What is the K in KM Technology

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Abstract: This article addresses the problem of how technology adds value to an overall KM solution. It presents the core problem of KM as matching contexts using *knowledge attributes* and defines KM technology as that which manages knowledge attributes. The paper illustrates this by analyzing several positive and negative examples of technologies and presents two challenges for knowledge management as a field. The requirement for KM technology to manage knowledge attributes can be applied in designing effective KM solutions, selecting KM products, devising a proper KM strategy, and controlling investments in KM. The definition of KM technology also provides a focus for research to bridge gaps in technology that currently limit the widespread use of knowledge attributes.

Keywords: KM technology, knowledge attribute, knowledge representation, context matching.

1. Introduction

There are many knowledge management (KM) products in the market. It is often not clear to a KM practitioner whether a KM product is indeed one. In the present work, we propose to classify technologies and tools into KM and non-KM ones based on an analysis of knowledge and how it is managed in knowledge management. Much has been written about how either KM is the same as information management or that it is different from it only in levels of abstraction (Zack, 1999; Grey, 1998; Skyrme 1997). We begin by presenting an overview of an analytical model of knowledge management built upon studies of what knowledge is and how it is transferred from one person to another in an organization (Firestone, 2001; Fuller, 2002; Ruggles, 1997). We model KM as a problem of matching contexts using *knowledge attributes* and show the role of technology in doing this.

Knowledge management is essentially about *knowledge* and about the *transfer of knowledge*. In general, members of an organization possess different kinds of knowledge. The purpose of KM is to facilitate effective transfer of the knowledge to others who have a need for the knowledge in carrying out their responsibilities in the organization. Other activities such as capturing, storing and retrieving knowledge and its meta-data are merely instrumental to the core objective of transferring knowledge to needy members of the organization. For the purposes of the present discussion, we assume that the person who receives the knowledge is a rational agent with sufficient capabilities to apply the knowledge effectively for the benefit of the organization.

In an ideal organization, anyone who needs some knowledge is always in close proximity (not just physically but also in terms of organizational roles and their relationships) to a person who possesses that knowledge. In reality, this is true to a significant extent only in small organizations. In large organizations, several other orthogonal or conflicting considerations prevent an organization from being structured exactly in the way prescribed above. For example, knowledge use may have to be geographically removed from the source due to conflicting needs of proximity such as to customers. In such organizations, there is a greater need for KM and KM technology and systems to bridge the resulting gaps in locations, time zones, languages, and cultures.

The model of KM described here is applicable to medium and large organizations (with approximately 100 people or more in its membership). This model is applicable to any organization or loosely formed community, although we sometimes refer to terms such as "business processes" or customers, since usually KM is most actively pursued in business organizations (Rao, 2003).

1.1 Modes of knowledge transfer and the role of technology

As stated above, a primary goal of knowledge management is to facilitate the transfer of knowledge from those who

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possess it to other members of the organization who need it to carry out their business activities effectively. The original and time-tested means for transferring knowledge is *directly* from one member to another in a synchronous communication between the two. The actual transfer happens typically using spoken (and where necessary, supplemented with written) language as the medium wherein the "speaker" serializes (or linearizes) the knowledge (s)he possesses so that it can be expressed in the language and transmitted to the "listener" who interprets and integrates the information represented in the language into the rest of the knowledge that he or she possesses. An important feature of such a transfer is the interactivity inherent in conversation (Akmajian et al, 1990, see Chapter 9; Grice, 1975) that allows for a variety of mechanisms that make the transfer effective, such as seeking and obtaining clarifications, reverse transfer for the listener to confirm to the speaker that the transfer has been correct, reactive elaboration, implicit negotiation and agreement upon what part of the knowledge can be assumed to be the shared background between the two parties, and so on (van Dijk and Kintsch, 1983).

The effectiveness and efficiency of direct transfer through language are often enhanced by the use of other media such as nonverbal signs, gestures, diagrams and graphical aids (Crystal, 1987, see Part XI). Direct transfer of knowledge in an organizational setting can be one-way through teaching, training, and consulting. It can also be mutual through collaboration where both (or all) collaborating parties provide as well as obtain knowledge from others.

