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Abstract

Knowledge management Systems (KMS) are IT applications that manage representations of organizational knowledge. This paper presents a conceptual model of KMS which adapts an artificial intelligence (AI) based view of knowledge. According to this view, knowledge can be defined in terms of agent, action, state, and goal. The conceptual model is intended to help differentiate the role of KMS from that of Information Systems (IS). The knowledge managed by the KMS is intended to enable an agent to choose actions that can be taken to accomplish a goal in the given state. The role of the IS is to make the agent aware of a situation described in terms of states, actions, and goal. The model suggests that whether we classify an IT application as KMS or IS depends on the contents it manages and to increase the effectiveness of KMS, it is often necessary to use IS that complement the KMS. Considering the importance and popularity of KMS in organizations, we believe the clarification of the role of KMS is useful.

Keywords: Conceptual modelling, Knowledge, Knowledge Management Systems.

1 INTRODUCTION

Organizations are willing to invest in the acquisition and development of knowledge management systems (KMS) because they recognize the importance of managing knowledge. However, surprisingly, it appears that confusion still exists on what KMS really are. For example, Maier (2002 p. 42) claims: "more traditional software like document management systems, data warehouses, and analysis tools are marketed increasingly as knowledge management systems" and Moffet et al. (2003 p. 8) mention that "[a]lthough the technological arena has received much publicity in recent years, confusion still exists over its implications for KM [knowledge management]. One of the main reasons for this has been the re-packaging of software applications under the KM label." Vaast et al. (2006 p. 316) reflect this issue by stating that "as new generations of KMS systems have come to the market, replacing "old" expert systems with recommender systems, for instance, the very definition of what the "knowledge" is that has to be managed with KMS has shifted. These shifts need to be better understood."

The objective of this paper is to clarify the distinct role of KMS within information technology (IT) applications. But as noted above, no clear view of KMS exists. Thus we first need to understand what KMS are. For this purpose we integrate the different views of KMS as discussed in the literature and present a conceptual model of KMS. A conceptual model is a representation of a domain constructed to support the understanding of the domain (Wand et al. 1999). The developed conceptual model of KMS is derived based on the role of KMS in managing representations of knowledge. Using an Artificial Intelligence (AI) view of knowledge, we suggest that knowldge can be represented in terms of an agent, actions, states, and goal. We use this definition to make a destinction between information and knowledge which we use to propose distinct roles for KMS and IS.

The rest of the paper is organized as follows. Section 2 develops and presents a conceptual model of KMS. Section 3 discussed the concepts of knowledge in the context of KMS. Section 4 discusses the role of KMS and IS. Section 5 is a conclusion.

2 A CONCEPTUAL MODEL OF KMS

To develop the conceptual model we first present a set of propositions anchored to the literature. By combining these propositions and representing them in a visual diagram, we obtain the conceptual model of KMS. To develop the visual diagram, we borrowed the Entity Relationship Modelling (ERM) notations: (1) a rectangle represents a concept, (2) a diamond represents a statement (verb) about several concepts, and (3) two arrows (not usually used in ERM) - one represents the direction for reading the verb and the other represents generalization.

2.1 Propositions

The KM literature views the role of KMS as providing for or supporting the creation, gathering, organizing, and disseminating an organization's knowledge (Alavi and Leidner 2001; Wakefield 2005). We consider KMS as systems for storing the explicit representation of knowledge, or for pointing at knowledge as a resource embedded in some implicit form in the organization.

Newell mentions (1982 p. 99) that "knowledge can be defined independent of the symbol level but can also be reduced to symbol level." This statement conveys the idea that (some) knowledge can be symbolically represented. Vaast et al. (2006) observe that representations of knowledge in early KMS were explicit and visible (e.g., rules and keywords), whereas knowledge representations in latter systems have increasingly tended to be implicit and invisible. Maier (2002) refers to implicit knowledge as informal knowledge (such as ideas and FAQ's) and mentions that KMS manages informal knowledge. Based on the above, we consider knowledge an abstract notion, that can be represented in explicit (formal) or implicit (non-formal) symbolic forms. Thus representation refers to both explicit and tacit knowledge (Nonaka and Takeuchi 1995).

