Knowledge Management in Modern Organizations

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Preface

Knowledge management (KM) has been growing in importance and popularity as a research topic and business initiative since the mid-1990s. This is sufficient time for KM to grow into a discipline complete with its own journals. This book presents 20 chapters that discuss the theory and implementation of KM. The chapters come from articles published in Volume I of the *International Journal of Knowledge Management* (2005) and have been updated to reflect the current state of KM.

The purpose of this book is to document the state and key issues of KM in 2006. It is targeted to academics, practitioners, researchers, and students. Academics will get particular value from the foundational chapters in this book that discuss the philosophical foundations of knowledge and KM. Additionally, the first four chapters establish the foundation of KM as a discipline. This is done to lend legitimacy to research in KM and to help academics establish courses and degree programs that focus on KM. Practitioners will get special insight and value from the case studies and chapters on KM impacts on organizations and measurement of KM, as they are focused on successfully implementing KM in business organizations. Researchers and students will benefit from all chapters.

How is this book intended to be used? First it can be used as a reader in KM courses. It probably shouldn't be used as a sole textbook for a general KM course, but it would add value to any course focused on KM in organizations. Additionally, it is a good book for those wanting to keep current in KM or to begin a course of study or research in KM. Finally, it is good for business professionals just wanting to know how KM could help them run businesses and organizations more effectively.

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Section IV

Knowledge in Organizations

Chapter XIV

The Role of Context and Its Explication for Fostering Knowledge Transparency in Modern Organizations

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Abstract

In order for a company to be oriented consistently toward its customers and their processes, it needs to customize its intracorporate processes and systems. The solution seems to be customer process-oriented portals that integrate companies' systems and provide transparent access to information objects stored in these systems. A key problem in this regard is finding relevant information objects in systems that not only are growing but also also are being disseminated. An additional challenge is making knowledge available at the right time and at the right place. A company's competitive advantage is rooted in this knowledge advantage as well as in the capability to transform this superior knowledge into market-driven business processes. The research questions addressed in this chapter are how the value of information objects is affected by the context in which it is considered and how associated

contexts can be uncovered for given situations. We introduce a continuum of context explication comprised of the relationships among data, information objects, knowledge, and their contexts according to their degree and ease of context explication. The extremes of the continuum, therefore, would be data with no context to explicate and knowledge with rich, person-specific context. We conclude that discovering implicit meanings and expressing those meanings explicitly increase information objects' potential values. In addition, we evaluate the full-text search, attribute-based search, and topic maps as approaches for knowledge discovery through customer process-oriented portals as well as providing patterns that indicate when to apply which approach. Two small case studies are presented of knowledge discovery through such portals. We conclude with suggestions for future research, based on our final deductions with respect to the study.

Introduction and Overview

Challenge

The use of information technology has given many organizations access to vast internal and external information repositories. Intranets, content management systems, and enterprise portals have become commonplace, providing employees with opportunities to discover knowledge enshrined in information objects (e.g., electronic documents) (Latham, 2001; WebCKS, 1999). Nonetheless, dealing with information and finding the right content are inefficient actions. Davenport, Harris, and Kohli (2001) stated, "Information management must begin by thinking about how people use information" (p. 63). This is a precondition for using information judiciously.

Although organizations currently have access to various information repositories, the process of knowledge discovery still has major shortcomings, such as the following:

- **Lack of information:** Finding information objects on a topic is frustrating if users know that they exist but cannot trace them.
- **Overload of information:** Knowledge discovery is time-consuming if too many information objects with no or little relevance are found.

One key to successfully minimizing these deficits is by controlling the semantics (i.e., the meaning of terms), making explicated context available, and methodically classifying information objects utilized in business environments (Dale, 2001; Felber & Budin, 1989). Various technological approaches—based on various degrees of context explication, such as discovering implicit meanings and expressing those meanings explicitly—have been proposed to address the lack of relevant information and the overload of remotely related information problems in knowledge discovery. Examples of such approaches are search and classification engines. Nevertheless, there are hardly any criteria available with which to support organizations' choices of an appropriate solution. Consequently, we present a

comprehensive overview of several approaches, their underlying principles, advantages, and constraints. To fulfill specific organizations' needs, criteria also are provided in respect of the degree of context explication required.

Objective and Research Approach

The overall objective of this chapter is to propose a continuum of context explication comprised of the relationships between information objects and their contexts in order to foster knowledge discovery. We will demonstrate that the continuum allows organizations to make deductions with regard to the appropriate approach with which to stimulate knowledge discovery through portals.

