DISSERTATION

Knowledge Management & Information Technology

Goals/Problems, Practical Approaches, and Proposed Solution

ausgeführt zum Zwecke der Erlangung des akademischen Grades eines Doktors der technischen Wissenschaften unter der Leitung von

Univ. Doz. Dr. Gerhard Budin

Institutsnummer: 476

Institut für Wissenschaftstheorie und Wissenschaftsforschung der Universität Wien

eingereicht an der Technischen Universität Wien

Fakultät für Technische Naturwissenschaften und Informatik

von

Dipl.-Ing. Georg Hüttenegger

Matrikelnummer: 9526159

Khekgasse 39/4

1230 Wien

georg@ist.org

Wien, Dezember 2003

Doctoral Thesis

Knowledge Management & Information Technology

Goals/Problems, Practical Approaches, and Proposed Solution

Supervised by Univ. Doz. Dr. Gerhard Budin

University of Vienna

Dept. for Philosophy of Science and Social Studies of Science

Sensengasse 8/10, 1090 Vienna, Austria, Europe

http://www.univie.ac.at/Wissenschaftstheorie/

and by o. Univ. Prof. Dr. A Min Tjoa

Vienna University of Technology

Institute of Software Technology & Interactive Systems

Favoritenstrasse 9-11/188/2, 1040 Vienna, Austria, Europe

http://info.ifs.tuwien.ac.at/ifs/home.html

Dipl.-Ing. Georg Hüttenegger
Khekgasse 39/4
1230 Vienna
georg@ist.org

December 2003

Abstract

This thesis examines the relationship of Knowledge Management (KM) and Information Technology (IT) using a holistic approach and view. Therefore, the first chapter presents definitions of knowledge and KM, discusses related fields to KM and knowledge types, argues what KM activities can be supported by IT, examines areas of IT related to KM, defines the focus of this thesis, and presents interesting artifacts. Generally speaking, KM is centered on becoming or staying competitive and IT is able to support such initiatives. As areas that require flexibility, creativity, and learning are especially in need of KM, this thesis concentrates on them.

Since there is hardly any complete description of the goals KM tries to achieve and the problems it addresses, the next chapter analyzes the goals of KM, problems to be addressed by KM-systems, goals and problems of a university, problems of (existing) KM-systems, and, finally, the requirements of a KM-system that supports a KM initiative that addresses the mentioned problems and does not suffer from the described problems. Furthermore, the identified requirements are supplemented by important non-functional requirements, as these are missing in the list of goals and problems.

Following the identification of requirements for KM-systems, chapter 3 discusses important preconditions and foundations for KM in general and KM-systems in specific. As a "complete" KM-system can only be part of a "complete" and holistic KM initiative, this examination presents indispensable issues for such KM initiatives and discusses the importance and relevance of each topic.

The next chapter presents three existing solutions, namely CYMANTIX.NET, the Oracle solution, and the Lotus/IBM solution (the Lotus Discovery System plus additional software). While CYMANTIX.NET does not offer as many features and functions as the other examples, it provides interesting ones. On the other hand, the Oracle solution also lacks many features but provides a solid technological foundation to build a KM-system and the Lotus/IBM solution provides many relevant features and functions and, thus, is capable of supporting limited KM initiatives. Finally, the chapter examines to what extent the three solutions address the requirements identified and what is missing.

Next follows the main chapter of this thesis describing the proposed IT solution in the context of a holistic KM initiative. Therefore, it starts with a discussion of principles such as participatory design, etc. that have to be adhered to when designing, implementing, and introducing the proposed KM-system. Then, the proposed KM-system is presented consisting of three major building blocks, namely the central user interface, the virtual information pool, and automation as well as further aspects. Furthermore, the chapter examines the relationship of eLearning and KM with regard to the proposed KM-system, discusses implementation issues, and ends with an evaluation of the proposed solution.

The concluding chapter summarizes this thesis and stresses the holistic point of view that is combined with proposing a "complete" IT system supporting KM. Furthermore, it discusses the pros and cons of this approach and the results of the evaluation. Finally, it presents areas that need further research and what the future holds for KM.

Zusammenfassung

Diese Dissertation untersucht die Zusammenhänge zwischen Wissensmanagement (WM) und Informationstechnologie (IT) unter Verwendung eines gesamtheitlichen Ansatzes und einer umfassenden Sichtweise. Daher werden im ersten Kapitel Definitionen von Wissen und Wissensmanagement vorgestellt. Weiters werden für WM relevante Forschungsfelder, Technologien, Klassifizierungen von Wissen, der Fokus dieser Arbeit, wichtige Artefakte sowie der Umfang, in dem IT WM prinzipiell unterstützen kann, diskutiert. Generell soll WM Firmen wettbewerbsfähiger machen und diese Arbeit untersucht, in welchen Bereichen und wie IT das unterstützen kann. Der Schwerpunkt liegt dabei auf Bereichen, die Flexibilität, Kreativität und Lernen voraussetzen, da WM hier den größten Erfolg verspricht.

Da es kaum eine komplette Beschreibung aller Ziele des WM und der Probleme, die es zu lösen versucht, gibt, enthält das nächste Kapitel eine Analyse der Ziele von WM, die Probleme die WM zu lösen versucht, die WM relevanten Ziele und Probleme einer Universität, bekannte Probleme von existierenden WM-Systemen und die Anforderungen, die sich aus dieser Analyse für ein WM-System ergeben. Zusätzlich werden auch so genannte nicht funktionale Anforderungen eines WM-Systems beschrieben.

Nach dieser Analyse werden im Kapitel 3 Vorbedingungen und Grundlagen von WM im Allgemeinen und WM-Systemen im Speziellen untersucht. Da ein "komplettes" WM-System nur Teil einer "kompletten" und ganzheitlichen WM-Initiative sein kann, werden dabei nicht nur die für WM-Systeme wichtigen Punkte sondern auch die wichtigsten Punkte für WM selbst diskutiert.

Im folgenden Kapitel werden drei bestehende Lösungen präsentiert (CYMANTIX.NET, die Lösung von Oracle und die Lösung von Lotus/IBM – das Discovery System mit Erweiterungen). Obwohl CYMANTIX.NET relativ wenige Funktionalitäten anbietet, stellt es einen interessanten Ansatz dar. Die Lösung von Oracle, andererseits, bietet ebenfalls nur relativ wenige Funktionen direkt an, stellt aber eine gute technische Basis dar, um ein WM-System darauf aufzubauen. Die Lösung von Lotus/IBM schließlich offeriert eine Reihe von WM-relevanten Funktionalitäten und ist in der Lage, eingeschränkte WM-Initiativen zu unterstützen. Insgesamt untersucht das Kapitel das Ausmaßder Unterstützung von WM durch drei exemplarische Systeme und analysiert in welchen Bereichen es noch Unzulänglichkeiten gibt.

Danach kommt das Hauptkapitel dieser Dissertation, dass die vorgeschlagene IT Lösung für eine "komplette" und ganzheitliche WM-Initiative beschreibt. Zuerst wird diskutiert welche Prinzipien, wie etwa "Participatory Design", während des Designs, der Implementierung und der Einführung eines solchen Systems berücksichtigt werden müssen. Danach werden die drei Grundpfeiler des WM-Systems vorgestellt, also der virtuelle Informationspool, das einheitliche Benutzerinterface und der Automationsaspekt, sowie die darüber hinausgehenden Teile der Lösung präsentiert. Im Weiteren untersucht das Kapitel den Zusammenhang zwischen eLearning und WM mit besonderer Berücksichtigung, was das für die vorgeschlagene Lösung bedeutet. Weiters werden noch Implementierungsaspekte diskutiert und im letzten Abschnitt wird die Lösung in Bezug auf die zu erreichenden Ziele und zu lösenden Probleme evaluiert.

Im abschließenden Kapitel wird diese Arbeit noch einmal kurz zusammengefasst und der Aspekt der gesamtheitlichen Betrachtung zusammen mit dem Vorschlag eines "kompletten" IT Systems zur Unterstützung von WM hervorgehoben. Weiters diskutiert es die Vor- und Nachteile der Lösung und die Ergebnisse der Evaluation. Abschließend wird noch kurz aufgezeigt, in welchen Bereichen weitere Forschungen sinnvoll und notwendig sind, und was die Zukunft des Wissensmanagements bringen könnte.

Contents

List of Figures

Acknowledgements

It is a pleasure for me to thank the many people who supported me in writing this thesis, either by sharing their knowledge or by reviewing drafts and providing useful feedback.

I am particularly grateful to my supervisors, Univ. Doz. Dr. Gerhard Budin and o. Univ. Prof. Dr. A Min Tjoa, for keeping me focused on the goal in hand and for their constant support and encouragement. Special thanks also go to ao. Univ. Prof. Dr. Jürgen Dorn for his support and help in early phases of my thesis.

Sincere thanks go to three friends of mine, namely Angela Dickinson, Dr. Johann Ortner, and Mark-René Uchida. Without their help, support, and encouragement I could never have finished this thesis.

I also owe thanks to Robert Baumgartner of Oracle Austria for providing insight into the Oracle Portal / KM solution and to Markus Wieland of RZB (one of Austria's larger banks) for his help and support on the Lotus solution.

Special acknowledgements go to my former employer, CYMANTIX Software GmbH, and all the wonderful people who worked there. They helped me start this thesis and supported me while I was employed by the company.

Many others provided feedback and help during the development of this thesis, most notably the members of the group for IT and KM of the PWM (Plattform Wissensmanagement—www.pwm.at an Austrian [online] platform for KM) platform.

Of course, all brand and product names are trademarks or registered trademarks of their respective holders, even when I fail to acknowledge them in the text.

Finally, I would like to express my deepest thanks to my parents and family who supported and encouraged me throughout my thesis as they have been doing since I can remember.

Chapter 1

Introduction

Nowadays Knowledge Management (KM) is a widely discussed topic. It is safe to assume that most readers will have heard of it, while others surely have already gained some experience in the field. Nevertheless, since KM is not an exact science, it remains necessary to present the definitions and views this thesis is based on and therefore begins with discussing, why organizations should be interested in KM at all.

Generally speaking, KM enables organizations to utilize their inherent knowledge in the most effective way. As we are moving more and more towards an economy, where information and knowledge are more important than traditional assets such as land and capital the importance of dealing with this topic is easily recognized. This is further illustrated by quoting Prusak[1]:

> Those of us who are attempting to do research in the areas of sustainable competitive advantage have come to the conclusion that the only thing that gives an organization a competitive edge – the only thing that is sustainable – is what it knows, how it uses what it knows, and how fast it can know something new.

This sentence from Prusak stresses the importance of managing available knowledge, while at the same time emphasizing the importance of the generation of new knowledge (the goal of the learning organization). A short discussion of this important relationship is given in section 3.5 and in section 1.2 defining the term Knowledge Management.

As the importance of KM was quickly recognized when the topic first gained popularity in the mid-1990s, there are already numerous reports of successful and failed initiatives available that provide important insight into the issues involved. Many of the early – primarily IT-driven – initiatives centered on the introduction of IT-based systems (e.g. Intranets) and failed to live up to the (high) expectations. Despite these failures, a recent overview paper by Harris [47] at the Gartner Group shows that the general idea of KM is still felt to be valid and of utmost importance. Most researchers and practitioners now agree that a holistic approach is required for successful KM.

[1]Taken from: Prusak, L: "The knowledge advantage." Strategy and leadership, March-April 1996, pp. 6–8.

Since this thesis is about KM & Information Technology (IT), two papers by Alavi and Leidner [2] and [3] provide an excellent overview of these topics. They summarize major relevant publications and discuss the relationships between knowledge, Knowledge Management, and Knowledge Management Systems. Equally important is the fact that these two authors have an economics background, the most important driving force behind KM (as a management discipline).

1.1 What Is Knowledge?

Despite the fact that scholars have devoted vast amount of time to the subject, there is still no generally accepted definition of knowledge. Therefore, I would like to quote Grey [44][2] who presents a rather pragmatic definition:

> Context-relevant, validated information clusters that emerge when people somehow deal/interact with information elements/people.

As we can see from this definition (and from many others in the field), knowledge is seen primarily as validated information[3]. Most researchers, nevertheless, agree that knowledge is personalized (individual) information and, thus, cannot be stored electronically.

Of course, philosophers like Polanyi or Popper (to name two of the more recent scholars) already gave great consideration to knowledge. Although there are quite intriguing definitions to be found, no single, generally accepted definition exists[4].

Alavi and Leidner provide a good overview of the different proposed definitions for knowledge in the context of KM (see [3]). They summarize attempts to differentiate data, information, and knowledge in a hierarchical form that come primarily from those with an IT background. In this view, data items are just raw numbers and facts, information is processed data and knowledge is authenticated information. While this remains a classical approach, more recently a researcher named Tuomi[5] has even proposed an inverse hierarchy (with information being the result of knowledge). Although these definitions provide limited insight to understand the nature of knowledge, they are actually

[2]Denham Grey is working in the field of KM at least since 1994. He has been one of the most active participants in the KMCI group [63]. The KM101 Summary [44] and its views of knowledge and KM seem to be especially well suited as a foundation of my thesis.

[3]Information is often defined as "data endowed with relevance and purpose". This particular definition is from Drucker, P.E. (1995): "The Post Capitalistic Executive." in P.E. Drucker (ed.) Management in a Time of Great Change New York: Penguin.

[4]With Popper, for example, we deal mostly with World 2 or "subjective" knowledge that can be tacit/implicit/explicit or with World 3 or organizational knowledge (the codified problems, models, etc.) that forms the basis of World 2 knowledge.

[5]This approach is described in his paper: Data is more than Knowledge: Implications of the Reversed Hierarchy for Knowledge Management and Organizational Memory; In Proceedings of the Thirty-Second Hawaii International Conference on Systems Sciences, IEEE Computer Society Press, Los Alamitos, CA, 1999.

of minor importance for most KM initiatives, since they only deal with knowledge that can be made explicit. Different types of knowledge are discussed in section 1.4.

Many researchers are not satisfied with the hierarchical definition of knowledge and have proposed a number of alternative definitions. Once more, Alavi and Leidner [3] provide a good summary of the most important alternatives: "Knowledge may be viewed from several perspectives (1) a state of mind, (2) an object, (3) a process, (4) a condition of having access to information, or (5) a capability." These different perspectives give rise to different views of KM and consequently to different strategies needing different systems to support KM.

What all these definitions result in (borrowing heavily from Alavi and Leidner [3]): Knowledge is personalized and needs to be expressed in such a manner as to be interpretable by the receiver. Furthermore, hoards of information are of no value for themselves; they only become useful if processed (possibly after some transformations) in the mind of an individual.

1.2 Definition of Knowledge Management

As there is no clear definition of knowledge, the futility of providing an exact definition of KM is obvious. Therefore, I would, again, like to cite Grey [44], who offers a pragmatic view of Knowledge Management:

> Broad-based discipline: mine (analyze) data; capture, create, store, catalog, validate, transform, and disseminate/share information; capture, emerge, store, catalog, and disseminate/share knowledge.

In other words, KM is about dealing with knowledge, possibly in the form of data or information. The consequence of such a general definition is, that it, thus, encompasses a wide range of issues of even whole research "fields" and, thus, one could say: KM is either everything or nothing at all. This means that KM needs to build upon different research areas and needs to incorporate the results of many fields ranging from IT/technology to psychology.

1.2.1 Does KM Include IT?

Although I am going to discuss related fields in section 1.3 (including certain classes of IT systems), it is of utmost importance to realize that KM is not about IT tools. Indeed, some KM initiatives might not even need any IT support (or tools) at all.

On the other hand, most organizations have already incorporated IT systems into their normal work procedures. In practice, the introduction of KM will almost always necessitate a change in working methods, and any IT system will have to be adapted accordingly. At the same time, even organizations that are not using IT systems in their daily work might well be planning to do so in the near future.

Generally speaking, (nearly) every organization of moderate size and above uses or plans to introduce computers, at least in parts of the organization (e.g.

office and management). Therefore, it can be assumed, that IT will have to be considered in the planning of a "complete" and holistic KM initiative in virtually any organization above a certain size (the actual number varying greatly due to cultural and organizational differences).

Thus, one can easily conclude, that although IT is not a necessity for KM, it needs to be considered in most realistic KM initiatives. The greater the extent of the KM initiative, the greater the need for a sophisticated KM-system supporting all relevant aspects seems to prove true.

1.2.2 Discussing Other Perspectives

While the definition given above by Grey is accepted at large, some researchers have a somewhat different view of KM. McElroy [73], for example, argues that crucial parts are missing in existing definitions of KM and calls the result "first-generation KM". He criticizes them as being: "All about getting the right information to the right people at the right time" based on the assumption that the required knowledge already exists. His line of thought continues with the claim that "second-generation KM" has to include aspects of knowledge creation. Thus, he calls for the integration of organizational learning and the theory of complexity to produce a new KM built on a sounder foundation.

Although McElroy stresses the differences between his own and previous approaches, in fact, his view does not really differ to the one held by Grey. While there are some discrepancies (especially on what other fields have to be incorporated in KM), both acknowledge the importance of creating new knowledge in a holistic approach.

Consequently, as Grey's definition is more in line with the KM mainstream, this thesis adheres primarily to this definition. However, it also includes and indeed looks at other potentially relevant issues, omitted by these definitions. Furthermore, it contains a discussion of the relations between KM and the learning organization in section 3.5.

Of course, there are numerous other definitions of KM that stress certain views and are based on different assumptions. However, for the purposes of this thesis, only one further approach will be considered, namely Sveiby [102], one of the most influential pioneers in the field. He is advocating the importance of maximizing the ability of an organization's members to create new knowledge. At the same time, he proposes to use the concept of intellectual capital to have some measurements of the current state and changes in intangible assets. Let me conclude this paragraph by quoting one of his "definitions" of KM: "To me Knowledge Management is: The Art of Creating Value from Intangible Assets".

1.3 Related Fields to KM

As we have already determined that KM is a broad-based discipline, it comes as no surprise that many related fields exist. In fact, there are so many that I deem it necessary to concentrate on discussing only the most important ones.

Certain classes of information management systems like "Management Information Systems" (MIS) or "Decision Support Systems" (DSS), to just name

two of the most common ones, claim to be KM-systems. Then again, it is sometimes argued that KM is merely a part of organizational development, though this seems to be a rather limited view. Cognitive Research in turn emerges as a potentially even more interesting field that may provide the answer to the phenomenon of human mind and finally allow an exact definition of knowledge.

This illustrates the potential importance of relationships between KM and other fields mentioned, such as Cognitive Research. Therefore, these will now be discussed in brief.

1.3.1 MIS/DSS/... versus KM

There is a number of IT systems that deal with data and information like Database Management Systems (DBMS) or Information Management Systems (IMS). Indeed, IMS is often, although by no means exclusively, used as a general term for a class of similar systems like Management Information Systems (MIS), Decision Support Systems (DSS), or Expert Systems (ES).

While these systems are capable of providing effective, but limited support for KM by helping to manage information (or even work with a "knowledge base" in the case of ES), their focus is too narrow for them to be classified as KM-systems. These systems were not designed with KM in mind, but were instead developed to address more "conventional" problems and tasks, like providing current sales figures or expenditures, to present two examples illustrating the fundamental difference.

Their claims have even lead to misconceptions as to what KM really is and are partly responsible for the failure of early KM initiatives (for example described in McElroy [73]). They represent a valuable class of technologies and ideas that need to be incorporated in a KM-system. Although these systems and technologies alone do not constitute a KM-system, they can and should form part of one.

1.3.2 Organizational Development / System Dynamics

Although I do not claim to be an expert in the field of organizational development (OD), it is obvious that both KM and the concept of the learning organization are often claimed to be merely a part of this field. While I cannot confirm these claims in the case of the learning organization (a concept most vividly promoted by Senge [92]), in my opinion, they are definitely incorrect in the case of KM (particularly when consideration is given to the work being carried out in cognitive research). Of course, there will always be overlapping areas: Some approaches to KM will only involve the application of organizational development measures, while others will encompass a wider range of issues.

The learning organization is heavily influenced by system dynamics (see a webpage of the Forrester group at MIT [104] for an introduction) and the work by Argyris[6] on organizational learning. Its primary goal is to provide tools and

[6]For example, see Argyris, C. and Schön, D. A.: *Organizational Learning: A Theory of Action Perspective*. Addison-Wesley, Reading, MA, 1978.

methods to help organizations to become learning organizations that give their members the freedom and encouragement they need to learn. This ultimately encourages the creation of knowledge.

As McElroy [73] maintains that creating knowledge is an integral part of his "second-generation KM", he consequently argues for the inclusion of organizational learning in KM initiatives. While KM obviously needs to take this into account, a learning organization has a slightly different focus. While both want to foster knowledge creation, KM is more concerned with the capture and re-use of existing knowledge, and can thus at times inhibit the goals of the learning organization itself.

Summing up, this section demonstrates some of the differences and overlaps that exist between the fields. While some KM definitions definitely call for placing KM in the area of organizational development, there are aspects, which simply do not fit.

1.3.3 Cognitive Research / Radical Constructivism

The fields of cognitive research and radical constructivism deal with the issues of the consciousness and the human mind. No valid and sound definition of knowledge will really be possible until a sound theory of knowledge has been developed in one of these two fields. To date, no such theory has established itself, although radical constructivism provides an interesting way of approaching the problem. It is based on the work of von Foerster, Maturana and Varela, Roth, von Glaserfeld, etc. and primarily proposes a self-referential nature of the human mind, thus raising doubts on the concept of objective knowledge, as the human senses do not reflect the true nature of the environment. Further information can be found, for example, in Maturana [71] (describing his work on autopoiesis – which roughly means self-making) and Schmidt [93].

This approach seems similar to that of System Dynamics (although I would consider System Dynamics to be a more pragmatic approach and radical constructivism to be a well founded way of dealing with consciousness and knowledge). Since these are very challenging topics and I do not profess to be an expert in these fields, I do not want to extend this discussion any further. Instead, I would like to conclude by arguing that there is no (and probably never will be a) generally accepted concept for the phenomena of consciousness and knowledge in this field either.

1.3.4 Does KM Differ from the Described Fields?

The previous sections might make the reader wonder, whether KM really is something new or how it differs from more traditional approaches. At the same time, they raise the question of whether KM-systems are also something new or if they are just more elaborate ("complete") MIS/DSS/ES systems.

In my opinion, KM is something new as it deals explicitly with knowledge (one of the major problems in this discipline). KM-systems as such are also something new as they offer more KM oriented functions than traditional systems.

A more rigorous discussion of this topic can be found in a paper by Spiegler [98], which discusses the differences between some of the fields mentioned above and KM (-systems). This paper explains why KM is a new idea and not simply a recycled concept. This subject is also handled in the research carried out by Essers and Schreinemakers [34] in which they state, that simply establishing a strict referential distinction between knowledge and information will not automatically lead to a safe delineation between IM and KM. Instead, they argue that KM has different objectives and point out the dangers of a control-oriented approach, as this could turn into 'mind-control'.

1.3.5 Differentiating KM in General

After arguing the distinctions between KM and some close research fields, it is important to provide differentiations between KM and other management activities in general. A number of papers like that of Rollet [89] or Romhardt [88] (centered on organizational development and denying that other approaches classify as KM) deal with this important issue. Other papers, e.g. Anklam [7], show that people use the label KM for activities not really contributing to the field (the mentioned paper talks about technical communications and the changes since the beginning of the discipline).

Since no generally accepted definition of knowledge exists, the same holds true for KM. Nevertheless, many activities and systems claim to be (a) KM (-system) making it difficult to find really relevant and important contributions while (b) at the same time are responsible for "KM" failures.

Summing up, this section presents references to papers discussing the differences between KM and other fields in general as well as the boundaries of KM. It, furthermore, demonstrates the importance of well-founded boundaries to activities just claiming to be KM (a difficult task for a field lacking an exact definition).

1.3.6 IT Is Enabling/Supporting KM

While the differences between KM and certain IT systems (MIS/DSS/...) have already been presented, the general relationship between IT and KM still needs to be discussed in more detail. Section 1.2.1 already established that KM is not about IT and, in principal, is possible without it. At the same time, this section argues that IT needs to be considered in the planning of most "complete" and holistic KM initiatives.

Consequently, IT supports and – to a certain degree – enables KM (a relationship similar to the support of other management activities by MIS/DSS/ESS...systems). Therefore, I am calling IT systems that support Knowledge Management, KM-systems (smaller systems might be called KM tools). A similar definition is provided by Alavi and Leidner in a paper (see [3]) that also contains an overview of the possibilities of IT to support KM. As a result of the fact that IT is "just" supporting KM, computer science plays no role in the difficult problem of defining KM itself.

Note, however, that while the term KM-system is often used for IT systems

as in this thesis, other authors refer to the result of a KM initiative, including, for example, organizational and IT changes, when using the term KM-system. This thesis, nevertheless, uses the narrow definition given in the last paragraph, and I hope that not too much confusion arises from this fact.

Wong and Aspinwall [117] recently published a paper discussing the relationship of KM and IT and come to the conclusion that they are not totally equivalent as KM consists of technological, technical, and social issues. While this is true for many cases, especially those considered in this thesis, KM is possible without any help from IT, as it can consist solely of social and organizational changes.

1.4 Knowledge Types

As many proposed classification systems for knowledge exist, the most commonly used one is presented in this section (namely tacit/explicit sometimes extended to tacit/implicit/explicit knowledge) together with a brief coverage of one of the numerous alternatives (namely embedded versus embodied knowledge).

Since my thesis is centered on the relationship of KM and IT, the most important distinction is to be made between knowledge, that is already available as data and information, the additional amount of knowledge that can be made explicit, and other resources that may enable people to gain new knowledge and insights.

In the field of KM, the most commonly used classification of knowledge is that into tacit (to make matters worse, sometimes called implicit) and explicit knowledge. While explicit knowledge is a generally accepted term for phrased knowledge like a formula, tacit knowledge is not defined so clearly. Definitions can be found, for example, in Nonaka and Takeuchi [79] or, presenting a more theoretical point of view, in Dienes and Perner [27] (containing a definition of the differences between implicit and explicit knowledge).

1.4.1 The Term Tacit Knowledge: Polanyi or Nonaka

The term tacit knowledge was first mentioned by Michael Polanyi who wrote in 1966 in his book The Tacit Dimension (p.4) "We can know more than we can tell.". Summing up, Polanyi views tacit knowledge as a combination of bodily experience and practice.

Nonaka and Takeuchi [79] make heavy use of the term tacit knowledge and are "responsible" for the common usage and "definition" in the field of KM. Although explicitly citing Polanyi they use the term with a wider meaning by including cultural aspects (like internalized judgments, norms, and ideals). While they do not rigorously define the term, one can find examples of what Nonaka views as tacit knowledge in his 1994 paper: A Dynamic Theory of Organizational Knowledge Creation [78].

The following paragraphs discuss the different meanings of the term tacit knowledge as used by Polanyi or Nonaka. The arguments are based on information obtained in discussions with my former colleague Dr. Johann Ortner.

In Nonaka's research (for example, see Nonaka and Takeuchi [79]) the most relevant arguments are presented with regard to the Kao Corporation. It results to three important principles/goals that are deeply rooted in Zen Buddhism (also presented as a major difference between Japanese and Western culture) and form the heart of the Kao Corporation:

- Serve (be of value to) the customer
- All people are equal
- The search for truth and wisdom

Nonaka says, "These philosophical principles form the tacit knowledge base for Kao. This tacit knowledge base guides the behavior of Kaos employees and serves as the key driver for its unique corporate culture."Thus, Nonaka discusses internalized norms that can be made explicit and ideals when mentioning the term tacit knowledge.

Polanyi, on the other hand, is talking about the way higher life forms (cats, dogs, birds, etc. as well as human beings) experience the environment. More specifically, how entities (like an apple) are treated as a whole instead of just a number of frequencies of light registered in the eye. The background of his research is based on empirical as well as Gestalt psychology. In his opinion, the knowledge to experience such entities as a whole is bodily knowledge, inaccessible to the linguistic and rational thought. Instead, it is the reference base for the meaning of certain words. All these facts together are the background for his often-quoted "definition" of tacit knowledge (he did not really concentrate on this topic in his research).

Nonaka, on the other hand, views tacit knowledge as internalized necessities, challenges, and normative pressure that coerce people into being creative. Although often writing of bodily experience, all mentioned examples represent cultural knowledge and are not included by the original "definition" of Polanyi.

It is easy to see, consequently, that internalized knowledge about the environment that is shared with other higher life forms like cats and dogs is fundamentally different from internalized "culture"and, thus, there is a fundamental difference in the meaning of the term tacit knowledge as used by Nonaka compared to Polanyi.

Thus, I conclude that while Nonaka (and thus many KM researchers) claims to build upon the term of Polanyi he actually operates with a vague term "invented" by him. This is not necessarily a problem but has to be taken into account when reading about tacit knowledge in KM literature, especially when both Polanyi and Nonaka are being cited as references.

1.4.2 Tacit/Implicit/Explicit Knowledge

Considering the "definition" of tacit knowledge that is "vague" at best, it becomes obvious that the simple differentiation between tacit (or implicit) and explicit knowledge has serious shortcomings. From my point of view, the more recently proposed extension of the tacit/explicit model to additionally contain

implicit knowledge (e.g., KMCI group [63][7] or Nickols [77]) seems more appropriate.

Let me present definitions of these three terms in the new model:

tacit This is knowledge we cannot tell. It cannot be expressed (therefore, sharing/transferring is very difficult).

implicit This is knowledge that we know and can tell if pressed to formulate it (but not available in linguistic terms in the mind).

explicit This is knowledge formulated in linguistic terms and available in the mind, thus being the only term with a widely accepted and sound definition.

Consequently, one has two options: Either to use the proposed tacit/implicit/explicit classification or to deal with tacit knowledge that is divided into expressible and inexpressible knowledge[8].

Please note, that the tacit/implicit/explicit model (as already argued in the section on the tacit/explicit model) is by no means sound from a philosophical or theoretical point of view. While this model is better suited for my thesis, the used concept of tacit knowledge remains different from the original definition given by Polanyi. In my opinion, this model seems to be more appropriate for KM than the more commonly used tacit/explicit differentiation. Thus, I conclude that it should be the focus of further research.

As the tacit/implicit/explicit classification of knowledge provides more clearly defined terms, I am going to use it in this thesis henceforth. Nevertheless, the popularity of the wider definition of tacit knowledge will make it necessary to sometimes use the terms implicit and tacit interchangeably. Consequently, there will be a remark or footnote in such a case.

1.4.3 Embedded versus Embodied Knowledge

Following the elaborate discussion of tacit, implicit, and explicit knowledge, I would like to present the embedded versus embodied differentiation in brief, to give one additional example of the numerous classifications of knowledge. Embedded knowledge is "within" an organization, while embodied knowledge is inside one member/person (an individual). It is easy to recognize that this model provides a different point of view and, thus, helps to gain a deeper understanding of the phenomenon knowledge.

Although this is very interesting for KM in general (like the many other proposed differentiations), its importance for (IT) KM-systems is rather low. Therefore, I am not going to discuss this (or any other) classification in more detail.

[7]This topic is discussed starting with Digest Number 146 (May 4, 2001) by Joe Firestone.

[8]The more general concept would be to see tacit knowledge in different degrees of expressibility.

1.5 What Can/Can't Be Done by IT

Up to now, this chapter focused on KM itself and on the possible role of IT in general. Therefore, a discussion what parts and processes of KM can be executed or supported by IT and in what areas this is not possible is still missing. While this issue is often mentioned in KM literature, in-depth discussions like that of Johannessen et al. [58] are rare.

The two most important issues IT is incapable to manage are, on the one hand, cultural and organizational issues and, on the other hand, tacit knowledge. These topics are of utmost importance for any KM initiative and need to be addressed by non-IT means. Nevertheless, IT can provide some limited capabilities to support tacit knowledge transfer (by allowing people to communicate, for example, with video conference capabilities). Furthermore, existing IT systems will need to be adapted and newly introduced ones customized in accordance with necessary cultural and organizational changes. Consequently, it is possible to argue that IT is even supporting the cultural and organizational changes as well as tacit knowledge transfer. However, as IT systems are very limited with regard to these issues, they need to be addressed primarily outside the technological realm.

In the case of implicit knowledge, on the other hand, both IT and non-IT activities are necessary to ensure that all relevant pieces are made explicit and inserted into the KM-system. This means that the IT system provides good capturing and insertion capabilities, while non-IT aspects have to encourage people to "insert" their important implicit knowledge into the knowledge base.

Finally, explicit knowledge, codified as information, is the domain of IT (in the form of information management). Although the management of information is done by the IT system, non-IT activities need to ensure that the system and its capabilities are embedded efficiently into the daily work processes. As a result, the available information is managed and made accessible in as many forms and ways as sensible, while at the same time being used as the data source for more advanced features that aim at generating new relevant information. Such generated information is supposed to allow users to gain new insights, thus, ultimately generating new knowledge.

Summing up, these last paragraphs demonstrate that IT and non-IT activities have to play their respective role in all three of the considered knowledge types. In the case of IT the focus is on managing information and providing communication possibilities. On the other hand, non-IT activities have to take care of the cultural and organizational aspects and have to ensure that any IT support is aligned with the goals of the KM initiative and the organizational work procedures.

1.6 Areas of IT Related to KM-Systems

Many areas of IT have a high importance for KM and KM-systems. Indeed, some of the presented technologies are – either alone or in combination – capable of supporting limited or specialized KM initiatives. Nevertheless, a "complete"

and holistic KM initiative needs a "real" KM-system that incorporates or integrates the mentioned technologies.

1.6.1 Business (ERP) Software from SAP / PeopleWare / Oracle

Business software is widely used to support organizations in areas like human resources, finance, and resource planning, etc. These systems represent a wide area of business related software products and are often called Enterprise Resource Planning (ERP) systems.

Not only do they contain valuable data about employees, customers, organizational hierarchies, projects, etc., but they also provide core IT functions for organizations. In most cases, they also "contain" a wealth of explicit knowledge (available in the form of data and information) together with contextual and historical information.

KM initiatives in organizations using business software (most of the bigger ones do) have two important tasks, namely to integrate the available information and, at least, the functions needed by the majority of the users (the goal is to integrate as much functions as possible).

1.6.2 Information Management Systems

Information Management Systems (IMS) primarily deal with structured information. As the relationship between IMS and KM-systems has already been discussed in section 1.3.1, there is no need for more details.

These systems contain highly relevant information and provide important functions. Thus, such systems should be integrated to enrich the KM-system if they are already in place.

1.6.3 Groupware Systems like Lotus Notes

Groupware systems like Lotus Notes (Domino) or Microsoft Outlook (Exchange) are used for unstructured communication and collaboration. They provide functions for coordinating meetings, sharing documents, etc. Often there are add-on products enabling even more direct collaboration like multiple people working with one and the same document or extended communication facilities like chat or video conferencing.

While the unstructured nature of the information available in Groupware systems makes it difficult to integrate, the knowledge "contained" makes it more than worthwhile to do so. Furthermore, some of the functions provided by Groupware systems are of major importance for KM (-systems) and, thus, need to be integrated.

1.6.4 Customer Relationship Management

Customer Relationship Management (CRM) can be viewed as special business software. The primary objective of CRM is to provide customers with the best service possible by facilitating all available information about past contacts and

purchases. At the same time, this information is used to find out what other products might be of interest to the individual customer ultimately generating increased sales.

Consequently, such systems can provide high quality information centered on customers, products, and feedback. Therefore, this information often will need to be incorporated in KM (-systems).

1.6.5 Artificial Intelligence

Artificial Intelligence (AI) is a technology that most of the time is not directly visible to the user of KM or related systems. Instead, it is used to provide "intelligent" functions in systems like CRM. This technology enables IT systems to appear smart by finding correlations, for example. Thus, it possibly is the single most important technology behind KM-systems, especially as it helps to differentiate KM-systems from IMS. Although AI is hidden most of the time from the user (as it is difficult to handle), expert users sometimes need functions based on this technology to directly exploit and explore the available data and information in every possible way.