We formalize the above in the propositions that knowledge (as managed by a KMS) *has representation* (Figure 1) and that it has two forms – *explicit* and *implicit* (Figure 2).

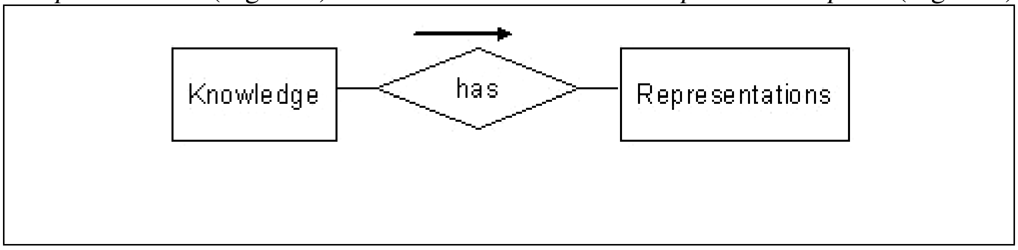

Figure 1. Statement 1: Knowledge has representations

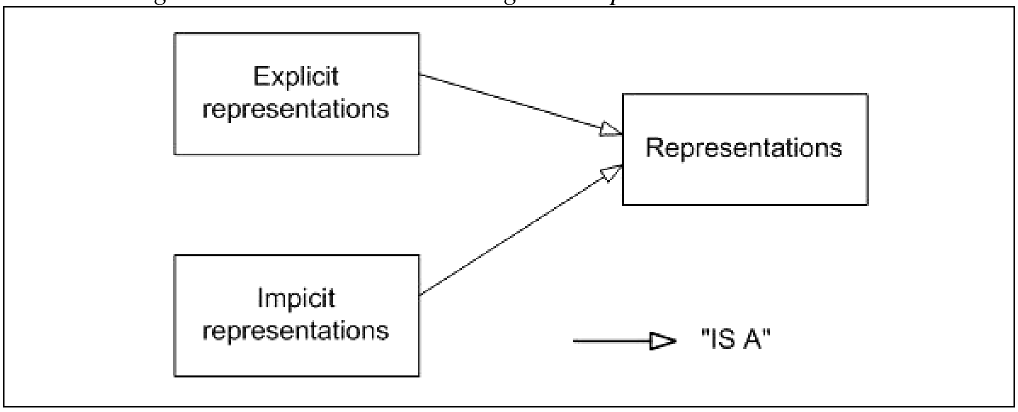

Figure 2. Statement 2: Knowledge representation can be explicit or implicit

The KM literature classifies KMS into *repository* and *network* (Alavi 2000) or *repository* and *dictionary* types (Gallupe 2001), depending if their role is to store knowledge or to point at where knowledge is located. The repository model focuses on the storage and retrieval aspects of knowledge (Wakefield 2005) and views knowledge as an object that can be collected, stored, organized, and disseminated. Typically knowledge repositories store documents with knowledge embedded in them (Kwan and Balasubramanian 2003). Thus a KMS can store explicit representations of knowledge (Figure 3).

