Towards a Design Theory of Autopoietic Knowledge Management Support Systems

El-Sayed Abou-Zeid, Concordia University, 1455 de Maisonneuve Blvd. W., Montreal, Canada, H3G 1M8; E-mail: el-sayed@jmsb.concordia.ca

ABSTRACT

The theory of autopoiesis, as a system-grounded way of thinking with biological foundations together with its extension into social domain, is used as a kernel theory for developing a design theory for knowledge management support systems. The "design product" aspects, meta-requirements and meta-design, are defined. Design methods are also suggested.

INTRODUCTION

As the awareness of the importance of managing organizational knowledge grows, the issue of how to build information and communication technology (ICT)-based systems to support knowledge management activities has been raised. However, as argued by Malhotra (Malhotra 2002), the underlying premises guiding the development of ICT-based knowledge management support systems (KMSS) increase the possibility of their failure. In fact, knowledge and its manipulating activities, by their very nature, are socio-technical phenomena in which social and technical factors interweave the ways in which people work (Alavi et al. 1999; Nidumolu et al. 2001; Pan et al. 1999). Therefore, a new "design theory" is needed to address the salient features of KMSS (Hahn et al. 2000). A "design theory", as explicated by Walls et al. (Walls et al. 1992a), must have two aspects - one dealing with the system (design product) and the other dealing with the procedures of designing the system (design process). In addition, these two aspects have to be grounded on theories from natural or social sciences, i.e., kernel theories.

The search for kernel 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.

To this end the objective of this work is to explore the potential of theory of autopoiesis as one of the kernel theories for dealing with both "product" and "process" aspects of autopoietic KMSS (AKMSS) design theory.

The remainder of this paper is organized as follows. In the next section, the issue of why a new approach for designing KMSS is need will be addressed. In the following sections the autopoiesis theory and autopoietic view of organizational knowledge are discussed. Then the autopoiesis theory will be used to derive a design theory for knowledge management support systems. The paper concludes by discussing the implications of the proposed approach.

WHY A NEW APPROACH IS NEEDED

In order to develop a design theory for KMSSs, the work to be supported by them has first to be described. This work can generally be described in terms of the characteristics of three elements: *organizational knowledge*, *the knowledge manipulating processes to be supported*, and *users and their work context* (Markus et al. 2002). The first element, *organizational knowledge*, has the following distinctive features:

- *Action-orientation*: According to Collins (Collins 1974), knowledge is a capability and thus creates the capacity to do something. Therefore, organizational knowledge is always anchored to business things toward which thought or action is directed or is communicated by the members of the firm (Hislop et al. 2000) and is constantly produced and re-produced through its business application (Augier et al. 1999) in order to create business value. One of the implications of the action-orientedness is its *indeterminacy*: As the business environment is in the state of continuous change and as organizational knowledge whatever its type is engrained in business activities, it is difficult to determine a-priori what knowledge will be requested, who will request it, who will supply it, and when and how the knowledge will be used (Abou-Zeid 2002; Markus et al. 2002).
- *Distributedness:* Organizational knowledge is spatially and temporally distributed as it is generated, owned and used by *autonomous* members of the organization, e.g., individuals and groups, and mobilized among them (Boland et al. 1996; Bonifacio et al. 2002). Moreover, the actions of organization members and their interpretation of symbolic representation of knowledge (explicit knowledge or information) are grounded in their *collective* tacit knowledge which has been formed in the course of past socialization and has become basic assumptions (Polanyi 1983; Tsoukas 1996).
- *Situatedness*: Knowledge cannot be disembodied from the people who carry it or from the situations in which they engage (Sierhuis et al. 1997). Therefore, using knowledge depends on the situation and people involved rather than on absolute truth or hard facts. Even the effective re-use of knowledge representations requires its re-creation to suit the local conditions (Boland et al. 1995; Collins 1993; von Krogh et al. 2000).