Closely related areas to AI are Data Mining (DM), Machine Learning (ML), and Knowledge Discovery in Databases (KDD). Although the technology behind all these areas is more or less the same, they try to achieve different goals. These – often "fuzzy" – differences are irrelevant for my thesis and, therefore, not discussed in detail.

Detailed information on DM is, for example, available in papers by Petrak [85] or by Witten and Frank [116]. For an introduction to ML, see Mitchell [76].

1.6.6 Other Areas

While the mentioned areas represent the most important ones, there are many other relevant technologies. Some are basic technologies like databases or middleware systems, while others are examples of more advanced ones. Examples of the latter are geographical information systems or tools for devices with limited capabilities.

Of course, there are numerous other technologies with a certain importance for KM-systems. However, for introductory purposes this overview should suffice.

1.7 Focus of this Thesis

Since this introduction is slowly reaching its end, it is time to define the focus and boundaries of this thesis. It needs to be absolutely clear what is included and what is not.

Generally speaking, I am proposing a KM-system and, therefore concentrating on technological issues of KM. Nevertheless, it is of utmost importance to consider KM as a whole for a sound foundation of such a system. From an organizational point of view, my solution should fit for many situations, although

this thesis is concentrating on areas where flexibility, creativity, and learning are of high relevance. Furthermore, mechanistic views of management are not considered, even though they often work reasonable well, as I am of the opinion, that the resulting behavior of management is not an appropriate foundation for my solution (without being able to argue this in a rigorous fashion).

The described system is intended for decision makers as well as individual staff (containing all the features both groups need). While it contains support for more conventional and standard requirements like document distribution, such requirements are more or less a side issue. The concept focuses on larger organizations that already have diverse systems in use and is more suited for non-routine tasks such as project management, software development, or more general product development. Although such a system would also address similar issues faced by smaller organizations, it is probably too complex and expensive for their needs.

Other researchers are trying to create tightly integrated IT systems that are based on conceptual knowledge. I think this approach is not feasible for the setting in question. While such a system should be superior from a technological point of view, a multitude of serious problems needs to be resolved first. One of the most important issues is the lack of clearly defined company wide (linguistic) terms in larger organizations (a problem sometimes also encountered in smaller ones). Consequently, I am not examining this topic in more detail.

1.7.1 High versus Low Tangibility KM Processes

A definition of the distinction between high and low tangibility processes can be found in Grey [44]. As I am concentrating on the former one, this difference is of high importance for my thesis.

Typical examples of high tangibility processes are project management, software development, or more general product development. While low tangibility KM processes, of course, also benefit from using the proposed solution, the net result is expected to be significantly lower. Low tangibility KM processes need far less support for flexibility and creativity and, therefore, are more concerned with automation (workflows), processes... than with e.g. identifying experts through their project experience.

1.8 Interesting Artifacts

To conclude this introduction, I would like to discuss relevant artifacts for KM (-systems) and possible classification systems for them. Henceforth, the term artifact is used to have a more general word for what data/information plus additional context and information represents. Later chapters will use this definition only in special places, while in most cases just using the terms data and/or information.

1.8.1 Classification of Interesting Artifacts

Numerous interesting classification systems defining different kinds of data/information (the source of artifacts with relevance to KM-systems) exist. For example, one is the distinction between structured and unstructured data. Another one is information itself (e.g. the manual for a VCR, describing how to handle the device) as well as Meta information (e.g. who wrote the manual, or who translated it into another language). Furthermore, there is the distinction between declarative and procedural knowledge[9]. Yet another distinction could be made of whether it is textual or image or data. All those distinctions serve specific purposes, while at the same time providing different views of reality.

With regard to KM-systems, there is no major need/application of these distinctions[10]. The single most important distinction to me is what audience is addressed by a particular piece of data/information. The more general the audience, the better from a KM point of view[11], as less context and transformation needs to be provided, respectively done.

As the solution to be proposed is supposed to address all relevant artifacts, it is necessary to define what pieces of data or information are of importance. Therefore, I would like to present an (incomplete) list containing relevant examples: process descriptions, procedures, rules, best practices, technical descriptions, annotations/comments, ideas, observations, concepts, experience, norms/standards, projects and tasks, skills, knowledge maps, FAQs, Meta information, mental models, micro articles, domain knowledge, incoming messages (e-mails, letters, phone calls, etc.), outgoing messages, and so on.

Another important property of such artifacts is the domain addressed by them. They could, for example, be about customers, companies, ones markets, organization's own products & services, competitors, employee skills, regulatory environment, methods & processes etc.

[9] Another issue where a widely accepted definition is missing.

[10] While the systems need to deal with the different forms adequately, the conceptual differences are just of minor importance from a pure technological point of view.

[11] As long as the "contained" knowledge is of similar importance and relevance.

Chapter 2

Goals, Problems, and Requirements of KM (-Systems)

As we are moving more and more towards a "knowledge society", many organizations feel the need to enhance their processes around the phenomenon knowledge. Numerous researchers (most of them working in the field of economics) such as Nonaka and Takeuchi (for example in [79]), Drucker, Prusak, Quinn, etc., argue, that knowledge and the related processes are key methodologies for organizations to stay ahead of competition. The most prominent (and broad) issues to be addressed are those of intangible assets (what an organization knows) and knowledge creation (knowing something new). Summing up, the ultimate goal of KM is that of a sustainable, competitive advantage.

While these broad issues help to illustrate what problems KM tries to solve, it is necessary to discuss the goals and problems of KM in more detail to be able to propose a "complete" KM-system. Furthermore, to define an IT system, it is necessary to have requirements and not just economic issues and "guidelines". These requirements, of course, need to be based on the identified goals and problems to be addressed by KM and are presented in the last section of this chapter.

2.1 Goals of KM

The following list of goals is primarily based on two KPMG research reports conducted in early 1998 (see [64]) and late 1999 (see [65]). Additionally, some of the mentioned goals are taken from papers cited in section 2.2 (with some goals being mentioned in more than one reference).

The elements of the list represent very diverse issues ranging from shareholder value to raising the potential for innovation. Please note that the following list is in no particular order:

- Improve decision-making
- Faster response times

- Support knowledge transfer
- Accelerate growth
- Discover new knowledge areas
- Strengthen core competencies/Defend market share
- Reduce costs/Increase profits
- Enhance product quality
- Enhance customer relationships/Improve customer handling
- Lower turn-around times (or product cycles)
- Reduce project time
- Raise potential for innovation/Create new business opportunities
- Support teamwork
- Enhance competitiveness/Increase market share
- Retain knowledge in company/Improve staff retention
- Enhance processes/New ways of working
- Increase productivity
- Re-use solutions/Share best practices
- Improve resource usage
- Support internal communication
- Make knowledge available
- Support creativity
- Increase share price

Of course, these goals are rather general and partly overlap. Nevertheless, they illustrate important reasons for introducing KM. The KPMG reports contain results of previous or ongoing KM initiatives and report that a surprisingly high number (over 90%) reached their goals[1].

The following list of goals provides a different point of view (inspired by a former colleague of mine, Dr. Johann Ortner) that tries to summarize and systematize the relevant issues in a slightly more formal way. Thus, while it presents an alternative way of formulating the goals of KM, this approach is intended to provide greater insight into the topic and does not claim to be superior in any way.

[1] As many of the participants, claiming that their organizations reached their respective goals, were responsible for those KM initiatives, the high percentage should be viewed with certain skepticism.

- Enhance transparency of communication flows, organizational structures, and all kinds of links
- Adaptability (to individuals and changing requirements): enhances the efficiency of work processes, prevents bottlenecks and idle phases
- Offering broad communication and transformation possibilities. As communication is the medium of information, it is necessary for knowledge transfer
- Support knowledge generation by offering context and visualization functions
- Support knowledge usage by providing transformations and diverse means of access
- Support knowledge exchange by offering diverse ways of communication and information management

Summing up, this section presents two lists of goals KM is supposed to address. The first one is more business oriented, while the second one provides an alternative point of view. Generally speaking, both have very much in common and supplement each other.

2.2 Problems Addressed by KM-Systems

General problems that are addressed by KM (IT deals mainly—if not exclusively—with information or data; for simplicity I am not discussing each occurrence of the term knowledge but instead it is used with a rather general meaning in the following sections) are listed below. These points represent a combination of diverse sources. Some problems are listed explicitly in the references (e.g. in the KPMG reports), others can be extracted from the goals of KM-systems described in the literature, last but not least some come from my discussions/experiences with other people working in the field or considering a KM initiative/system.

- "We do not know what we know"/Internal experts cannot be found
- "Re-inventing the wheel/Making the same mistake twice"/Not invented here syndrome[2]
- "Information overflow"/Knowing it is there but not finding it/Automatic production of irrelevant knowledge/Filtering information based on tasks and long-term interests[3]

[2]This problem is reported particularly often in literature but the question remains whether it really is of such high importance. When looking at a similar field – Software Development and Re-use (for example, see Basili et al. [10] or [11]) – there is conclusive research that "re-inventing the wheel" often is the most appropriate solution.

[3]The 1998 KPMG report [64], for example reports "too much knowledge" on page 17, which is a rather problematic description when thinking about the distinction between information and knowledge.

- "No/Inadequate automatic notification"
- "No/Inadequate distribution of new "knowledge""
- "Missing/Inadequate capture of employee knowledge (including implicit knowledge; both for sharing and for retaining the knowledge of employees leaving or retiring)"[4]
- Hiding information/Political use of information[5]
- Barriers to information sharing/Delays in information sharing/Distortion of information
- "Missing "history"/Traceability"
- "No multiplication of the knowledge of experts" or experts overloaded with routine questions
- "Lack of knowledge provided for greater insight into a situation or to decide which actions should be taken"
- Missing context (already partially addressed by the point about history)/Allowing items to appear in multiple places/folders (=> one form of ambiguity)
- Using theoretical knowledge for practical problems
- No time (budget) to share knowledge[6]
- Not using technology to share knowledge effectively[7]
- Difficulties in capturing tacit knowledge[8]
- Inaccurate/Out-of-date information
- Integrating new employees/acquisitions/sites[9]

[4]The real problem may be lost knowledge of best practices in a specific area of operation. This problem is also discussed in a recent paper by Coakes et al. [22] together with possible solutions like exit interviews, knowledge capturing, etc. Furthermore, a paper by Babilon [8] explicitly discusses the use of best practices within NCR as part of their KM initiative.

[5]Although this problem is reported quite regularly, it is rated as being of low importance in the KPMG reports. Generally speaking, it would instead appear that people are often indifferent to KM-systems, which is in turn misinterpreted as information hiding.

[6]This problem demonstrates that even KM initiatives where people realize the importance of the topic might still fail due to simple but fundamental problems.

[7]Very simple examples are providing information about competitors and employees skills. Even such simple pieces of information often are not easily accessible.

[8]Many researchers argue that capturing tacit knowledge offers great potential for KM-systems. In light of the discussions in the first chapter, it is obvious that while implicit knowledge can be made explicit, this is not the case for tacit knowledge as defined by Polanyi.

[9]Additional problems arise if the units trying to share knowledge have different corporate or cultural backgrounds. While access to best practices is often proposed to address this issue, they are at best a limited solution when faced with different backgrounds.

- Sharing/Co-operation with universities/suppliers/customers/... does not work
- Input for quality improvements is missing
- Missing information on competitors/products and new/innovative services[10]
- Prevent alternative decision for the same topic/project
- Inefficient processes for knowledge creation
- No use/adaptation of external knowledge
- Costs for knowledge creation are too high
- Compatibility and externalization problems
- Important knowledge is forgotten / lost
- Missing capture of experiences gained in projects/Provide everything related to a project[11]
- Adaptation of information to user preferences and device/access capabilities
- Damaged relationship to key clients/supplier when the account manager leaves

These issues demonstrate what can and does happen if a working KM-system / initiative is not in place. Ultimately, all these problems lead to the loss of significant income by losing knowledge, for example, on best practices in a specific area of operation. Therefore, this illustrates the importance of KM to all organizations (being small or big, low-tech or high-tech). Not surprisingly, organizations that have already been hit by one of the mentioned problems are more likely to have a KM-system than those not yet hit (–hard enough–).

While virtual teams and organizations are suffering from many of the mentioned problems, there are important differences that necessitate adapted or very different solutions. The single most important reason for this is that such teams have less common "context", as they are from different organizations and/or cultures. Furthermore, they suffer from having hardly any personal meetings, whereas time differences pose an additional problem, as do expensive travels for any actual meeting.

More detailed information on virtual communities – an area closely related to virtual teams/organizations – can be found in Merali and Davis [74]. The authors discuss the topic of knowledge capture and utilization in virtual communities, thus, offering greater insight into the problems virtual groups in general encounter.

[10]The importance of information about customers, products/services, competitors, etc. is also discussed in a paper by Chen et al. [21].

[11]For example, NCR's initiative as presented by Babilon [8] describes the inclusion of best practices and lessons learned to their knowledge base.

2.3 Exemplified Goals and Problems of a University

While the previous sections presented general goals and problems to be addressed by KM (primarily from an industry point of view), this section is concentrating on relevant issues of universities. The background is provided by the Vienna University of Technology, although no full-blown KM initiative is planned at the moment. It comes as no surprise that university related issues are often identical or similar to generally identified goals and problems. Finally, in section 5.4.3 there is a discussion how the proposed solution addresses the exemplified issues and what areas cannot be solved satisfactorily by an IT system.

2.3.1 Goals

The following table presents identified KM goals for a university and compares them to general identified goals (taken from section 2.1). It is easy to recognize the numerous and striking similarities (with only one counterpart missing).

Exemplified Goal	**General Identified Goal**
Better qualitative output (research results, lecture notes, etc.)	Enhance product quality
Supporting/Better communication between staff members, students, and external partners	Support internal communication / Enhance customer relationships
Support cooperative work (also with other staff, students, and external partners)	Support teamwork / Support knowledge transfer
Support curriculum (e.g. what lectures it consists of, which additional lectures might make sense)	
Becoming more attractive to students and researchers	Enhance competitiveness / Increase market share
More efficient ways of working	Increase productivity / Reduce costs
Provide all available "knowledge" (i.e. information/data)	Make knowledge available
Capture the knowledge that is produced (in the form of papers, memos, discussions, etc.)	Retain knowledge in company

This table demonstrates that only curriculum support is identified as a goal of KM in universities, which has no counterpart in the list of general goals of KM[12]. While some of the mentioned issues are more "soft" (hard to address by IT), e.g. better qualitative output or becoming more attractive to students and researchers, others can be directly addressed by means of IT, e.g. more efficient ways of working or supporting/better communication/cooperative work. As this latter category consists of goals that provide qualitative and quantitative

[12] Although curriculum support is not listed in the previous sections, there are a number of non-university organizations that encounter similar problems as universities, especially companies offering courses.

improvements, the (hopefully) positive results of a KM initiative (and a KM-system itself) can be measured and evaluated.

A third category of the presented goals is more "knowledge centered", e.g. providing all available "knowledge" or capture new knowledge. Therefore, the effects a KM initiative has on these goals can only be measured in qualitative terms. Furthermore, it is of utmost importance to assess what effects the additional available information (achieved by integrating diverse sources or supplementary capturing of new items) has on the organization (essentially, whether the positive effects justify the costs).

2.3.2 Problems

After discussing the similarities and differences of goals of universities compared to general ones, the next step is to compare the problems encountered by universities relevant from a KM point of view with more general ones presented in section 2.2. The following table provides a comparison that identifies similar problems as well as additional ones without a counterpart to be found in the list of the general ones.

Exemplified Problem	**General Identified Problem**
No automatic distribution of information	No/Inadequate automatic notification
No management of interest profiles	No/Inadequate distribution of new "knowledge"
No support in managing curricula	
Inadequate capture of "knowledge" of employees/students/etc.	Missing/Inadequate capture of employee knowledge
Inadequate support for information sharing	Barriers to information sharing / Delays in information sharing / Distortion of information
Inadequate/Missing context/history of individual pieces of information	Missing "history"/Traceability
Ambiguity not supported	Missing context/Allowing items to appear in multiple places/folders (=> one form of ambiguity)
Inadequate support of co-operations with external partners (other organizations, e.g. industry)	Sharing/Co-operation with universities/suppliers/customers/... does not work
No capture of experiences gained in projects	Missing capture of experiences gained in projects/Provide everything related to a project
Inadequate systems for finding/accessing relevant information	We do not know what we know
No system for identifying/finding experts	Internal experts cannot be found
Too much information available (i.e. the wrong information)	"Information overflow"/Knowing it is there but not finding it

As this list is not backed by any literature (contrary to the one containing the general identified problems), it is necessary to discuss the items in more detail. Although some of the actual problems may seem simple, they need to be addressed by a "complete" and holistic KM initiative.

No automatic distribution of information At the moment, e-mail is the most sophisticated mean to "push" information in many universities. An integrated solution will make e-mail and similar functions more powerful and flexible as all kinds of group and other addressing mechanisms become available[13]. While such advanced mechanisms partly address the problem at hand, they only provide very limited automation support. Therefore, any KM-system needs to provide functions to notify users of new information items that have a high relevance for their daily work and their interests. This can be accomplished by using interest profiles and considering what work (e.g. project) the user currently has to accomplish.

No management of interest profiles Already mentioned in the text on the previous issue, interest profiles are of high importance for a KM-system. Currently many universities use limited systems like mailing lists or newsgroups to address the eminent need. A KM-system needs to keep track of the interests of each user and allow the manual adaptation. Furthermore, it needs to propose the addition and removal of interests according to highly sophisticated assessments of the users' real needs. Using interest profiles and similar relevant information a KM-system is capable of notifying users of new items that have a high probability of being of interest/relevant.

No support in managing curricula As already mentioned, this issue is the only one where I could not identify a counterpart in the list of the general problems to be addressed by KM. At the same time, there is only limited support to manage a curriculum by technological means. On the other hand, a number of potential relevant technologies like knowledge maps and visualization functions exist that promise to ease the problem. Knowledge maps and visualizing the curriculum or parts of it allows identifying areas where many similar courses are offered as well as what areas are lacking courses. A precondition for such functions is that only compatible and known terminologies are used. Of course, any resulting curriculum is important information in itself and helps students to get a better understanding of the university's offer.

Inadequate capture of "knowledge" of employees/students/etc. Sophisticated support in this area is more or less non-existent in most universities. Of course, there are, for example, all kinds of libraries that offer searching capabilities and make all kinds of information available. Nevertheless, the offered functions are diverse and unsatisfying in one

[13]However, one must keep in mind that the provision of powerful push mechanisms needs to be accompanied by guidelines how to use them. Otherwise, there is the very real danger of misuse and, as a result, of flooding people with irrelevant information.

respect or another, while many potentially relevant information sources like newsgroups and e-mails are not included. It is, therefore, necessary to capture as much relevant information as possible, while, at the same time, offering the available information in a consistent and efficient way.

Inadequate support for information sharing At the moment, information sharing is achieved by mailing files, using a newsgroup, e-mail discussions, or personal meetings, etc. Generally speaking, these mechanisms are rather awkward and problematic from a KM point of view, as such unstructured information flows not only are difficult to integrate but also have proven to be ineffective and error-prone. Thus, there is the need for more consistent and structured means of information sharing to capture relevant knowledge and provide effective communication possibilities to partners and within an organization.

Inadequate/Missing context/history of individual pieces of information Every information item has a context and a history, which are of utmost importance to interpret items correctly and to understand what they contain. Although Document Management Systems (DMS) provide these capabilities, they are not in widespread use and do not incorporate all of the relevant pieces of information (for example, discussion forums are not provided or managed by most DMS). Consequently, a KM-system needs to capture context and history for all the available items, using all the available hints it has so that the system does not need to query the user for this information. Such context and history is, of course, very important for managing interest profiles or notifying users, to just name two examples.

Ambiguity not supported There is hardly any mechanism addressing this issue at the moment and definitely no satisfactory solution. Nevertheless, there is the need to provide pieces of information in multiple locations and forms. Although hyperlinks are used widely these days, they do not really solve the issue at hand, as they are just providing one-way and weak connections. Instead, there is need for a more consistent and powerful solution[14].

Inadequate support of co-operations with external partners As the issue of information sharing has already been discussed separately, the single most important problem remaining is that of cooperatively working on a desired result like a document. There are many ways of supporting this, for example, providing bi-directional access to the current version of the document. Furthermore, flexible and powerful means to communicate have to be provided and need to be accompanied by a powerful permission system to guarantee confidentiality.

No capture of experiences gained in projects While projects often use considerable time on general organizational and technological problems,

[14]For example, the Xlink and Xpointer standards by the W3C show that this problem is the focus of ongoing research.

such experiences are often not made available. Consequently, projects are "doomed" to spend time and energy on problems already solved by other members of the same organization. Although IT can provide functions to allow the easy insertion and retrieval of experiences gained in projects (for example, micro articles), the most important issue is to adapt the existing or introduce a new corporate culture to promote sharing experiences and to provide and search for help.

Inadequate systems for finding/accessing relevant information While there are many closely related issues, this particular one stresses the importance of providing efficient ways to all relevant information items a university has access to. While IT offers many technologies and functions to address this problem, integrated systems resulting from the usage of the relevant technologies are not yet widely used. Although building such a system is difficult, it is the most promising solution of this issue.

No system for identifying/finding experts At the moment, most universities lack systems that identify experts or people knowledgeable in a specific area. As such systems failed to meet their objectives in industry, it is of utmost importance to use a different approach. Therefore, such a system needs to maintain a list of fields and track affinities of people to those fields. Consequently, the resulting list of experts is always kept up-to-date without the need for manual input or changes[15].

Too much information available (i.e. the wrong information) Most of the issues described have a potential of adding to the information overload many people already experience. While KM initiatives try to provide all relevant information, KM-systems need to provide filters and ways of accessing that reduce the amount of information the user needs to look at to find the relevant items. The key to offer potentially relevant items is to consider information about the user's situation like his interests or his hierarchical status. Such information can also be used to push items to users that have a very high probability of being of interest (and skipping the rest).

Summing up, the problems to be addressed by a university are often quite similar to those encountered in industry (considering, for example, research co-operations, this comes as no surprise). Furthermore, the discussion of the university problems in detail illustrates that many issues are of relevance to both types of organizations. The different number of mentioned problems finds its explanation in the fact that in section 2.2 this thesis provides a summary of problems identified by many experts in many organizations with a diverse background.

[15] Although such a database addresses the need to offer multiple ways of finding and accessing expertise, one should not expect the whole organization to use this functionality, since many members will prefer other ways of acquiring the information they need.

2.3.3 Conclusion

The exemplified goals and problems of a university do not only illustrate practical, real world problems in their domain, but at the same time help to understand the more general goals and problems described in earlier sections of this chapter. Consequently, this section demonstrates that a "complete" and holistic solution is the best way to address all the diverse issues KM tries to resolve. While shrink-wrapped software cannot be the basis of a KM initiative, it is a reasonable approach to define a concept of one KM-system for different types of organizations[16].

2.4 Problems of KM-Systems

As reports about successful and failed KM initiatives using various IT systems/tools exist, it is important to analyze the reports before defining the requirement of a KM-system. A newly proposed KM-system, of course, needs to address all problems that have been encountered in similar systems so far.

Many descriptions of such problems can be found in literature (e.g. Romhardt [88], Fagrell et al. [36], Döring-Katerkamp and Trojan [30][17], or in a recent overview paper by Harris [47] at the Gartner Group). The following list shows the problems either most commonly identified or being of highest importance:

- System not accepted/used / Lack of user uptake due to insufficient communication
- Information is not stored/classified/found properly in KM-system
- Using theoretical knowledge for practical problems
- KM not integrated into normal work procedures
- Users do not see the personal benefits[18]
- The "knowledge" distribution system does not make sense
- Lack of time (a problem that should be solved by KM)
- Lack of training
- Difficulty/Failure to capture tacit knowledge[19]

[16] Please note that actual implementations of the proposed concept can vary to a high degree and that organizations may choose to implement only certain parts of it.

[17] Presenting a study with 347 participants from 12 countries on KM containing results of encountered problems.

[18] While incentive systems fail to provide long-term motivation they may help to start the process and give people an immediate reward (-> benefit). This issue is discussed in more detail in section 3.2.1.

[19] Once again, one should not forget that the real problem would most probably lie in the capturing of implicit, informal, and contextual information.

- Senior Management does not support the initiative
- Unsuccessful as a result of technological problems

As these problems either are organizational ones or related to the actual realization of the KM-system, building a "complete" and holistic KM-system is possible using currently available technology. Of course, all issues related to IT need to be considered and addressed by the proposed solution, while the KM initiative itself has to take care of the non-IT problems.

Further information can be found in a paper by Malhotra [69] that contains a discussion of problems of KM-systems together with insights about the suitability of certain approaches. The author continues by describing what issues need to be taken into account in the case of a next generation KM-system. Summing up, the paper presents very interesting and important arguments, why certain KM-systems failed, that need to be considered when proposing such a system.

2.5 Requirements for KM-Systems

Beginning with this section, this thesis will concentrate on technological (IT) aspects. Consequently, non-IT aspects will only be discussed as necessary for the purpose of this thesis.

As the previous sections of this chapter presented the goals and problems to be solved by KM both from a general point of view as from a university point of view and what problems were encountered by other KM initiatives with IT support, the next step is to present the requirements of a KM-system. Every IT system needs to be based on requirements to be fulfilled and those of a KM-system need to be based on those goals and problems of KM that IT is able to address to a certain degree.

Figure 2.1 shows the relationship between the problems presented and the requirements identified. Despite the fact that many problems are addressed by multiple requirements, they are depicted by the requirement that best addresses the issue. Furthermore, there are three problems, which could not be classified correctly, as they represent monetary and non-functional issues. Nevertheless, the figure gives an impression of the relationships between the problems and the requirements identified.

2.5.1 Capturing

Capturing is one of the most basic requirements of a KM-system, as it allows users to add information to the KM-system. While the solution needs to handle diverse information items like documents, context, skills, etc. directly, other types of information, especially context, history, and all kinds of unstructured information, should be added automatically. This automatic capturing is made possible by incorporating KM into the normal work procedures and, thus, the system is able to determine the context of an information piece with a high certainty. Indeed, this important additional information needs to be provided by the user should the system not be capable of determining it.

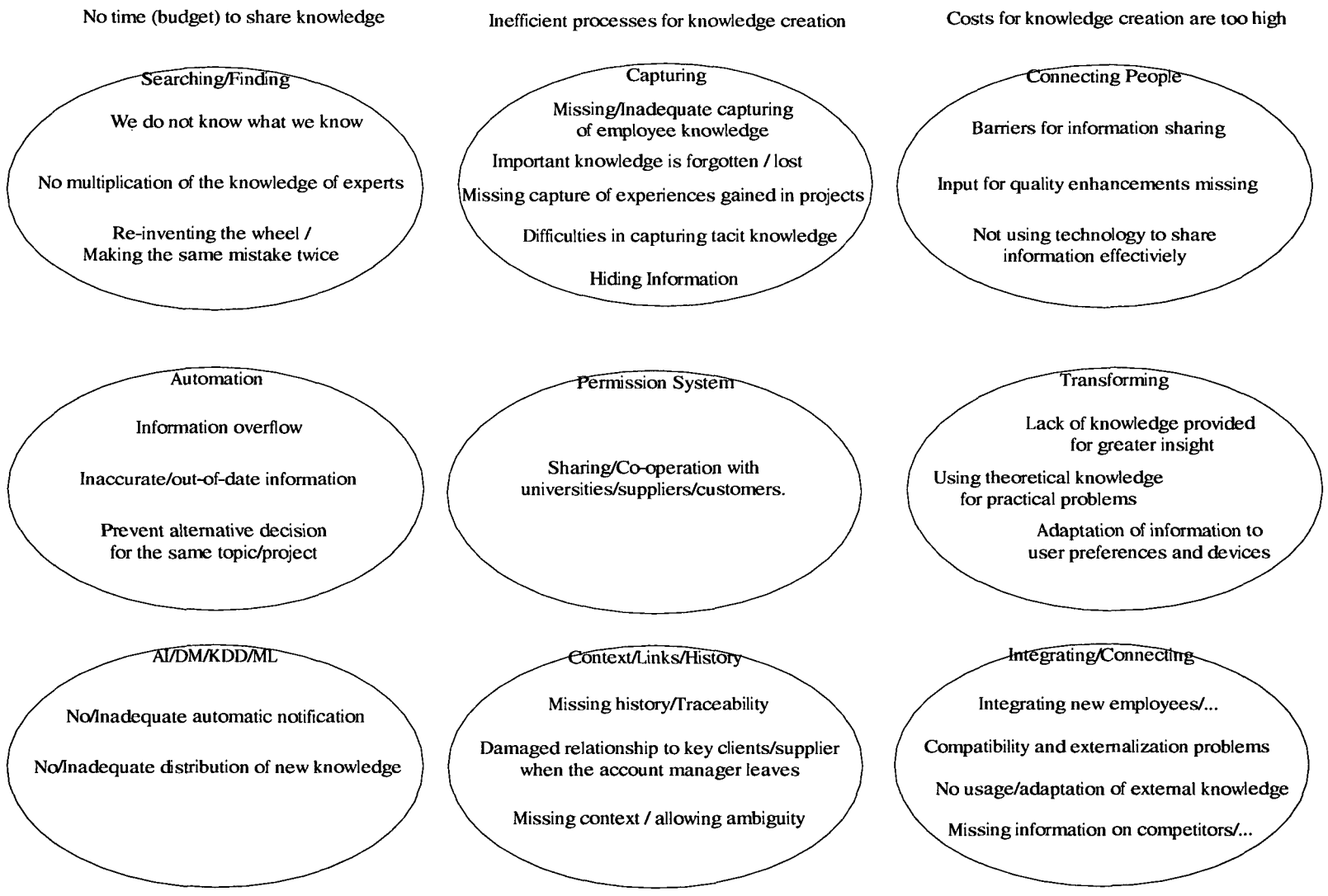

Figure 2.1: Depiction of KM Problems and Resulting Requirements

2.5.2 Integrating & Connecting (technologically)

As most organizations have a variety of different systems containing relevant information and data, a KM-system has to provide access to them. Therefore, the system needs to integrate all potentially relevant items and connect all existing and introduced systems in the most effective way, namely two-way communication. The importance of two-way connections is illustrated by the fact that less elaborate mechanisms will often fail to provide full and satisfactory access to the information and functions of other systems[20].

As a "side" effect, integrating and connecting all relevant systems and information minimizes delays and distortion that often occur in the absence of such an integrated KM-system. At the moment, the real information of a customer reaches support and/or development only in rare cases without serious distortion due to various steps and transformations it has to go through.

A more detailed description of systems that are candidates for integration (like business software, Groupware systems, CRM, etc.) is provided in chapter 5. Summing up, integrating and connecting enables a KM-system to gain access to all relevant information and provide a more complete set of functions than possible otherwise.

2.5.3 Transforming

There are two major problems to be addressed by transformations: Adapting information and data so that the KM-system is able to efficiently access it and to change data and information so that it can be included in the storage of the KM-system itself. Thus, transforming is either done as part of a two-way connection (as described in the previous section) or to enable (regular) imports of information not suitable for more elaborate connections. The second category consists of external sources like universities, consultants, suppliers, etc. and of sources where an elaborate integration is not feasible or that will be replaced in the future (the best examples of this category are old legacy systems).

Another important example of applying transformations is provided by Data Warehouses. As such systems provide high quality information, integrating their information and functions into the KM-system is very important. Consequently, since operational databases are data sources for a Data Warehouse, many of them do not need to be integrated.

2.5.4 Storing

As storing is a basic functionality provided and used by virtually all IT systems, most organizations have a variety of examples in usage. For example, DBMS offer basic functionality, while systems like DMS handle the storage of information items like documents and files.

A KM-system needs to offer certain functions like the provision of annotations, version control capabilities, and change logs for all managed information

[20] At the same time, costs of introducing and maintaining such a connection may be prohibitive in some cases.

items, whether they are actually stored in itself or not. The resulting data of these functions provides additional relevant information that needs to be considered by other parts of the KM-system.

Together with the aspects of transforming, integrating, and connecting, this aspect is responsible for transparent and efficient access by other functions of the system. Failure in this respect would diminish the potential benefits of the whole KM initiative.

2.5.5 Flexible & Adaptable Permission System

As a system integrating and incorporating all potentially relevant information an organization has access to also contains confidential and restricted material, a powerful, flexible, and adaptable permissions system is a necessity. The most important issue is to guarantee confidentiality and adhere to legal restrictions as necessary, while providing full access to all legitimate users. Furthermore, such functionality provides a foundation to offer limited views to the organizations' information pool to the outside (e.g. as one of many Extranets or even as the data source for the Internet page of the organization).

The most suitable foundation of such a permission system is a central user database as provided by directory services that also allows to offer Single Sign-On functionality (a very important feature for user friendliness of systems in general). Other potentially important functions based on the permission system are to have a form of "showing only" (like possible with Microsoft NetMeeting) or limited usage rights (like a PDF file that is not printable).

2.5.6 Connecting People

The requirement of connecting people addresses the issues of allowing teams / organizations / etc. to communicate using a wide variety of electronic means. While the resulting communication is often unstructured in nature and, thus, difficult to make it accessible, other parts of the system can utilize the available information and provide better results.

Consequently, this requirement can be fulfilled by providing e-mail, discussion forums, chat rooms, phone and/or video conferences[21], suggesting available expertise, provide information about holidays or sick days, etc.

2.5.7 Artificial Intelligence / Data Mining / Knowledge Discovery in Databases / Machine Learning

The most advanced functions a KM-system should offer are based on AI/DM/KDD/ML technologies that allow the generation of new information to allow users to gain insights not easily made otherwise. Thus, these functions go beyond mere information management, as they create new items.

These technologies have already proved effective in diverse fields and make systems seem to be intelligent. At the same time, a KM-system has many functions like providing knowledge maps, similar documents, affinities of people

[21] Using speech mining to provide limited access to the information.

to fields, etc. that are based on such technologies. Thus, they are one of the most important foundations of the resulting KM-system.

2.5.8 Handling & Capturing Context, Links, and History

While DMS systems offer limited support to handle context, links, and a history of documents or files, KM-systems should offer this functionality for every information piece available in the most flexible way. For example, users should have the ability to create links (like connecting items related to a project) manually, while the system creates such connections of its own based on the context, history, and content of an item.

Equally important is the provision of ambiguity, a requirement that needs to be addressed in various layers of a KM-system, for example by allowing items to be linked to multiple locations (folders, other items, etc.). Summing up, the described functions of handling context, links, and history need to be provided throughout the resulting system.

2.5.9 Automation

While automation is the key for many of the advanced features a KM-system has to consist of, it also frees people from having to perform routine tasks. These features are based on AI/DM/KDD/ML technologies allowing high quality results and are being performed regularly or constantly.

Important examples of tasks that can be automated include: Updating a available skills database (using information like authorship, being a member of a project team, etc.); Automatic classification of messages (incoming and internal e-mails, letters, etc.); Identifying processes or work flows by profiling user actions; Automatically notifying users of new information, for example, based on tasks and long-term interests; Providing suggestions to update a user's interests; Constantly re-evaluating an assessed value of pieces of information (in order to deliver only current items).

2.5.10 Searching/Finding & Retrieving

From the users point of view one of the most important and visible aspects of a KM-system is that of searching, finding, and retrieving information items. Although addressing this requirement is only possible by using many other functions of the KM-system, the result has to be a simple, powerful, and consistent interface for the users.

Consequently, a powerful search mechanism needs to provide access to every single piece of information that is available to the KM-system (regardless of whether it is stored, integrated, or generated). At the same time, search results have to consist of the most relevant pieces taking the user's interests, the assessed value of matching pieces, correlation between items, and permission and costs associated with information retrieval into account.

Another issue of great importance is to consider offline capabilities, address devices with limited capabilities (like PDAs), or slow and unreliable network

connections when designing and implementing an actual KM-system. Additionally, the system needs to adapt to each user and provide the capabilities and results in a way best suited taking their current interests and tasks into account. Furthermore, the system needs to support different cognitive styles by offering the available content and functions in different ways (for example, while some persons grasp concepts faster if presented in a figure, others are more oriented towards speech).