For all direct transfers, the scope and role of KM, in addition to providing the necessary communication infrastructure, is to manage the meta-data of who knows what in the form of an expertise directory that classifies what people know in a systematic way. KM can also facilitate direct transfer by setting up organizational groups (or communities) for ownership, nurture, and accumulation of knowledge in various areas of interest. A secondary role may be to capture some of the knowledge being transferred during collaboration so that it can be shared in indirect ways at a later time as outlined below.

Direct transfer is very effective but not quite scalable due to time constraints, difficulties in synchronizing knowledge exchange, member attrition and widening geographical, cultural, linguistic, and time-zone spreads in a large organization.

Early inventions of writing, paper, and printing, further enriched by the more recent introduction of computers, computer networks, and their applications such as on-line storage and on-line communication, enabled indirect transfers of knowledge through written communication: books, papers, reports, e-mails, discussion forums, etc. In an indirect transfer, the communication can be asynchronous. The two parties may not know each other and may never meet each other. Traditional mechanisms for scaling up the scope of indirect transfers include publishing and libraries that can be considered early *knowledge dissemination systems*. With the introduction of computers, a member can use computer systems to browse through or search an on-line repository of organizational knowledge and obtain meta-data of others' knowledge.

Indirect transfer of knowledge also employs embodiments (i.e., serialization or linearization) in spoken or written language in addition to other graphical media (together referred to as *content)*. However, the embodiments in this case are not generated dynamically at the time of transfer; rather, they are captured and stored by a knowledge management system. Moreover, they must necessarily be accompanied by sufficient meta-data such as ontological classifications (Rosch, 1978; Sowa, 1999; Web Ontology Language (OWL), http://www.w3.org/TR/2004/REC-owl-guide-20040210/), background axioms, contextual descriptions and constraints on applicability. This is necessary in the absence of conversational negotiations and nonverbal communication that characterize direct transfers. The lack of such human communication mechanisms necessitates the additional attributes that enable efficient selection of knowledge sources that are both relevant and applicable to the context of a knowledge need in the organization. Relevance

(Baeza-Yates and Ribeiro-Neto, 1999; Salton, 1983) is a measure of how well the subject areas of a knowledge source match those of the present knowledge need. Applicability or usability is a measure of how easily and how effectively a relevant match can be used to satisfy the knowledge need. A knowledge source may be highly relevant yet have low applicability due to a variety of reasons such as its assumed background, lack of clarity, being too specific to the prior context, differences in language or organizational sub-cultures, being out of date, etc.

Indirect transfer has two basic requirements:

- An agent to store and manage sufficiently rich meta-data and make it available to needy members. Agents can be a publisher, a library, or an information store such as websites, KM systems, or an on-line discussion forum.
- A mechanism for identifying an embodiment of knowledge and matching it against future knowledge needs of members. Each embodiment of knowledge must have a signature the attributes of which can be readily matched with the requirements of a member.

As already noted, large organizations cannot adopt an ideal structure where every knowledge need arises in the immediate neighborhood of an appropriate knowledge source. It is insufficient to merely facilitate direct knowledge transfer by providing communication infrastructure and expertise directories. While these can overcome geographical distances to a large extent, they cannot adequately address cultural, linguistic, and time-zone gaps. KM in such organizations must necessarily lean heavily on indirect transfer mechanisms.

2. The KM problem

A knowledge need may arise as a part of any organizational process. For example, a knowledge need may arise in understanding the market, answering a customer's queries, designing a solution to a problem, or planning an event. In a small organization, how to obtain the necessary knowledge to satisfy the need is usually apparent to the person responsible for the process. For example, the person may know whom to ask in the organization to obtain the right knowledge. In large organizations, it is unlikely that the person will know everybody else or every 'place' in the organization (physical, such as libraries and file cabinets with records, or virtual, such as intranet websites, databases, and digital repositories) so as to determine the right person or place from whom to seek the knowledge. There is hence a need for KM technology and systems to bridge the gap and help the person match the context of the present knowledge need to stored contexts (of previous acquisition or use) most relevant to the present context.