A review of the knowledge management literature provided a comprehensive overview of the topic and related works. Furthermore, it revealed the gap between research on an information object's context and its explication. Desk and action research (e.g., prototypical implementations of our conceptual approaches, led to logically deduced concepts (Checkland & Holwell, 1998), while the case research allowed the deduction and validation of these concepts. In terms of our research questions, the latter was particularly suitable since the research and theory are still in the early stages of formulation (Benbasat, Goldstein, & Mead, 1987). Consequently, the research and descriptive processes also were influenced by the results of workshops conducted and projects undertaken with our corporate partners during the action research (Gummesson, 2000; Whyte, Greenwood, & Lazes, 1991). We currently are testing and expanding the findings with other partners as well.

Structure of the Chapter

The subsequent section deals with related works in the area of knowledge discovery and portals. It also defines the most important and relevant terms for an understanding of the research field.

In the third section, we describe the challenges facing knowledge discovery. Thereafter, we introduce three major approaches for discovering knowledge through portals by providing a chronological outline of the different development phases. We describe the three approaches—full-text search, attribute-based search, and topic maps—with reference to their characteristics, advantages, and restrictions in relation to context explication.

Knowing the three approaches' capabilities and constraints, and based on given prerequisites, we then propose a continuum of context explication, providing criteria for and advice in respect to choosing an appropriate solution.

In the penultimate section, we provide two examples of how the continuum was applied successfully in a normal work situation. This was done at two institutions where, based on different prerequisites, we chose and implemented different solutions for knowledge discovery. Finally, we draw conclusions and propose directions for further research.

Related Work and Definitions of Terms

In this section, we introduce the theoretical background and define the most relevant terms. We identify related works and explain how they differ from our approach.

Knowledge and Context

Within the literature there are many definitions of knowledge (Biggam, 2001; Davenport & Prusak, 1998; Lai & Chu, 2000; Murray, 1996; Nonaka & Takeuchi, 1995; Polanyi, 1966; Sveiby, 1997) (see Table 1). Some of these references also provide detailed discussions on the differentiation of the terms, data, information, and knowledge, as well as discussing knowledge types and their classification (see Figure 1).

In our view, knowledge comprises both information and person-specific aspects, such as experiences, values, and insights. An important characteristic of knowledge, which simultaneously distinguishes it from information, is its strong affinity to activities (Davenport & Prusak, 1998). Individuals act and react in keeping with their experiences and intrinsic attitudes. Knowledge, on the other hand, is much more than transformed information and, therefore, cannot be represented in the form of information objects or data. Polanyi (1966) developed a concept of implicit knowledge that he described as follows: "We can know more than we can tell" (p. 4). We concur with Polanyi's (1966) basic concept that knowledge's implicit and explicit dimensions are complementary—all knowledge contains both dimensions. Pure explicit or implicit knowledge, or the conversion of one into the other, is thus impossible.

Many of the previous definitions of knowledge have context as an important common aspect. One form of transition from information to knowledge is contextualization. Dey and Abowd (1999) define context as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interac-

Figure 1. Data, information, and knowledge (Klemke, 2000)