2.5.11 Embedding into Normal Work Procedures

While embedding KM-systems into normal work procedures is not necessary from a theoretical point of view, there are overwhelming reasons to do so. The two most important ones are: Separate systems are a burden for users and, consequently, often ignored. Secondly, only an integrated system is capable of automatically capturing contextual information, thus, being able to offer additional information without additional input.

Together with the aspect of participatory design (described in section 5.1.2), embedding KM-systems into the normal work procedures is the key to user acceptance and high quality information inside the KM-system. Summing up, KM-systems need to be integrated into everyday work so that they can capture information and support users properly and without additional overhead.

2.5.12 Related Issues

After presenting the main requirements a KM-system has to fulfill, there are two smaller issues that, nonetheless, need to be mentioned. These will now be discussed in brief.

Provide Transparency

While many of the presented requirements address the need for transparency, its importance justifies this section. Although I am not going to provide a detailed discussion, transparency is a key issue for KM in general and, therefore, needs to be addressed by organizational and technological means. Ultimately, transparency allows people to see the context of information items, decisions made, etc. and, thus, is necessary from an organizational point of view and has to be provided by technological means within the KM-system.

Provide Traceability/"History"

While the need for managing history has already been argued above, traceability is a more complex concept as it is related to transparency, history, and many more issues. The key is to enable users to comprehend and retrace what has happened with a certain information piece and everything related to it (e.g. within the context of a project).

2.5.13 Non-Functional Requirements

While non-functional requirements are often neglected or addressed when problems arise, it is of utmost importance to address these issues from start. As the two most important non-functional requirements for a KM-system are speed and ease of use, their importance is obvious. Indeed, failing to provide a fast system with an intuitive user interface may "doom" the whole KM initiative irrespective of whether the other requirements are addressed to the fullest extent possible or not.

2.5.14 The Overall Picture

Summing up, all the mentioned requirements together describe what issues the proposed KM-system has to address. While some issues need to be addressed by organizational as well as technological means, only the latter ones were considered in detail.

Figure 2.2 shows the identified requirements and is supposed to provide a better understanding of the correlations between the different issues. While some requirements would fit in more than one place, this depiction presents them where they best fit into the figure as a whole. Two requirements do not find a definite place (therefore drawn one at each side), namely automation and connecting people, as they have to be done at all levels and in all forms possible.

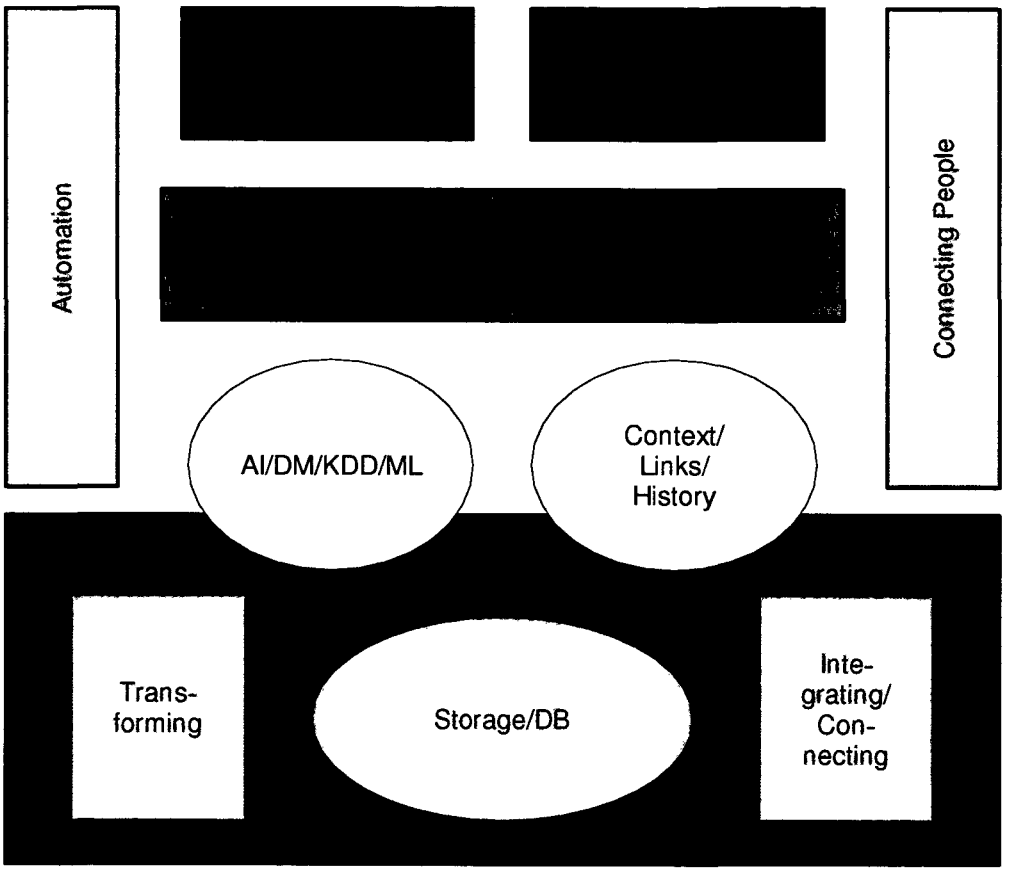

Figure 2.2: Grouping the Requirements of KM-Systems

Chapter 3

Preconditions/Foundations for KM (-Systems)

While the previous sections presented the requirements of a KM-system, this chapter discusses necessary preconditions and foundations of KM-systems and KM in general. Although not all of the elements to be presented are absolutely necessary, all discussed issues provide significant benefits.

While this thesis concentrates on preconditions for KM (-systems), one should always keep in mind that any KM initiative should first identify and tackle their KM needs, i.e. the problems to be solved and important "soft" (or human) issues centered on people and processes. Not before preliminary results are available should IT concerns be regarded and addressed. This line of argument finds support by current research activities, stating, why purely IT driven KM initiatives have failed (for example, McDermott [72] or Malhotra [69]).

3.1 Want To Do KM and Know the Reasons Why

Any organization considering the introduction of KM should ensure that all relevant forces – **all** levels of management and effectively every single member – realize the importance and benefits of KM and want to do KM! Without such a commitment any KM initiative is determined to fall short with regard to its goals. Thus, organizations facing this problem should look for other means to improve their operations, although, the impact on the organization's bottom-line will most probably be diminished.

Of course, wanting to do something and knowing the reason why is not only important for KM but for every initiative trying to change the way an organization works. For example, Senge discusses this issue in his book The Fifth Discipline (see [92]) in the case of the learning organization.

One of the most promising ways towards such a commitment is a shared vision accompanied by purpose and policies. Of course, the personal visions of every member of the organization have to be based on the overall vision (and vice verse). Summing up, wanting to do KM and knowing the reasons why is the single most important success factor, as it provides motivation that helps to overcome most obstacles.

A more pragmatic point of view is taken by Vossen [110] in a paper about strategic knowledge acquisition. He ascertains that knowledge acquisition is becoming increasingly important and describes three important conditions (coordination, communication, and long-term contract) to support it. While the paper does not deal with IT, it contains important arguments for sections in this chapter i.e. the importance of a sharing culture and of setting and evaluating goals as one of the most important factors of strategic acquisitions.

3.2 Sharing Culture/Organization

Although members of an organization committed to do KM should easily recognize the importance of sharing (knowledge, etc.), the increasing application of hire & fire according to the current state of economy or the order book does not foster a sharing culture in the least. While there is hardly any literature taking this important topic into account, a paper by Trauth [106] is one of the rare exceptions containing an in-depth discussion of this issue.

Generally speaking, sharing is a necessity for KM and, thus, organizations need a sharing culture to do KM. Furthermore, such a culture should and does foster collaboration. Both collaboration and sharing enable the members of an organization to experience the benefits of KM.

Relevant research is conducted in many fields, for example, a paper by Bettoni et al. [12] offers interesting insights into the motivation of members of Communities of Practice (CoP). CoPs cope with very similar problems as KM in general (seeing CoPs as a special form of KM) and Bettoni et al. argue that basic needs like safety and job security will always dominate any other need (like recognition for knowledge sharing).

Another topic of utmost importance is trust and a paper by Weggeman and Berends [113] describes the importance of trust for knowledge sharing in more detail. They show that collective ambition (this is similar to the proposed want to do KM – although the authors do not mention KM as an ambition for itself) together with trust is needed for horizontal knowledge sharing. In my eyes the arguments are true for every knowledge sharing activity with varying degree (without trust superiors still will get information but not as much as they would like/need).

Considering the functions and technologies IT has to offer to support sharing, there is a multitude of possibilities like those provided by Groupware systems alone. Chapter 5 contains a detailed discussion how IT is able to support knowledge sharing. Despite these technological capabilities, personal meetings remain one of the most effective forms of knowledge transfer. Facilities that seem to be irrelevant from a narrow-minded KM point of view often have a higher impact than management initiatives. Summing up, social factors are the key to knowledge sharing and, thus, KM initiatives need to take special care creating (as far as possible) and fostering sharing and a sharing culture.

3.2.1 Intrinsic versus Extrinsic Motivation

After arguing the necessity that an organization is committed to KM and bases its KM initiative on a sharing culture, it is important to discuss the important issue of motivation[1] that is the foundation for sharing and commitment.

There are two major types of motivation, namely extrinsic motivation that is imposed from the outside and intrinsic motivation that is originating from within a human being. While extrinsic motivation is based on incentives, rewards, or the fear of punishment, intrinsic motivation satisfies an individual's inner needs, such as being accepted by others.

More rigorous definitions and a detailed discussion of the relationship of motivation, knowledge transfer, and different organizational forms can be found in a paper by Osterloh and Frey [80]. Basically, the authors argue that extrinsic as well as intrinsic motivation is necessary for tasks requiring creativity. At the same time, organizations have to address the problem of opportunistic behavior by some of its members.

A number of papers and reports containing discussions on the use of extrinsic motivation[2] conclude that this form of motivation is ineffective in the long run. Poorly designed incentive programs often suffer from opportunistic behavior by members of the organization and, thus, may even diminish other positive effects. However, extrinsic motivation such as rewards can be used to stress the importance of the KM initiative (monetary rewards are very effective in demonstrating the commitment of the organization) and to provide an initial "boost". Indeed, this line of argument is consistent with the findings of Stuart and O'Donnell [99]: Financial rewards were only judged relevant by a quarter of the employees and especially newer members of the organization in question.

3.2.2 Incentives

Summing up, the paragraphs above illustrate that while extrinsic motivation has limited long-term effects, it is able to provide initial thrust to a KM initiative. For example, user tracking (provided by any reasonable IT-system) is a simple and effective way to gather necessary data for a incentive systems (consisting of bonuses, airline miles, etc.). However, the crucial aspect is to select a metric that fosters sharing and re-using as directly as possible (as people will definitely optimize for the metric). In most cases the most appropriate approach will be to start with a simple model for the metric that gets refined over time keeping the metric aligned with the goals of the KM initiative.

[1] At the same time, this issue is often overemphasized in many KM papers. In fact, I have often heard people say, "People are motivated when they enter an organization". Most people want to do their work and gain recognition for their results. Thus, removing obstacles and preventing people from losing their motivation may be all that is needed.

[2] In Senge [92], one finds a closely related concept described on page 225. Senge presents the difference between a negative and a positive vision and the underlying principles of fear versus aspiration (while fear is a powerful source of motivation in the case of short-term goals, aspiration supports long-term goals). Summing up, extrinsic and intrinsic motivations represent negative and positive forces and their effects are similar to those discussed by Senge in the case of vision.

3.3 Truthfulness

While truthfulness often is assumed to exist and not given a second thought, its importance cannot be overstressed. Consequently, this section is discussing this topic in more detail.

Numerous researchers in various fields[3] have been arguing the necessity of truthfulness. The two most important issues to be addressed are the need of management to get correct and current feedback, while subordinates require the absolute certainty that this information will not be used against them (including "help" by management to solve a "problem").

Therefore, it is imperative to ensure that people have no need to cheat, before elaborate mechanisms and activities are put in place that assume that information items are valid. Establishing a culture of truthfulness will require the adaptation of policies and processes in many cases and sometimes necessitate drastic changes of the old habits of an organization.

While the given arguments illustrate the importance of truthfulness in a general (KM) context, it also plays an important role for KM-systems. These systems use the electronically available information in various ways such as transforming it, searching for unknown correlations, providing data to other systems, notifying users automatically of new items, etc. Therefore, it is easy to see that incorrect or misleading information can lead to major and costly problems for the organization as a whole (especially in the case of a highly automated system). Of course, effective KM-system have to provide mechanisms to reduce the potential problem but will generally assume that the available information is correct and not the opposite.

Summing up, truthfulness is a topic of utmost importance for KM in general and especially in the case of KM-systems. Only if correct and current information is available, will an organization be able to make intelligent decisions that are supported by an effective IT system.

3.4 Set and Evaluate Targets for KM

KM – as any other initiative within an organization – has to justify the costs and changes necessary to introduce and implement it. Despite the fact that effects caused by KM are complex in nature, often address soft issues such as motivation[4], and are hardly separable from effects induced by other initiates, measuring and evaluating the (positive) results of KM needs to be done. However, a general and satisfactory solution to evaluate the effects KM has on an organization is still missing.

As many KM initiatives have failed to prove their effectiveness (see for example Harris [47] at the Gartner Group), organizations need to ensure that

[3]Once more, Senge [92] stresses the importance of the topic throughout the book (the best description can be found on pp. 159–161). In the field of project management or software engineering, this issue is recognized for its importance (i.e. described in the influential book of Frederick P. Brooks Jr.: The Mythical Man-Month originally published 1975).

[4]The range of goals to be achieved and problems to be addressed by KM has been discussed in chapter 2 already.

their investment is having effect on their bottom-line. Therefore, any organization planning a KM initiative has to identify as many figures as possible that will be influenced. A possible way to evaluate the effects can be found in the doctoral thesis of Romhardt [88] that describes how to set knowledge targets and evaluate the results (for example, to be found on p. 116; on pp. 125–129 he describes Management by Knowledge Objectives, thus, transferring the idea of Management by Objectives to the field of KM[5]).

A more recent approach has been proposed by Firestone [38] in a paper about estimating benefits of KM. He proposes concepts, methodologies, and tools to improve the estimation of KM benefits. The subject is also handled in the research carried out by Kingsley [61] in which he presents a discussion of different ways to measure the "return of KM" and how to justify the costs of KM in the field of law firms.

As KM has many effects on an organization, addressing "soft" issues and/or being in the center of other initiatives taking place in the same period of time as the introduction of KM, it is a complex problem to evaluate the effects of KM. Nevertheless, there are goals such as customer satisfaction, lower turn-around times, and reduced project time that can and should be monitored as a way to measure the effectiveness of the KM initiative. However, one should always keep in mind that many important issues of KM cannot be measured easily (if at all possible). Therefore, the KM initiative as a whole should be judged by the measurable output.

Summing up, while there are many promising approaches to evaluate the effects and justify the costs of KM, no general and satisfactory solution exists. Nevertheless, a "complete" and holistic KM initiative needs to address this issue and provide as many figures as sensible.

3.5 KM and Innovation/Creativity (the Learning Organizations)

While the concepts of KM and the learning organization address similar issues and have many things in common, the relationship between the two topics is a complex and difficult one. Indeed, some researchers are arguing that they are even contradicting or hindering each other[6], while others claim that the learning organization is a part of KM.

Perhaps the most important point in the discussion is the fact that knowledge is a product of learning and, thus, learning organizations are producing knowledge. Obviously, this knowledge can and should be "managed", for exam-

[5]Whether or not Management by Objectives itself is a good idea, remains a widely discussed topic and important arguments in favor and against it exist.

[6]For example, a paper by Johannessen et al. [58] argues that using the entire knowledge base of an organization leads to continuous innovation and not revolutionary changes. Furthermore, the authors mention a number of papers that describe how tacit knowledge promotes continuous improvements. Summing up, they argue that the usage of tacit knowledge and the entire knowledge base of an organization allow evolutionary improvements, thus, only allowing reaching a certain point. Another discussion of these issues can be found in research by Hahn and Subramani [46] p. 308.

ple by KM. However, forcing the members of an organization to use/re-combine existing knowledge whenever possible can hinder creativity in many ways, for example, simply by diverting attention. McElroy [73], on the other hand, views KM as being responsible for both the demand-side and the supply-side of knowledge and, consequently, proposes to integrate organizational learning in KM. As KM is responsible not only for managing the existing knowledge but also for the process of creating new knowledge in this view, he stresses the necessity that KM addresses all knowledge processes and calls the result a "second-generation KM".

While McElroy's point of view illustrates the position and the arguments of a number of KM researchers, this opinion does not represent the KM mainstream. Nevertheless, his arguments show the importance of many issues that were neglected in past KM projects. However, addressing these issues does not necessitate an extended definition of KM.

One way to ease the potential conflict is to provide a constant re-evaluation of the "value" of information items (identified as one requirement of a KM-system in section 2.5.9) in order to deliver only up-to-date items and allow to remove outdated items. On the other hand, the learning organization is focused on encouraging people to search for new ideas/possibilities[7]. A similar issue is discussed in a recent paper by Cegarra Navarro and Dewhurst [19] where unlearning is analyzed as a prior step of the creation of intellectual capital.

The previous paragraphs have shown the close relationship of KM and the learning organization. As a combination of the two topics will often be in the interest of an organization, it is important to discuss ways to minimize the conflicts that arise from such a combination.

Integrating the two topics could be realized by having users conduct a exhaustive search (using powerful and fast search mechanisms) before deciding whether re-using a existing solution, building on top of existing results, or inventing a new solution (probably after deciding that a existing solution is not a suitable basis for the problem to be solved) is the best approach. Thus, the available knowledge is taken into account, while people still are encouraged to consider a new solution.

This line of argument finds support in a paper by Ruiz-Mercader et al. [90] showing that there is a positive and significant relationship of individual learning, traditional and collaborative technologies with organizational learning in small and medium sized businesses. As KM and the learning organization are closely related topics, one can assume a similar relationship in the field of KM.

Summing up, the relationship between KM and the learning organization is a difficult one. On the one hand, a successful KM-system hinders creativity and invention to a certain degree, on the other hand, these topics are closely related and a combination seems the best solution for most organizations.

[7]Even relevant pieces of information might not support this goal.

3.6 Identifying Relevant Objects

As KM (-systems) has (have) to deal with a wide range of objects, this section discusses the most important types of them. The objective is to identify organizational aspects as well as relevant pieces of information (i.e. data about an appointment).

A KM initiative needs to analyze the organization and its processes[8] in the early stages of the project. Using the result of the analysis enables the project to concentrate its efforts on the processes that either matter most or have the greatest need for adaptation. The next step is to identify the relevant information artifacts of these processes and to work out what additional information might be retrieved, captured, or generated in order to support the processes to be changed. A discussion about the different types of artifacts and examples of them can be found in section 1.8.1 (listing just some of them: process descriptions, documents, appointments, yellow pages, etc.).

3.6.1 Processes & Modeling

Every organization has its processes and ways of working whether those are documented or not. Modeling the existing ones helps to understand the organization and provides a foundation for discussions about possible changes. Furthermore, a KM initiative will often find that new processes have to be introduced and old ones become obsolete.

The difference between low and high tangibility processes has already been described in section 1.7.1. While creating models for all processes of an organization is an important task for a KM initiative, executing processes by a workflow engine only makes sense for low tangibility processes. However, the analysis of the necessary processes of an organization might enable to change a process in a way so that it becomes a low tangibility process as a side effect.

Summing up, a KM initiative should analyze and model all relevant processes, to define how things can be done and how KM can support the organization. While standardization and automation allow to execute processes in the most effective way when flexibility is not a big issue, other activities should not be bound to the limits of a process model (for example, when creativity is necessary to accomplish a task).

3.6.2 Best Practices

As many researchers propose the adoption of best practices as a way to improve processes, let us take a look at this topic. Best practices are the processes or methods used by organizations ahead of competition in a certain field. However, there are some problems associated with this concept. For example, the comparison of organizational practices is a difficult and complex task considering the different cultures and supporting processes in place[9]

[8]The high likelihood that processes will need to be adapted has already been shown in two other sections (about the sharing culture and the importance of truthfulness) of this chapter.

[9]These differences make a comparison very difficult, if not impossible, to accomplish.

The whole idea of best practices is to transplant isolated procedures of a successful organization to another one assuming that there will be similar effects. Of course, many people trying to use best practices adapt them to their own environment. However, if used to improve ones way of working by analyzing the work procedures of successful competitors, the whole idea does not seem like a revolutionary concept any more (that should be used, nevertheless, whenever appropriate).

To overcome the problems associated with best practices there are two sensible approaches. One is to limit the application of best practices to similar environments/contexts[10]. Another approach is to remove/identify any relevant cultural or organizational aspect from the best practice in question in order to gain a generic best practice. Of course, such a generic best practice will need careful adaptations before an organization can hope for the intended effects to take place.

In other words, best practices are no panacea but can help to improve work procedures. Therefore, the concept should be integrated into a KM initiative.

3.6.3 Conclusion

Summing up, this section discusses relevant objects of a KM initiative, most notably processes and process models as well as best practices. Furthermore, the subsection discussing best practices illustrates the importance of distinguishing internal and external information/knowledge (by arguing that best practices from the outside may not fit the organization in question). Of course, the issue of the different degree of applicability of internal and external information needs to be considered for information artifacts in general.

3.7 Barriers and Obstacles: Removing and Building

Numerous KM researchers argue that one of the most important tasks of KM is to remove barriers to information sharing by organizational changes or technological means. However, some barriers are a form of protection and not an obstacle to information sharing. Therefore, a KM initiative needs to carefully review existing barriers and work out a concept describing what barriers should be removed, which ones should stay, and what new barriers are required to achieve an optimal level of information flow and protection of the affected people.

A description of a barrier to an important flow is presented in a paper by Bircham [13] showing, that how questions are asked has a huge impact on the answers. She continues by describing that management does not get the relevant information because the wrong questions are used. This is a good example of a barrier that effectively is stifling communication and is not noticed easily.

In other words, barriers and obstacles (to information sharing) have to be considered and reviewed by a KM initiative. The result has to be a concept

[10]Similar environments can be found in parts of big corporations, for example. Within such a context, best practices should easily be re-usable.

describing what barriers will stay in place, have to be removed, or have to be put in place.

3.8 General Organizational Aspects/Changes

As there are many relevant organizational aspects with regard to KM, there are many studies and papers discussing these issues. On the one side studies like those of KPMG (see [64] or [65]) and on the other side Nonaka and Takeuchi [79] argue that members of lean organizations (nowadays, one of the most popular organizational forms) often lack the time and budget necessary to effectively share their knowledge. Nonaka and Takeuchi, furthermore, stress the importance of middle management, as this is the only group not concerned with either the big picture or details alone. Therefore, these arguments demonstrate that the members of an organization doing KM have to have the necessary time and budget in order to be able to share knowledge[11].

Other relevant aspects include the question what organizational structure is suited best for people that have to work together effectively (a topic that is discussed in a paper by Ferrán-Urdaneta [107]). One answer is provided by communities (especially in the form of virtual communities), which is discussed in more detail in a paper by Merali and Davis [74], for example.

Another important issue is to respect traditions and the current structure of organizations. Since these aspects are often neglected, many KM initiatives run into serious trouble and sometimes even fail due to this fact. If, on the contrary, these aspects are taken into account and considered they provide valuable input and help to ensure the acceptance of new structures. One way of addressing this issue is provided by participatory design that is described in more detail in section 5.1.2.

Summing up, this section illustrates what organizational aspects need to be taken into account by a KM initiative. These issues include problems encountered by lean organizations, the question of what organizational structure is best suited to KM, and the importance of respecting and considering traditions and the current structure of an organization.

3.9 Conclusion

This chapter describes necessary preconditions and aspects of a KM initiative and a KM-system ranging from the "wanting to do KM and knowing why" to general organizational aspects. Of course, there are numerous other important aspects to be considered, which comes as no surprise as KM taken seriously changes the way an organization works. Therefore, the presented issues either are of utmost importance to KM itself or are of high relevance to a KM-system.

[11] The success of the whole KM initiative is at risk, if this issue is not handled satisfactorily.

Chapter 4

Existing Systems/Solutions

As numerous IT systems exist that claim to support KM or indeed provide support, this chapter analyzes three systems that represent different ways of addressing the needs of KM[1]. These three systems are the solutions provided by Oracle, Lotus/IBM, and a smaller solution the author helped to develop (CYMANTIX.NET). For each system the reader will find a description of the features and functions, screen-shots providing limited insight into how the system looks, and an analysis discussing strong and weak points of the solution.

A multitude of other interesting and relevant solutions such as HyperWave (i.e. the Information Server), the KM solution of Ernst & Young (described in a paper by Ezingeard et al. [35]), or smaller but noteworthy solutions, for example, FieldWise (presented in a paper by Fagrell et al. [36]) exists. However, these three mentioned examples already suffice to illustrate the differences between such systems. While the HyperWave solution provides a rich set of features and functions similar to the Lotus/IBM example, the Ernst & Young example is a system tailored for the need of one organization and the FieldWise system is supposed to address specific KM needs. Still other solutions are centered on single aspects such as portal solutions or systems centered on a AI algorithm and would classify as KM tools at best.

The primary focus of this chapter is to present and analyze important and relevant examples of KM-systems. The next chapter will present principles and features of the proposed KM-system and the results of the following analysis is crucial to illustrate the principal viability and uniqueness of the proposed solution.

4.1 Problems Addressed by Practical Solutions

The majority of KM-systems described in literature is focused on addressing a confined number of KM issues. While there is only a limited number of

[1]Please note, that from this chapter onwards most occurrences of the goals and problems of KM do not differentiate between KM issues that can be supported by IT and those where this is not possible.

comprehensive[2] solutions, they are the most relevant examples in the context of this thesis.

For example, KM-systems like the Lotus/IBM solution or the system used by Ernst & Young address a wide range of KM problems and, thus, qualify as comprehensive solutions. On the other hand, smaller systems such as FieldWise do not provide support for the whole spectrum of goals and problems to be solved by KM and, therefore, only address a confined range of KM problems. However, even the comprehensive solutions are not addressing the full range of KM issues using the full potential of IT.

Summing up, existing KM-systems can be differentiated by analyzing the range of KM issues they address. Although there are very powerful and complex solutions, no system exists that addresses all identified requirements to the extent possible by technological means.

4.2 CYMANTIX.NET

Although CYMANTIX.NET neither represents a commonly used KM-system nor offers a wider range of functions than the other two examples, it is included in this chapter for two reasons: As a former part of the development team, the author possesses intimate knowledge of the functions and planned features and, secondly, CYMANTIX.NET provides interesting solutions for some KM problems.

This section is based on the never published version 2.0 of CYMANTIX.NET that would have been available in late 2001 / early 2002[3]. As the development was focused on providing a German version first, the screen-shots show the preliminary German version[4].

From a technological point of view, the main characteristic of CYMANTIX.NET is the usage and application of XML throughout the system. In other words, the used information entities are stored as XML documents in the database[5] and only converted to be displayed as HTML in the user's browser by XSLT style-sheets in the front-end of the system. Consequently, all interfaces of the solution to the outside, for example, to import or integrate other information sources, are processing or providing XML documents. Of course, all (user) input is sent in the form of XML documents from the front-end to the other parts of the solution.

The major features of CYMANTIX.NET include:

Individual and Group Views The hierarchical structure of CYMANTIX.NET is based on user and group views that provide folders representing the results of queries executed on the stored data. This allows

[2]Of course, as the term comprehensive is not an exact one, the actual number is open to discussion.

[3]The company had to declare bankruptcy end of October 2001 and the development of CYMANTIX.NET is stopped (most probably forever).

[4]The screens-hosts were taken in October 2001 using an alpha version of the 2.0 release and have been modified to include the correct icons for the different file types (a functionality that had not been implemented at the time the screen-shots were taken).

[5]Using the native XML database Tamino from Software AG.

creating folders containing all items that, for example, have a certain text as part of their title, a link to a certain topic or another information piece, etc. Consequently, one and the same item can appear in many folders at the same time.

Bi-directional Links between all Types of Information Entities The system allows to create links between related information items. These links are bi-directional and can be used for many purposes such as documenting two items to be related. It was planned to extend this functionality to include typed links and to offer automatically generated ones (for example, to provide access to similar documents).

A Flexible and Adaptable Permission System As access to the system and its information items (including the structure itself) is controlled by a fine-grained permission system, users see exactly those items that should be available to them. Obviously, this means that users may see different items in one and the same folder. Furthermore, permission templates are provided to free users from having to worry too much over the question what permissions are adequate for a certain item.

Full Text Retrieval Capability The search mechanisms enabled to find items based on queries for groups of words or even parts of a word in all relevant fields. These include longer text fields and made possible by using full text retrieval capabilities of the used DBMS.

Capturing Usage Information The system monitors usage information by keeping track of a detailed change history and recording the last access time of individual users to stored pieces. While this usage information provides a form of traceability, it was also planned to use this information for advanced features such as interest or process profiling.

A number of planned features had already been analyzed by the end of 2001 (development prototypes existed for some of them). The single most important example was connectivity and integration with the Microsoft PIM and Office software to add e-mail, calendar, and office functionality (allowing the easy insertion and retrieval of documents). Another planned feature was to compute similarities between documents and offer the user this information as additional context (based on technology provided by the Austrian Research Center). While the alpha release contained a user and group management, it was planned to use a directory service instead to ease user administration. Furthermore, it was discussed to offer the integration of a DMS so that customers could choose whether the base functionality of CYMANTIX.NET was sufficient for their needs or they needed the functions of a full-blown DMS.

Numerous features and functions were considered for integrating or providing them in later releases. These included user defined information types, user defined views (not just the queries themselves), or synchronization with different devices (like PDAs).

Although the CYMANTIX.NET design allows the integration of features and functions at all three existing layers, the easiest way is to add frames

from other systems to the CYMANTIX.NET web interface (similar to a portal server). Of course, if a tighter integration is needed the other two layers provide the capability to incorporate or provide XML documents and functions.

4.2.1 Screen-shots

A main issue to be addressed by the user interface is that it has to be intuitive and lower the time necessary for training. Although this cannot be experienced by studying screen-shots, some points such as the similarity of the hierarchical structure to the Windows Explorer are obvious.

Figure 4.1 presents the screen of a user after a successful log on. The tree structure visualizing the hierarchy of the information items is on the left, while the items of the selected folder are show in the center and the context (or permissions) on the right side. Above one can see the possible actions (such as choosing another action, changing the selected information item, or following a link).

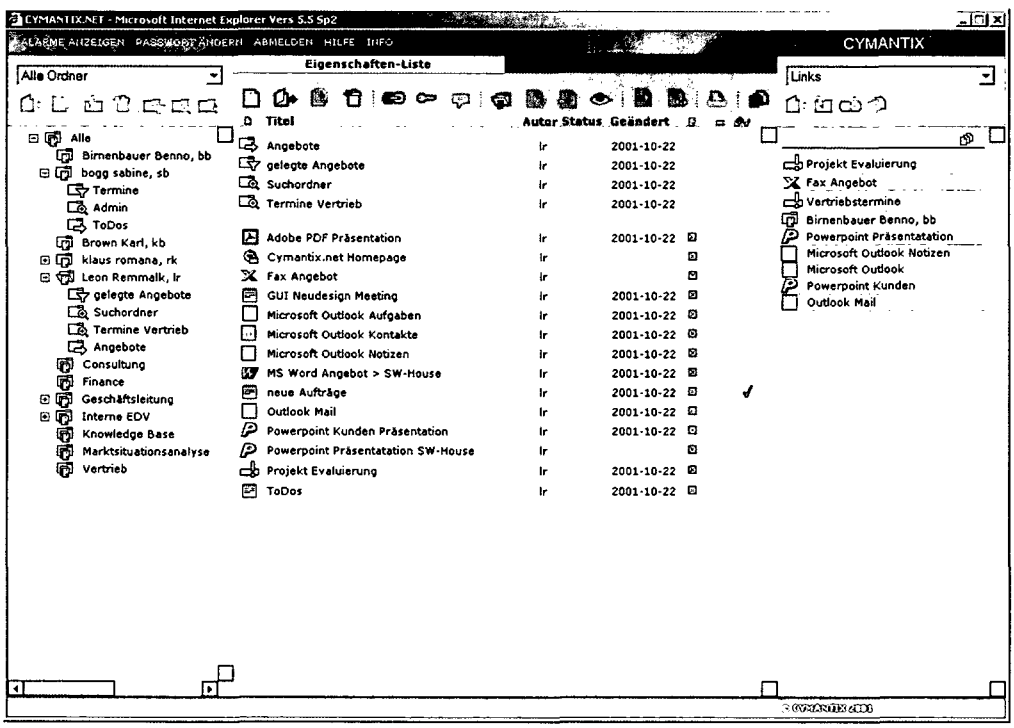

Figure 4.1: The Main View of CYMANTIX.NET

In figure 4.2, we see the permission dialogue (with the permission templates still missing). This dialogue offers to assign all sorts of permission to users and groups (including whether the item is shown in a user's or group's "personal" folder).

Figure 4.3 presents the primary screen when the details of a information entity (the shown attributes are common ones except for the file path) are shown in the center and the permissions on the right side. Indeed, this screen-shot

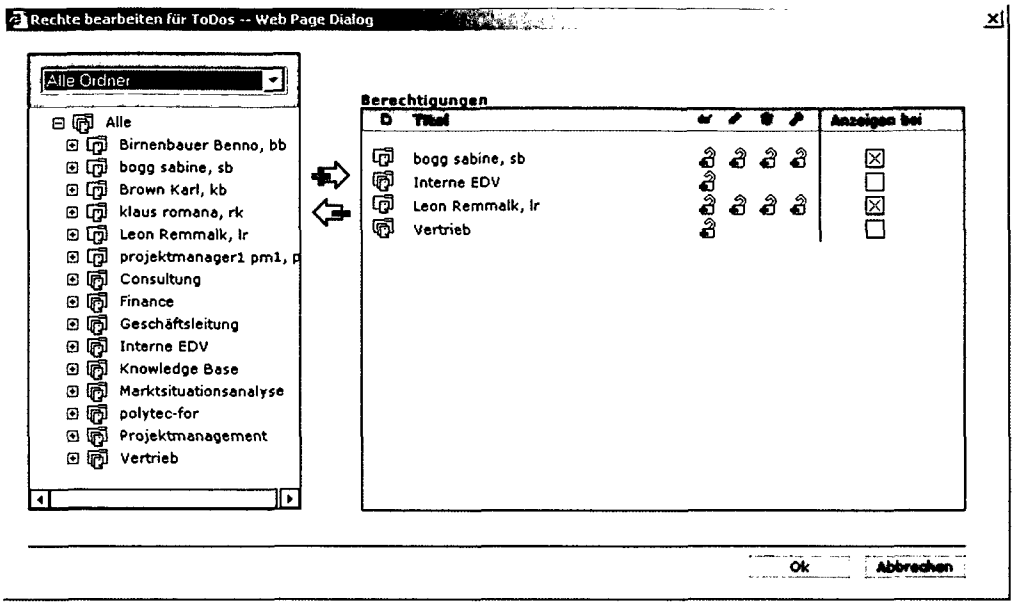

Figure 4.2: The Permission Dialogue of CYMANTIX.NET

demonstrates the different uses of the frames the web interface of CYMANTIX.NET consisted of. Furthermore, search queries were entered in the left frame and results appeared in the center in a similar way as the content of a folder that is depicted in figure 4.1.

4.2.2 Analysis

All in all, the CYMANTIX.NET system is best suited for the management of explicit information in the case of ad-hoc workflows or environments and groups that require a flexible IT solution. Furthermore, the used technologies and the offered permissions system provide a suitable basis for information sharing within an organization and even with partners (possibly by offering an Extranet). Although the concepts for integrating functionalities are sound, they have not been implemented.