Knowledge management involves capturing content that embodies knowledge as well as meta-data that identifies and describes the knowledge, storing and retrieving them, and motivating members of the organization to contribute, seek and re-use such content and meta-data. It may be noted here that some other activities concerning knowledge, primarily knowledge creation and acquisition, involve organizational functions such as education, training, human resources management, corporate acquisitions, etc, which are normally considered to be outside the scope of knowledge management. While each of these activities poses challenges for technology, organizational processes, and people management, they are merely instrumental to the core purpose of KM which is to re-use knowledge effectively to derive benefits for the organization. Re-using knowledge involves finding the right piece of knowledge in the context of a given knowledge need. This is a nontrivial problem in a large organization where a typical context of re-use has a number of potential matching prior contexts (or appropriate generalizations and abstractions of such contexts) in which the organization obtained or used knowledge. Thus, the core problem for KM in a large organization is one of matching the context of a knowledge need to a number of prior contexts so as to identify ones that are most relevant to the present need. The prior context may be one of acquiring the knowledge in the form of codified content (e.g., a document published within or outside the organization), of capturing the meta-data about the expertise possessed by a member of the organization, or of having applied knowledge to satisfy a

previous knowledge need. It is assumed for the present purposes that the organization has put in place a set of systems, technology and tools, people, and processes and strategies for capturing, storing, and retrieving meta-data about such prior contexts. Also, the problem is often made easier by shared organizational cultures and processes, complementing the role of technology in well-managed organizations.

A critical sub-problem in performing the match efficiently is to extract a subset of the attributes – called *knowledge attributes* - of present and prior contexts so as to be able to efficiently find relevant and applicable matches between the two in a large organization where there have been a large number of such prior contexts involving a number of experts or other potential sources of knowledge. We will show how knowledge attributes are different from *data* and *information attributes* that do not, in general, produce relevant and applicable matches of knowledge contexts.

As a simple example, consider a knowledge need where one is trying to locate a document that might satisfy the need. It is unlikely that the need would be satisfied by being able to specify, or extract, such attributes as the word count of the document being sought, or its format or author's name or its URL address; while it is more likely to be met by being able to extract attributes such as the subject matter or the gist or the intended audience of the document they are seeking. Similarly, if one is looking for experts in the organization to help meet the knowledge need, it is unlikely that the known context also provides the phone number or email address or name of the person being sought. Rather, they may be able to extract from the context the area of expertise and particular types of knowledge in that area that the person must know. The KM problem is being able to provide relevant and applicable matches using such attributes given a large organization with large volumes of captured content and large numbers of experts.

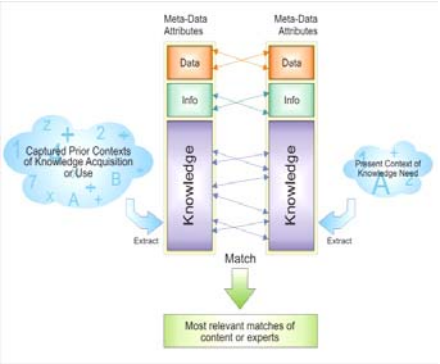

Figure 1: The core problem of KM

3. What is the K in KM

Intuitively, it seems appropriate to think that KM needs to manage much more than just data or information (Davenport, 1999; Davenport and Prusak, 1998; Sveiby, 1994). Data, for the present purposes, is any collection of bits and bytes with a known structure. For example, a sequence of bytes, characters or a table with rows and columns of numbers is data. Information is data endowed with sufficient context and semantics to be useful to the reader. For example, a database manages data such as a table of telephone numbers and email addresses; application software supplies context and semantics to the numbers and strings stored in the table to be able to serve useful information to the user, such as the contact information for a particular person in the organization.

Information can be structured to various degrees (but is rarely fully devoid of all structure). Structured information is sometimes loosely called 'data'. The term "unstructured" information is often used to refer to information that is ill structured, or semi structured, or not fully structured. Semi-structured information – often termed *content* - can be represented in the form of text in a natural language, audio, video, and other media (Crystal, 1987, see Part III). Content management is merely information management where the information is in text, video, and other unstructured forms (as opposed to structured data).

