Autopoietic Approach for Information System and Knowledge Management System Development

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INTRODUCTION

In the last decade a new generation of information systems (ISs), such as Web-based information systems and knowledge management support systems, have emerged in response to ever-changing organizational needs. Therefore, the need for new "Information System Design Theories" for the emerging ISs is recognized. According to Walls, Widmeyer, and El-Sawy (1992), an "IS design theory" must have two aspects—one dealing with the description of the system and one dealing with the prescription, that is, the process of developing of the system. The prescription aspect includes a description of procedures and guidelines for system development. In addition, these two aspects must be grounded on theories from natural or social sciences (i.e., kernel theories).

As information systems are socio-technical phenomena in which social and technical factors interweave the ways in which people work, the issue of "how to integrate the work activity and social context of users into the IS which is being designed" becomes one of the principal problems of IS development (Bai & Lindberg, 1999). Therefore, the development of new IS design theories requires a closer look at the system theories that go beyond the traditional system theory that is based, among other things, on Cartesian dualism (i.e., mind/body or cognition/action) and on a model of cognition as the processing of representational information (Mingers, 2001). One of the candidate theories is the theory of autopoiesis, which can be best viewed as a system-grounded way of thinking with biological foundations, together with its extension into social domain.

BACKGROUND

In order to conceive of living systems in terms of the processes that realized them, rather than in terms of their relationships with an environment, Maturana and Varela (1980) coined the word *autopoiesis* (αυτοσ = self, ποιενιν = creation, production) to denote the central feature of their organization, which is "autonomy." The meaning of this word coveys the very nature of living systems as systems that maintain their *identity* through their own operations of continuous self-renewal. Moreover, these systems could only be characterized with *reference to themselve*s and whatever takes place in them, takes place as necessarily and constitutively determined in relation to themselves—that is, *self-referentiality.*

One of the key concepts of autopoiesis is the distinction between organization and structure. On one hand, *organization* is the capability of a system to reproduce its identity by referring constantly to itself, through the alternate reproduction of its components together with the component-producing processes, that is, the capability of a recursive self-reproduction. On the other hand, *structure* is the realization of a system's organization through the presence and interplay of its components in a specific realization space. While organization is necessary to establish system unity and identity, structure is necessary because different spaces of its actualization impose different constraints on a system's components (Maturana & Varela, 1980). By rough analogy, an algorithm for solving certain problem can be viewed as a description of the system's organization, whereas the corresponding computer program can be viewed as the realization of this organization (structure) in a certain space (programming language).

Autopoietic Systems

An autopoietic system is defined by Maturana and Varela (1980) as "a network of processes of production, transformation and destruction of components. These components constitute the system as a distinct unity in the space of its actualization and they continuously regenerate and realize, through their interactions and transformations, the network of processes that produce them" (p. 135).

Among the distinct characteristics of the autopoietic systems, the most relevant ones are:

- *The simultaneous openness and closure.* Autopoietic systems are *open* with respect to structural interaction with the environment, that is, *structural openness*, which is an unavoidable consequence of the fact that system elements must satisfy the particular requirements of the physical domain in which they occur, while they are *closed* with respect to their own organization, that is, *organizational closure.* The recognition of *the* *simultaneous openness and closure* of autopoietic systems is in opposition to the tradition for which a system is one or the other but not both. This interpretation is possible only because of the clear distinction between organization and structure (Bednarz, 1988).

- *Structural determination.* The state transition a system undergoes in response to environmental perturbations is entirely determined by its structure at that time. Moreover, a system specifies which environmental perturbations may trigger which structural changes. In other words, the environmental perturbations could trigger the system's structural changes but can never determine or direct these changes. Moreover, a system specifies which environmental perturbations may trigger which structural changes. Over time, through ongoing interactions with the environment, an autopoietic system will experience what Maturana and Varela (1992) describe as a *structural drift,* or a gradual change to their structure. The nature of this change is determined by a previous system's history of structural changes, that is, its *ontogeny.*

Higher-Order Autopoietic Systems

Two (or more) lower-order autopoietic systems can be "structurally coupled" to form a higher-order autopoietic system. Structural coupling is the ongoing process of the congruent structural changes between two (or more) systems that results from recurrent interactions between (among) them. Therefore, structural coupling has connotations of coordination and co-evolution. Moreover, following structural determination principle, two structurally coupled systems means that each of them selects from its possible structural changes those that are compatible with those in the other system and, at the same time, are suitable for the maintenance of its identity.

Social systems, such as enterprises, are constituted through the process of third-order structural coupling, or social coupling, the one that occurs between (or among) two (or more) second-order autopoietic systems. However, the unique feature of any human social system, such as an enterprise, is that the social coupling among its constituents occurs through "language in the network of conservations which language generates and which, through their closure, constitute the unity of a particular human society" (Maturana & Varela, 1992, p. 196). From this perspective, language is viewed as an example of social structural coupling that generates the self and creates meaning through interactions with others. Moreover, language represents what Maturana and Varela would describe as a consensual domain, which is the domain of arbitrary and contextual interlocking behaviors (Mingers, 1995a, p. 78). Within a consensual domain, two autopoietic systems would be able to observe the attribution of meaning to common events and undertake coordinated actions.

Autopoiesis and Cognition

Cognition is the term conventionally used to denote the process by which a system discriminates among differences in its environment and potential states of that environment. The evidence for this cognition is effectiveness of system behavior in response to the environmental perturbations. Today's dominant perspective on cognition, and consequently IS, is the idea that effective action is explainable in terms of manipulating formal and static representations of the objective reality (Mingers, 2001).

According to the theory of autopoiesis, perception is neither objectivist nor purely constructivist (Varela, 1992, p. 254); rather, it is co-determined by the linking of the structure of the perceiver and the local situations in which it must act to maintain its identity. This is the basis of *enactive (embodied) cognition,* which implies that the autopoietic system's activities condition *what can be perceived* in an environment, and these perceptions, in turn, condition future actions. In this view, "a cognitive system is a system whose organization defines a domain of interactions in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaving in this domain" (Maturana & Varela, 1980, p. 13). Therefore, cognition, according to autopoietic theory, is essentially embodied. Or, in the words of Maturana and Varela (1992): "All doing is knowing, and all knowing is doing" (p. 26). In addition, cognitive domain of an autopoietic system is defined as the domain of all the interactions in which it can enter without loss of identity (Maturana & Varela, 1980, p. 119).

APPLICATIONS OF THE CONCEPTS OF AUTOPOIESIS IN IS DEVELOPMENT RESEARCH

The use theory of autopoiesis in IS research can be classified into two main categories: metaphoric and theory-oriented approaches (Beeson, 2001).

Metaphoric Approaches

Kay and Cecez-Kecmanovic (2002) used the concepts of *social coupling* and *consensual domain* to explain processes underlying the IS-organization relationship and how it impacts on the competitive advantage of an organization. They showed how processes of recurrent interactions between members of different groups—analysts, the IS team, and external clients—within the organization's work environ-