Overall, the basic functions of CYMANTIX.NET offer many of the features a "complete" KM-system should provide, most notably the aspects of Searching/Finding, Permission System, and Context/Links/History. At the same time, the issue of Connecting People is addressed by the concept, which means that the system itself plus the integrated Groupware offer a satisfactory solution. Other issues such as Data Mining and Integration/Connection were planned but not available. Indeed, there are issues that are not addressed at all such as Automation, Transforming, offline functionality or support for AI technologies (i.e. by using or generating knowledge maps or ontologies). Summing, many important features and functions are missing in CYMANTIX.NET, while it illustrates an interesting approach.

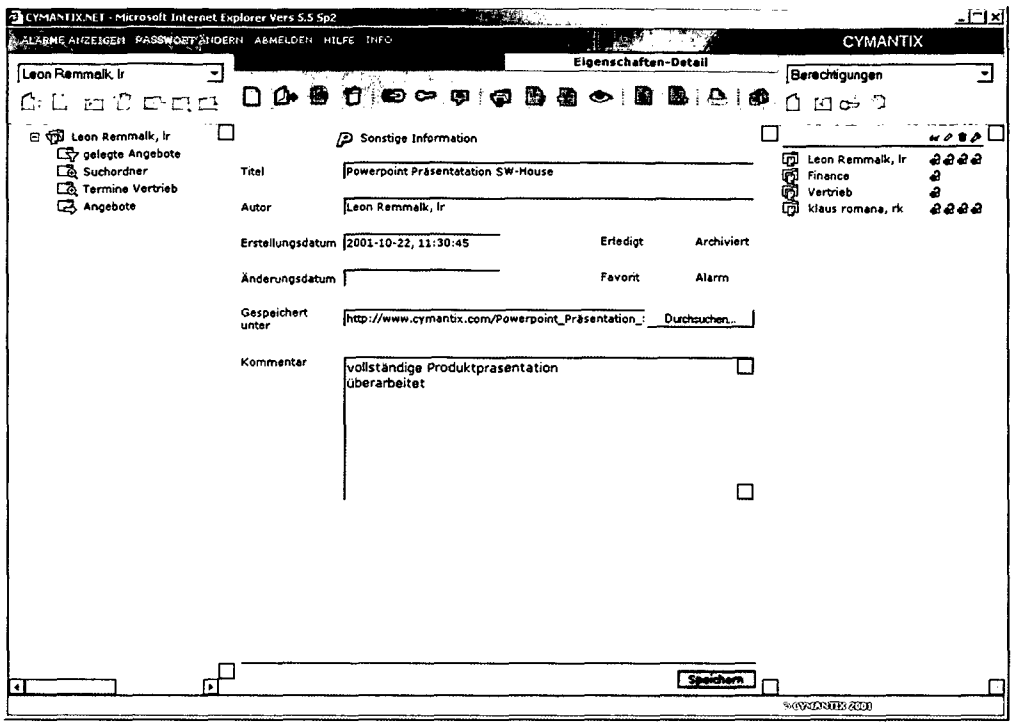

Figure 4.3: The Details of a Information Entity in CYMANTIX.NET

4.3 Oracle

The following description and analysis of the Oracle KM solution is based on information available on the Internet, on the material of a presentation held by Oracle and Contrast Management-Consulting on November 28, 2001, and on information acquired during a personal meeting with Robert Baumgartner of Oracle Austria in Spring 2002. As the presented screen-shots are taken from the presentation just mentioned, some of the texts are in German.

The center of the Oracle solution is the Oracle Portal that itself is a part of the Oracle 9i Application Server. While these products do not require a Oracle database, they work best on top of a Oracle 9i Database. The Portal addresses issues such as integration, searching & finding, and Content Management System (CMS) functions and allows users to adapt the user interface to their personal needs. Furthermore, the solution includes basic DMS functionality such as handling versions or check in/out and supports the integration of Groupware systems and their functionality (prepared for Exchange/Outlook and Domino/Notes). Accessing information is supported by a hierarchical structure and a powerful search functionality (based on a Oracle database feature offering full text retrieval that is able to read over 150 file formats when installed – user-defined ones can be added). The user management is performed by a directory service (any LDAP v3 compliant one can be used) and the Portal provides Single Sign-On capabilities and, of course, utilizes the feature itself. Documented APIs (based on XML and other standards like HTTP/SMTP/FTP)

are used for the connections between the different parts of the solution as well as to foreign systems and Development kits for these APIs are provided. The upcoming Portal version will also help to integrate normal applications by providing a WebDAV interface (so that users can navigate in the Portal structures with the Windows Open and Save Dialogue or a web browser, for example).

4.3.1 Screen-shots

The following screen-shots provide an overview on the look & feel of the Oracle solution. Thus, it accompanies the description given above and should make some points clearer to understand.

The figures presented in this section show the login page (figure 4.4), the initial page after the login (figure 4.5) including search functions and showing the personalization, the integrated mail functionality (figure 4.6) demonstrating the Oracle mail solution, a hierarchical view on the available data (figure 4.7), the forums feature (figure 4.8) providing access to the available forums, and the initial page of the sales portal (figure 4.9) as a part of the dashboard the solution offers.

As we can see, even the Login page (figure 4.4) is composed of multiple frames handled by the Portal. After a successful login, each user has his personal start page (figure 4.5) that is adaptable to the user's need (by either the user himself or the system administrator).

The described mail and PIM integration is shown in figure 4.6 demonstrating that the user's mail folders are accessible within the Portal as are the other functions provided by the embedded Groupware (for example, a shared calendar or to dos).

While the search functionality is not visualized by a screen-shot, the hierarchical view is depicted in figure 4.7. As illustrated by the screen-shot users are able to navigate in the hierarchical structure (the figure shows a structure of Oracle itself that allows users to access documents of certain regions or countries).

The Oracle solution provides forums that allow the users to communicate in a structured way. Figure 4.8 shows this functionality that is integrated in the Portal and easily accessible by the users.

The final screen-shot presents the Oracle Sales Portal in figure 4.9. While this functionality is specific to Oracle itself, it illustrates how additional functions can be integrated into the Oracle solution (at the same time, demonstrating that such features have to be added and are not built-in).

4.3.2 Add-On Products / Further Possibilities

The Oracle product portfolio provides a wide range of systems that offer additional functions. For example, the issue of customized access for devices with limited capabilities is addressed by 9iAS Wireless. At the same time, a full-blown workflow engine is available by the 9iAS Workflow product as is connectivity to other systems such as SAP R/3 or Oracle HR. As all major Oracle products feature a web interface and can be integrated into the Portal, it is

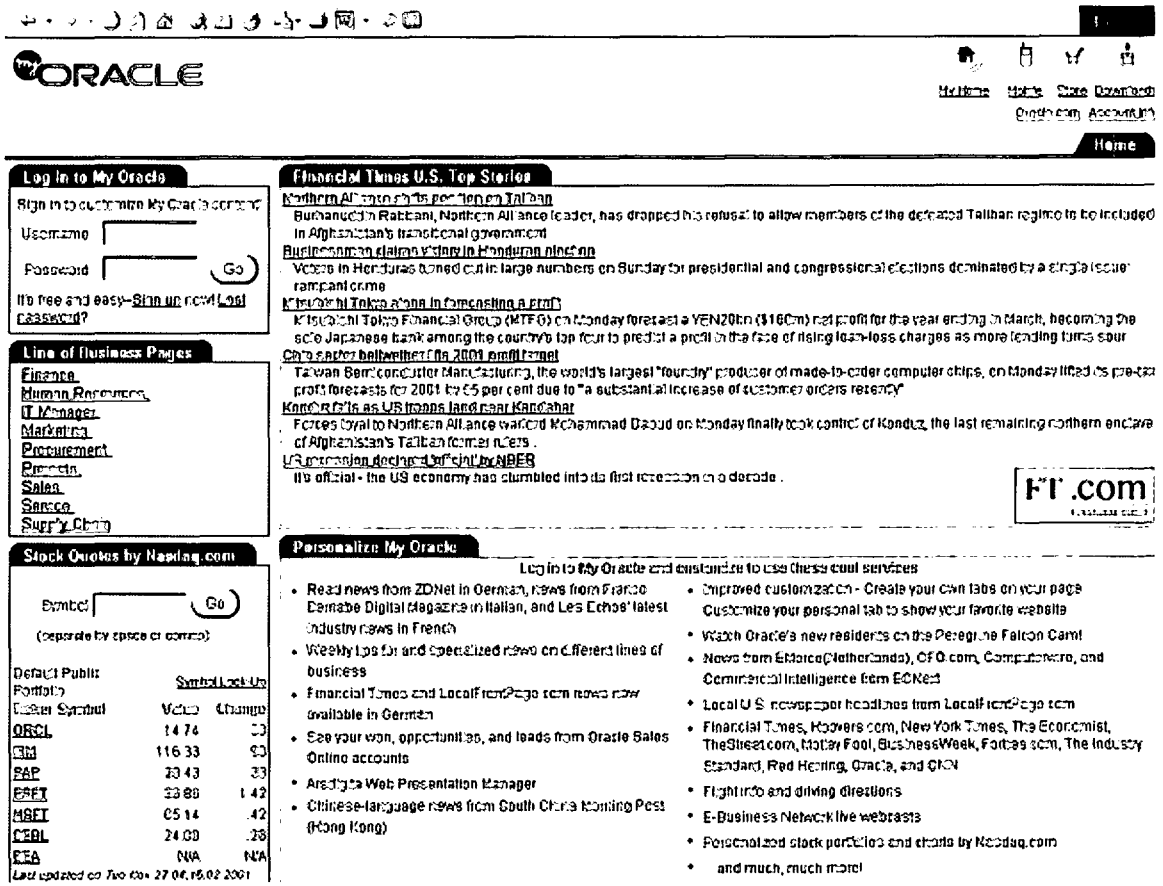

Figure 4.4: Oracle Solution Login Page

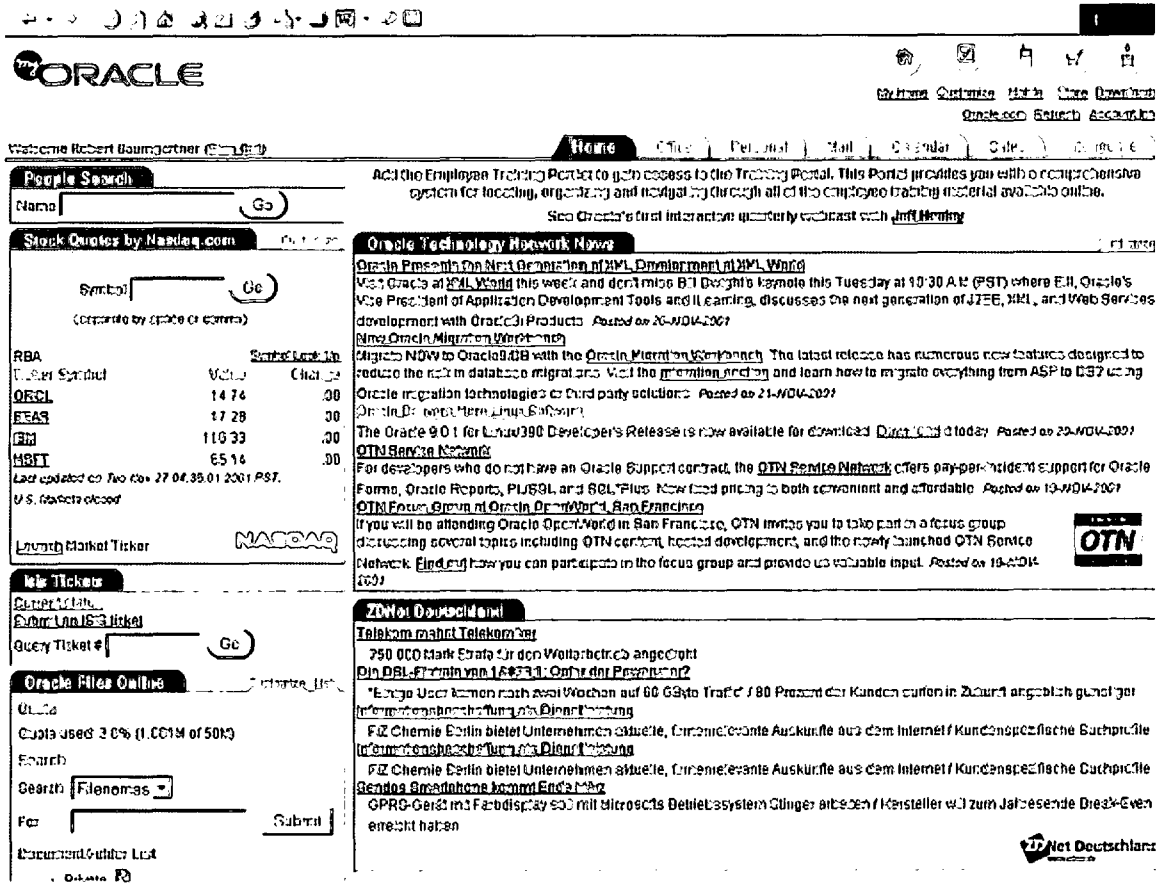

Figure 4.5: Oracle Solution Initial Page

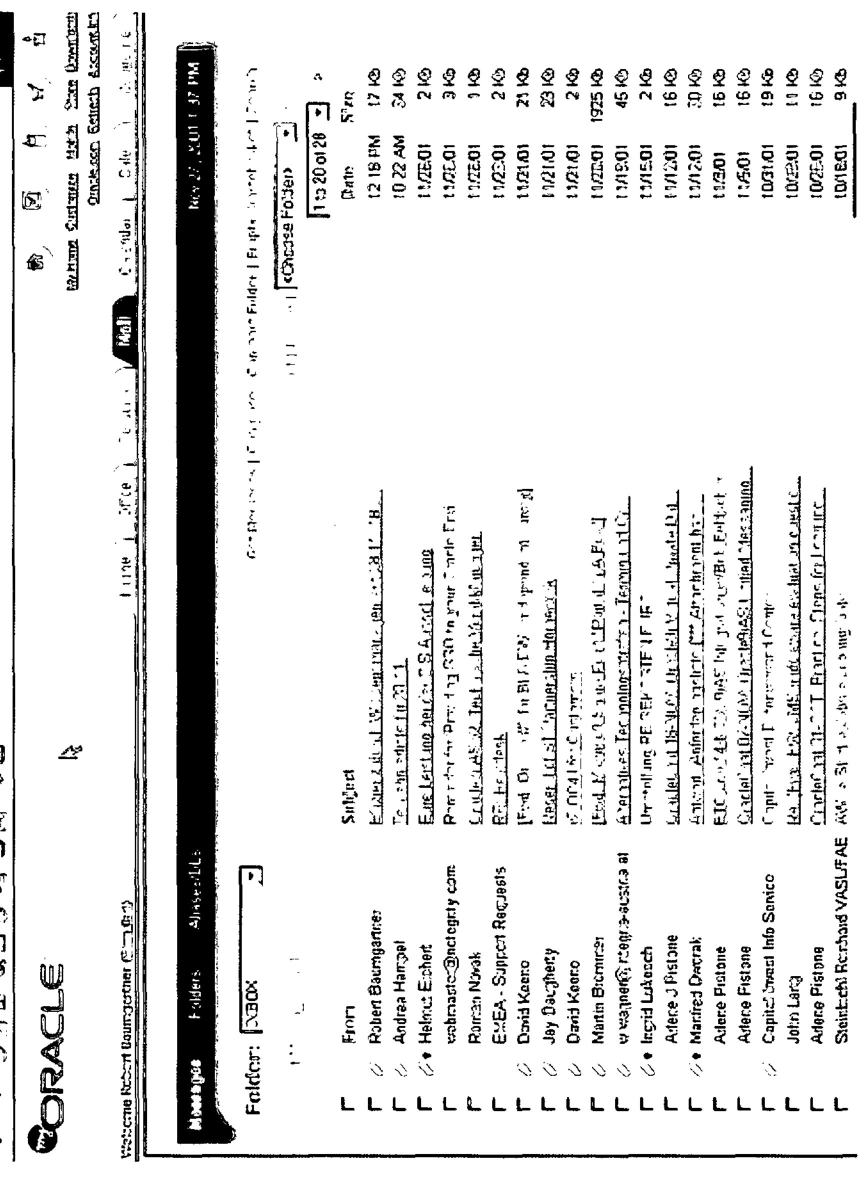

Figure 4.6: Oracle Solution Mail/PIM Page

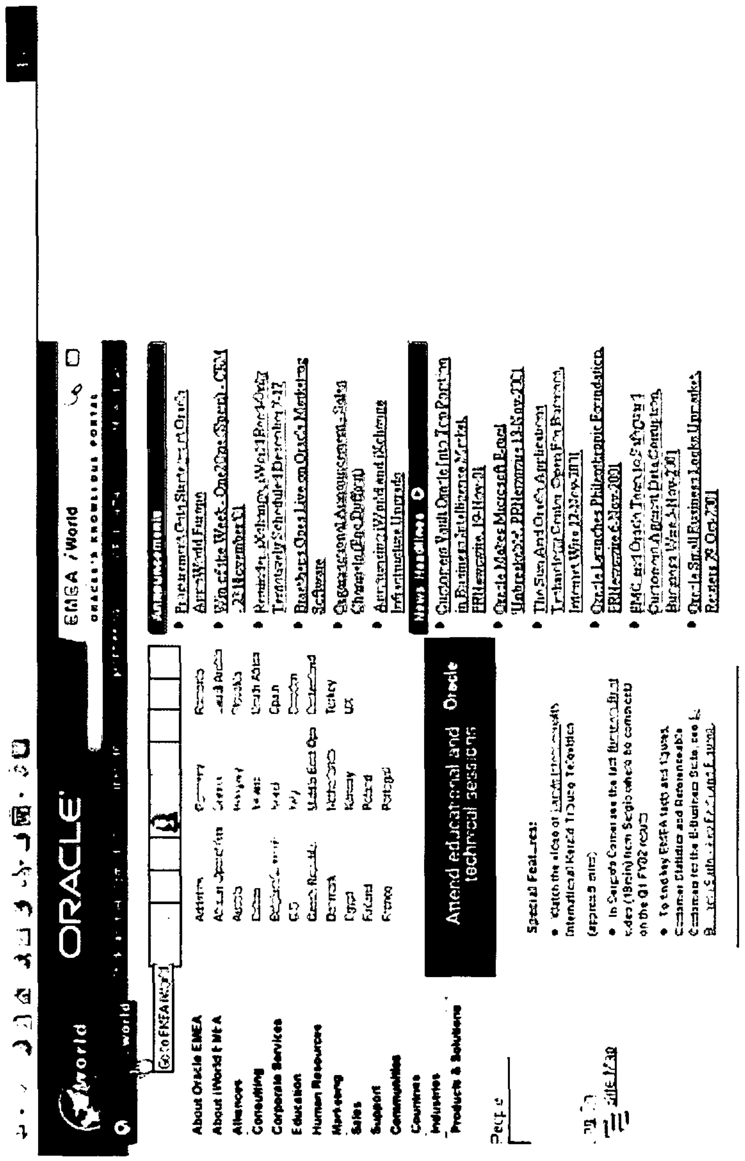

Figure 4.7: Oracle Solution Hierarchical View

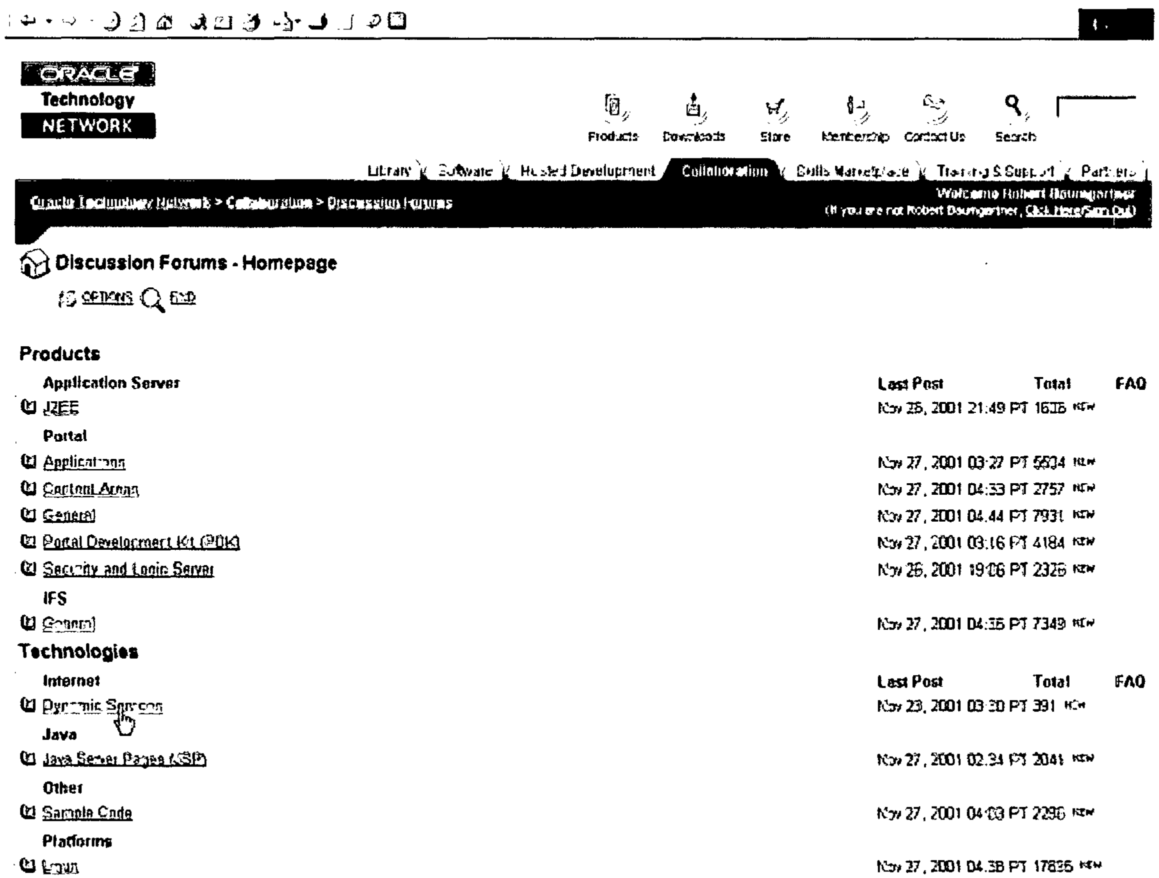

Figure 4.8: Oracle Solution Forums Page

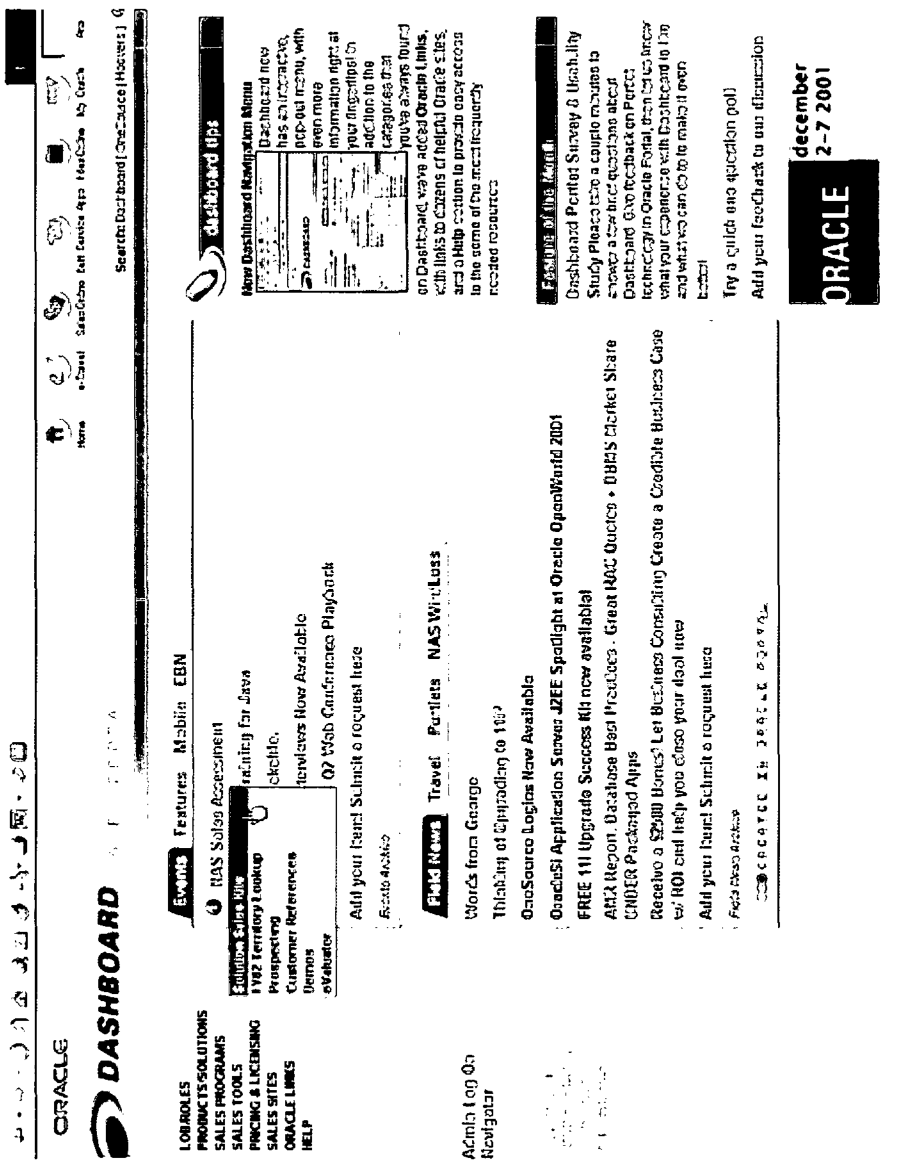

Figure 4.9: Oracle Solution Dashboard/Sales Portal Page

possible to add various other functions such as, OLAP (On Line Analytical Processing), ad-hoc Queries, Reports, or Data Mining functionality.

To address issues beyond the scope of available products and functions, it is possible to build further functionality using the development kits of Oracle. Important examples are the 9i Lite database for the implementation of offline applications and synchronization functions, or the support for mainframe connectivity.

4.3.3 Analysis

All in all, a combination of Oracle products (as presented with the screen-shots) is able to address a major part of the identified requirements to a certain degree. However, most of the provided functions are centered on managing structured data and solutions of other issues such as Data Mining or Personalization seem to provide a limited set of capabilities (for example, the personalization feature has been developed for online shops). Furthermore, the Portal offers some features to address issues of organizations that need to be flexible but these capabilities are not supplemented by functions of other products. Therefore, these features do not offer satisfactory support in this domain.

Summing up, the Oracle solution provides superior technological means to manage explicit information. On the other hand, the support for the transfer and capture of implicit information has serious shortcomings.

4.4 Lotus/IBM Software (Knowledge Discovery System, Notes, ...)

The following description and analysis of the Lotus/IBM KM solution is based on available information on the Internet (for example, the Lotus Internet page [28]), on an article of Weber in the magazine c't 20/2001 [112], and on information by Markus Wieland who was responsible for a (canceled) project to use the Lotus KM software at the RZB (Raiffeisen Zentralbank—the central institute of one of the largest banking sectors of Austria). The screen-shots are taken from a presentation of the Discovery System product by Lotus.

There is a wide range of tools and systems offered by Lotus and IBM that are capable of supporting certain aspects of KM. For example, advanced Groupware functionality is available with Lotus Notes/Domino and there are numerous tools and enhancements available. However, the Lotus Discovery System consisting of the Lotus Discovery Server and the K-Station is **the** KM product of Lotus and, thus, the focus of this analysis. The K-Station is a portal software and IBM is currently concentrating portal functionality in its WebSphere application server and, therefore, the K-Station will most probably be integrated in the future. The Discovery Server is based on AI technology and provides advanced functions such as knowledge maps. A multitude of other Lotus products such as InstantMessaging (as the formerly known SameTime will be called in version 6.5), QuickPlace, or products supporting eLearning offer functions relevant from a KM point of view.

All in all, the heart of the Lotus KM solution is the Discovery Server that utilizes all available data and information to generate taxonomies, compute affinities between topics and people (identifying them as "experts"), etc. Other parts either provide the necessary information or offer established technologies such as Groupware or Instant Messaging (of course, these issues are of great importance for a KM initiative as has already been demonstrated).

4.4.1 Screen-shots

The following figures (4.10 and 4.11) demonstrate the look & feel of the Lotus solution. While there are, of course, numerous other important aspects of the system, the presented figures illustrate the most important aspects of it.

These other aspects represent traditional technologies offered by separate products such as Lotus Notes, InstantMessaging, or QuickPlace. Therefore, these aspects have a different look & feel but can be integrated easily into the Discovery System.

The first screen-shot (figure 4.10) shows the screen of a user interested in the topic of "domino notes client". It visualizes the People (showing one knowledgeable person), Places (none available in the example), and Things (the available documents) slogan that Lotus propagates. Furthermore, we see a part of the taxonomy behind (presented by the Subcategories) and the search capability can be identified on top of the page.

Figure 4.11 demonstrates how the result of a search looks like. The user has the possibility to choose whether he is looking for documents, knowledgeable people, places (perhaps containing discussions about the searched topic), or categories related to the query. The scores presented are the result of rather complex operations not fully disclosed by Lotus (definitely going beyond simple full text or authorship systems).

4.4.2 Detailed Discussion

As Lotus Notes is one of the most prominent examples of a system providing Groupware functionality, there is no need for a detailed discussion of the provided functions. Furthermore, the K-Station is an example of a portal system and, therefore, a brief discussion of its features suffices. The K-Station provides user and group views to the offered information and functions, most importantly integrated information sources such as Lotus Notes, Microsoft Exchange/Outlook PIM, or search engines such as Google.

This section already established the fact that the Discovery Server is the most important part of the Lotus/IBM solution. This server is working with one or more taxonomies that can be entered manually or be generated to classify pieces of information and fields of expertise. Although generated taxonomies will often need adaptations, their usage reduces the amount of time to acquire one in virtually all cases. As multiple taxonomies will be needed to accommodate the needs of the different parts of larger organizations, combining multiple taxonomies is necessary and should be possible since version 1.1. After the

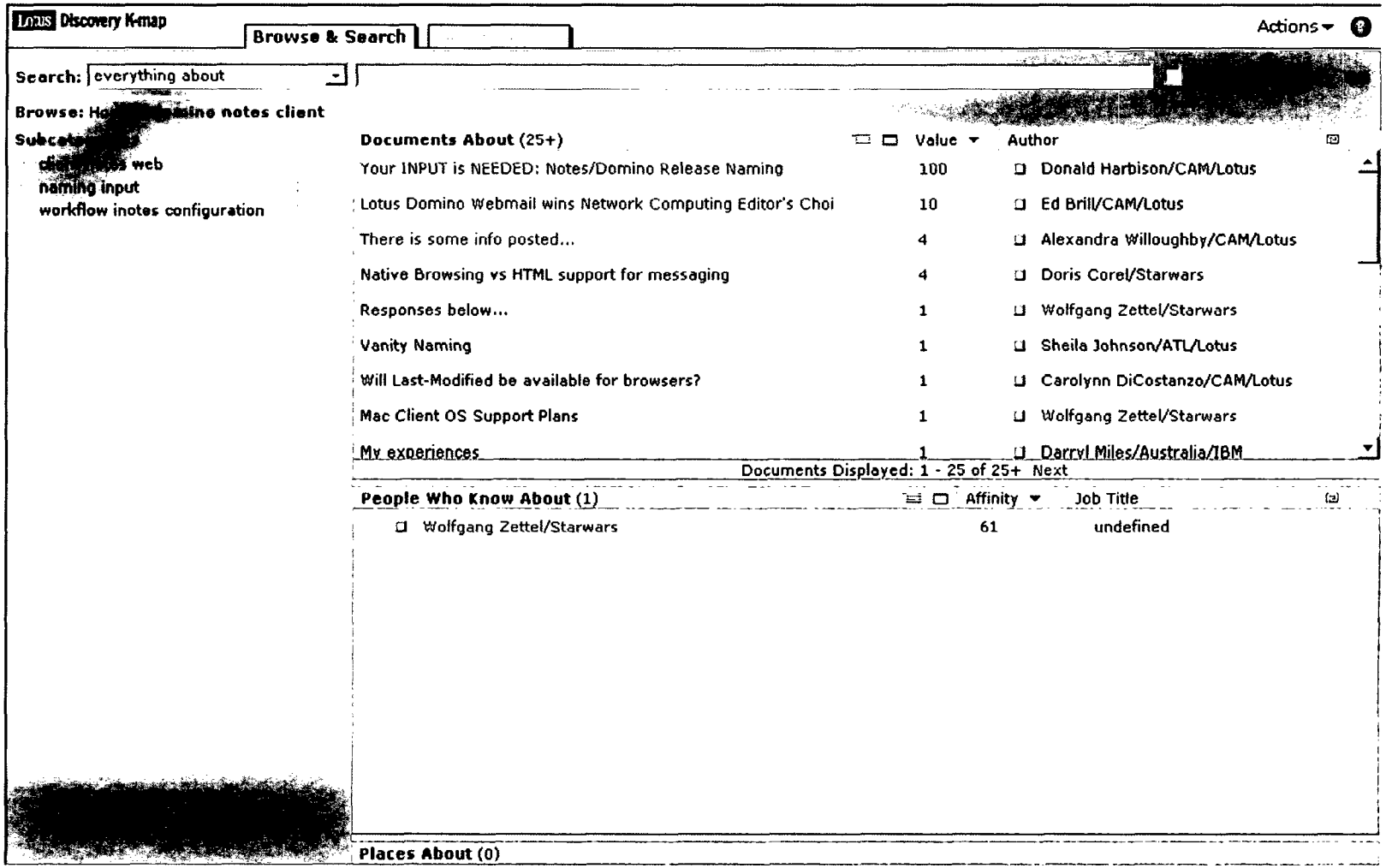

Figure 4.10: Lotus Solution Browse & Search Page

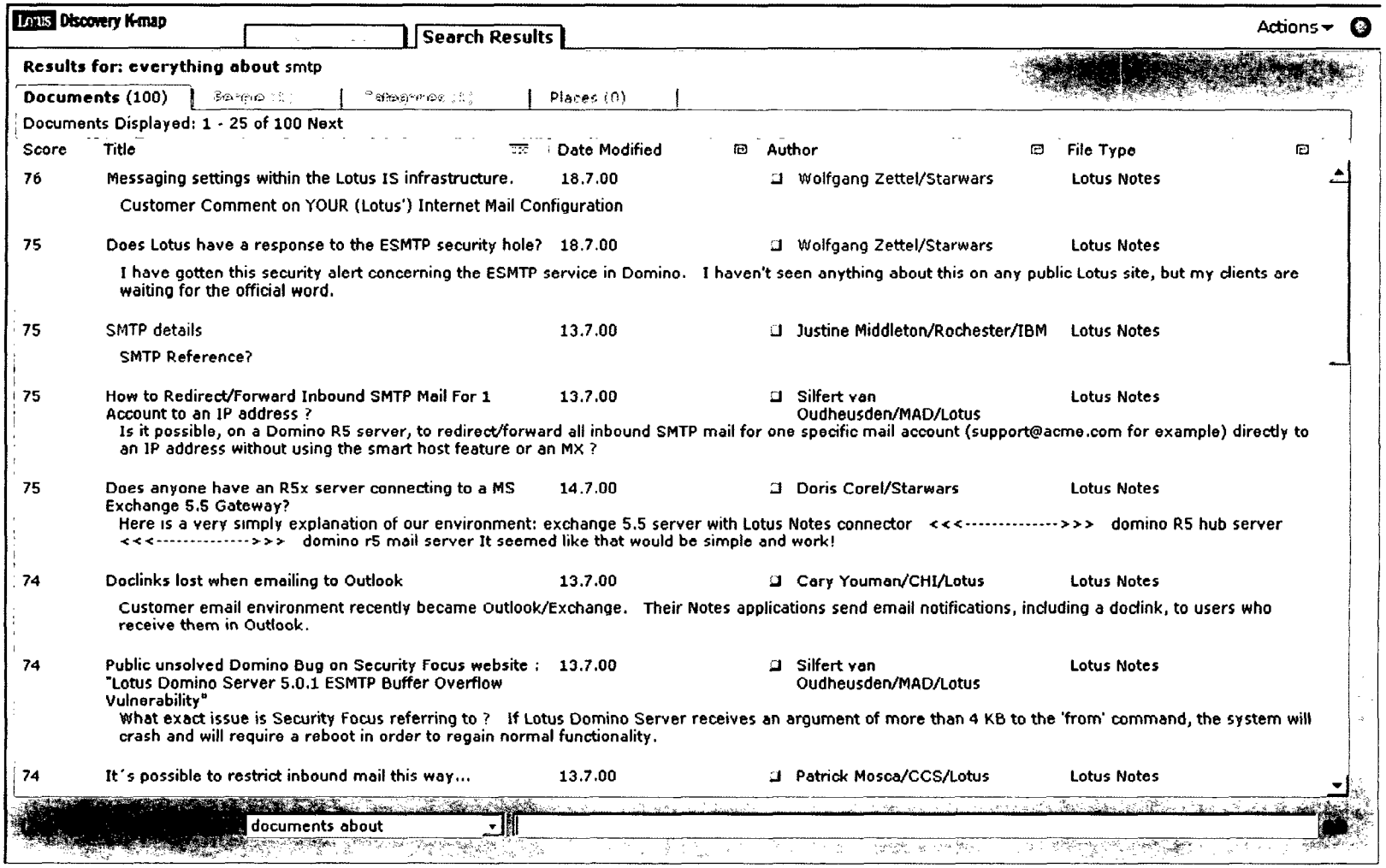

Figure 4.11: Lotus Solution Search Results Page

hierarchy(ies) have been defined, the software is ready to classify all pieces of information in the defined places.