Knowledge has been defined in the literature as that which enables a rational agent to act in accordance with a plan to achieve a goal (Newell, 1982; Russell, 1926; Schank and Abelson, 1977). For example, an agent might achieve a goal by applying its knowledge to formulate and

execute a plan, to make a decision or to explain an action. For purposes of KM, knowledge does not mean the deductive or inferential closure of predications. It also includes explanations, interpretations, and annotations on the predications that may be important for relevance and applicability.

The continuum from data to knowledge constitutes a subsumption hierarchy in that information is also data and knowledge is also information. That is, a piece of information can always be considered data but not vice versa. Similarly, knowledge is always information. In view of this, we take the liberty of using the term data below when we need to refer to any of data or information or knowledge (as might be apparent from the use of the term data in meta-*data* (e.g., Dublin Core Metadata Initiative, http://www.dublincore.org) which is further classified below into attributes at the three levels).

Any data that is captured and stored must be accompanied by sufficient meta-data (or data about the data) to be applied usefully in future contexts. Meta-data can be considered to be a set of attributes of the data. For the present purposes, we can ignore the difference between attributes and relations and include binary or n-ary relations in the set of 'attributes'. We propose to classify the attributes into the following three levels:

- *Data Attributes:* meta-data attributes at this level include attributes such as record structure, syntax, size, encoding, etc.
- *Information Attributes:* at the information level, attributes include language, dialect, version, template and format, author's name, date, previous usage statistics, ISBN and other classification numbers, a Resource Definition Framework (RDF, http://www.w3.org/RDF/) description, an expert's telephone number and addresses, etc.
- *Knowledge Attributes:* At this level, the attributes describe the knowledge itself as well as its applicability in a context. Attributes that describe the knowledge itself include aboutness, gist, ontological mappings and Web Ontology Language (OWL, http://www.w3.org/TR/2004/REC-owl-guide-20040210/) specifications. Aboutness (Bruza, et al, 1999) is a generalization of the idea of subject or topics. Instead of merely placing the piece of knowledge in one or more bins of a classification system, aboutness enables one to answer the question "is this about x" where x may be a complex description of a context (e.g., a logical combination of several subjects with various further restrictions, conditional relaxations of constraints, etc.). A gist (Wical, 1999), as opposed to an abstract or a summary, need not be a condensed piece of text. Rather, it can be a complex representation of the essential contents of a piece of knowledge that can enable the user to visualize the contents from any chosen point of view. Knowledge attributes concerned with its applicability include the intended target audience, background assumed, ratings and reviews, author's knowledge profile, conditions or constraints to be considered in applying the knowledge, etc.

Knowledge attributes enable better matching of contexts and more effective application of the knowledge by:

- normalizing against differences in language and usage, culture and views of the world, terminologies used, and domains of interest.
- providing grounding for a knowledge asset in the space of all knowledge present in the organization by linking it implicitly with other assets in related areas or through other similarities in knowledge attributes (e.g., in terms of applicability)
- taking the KM solution beyond the content of knowledge by representing attributes of applicability of knowledge to specific contexts of re-use

An important distinction between knowledge and information attributes is that while data and information attributes are about the *container* or embodiment of the knowledge (i.e., a knowledge asset such as a document or a person), knowledge attributes are about the knowledge *contained* in the container.

3.1 Knowledge representation in KM

An important consideration that arises in the context of KM is related to the principles that distinctively define the

properties and specific forms of representation of the knowledge that is managed. For example, what should be the nature and properties of the representation of knowledge that effectively enable its exchange in an organization, as distinct from, say, data and information exchange? While recognizing that this question is of fundamental significance to the area of knowledge management, it is of interest to note that the notion of knowledge representation (KR) has its origins in the classical debates of artificial intelligence (AI) and cognitive sciences (Barr and Feigenbaum, 1981; Brachman and Levesque, 1985; Davis, et al, 1993; Minsky, 1975; Sowa, 1999), whose elements are therefore germane to the present discussion. In the following, we describe this briefly, and define KR in the context of KM through an exploration of the differences between the basic intents of the two fields.