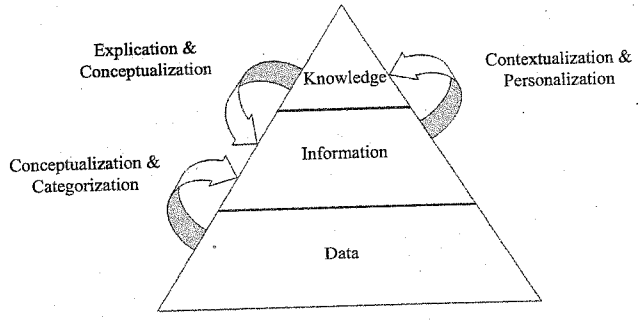


Table 1. Overview of selected definitions of the term knowledge

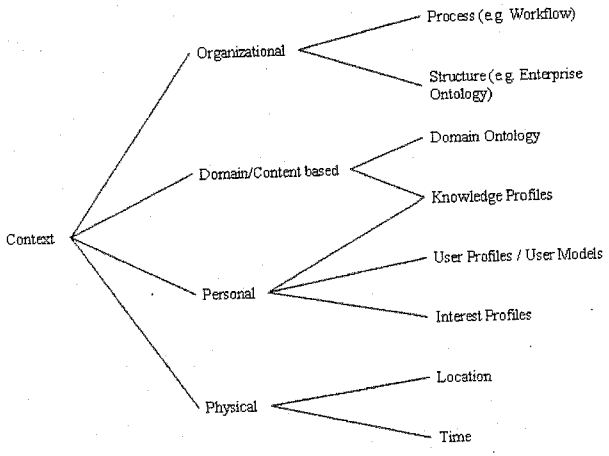
Author	Definition
Davenport & Prusak (1998)	"Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers" (p. 5).
Nonaka & Takeuchi (1995)	"First, knowledge, unlike information, is about beliefs and commitment. ... we consider knowledge as a dynamic human process of justifying personal belief toward the 'truth." (p. 58).
Alavi & Leidner (1999) Lai & Chu (2000)	Knowledge is created and organized by the very flow of information, anchored by the commitment and beliefs of its holders. Information becomes knowledge when it is processed in the mind of an individual, and knowledge becomes information when it is articulated or communicated to others in the form of text, computer output, speech or written words, and so forth.
Murray (1996)	"Knowledge solves a problem; it produces competence leading to effective action."(p.5). "Making the tacit explicit often includes the following activities: ... Identifying terminology that is clearly understood and using language that is appropriate for the culture and context."(p.4).
Sveiby (1997)	Knowledge is the capacity to act within context.
Polanyi (1966)	Tacit knowledge is personal, context-specific, difficult to express in verbal, symbolic, and written form, and therefore hard to formalize and communicate.
Biggam (2001)	"- It must be true. - The perceiver must believe this to be the case. - The perceiver must be in a position to know this to be the case." (p. 3)

tion between a user and an application, including the user and applications themselves" (p. 3f). Similarly, Sowa (2000) describes context in its nonlinguistic meaning as "situation, environment, domain, setting, background, or milieu that includes some entity, subject, or topic of interest" (p. 275).

Klemke (2000) describes the differentiation of context types by means of a level-based approach. The first level identifies the following context dimensions: organizational, domain-/content-based, personal, and physical. These dimensions are specified in more detail on the second level (e.g., the organizational dimension is subdivided into a process and a structure component). In spite of the common assumption that context consists only of implicit information, the previous definitions allow context to be either explicit or implicit. In this chapter, we reveal that the explication of information objects' implicit context (i.e., the discovery of implicit meanings and expressing those meanings explicitly) supports the creation of new knowledge. Moreover, we describe various approaches with which to achieve this.

Klemke (2000) recommends a holistic understanding of context by means of several dimensions (see Figure 2) and the implementation of an integrated architecture to trace and maintain context models. In addition, the literature regards contexts as having different characteristics and uses different approaches to model these contexts (e.g., workflow process context is modeled by workflow management systems (Wargitsch & Habermann, 1998), while organizational structures are modeled by enterprise ontologies). Conversely, we focus directly on information objects and their contexts and provide approaches with which to discover,

Figure 2. Context typology (Klemke, 2000)



explicate, and use these contexts in various situations in order to increase the information objects' potential value and to stimulate knowledge discovery.

We believe that all documents ultimately are information objects. Users are able to create knowledge by processing and understanding them, although the information objects do not comprise knowledge. However, we recognize that some KM researchers differentiate between information and knowledge object documents (i.e., they acknowledge that documents with context can be knowledge objects). This chapter considers all documents as information objects and requests that the readers accept this viewpoint throughout the rest of this chapter.

Knowledge Discovery as an Important Knowledge Management Activity

Many knowledge management activities, methods, and modules have been discussed in the literature. Lai and Chu (2000) suggest an integrated knowledge management framework that comprises the following activities: initiation, generation, modeling, repository, distribution and transfer, use, and retrospect. Davenport and Prusak (1998) differentiate between specifying a requirement and capturing, distributing, and using knowledge. Probst, Raub, and Romhardt (1999) present a pragmatic approach to the organizationwide management of knowledge. This approach comprises six core processes and two pragmatic modules: the identification, acquisition, development, distribution, use, and preservation of knowledge as well as knowledge's objectives and performance measurement. Nonaka and Takeuchi (1995), Andersen (1996), and Alavi (1997) offer relatively similar classifications of knowledge management activities.

All these approaches have a method in common for the identification or use of knowledge, whether implicit or explicit. Unused knowledge that generally is found within organizations can be uncovered with appropriate methods and, thereafter, utilized. Knowledge discovery methods additionally foster knowledge transparency in organizations as well as supporting users to find relevant information objects. They are a necessary precondition for the core processes of knowledge identification and knowledge use (Probst, Raub, & Romhardt, 1999). They not only improve the organizational use of existing individual and common knowledge but also contribute to the knowledge generation process (i.e., the development or collecting of new knowledge) (Güldenberg, 1996).