Another major feature of the Discovery Server is to discover affinities between people and topics. While it is obvious that the solution uses an advanced algorithm (it even identifies the correct affinity if the document is inserted by somebody else; for example, a secretary), Lotus is not revealing the actual mechanisms behind. All in all, this functionality works surprisingly well and provides a form of a skills database.

Even without additional products, the Discovery System provides functions to support group collaboration such as restricted shared places or role-base actions. If more features are needed, other products such as InstantMessaging or QuickPlace can be integrated and provide collaboration features such as chat and forum. InstantMessaging, for example, adds the information whether an expert that was returned by a specific query is on-line at the moment and offers the possibility to chat with the person, send an e-mail, etc. in that case.

If the offered capabilities to search and find documents are insufficient, the IBM Enterprise Information Portal (EIP) can be added to enhance those features. The EIP is capable of connecting to hundreds of data types, syndicated content, etc. and allows to search within all the available data.

4.4.3 Analysis

While the Discovery System is supposed to be an independent product, at least version 1 required a Domino server managing the user accounts and providing other services. Furthermore, while it is easy to integrate Lotus Notes applications, there is the need to adapt all non-standard applications to the needs of web access[6]. Of course, such adaptations incur high costs.

Although using and maintaining different taxonomies for all larger parts of an organization is the best solution from the users point of view, the costs of such an approach have to be considered. Therefore, it is important to decide how many taxonomies are necessary in an early phase of a KM initiative.

Summing up, the described technologies and systems, especially the Discovery Server, provide solutions to many of the identified requirements of KM-systems. The combination of conventional features such as Groupware functionality and advanced technologies such as maintaining taxonomies and expertise profiling is suited best to address the issues at hand.

4.5 Evaluation of the Existing Solutions

Each one of the three described solutions has its clearly defined focus that separates it from the others. For example, while CYMANTIX.NET offers significantly less features and functions than the other two systems (to a certain degree the difference can be found in additional products integrated into the two systems), it represents the most tightly integrated solution. Strong points

[6]The applications are able to run without any modification but are hardly useable in that form.

of CYMANTIX.NET are the provision of all kinds of context and bi-directional links. The Oracle solution, on the other hand, is focused on handling large amounts of structured data (best stored in an Oracle database) and providing all sorts of relevant technologies but also offers additions to handle unstructured data in special areas. Finally, the Lotus solution offers the most powerful functions to manage unstructured data and information with the Discovery Server and superior Groupware functions when combined with the Domino server (the most sensible approach).

4.5.1 Problems Addressed Efficiently

Two points all three solutions provide are a flexible and adaptable permission system and full text retrieval capabilities. While basic usage information is recorded by all three solutions, it does not seem to be integrated well in the case of the Oracle solution. Finally, all systems offer support for ambiguity, which CYMANTIX.NET even includes as part of its concept.

4.5.2 Problems Addressed to a Certain Degree

Not surprisingly, Groupware functions are best addressed by the Lotus solution when combined with a Domino server. While Oracle has and offers its own (less elaborate) Groupware system, CYMANTIX.NET needs to integrate an existing one (which is also proposed by Oracle for its own solution).

Access to external systems / information is included in all systems. While CYMANTIX.NET does not provide an actual implementation to evaluate that capability, the Lotus and Oracle solution provide access to a multitude of data sources directly, with third party software, or through pieces of individual software.

As CYMANTIX.NET should be used either stand-alone or integrated with other systems, it does not offer Portal functionality itself. The solutions of Lotus and IBM, on the other hand, include a portal server and many of the offered functions are integrated using this functionality.

Although all three solutions offer hierarchical structures (especially powerful in the case of the Lotus systems with the generated taxonomies), there are shortcomings in each case. Therefore, the hierarchies need to be defined or refined manually.

4.5.3 Problems Not Addressed At All

While none of the products addresses the need to synchronize with mobile devices or to provide offline functions, there are third party products for some aspects of Lotus Notes. Nevertheless, none of the systems offers direct support.

A functionality missing in all three solutions is to use AI methods directly. Although only a small number of users will have the actual need, this represents an important issue.

Chapter 5

The Solution

This chapter presents the proposed solution of the goals and problems of KM and the resulting requirements (as described in chapter 2). At the same time, this solution is a "complete" KM-system and, thus, differentiates itself from the systems described in chapter 4. While the proposed KM-system concerns itself only with technological issues, the next section, centered on principles of a KM-system, also contains brief discussions of sociological and organizational issues. Afterwards, the solution and its building blocks are presented and discussed. As eLearning is a topic closely related to KM and often argued to be a part of it, the relationship of eLearning & KM is discussed in the following section. Finally, implementation issues are considered and an evaluation of the solution is provided.

5.1 Principles

Section 2.5 presents the requirements KM-systems have to address. Consequently, this section is now presenting principles of KM-systems from a technological point of view and within the bounds of the proposed solution. These principles are used as guidelines for the proposed KM-system. While some of the presented principles are general ones (like not introducing a new tool), others, (e.g. Single Sign-On) are more specific, though all are of high importance.

Of course, many of the postulated principles are addressed by existing systems and in fact every single one of them is already implemented in some piece of software. However, the whole set (combination) of exactly these principles and the "complete" KM-systems based on them is unique.

5.1.1 General Principles

While the principles presented next are general ones, adhering to them is vital when designing a "complete" KM-system. However, as no implementation is presented[1], an actual initiative might decide to disregard certain principles. If there are good arguments for ignoring one of the principles, it should be done.

[1]Not only is it very expensive to build a KM-system, but adapting a solution to the needs of an organization is another obstacle.

For example, the first principle is "no new tool" and there are reasons to ignore it, for example, when the KM-system is built on top of an existing system. In many cases an Internet/Intranet solution is the most appropriate approach to build and introduce a KM-system. Consequently, the question arises whether an Intranet is a new tool[2]

No new Tool Overall, the principle of "no new tool" is one of the most important issues, as users are familiar with existing systems and their re-use, thus, allowing an easier introduction of the KM-system. However, as the user interface of the KM-system determines how effectively the actual users can work with it, any existing system considered for re-use has to adequately support all (or most) of the GUI issues of the solution. Otherwise, this principle has to be ignored and, at the same time, one should try to reduce the number of systems people have to deal with by replacing the user interfaces of at least two existing systems.

Utilize Groupware/Provide Communication A "complete" KM-system definitely needs to offer sophisticated Groupware functions. At the same time, data and information available by Groupware systems, for example, meeting and communication related pieces of information, have to be integrated into the knowledge base of the solution, as certain aspects of automatic information generation or advanced queries rely on this information. Furthermore, the KM-system has to provide flexible and diverse ways of communication either by utilizing Groupware functions or offering a number of them directly[3].

Storing/Archiving As Organizations are constantly generating new information items in various forms (documents, etc.) that need to be stored and eventually archived, the need for storing and archiving capabilities is obvious. As this functionality is typically offered by DMS, the most practical approach is to integrate one of those systems. Summing up, the key issue is to integrate the capabilities for storing and archiving, possibly extended by the ability to handle portions of documents.

Provide Context/Links/History The provision of context, links, and history by the proposed system allows the users to access related information items, browse the change history, and be aware of historical and project context. Consequently, this information has to be captured whenever possible and generated if feasible.

Yellow Pages/Shielding Experts As yellow pages / a skills database allow people to find experts within an organization, they represent an important functionality of the proposed system. Therefore, they have to be kept

[2]If an Intranet system is introduced, it definitely classifies as a new tool. At the same time, Internet and Intranet applications are widely used and users are familiar with them. Therefore, using an Intranet for the KM-system is a valid case of "introducing a new tool".

[3]Please note that integrating a Groupware system and only adding functions missing is the most sensible solution in virtually every case, as current Groupware systems are highly sophisticated and there is no justification to build a new one.

up-to-date and made available. At the same time, experts have to be shielded from routine questions, for example, by requiring members of the organization seeking assistance to read the relevant FAQ before any actual contact, to prevent the experts from becoming overloaded. Although this principle is very important, one has to keep in mind that typically only a minority uses such systems[4]. Nevertheless, a skills database is especially helpful to newcomers, who typically lack an informal network, in finding knowledgeable people.

Provide Ambiguity As ambiguity is encountered constantly in real life, a KM-system has to support this facet of reality. A simple example is to have one and the same document appear in multiple views / folders. The proposed system has to offer support for ambiguity in different forms and ways.

Integration of all Relevant Information Perhaps the single most important principle is to integrate all available information. The key issue is to provide effective access to all information that might be of interest to the users and other parts of the system. Based on this information, users are able to decide more accurately, while, at the same time, advanced algorithms are able to generate new relevant information.

Powerful Search/Retrieval The proposed KM-system needs to provide an integrated search and retrieval functionality that gives the users access to every single piece of information. While the data might be stored in various systems, the solution should offer a uniform way of searching and presenting the results[5].

Hierarchical Access Hierarchical access is complementing the principle of "powerful search/retrieval", as the proposed KM-system should support different cognitive styles and the mentioned examples are addressing the most important ones. While file systems offer a simple solution, more complex ways of providing access are, for example, knowledge maps.

Adaptability of the Solution Although adaptability has already been identified as a requirement in section 2.1, this issue is an important principle of the proposed solution. As there will be normal and power users in most cases, both groups need to have their problems addressed. Therefore, the system has to allow customization of the working environment as far as possible, considering the costs such diversity can cause. The key point is allowing the look & feel of the solution to be adapted to each user's individual needs, while at the same time limiting the costs imposed by supporting staff.

[4]In most organizations the majority of its members uses informal networks to get the answers sought. Consequently, one should assume that many people would not use such a system, while others will benefit from it.

[5]However, as some of the underlying systems will offer different search capabilities than others, the user interface for the advanced search mechanism might not be able to hide such discrepancies.

Automation While automation is presented as a requirement in section 2.5.9, it also represents a principle of the KM-system. As the description of automation as a requirement already contains examples of its application and illustrates the importance of this issue, an additional discussion seems avoidable.

Based on the requirements (see section 2.5), the presented list illustrates those general principles that can be discussed in brief. The more complex principles are described in the following sections in more detail.

One important issue that has already been mentioned above is that of supporting different cognitive styles. As this is more a general issue than a principle of its own, this paragraph provides a short discourse. The proposed solution needs to offer diverse possibilities of using it (additional to the need of adaptability that has already been established) so that the different ways of people to learn and work are supported. Therefore, the system needs to offer functions such as a forum, chat capability, knowledge maps, powerful means of searching information, an index, yellow pages, etc. Not only does this aspect provide additional arguments for some of the principles above, but it also has to be taken into account by a "complete" and holistic KM initiative. Summing up, the different cognitive styles of people are one of the most important arguments that all the functions and features that have been and will be described are necessary.

5.1.2 Individual Solution: Participatory Design

This section illustrates and discusses the importance of an individual solution for every encompassing KM initiative. As this thesis already presented the importance to analyze an organization and its processes before dealing with any IT issues at all, an individual solution is the only way to address all issues of an individual organization[6].

One of the most effective ways that results in an individual solution is using the methods of participatory design. A paper by Hoffman et al. [52] (although primarily describing issues that form the background of another principle of the solution) presents and demonstrates why and how participatory design can be applied.

Perhaps the single most important issue of participatory design is that each design or re-design of a process by the KM initiative is done together with the members of the organization that will have to execute it. Thus, this integration ensures, at the same time, that the current situation and ways of working are taken into account, as superiors often lack the knowledge of important details of work procedures. Furthermore, this integration will result in important input on how to improve the current ways of working. Equally important is the fact that all people who have helped to define the new processes will know how they

[6]Of course, shrink-wrapped software is capable of supporting KM initiatives to a certain degree and each organization has to decide whether they can use such a package, while, at the same time, accepting limitations in some areas.

are supposed to work and why they are designed that way and will be able to help other members of the organization in implementing and executing them.

While it is obvious that this principle is addressing organizational and process-related aspects, the results of employing this principle are essential to the success of a "complete" KM-system in the context of a "complete" and holistic KM initiative. Perhaps the most important issue is that this principle ensures that the current situation of an organization is taken into account and that members of an organization are integrated in the process of defining and changing work procedures.

5.1.3 Differentiate Short from Long-Term Effects

While this principle cannot be addressed by a feature or functionality of the proposed system, it needs to be considered by a KM initiative and during the design, implementation, and introduction of a KM-system. Therefore, a KM initiative needs to define how it measures the effect it has on the organization and the KM-system has to provide data necessary for this evaluation. Furthermore, the KM initiative and the KM-system together have to enable the realization of short-term effects to encourage the adoption of the new system and the new work procedures.

Early Effects to Encourage Usage

KM (as well as a KM-system) needs reinforcing influence to establish itself in an organization and early (or short-term) impact that demonstrates the positive effects head-on. This is the best way to convince the organization's members of the validity and benefits of KM. While participatory design is one of the principles that helps to design and implement a system that allows working more effectively from the beginning, a KM initiative that fails to deliver short-term benefits will encounter serious problems and may subsequently fail[7].

A paper by Mahe and Rieu [68] describes a pull approach that promises immediate effects of KM, especially in the case of small to medium sized enterprises, thus, providing one possible way of dealing with this issue. The authors continue by describing, when the pull approach needs to be accompanied by a push-approach in order to address the whole range of KM problems. While this paper also states that smaller companies will often lack the resources to implement an elaborate approach, less elaborate approaches will not be able to provide all the positive effects of KM. Overall, this approach shows that similar arguments are discussed by researchers and proves the point made. Another paper by Koneru [62] presents the use of knowledge networks for real time project management and reports that a working and populated (information) repository was the key to generate the necessary attraction to users. Thus, this paper also illustrates the importance of early effects for KM.

[7]Lacking short-term benefits a KM initiative can only concentrate on convincing the members of the organization of the long-term effects. However, there is the danger of loosing support by management and the lack of uptake by all members of the organization that may effectively "doom" the whole initiative.

The Danger of the Low Hanging Fruit

While the previous paragraphs argued that providing short-term effects is essential, there is a grave danger associated with this approach, namely only reaching for the low hanging fruits and missing important benefits. As some short-term benefits either have negative long-term effects or prevent to benefit from other effects, a KM initiative needs to consider all short-term and long-term effects in combination to address the potential problems symbolized by low hanging fruits.

Conclusion

The KM initiative and, consequently, the KM-system have to be modeled, designed, and introduced in a way that the organization's members recognize immediate positive impact, while the foundation for long-term effects is being established. Furthermore, together with clear and simple explanations of the long-term effects the immediate positive impact helps to realize the whole range of positive benefits of KM.

5.1.4 "Supporting" Tacit and Implicit Knowledge

Although IT cannot capture tacit knowledge and is incapable of managing knowledge, KM-systems have to provide support for knowledge transfer by humans and capture all possibly relevant pieces of information. While implicit knowledge can be captured whenever it becomes "available" in an electronic form (for example, sent in an e-mail), such information normally represents unstructured or contextual information. As the definition of tacit knowledge states that it is inexpressible, this kind of knowledge cannot be captured by IT systems. The proposed solution provides diverse ways of communicating and collaborating, and therefore offers support of tacit knowledge transfer to a certain degree (for example, by offering video conferences or allowing people to work on a shared document). More information on the possible support of tacit knowledge by IT can be found in a paper by Johannessen et al. [58] describing the impact investments in IT have on tacit knowledge. Therefore, a KM initiative needs to foster and support sharing of tacit knowledge using mainly non-technological means. For example, it might help to provide informal meeting spaces such as a coffee room. Indeed, one of the most prominent and important points described in literature is to provide time and space for informal knowledge transfer (space management).

On the other hand, supporting the extraction, sharing, re-combination, and retrieving of implicit knowledge can be done or is supported by a range of technologies[8]. Consequently, this principle mainly calls for the support of implicit knowledge by the KM-system that is very relevant for high tangibility processes.

[8]Most of these technologies or systems claim to support tacit knowledge, as the authors of the respective papers use the tacit / explicit classification of knowledge.

5.1.5 Integration Into Normal Work Procedures

While the principle of integrating KM into normal work procedures has been mentioned and argued for previously, its importance justifies this section. At the same time, this principle is based on the corresponding requirement (see section 2.5.11) and descriptions in literature (for example, a paper by Hoffman et al. [52] describes embedding KM in everyday work).

The most prominent (and obvious) problem to be addressed by this principle is that of avoidance of a separated KM-system. Integrating KM into normal work procedures not only helps to address this problem, but also reduces the time needed to insert information into the KM-system. As people are experiencing more and more pressure to work more effective, the KM-system should aim to reduce the time needed for inserting the necessary information into corporate systems. To put it in a nutshell, a KM-system is only effective if it saves time and improves quality.

The importance of providing an integrated system is also illustrated in a recent paper by Fehér [37] containing a description of a KM-system that was not accepted by fresh employees and one even remarked (sic!): "We feel almost as a punishment the handling of the knowledge base". Therefore, one needs an integrated system that is easy to handle and saves time.

While many of the described principles are very important, this particular one represents a cornerstone of a successful KM-system and should be a top priority[9]. Overall, there are two options for integrating the KM-system in the normal work procedures: Either using one system that offers all necessary functions, or integrating the available systems.

While using/enhancing one integrated system has its pros and cons, it is not necessary and, therefore, should only be done if the organization already uses one system for most of the needed functions. Among the many advantages of one integrated systems are the consistent and integrated user interface and the usage of a known tool. While the disadvantages depend upon the actual system, typical problems are encountered when integrating other systems or trying to adapt the solution.

The alternative to a single system offering all functions is to integrate diverse systems and their data. If no suitable system is in place, the most appropriate solution is to use a portal (Intranet) to integrate all relevant systems. Of course, this is a violation of the principle "no new tool", which can be justified as no other suitable basis exists and Intranet applications are very common: a concept most users already are acquainted with.

As there are ongoing research activities and software projects addressing the problems of integrating heterogeneous information, there is no need to go into further detail. For one of the most active research projects in this area (the TSIMMIS project) please consult the papers by Chawathe et al. [20], Li et al. [66], and Papakonstantinou et al. [82] or their publication list (see [105]). Furthermore, in chapter 4 there are descriptions of existing solutions and how they address the problem of integrating a multitude of data sources.

[9]While this principle might not seem to be that important from a theoretical point of view as people should be willing to use a KM-system (in theory), the numerous reports of failed systems illustrate the paramount importance.

Comprising, the issue of integrating KM into the normal workflow (in technological terms: to integrate existing systems / functions and the KM-system) is probably the single most important principle. While using/enhancing an already available tool (e.g. Lotus Notes) is an option to be considered when the organization in question already relies on a sufficiently powerful system, the more general approach is to integrate available tools, for example, into an Intranet portal.

5.1.6 Considering On-line/Offline Capabilities

This particular principle demands that a KM initiative considers what amount of support is provided for offline usage or access via slow and unreliable network connections (if any at all). As most current systems and technologies are optimized for usage with a PC connected via a Local Area Network (LAN), their functions are not available offline and often are hardly useable with slow and unreliable network connections.

The important point is to decide what functions need to be available offline or in the case of slow network connections (or with limited devices like 'smartphones') from the point of view of the KM initiative. Overall, the KM initiative needs to decide what costs can be justified by the potential benefits.

Therefore, the KM initiative needs to evaluate what parts and functions of the system need to be available offline or via limited network connections. Afterwards, the necessary expenditure for each requirement can be assessed and a strategy deciding what functions are necessary and what costs can be justified. As the most probable candidates for these functions are members of an organization with outside duty or (project) managers, some functions will be needed in many cases. Consequently, all parts of the solution that have to provide offline functions or access via limited network connections have to take these requirements into consideration (for example, a system delivering pictures will have to provide an overview with small sized preview images).

As faster and faster network access becomes available in more and more places, an organization could consider not addressing the presented issues and instead provide its members with the highest possible bandwidth connection wherever needed. Of course, this would make the KM-system simpler and less expensive. However, high bandwidth network access is rather expensive and unreliable at the moment and therefore, this point will need to be considered for some time to come.

5.1.7 Open APIs, Formats (XML) for Integration/Exchange

As a KM-system is a central IT system of each organization using it, integration and exchange of/with other systems has to be as easy as possible. Therefore, open APIs and formats should be used wherever feasible including external as well as internal connections.

Since the importance of this principle is obvious and often described in literature, this section concentrates on the consequences it imposes on the KM-system. Although building a KM-system consisting of many parts with clear

interfaces using open standards between them is expensive and poses potential performance problems, it is absolutely necessary to build a central system in this way. Furthermore, existing standards and systems such as the LDAP protocol and LDAP servers should be used and integrated.

Current trends in software engineering support the presented arguments and guidelines. Perhaps the best example of an open standard is the Extensible Markup Language (XML) that allows describing classes of documents (using a Document Type Definition (DTD), XML Schema, etc.) and eases the exchange between systems tremendously. Two other important trends are that of web services based on XML (e.g. SOAP) or reusable software components (e.g. J2EE, .NET). Summing up, recent trends in computer science stress the importance of open standards and offer a wide range of solutions to technological problems the KM-system has to address.

A KM-system that adheres to this principle consists of parts with clear interfaces and, thus, allows the easy exchange of sub-systems and the integration of new functions (provided by new systems). While the initial costs of a KM-system neglecting this principle might be lower, the loss of flexibility and potential future costs are compelling arguments against such an approach.

5.1.8 Usability

Although the need for usability has been discussed in various places in this thesis, its importance warrants a section of its own. Other principles such as integrating KM into the normal work procedures, participatory design, powerful search/retrieval capabilities, supporting ambiguity, not introducing a new tool, or integrating Groupware functions are important issues to provide a usable solution.

While new software products are always praised for their ease of use, many actually have serious deficiencies in this respect. Therefore, it is imperative to ensure a high degree of usability for the proposed solution, as a failure in this regard will make users avoid the system.

Overall, a usable system that also provides early benefits to encourage users, will allow early adopters to convince others of the advantage of using the new system. A well-defined KM-system will then provide additional benefits as the usage and amount of available information rises.

Summing up, the principle of usability is addressed by many of the presented principles, while, at the same time, it has to be considered as an important aspect of its own. Therefore, any KM initiative needs to put great emphasis on developing a solution with superior usability.

5.2 Features of the Solution

This section presents the proposed solution (KM-system) that addresses the identified requirements, adheres to the discussed principles and, thus, offers a "complete" IT solution for a "complete" and holistic KM initiative as described in chapter 1. Furthermore, the described solution is based on the assumption

either that the preconditions and foundations (see chapter 3) are established already or that it will be done by the KM initiative. However, the following text does not describe an implementation, instead it discusses the available technologies and how they can be integrated and form one, coherent KM-system.

Of course, there are a number of papers that illustrate available technologies and propose IT solutions:

- A paper by Marwick [70] discusses available technologies and what features and functions they offer with respect to KM.
- Vroom [111] presents a system tailored for design engineering that contains some of the functions and ideas also found in the proposed solution.
- In a paper by Swami et al. [103] a system is presented together with a graphic of its design that proposes an integrated solution containing an intelligence layer. While this is similar to the presented solution, the focus of the system described by Swami et al. is on the oil and gas industry and it lacks important features and functions compared to the presented solution.

There are two important points that differentiate the proposed system from other approaches. The KM-system includes all available technology that is mature enough for inclusion (technologies relevant for such a system are maturing fast and new ones are arising) and the proposed solution represents a concept that is extremely complex and expensive to build (thus, discouraging efforts to work on such a concept). Of course, an individual KM initiative may well decide to implement parts of it and use the proposal only as a guideline and distant goal. As this is the key section of this thesis, the most important issues (features and ideas) of this section have already been presented at the ECKM 2003 (see Hüttenegger [53]) and in a paper included in the Electronic Journal of KM (see Hüttenegger [54]).

Although the re-use of systems already available to implement the new KM-system would reduce the necessary costs, the presented solution is based (whenever necessary) on the assumption of an open integration platform that is often missing[10]. Therefore, Figure 5.1 presents the building blocks the solution consists of and the most important relationships between them.

Within and around the building blocks (each one in its own color) are the most important components that address the identified requirements and adhere to the presented principles. Perhaps the most important building block is the central UI, as the users have to be provided with an easy and intuitive user interface that, at the same time, offers all of the available features and functions, allows adaptations to it, and supports different cognitive styles as well as different access devices / capabilities.

The most important part of the central UI is the Computer Supported Cooperative Work (CSCW) block on the upper right, as it represents features and functions most users are already acquainted with (by using a Groupware tool).

[10] A typical example of an open integration platform is an Inter/Intranet portal but other technologies are available or might be introduced.

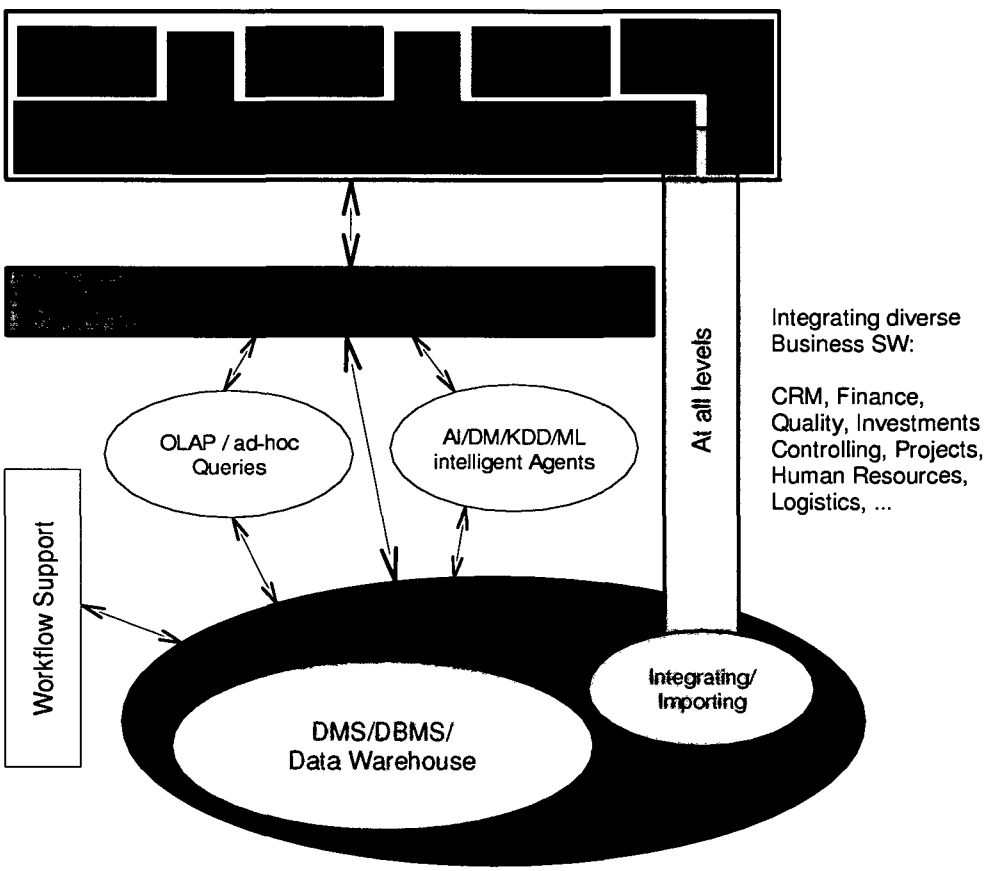

Figure 5.1: Overview of the Proposed Solution

Of course, the data available by CSCW systems needs to be integrated and made available through the virtual information pool. While the most appropriate approach would be to integrate Groupware functions into the system, the wide usage of powerful existing systems necessitates a compromise. Therefore, it will be necessary to integrate a Groupware tool and support the most important features and functions directly with the new system.

On the bottom of the figure, one can see the virtual information pool that needs to integrate data and information sources, full-grown business software systems, etc. and has to manage and provide access to all the information other parts of the system require. Therefore, this part has to offer a consistent interface that provides effective[11] access to all the information, while integrating the diverse sources disregarding whether they are unstructured, structured, simple or difficult to access. Furthermore, the figure shows a DMS as part of the pool's core, which is a suggestion and actual implementations might want to use a different system or integrate a DMS instead of building on top of it.

The aspect of integrating and importing is a very complex and difficult issue, as most organizations have a variety of diverse systems in use and new ones are being introduced constantly. At the same time, the proposed solution consists of available systems and new ones that provide important functions, which aggravates the problem at hand. However, it is absolutely necessary to integrate or import all available data, which at the same allows to reduce (or eliminate) redundant information.

The third major building block addresses the aspects of automation, transformation, and all forms of AI technology. Therefore, it consists of OLAP / ad-hoc queries to analyze the available data, all kinds of AI technologies (AI / DM / ML / KDD), and workflow support (it will be discussed that full-blown workflow support is optional, while there are many cases where a workflow can be used to provide certain functions).

AI technology provides the most advanced features and functions of the proposed solution such as classifying pieces of information, computing the similarity of documents based on their content, maintaining and suggesting changes to user profiles (interests), etc.[12] Summing up, the clever usage of AI algorithms allows the system to fully utilize the available information and provide important functions and pieces of information.

The following sections describe the three major building blocks in detail as well as additional aspects that do not fit in one of the three blocks (while some of these issues are presented in the figures of the solution and its building blocks, others will be mentioned in the text only). Furthermore, important base technologies that are assumed to be in place already are described in brief.

[11] Therefore, it is necessary to offer all functions of other systems, to provide a generic interface, and combine these topics with effective, high-speed access.

[12] Other examples like generating and maintaining taxonomies, optical character and speech recognition, etc. demonstrate how the application of AI algorithms provides information to be used by other parts of the system.

5.2.1 Central User Interface

The logical solution for the problems to be addressed by the central UI is a portal, as it represents the most up-to-date software solution addressing the need to integrate diverse information sources and offers numerous functions in a uniform way. Since all major software companies have introduced portal products in the recent years, a suitable basis exists, which can be adapted and enhanced[13] to fulfill the requirements the proposed KM-system has.

Before presenting the major components of this building block, this section discusses a "technicality" of major importance, namely separating content from layout (media) and functions. While Cascading Style Sheets (CSS) allow addressing different media (like speech or print), Extensible Stylesheet Language Transformations (XSLT) support a strict separation of the information to be displayed and the media it will be viewed. Although the Extensible Stylesheet Language (XSL) standard is even more powerful than XSLT, there is no necessity for it regarding the issue of separating content from layout (media). While ASP.NET by Microsoft, to name another example, supports a similar approach, the older standards of Java Server Pages (JSP) and Active Server Pages (ASP) do not enforce the needed separation (although it is possible). Another interesting type of technology is represented by the XML-based User Interface Language (XUL) that allows easy adaptation and customization of the user interface (e.g. used in the Mozilla/Netscape 6.x/7.x browsers).

CSCW – Groupware

CSCW or Groupware tools are an indispensable part of the proposed KM-system, as they provide a multitude of ways to communicate and collaborate. Furthermore, most organizations already use such a tool and their members are acquainted with it. As they provide many important features of a KM-system in an efficient way, the most sensible approach is to integrate the tool already in place (or introducing the most appropriate one) with the KM-system.

As providing Groupware features and functions is of utmost importance, the integration has to provide seamless access and all functions of the Groupware tool[14]. The relevance of Groupware support is also highlighted by a recent paper of Brachos et al. [14]: "... Groupware technologies have been identified as appropriate technology to support knowledge work and sharing process ..." that summarizes three other papers. However, most Groupware tools lack support for important ways of communicating and collaborating. Consequently, additional products (e.g. Lotus QuickPlace) offering features such as asynchronous communication (discussion and forum capabilities[15]) or virtual spaces for users,

[13]The simplest way to enhance most portals is by developing portlets to offer the desired function. Although portlets are not yet defined in an exact way, they are generally responsible for a certain area of the screen and interact with the portal and other portlets (ultimately the user).

[14]A first step might be to provide read-only views by the central UI directly, while the other functions are available by the Groupware tool.

[15]A paper by Adelmann and Jashapara [1] presents a KM initiative that primarily relies on the use of a discussion forum.

teams, and projects have to be included in the KM-system. Another relevant feature is to support "e-meetings" (e.g. Lotus InstantMessaging and Microsoft NetMeeting) by offering audio and video conferencing capabilities. While audio and video conferencing allow the transfer of tacit knowledge to a certain degree (one of the very few ways to address this problem with IT), the communication itself becomes available as data to the system and provides valuable input of other parts of the system (e.g. expert identification, CRM support, or capturing experiences gained in projects). Furthermore, these communication methods improve the collaboration of distributed teams and help establishing trust between the members, as they can actually "see" each other.

Another issue of the central UI closely related to CSCW is the provision of ambiguity. Therefore, the system needs to offer mechanisms so that one and the same piece of information can appear in different parts of the system (for example, different folders of the hierarchy). As this concept is very different from that of a normal file system most users are acquainted with, one has to ensure that the users are aware of the consequences (deleting an item in one folder might delete it in the virtual information pool). A possible way to offer such functionality is to provide bi-directional (and possibly typed) links between different information items (e.g. available in the HyperWave Information Server or CYMANTIX.NET) that also allow to model relationships between different pieces of information.

As the aspect of CSCW also necessitates the integration of "old" media such as telephone and fax from a general point of view, systems offering such capabilities (e.g. Unified Messaging solutions) have to be integrated into the KM-system. Overall, the proposed KM-system supports the issues of CSCW if and only if all technologies that support communication and collaboration are considered (and most of them included).

Support for Different Access Devices

One of the principles of KM-systems demands to consider offline usage or access via slow and unreliable network connections. Therefore, the KM-system needs to provide support to access and use functions of it everywhere.

Each KM initiative has to determine, whether offline support is necessary. While the KM-system has to provide import and synchronization functions for the offline part of the system if disconnected operations are imperative, more advanced features of the solution will not work offline and, thus, users of this part of the solution will not benefit from advanced functions while being "on-the-road".

While most organizations will have no need for specialized services that offer limited support for media like telephone, fax, or push services (e.g. an SMS containing e-mails), crucial pieces of information can be delivered in this way. Overall, this is neither offline nor on-line access but something between and should be offered only if there is no other way to address an important need for information.