AI and cognitive sciences find it useful to understand KR through the different roles played by a representation (Barr and Feigenbaum, 1981; Davis, et al, 1993). Accordingly, a KR may be considered to be a surrogate used by an agent to reason about the world, inhere and create (a series of) ontological commitments in the agent, be a model that supports reasoning with both sanctioned and recommended sets of inferences, function as a medium of computation, and be a language in which humans express statements about the world. Given the need for ensuring 'reasonably' sound inferences, the basic tools for representation (for e.g., logic, rules, frames, semantic nets) permit of different reasoning models, arising from mathematical logic (e.g., first order logic), cognitive psychology (e.g., goals, plans and complex mental structures) (Johnson-Laird, 1983), biology (e.g., connectionism, geneticism), statistics (e.g., probability theory) and economics (e.g., rationalism and utility theory). It is in the representation of knowledge based on the broad perspective described above – and utilizing minimalist forms to ensure deductive or inferential closure of predications – that AI provides a formal basis for automated reasoning (as may be implemented in an intelligent machine) which, in theory at least, is capable of mirroring and replicating, or modeling and explaining, the human reasoning process.

However, since a fundamental assumption of KM is that discourse forms the essential means of providing semantics in knowledge exchange, knowledge, as noted earlier, does not mean only the core axioms and predications. Furthermore, given that knowledge itself is considered an internalization of the representation in the transferee's mind, the burden of reasoning and the associated computing is largely transferred to his/her cognitive structures (Barsalou, 1992; Jackendoff, 1983). Such internalized knowledge enables the user to act by applying it in a relevant context to execute plans and achieve goals. Internalization (or assimilation) may involve integration with one's conceptual and episodic/experiential memory through association, generalization, tuning of existing knowledge, etc.

Hence, in KM, the need for a representation to support formal reasoning with both sanctioned and recommended sets of inferences, and the need for it to function as a medium of computation are significantly diluted. Thus unburdened, the role of KR in KM can be stated by defining *a knowledge representation as the set of knowledge attributes necessary for efficiently finding relevant and applicable matches for the context of a knowledge need*.

It may be observed that the concept of KR in knowledge management is more in line with recent applications of this concept in the development of the semantic web (http://www.w3.org/2001/sw, the semantic web homepage); although presently these applications are to the large part concerned with information level representation except for the ontology based classification of subject matter.

Apart from representing knowledge attributes, for supporting indirect knowledge transfer, KM requires knowledge itself to be represented, albeit in less formal or semi-structured embodiments such as natural language texts or other media. In the case of direct transfer, the knowledge itself may not be represented at all outside of what is attributable to the human experts who possess the knowledge.

Knowledge representations can be designed, stored, secured, transformed, enhanced, etc. In other words, they can be "managed". Knowledge itself can be acquired, augmented, represented (at least partially) and shared, apart from being used (i.e., applied in action).

In light of the above, a useful definition of knowledge management is

> *the strategic management of knowledge representations and people in an organization using technology and processes to optimize knowledge sharing.*

3.2 Data, information and knowledge attributes: an example

Consider the following example that illustrates the differences between a data management system, an information management system, and a knowledge management system.

A data management system may store employee data such as employee numbers, names, departments, and email addresses (Table 1). This data can be retrieved by writing an appropriate query in a machine-readable language like SQL.

Table 1: Numerical and string data about employees in MyCompany

Employee Number: Integer(4 bytes)	Name: String	Department: Enumeration (from DepartmentTable)	Phone number: String of digits	Email address: String (*@*)
123	Helpdesk	MIS	111 2233	help@mis.MyCompany.com
234	John Doe	MIS	111 2244	John234@MyCompany.com
345	Jane Doe	MIS	111 2255	Jane345@MyCompany.com
456	KIA (Knows It All)	MIS	111 2266	KnowsItAll@mis.MyCompany.com

This data is useful only when it is interpreted in an appropriate context to provide information to users. For example, the numbers and strings in the above table can be interpreted to generate information that can answer questions (or information needs) of the kind "How do I contact Mr. X?"