Portals

Portals have been discussed as an integration concept for user access to personalized information and applications since 1998 (Bristow, Dickinson, Duke, Henry, & Makey, 2001). Although there are many descriptions of portals (Davydov, 2001; Dias, 2001; Kalakota & Robinson, 2001; Röhricht & Schlögel, 2001; Schwarz, 2000), we focus on them as Web-based, personalized, and integrated access systems to internal and external applications and information repositories.

Portals support knowledge-oriented processes by providing users with a graphical front-end integration of back-end systems that comprises, among others, integration, personalization, and administrative services. Knowledge discovery methods through portals are supported mainly by navigation and search mechanisms (Fleisch & Österle, 2001; Puschmann, 2003). The role of search mechanisms is especially significant in these methods, as the following section shows.

Knowledge Discovery Through Portals

As stated previously, search and retrieval play a vital role in the concept of portals, but knowledge discovery through portals faces special challenges (Baeza-Yates & Schäuble, 2002; Raghavan, 2002).

- **Heterogeneous structures and formats:** Information objects are stored in multiple, roughly structured formats, classified in various ways, and presented in various languages. Portal users, therefore, need a standardized view of all the available information objects.
- **Distributed and redundant information:** Organizations have information objects that reside in a variety of sources (e.g., e-mail, content management, and file server systems) in a partly redundant way. Knowledge discovery processes have to offer mechanisms that connect these repositories to the portal to provide users with a consolidated view.

- **Protected content:** The role of each individual portal user dictates which information objects that individual is able to access. In the process of knowledge discovery, navigation entries and search results have to be filtered in order to display only the information objects accessible to the user (i.e., secure access has to be provided).

Addressing these challenges is fundamental to supporting knowledge discovery methods through portals (Andrews, 2003). The following sections illustrate three major approaches with which to achieve this objective by providing a chronological outline of different development phases.

Full-Text Search

The classic full-text search has been an established retrieval approach since the early 1990s (Rappoport, 2002). A search engine is an information technology component of a portal that acts as a central instance between the user's information need and the available information objects that are stored in one or more repositories. Users convert their information need into a search query and enter it in a search field within a portal. In order to respond to the user queries, a search engine indexes each information object, representing it as a set of weighted words. The search engine compares the entered terms with the previously indexed information objects and provides the users with a result list.

The benefits for users are as follows:

- **Speed:** Searching the content of multiple repositories by means of a single query is faster than searching each application individually by means of separate queries.
- **Ease of use:** Currently, the full-text search is well-known, and most users have some experience in this (Gordon & Pathak, 1999).
- **No prestructuring required:** Since the relevant terms are indexed automatically, no human-driven intervention is necessary.

Since the expressing of an information need in a single query has a strong impact on the quality of the search results, the main restrictions of the full-text search emanate from the following semantic issues:

- **Wrong or too many results:** Receiving search results that refer to information objects with no or little relevance is time-consuming (Cathro, 1997). In this context, the challenge is for users to anticipate the correct terminology (i.e., to match the authors' terminology).
- **Spelling:** A user's query should be orthographically correct.

As shown, the full-text search is dependent on the information object's content, because its context is contained solely within the information object itself. The authors do not provide explication during the information object's creation, nor does a system later do so.

Attribute-Based Search

To overcome the restrictions of the full-text search, the attribute-based search was developed in the mid-1990s (Cathro, 1997). This approach is based on a context explication model that stores an information object's context as metadata (i.e., data about the data) (Berners-Lee, 1997). The metadata are stored with the information object itself and can be viewed and retrieved by users and applications. Common metadata attributes that are associated with information objects include the author's name, date of publication, source of publication, and so forth. The attribute-based search during knowledge discovery through portals would therefore permit structured queries on the context explicated in information objects' metadata (McGovern, 2001). Currently, there are several metadata standards e.g., the Dublin Core Metadata Element Set, which proposes 15 fields or attributes according to which a document can be described (Baeza-Yates & Ribeiro-Neto, 1999; Dublincore, 2003).

The major benefits of the attribute-based search are as follows:

- **Reduced result sets:** Compared to the full-text search, users retrieve relevant information objects more swiftly.
- **Controlled vocabulary:** Users can choose standardized terms from drop-down lists.
- **Personalization capabilities:** Search queries can be enriched automatically with personalized information (user attributes, such as roles, language, and organizational unit).

But there are also certain constraints:

- **Maintenance of controlled vocabulary:** Although this approach is less time-consuming when users want to find relevant information objects, human intervention is required at the time of creation in order to provide them with appropriate context attributes.
- **Metadata are stored with the information object itself:** Since terms could change over time, reclassification may be necessary. Alternatively, reclassification could be avoided by separately mapping old terms with new ones (e.g., with a customized thesaurus).