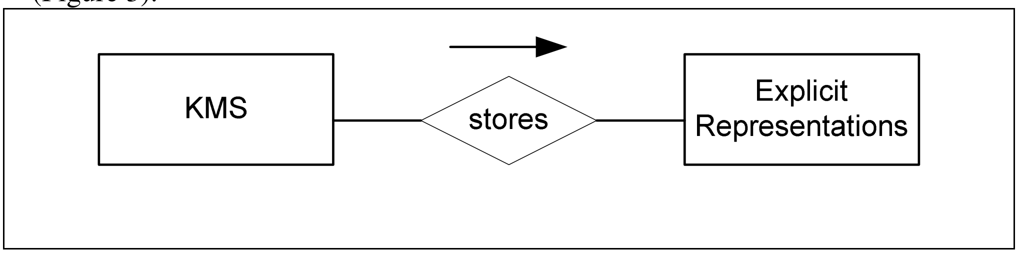

Figure 3. Statement 3: KMS stores explicit representation of knowledge

The network (directory) model allows a user to locate a knowledge source by pointing to it. Gallupe (2002) mentions that KM dictionaries point at knowledge sources such as people, documents or databases. An example is organizational knowledge maps that enable locating knowledge or individuals possessing knowledge (Offsey 1997). Based on this we suggest that KMS can point at representation of knowledge (Figure 4).

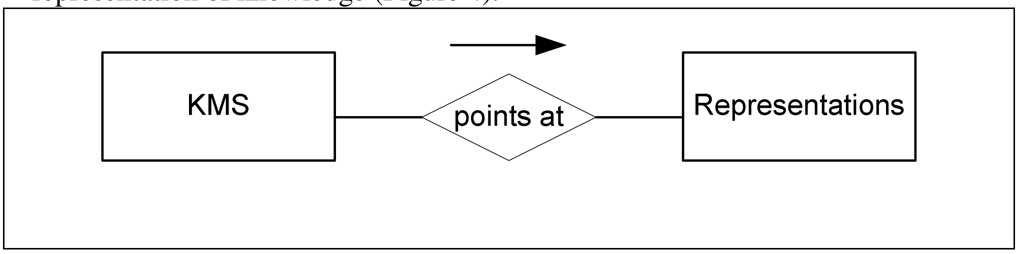

Figure 4. Statement 4: KMS points at representation of knowledge

Borrowing the storage metaphor from individual-level memory processes, Walsh and Ungson (1991) present the notion of retention facilities (containers) of organizational memory. We reflect this in Figure 5.

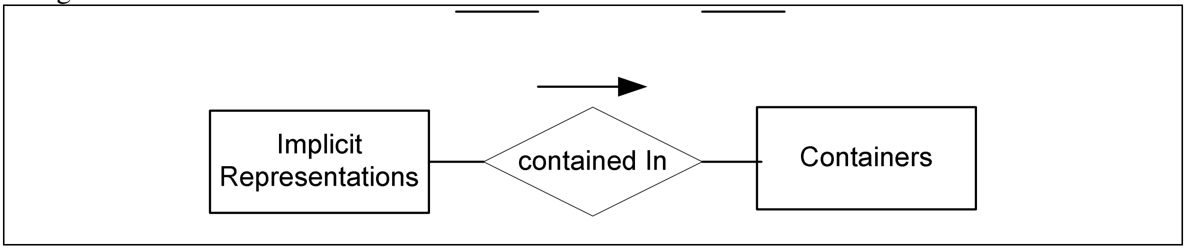

Figure 5. Statement 5: Implicit representation of knowledge are contained in containers

The notion of containers can be classified into two types: *individuals or agents* and *organizational transformers* (Walsh and Ungson 1991). Individuals retain information based on their own experiences and store knowledge in their own capacity. Transformers are ways (and mechanisms) by which an input can be converted to an output and the logic underlying the transformers can be considered embedded knowledge. Davenport and Prusak (1998) mention that knowledge often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. Recall, our definition of knowledge is based on actions that can be used to change states. This fits well with the ideas of transformers as knowledge enables transformations to occur. We describe the two types of containers in Figure 6.