A more involved example of an information need may be: "How can I contact the MIS department?" This involves a more complex translation of the question to arrive at an appropriate data retrieval query. The translation can be done by humans or by computer systems (i.e., information management systems). In either case, this is still an information need and an appropriate answer given the above data may be: You can call their helpdesk at 111 2233 or email to help@mis.MyCompany.com

However, to meet knowledge needs, new attributes have to be introduced. Consider a knowledge need, such as: "How do I find out about MyCompany's prior credentials and experience in xyz technology?" In the context of this knowledge need, the person who has the need may have a goal such as: "Sell some product or service in xyz technology to a customer." His or her plan for satisfying the goal may involve a step such as: "Present prior customer credentials in xyz technology to the customer." In trying to carry out this step of the plan, the person may generate the knowledge need: "How do I find out about prior customer credentials in xyz technology?"

Table 2: Representation of knowledge attributes of experts in MyCompany

Employee No. (from Employee Table)	Knows about <ontology-nodes>	Expertise rating	Knowledge-sharing cases
123			
234	databases	70%	Case1, Case457
345	Japan	90%	Case2, Case3
456	xyz, past customers	80%	Case23
…			

Let us assume for the purposes of this illustration that the organization does not contain any documentation of prior customer credentials but that it has several people who possess that knowledge. An appropriate answer to the

knowledge need in this context may be: "Consult Mr. KIA in MIS. His phone number is 111 2266 or email him at KnowsItAll@mis.MyCompany.com"

What does a system need in order to generate the above answer? It needs knowledge representations of the kind shown in Table 2 above. Knowledge attributes such as the areas of expertise of employees such as Mr. KIA knowing about the area of prior customer credentials, ranking and ratings of everyone's expertise in the areas, cases of previous knowledge sharing by them in the areas, etc.

A system that can manage such knowledge attributes and answer the knowledge need is a knowledge management system. The system that answered the information need above is not a KM system since it did not match present and prior contexts at the knowledge level. That system could satisfy the above knowledge need only if the person already knew that Mr. KIA in MIS is a good source of knowledge of prior customer credentials in xyz technology. Similar and more capable technologies for handling knowledge attributes are needed to support KM through indirect transfer.

4. What is KM technology

The term KM technology is often used loosely to include any technology that is used in an overall KM solution, such as a variety of information and content management, communication and collaboration technologies. The few attempts made to put KM technology on firm foundations (e.g., Ruggles, 1997, see pp. 3-4; Tiwana, 2000), however, do not seem to be able to clearly delineate the particular qualities that characterize KM technologies.

As may be apparent from the example above, KM technology uses the same enabling technologies such as pattern matching, data base retrieval, and communication over TCP/IP networks as data processing and information management systems. The difference is entirely in the nature of the attributes managed by the systems.

Any KM technology obviously enables knowledge sharing among the members of an organization. More importantly, however, a ***KM technology*** *is one that enables sharing of readily updatable knowledge by efficient matching of present and prior contexts* ***using knowledge attributes***.

This is not to say that information attributes are unimportant to KM; often, attributes such as the language that a knowledge source speaks (a document or a person) or its degree of verbosity, can be an important factor in determining its relevance and applicability to a knowledge need. Nevertheless, information attributes themselves are not sufficient to provide efficient matches of available knowledge to meet knowledge needs.

It may also be noted here that although commonly available communication and collaboration technologies (telephones, electronic mail, message/messenger services, etc.) as well as traditional information distribution media (newspapers, printing and publishing, radio, television, audio and video records, etc.) enable sharing of knowledge, they do not qualify as KM technologies since they do not manage knowledge attributes adequately to meet the knowledge needs of large organizations. Traditional publications in the form of books and journals, in particular, do not enable dynamic knowledge sharing through quick and easy updates. In order to optimize the sharing of knowledge to meet knowledge needs as they arise in an organization, a KM solution must allow the most current knowledge, however informal or ill-packaged it is, to be shared without an undue delay.

Table 3 applies the above definition of KM technology to a number of technologies and states the conditions under which a particular technology is a KM technology, or the reasons why it is not.