It is clear that because the information objects contain content and explicated context, both maintained by their author at the time of creation or during maintenance changes, the attribute-based search actually is based on context explication.

Topic Maps

The initial idea behind topic maps, which date back to the early 1990s, arose from the need to model intelligent electronic indexes (of books), tables of content, glossaries, thesauri, or cross references in order to merge them automatically. During many years of discussion

and evolutionary development cycles, the topic map model has developed into something very powerful that no longer is restricted merely to the modeling of indexes. The ISO standard ISO/IEC 13250 Topic Maps, adopted in 1999, defines a model and architecture for the semantic structuring of link networks. Topic maps establish an associative network between subjects, which represent information objects, and provide navigation paradigms that allow them to be searched. By applying topic maps to large sets of heterogeneous information repositories, reusable and structured semantic link networks are created on a level above those resources (Rath & Pepper, 1999). The key concepts of topic maps are topics that represent real-world subjects, occurrences of topics, and relationships among topics (topic associations). In addition, the topic map standard provides extended concepts of scope, public subject, and facets. For a comprehensive introduction and reference, refer to Rath and Pepper (1999) and ISO/IEC 13250 (2002).

Topic associations describe the relationships among topics. They are completely independent of the information object itself and, therefore, represent the topic map's essential added value. The addition of topic associations to the concept of topics enables topic maps to model information networks.

Topic maps organize information repositories in a new knowledge space by relating them to topics and structurally associating them. Furthermore, they enable heterogeneous sets of information repositories to be used in an integrated way by interrelating them by means of a unifying conceptual framework. Another characteristic of topic maps is that they are well-suited to represent ontologies. Consequently, they facilitate the description of a shared common understanding (e.g., about the kinds of objects and relationships that are being discussed) (Wrightson, 2001).

The link mechanism between topics and topic occurrences provides a means with which to bridge the gap between knowledge representation and information management fields (Pepper, 1999).

Since the human brain always remembers memorized issues in a specific context (Goldfarb & Prescod, 2000), association is the basic way of thinking. Topic maps support this way of thinking by pointing to related themes when a user searches for a specific theme.

To summarize, topic maps have the following benefits:

- **Creation of knowledge structures:** Applying topic maps to information repositories generates knowledge structures. They form structured, semantically linked networks above large sets of information repositories.
- **Creation of metalayers:** Transparent access to information objects is provided by searching and navigating knowledge structures (i.e., a metalayer above the information objects). Modifications of the metacontext do not affect the information objects or their descriptors. Searching in topic maps can be compared to searching in knowledge structures.
- **Discovery of new context:** Added value is achieved by the creation of new knowledge through the discovery of new contexts.
- **Support of human thinking:** Topic associations support the basic way of thinking by providing interrelating themes.

Some basic constraints are as follows:

- **Effort required for topic map creation and maintenance.** Intense human effort is needed to define, create, and maintain topic maps. Persons who manage topic maps need expertise in both topic map concepts and paradigms as well as in the specific domain to which the topic map applies.
- **New search paradigm.** Users have to learn to use the topic map search concepts and to adopt the associative way of thinking, while they are familiar with the full-text or attribute-based search concepts and their flat result sets.

As has been described, topic maps provide strong concepts and paradigms with which to discover and explicate information objects' contexts, thus relieving authors and users of the need to provide metadata or descriptions. The explicated context does not form part of the information object and even can be used without it. However, specifically skilled persons are required to support the process of context explication. Concepts for the organizational and process integration of such knowledge workers are introduced in detail in Smolnik and Nastansky (2002). In general, they need expertise in managing topic maps as well as in the specific domain to which the topic map applies.

The Continuum of Context Explication

As pointed out in our motivation, context has been recognized as an important aspect to consider when looking at the meaning of information with respect to knowledge discovery and knowledge creation. In the previous section, we presented three approaches with which to find information objects and with which to recognize, represent, and use contextual information through portals. Even though these approaches have supporting users to find relevant information objects in common, they focus on contextual information in different ways and with varying intensity.

The introduction of the continuum of context explication was one of the major results of our research. This continuum focuses on data, information objects, and knowledge as portals' basic subjects as well as on their varying embodied degree of context explication. Furthermore, it describes approaches with which to find and use information objects and contextual information (see Table 2). We define five approaches, each with a differing degree of context and explication simplicity: three approaches relate to information objects and search methods' chronological development, with the other two forming a logical extension of data's transition into information and information into knowledge. Based on given prerequisites, we furthermore provide criteria for and advice in respect to choosing an appropriate solution.