The aforementioned distinctive features of organizational knowledge require that *K- manipulating processes*, the second element, to be *social* and *contingent*. First, since organizational knowledge is distributed and context-dependent, most K- manipulating processes involve social interactions among organization members. Moreover, knowing and learning are inherently situated and distributed phenomena, residing in a series of non-localizable associations between social and material elements (Araujo 1998; Nidumolu et al. 2001). Second, as organizational knowledge is action-oriented and situated the type of its manipulating processes and the patterns of their execution are contingent upon these factors.

These characteristics of organizational knowledge and its manipulating processes call for re-conceptualizing *users of KMSS*, the third element, as *active social actors*. First, the use of knowledge and the interpretation/re-interpretation of explicit knowledge (or symbolic knowledge representations) cannot be disembodied from the user. Therefore, *the users of KMSS have to be considered as constituents of such systems who play specific roles in their operations*. Second, because of the distributed nature of organizational knowledge and the sociality of its manipulating processes, i.e., involve social interactions among organization members, the concept of the KMSS user is best described as a social actor - defined as "an organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry" (Lamb et al. 2003), p. 218) .

The distinctive features of organizational knowledge and its manipulating processes, together with the concept of active social actor suggest that the dominant capture/codify/store approaches (Hildreth et al. 2002) for developing KMSS are ineffective (Malhotra 2002; Swan et al. 2000). First, these approaches are based on the conceptualization of an ICT-based system as a representation of another pre-given "real world" system that enables its users, through its processing functions, to obtain information about a certain domain without having to observe it (Wand et al. 1995). Central to this conceptualization is the notion of "representability", i.e., the capability of representing the knowledge about the pre-given and objective things that exist in the real world using static structures such as entities and objects. Underlying this notion is the assumption that knowledge exists independently of human knowers (Hirschheim et al. 1995) and consequently

can be publicly owned by the organization (Wasko 1999). However, knowledge representations, which are static and context-independent structures, cannot be equated with knowledge, which is dynamic and context dependent (Malhotra 2002). Second, these approaches treat the user as an atomic individual capable of articulating her/his knowledge requirements well (Hahn et al. 2000; Lamb et al. 2003). Moreover, they consider users as external entities who have no major role in manipulating knowledge, i.e., *disembodiment assumption*.

OVERVIEW OF THEORY OF AUTOPOIESIS

In order to conceive of living systems in terms of the processes that realized them, rather in terms of their relationships with an environment, Maturana and Varela (Maturana et al. 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, i.e., *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 re-produce its identity by referring constantly to itself, through the alternate re-production of its components together with the component-producing processes, i.e., 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 system's components (Maturana et al. 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 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." (Maturana et al. 1980), 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, i.e. *structural openness*, which is 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, i.e. *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 (Maturana et al. 1992) describe as a *structural drift*, or a gradual change to their structure. The nature of this change is determined by previous system's history of structural changes, i.e., its *ontogeny.*

Higher-Order Autopoietic Systems

Two (or more) lower-order autopoietic systems can be "structurally coupled" to form higher-order autopoietic system. S*tructural 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 which 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 et al. 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 defined as "the domain of interlocked conducts that results from ontogenetic structural coupling between structurally plastic organisms" (Mingers 1995), 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.

THE AUTOPOIETIC PERSPECTIVE OF ORGANIZATIONAL KNOWLEDGE

The underlying premise of the dominant perspective on cognition is that effective action is explainable in terms of manipulating formal and static representations of the objective and pre-given reality (Mingers 2001). In contrast, according to 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 has to 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 et al. 1980), p. 13). 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 et al. 1980), p. 119). Therefore, knowledge is not an object that may be captured, packaged, processed and distributed. Rather, it is an embodied notion.

Moreover, the concepts of structural coupling and consensual domains provide the bridge between the cognition of the individual and the patterned behaviors that are often described as 'organizational knowledge' (Kay et al. 2005)..

As discussed in the previous section language is viewed as an example of social structural coupling that generates the self and creates *meaning* through interactions with others. According to theory of autopoiesis "it is by languaging that the act of knowing, in the behavioral coordination which is language, [which] brings forth a world" (Maturana et al. 1992)(p. 234). In other words, meaning arises as pattern of relationships among the linguistic distinctions done by firm's members through the process of languaging.