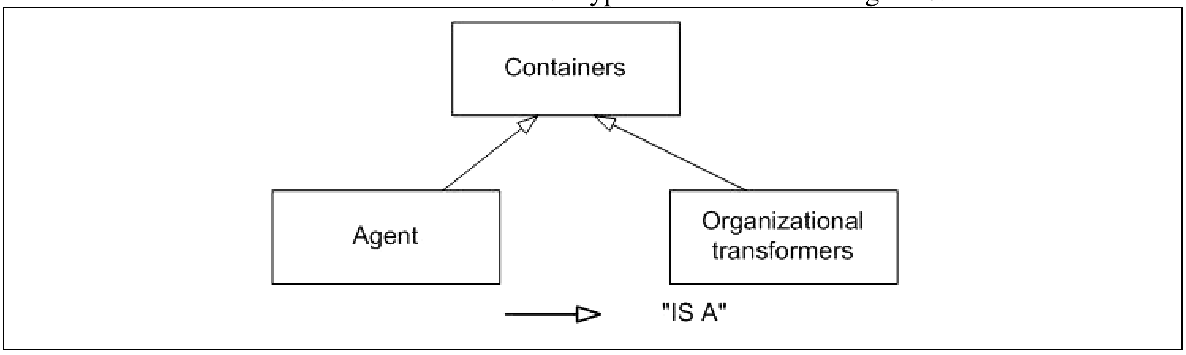

Figure 6. Statement 6: Containers can be agent and organizational transformers

We summarize the above discussion in the propositions listed in Table 1.

1. Knowledge has representations
2. Representations of knowledge can be explicit or implicit
3. KMS stores explicit representation of knowledge
4. KMS points at representation of knowledge
5. Implicit representations of knowledge are contained in containers
6. Containers of implicit knowledge are of two types: agents and organizational transformers

Table 1: Statements underlying a conceptual model of KMS

2.2 The Model

We combine the above statements (summarized in Table 1) as the conceptual model of KMS. We depict these relationships in a diagram (Figure 7). Note that the novelty of this model is not in the individual statements but in combining them into one model.

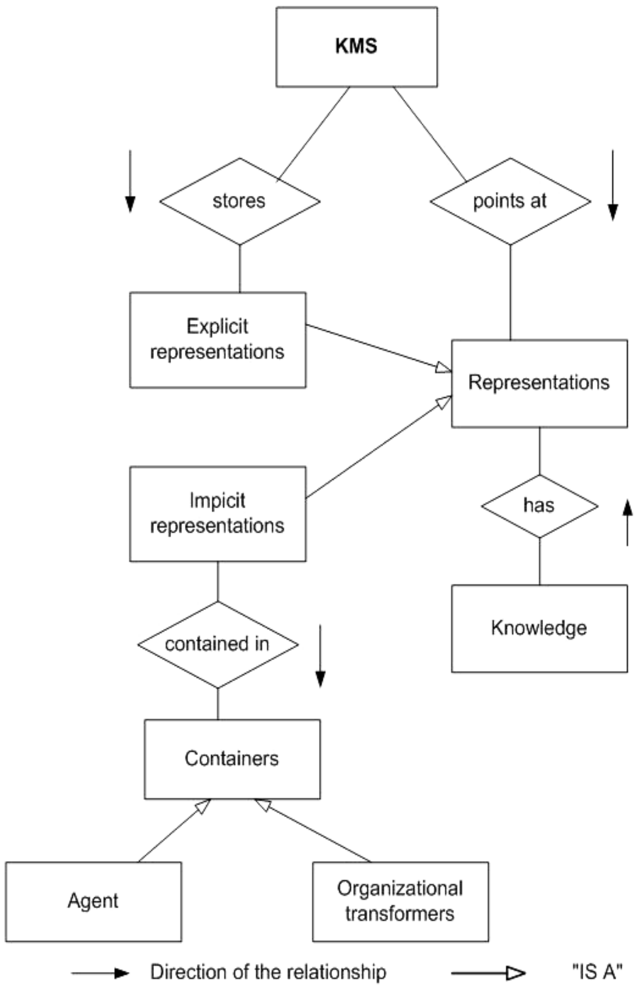

Figure 7. Conceptual Model of KMS

3 DEFINING KNOWLEDGE IN THE CONTEXT OF KMS

The conceptual model of KMS was developed by analyzing the current literature on KMS. The model indicates that KMS manage (namely, either store or point at) representations of knowledge. To identify the role of KMS, it is important to understand the concept of knowledge as managed by KMS. The KM literature provides many definitions of knowledge, such as "justified beliefs" (Nonaka and Takeuchi 1995) and "experience and values" (Davenport and Prusak 1998). However, no generally accepted definition is available (Spender 2003). Thus, we first need to define our view of knowledge as managed by KMS. In this section, we discuss the concepts we use to define knowledge and then link these concepts to KMS.