Data Approach

Data are meaningless symbols without content and context that have no context to explicate. Depending on the data quantity and the relevant domain, there are several methods with which to transform data into information objects or even into domain-specific knowledge. For example, in the knowledge discovery in databases and data mining research domains, the identification of patterns in large structured data sets results in the nontrivial extraction of implicit, previously unknown, and potentially useful knowledge (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). Processed and conceptualized data, such as documents created by authors, are defined as information.

The data approach is appropriate for the following situations:

- No or little interaction with users, authors, or knowledge workers
- Large structured data sets
- Possible automatic data generation or collection

Information Approach

Even a simple information object contains some kind of content (e.g., text, audio annotation, or spreadsheet). Although the information object may provide no explicit context like descriptors or other contextual information, it inherently contains context. The context, however, is interwoven with the content and is difficult to conceptualize, which means that the methods implemented to find requested information objects have to rely on the content and cannot access contextual information. A typical method is the full-text search, as described previously. Normal full-text search engines use information objects' indexed contents to respond to a query and do not access contextual information at all. No effort, therefore, is made to explicate context as neither the authors nor the users provide or use explicit contextual information.

The information approach is appropriate in the following situations:

- Many users who have little or no experience with enhanced searching approaches or who are unwilling to use them
- Authors who have no experience describing their information objects
- Numerous unstructured information objects

Descriptor Approach

Information objects often are enriched with metadata (i.e., they contain content and explicit contextual information). Examples are Microsoft Word documents, Adobe PDF documents, or semi-structured documents in a groupware-based office environment.

Table 2. Continuum of context explication

Data approach	Information approach	Descriptor approach	Meta context approach	Knowledge approach
user, author, knowledge worker	user, author, knowledge worker	user, author, knowledge worker	user, author, knowledge worker	user, author, knowledge worker
Large structured data sets	Unstructured information objects	Semi-structured information objects Information objects with descriptors	Large sets of heterogeneous information repositories	Information objects in person-specific contexts
Data	Information object: Context, Content	Information object: Content	Meta context; Information object: Content	Competencies, experiences, values, and insights; Meta context; Information object: Content
Pattern identification	Full-text searching	Attribute-based searching Resource Description Framework	Topic maps	Action: Communication Cognition Construction
Ease of context explication → Context				

In contrast to the information approach, information objects contain not only implicit contextual information but also explicit contextual information. As previously explained, a standard for formulating contextual information is the Dublin Core Metadata Element Set that proposes specific attribute classes for the description of an information object. Another concept for structuring and providing metadata is the resource description framework (RDF), which is resource-oriented. Its main objective is the description of resources and their relationships to other resources, with the description mostly residing in the resource.

In contrast to the information approach, some effort is necessary to enrich an information object with explicit contextual information. Authors have to provide this information at the time of creation. In addition, software systems try to maintain some of the contextual information.

The advantage of the attribute-based search as a retrieval method for information objects is dependent on the quality of the provided explicit contextual information (see the introductory section on the attribute-based search). If the metadata are wrong, misleading, or incomplete, the attribute-based search will provide insufficient result sets; if not, the attribute-based search provides more accurate results, which, to a certain extent, will fit the user's context.

The descriptor approach is suitable in the following situations:

- The authors are both trained in and skilled at describing their information objects.
- The information objects contain descriptors.
- There is a large quantity of semi-structured information objects.

Meta Context Approach

When extending the descriptor approach, information objects are described not only by metadata that reside in the information object but also by subjects, concepts, or themes that form contextual information in a metalayer above the information objects. This contextual information is not necessarily stored explicitly within the information object.

Topic maps provide strong paradigms with which to discover, maintain, navigate, and visualize this metacontext and thus explicate the context of an information object (see the introductory section on topic maps).

The semantic relationships among information objects are expressed by associating topics. This semantic network links various information objects' explicated contextual information and discovers new contexts. The discovery of these new contexts supports users in creating new knowledge when they associate known information objects in a new way with other information objects. To achieve these benefits from explicated and new contexts, substantial effort has to be invested to define, create, and maintain a topic map. This effort is disproportionally higher than the definition of metadata in the descriptor approach. In the latter case, authors or software systems explicitly provide contextual information. Authors know what they publish and easily can describe their information objects. In the metacontext approach, knowledge workers are needed to provide and maintain a topic map.

The benefit for users depends on the quality of the knowledge workers' work. If the metacontexts layer covers the entire domain of interest and contains rich and numerous topic associations, users will be able to explore the search domain easily. Thus, they will be enabled to discover new contexts and to leverage and enhance their knowledge.

