purpose). It has a purpose that is established by its creators. The elements used in this social information system are people, rules and procedures. An organizational member has individual subjective experiences that supply the meaning of the organizational experience to each member. The organization is 'as invented' for the purpose or task that it was designed.

Social Information System

The social information system is concerned with 'Subjective – Reinvention'. A Social subsystem seeks to understand the basis of human life by including the subjective experiences of individuals and including the adaptations and integrations that users work through for themselves about the nature and use of their information systems. The elements used in defining the Social subsystem are people, hardware, rules and procedures that's social entities share the meanings of evolutionary social change. For example, most everyone understands what it is to be part of an organization; it may or may not be virtual. Organizations are created for a purpose and have activities, rules and procedure, even if they are informal. We will include the adaptations and integration that a organizational member works through for himself about the nature and purpose of the organization. In a social information system the member reinvents the purpose, rules and procedures to include the own personal needs. The individual member maybe lonely or want a promotion at work. Their behavior and interactions attempt to achieve a new purpose. Thus, reinvention occurs through the subjective experiences of individuals that the person has worked through for himself about the nature and purpose of the organization. Now let's go through this example and connect it to this category.

Input – people, rules and procedures
Output – an organizational member
Feedback - organizations define their purpose, they have activities, follow rules and procedures, even when they are informal but evolve as personal needs are expressed directly or indirectly by the organizational dynamics.

A social information system serves an objective function concerning the acquisition and transfer of information, the carrier of which is a social unit. An organization is dedicated to a certain kind of information (depending on the purpose). An organization is a social method of managing people but is adapted and integrated into individual needs and purposes. The elements used in this social information system are people, rules and procedures. An organizational member has individual experiences that can influence the common purpose that the organization was created for and can and/or will change the outcome of the experience. The organizational member is a social information system that is being used 'as reinvented' by its evolution.

Conclusions and Suggestions for Further Work

This researcher has found that a classification of information systems is not easily developed, because of their diversity and continuing evolution in structure and function. Earlier differences like manual versus automated data processing are no longer suitable In this paper, this researcher outlined a framework that can be used to analyze a range of information systems at invention and when reinvented. The integration of relevant aspects of system theory, general systems theory and living system theory, sociotechnical theory, critical theory and inquiring systems into the information systems domain is to open up the possibilities for research by providing a set of new categories that have new insight. In addition, this framework articulates "an awareness" of the systems that the information system domain is embedded within, supplying a more comprehensive understanding of the natural world and a deeper and richer subsystem approach to understanding information systems. This awareness can be used for investigating how social systems create, change and adapt their information systems. This awareness expands the system lifecycle and maximizes its utility.

In conclusion, what we need is a framework that ties everything together, that allows us to understand information systems, society, the world, and our place in relation to it all. It would synthesize the knowledge and wisdom gathered in the different scientific disciplines, philosophies and across the many theories. Rather than focusing on small sections of social reality, such as technical information systems, this framework provides us with an understanding of the need to completely examine (for wholeness). To place the subsystem within the context of the social system that it is embedded within. We must strive to understand all living systems; they offer us insight into the complex natural world of change and adaptation. But in particular, it would help us to analyze and understand, and therefore cope with the continued growth in complexity, change and adaptation of information systems as social reinventions. C. West Churchman (1971) asked "Can the creative be designed; can nature be designed? If so; will the design really produce improvement, or will the improvement be relativistic or illusory?" This researcher

challenges myself and others to do future research that contemplates and questions what we know about information systems. We must continue to ask questions and search for a richer and deeper understanding of information systems. The framework should be tested rigorously with many examples of information systems. The right questions are the beginning….a foundation for better research, better information systems and a better social reality.

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