3.1 Concepts for defining knowledge[1]

Following Newell (1982), we view knowledge as related to agent, actions, and goals. In the following we briefly define these terms as described in the literature.

An agent can be defined as an entity that acts upon the environment it inhabits (Wooldridge 2000). Thus agents can bring about changes in the environment (Castelfranchi 1998). An agent's environment contains a collection of objects (agents and resources) that agents are able to (at least partially) perceive and manipulate (Logie et al. 2003). Agents and their environment have states

[1] The concepts are described in full in (Bera et al. 2009).

(Brafman and Tennenholtz 1997). The goals of an agent reflect the desires the agent has intends to fulfill (Logie et al. 2003; Luck and Inverno 2001). These goals are a subset of the agent's and its environment possible states. An agent possesses capabilities - a repertoire of possible actions it can perform to modify the current state (of itself and the environment) (Rudowsky 2004; Wooldridge 2000). Since agent's behavior is aimed at producing some result, agents are considered to be goal-oriented (Conte and Castelfranchi 1995).

Newell's view of knowledge (Newell 1982) is popular in the AI community (Musen 2004). Newell employs the notions of agent and action to define knowledge. Newell states: "[t]he gross anatomical description of a knowledge-level system is simply (and only) that the agent has as parts, bodies of knowledge, goals and action" (Newell 1982 p. 99). The agent processes the knowledge to determine what actions to take in order to attain its goals. Note that the actions selected by the agent need not be performed. This is in accordance with Newell (1982) who mentions that selection of an action does not mean it is executed, but rather becomes a candidate for execution.

Based on the above concepts we suggest that knowledge is a quaternary relation among the agent, current state, goal, and actions. Accordingly, we define knowledge as, "*given the states of the agent and the environment, knowledge is the ability of the agent to select actions (from those available to the agent) so as to change the current state to a goal state.*"

3.2 Application of the knowledge definition

To understand how the above concepts can be used to define knowledge, we provide an example. Consider an applicant applying for a job in an organization. The human resources department reviews the application and decides on hiring the applicant, rejecting the application, or withholding the application to obtain more information. The possible agents in this example are: the applicant, human resources employees, and the manager who requested an employee will be hired. However, if we deal with decisions within the organization, the relevant agents for analyzing the required knowledge do not include the applicant. In this case, the application can be considered an entity whose state requires a change from "awaiting hiring decision" to "decided upon." The possible actions to be taken by agents might include assembling information (such as quality of other applicants), obtaining opinions, and deliberating the merits of an applicant. The outcome of executing these actions will be to change the state of the application (from "awaiting decision" to "decided"). In this case, knowledge is the ability of the HR department to select actions in order to decide whether to hire the applicant or not.

3.3 Linking knowledge to KMS

In this subsection we relate the concepts used to define knowledge to the KM literature.

The agent-oriented approach towards knowledge is also quite common in the KM literature. For example, Elst et al. (2003) mention that agents can be seen as a natural metaphor to model KM environments. In the context of designing KMS, Maier (2002) mentions that knowledge is developed collectively and its distribution leads to continuous change, reconstruction and application in different contexts by different actors in the organization. The notion of knowledge in the literature is also related to actions and goals. For example, Musen (2004 p. 77) mentions "[k]nowledge does more than account for what exists in the world, it directly links goals to actions. Knowledge lets an agent enact procedures to attain its goals."