Whenever feasible, on-line access to the KM-system should be provided. However, a number of issues has to be addressed, to provide relevant functions

together with the necessary user friendliness. While the issue of slow and unreliable network access is common to notebooks, PDAs, and 'smartphones', only the latter two currently lack big screens and processing power[16].

Consequently, the KM-system should provide as many functions as possible (of course, **all** of the core features) in the described cases. While similar issues are already addressed by Internet applications (e.g. e-Business applications such as online banking services have to deal with slow and unreliable network connections and limited access devices), the proposed system has to offer a solution superior to most existing ones. Therefore, the system needs to adapt to the device capabilities (e.g. offering a UI version that does not extensively use graphical images or other bandwidth consuming items), by using just one logical definition of the interface and thus supporting the whole range of access devices.

Powerful Search/Retrieval

Powerful search and retrieval capabilities are a cornerstone of the system from a user's point of view, as it allows finding and accessing the wealth of information available by the KM-system. Of course, this feature depends on the information available by the other two building blocks (the virtual information pool, and generated information).

The KM-system needs to handle structured and unstructured information, while providing different functions to the different types of users. Therefore, the solution has to provide search engine functionality and enhance the effectiveness by allowing different ways of searching (a simple example is the usage of a thesaurus), considering the interests of the user, and considering the similarity of documents, as it is of utmost importance to just deliver those information items with a high probability of being of interest.

At the same time, other users will prefer to navigate and find information by using different hierarchies. While the simplest hierarchies are maintained manually and are similar to a shared file system, more advanced examples include taxonomies, ontologies, knowledge maps, and topic maps[17]. These terms are closely related (e.g. an ontology is a taxonomy—a classification system—together with semantic meaning). Although taxonomies and knowledge maps can be generated automatically, the results often need manual adjustment, which still saves a huge amount of time and allows having the system keep the result up-to-date.

As the system aims to find all relevant pieces of information within the virtual information pool, this includes Meta information, addresses, a telephone book, yellow pages or a skills database, etc. Except for the last item, Groupware tools should provide the required information and it poses no problem to include it in search results. Yellow pages, on the other hand, are discussed in more detail in section 5.2.3 and it suffices, therefore, to state that knowledgeable

[16] Although, the CPUs of PDAs and 'smartphones' are becoming more powerful at a tremendous speed, they are still much slower than those of PCs are.

[17] One could view the hierarchical directory of an Internet portal (e.g. Yahoo!) as a taxonomy.

people have to be returned as a separate category within the integrated search functionality.

Linguistic Ontologies As there are no formal ontologies that address the full range of issues most organizations have to deal with[18], linguistic ontologies[19] are a technology that can be applied in many areas. One of the most prominent examples of a linguistic ontology is WordNet ® [118] on the English language. For example, the possible use of linguistic tools to build ontologies is described in a paper by Golebiowska et al. [41].

Information about the possible usage and differentiations to other terms and areas can be found in Banerjee and Mittal [9] and Magnini and Speranza [67]. Especially the latter paper cites some definitions and describes differences between formal and linguistic ontologies, while it also presents an example of a generated taxonomy as an application of linguistic ontologies[20].

Banerjee and Mittal [9], on the other hand, describe the possible use of such ontologies to enhance search capabilities of digital libraries. While their approach is addressing a problem (limited and slow access to documents) that should not exist in the case of the presented system, enhancing search capabilities by integrating one or more linguistic ontologies is recommended, although not absolutely necessary.

Summing up, linguistic ontologies are an interesting and valid addition to the solution, as they allow enhancing the search capabilities provided, and enabling other functions to achieve better quality. However, their inclusion is not absolutely necessary for a "complete" and holistic KM initiative.

Topic Maps Topic maps represent a very recent technology similar to ontologies and taxonomies that claims to support KM and is defined by an ISO/IEC standard (see ISO [56]), a fact that enhances its potential usefulness. Detailed descriptions as to what extent problems may be solved by topic maps and how this might be done are provided, for example, in papers by Pepper [83] or Rath [87]. Generally speaking, topic maps define a format for hierarchies of concepts, which allows representing taxonomies and ontologies as a topic map in a standardized format (easing imports, exports, etc.).

On the other hand, the master thesis of Carlstedt and Nordborg [18] illustrates serious shortcomings and conceptual problems of implementations available in 2002 (e.g. no support for bilingual topic maps). However, a paper by Smolnik and Nastansky [97] argues the usefulness of integrating topic maps in a process-oriented Groupware. Overall, the paper presents an interesting approach but seems to be overly optimistic considering the problems illustrated in the master thesis.

All in all, the available literature shows that topic maps are a relevant technology from a KM point of view, especially as they can be used to represent

[18]Of course, any available formal ontology should be integrated, as it will yield better results than using taxonomies or linguistic ontologies.

[19]Linguistic ontologies normally lack some of the features of a formal ontology like the terms being disjoint, which is the case in WordNet ®.

[20]Demonstrating that these terms are closely related and hard to define in an exact way.

taxonomies and ontologies in a standardized format. On the other hand, there is no necessity to include topic maps in a "complete" KM-system.

Context/Links/History

While the issues of context, links, and history are not only related to the user interface, they are a very important part of it, as their provision enhances the usability of the UI and the system as a whole. Therefore, this additional information needs to be available whenever it might help the user.

Providing context is done by offering access to all related pieces of information, for example, other information items linked to the one viewed at the moment or pieces of information with similar content. Ultimately, context consists of the project the item belongs to, related customers or products, etc. While some of these properties are handled by Meta data, others such as annotations need explicit coverage by the KM-system. Another (complementary) way of providing context is by supporting (typed) links between pieces of information.

On the other hand, history is a related concept, as it allows comprehending who and when an item has been changed. Of course, the discussed integration of a DMS helps to address this issue, but history needs to be available for all information items and has to include access logs. As a result, these functions enable, for example, the retrieval of everything related to a certain project.

Summing up, context, links, and history are closely related concepts that help to comprehend what has happened with a piece of information. Together these topics enable to navigate and retrieve related information items that have no apparent affinity.

Additional Capturing

While most of the issues presented in this section are centered on utilizing and providing / transforming information already available, additional capturing is a very important point to gather new relevant information by the KM-system. However, the solution needs to ensure that only those information items not available otherwise are captured, as it is imperative that users only have to enter pieces of information that are important for the KM-system[21].

The most relevant artifacts from a KM point of view are all sorts of experiences and lessons learned, for example, FAQs and experiences gained in projects. As possible artifacts include micro articles and best practices (discussed in section 3.6.2 from a general point of view), basic support is available by the set of features of the solution. While more sophisticated support should be easy to implement and integrate, it might require an additional tool.

Visualization

The necessity of supporting different cognitive styles has already been discussed, therefore, the importance to provide visualization functions comes as no sur-

[21] As most users are already spending a great deal of their time entering information into different systems, the amount of time necessary has to be reduced by the solution instead of being increased.

prise. For example, similarity and nearness, can be expressed with differing distances from the center (possibly, the currently selected information item). Furthermore, graphs and bars often help to actually "see" a point "hidden" in the information (e.g. the importance of a certain piece of information). The usefulness of visual tools in a KM environment is also discussed in a recent paper by Sharp et al. [94].

While visualization in general offers excellent ways to depict connections, hierarchies, or workflows, 3-D representations help to use OLAP functions and to present the results of the application of AI algorithms. However, one has to be careful where to add visualization, as it might distract and misguide at times.

Summing up, visualization is important, as it helps to support different cognitive styles and offers excellent ways to present certain aspects of the available information. Nevertheless, it needs to be used with care, as it might distract users.

Handling Suggestions/Interests/Notifications

While the user needs the possibility to adapt the look & feel of his personal view of the solution, the system also needs to adapt to his interests. Therefore, the system maintains a list of these interests and suggests interesting documents and whether new interests should be added or old ones be removed by monitoring the user's behavior.

The actual distribution of notifications is simple and can be handled by workflow functionality or special features of the Groupware part of the solution. Therefore, there is no need for any further discussion.

A paper by Minor and Wernicke [75] shows (as just one example) that the adaptation of IT systems to the users' needs is widely accepted as an important issue for advanced KM-systems. In the case of Minor and Wernicke they present a system where agents collaborate and exchange information to improve the interpretation of the users' requests.

Summary

The previous pages describe the features and functions of the central UI of the proposed KM-system. Not only is it one of the three major building blocks the solution consists of, but it also determines the look & feel and, ultimately, the acceptance of the system as whole

Figure 5.2 shows all the technologies and functions behind the user interface as well as how they work together to provide this first building block. Through the UI functions, all the functionality of the whole KM-system is made available to the end user. Necessary adaptations for different access devices are an integral part of the system thus consistently offering the subset of functions that makes sense for limited devices (like PDAs, mobile phones, bandwidth-limited connections etc.).

This figure also shows three conceptually different sets of functions:

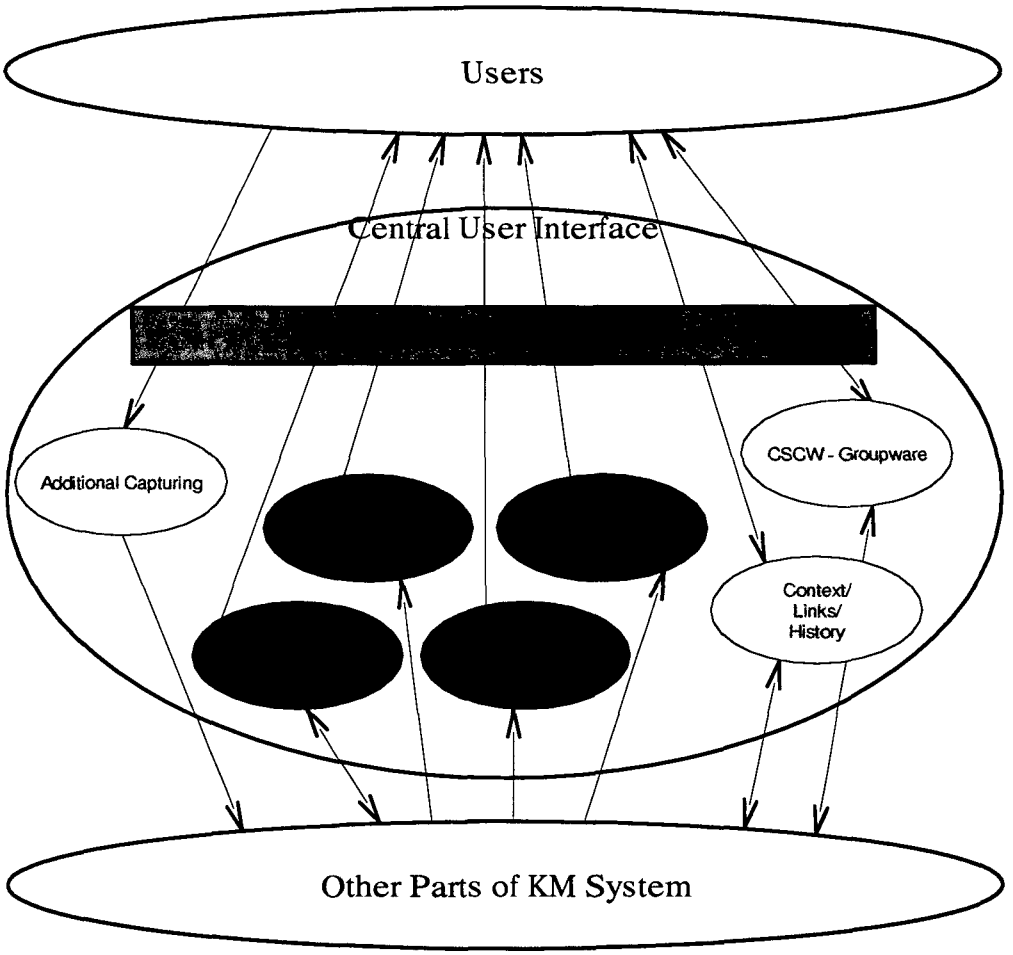

Figure 5.2: The Central User Interface of the Proposed Solution

Capturing As a rather broad function there are no other examples of this set. It represents the aspect of getting (additional) information into the system. Whilst using implicitly available information this aspect should minimize user input.

Presenting/Delivering This aspect includes: Visualization, Powerful Search/Retrieval, Handling Suggestions / Interests / Notification, and Topic Maps/Taxonomies/Ontologies. While a certain amount of interaction with the user and other parts of the resulting system is part of these functions, their primary issue is to deliver information to the user. To accommodate different types of users, multiple powerful mechanisms are offered and are accompanied by e.g. push mechanisms, in managing interest profiles together with suggesting possibly relevant new documents to the affected user.

Interaction Finally, interaction is the most important factor for both the CSCW/Groupware functionality and for Context/Links/History. These functions are similar to the previous ones as they deliver and present information. At the same time, they are providing means to communicate, capture current and provide past context. Summing up, they are essentially bi-directional, which is not the focus of the described functions so far.

On the bottom of Figure 5.2, one can see "Other parts of KM-System" together with the most important connections to the various functions. Please keep in mind that the arrows are indicating the important directions of data and information flows and are not meant to be exact descriptions.

Summing up, this section discussed the necessity and the most important benefits of the single and central UI, the two most important reasons are:

- To build one consistent UI at the top level of the virtual information pool, and
- to be able to integrate all functionality/systems where this is not possible at lower levels or at least only to a certain degree.

This interface has to provide diverse access possibilities, such as powerful searching, hierarchical access, and access for limited and offline devices. This interface is also a good chance to realize a quick win by replacing and integrating at least two previously used systems in the first phase of the implementation of the resulting KM-system.

5.2.2 Virtual Information Pool

The virtual information pool is a knowledge base that incorporates all relevant information while not necessarily storing it, thus forming a virtual pool of information. It allows all relevant data available to the organization to be found and accessed. Consequently, many of the presented features of the central UI are actually based on functions provided by the virtual information pool.

The pool provides the primary storage of the system (most probably a DBMS together with a DMS) and integrates other available data sources or systems. At the same time, it needs to manage Meta and link information (possibly using a link engine) and all kinds of data necessary for the diverse features and functions (the full text index, data describing the similarity of documents, usage information, document summaries, etc.) that is automatically generated by other parts of the system.

One of the most important issues is that every single item is available via full text retrieval (FTR; in the original and converted form, for example, XML/HTML) together with document summaries. Another technique that proved effective for KM-systems is to split documents into parts usable without the other parts, thus allowing more effective re-use if the splitting is not too expensive to perform. Of course, the need for FTR functionality requires that the virtual information pool is capable of supporting all (widely) used document formats.

DMS/DBMS/Data Warehouse Functionality

The core of the pool is provided by a DBMS and/or a DMS that enables the system to effectively store all kinds of information that either are only available by an inefficient way of access or not at all. An actual implementation might also integrate a Data Warehouse, as they offer elaborate mechanisms for data transformation that can be of help.

Summing up, this central storage contains the data directly managed (such as configuration data; possibly generated information that provides the basis for search and notification functions) by the KM-system. Furthermore, all imported information is stored here.

Integrating/Importing

The aspect of integrating data sources is the most crucial one of the virtual information pool, as it is imperative to build a fast and scalable solution that allows an expressive and powerful interface to be provided to the other parts of the system.

Integration of all possibly relevant data allows to access pieces of information not yet regarded as valuable information such as recordings and videos of meetings or conferences, as this data can be made accessible by speech mining or by analyzing videos to a certain extent[22]. A more detailed discussion of these issues can be found in section 5.2.3.

While the integration of Groupware tools has already been presented in describing the central UI, it also has a high importance for the virtual information pool to integrate the data of CSCW software. Therefore, the features and functions of CSCW software have to be available via the central UI and the data via the pool.

On the other hand, importing is the appropriate solution to integrate data from systems that will be put out of use. Replacing old systems also helps to reduce complexity as one system less will need to be maintained separately.

[22] For example, Brown et al. [16] describes this idea.

Since numerous systems exist that are candidates for integrating their data into the solution, the following description presents the most important examples:

Standard Business Software As the name business software is used with very different meanings, it is difficult to separate this category from the others. However, for the purpose of this thesis the definition is that software supporting core business processes is business software. Consequently, the most important software vendors in this field are SAP with its R/3 and other systems as well as Oracle with its multitude of business applications (other important examples are PeopleSoft and Microsoft). On the other hand, CRM systems are described separately

While some of the information and functions provided by business software (e.g. finance) are only of minor importance for the KM-systems, functions supporting Human Resources (HR), project management, sales support, etc. are of high relevance. An issue of utmost importance is to integrate all systems using a two-way connection so that changes made in one system are propagated to the other one.

Customer Relationship Management (CRM) CRM software supports sales and support forces of organizations by collecting and providing every piece of information related to a specific customer. Therefore, it enables to offer customers a better service and, for example, to guess what other products they might be interested in. As all this information is of high interest to the whole organization, it should be made available via the KM-system to all members of the organization.

A recent paper by Cochrane and Ong [23] argues how customer retention is achieved by integrating KM, CRM, and DM. Therefore, this paper proves the relevance and importance of including CRM functions and data into the solution.

Unified Messaging (Telephone/Fax/...) Although the necessity to integrate all kinds of messages has already been presented in the paragraph describing CSCW support, all these pieces of information have to be integrated and made available by the virtual information pool. This integration allows other functions of the system to analyze the messages and make them accessible to the users, for example, by using speech mining.

General existing Tools and "Databases" Most companies also have a variety of other tools that could provide relevant information and, thus, will have to be integrated. A simple example is a bug database but there are many other examples of such tools and databases.

Summing up, integrating and importing information is one of the most important tasks fulfilled by the virtual information pool. At the same time, it allows to aggregate diverse data and functions so that other parts of the system are able to use a consistent interface.

Integrating/Importing External Information

A special case of integrating/importing information is manifest, when the source of relevant information lies outside the organization, for example, provided by suppliers (perhaps part of a supply chain), customers (channel partners, end customers, etc.), or consultants. The key to success is to define interfaces and adapters and possibly make the outside source appear as an inside one to the rest of the system.

Even when using such an approach, there are grave problems to be addressed when integrating external information. One has to map permissions, attend to the issue of costs associated with accessing the outside source, and provide a solution that allows fast and efficient access to the information. To address all these issues, the system will have to maintain indices of the outside content and cache information items inside the virtual information pool (using a configurable caching strategy).

Interface to the "Outside"

Three aspects have to be considered when the issue is to provide an interface to the "outside". As the first topic is to provide information and functions to other systems, this is supported primarily by the central UI that provides APIs, XML/HTML documents and, for example, a WebDAV interface. The second topic is to provide parts of the Intranet as an Extranet to a partner (of course, with the option of multiple Extranets at the same time) or even as a part of the Internet page of the organization in question. Both Extranet and Internet pages are supported by the KM-system and easy to administrate.

Of course, the mentioned issues are not directly associated with the virtual information pool (on the contrary, they are addressed by functions of the central UI). On the other hand, structural aspects have to be addressed by the pool, while permission and user management are discussed in section 5.2.4 on permissions. However, the structural issues should pose no problem, as the solution has to use/provide a highly flexible structure anyway.

The third topic is the most important one, as it centers on the issue of providing transparent and efficient access to all the available information. This issue has already been described in other paragraphs, however it actually is the single most important part of the interface to the "outside" (in this context the other parts of the system). Summing up, the interface needs to offer all necessary functions in a consistent and effective way.

Summary

The previous sections of this thesis describe all relevant aspects of the virtual information pool of the proposed solution. Whilst being responsible for providing consistent and fast access to **all** available information and data, it provides the basis for the other two building blocks (namely the central user interface and automation) of the KM-system.

Figure 5.3 shows the functions and features of the virtual information pool as well as the most important connections within. The single most important

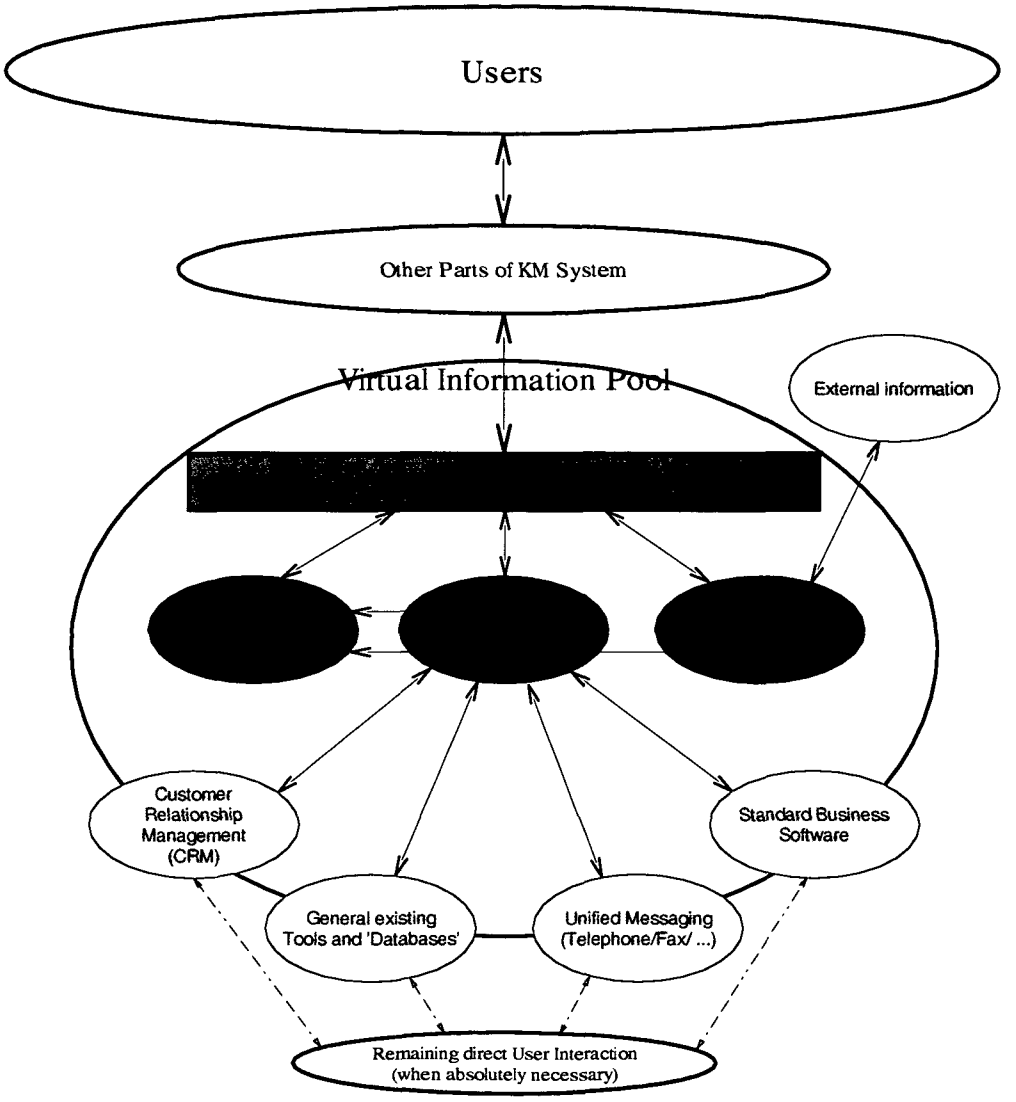

Figure 5.3: The Virtual Information Pool of the Proposed Solution

aspect of the pool is the "Interface to the Outside", as it allows every single function to consider all data and information that might be relevant for its result.

By integrating/importing external information, the pool is able to include high quality external databases, for example. To allow transparent access through the interface even to sources outside an organization such integration needs careful planning: One has to consider permission, potential cost, and performance issues and solve all of them in a satisfactory way.

Integrating and importing all kinds of information and data forms the heart of the virtual information pool. Especially relevant sources are: standard business software (like human resources, enterprise resource planning, etc.), more specifically customer relationship management, unified messaging (with information about phone calls, faxes, etc.), and general existing 'tools' and 'databases'. Not shown in this picture (as it appears in Figure 5.2) is the CSCW/Groupware aspect that not only provides a user interface but is also needed as a data source.

General DMS/DBMS and especially Data Warehouse functionality are managing/using/enriching all the available information to fulfill the promise of a consistent interface.

On the bottom of Figure 5.3, one sees 'Remaining direct User Interaction'. Generally, the approach calls for a complete replacement of such alternative ways of user interaction, on the other hand, as this will hardly ever be possible, at least in a first step, it is included as another data/information source.

The last sections together with this summary including figure 5.3 describe the functions and issues of the virtual information pool of the proposed KM-System. Providing consistent access (in all respects including availability and speed of access) to all information available to an organization is the indispensable basis for the other two major building blocks of the solution.

5.2.3 Automation

The last of the three major building blocks is Automation, a topic that not only has been identified as a requirement but also as a principle. Technically speaking the whole building block consists of simple and complex activities that often are based on AI technology.

Very basic tasks performed by the building block of Automation are, for example, imports done in regular intervals, an activity that may be necessary due to performance reasons or because it is the only way to provide up-to-date information.

AI/ML/DM/KDD

As the field of AI has been an active research area for centuries, there are many methods that provide fairly good results and are used for various purposes such as pattern recognition. For introductions into the field and a framework please see the papers by Mitchell [76], Witten [116], and Petrak [85].

AI technology allows (among others) to identify clusters of similar documents, to find correlations between attributes, to reveal rules or correlations between attributes and a target attribute, or to identify hidden patterns of human behavior.

The uses of AI technology by the KM-system are direct and indirect. The latter category, for example, includes Optical Character Recognition (OCR) and speech mining, while direct uses include finding similar documents, generating a possible knowledge map, finding patterns in the system's usage, classifying pieces of information, or uncovering interests and expertise of users.

Yellow Pages/Skills Database

Although section 5.2.1 already presented a brief discussion of this topic, the proposed technological basis needs yet to be presented. As the expertise of members of an organization is initially stored in the HR system, it also provides a good place to keep the data of the yellow pages sub-system.

As the primary problem of existing skills databases is the missing or inconsistent update of its content, automation is the logical answer. However, such an update is only possible by utilizing sophisticated AI technologies that consider all the information available by the virtual information pool. The Lotus Discovery System illustrates the technological feasibility and uses such attributes as authorship, annotations made, or writing e-mails to compute an affinity of a person to a topic. A similar function is offered by the Expert Locator described in a recent paper by D'Amore et al. [25]. Summing up, such functionality can be realized and has to be included in the proposed solution.

As an overly successful skills database might overload experts with routine questions, there is the need to shield them from simple questions[23]. One way of limiting the potential negative effects of yellow pages is to ensure that people actually take a look at answers previously provides (probably structured in the form of Frequently Asked Questions (FAQ)), while at the same time providing information about available experts (taking their availability as provided by their calendars into account).

Knowledge Maps/Clustering

A question not yet answered is how clustering (a term mentioned in section 5.2.1) or the creation of knowledge maps actually works. It is another example of AI technology[24] put to practical use.

Section 4.4 already described one example of a knowledge map that is the result of the application of clustering. Although other methods to build knowledge maps exist, clustering is the most appropriate solution for the proposed KM-system.

[23]For example, HyperWave has developed such a system that stores all the questions and the corresponding answers. Whenever a new question is entered, the system computes the similarity to already answered questions and offers possible answers.

[24]One might argue that clustering is the "simple" application of statistical methods. However, this thesis is using the terms AI/DM/ML/KDD for these methods too, as the distinctions are fuzzy and AI relies on statistical methods anyway.

As any knowledge map is used to search and retrieve documents, the system needs to ensure that their content is always up-to-date. Therefore, the insertion of new documents (also into integrated systems) has to initiate the inclusion of them in the knowledge map. As taxonomies are very similar and should result from clustering too, the same holds true for them.

Another application of clustering is to compute measures of the similarity of documents, thus allowing to present similar pieces of information as context or to improve search results and functions.

Using and utilizing clustering and its results provides powerful functions that are essential for searching, retrieving, and providing context. While there would be other ways of achieving similar results, the usage of AI technology is the most appropriate solution[25].

Classifying Messages

Although not every organization needs the capability to classify messages, many will benefit by an automatism that routes messages to a correct recipient with a very high probability. Therefore, every organization facing the problem of having to route many similar incoming messages should include this function in their KM-system.

As already many applications of this technology exists, interesting research is described, for example, in papers by Fürnkranz [40] (demonstrating the classification of text), Hagedorn [45] (illustrating what to do with results of automated classification), or Hoch [51] (describing the classification of incoming business letters).

When the KM-system includes the capability to classify messages, the solution is capable of analyzing what has been done with a certain class of messages and can propose an automated workflow to make the handling more effective. At the same time, this technology can be used to distribute certain kind of messages that addresses one person to a group.

Speech Mining/Image Similarity/Analyzing Video

These topics are at the center of current research (for example, see Brown et al. [16]), as they promise to provide a wealth of additional information. As preliminary results are available that can be used to address special requirements, these technologies should be considered and integrated into the solution if possible.

Important applications of these technologies include finding similar images/pictures[26], analyzing recorded conversations or more general speech data, and extracting information from videos (for example, a filmed presentation). While speech mining already is the most mature technology at the moment, its

[25] Although some results of this technology might need manual adaptation before they are actually used.

[26] One of the most important problems preventing the widespread use of the underlying technology is the difficulty of describing images.

progress in the field of speaker independence and poor recordings (for example, phone conversations) indicates that its applicability will grow in the near future.

While a general solution to include these resources in an information pool does not yet exist, there are promising results that encourage the storage of the data and might be used to offer limited support in this area. As video analysis consists of speech plus additional extracted information from the optical part (text identified by OCR or identifying people and changes), it can provide valuable results even now. A recent example of video analysis is described in a paper by Zerzour and Marir [120] focusing on a proposed object-oriented model.

General Data Mining/Exploration/...

While AI technologies often are used to realize other functions, they can be used directly by expert users that, for example, need to perform exploratory analyses (one example presenting a rather theoretical discussion of one technique can be found in the dissertation of Kaski [60]).

Generally speaking, the different AI technologies can be used to identify all sorts of correlations (for example, what products are often jointly bought and how similar documents are) or, for example, to generate decision trees that describe the influence a certain attribute has on a decision (could be what attributes indicate a high risk of an applicant for a loan).

A positive aspect of AI technology is that some of the algorithms are effective in analyzing structured data, while others are able to handle huge amounts of unstructured data. While all the related methods require background knowledge to apply them and to interpret the results, they often allow the users to gain insights they could not have achieved otherwise. Although it is incorrect to call that fact knowledge discovery (as is done in the term KDD), these technologies allow people to discover interesting and relevant information.

Summing up, the presented AI technologies help to analyze the available information and allow users to gain insights they could not achieve otherwise. At the same time, the results are hard to interpret, thus limiting the applicability of this approach.

Monitoring Usage/Constant Re-evaluation

These two topics have a high importance for the KM-system. For example, monitoring usage provides data helping to identify, what parts of the system are used and how, as well as what pieces of information are hardly ever accessed. At the same time, this information can be used to reward the authors of items that are accessed frequently.

Furthermore, together with the application of AI technologies monitoring usage allows to discover interests and suggest the addition and/or removal of interests that no longer seem to be relevant. Of course, the stated interests as well as the usage statistics have to be considered when search results are returned to offer the user exactly the information he needs. However, it has to be clear what results are returned or missing because of this consideration.

One point that has already been discussed in the paragraph on classifying messages is that the solution is capable of identifying workflows by analyzing what people are doing with certain pieces of information. Of course, such workflows are candidates for automated execution by a workflow engine and demonstrate one of many benefits only possible by the usage of an integrated solution as the presented KM-system is one.

Constant re-evaluation is another important aspect to ensure that the system only offers relevant information to the user. As a purely automated assessment of artifacts is difficult, feedback by users is of utmost importance (for example, with a rating system that allows people to judge how correct and helpful one piece of information is). Furthermore, the usage data has to be taken into account when evaluating items (especially since rating systems often are ignored and usage data is the only "feedback" provided). Consequently, artifacts with a high-assessed value will have a higher ranking within search results than those with a lower assessed value. Ultimately, artifacts with an extremely low assessed value may be transferred to an archive to help to reduce the storage necessary for the KM-system.

Summary

The previous sections described the features and functions the automation aspect of the solution offers. Utilizing the integrated knowledge base provided by the virtual information pool, automation is the key to go beyond a 'mere' Information Management System (IMS). Situated between the knowledge base (thus being able to work on all available information) and the user interface, it provides functions and features that separate it from simpler and smaller solutions.

The important issues and technologies as well as the most relevant connections between them are depicted in Figure 5.4. The central user interface – as the only part interacting with end users – shields them from the automation aspects, whereas the virtual information pool provides diverse data and information necessary for all the automation functions.

Let us now turn to the individual points of the automation aspect:

Yellow Pages / Skills Database Using the wealth of information available through the virtual information pool, this subsystem updates the skills database automatically. Whilst this may result in a lower quality than would have been achieved through human intervention/input, the information is always up-to-date and the updating process requires little or no manual input[27]. Relevant information includes: Project membership, written documents, accessed information, hours booked on certain subprojects, discussions via e-mail, forum, chat, etc.

General Data Mining Expert users can make direct use of the data mining functionality, thus allowing direct exploration of possible correlations,

[27] Whilst this type of automatic update is by no means perfect, manual updates can also be unreliable and with the information available in the integrated system, an automatically generated informed guess might be quite acceptable.

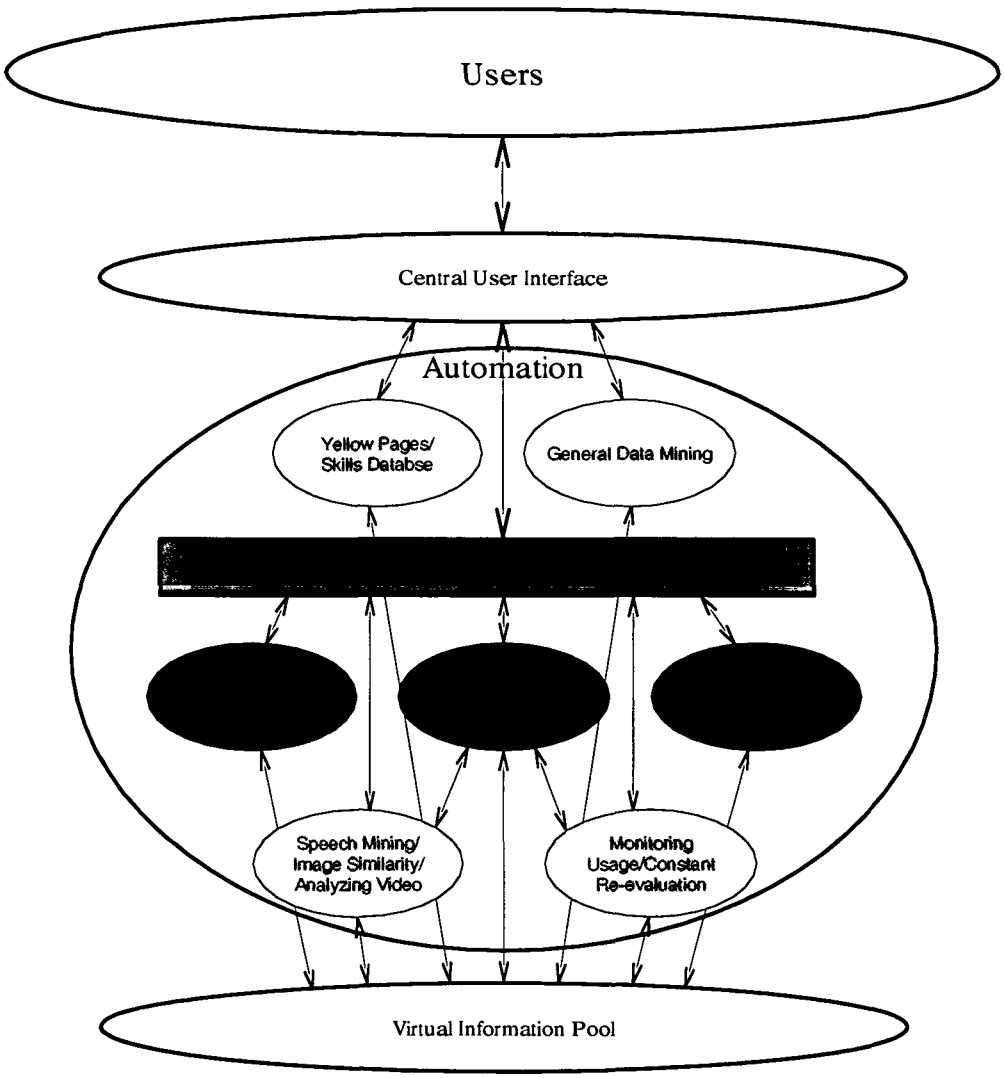

Figure 5.4: The Automation aspect of the Proposed Solution

gaining new insights, etc. This positions it nearest to the user interface, as they need close integration.