In this context "languaging" refers to "the process in which language is not only maintained but is constantly being developed based on previous language" (von Krogh et al. 1994), p. 61). Organizational languaging, therefore, means *word choice in usage*, the process by which meaning emerges as a relationship between and among the various linguistic descriptions (distinctions) that actually used by members of the organization during their interaction with themselves or with external entities. Moreover, organizational languaging covers two domains: writing and conversations (von Krogh et al. 1995).

A PRELIMINARLY DESIGN THEORY FOR AUTOPOIETIC KMSS (AKMSS)

Table (1) summarizes the components of an information system design theory (ISDT).

AKMSS Meta-Requirements

One of the implications of theory of autopoiesis is that organizational knowledge

Table 1. Components of an information system design theory (ISDT) (Walls et al. 1992b)

Design Product	
1. Meta-requirements	*Describes the class of goals to which the theory applies.*
2. Meta-design	*Describes a class of artifacts hypothesized to meet the meta requirements.*
3. Kernel theories	*Theories from natural or social sciences governing design requirements.*
4. Testable design product hypotheses	*Used to test whether the meta-design satisfies the meta-requirements hypotheses.*
Design Process	
1. Design method	*A description of procedure(s) for artifact construction.*
2. Kernel theories	*Theories from natural or social sciences governing design process itself.*
3. Testable design process	*Used to verify whether the design method results in an artifact which hypotheses is consistent with the meta-design.*

is an embodied (enactive) notion and it cannot be treated as an object. Furthermore, it indicates the crucial role played by languaging in creating and sharing new knowledge. This perspective implies that KMSS can be best conceptualized as "an additional medium through which interlocking behaviors may converge and the congruities of context, that give rise to consensual domains" (Kay et al. 2005). Therefore, the meta-requirements of autopoietic KMSS can be stated as follows:

- An AKMSS should support organizational knowledge evolution and sharing through organizational languaging.
- An AKMSS should support the two aspects of organizational languaging: writing and conversations.

AKMSS Meta-Design

One of the implications of autopoietic "structural determination" principle is that the same environmental stimuli are perceived differently by different firm's members. Therefore, each member develops a repository of tacit personalized knowledge that allows him/her to make sense of reality. Such personalized knowledge can be *partially* described in terms of a "personal ontology". According to Gruber (Gruber 1993) an ontology is *an explicit specification of a conceptualization of a domain*. Therefore, changes to any of the three elements in the definition can cause changes in an ontology: (1) changes in the domain, (2) changes in conceptualization, or (3) changes in the explicit specification (Noy et al. 2002). Furthermore, such changes (ontology evolution) frequently occur in a distributed environment through interactions among different firm's members over different contexts (Bouquet et al. 2003). Therefore, the class of artifacts that meet the meta- requirements of AKMSS is:

- A set of firm's members (stakeholders) evolving personal ontologies.

AKMSS Design Method

Beside the evolution of firm's members (stakeholders) personal ontologies caused by their interactions, these interactions can result in merging or aligned personal ontologies. In merging, a single ontology that is a merged version of the original ontologies is created. Often, the original ontologies cover similar or overlapping domains. In alignment, the two original ontologies persist, with links established between them.1 Alignment usually is performed when the ontologies cover domains that are complementary to each other (Noy et al. 1999). Therefore, the design methods of AKMSS are:

- Personal ontologies creation, evolution, merging and alignments methods.

CONCLUSIONS

We contend that the theory of autopoiesis, as a system-grounded way of thinking with biological foundations, can be useful as one of the kernel theories for both of "design product" and "design process" aspects of KMSS's design theory. There are several implications for the KMSS development process deriving from our theoretical orientation. First, organizational knowledge is an embodied (enactive) notion and it cannot be treated as an object which can be captured, packaged and processed. From this perspective, organizational knowledge is nothing but a "purposeful coordination of action" while what is called explicit knowledge (symbolic knowledge representations or information) is the symbolic description of action (Zeleny 2005). Second, the role of "languaging" in creating new knowledge is emphasized. Third, the conceptualization of KMSS as the medium in which the organizational languaging can be realized is introduced.

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