The proposed definition of knowledge in the context of KMS leads us to suggest an important proposition about KMS. KMS should be considered as a system used by agents to support problem solving. Specifically, an agent uses KMS to determine specific actions that are required to attain goal (usually based on knowledge created by other agents). In other words, the problems the agent tries to solve using the KMS can be defined in terms of current and desired states. Implied in this is that the desired state is different than the current one in some important aspect. If no such gap exists, there would be no need for action. Gallupe (2001) supports the state-based view by stating that "KMS are used to solve problems, "[w]e define problems in the context as "desired states" (2001 p. 67)."

Accordingly, he suggests that KMS should support problem solving related practices including: identifying the problems that can be solved; storing the knowledge to solve the problem, and transfer the stored knowledge to others. However, problems for which KMS support is needed are often not apparent or simple and have been even referred to as "wicked problems" (Gallupe 2001). Indeed, it can be claimed that the essence of KM in general is dealing with such problems.

4 DEFINING THE ROLE OF KMS

In section 2, we presented a model of KMS by using concepts from the literature. An important aspect of the model was that KMS does not manage knowledge but only its representations. In section 3, we defined knowledge in terms of agent, action, state, and goal. These elements indicated what should be included in knowledge representation. We now turn to how the models can be used to distinguish between KMS and IS.

4.1 Differentiating between KMS and IS

To differentiate the role of KMS from that of IS, we first need to discuss the difference between knowledge and information as related in the KM literature. This distinction can help clarify the role of KMS. The KM literature presents several contrasting views of the relationship between knowledge and information. Some researchers (Bhatt 2001; Davenport 1997; Hicks et al. 2002) consider the link between information and knowledge to be "linear" while others (Li and Kettinger 2006) suggest new knowledge can be directly created from existing knowledge.

The above differing views point at a need to clarify the relationship between information and knowledge in the context of KMS. We suggest that our proposed conceptual model can be used for this purpose. We first observe that according to the model the link between information and knowledge is "non-linear" i.e. knowledge does not have to evolve from information. Recall that the proposed definition of knowledge is the ability to select actions to accomplish a goal, when the state of affairs is given. Thus, to know which knowledge is required, an agent needs to first identify the current state, goal state and available actions. We suggest that all these aspects of the situation can be considered information. We claim that information helps agents recognize the context in which the knowledge is required. As the perceived state might affect the selection of actions, information is used to provide context for the needed knowledge and to help identify the required knowledge. This view is in agreement with Weinberger (1998) that information can help the agent identify actions, perceive alternative actions (such as by identifying an action that the agent was not aware of), create a selection mechanism for action (such as rule or preference), and help the agent to select particular actions. However, these activities do not relate to the nature of the actions, but rather to the ability to identify actions. In this vein, Weinberger (1998) mentions that factual information is insufficient for selecting actions. Rather this information will help understand the situation (or context) based on which actions are to be taken. This information, in turn, can help an agent develop understanding of the outcomes of possible actions.

The above distinction and relationship between information and knowledge in the context of KMS can help clarify the differences between IS and KMS. The role of an IS is to help an agent become *aware* of a situation. This situation involves the current state, desired state, and the actions that are available to the agent. The IS can provide this information or the sources from where this information can be obtained. In contrast, the role of a KMS is to enable the agent to *choose* actions that can be taken in this situation.

More specifically, two roles of KMS can be identified. First, KMS are intended to be used by agents to help them *evaluate* the available actions in a particular situation. This is particularly relevant as the number of actions that an agent can choose from can be very large and thus the agent needs to narrow down the number of actions to a manageable set. The evaluation of available actions can be provided by KMS explicitly or implicitly. This information can then help the agents to select actions. To elaborate, consider that some IT tools (such as Business Intelligence- BI) can provide an analysis of past actions and their outcomes. If past actions can be related to the current available actions, the agent might be able to infer the possible outcome of actions in a given context. Such information about past actions and their effects can affect the choice of actions by an agent.