Base for Notifications, Interests, Push, Intelligent Hierarchies, etc. This issue represents all the automation items below and is relevant mostly from a conceptual point of view. It is up to an actual implementation whether this is a dividing line or not.

Knowledge Maps / Clustering This is the foundation of providing access to possibly related documents through various means. Users are offered or may search for similar documents and can browse in the available knowledge maps (e.g. being based on generated and automatically updated taxonomies).

Classifying Messages Especially interesting when information is not addressed personally and has to reach a correct recipient, taking e.g. holidays and substitutes into account. This can be used for customer messages but equally for internal ones (e.g. hotline etc.).

AI/ML/DM/KDD Perhaps the heart of the automation aspect is the utilization of the possibilities of various forms of AI/ML/DM/KDD. This is not only based on the knowledge pool directly but also on the fact that these technologies allow the resulting solution to provide information – not integrated or captured – in a number of ways such as automated summaries or providing 'links' to similar documents to illustrate just two of the many possibilities.

Speech Mining/Image Similarity/Analyzing Video While these technologies are not yet fully mature they help to integrate speech, images and videos as resources with the resulting solution making them accessible to a certain degree. Especially speech mining has already proven its practical applicability for more than specialized requirements.

Monitoring Usage/Constant Re-evaluation This aspect is especially important, as users will seldom provide the system with a rating of the information they accessed. Therefore, it is necessary to assess the usefulness of information automatically, thus showing the potentially most relevant information while at the same time reducing the assessed 'value' of no longer relevant information. Re-evaluation can also be important to manage the volume of stored data by providing hints what could possibly be removed from online access (e.g. to an archive).

Summing up, the previous sections and this summary including figure 5.4 describe the last of the three major building blocks of the solution: The automation aspect that utilizes the most advanced technology available to provide benefits not provided by other solutions. Furthermore, the fully integrated virtual information pool is another indispensable basis for the automation aspect that is lacking in other available solutions.

5.2.4 Further Aspects

As there are aspects of the KM-system that do not fit in one the three described building blocks, the following paragraphs examine those issues in detail. Equally important is to examine whether a peer-to-peer approach would be a suitable basis for a KM-system.

Workflow Support

While CSCW tools, DMS, etc. often provide limited workflow support that can be used by the solution, support for the execution and modeling of rigorously defined workflows may be missing. Whether or not a full-blown workflow engine and corresponding process modeling tools have to be provided by the KM-system needs to be determined by each KM initiative. However, as the proposed solution focuses on the support of high tangibility processes, there is no definite need for this functionality.

At the same time, workflows can help to work in the most effective way and, at the same time, artifacts used by workflows often represent valuable pieces of information. Furthermore, definitions of workflows (ideally in different levels of detail/abstraction) can be used as high quality data for the KM-system on the organization using them.

One important feature of the solution is to notify users of all kind of relevant items that are inserted or are related to one interest of the user. As (even simple) workflow engines provide features to push information items to users, they can provide this functionality.

Permission and User Management System

The aspect of the permission and user management system of the solution is a crucial one, as only a system capable of guaranteeing confidentiality will be used to distribute sensitive information. Of course, the most practical approach is to use a directory service (many organization already possess; if no central user management service is available there are, for example, high quality open source products such as Open LDAP that can be integrated) to address the need for a user management system.

The KM-system needs a highly flexible permission and user management system, as many different systems have to be integrated and the solution needs to ensure that only legitimate users have access to restricted information[28]. At the same time, the permission system is the foundation of Extranets that provide access to exactly those pieces of information relevant for a specific partner, while potentially offering all features and functions of the solution.

As this service needs to provide the security mechanisms that one and the same integrated portal can be utilized as the Intranet, multiple Extranets, and a part of the Internet page of the organization, it needs to offer fine-grained access control limiting the available information and functions for individual users and user groups.

[28]There may even be legal restrictions that need to be adhered to by the organization and, thus, supported by the KM-system.

As directory services manage user attributes and can be configured to provide this function to normal users, it can be used to address the need of adaptation of the solution by the user and helps to ease administration of the solution (as a part of the configuration is controlled by the users themselves). Finally, a precondition for this service is its ability to synchronize its content with other directory services, as a "complete" KM-system will have to address this issue (for example, to allow easy integration of systems with an independent user management).

Single Sign-On While offering Single Sign-On functionality is more or less a technicality, its existence is of high importance, as it allows the solution to appear as a single system, which – in reality – it might not be. Furthermore, Single Sign-On saves user time, eliminates many password problems, and improves the acceptance of the KM-system.

OLAP / Ad-Hoc Queries

Although OLAP and ad-hoc queries were already mentioned in the description of the automation building block of the solution, they represent a separate issue. While most of the exploratory features described until now deal with unstructured information, OLAP and ad-hoc queries (Data Warehouses are similar) represent mature and powerful technologies to manage structured information. Therefore, these functions should be integrated in the KM-system and offered by the central UI.

While OLAP represents static analyses and methods, ad-hoc queries are executed whenever a user wants to discover information and correlations. As OLAP typically uses a Data Warehouse to achieve its results (for example, sales figures to middle and upper management) and it already has been proposed to include a Data Warehouse in the virtual information pool, it should be integrated in the solution. On the other hand, ad-hoc queries allow exploring structured data pools, most importantly the virtual information pool.

Summing up, OLAP and ad-hoc queries help users to discover unknown information and correlations. At the same time, these functions can also be utilized by other parts of the solution and, therefore, should be included in the KM-system.

5.2.5 Why Not Peer-To-Peer (P2P)?

Although P2P systems have often been discussed as Groupware tools supporting communication and collaboration, most of them are not suitable to even form a part of the system. However, there is one especially prominent and recent example that explains this section on P2P: Groove by one of the inventors of Lotus Notes.

Perhaps the most interesting feature offered by P2P solutions like Groove is the superior capability of operating offline. These systems offer most of their functions when disconnected and, thus, address a need of many (project) managers, consultants, etc.

However, these solutions lack most of the features a central service is able to offer (and this is a limitation very hard to circumvent). Another difficult problem is that of integrating diverse systems and their features and functions in one KM-system, when many parts require on-line access, while others are designed to work offline. Overall, P2P systems are not yet mature enough to be part of a "complete" KM-system (at the same time, high-bandwidth on-line access is being made available to more and more parts of the world and could effectively address many needs currently tackled by P2P systems).

5.3 eLearning & KM

As both KM and eLearning address the issues of knowledge sharing and learning, this section examines whether eLearning is something separate or can be considered a part of KM. While the key argument that eLearning is a part of KM is that learning creates knowledge, individual learning often poses problems either not addressed by or not a primary goal of most KM initiatives (for example, information transfer in the form of online-slideshows with product information is only a minor issue of KM).

Searching for a definition of eLearning, one quickly realizes that there is no formal definition that is accepted by the majority of eLearning researchers. However, what most researchers argue boils down to the issues of delivering documents and supporting the activity of learning by electronic means (most importantly the Internet). Furthermore, Blended Learning is a recent trend that enhances eLearning with human contacts and guidance (for example, group meetings with tutors). Overall, there are two major trends in the field of eLearning: Technology-enhanced learning using IT to support traditional learning activities and technology-delivered learning utilizing IT to handle most issues of non-traditional learning activities.

5.3.1 Opinions about eLearning & KM

As there is hardly any literature examining the relationship of eLearning and KM in detail, the following paragraphs discuss different opinions (sometimes inferred from statements regarding similar fields or issues). Overall, some experts stress the differences, while others argue that eLearning is an application of KM, and still others point to the differences of eLearning implementations and KM. Therefore, this thesis examines some of these opinions starting with the following description:

Verna Allee [4]

> Is arguing that at least in late 2000 that most prominent eLearning solutions presented at big conferences do not address issues of KM and states that: "eLearning could be a cornerstone of knowledge management but most eLearning companies have failed to master the basic theory and practice of knowledge management." She continues to reason that eLearning vendors lack any understanding or strategy of/for KM and, thus, are missing the huge strategic impact of intellectual capital measures. To put

it in a nutshell, in her eyes eLearning can be a cornerstone of KM but does not offer relevant support at the moment.

Roy Williams [115]

Argues in a similar way: He writes that eLearning is often only distributing already available content with small adaptations at best. Thus, making public courses even less available than before (as there are costs involved in getting and using the course online). Therefore, he observes that practical eLearning implementations are very simple systems and implicitly establishes that such systems are very different from "complete" KM-systems.

Denham Grey [44]

Presents some short descriptions about eLearning and KM as well as the overlap. The most important sentence in his publication is: "The distinction, differences and dividing lines between KM and eLearning can be fuzzy." The following explanations of the paper show that he argues that the primary issues eLearning and KM are trying to solve are different but there also is a big overlap.

Grützner et al. [43]

The authors present a systematic approach for a "combined learning and knowledge management environment (LKME)". Therefore, in their point of view integrating eLearning and KM is important (and possible). Overall, their approach of producing small courseware modules is similar to producing micro articles as "lessons learned"of projects.

Michael Hess [50]

The paper describes the current activities in security policy regarding Knowledge Management and eLearning. As these activities are pursued separately and combining both is not an issue mentioned in the text, the participants of the conference on security policy see no need for an integration or combination. However, one has to keep in mind that most people working in the field of security policy are neither KM nor eLearning experts (at the same time, their application of the term KM is rather broad).

Aban Budin [17]

Her thesis argues that KM should be integrated in library management. At the same time, distance learning is described as a recent and important trend to be addressed by libraries. While there is no explicit discussion about the relationship between distance learning and KM in the thesis, KM is seen as some sort of basis (support) for library management including distance learning. Summing up, distance learning is not seen as a part of KM but instead KM is seen as supporting library management in general.

Mark W. McElroy [73]

> Does not directly address the issue of eLearning but discusses the relationship of organizational learning and KM in detail. In his opinion a new "second-generation KM" needs to include organizational learning (supporting knowledge creation) and argues that the missing integration of organizational learning in KM has been responsible for many of the KM failures reported. Ultimately, he argues that KM needs to address all knowledge processes be they the basis for creating, finding, sharing, or re-using it. Although eLearning is not mentioned in the publication, it is sensible to ascribe eLearning to learning and conclude that McElroy indirectly argues that eLearning is a part of KM.

Altman et al. [5]

> The authors present an application that integrates KM and media management to compose personalized views of learning content. From the short paper (accompanying a demo) one gets the impression that the authors are using a very limited definition of KM. Thus, although this paper calls for an integration it is doubtful whether the authors have considered this aspect in sufficient detail to base any conclusions on it.

Debora Jasek [57]

> Is discussing distance learning, a concept encompassing eLearning in her view. She argues that different distance learning techniques such as internal web pages, shared databases, and Groupware may be used for KM as well. Therefore, this is an interesting view, as "conventionally" (like in this thesis) the mentioned techniques are argued to be important parts of KM-systems. However, this obviously makes these techniques an overlap between the two fields in Jasek's point of view. Generally speaking, the author argues that distance learning can be used for KM, thus, more or less proposing integration.

Summing up, the stated opinions are similar, although the (implicitly or explicitly) drawn conclusions are rather different. While the classical distribution of learning material clearly is seen as a side issue at best, most arguments viewing eLearning as an important part of KM are centered around Groupware functions and the aspect of supporting people to communicate and collaborate.

While there are related issues both fields deal with such as the similarity of the "easy production" of learning content and capturing "lessons learned" or the topic of supporting communities and their discussions, especially the management of eLearning material is not of particular importance from a KM point of view. However, the data (for example, on skills) resulting from eLearning activities are relevant information to be included in a KM-system.

Conclusion

While there are convincing arguments to view eLearning as a cornerstone of KM, many organizations have no serious problem regarding their learning activities

and may be content with relying primarily on conventional learning and external services.

Overall, there are relevant overlaps of eLearning and KM. Therefore, including eLearning in a "complete" KM-system is recommended in general and should be done, if the organization in question views eLearning and KM as being important problems to be addressed.

5.3.2 Current Trends in eLearning

As the previous paragraphs already illustrated the similarities between eLearning and KM, it comes as no surprise that many current trends in the field of eLearning are similar to aspects of KM (-systems). For example, both fields discuss: Integrating all relevant aspects (systems), establishing and using (open) standards, utilizing AI technology (such as agents), trying to use semantic information (taxonomies, ontologies, etc.), supporting communication (i.e. communities), etc.

Integrating all relevant aspects into a single system is a widely accepted way of improving the effectiveness and user friendliness of the resulting system and is illustrated, for example, in recent papers by Grützner et al. [43] and Williams [115]. As this aspect is very general, there is no need for any further discussion.

Of course, open standards are important to eLearning and KM, but also to all other fields that need to integrate diverse systems. In the case of eLearning one not only needs to integrate systems but the different parts of the system have to be able to interpret the available content. For example, Currier and Campbell [24] state the importance of interoperability standards from a more general point of view, while Panteleyev et al. [81] demonstrate how, for example, the semantic web standard can be used to enable advanced features of eLearning system (constructing personalized learning programs).

AI technology is an important foundation of KM-systems and, at the same time, enables the creation of advanced eLearning features. As these activities are currently centered on providing personalized learning environments, one needs a model of the knowledge of the learner (for example, described by Shi et al. [95]). Another interesting idea is the creation of personalized courses that is described in a paper by Panteleyev et al. [81]. While promising, preliminary results exist, the available solutions have limited applicability and, therefore, further research is called for. On the other hand, a paper by Grützner et al. [43] describes a more practical approach that proposes (among other issues) to use decision support techniques to select appropriate defaults and questionnaires.

In both fields taxonomies and ontologies are widely discussed, as they can be used to improve search and access capabilities. However, they can be used for more advanced applications such as the one described in a paper by Fischer [39] describing how ontologies and taxonomies can be used to support the creation of courses and multiple-choice questions for exams. Based on Meta data the described system (Multibook) is able to come up with (most of the time) sensible multiple-choice questions and possible lessons. Although the system is not yet fully mature, it demonstrates one of many possible uses of Meta and ontology information.

Supporting diverse ways of communicating is another issue both fields try to address and Communities of Practice are a good example that demonstrates the overlap of the two fields. Generally speaking, there are two issues at hand: Having Groupware tools to support peer-to-peer ways of eLearning and enhancing the learning quality by providing additional ways of communicating and collaborating than offered by traditional approaches (such as distance learning with a tutor/teacher). As the communication possibilities offered by an eLearning platform often have to suffice in the case of peer-to-peer approaches, their importance needs no further argument. On the other hand, in the case of traditional approaches with a tutor or teacher there often are face to face meetings accompanying the remote learning and, thus, supporting communication is not that important. However, Groupware features can be used to enhance the learning experience in any case. For example, a paper by Rapanotti et al. [86] describes how distance learning can be enriched with a voice Groupware and concludes that it helps the students to achieve their goals. A paper by Williams [115], on the other, hand argues for the general necessity of providing interaction possibilities.

Supporting Curriculum (Development)

Although the topic of supporting curriculum has been identified as being specific to universities (and only a small number of other organizations) in this thesis, both eLearning and KM have to address this issue. For example, a paper by Brook Hall [15] discusses relevant aspects and calls for a framework for the development of course material.

All in all, KM for educational organizations and many forms of eLearning have to support the development and "maintenance" of a curriculum and, thus, this aspect is a common one. In a wider perspective, the issues of managing students, their courses, grades, etc. are also relevant for the mentioned types of KM and eLearning initiatives.

Summing up, a "complete" KM-System for educational organizations will have more in common with an eLearning system than a KM-System for non-educational organizations. At the same time, many universities, etc. are already offering limited eLearning capabilities, while KM is an important topic for them. Therefore, a KM-system for such an organization definitely should include comprehensive eLearning capabilities.

Blended Learning

As pure eLearning approaches often failed, vendors of eLearning solutions are currently promoting the so-called Blended Learning. Blended Learning is eLearning combined with human instruction and a discussion of this topic can be found, for example, in a publication by Hess [50].

It comes as no surprise, that pure online learning without any social interaction has run into problems, as similar issues have to be taken into account by KM initiatives (as has already been argued in this thesis).

Therefore, this new trend just acknowledges the basic fact, that IT solutions alone are not sufficient when it comes to knowledge related processes. At the

same time, the promotion of Blended Learning illustrates that many vendors have realized the problem and are taking steps into the right direction.

Conclusion

From a general point of view, current eLearning and KM trends have very much in common. However, relevant differences remain when examining the relationship in detail.

While providing superior communication capabilities is one of the most important issues, Meta information, taxonomies, and ontologies together with AI technology have to be considered and provide relevant functions. All these technologies enable the resulting system to support the users by proposing questions, course sequences, possible curricula, etc., thus, providing benefit not possible without their usage.

Another interesting finding is that eLearning and KM-systems for educational organizations have more in common than KM-systems for other organizations. While any "complete" KM-system should be an individual solution, most educational organizations should definitely include full-blown eLearning capabilities in their KM-system.

5.3.3 eLearning and the Proposed Solution

There are two important issues to be considered when discussing the relationship of eLearning and the proposed solution. The first one is whether the proposed KM-system is capable of supporting eLearning. As eLearning has not been identified as a KM requirement, there is no explicit eLearning support (except for the management of curriculum in the case of universities). However, the solution offers a variety of ways to communicate (of course, except face-to-face meetings), which should address the needs of eLearning in this respect. As eLearning is not fully supported by the proposed solution, any organization interested in introducing both topics should include third party eLearning functionality in their KM-system.

The second important issue is that of integrating eLearning functionality (or material) in the proposed KM-system. Not only does this provide additional functionality to both initiatives but it also makes the eLearning material (high quality explicit information) available via the information pool (for example, to all the advanced technologies of the automation building block). For example, the small courseware modules described in a paper by Grützner et al. [43] are excellent additions to the pool. Of course, other relevant items include condensed information on courses taken, etc. and can be used to keep the skills database up-to-date. Overall, eLearning capabilities add relevant information as well as (indirectly) usage information to the virtual information pool.

Conclusion

While eLearning capabilities are not necessary for the proposed solution, they offer valuable additions, as a wealth of interesting and relevant information

is made available to the KM-system by integrating (and using the) eLearning capabilities.

In the case of educational organizations such as universities, this thesis strongly recommends to integrate eLearning capabilities in the KM-system (a recommendation backed by the requirement to support curriculum for KM initiatives of such organizations).

5.3.4 Summary

While eLearning at least has a different goal than KM, both the proposed KM solution and eLearning can benefit from each other. High quality explicit information gets added to the KM-system, while eLearning activities can utilize the powerful and flexible ways of communicating offered by the KM-system. Therefore, the three most important points of eLearning (the material and its administration, face to face meetings, and electronic communication capabilities) can all be supported in the most effective way by an integrated initiative.

Even if eLearning capabilities are not included, the proposed solution offers functions that can be used to support virtual communities and for the capture and distribution of relevant knowledge, albeit not providing a complete set of functions.

5.4 Implementation Considerations

This section discusses the most important issues that need to be considered when actually implementing the proposed solution. Furthermore, it contains an examination, on how the KM problems of a university could be addressed by practical means of the proposed solution.

However, as this thesis does not describe a concrete IT system, the following conclusions and examples are based on what can be done using a theoretical point of view and a high level of abstraction, since a detailed description of the technological details would not be feasible.

There are two important steps when considering an implementation of the proposed KM-system, namely planning/building[29] a solution and execution issues. Therefore, this thesis will first present general issues and then use the same approach for the KM problems of a university.

5.4.1 Planning & Implementing the Solution

As the presented KM-system is tailored to bigger organizations and proposes to integrate numerous systems and technologies, it is important to examine the most important issues to be addressed when planning and implementing the solution. The high importance of this task is illustrated by the fact that larger organizations already have complex systems (for example, executing elaborate workflows) in place that will have to be integrated.

[29] Of course, these two issues can and often will be separated but for the purpose of this thesis they are examined together.

Although it has been mentioned in this thesis already – any KM initiative should start by defining the goals and scope of it. Consequently, one of the most important tasks is to define what processes will be adapted/created/removed/left unchanged and to determine how elaborate a KM solution is needed to support the state of KM to be achieved. Based on the identified needs to be addressed by the system, one has to derive the necessary features and functions of the KM solution that will represent a subset of the presented "complete" KM-system.

The next step after the definition of the solution to be implemented is to analyze the systems in place determining whether they can be integrated or adapted for the issues at hand. However, as some systems will pose complex problems when trying to integrate them, these systems either need to be modified thoroughly (that may be impossible, as, for example, with a legacy, closed-source system) or replaced (often imposing high costs). Nevertheless, if the offered information and/or functions are not absolutely necessary, one way to address the problem is to leave the system alone in the first step or to export/import necessary data.

Having defined what systems can be integrated and what other parts of the solution need to be bought/built, one needs to define what functions will be made available at what point in time. Although, the optimal solution would be that the whole system is made available in one-step, this approach is unrealistic for even moderately sized KM initiatives (and smaller ones will and should not bother with the proposed system anyway) due to the complexity of the resulting solution. However, core functions allowing people to recognize early positive benefits have to be available with the first version introduced.

While the next step is to define the new processes and to change old ones, it is important to consider how the processes have to look like in the time between the initial and the "final" release of the KM-system. Therefore, the system and processes have to be built in a way that allows the members of the organization to effectively do their work.

As the solution is proposing to use taxonomy or a related concept (i.e. ontology or topic maps) providing enhanced hierarchical access and supporting many other functions (e.g. improved search capabilities and offering related documents). As defining a taxonomy (or all that are needed) is a time consuming tasks if done manually, the most practical approach is to generate and adapt one to the needs at hand (as this has already proven to be feasible and effective).

From a pure technological point of view, there are three fundamental issues that need to be addressed in the first release. The virtual information pool using advanced integration techniques has to be realized, the integration (or introduction) of a user management needs to be done, and the integration of (at least the most important) CSCW functions is of utmost importance. Together these three issues provide the foundation for the whole system and all the other functions and parts.

Of course, any future project that has relevance to KM (e.g. modifying/adding processes or providing relevant information/functions) has to utilize the established basis. If this principle can be established, it can be assured that

all necessary changes are made to ensure the continuing success of the KM initiative and to continually enhance the KM solution.

If an organization often co-operates with other organizations or depends on external data sources, integrating information and functions of foreign systems needs to be done. As such integrations pose potentially difficult problems, typical examples should be integrated as soon as possible to validate the selected approach and gain experience. At the same time, this integration aspect stresses the importance of a powerful and flexible permission system and an effective management of costs associated with access to external systems.

While the help and input of the future users is necessary in defining the new processes and functions, their participation is also essential while implementing the solution. Furthermore, they should be given the chance to test early versions so that their input can be taken into account and they learn to work with the system. As integrating future users ensures that some issues are resolved before the roll-out happens and that there is a number of knowledgeable users from start, associated expenses will easily pay off.

One issue of great importance in countries with strict privacy laws (e.g. many countries in Europe) is to define what data cannot be used (primarily non-anonymous data). At the same time, it may be necessary to obtain the consent of members of the organization allowing the use of certain pieces of information (users should be informed, even if there is no law protecting their privacy) and to define what exactly happens with what data. While this is just a side issue of KM, it is very important in Europe and needs to be considered.

Last but not least, before actually introducing a system that changes many work procedures, it is of utmost importance to muster all the support available (especially of top management but essentially the more the better) to ensure that the system actually gets used. Please note that shortcomings regarding this respect will diminish the positive effects of KM.

5.4.2 Working with the Solution

As there will be many problems and shortcomings included in the initial version of the KM-system (a fact observed in virtually any reasonably sized software project), time and budget needs to be assigned to address all these issues and to tweak the solution. Of course, all the included metrics have to be adjusted to accommodate the actual needs of the users and this includes the incentive system (as people will optimize for the metric) as well as tuning functions like search capabilities (for example, finding documents or experts).

As Groupware (CSCW) systems have been in practical use for several years, there are relevant results discussing usage issues (problems) of such systems. Since the proposed solution is including Groupware functions and, at the same time, offering advanced communication and collaboration features, these research results have to be examined. For example, a paper by Vandenbosch [108] describes that communication patterns were similar after a Groupware system (Lotus Notes) was introduced than they were before. Especially people who keep to themselves most probably will not use many of the communication features regularly. However, as the proposed solution integrates all the avail-

able information sources and systems, even such people will provide important pieces of information. While a paper by Davenport [26] reports similar findings, more recent studies on virtual communities indicate that new means of communicating change the way people communicate (people are offering information they would not give in face-to-face meetings[30]). Nevertheless, all these effects have to be researched in more detail and results need to be incorporated in KM-systems. For the proposed solution these arguments illustrate that many users will not use the full range of communication features and that those who use them can be expected to be more open than in face-to-face meetings.

Overall, these points illustrate that the system usage needs to be monitored and adaptations have to address identified problems and shortcomings. Furthermore, the fact that this improvement is going to happen has to be communicated and any feedback needs to be considered for inclusion in the enhanced version(s). As a phased introduction of the features and functions of the system is planned, refinements will have to be made after each phase, especially after the system is complete.

While system monitoring and direct user feedback is important to address the obvious problems, evaluating the system with respect to the goals and problems the KM initiative has to address is necessary. As the proposed KM initiative changed the normal work procedures and, thus, represents a major change of any organization, this has to be done multiple times a year in the beginning. Another issue of utmost importance is to adjust the processes that have been introduced or adapted with the KM-system, as the initial version often will not represent the most effective and comfortable solution.

As organizations have to face new challenges constantly, the KM-system will have to be changed accordingly. Consequently, this illustrates another important reason why the solution needs to include a powerful yet flexible integration platform with an elaborate permission system and the central & single UI. As these three aspects are crucial for the success of the solution, any problem within or concerning those needs to be solved as fast and permanent as possible.

As new challenges often necessitate changing processes, the solution has to support any corresponding change. In the case of strict processes this is possible by using an executed workflow that can be adjusted easily. On the other hand, flexible processes cannot be handled in such a simple way and have to be addressed by organizational means.

The only important issue not yet discussed is that of automation issues. However, discussing what working with these aspects will be like is difficult at a higher level and will depend on the actual implementation in many cases. Nevertheless, AI technology is the foundation of many important features and functions such as generating context and computing document similarity and the effect of these features can be measured and monitored. As these technologies are the most complex ones (and not yet fully mature), fine-tuning is the key to benefit from what the related features and functions have to offer.

[30]This issue also illustrates cultural differences, as in the middle east, for example, people would be obliged to repay any favor (information) given in face-to-face meetings and that is not the case in virtual communities. However, these cultural aspects are far beyond the scope of this thesis.

Summing up, a multitude of tasks has to be performed starting with the rollout of the first version. As a phased introduction of the full system is proposed[31], the results of measuring and evaluating the solution in the meantime (and after the introduction of the complete system) can be incorporated in the following phases. Finally, the system needs to be adaptable to maintain it, to integrate new features and systems easily, and to allow for adaptations necessary to accommodate new challenges and changed circumstances.

5.4.3 Examining the Exemplified University Problems

While the previous paragraphs discussed the issues of planning, implementing, introducing, and refining the solution, the following paragraphs discuss how an actual KM-system representing the solution may address the goals and problems of a university (described in section 2.3). Therefore, ways of implementing the solution and execution issues are examined.

Proposed Implementation(s)

As it has already been pointed out, the implementation of the virtual information pool is crucial in providing the foundation of the whole KM-system. While it provides transparent access to all the possibly relevant data (including access to external information sources), it also contains and provides the results generated by the building block of automation such as context, history, document similarity, classification, etc.

On top of the virtual information pool the other features and functions of the solution provide the necessary capabilities to the users. As the acceptance and uptake of the system depends on the users, the single & central UI (and the fact that it provides a single and consistent user interface) is an essential element of the solution to be designed and implemented with utmost care (and based on the principles of participatory design). The features and functions provided by the building block of automation, on the other hand, are based on the virtual information pool and provide their features through the central UI in a way as uniform to the users and implementers as possible.

No automatic information distribution There are two major issues that address this problem, namely to offer flexible means of pushing information and to notify users of possibly interesting pieces of information automatically. While the first issue is addressed by Groupware functions such as mailing lists, the second one is based on classifying information items and managing user profiles containing interests. Of course, this mechanisms needs to be customizable by the administrator and each user so that only items that have a high probability of being relevant are pushed to the user and that the amount of items pushed can be adapted. As computing the mentioned probability is a complex task, the users are actively asked

[31] As already discussed, such a complex system can hardly be put in place in one step. At the same time, a phased introduction allows improving the system with every step by incorporating user feedback.

to rate how relevant an item pushed actually was (and what interests it is related to) and, thus, having a way of adjusting what information is presented to them.

No management of interest profiles The discussion of the last issue already discussed the necessity to manage interest profiles, which is a problem to be addressed at the same time. While users of course are able to administrate their explicit interests, the system also considers what information items the user classified as interesting (lacking such classifications the system can make assumptions based on the time individual pieces of information are "viewed" by the user). As the technology of clustering allows computing similarities to other documents, it allows presenting users with information items similar to those they rated as being of interest (or viewed for a reasonable amount of time and have a considerable similarity).

One way of efficiently managing the interests of individual users is using the terms of a corresponding hierarchy (for example, taxonomy or ontology). However, the problem that many terms have different meanings depending on the context has to be addressed when using this approach (also considering that multiple taxonomies may be in use to accommodate the needs of different departments). Therefore, descriptions of each term are important to allow the system to differentiate what interests a document actually addresses. Of course, clustering and the computation of interests treated within can only try to appear intelligent and will, at times, fail to do so. Finally, the system also has to propose the addition and removal of interests according to user feedback and statistics of viewed documents.

Therefore, the system needs to track whether a user does not view items related to certain interests stored in his profile or, on the other hand, accesses items related to interests not in his profile. If either of these conditions is met the system has to query the user whether he wants to remove or add the interest in question from/to his profile. Of course, the user needs the option of delaying the decision or answering that he does not want to be bothered by the mechanism anymore. One idea for universities is to add courses to the list of possible interests (if they are not already within the hierarchy of terms of the university) so that the described mechanisms also address the needs of individual students regarding the classes they take in a semester (the system could automatically add and remove the classes from the user profile according to the attendance of a student).

No support for managing curriculum Although not all of the discussed issues of the following paragraphs are related to KM, they are important for a complete coverage of the KM related ones. Of course, a foundation for any support by IT is to represent each curriculum and all the associated information (for example, the variants or required courses) in electronic form. While support for the development of a curriculum is

provided by features that, for example, support communication and collaboration[32], the crucial issue is to (first capture and then) represent the curriculum in all its details. Furthermore, the solution needs to provide and manage the related pieces of information such as variants, frequently asked questions, data on courses (time & date, content, field, restrictions, prerequisites, etc.), preconditions to be fulfilled, etc. Consequently, the system can combine the information available about individual students (courses taken, his grades, history, etc.) and the curricula to provide support in various ways such as proposing timetables, notifying of relevant changes (of courses, etc.), offering frequently asked questions (relieving teachers from routine questions), etc.

From a more general point of view, the issues related to supporting students are of interest to organizations in general. While an actual implementation will hardly be re-usable, similar features can help to manage not only a member's skills (done with a skills database) but also his past courses, potentially proposing what future steps can help to improve strengths and address weak points of somebody. Consequently, the importance of this issue and why it helps organization in general should be easy to recognize and illustrate why such support is sensible as a part of the proposed solution.

Of course, section 5.3 already discussed that integrating eLearning capabilities in the KM-system should be done for educational organizations and includes supporting curriculum. Therefore, the previous discussion illustrates what either can be done standalone or has to be offered by full-fledged eLearning support.

Inadequate capturing of "knowledge" of employees/students/...

Members of a university are constantly generating all kinds of information that often have a high relevance. While the most prominent and important examples (all kinds of papers and the thesis for the different academic degrees) are made available in electronic form more and more often, many pieces are only stored in isolated systems if done at all. One way of addressing the problem is provided by the virtual information pool that integrates all the available information sources (making it search-able and accessible) and includes offering broad communication (e.g. newsgroups, e-mail, etc.) and collaboration capabilities, diverse databases, all sorts of scientific output (such as technical reports, etc.), etc.

Another major issue is to capture information generally not yet available to IT systems such as speech, images, and the content of videos. Although the related technologies of speech mining, image similarity analysis, and video analysis do not represent mature technologies, they can provide limited access to those resources already. Therefore, these technologies

[32] A university that needs to change curricula frequently should consider integrating a tool providing explicit support for the ongoing work of adapting and creating curricula.

should be analyzed for their applicability to capture important meetings, speeches, conferences, etc. and be used accordingly.

Inadequate support for information sharing Although many people do not even realize that sharing information often is a major problem (as simple, ad-hoc methods help to address this problem to a certain degree), the proposed solution is offering a wide range of functions addressing this need. While the virtual information pool stores all relevant pieces of information and provides powerful ways to find and access them, other features such as version control and having a single version of each item[33] supplement this functionality.

With the KM-system in place information sharing consists of granting permissions and possibly sending a link to the intended recipient. As the virtual information pool integrates all available information, it is important to realize that this method allows sharing **all** pieces of information available to an organization in electronic form.

Of course, there are two important organizational issues, namely establishing a sharing culture and ensuring confidentiality. While the first issue is a precondition for a reasonably working KM solution, the latter one has to be ensured by the system. However, any organization should have clear guidelines to decide what information is confidential and it should be the least possible amount of information.

Inadequate context/history of individual pieces of information This is another problem primarily addressed by the information pool and the central UI together. As virtually all modifications to information items are done through the central UI, capturing history is a straightforward task and allows providing transparency and traceability. Furthermore, the history of pieces of information can be used as information itself by allowing searching for items with a certain history entry or trying to uncover workflows by analyzing the history of information items.

Context, on the other hand, represents a much more complex issue that often helps to understand the item itself, as it describes such information as what project or process it belongs to, what similar documents exist, etc. Consequently, the system should keep track of all this information and capture it automatically if possible (for example, determining the project or at least offering the user a list with all the projects he is currently assigned to). Summing up, any organization needs to analyze the context a piece of information can have and capture as much as possible.

Ambiguity not supported As pieces of information often belong to multiple places, this issue needs to be addressed by supporting ambiguity. However, it has already been described that the solution offers views that contain results of searches as well as version control capability. Therefore,

[33] Of course, offline access is an exception and synchronization is necessary in this case, as has already been illustrated.

the important point is to make the concept understood by organizational means and provide easy ways of dealing with the offered functionality.

Inadequate support for co-operation with external partners While this problem is similar to supporting information sharing within an organization, the extent of the necessary support needs to be analyzed and defined and any issue not addressed already has to be solved. Consequently, the simplest way is to offer usage of the system by partners via Extranets and that possibility will be sufficient in many cases. However, if access via Extranets is offered to partners every member of the organization dealing with confidential information has to ensure that he does not grant permission to partners that are not entitled to it.

In an ideal world all organizations have the proposed solution in place and easy connectivity between each other is rather simple (integrating other virtual information pools as external data sources). Of course, this will not be the case and, therefore, one needs to utilize more cumbersome and complex ways of integrating the necessary information (e.g. the phone book of the partner organization). At the same time, the solution needs to offer communication and collaboration facilities that include the partner organization (possibly by using the virtual information pool) and always make clear where a piece of information is actually originating from (whether it is from one of the partners or not), as this allows to duplicate important items before the co-operation effectively ends.