Table 3: Illustrative positive and negative examples of KM technology

	Technology	KM √ / Non-KM ×	Why not KM or KM only if
1	Coffee cup, water cooler, …	×	do not manage any knowledge attributes
2	Telephone/voicemail/instant messenger	×	only an enabling technology for communication
3	Spreadsheet	×	manages only data and data attributes
4	Database	×	manages data and data/information attributes
5	Email	×	does not typically manage any knowledge attributes of the contents of the messages
6	Email question auto-answering system	√	is able to match the knowledge needs expressed in a question to prior (or frequently answered) question-answer pairs
7	On-line discussion forum, community of practice, agony aunt columns in newspapers…	√	for e.g., search/navigation is supported through ontology nodes and specifications of applicability and relevance
8	Chat/whiteboarding/project sharing	√	is able to capture sessions and classify them automatically using knowledge attributes
9	Content management	√	supports knowledge-level functionality such as auto-classification of content against ontologies, retrieval by aboutness and extraction of gists
10	Expertise directory	√	provides matches by subject areas, level of expertise, reviews and ratings, etc
11	Knowledge discovery, data mining, …	√	automatically discovers knowledge to fill gaps in knowledge repositories
12	Intelligent agent, ibot, …	√	for e.g., is agent for K-attribute elicitation from those having knowledge needs, intelligent agent for conversational negotiation with KM systems
13	Web server, portal, …	×	manages only content
14	Traditional library	×	knowledge is not readily updatable
15	ERP system	×	manages data and data/information attributes
16	Document security package	×	prevents knowledge sharing in some cases
17	Collaborative authoring tool	×	handles only information attributes
18	E-learning system	×	currently, unable to represent and manage learning objectives or evaluate students at the knowledge level
19	Search engine	×	provides matches using only information attributes
20	On-line review and rating system	√	generates applicability attributes

5. Challenges for KM

The ideas of knowledge attributes and their use in KM tools for effective knowledge sharing can be applied to pose two challenges to the field of KM:

- **Cultural challenge:** How to get people in an organization to appreciate the value of knowledge attributes and how to motivate them to put in the effort required, if any, to generate or extract knowledge attributes and use technology that exploits knowledge attributes? Reasons for not using knowledge attributes may be complacency, apathy, lack of awareness, lack of understanding or proof of their value, or technology not yet being up to the mark.
- **Technological challenge:** How to build KM systems that make effective use of knowledge attributes to enrich user interactions with systems on the lines of human conversational interactions? Hurdles in research and development directed towards this goal include too much hype and confusion in KM product markets (Wilson, 2002), lack of conviction and funding, and significant gaps in necessary technology.

Humans can, for example, instantaneously determine the relevance of a text to a context, or effortlessly capture the gist of a document from a desired point of view. In terms of creating similar abilities in systems, there have been a few somewhat successful attempts to build technology that can automatically derive knowledge attributes from information attributes, often using statistical techniques with ample amounts of empirical training (e.g., automatic theme and gist extraction and automatic conceptual classification). In general, however, in today's state of the art of technology, keyword searches, extracted summaries (Mani and Maybury, 1999), and pigeonhole classifications continue to be readily accepted as KM technology. For KM to clearly demonstrate value to large organizations, there is an urgent need to appreciate that KM technology should be able to do more.

A related challenge for KM systems is to prevent fragmentation of knowledge in growing organizations where knowledge sources tend to become either disconnected or incompatible with each other. Preventing fragmentation requires certain knowledge attributes (e.g., taxonomy, applicability attributes) to be centrally managed. This poses both cultural and technological challenges, for e.g., in creating and managing a unified classification system with multiple views for different constituencies in the organization. KM systems, on the other hand, ought to be decentralized or loosely federated and not only well-integrated with all enterprise information systems but also modularized and easily distributable to keep pace with changing organizational needs.

6. Conclusion

KM can benefit from technology that manages knowledge attributes as well as from a variety of non-KM enabling technologies for communication, information management, and others. Understanding what is managed by KM technology is essential to the proper design of KM solutions and selection of KM products. This understanding also enables us to focus on the effectiveness of managing knowledge in an organization rather than continuing to expect returns from an inadequate KM solution such as a simple combination of a search engine, an intranet portal, and an on-line chat system. It allows the organization to devise a proper KM strategy and control its investments in KM. One can also use the idea of knowledge attributes as a basis to develop a model of assessing the maturity of KM implementations and for providing diagnostic feedback on improving the maturity. The definition of KM technology provided in this paper also provides a focus for research in KM technology to bridge the gaps that currently limit the widespread use of knowledge attributes.

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