The second role of KMS is to *modify* the choice of actions that are available to the agent. This type of KMS can be termed *learning systems* as they can help an agent to modify its choices. In comparison, an IS provides agents with the context in which knowledge is required, in terms of current and desired states, and available actions. As an example, consider a BI tool that performs an analysis of the outcomes of past actions. If such analysis can help an agent modify the rules for selection of available actions then this tool serves in the role of KMS.

A particular requirement for the IS in the KMS context can be identified. Hahn and Subramani (2000) suggest that a repository of information presented to an agent for selecting actions may not be helpful to the agent for two reasons. First, the agent may not able to identify the *relevant* (or useful) information in the repository. Second, if the relevant information is not presented in a form enabling the agent to relate it to the problem situation, the information cannot be used. Accordingly, a requirement is that an IS presents information in a form that can help agents understand the situation in a way that can serve to choose actions.

We summarize the above roles of KMS and IS in the KM context in Table 2 below.

Role of IS	**Role of KMS**
Provide information about current states, goal, and list of actions	*Evaluate* the available actions and provide rules for choosing actions
Provide sources of information about current states, goal, and actions	*Modify* the rules for selection of available actions

Table 2: Distinguishing the roles of KMS from IS

The above analysis leads to two conclusions. First, KMS and IS have complementary roles with respect to KM context. Recall that knowledge is a quaternary relationship among agent, actions, current states, and goal. From an agent's perspective, it is important to identify the current state and the specific set of actions that are required to change the current state to goal state. An IS provides information about the current state which is the context in which the agent selects actions. The KMS provide the knowledge to help chose the right actions. Thus, usually a KMS and IS should be used together by a user. The second conclusion is that whether an IT application will be classified as an IS or KMS will depend on what content it manages. We elaborate on the second conclusion in the next subsection.

4.2 Classifying KM tool as IS or KMS

As mentioned in the introduction, several software products have been proposed as KMS. Maier (2002, p. 74) mentions, "many authors use the terms *knowledge management tools* or *knowledge management systems* to describe systems with quite similar intentions and functions. So far, there has been no clear distinction between these two terms." Table 3 discusses few IT applications such as Document management systems, Intranet, Groupware, and Business Intelligence. These applications are often cited as KM tools (Maier 2002).

KM tool	Description
Document Management Systems (DMS)	A tool that denotes the automated control of electronic documents through their entire life cycle within an organization from initial creation to final archiving (Turban et al. 2007). It provides functions to store and archive documents, navigate and search documents for version control (Maier 2002).
Intranet	An internet based technology that consists of a bundle of applications for accessing and sharing databases (Maier 2002).

Groupware	A web based tool that supports group interactions (Watson 2003). Examples include web conferencing and remote desktop sharing.
Business Intelligence	Business intelligence deals with organization, analysis, and communication of corporate data to support effective decision making (Turban et al. 2007).

Table 3: Descriptions of KM tools

Using the distinction between IS and KMS discussed above, KM tools can be differentiated according to the role they play in KMS. Specifically, if a tool provides descriptions of how to select actions (such as organizational procedures and best-practices) that can be taken to accomplish certain goals, then it acts in a KMS role. It follows that tools such as Groupware, DMS and Intranet can be considered KMS if they are used to help the agent in selecting actions. For example, an Intranet application might provide web links to suggest that some available actions are more desirable than others. Another example is a knowledge dictionary that points to knowledge sources (such as people). Such tools can help an agent to evaluate available possible actions and choose among them. Thus, we consider directory systems as KMS. On the other hand, a tool might just provide information that can be useful for the agents to become aware of the state of the environment (this would be the usual role of many transaction processing systems, but such a role can be sometimes fulfilled by documents). For such cases the tool will be used in the role of an IS. Finally, consider an IT application that lists few actions that *must* be taken in a certain situation. If no human choice was originally involved in determining the actions, this application will be classified as IS. However, if the list reflects a choice that would be done by another agent, we would consider this a KMS. Typically such choices are captured via a set of rules (as in an expert system). On the other hand, the same application can be classified as KMS if it helps the agent to narrow down the list of available actions that can bring about the goal. Note that the original list of actions need not be created manually by a user. In contrast, applications that perform routine functions are most likely to be considered as IS. Such applications have limited but predefined actions that must be performed to reach a goal state. For example a tool that converts paper based documents to electronic forms has few actions to be taken such as scanning a document and creating a portable document format (pdf) file.