The meta context approach is suitable in the following situations:

- Knowledge workers who are familiar with both topic map concepts and the domain of interest
- Manageable domains of interest
- Existing taxonomies for the domains of interest
- Users experienced in searching and navigating topic maps
- Large sets of heterogeneous information repositories

Knowledge Approach

So far, we have focused only on the human factor in very specific perspectives, such as authors defining the metadata of information objects or knowledge workers developing topic maps. The human factor plays a decisive role in the conversion of information into knowledge. We subsequently differentiate two facets of the human factor.

First, there are the competencies, experiences, values, and insights that form a rich, person-specific context. This context is a feature of knowledge's implicit dimension and hardly can be explicated (Polanyi, 1966). Within this context, a highly individual and subjective meaning is assigned to an information object. Second, users' active involvement is a necessary precondition to convert information into knowledge. This active involvement comprises actions like communication, construction, or, more intrinsically, cognition. If users experience an "I see!" or epiphanic moment as a result of some action, knowledge is created.

Characteristics of the knowledge approach are as follows:

- Competencies, experiences, values, and insights
- Information objects in person-specific contexts
- Creation of knowledge through human actions (e.g., cognition of information objects)

Small Cases and Lessons Learned

In this section, we present two small cases derived from prototypical implementations at two institutes. They illustrate the benefits and constraints of the previously discussed approaches presented with respect to the discovery of information objects and the subsequent stimulation of knowledge creation.

The first case meets the criteria of both the information and descriptor approaches in the context explication continuum introduced in the previous section. The second case is an example of a solution addressed by the metacontext approach. Motivated by the participatory action research theory (Whyte et al., 1991), our selection of these two cases was based on their significance and the available information in order to achieve an appropriate reliability and validity (Yin, 1994).

A Combination of the Full-Text and Attribute-Based Searches at the IWI

Within the Institute of Information Management (IWI) at the University of St. Gallen, we have several departments, each with two or more competence centers. Project managers lead these competence centers and are responsible for achieving their objectives. Each competence center produces many information objects (e.g., lecture materials, presentations, and publications). These materials are stored in different systems (e.g., file servers, groupware-based office environments, or Web content management systems).

From a terminological point of view, all information objects have one thing in common when contextualizing the content: they all deal with specific topics (e.g., knowledge management, enterprise application integration, business networking, etc.). Since most of the information objects are semi-structured and the maintenance of the metadata is manageable, the continuum of context explication led us to a hybrid approach. In order to reduce the maintenance effort required to achieve the controlled terminology of an attribute-based approach as well as the risk of a misspelled full-text search, we chose a combination of the two.

In an internal project, we proclaimed *topic* as the most important descriptor in contextualizing an information object's content for storage and eventual retrieval. Relevant topics previously had been collected from all the local competence centers and stored in a single parameter database. As far as a specific topic (e.g., portal) is concerned, the following contextual information is embodied in our definition framework: *Item* (preferred term for topic), *Assigned to* (responsible competence center), *Status* (draft, active, or frozen), *Synonyms* (similar terms or different languages), and *Description* (description of the term). A document history supports the traceability of modifications (Kremer, Kolbe, & Brenner, 2003). These topics subsequently are used to classify information objects (e.g., within our team databases or literature and publication applications).

The following challenges motivated us to conduct the previously described project and to implement a combination of the full-text search and the attribute-based search:

- **Availability and access:** Users inside and outside the IWI had to be able to search and to access IWI's information objects in an effective and transparent way, although they had not been provided with any navigation and search mechanisms.
- **Consistent and controlled terminology:** The authors had to be supported by a consistent and controlled terminology, because they had defined information objects' metadata without following any organizational rules or standards, or they had not used metadata at all. This led to an uncontrolled and not utilizable terminology and, thus, to no rational classification of the information objects.

Currently, there are about 350 topics overall, owned by 30 competence centers. Approximately 11,000 documents have been classified according to the introduced topics for eventual retrieval through intranet and extranet portals. Having used this approach for almost a year, we have been able to derive the following success factors from our observations of the effort to solve the challenges:

- **Simplicity:** A lean context explication framework with only a few dimensions reduces the workload associated with information object classification, which increases user acceptance. Authors classify their information objects according to the introduced terminology during the creation phase. Thus, no subsequent reclassification and editorial work is needed.

- **Mixture of centralization and decentralization:** A few simple, centralized rules for topic definitions are helpful (e.g., naming conventions). Decentralized, responsible team members make the detailed decisions regarding terms, thus reducing coordination overheads.