4.3 A medical example to identify the roles of KMS and IS

To illustrate the different yet complementary roles of IS and KMS we provide an example from the medical domain. Consider a situation where a physician needs to treat a patient with hypertension (indicated by high blood pressure). In this case, the agent (physician) has to select treatments (actions) that will change the state of the patient with high blood pressure (current state) to that of reduced blood pressure (goal state).

Often use of different treatments in a medical domain might lead to the same goal. For example, in this case, a physician can prescribe a patient to modify his/her lifestyle (such as change in diet) or prescribe an antihypertensive drug. Use of either treatment might result in achieving the same desired state (i.e. a reduction of blood pressure of the patient to a desired level). Thus this scenario leads to a *knowledge situation* where a physician has to decide what actions are necessary to change the current state of a patient to that of a desired state. We suggest that to help the physician to refer to specific treatments, some IT applications can serve in the role of IS and some in the role of KMS. Table 4 and 5 explain the specific tasks that might be performed by the IS and KMS to fulfill their roles. The tables also suggest that a specific KM tool can be classified as KMS or IS depending on the content that is provides. For example, if a Document Management System (DMS) provides the list of different treatments for hypertension then it might be classified as IS as it provides the list of available actions that the physician can take. On the other hand, if the same DMS can provide an analysis of patients' history treated with a particular treatment of hypertension then this analysis can help the physician to decide whether to consider or avoid that treatment. For example, if the analysis indicates that a significant number of patients with hypertension and similar circumstance were unable to reduce hypertension with lifestyle change only, the physician might decide to prescribe an appropriate medication to the specific patient.

Role of IS	Examples
Information about current states and goal state	List of blood pressure readings of the patient with patient's treatment history
List of possible actions	List of possible treatments: 1. Modify lifestyle for three months followed by checkup 2. Prescribe anithypertensive drugs 3. Modify lifestyle and prescribe anithypertensive drugs 4. Modify lifestyle, prescribe anithypertensive drugs, and refer to an expert
Sources of possible actions	Medical guidelines available on the Web and in Medical journals

Table 4: The role of IS in the medical treatment example

Role of KMS	Examples
Evaluate the available choice of actions	A tool that analyses past clinical situations. The result might indicate that a significant number of patients with similar circumstances who were prescribed lifestyle modification treatment only, did not actually manage to modify their lifestyle. The tool thus helps to rank lifestyle modification treatment in this case as of low value.
Modify the rules for selection of available actions	A tool that suggests different (or additional) treatment options available to the physician when the patient has additional health conditions such as diabetes or pregnancy. Such tool helps to modify the rules for selection of actions as under such cases (e.g. diabetes) some treatments are no longer available for the physician to suggest.

Table 5: The role of KMS in the medical treatment example

5 CONCLUSION

This paper defines the role of KMS in terms of a conceptual model of KMS and an AI view of knowledge. In the model, KMS manage representations of knowledge which can be represented in terms of agent, actions, states, and goal. The paper contributes in several ways. First, it clarifies the role of KMS with respect to KM technologies. Understanding this role can help identify when some KM technologies (such as document management systems) are actually used for knowledge management. Thus, a distinction can be made between the technologies that can be used for KMS and actual KMS. Second, the model indicates the relationships between KMS and IS. Some technologies can be used in either role depending on the managed contents and how it is used. Third, the definition of knowledge points at a possible way to index knowledge. We demonstrated the role of KMS and IS using a simple medical example.

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