On the one hand, these success factors ensure that the terminology is maintained with very little effort. On the other hand, users benefit from the manageable and consistent terminology during their search.

Topic Maps at the GCC

As pointed out in Smolnik and Nastansky (2002), groupware-based office systems provide an excellent environment for organizational knowledge management. Within the Groupware Competence Center (GCC) of the University of Paderborn, the GCC K-Pool (GCC Knowledge Pool) is used in almost every facet of operative work. It is a groupware-based repository for several kinds of information objects, which chiefly maintains information on books, conferences, links, media objects, contributions, articles, and software. The different information objects are enriched with numerous descriptors:

> *categories are used to set information objects in various contexts, keywords describe the information objects in detail, and publishing information provides further explanation.*

Even though there were many semantic relationships among the information in these databases, it was scarcely possible to navigate among them or to identify knowledge structures. The capabilities to access information objects were restricted to a basic full-text search and navigating through context-sensitive views and categories. Full-text indexes, however, are insufficient when searching for information, while structures such as document types or taxonomies are sometimes too confining to qualify or categorize information objects (Biezunski & Newcomb, 2001). Furthermore, the usage and the scope of these techniques are limited to a single database.

Using the generic approach of applying topic maps to groupware-based organizational memories as described in Smolnik and Nastansky (2002), we applied the search and navigation concepts discussed in the introductory section on topic maps to the GCC K-Pool. We exhaustively defined a topic map template that comprises topic types as well as association types and describes the skeletal structure of the topic map. Typical topic types are *author*, *title*, *publisher*, or *place*; whereas typical association types are *author writes title*, *publisher publishes title*, or *publisher is located in place*. Software agents automatically create and maintain the topic map that is applied to the GCC K-Pool.

The GCC K-Pool topic map facilitates the creation of knowledge structures and metalayers, the discovery of new contexts, and supports users' cognitive capabilities. Furthermore, users are able to search and navigate the GCC K-Pool topic map in several ways. A text-oriented Web browser interface also provides intuitive access. Additionally, users can explore the

GCC K-Pool topic map by using two visualization tools: The K-Viewer, a two-dimensional approach with auto-layout capabilities for restructuring the topic map visualization, and the Sky Surfer, a three-dimensional approach with extensive navigation and search functions. These different topic map visualization approaches are described in detail in Smolnik, Nastansky, and Knieps (2003).

The GCC team consists of highly skilled researchers familiar with topic map concepts and with expertise in the Center's everyday subjects. Users and authors are supported by a slightly distinctive taxonomy. These preconditions meet the criteria that are required for the context explication continuum's metacontext approach. An excellent environment for the deployment of topic maps has therefore been created. We have used this approach for several months now and have observed the following main results:

- **Understanding work contexts:** Users understand better how their work subjects are related when interrelating themes or information objects are utilized. They are able to explore the domain of interest in an intuitive way, and thus, they are able to retrieve relevant and related information objects. The result of both observations is that users' creation of knowledge is stimulated.
- **Low maintenance:** Once configured and created, the topic map is updated automatically. Software agents insert new information objects, topics, and topic associations and delete outdated ones. For the acceptance of such an IT system in an organization or in its subunits, little maintenance effort is important.

Conclusion

As shown, information objects' context and context explication play an important role in the area of knowledge discovery and portals. As there are several possible approaches, the real task for knowledge discovery begins with the selection of the appropriate solution for context explication. Consequently, we have illustrated three approaches—full-text search, attribute-based search, and topic maps—each of which has been described according to their characteristics, benefits, and constraints as far as context explication is concerned, and aligned in our context explication continuum. Successful application of the specified criteria has been illustrated by the implementations at two institutes.

Future Areas of Research

To enrich our proposed model for context explication, we see at least four areas of future research. First, we will evaluate further the distinctness of situations in terms of applying the continuum's elements by adapting GCC's topic map framework to IWI's content. Even if the preconditions are different, this might lead to insights into the various approaches' degree of exchangeability. Second, we have to determine whether patterns can be found

that will facilitate transition (e.g., from topic maps to the full-text search or the full-text search to the attribute-based search). Third, we would like to extend our continuum with indications regarding knowledge's implicit dimension by including the explication of skills and skill management. Fourth, we will validate and expand our findings with other external partners. We will focus specifically on industries other than academia to generalize the validity of the continuum. In addition, while we have focused on customer process-oriented portals, we will evaluate the continuum's application in portals that are designed for other purposes. We therefore envision that knowledge discovery through context explication will provide a comprehensive framework with which to support knowledge management processes productively.

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