Another important aspect is that of supporting virtual teams. While many issues are already addressed and have been discussed, the problem presented here illustrates the importance of providing, for example, virtual meetings or other advanced ways of communication and collaborating (on shared documents) in the context of co-operating organizations.

No capture of experiences gained in projects While the actual problem of missing capture of experiences gained in projects cannot be addressed by means of IT, the proposed solution captures as much information as possible and offers capabilities to store additional material. Therefore, the KM-system is capable of delivering (nearly) everything related to a project whether it is an e-mail, text document, etc. or not. For example, the generated summaries of stored documents could be a starting point for micro articles that are a way of capturing important information. Of course, many other types of information should reflect experiences made during a project such as frequently asked questions, processes, etc. Summing up, there are many ways to store experiences gained in projects and the solution offers a wide range of ways to input it, while the principal issue needs to be addressed by organizational means.

Inadequate systems for finding/accessing relevant information The whole proposed solution is offering a wide range of functions addressing the problem of finding and accessing information. While the user either can utilize different hierarchies (e.g. automatically updated taxonomies)

to find relevant items, he also may use the powerful search mechanisms, navigate using visualization techniques, or retrieve information by "browsing" similar or related documents (for example, the result of clustering). Of course, the key to allow all these ways of finding information is the powerful permission system that ensures that confidentiality is ensured whenever necessary.

One especially important feature that helps to "browse" through the virtual information pool is the generation of summaries that help to grasp what a document is about in a short amount of time. As results of searching for general terms often deliver a huge amount of hits, this functionality helps to find the documents the user is looking for.

Summing up, offering all these diverse ways of accessing and finding pieces of information is extremely important, as different cognitive styles need to be taken into account and many users will prefer to choose the most appropriate way to find a document each time they have to. At the same time, the system offers old versions and has to provide the ability to compare the different versions of documents for the most important formats of an organization.

No system for identifying/finding experts To address this issue the system uses AI technology examining the information available in the virtual information pool to identify experts. While such persons may not be experts in a strict sense, they have an affinity to a certain topic and most probably are knowledgeable in the area in question. The most important pieces of information considered are Meta and historical information (e.g. authorship, accessing documents, writing or changing them, etc.) as well as the content of information items with a defined author such as e-mails or entries in a discussion forum.

The importance of an automatism for this aspect is illustrated by the fact that there are many papers reporting on manually updated systems that are incomplete and often neglected[34]. Although an automatically updated system will also be neglected by many members of an organization, there are two important points that justify its existence, namely the reduced expenditures necessary to keep the database up-to-date and the provision of a system that allows people to find all persons knowledgeable in a certain field. Furthermore, the interface of the skills database should make use of the taxonomy to allow narrowing or widening the search for experts, if too many or none at all have been found.

Too much information available (i.e. the wrong information) While this point is a crucial issue to be addressed by KM-systems, the description of the solution might provoke the assumption that it would add to the problem. However, many of the presented features and functions are instead designed to address the problem, as they try to use all available

[34]Many members of an organization are using their informal network instead and one has to consider the fact that this will not change.

information of the organization and on the user in question to offer only those pieces of information that have a high probability of being relevant. Therefore, the system offers the management of user interests, fine-grained search options, a skills database, different ways of accessing one and the same information pool. Summing up, the system is offering different ways to find information so that users can decide what way best addresses their needs, while the solution always considers the interests of each user to offer the most appropriate items.

The Solution & the Proposed Implementation As the items of the previous description discuss how the proposed solution addresses the exemplified problems of a university, they illustrate what means the KM-system offers for each problem. At the same time, the solution addresses problems to be solved not easily identified by users, for example, supporting different access devices or offline functionality. However, please keep in mind that the most important issues of a KM initiative are described in section 5.1 on the principles of the solution.

Summing up, the previous paragraphs describe a subset of the solution in more detail to allow the reader to gain a better understanding how and by what means the KM-system addresses the identified problems.

Execution Issues

As the previous paragraphs presented implementation issues, the next points to be discussed are execution issues that consist of planning, introducing, and working with it (improving it). Once again, this examination will concentrate on the exemplified problems of a university and KM for a university in general and try to work out the proposed issues more clearly.

Planning The two most important activities of planning a KM-system for a university are to define new processes of the university in question (always together with the people knowing how things are done at the moment) and to define the KM-system based on the presented principles, offering the described features and functions, and supporting the defined processes.

In the case of a university the team of the KM initiative should include members of the central organization, the IT department, and various institutes. Furthermore, help and input by students can be extremely valuable.

After the team has identified the goals and problems to be addressed by the KM initiative, it has to identify all processes that are relevant for the initiative. Afterwards, existing systems containing relevant information and/or offering important functions have to be identified. The next phase iteratively defines the KM-system and the future processes of the organization, thus, coming up with the envisioned state of KM and all related processes and systems.

The last topic of the planning phase is to define how the KM-system will be implemented and what intermediary steps make sense, as such a complex system, that is accompanied by constant changes and the introduction of many diverse processes, cannot be introduced in one step. Therefore, the team needs

to decide what functions are necessary in the first version and how the affected processes should work until the KM-system is completed.

Consequently, the initial version of the KM-system to be introduced has to provide as many benefits and quick wins as possible in order to allow each user to be more effective and "feel" the advantages of working with the new system. One of the most important points ensuring that the new system and the new processes are effective is the inclusion of those people who have to perform the work in the design. Furthermore, rewards (most often monetary ones) can help to get the system started (but one should never rely on this source of motivation alone).

Building/Introducing The logical starting point of implementing the KM-system is to create the framework that includes the superior integration capabilities needed. Afterwards, a working version of the virtual information pool, offering the designed interfaces to the outside world, has to be created.

Certain key issues of the KM-system have to be provided by the framework: one of the most important ones being the user management. While this part may be based on an existing system or on an introduced directory service, the important point is to implement the powerful and flexible permission system on top of it. At the same time, this part has to manage all user relevant configurations and provide the foundation for the Single Sign-On functionality. Another key issue is the integration of CSCW (Groupware) features and functions, as the information available by this integration is crucial and has to be included in the virtual information pool. Furthermore, CSCW features are very visible and their inclusion demonstrates the goals and range of the KM initiative.

An issue of high importance is the definition of the used taxonomies and/or ontologies that need to be defined by the KM team. As the result has to be integrated in the initial version, this topic should be one of the first ones to be done (possibly after the implementation started). Furthermore, these hierarchies have to be included to enhance search capabilities and are necessary information for other applications of AI technology (as already described in multiple places).

For the initial version of the system the data sources to be included have to be either important ones or those that can be integrated easily, as these two categories together will provide a wealth of information already. Of course, the other relevant data sources have to be integrated until the KM-system is complete and new systems have to work with the solution from the beginning.

As external data sources provide important information, the team needs to decide which external source should be included and whether this is feasible. Although integrating external data sources is often complex and very costly (for example, charging each access to it), the most important ones need to be included as soon as possible.

Since user acceptance is of utmost importance for any KM-system, a pilot phase is recommended and allows adapting the system according to user feedback before an actual rollout of the system. As the pilot users have to be aware of how the system is supposed to work, they should be part of the team.

While including future users in the team is necessary for a pilot phase, it also allows the team to adjust its system to real world users. At the same time, these pilot users are the best way to ensure that there are some who already know how to work with the system. Of course, training for all users of the system is necessary, nevertheless.

While some members of the university will know why the KM-system is being put in place, others will have to be introduced to the concepts and motivated to use it. Consequently, motivation has to be provided by the senior staff of the university (a group that needs to be informed regularly and their input taken seriously) and possibly by financial rewards for usage in an initial phase. Another source of motivation is, for example, having statistics whose information items are the most accessed ones (also re-assuring the users that their input is important).

A difficult issue is the inclusion of students in the case of a KM-system for a university. While the usefulness of the initial system may be limited for them due to restricted permissions, they should be able to use the communication and collaboration features immediately (for example, support for virtual teams will often help students performing project work in groups). Although certain features and functions will neither be available initially nor to students, the offered capabilities and the available information will increase quickly and students will be able to take advantage of the growing offer.

Using/Improving As a "complete" KM-system will be introduced in phases, the schedule describing how the solution will be introduced needs to be made publicly available. At the same time, the KM initiative needs to ensure that the new system is becoming a part of normal work procedures from start, as this is the only way to address the goals and problems of KM.

It has already been established that usage monitoring provides important clues what parts of the system need to be improved. Another important issue is to get feedback by the user and discuss what changes can be made to address shortcomings (while viewing first reactions with certain skepticism, as any new system is facing a certain resistance).

Regarding the schedule of the complete KM-system, there are two important points each release has to incorporate, namely the most important improvements identified and at least one major new feature. Thus, each release will provide important functional and non-functional improvements.

Another major issue is that of fine-tuning various metrics of the KM initiative (similar aspects have already been discussed). Therefore, the configuration of AI algorithms, the incentive system, the search engine, generating/computing context, etc. needs to be monitored and adjusted regularly.

One issue that is especially important in the case of a university is that of cost control. As access to external data sources, certain search capabilities or functions, etc. may be expensive, it could be necessary to restrict access to them[35] or bill their usage. While this issue has to be dealt with in a reasonable way, the ultimate goal of the KM solution is that no such limitations exist.

[35] Of course, this is contradicting one of the central issues of KM and, therefore, should be done only if absolutely necessary.

Conclusion

Although the previous paragraphs illustrate how the proposed solution is addressing the problems of KM a university faces and discuss the issues of planning, building, and introducing it, the basis is the presented concept. Therefore, the results are theoretical in nature and high level ones and the KM-system is provided in the form of architecture and not a software design.

The important point of the previous discussions is to illustrate how the KM-system addresses the identified problems and to provide guidelines and hints how it can be done. Together these aspects show what the KM-system is capable of achieving.

Summing up, the previous discussions illustrate how the KM related problems of a university can be addressed by the KM-system. Obviously, this means that there is no description how the general identified goals and problems of KM are solved, but there are many similarities and, thus, this section shows the validity of the proposed approach for a subset. At the same time, the result can be used as a starting point for a more general initiative.

5.5 Evaluating the Solution

Evaluating the results of this chapter is a difficult and complex task, as there is no real implementation that can be judged, solely an architectural concept and high level design is currently available. However, an evaluation needs to be done and will be based on whether the proposed approaches are technologically sound and valid and how the solution addresses the identified issues to be solved by KM-systems.

Therefore, two of the most important issues of the evaluation are comparing the solution with existing solutions (as described in chapter 4) and analyzing the extent to which the solution addresses the problems to be solved (as described in section 2.2). While the comparison with the existing solutions illustrates the similarities and differences between the solution and them, the analysis illustrates what requirements are addressed to what extent and discusses the current limits of IT in regard to KM.

5.5.1 Evaluating the General Results

From a general point of view, this thesis presents a software architecture and/or high-level design (depending on the definition used) and, therefore, one needs to make a judgment based on how an implementation might look like. Although this approach poses many difficulties, it is simplified by the fact that the author helped to build CYMANTIX.NET and, therefore, has been part of designing, implementing, and evaluating such a solution.

Let us first examine the three major building blocks the solution consists of:

Central User Interface The principal viability of creating a single & central UI is illustrated by the fact that portals (often called Enterprise Portals)

are already offering similar capabilities. At the same time, such portals are a good example of an existing technology that fulfills many of the described requirements and principles. Furthermore, a portal either is "no new tool" or represents the least possible violation of that principle (as most users will be acquainted with Intranets or the Internet).

While portals already proved their ability to integrate very diverse functionality in one central UI (for example, the Oracle solution as presented in the screen-shots in section 4.3), most of them just offer a shallow integration of the features and functions behind. Consequently, the described single & central UI has to consist of more than one of the available portal servers to offer seamless integration of features and functions provided by other systems. The importance of this aspect is illustrated by the goal of the proposed solution that normal users should not need to use any tool or UI outside the solution to provide a consistent look & feel and to integrate all the available information.

This discussion shows that the KM-system requires a tight integration of all systems offering relevant features and functions not currently available in the proposed scale and scope that allows providing a consistent look & feel to the users. While the high costs to realize such a solution are the most important reason that such a system does not exist, other problems such as inadequate interfaces, security issues, non-functional requirements (for example, performance), etc. have to be addressed when building the KM-system.

As the last paragraph illustrated the problems a single & central UI poses, the following itemization presents the reasons why it has to be done in the case of a "complete" KM-system:

- The system needs to be able to consider all user actions and input to provide the information necessary for many features and functions of the solution.
- The full integration of all relevant systems allows users to be more effective in their daily work, while at the same time capturing important Meta information and data for other parts of the system. However, this effect will vary wildly as does the status quo in organizations.
- A crucial aspect of any KM-system is its need to be accepted by the users. Therefore, usability is of utmost importance and a single & central UI is one of the most important topics to achieve superior usability.

Comprising, the proposed central UI is feasible (though not cheap) from a technological point of view. While the presented arguments illustrate why such a UI does not yet exist, it also discusses the reasons for its necessity.

Virtual Information Pool While the general idea of integrating all available information of an organization is not new, there are numerous difficulties

that prevent that vision from becoming reality. For example, the difficulties of synchronizing a PDA (a Personal Digital Assistant such as a Palm Pilot) with a PIM (a Personal Information Manager such as Microsoft Outlook, Lotus Notes, etc.) illustrate many of the difficulties encountered in general such as mapping items with attributes that do not exist on the counterpart, have a different form, etc. However, this problem is well-known and solutions for many combinations (for example, integrating mainframe transactions in web-based systems) exist.

Another example of similar activities is provided by Data Warehouses that offer condensed information from diverse sources to executives. Although they do not provide the proposed integration, they illustrate that IT is capable of realizing a similar idea.

Together these examples prove that the virtual information pool is feasible in principal. While many of the currently used approaches to ingrate diverse data sources are very expensive and inefficient, more and more connector architectures (tools) become available that are able to plug in many existing systems and integrate their data and functionality. At the same time, newer software systems are generally better suited to be integrated as they utilize frameworks (for example, application servers) that make it easier to integrate them. Equally important is the fact that more and more systems are built to be inter-operable and thus offer documented interfaces using standard middleware.

Overall, the proposed approach to integrate all relevant data in one virtual information pool is feasible (as most of the associated details have been solved in specialized solutions) but very expensive with current means. However, the trend to open standards and interfaces as well as the improving capabilities of connector frameworks is reducing the problems integration faces. Summing up, building the virtual information pool is possible but represents a complex and difficult task for the time being.

Automation Automation is an aspect widely used, utilized, and introduced in most organizations already. Perhaps the most appropriate example of this aspect is provided by workflows and workflow engines that execute the defined steps and information flows of a process. Another relevant example that also demonstrates the range of this topic is given by Internet search engines, as they integrate more and more information, while deleting no longer available one (although not instantaneously), at the same time.

Although the mentioned examples already illustrate the diversity of this issue, the application of AI technology is another example of it. As AI technology allows a computer to appear being intelligent by utilizing all the information available (including taxonomies, ontologies, etc.) and generating new pieces of information, this is one of the most important aspects of KM-systems.

Not surprisingly, there are (KM) systems that contain many of the described features and functions. The most important example presented

in this thesis is the Lotus Discovery System capable, for example, of constructing, updating, and using taxonomies, finding affinities between fields of interests and people, identifying similar documents, etc.

While the solution provides similar capabilities, it is based on a broader information pool and includes a complete range of features addressing the identified KM requirements. For example, the partially automated management of user interests enables other automatic mechanisms to notify users of interesting new documents. Furthermore, this aspect also includes the usage of advanced technologies such as speech mining, image similarity, or video analysis making a wide range of potential information available to users.

Overall, the necessary technology for the described features exists already, a fact that is demonstrated by the Lotus Discovery System (or HyperWave products, etc.). While some of the applied technologies are not yet mature and others are difficult to integrate in a way that they generate the desired output, the principal applicability of the presented approach is out of question. Summing up, this field provides important and relevant technology and ongoing research is aiming to improve the range of its application.

Some readers might argue that the presented approach is an application of Enterprise Application Integration (EAI). While there are many similarities and overlaps, a principal difference is the different focus of the proposed solution versus EAI. Although EAI tries to streamline the systems an organization uses, it does not address the full range of issues the proposed KM-system does. However, EAI is another important trend that aims at integrating systems and, thus, will ease the difficult task of doing so for every initiative with this goal.

Summing up, EAI technology and techniques help to implement the proposed solution and, thus, illustrate the technological feasibility of the presented system. However, as the reasons for EAI are different from those of KM in general, the topics should not be confused with each other.

Summary While the previous discussions of the three major building blocks illustrate the technological feasibility of the solution, they also provide hints and guidelines how to implement them. For example, the central UI can be realized using portal technology that already proved its applicability in this field. On the other hand, the virtual information pool represents a difficult and complex goal. However, there are various examples of related systems and technologies (for example, Data Warehouses, EAI, etc.) that address many of the issues at hand. Finally, automation is a widely used technique in numerous systems. While automation covers simple topics like workflow automation, it also includes advanced AI technology in all its forms that allows the system to offer relevant information not available otherwise (as done by the Lotus Discovery System). Summing up, the previous paragraphs illustrated the principal feasibility of the solution and in what way it differs from existing systems.

Comparing with Existing Solutions

As the technological feasibility of the proposed solution has been presented, the next task is to compare it with the existing solutions described in chapter 4. Together these two aspects illustrate similarities and differences to existing approaches and concepts.

Although there are numerous systems claiming to support KM, the described examples cover most of the field and represent different approaches. Therefore, this comparison provides a good overview how the proposed KM-system differs from existing solutions.

CYMANTIX.NET As CYMANTIX.NET was designed with KM in mind and based on an information pool, its concept is similar to the presented one. Furthermore, it supports different ways of finding information, offers bi-directional links, provides ambiguity, etc. and, at the same time, important additions and enhancements had been planned (integrating a powerful full text search engine, etc.). However, the aspect of integrating diverse systems and their features is missing, as are most of the automation aspects the proposed solution includes. Furthermore, the central UI is more an idea (to integrate functionality in the web-interface) than a reality as only prototypes for integrating Microsoft Outlook exist.

Oracle This thesis already determined that the Oracle solution is offering a sound technological foundation to build a KM-system but lacks many important features in its current state. However, the flexible ways of integrating IT systems are one of the strong points of the Oracle solution that includes infrastructure to include data in a single information pool. Furthermore, a portal server and a Single Sign-On functionality both based on a directory service are offered. On the other hand, there is only limited support available addressing the aspect of automation and while it is possible to implement elaborate schemes to integrate other systems, the provided functionality only offers a shallow integration. Therefore, the Oracle solution could be a suitable foundation[36] to implement the proposed KM-system and offers important features and functions but does not address the whole range of KM requirements identified.

Lotus/IBM Software The Lotus Discovery System (plus additional products of Lotus/IBM) is the best example of a system that addresses key problems of KM. Furthermore, a suitable setup consists of combining the Discovery System with a PIM such as Lotus Notes or Microsoft Outlook, the IBM Enterprise Integration Portal, and various IBM products to integrate mainframe transactions, etc. Consequently, the Discovery System uses AI technology to compute similarity between documents, generate a taxonomy, or identifying affinities between people and topics. Therefore, this system offers a number of features and functions to be included in the proposed solution.

[36] Of course, a detailed analysis is needed to examine whether using the Oracle solution is the most appropriate solution for a specific KM initiative.

However, the mentioned systems are not closely integrated and do not provide a virtual information pool or a true central UI. Consequently, this solution is not able to take full advantage of the information pool and users still have to cope with the different look & feel of the integrated systems, thus, limiting the positive effects of the system in general.

Summary Overall, all three presented systems provide support for a set of KM related problems but do not address the whole range of problems, which differentiates the proposed solution from them. While CYMANTIX.NET includes interesting ideas, many features and functions are missing. As the Oracle solution does not address many requirements directly, it also lacks many important features and functions but provides a sound technological foundation to implement a KM-system. On the other hand, the Lotus/IBM software offers the most advanced and elaborate capabilities addressing many requirements of KM. While the solution may, therefore, be suited for KM initiatives with a limited focus, it does not offer the whole range of features and functions necessary to address all the KM-related requirements identified in section 2.2.

5.5.2 How the Solution Addresses the KM-related Problems

As the previous sections determined the technological viability of the proposed solution and how it differs from existing systems, the last issue is to discuss to what extent the requirements of KM are addressed by the KM-system. Consequently, the itemization does not discuss every single feature of the solution and, at the same time, presents topics that IT can address only partially or not at all.

Let us, therefore, take a look at the problems of KM in general and examine what the solution offers to address them:

- **"We do not know what we know"/Internal experts cannot be found:** As this is one of the most prominent problems to be solved by KM, there are multiple features and functions addressing it, for example, the powerful search mechanism, an automatically updated skills database that helps to find experts, providing generated summaries and taxonomies, etc. Summing up, a whole set of functions addresses this topic.

- **"Re-inventing the wheel/Making the same mistake twice"/Not invented here syndrome:** One way of reducing the mentioned problems is to provide powerful search mechanisms that provide quick and easy access to the whole information pool of the organization in question. Furthermore, the solution provides ways of capturing experiences gained in projects and project context, thus, allowing users to find everything related to a project as well as "lessons learned". However, the KM initiative also has to create a sharing culture motivating people to externalize their knowledge and search for and re-use available information. Consequently, the issue of the "Not invented here syndrome" can only be solved by organizational and cultural means and not by those of IT. Summing up,

the solution provides the necessary functions to capture, input, and re-use past experiences. However, the usage of these features needs to be ensured by organizational and cultural changes that foster a sharing culture.

- **"Information overflow"/Knowing it is there but not finding it / Automatic production of irrelevant knowledge/Filtering information based on tasks and long-term interests:** While these issues are related, they describe slightly different problems. Therefore, a whole range of features and functions addresses them, for example, the first issue is addressed by the powerful search mechanism that allows specifying exactly what one is looking for. At the same time, the first two and the last issue are taken care off by the management of user interests (proposing the addition and removal of interests) and considering them when presenting search results, pushing pieces of information to users, etc. On the other hand, the problem of automatic production of irrelevant knowledge is a serious risk of the proposed solution and close monitoring is needed to ensure it does not happen. However, one rather needs to risk a little annoyance triggered by irrelevant information pushed to users than not to push important pieces of information to people that need it.

- **"No/Inadequate automatic notification":** As already described in the paragraph above, the system manages interest profiles for each user and pushes pieces of information that have a high probability of being of interest. At the same time, the system allows to notify groups of users and send them links to information items (strictly speaking not an automatic notification though). Furthermore, the system offers the capability to inform users, when new items are entered in the virtual information pool that match certain criteria. Of course, an actual implementation is free to add even more sophisticated features. Generally speaking, the solution effectively solves this problem.

- **"No/Inadequate distribution of new "knowledge"":** The features and functions addressing this problem are the same as those described for the issue of "No/Inadequate automatic notification". However, additional support for this problem is offered by "traditional" Groupware features that allow pushing information manually or defining what pieces should be pushed automatically to what recipients. Nevertheless, one needs to carefully monitor the amount of information pushed to individual users to ensure that only relevant pieces are sent.

- **"Missing/Inadequate capturing of employee knowledge (including implicit knowledge; both for sharing and for retaining the knowledge of employees leaving or retiring)":** Although this issue is often identified as one of the most important problems to be addressed by KM, IT is not capable of offering a satisfactory solution to it. However, many of the described features and functions allow users to input their experiences and externalize their knowledge. At the same time, the integrated system captures a wide range of information entered by each user such as e-mails,

documents, recorded conversations, etc. and allows accessing it. Therefore, a wide range of information items is available after a member of an organization has left. However, a satisfactory solution of this problem is only possible by organizational means and, for example, a recent paper by Coakes et al. [22] proposes exit interviews as a way of retaining important knowledge.

- **Hiding information/Political use of information:** Although the proposed KM-system makes it impossible to actually hide any piece of information short of deleting it, people may elect to distort the available information. As distortion is a serious problem to the whole KM-system, one needs to minimize the problem as far as possible by cultural and organizational means! Therefore, chapter 3 discusses necessary preconditions of KM that include the issue of truthfulness as one of the most important points. However, the solution itself uses technologies that are able to cope with a certain amount of false data but will ultimately fail if the percentage of distorted information becomes too high. Summing up, the solution effectively addresses this problem, if the KM initiative itself is able to create a sharing culture adhering to the principle of truthfulness.

- **Barriers to information sharing/delays in information sharing/distortion of information:** As the proposed KM-system allows to share each piece of information in its original form (including recorded conversations, meetings, etc.), pieces of information can be shared among all members of an organization. Of course, the processes have to allow granting the necessary permissions, and indispensable transformations have to ensure that information is not distorted in any way. Consequently, the problems are addressed by the solution as far as possibly by means of IT. As barriers not only hinder information sharing but also shield people, the KM initiative has to decide what barriers have to be removed and what new barriers are necessary. Furthermore, an organizational change that provides space and time for social interaction is a powerful way of addressing the problems at hand.

- **"Missing "history"/Traceability":** As the solution provides a detailed change history plus old versions of documents, this issue is solved by the KM-system. Consequently, users can retrace all changes and understand what modifications have been performed and by whom.

- **"No multiplication of the knowledge of experts" or experts overloaded with routine questions:** The most important function addressing this problem is the provision of frequently asked questions that also help to shield experts from routine questions. On the other hand, yellow pages allow finding experts and profiting from their knowledge. At the same time, information items entered by experts have a certain chance of being pushed to people interested in the topics discussed in those documents.

- **"Lack of knowledge provided for greater insight into situation or to decide which actions should be taken":** While technology is not capable

of solving this issue, a number of features help to diminish it. Therefore, past experiences and yellow pages allow gaining greater insight and profiting by the help of experts. At the same time, the KM initiative should consider this problem and initiate the necessary organizational changes to address this issue together with the described features and functions.

- **Missing context (already partially addressed by the point about history)/Allowing items to appear in multiple places/folders (=> one form of ambiguity):** As the solution supports integrated workflows, capturing context can be done automatically or at least be supported by the system. Furthermore, additional context is provided by offering the history of items, computing which documents have a similar content, etc. On the other hand, the issue of allowing items in multiple places is offered by the central UI and supported by the virtual information pool. Therefore, the KM-system includes the solution to this problem in its concept. Summing up, both issues are addressed by the KM-system.

- **Using theoretical knowledge for practical problems:** Although the solution cannot address this problem directly, users can search experiences gained in projects to gain an understanding how past projects solved certain issues. However, a satisfactory solution can only be achieved by organizational means (if possible at all).

- **No time (budget) to share knowledge:** Although an IT system is not capable of solving this problem, the proposed solution represents a system that allows working more effective and, thus, provides users with a certain amount of time that can be used to share knowledge. At the same time, this issue illustrates the importance of providing an integrated solution and refrain from introducing an additional system. However, every system will fail if the users have not enough time to use it properly and, therefore, the KM initiative needs to ensure that people get the time they need and understand how KM is going to help them.

- **Not using technology to share knowledge effectively:** As the proposed system offers a wide range of ways to share information and supports all forms of communication accessible to IT in some way (including video and phone conferences, meetings, presentations, etc.), this aspect is handled very well by the solution. However, the KM initiative has to provide the necessary time and budget to foster a sharing culture (that also encourages people to exploit the offered features and functions).

- **Difficulties in capturing tacit knowledge:** Although IT is not capable of capturing tacit knowledge, the solution offers features and functions to capture implicit knowledge. At the same time, various media such as recordings (speech, video, etc.) that may or may not contain knowledge are made accessible via the KM-system. Therefore, IT does all it can to provide a satisfactory solution. However, this issue needs to be addressed by organizational means and the solution can only provide limited support.

- **Inaccurate/Out-of-date information:** As the KM-system allows working with one and the same item for virtually every possible usage, this problem is solved to the degree possible by means of IT. Of course, if necessary updates to information items are not entered, the delivered pieces will be out-of-date, but the problem of old copies of documents floating around is effectively solved.

- **Integrating new employees/acquisitions/sites:** While these issues have to be addressed primarily by organizational means, IT is able to support these activities. As the solution offers information on processes, past experiences, available experts, etc., new members of an organization have a wide range of ways finding the information they need or seeking help by the experts. On the other hand, integrating acquisitions or sites is a complex and difficult task, as existing information and some systems will need to be integrated in the solution. Furthermore, processes might have to be changed and all sorts of other adaptations of the KM-system will become necessary. As the solution is designed to be adaptable, these changes should be relatively (compared to less flexible systems) simple and inexpensive. However, the main tasks of integrating acquisitions and sites are organizational ones and IT is just a way of supporting them.

- **Sharing/Co-operation with Universities/Suppliers/Customers/... does not work:** As the proposed solution features a flexible & adaptable permission system, the most reasonable solution is to grant the required access to all partners that need it. On the other hand, closer co-operations call for a closer integration and, thus, the virtual information pools of the organizations in question should be enhanced accordingly. Once more, the permission system is the key to integrate foreign information and to grant access to the information pool. However, as each co-operation has its special requirements and restraints, this issue cannot be addressed by a feature or function of the solution. Instead, each case needs to be considered separately and the appropriate way of offering communication, collaboration, etc. methods has to be defined.

- **Input for quality enhancements missing:** While this issue needs to be addressed by organizational means, the solution offers a wide range of communication capabilities that may help to motivate people to provide their valuable input. Nevertheless, IT is only supporting the solution of this problem.

- **Missing information on competitors/product and new/innovative services:** As the proposed KM-system offers many ways of distributing information and allows notifying users of new relevant pieces of information, the solution provides efficient ways of distribution such information. However, the KM initiative needs to ensure that such information is made available and access is granted to all interested parties.

- **Prevent alternative decision for the same topic/project:** Although this problem is not addressed effectively by means of IT at the moment, there

is an interesting research project underway in England that tries to build such a system. Nevertheless, even the presented features and functions of the proposed solution offer relevant support, as they allow finding everything related to a project. Furthermore, it is possible to record all relevant meetings and use speech mining to access this information. Summing up, limited support is available and a solution is the center of current research.

- **Inefficient processes for knowledge creation:** As this is a rather general problem, it needs to be addressed by the KM initiative itself using organizational means. However, the proposed system reduces the negative effects of this problem by capturing many pieces of information with their context automatically and easing the insertion of new information items.

- **No use/adoption of external knowledge:** This is an issue similar to the "Not invented here syndrome" and, thus, can only be solved by organizational and cultural means. However, the system integrates external information sources and provides communication capabilities that can be facilitated by external users and, thus, helps to diminish this problem.

- **Costs for knowledge creation are too high:** As the proposed solution supports the easy creation and capture of information and offers elaborate assistance in finding available pieces, it effectively reduces the costs for inserting and retrieving information. However, knowledge creation itself is only supported by the KM-system and has to be performed by the members of an organization. Therefore, it needs to be addressed primarily by non-IT means.

- **Compatibility and externalization problems:** Since the KM-system is based on the virtual information pool and represents an integrated system, the problems of compatibility and externalization are addressed efficiently. Although some problems regarding these issues will remain, the solution features an effective interface to the outside, is capable of handling a wide range of formats, and offers synchronization capabilities with other systems/devices.

- **Important knowledge is forgotten / lost:** The proposed solution is keeping every piece of information available (at least in an archive) and, therefore, knowledge that has been explicated will never be forgotten or lost. Furthermore, the integrated system and its related processes should ensure that every important information item becomes available to the virtual information pool. Therefore, the "only" remaining issue is to motivate people to explicate important knowledge and store it in the system.

- **Missing capture of experiences gained in projects/Provide everything available for a project:** While the technological issues of this problem are addressed effectively by the KM-system as it captures the related project to each piece of information, the KM initiative needs to ensure that all relevant information items are entered in the system. Summing up, a

successful KM initiative together with the proposed solution represents an effective solution of this problem.

- **Adaptation of information to user preferences and device/access capabilities:** While the general problem is addressed by the presented KM-system, many details will have to be considered by an actual implementation. However, the necessary technological foundation is included in the proposed solution and an actual KM initiative will need to decide what amount of support is necessary and justifiable.

- **Damaged relationship to key clients/supplier when the account manager leaves:** As relationships to key customers often depend on personal acquaintance, an IT system cannot solve this issue. While it can (and will) record and capture all potentially relevant pieces of information and make them available, the KM initiative has to address this problem primarily with organizational means (for example, having backups for key personnel.

Summary The itemization presented above illustrates that the proposed solution addresses all issues where IT is capable of being part of the solution. However, many of the problems identified are either intractable to IT or can only be solved by a combination of organizational and technological means. Nevertheless, as the KM-system addresses all the KM requirements identified, it can rightfully claim to represent a system supporting a "complete" and holistic KM initiative.

Evaluating the Solution for the Exemplified University Problems

As there has already been a detailed discussion of the special KM problems of a university in section 5.4.3, there is no need for a further treatise. Consequently, the content of the mentioned section illustrates that the proposed solution addresses the particular KM needs of universities.

Therefore, the KM-system not only addresses the KM problems in general but also those of universities. Thus, the described solution is capable of addressing and/or supporting all KM issues with a relationship to IT.

5.5.3 The Big Picture

The discussions above illustrate that the described KM-system is offering more KM relevant features and functions than the examined examples of available system and that it addresses all KM problems to the extent possible by the current means of IT.

The first major topic of this section is the evaluation of the three major building blocks that proved their technological viability and provided hints how certain aspects can be implemented. The section continues with a comparison of existing solutions (already presented in chapter 4) with the proposed one that presents shortcomings of the existing solutions.

The major part of this section is dedicated to analyzing how the proposed solution addresses the identified KM problems (described in section 2.2). While some problems have to be solved by organizational means, others can be addressed by a combination of IT and organizational means, while still others are even primarily addressed by means of IT. As the exemplified problems of universities have already been examined in detail, this section only contains a short discussion determining that the problems identified are addressed to the extent possibly by means of IT.

Together these aspects illustrate the fact that the solution supports all aspects of a "complete" and holistic initiative. As this support is more comprehensive than that provided by currently available systems, the proposed solution represents a "complete" KM-system.

Chapter 6

Summary and Conclusion

This thesis provides an examination of the relationship between KM and IT and combines a holistic view with an IT focus throughout the text. Therefore, it presents a point of view that is not widely discussed by researchers (if done at all) and is, thus, able to offer new insights of the issues at hand.

6.1 KM: Its Goals and Problems

The first chapter discusses important definitions, such as the range of KM and related fields, investigates to what extent KM finds support by IT, and attends to the focus of this thesis. While most of the presented definitions are widely accepted, the critique of the term "tacit knowledge" as used by Nonaka and the discussion why the distinction between tacit, implicit, and explicit knowledge is superior to the simple tacit/explicit differentiation are not mainstream but, nevertheless, important to the rest of this thesis.

Generally speaking, the goal of KM is to make organizations more competitive by improving the way they handle key aspects and processes in respect of knowledge. Of course, "KM" activities have taken place since mankind exists, but KM is the first field to address this issue explicitly in a coherent and effective way.

As there are many fields related to KM, the introduction discusses only the most important ones. Furthermore, the focus of this thesis is defined in concentrating on providing a "complete" KM-system for areas requiring flexibility, creativity, and learning in the context of larger organizations (for example, product development, aspects of software engineering, project management).

6.1.1 IT Only Part of the Solution

One observation about the relationship between KM and IT is of utmost importance for anyone in the field: IT is not capable of managing knowledge and probably never will be[1]. However, IT is very effective in managing data and information among other things and, thus, can support KM.

[1]Computers would need a consciousness to have/store or "possess" knowledge!

Although KM does not necessarily require IT, organizations using computer systems in their normal work procedures will be better off to plan and implement necessary changes to integrate IT in their KM ambitions. Consequently, a "complete" and holistic KM initiative for organizations with IT systems already in place need to consider IT to support a "complete" KM-system, which in turn seems the only way to "unleash" the full potential of KM.

6.1.2 Goals/Problems and Requirements of KM (-Systems)

As there is no widely accepted definition of KM, the goals it tries to achieve and the problems it tries to solve is examined in detail in the second chapter. Furthermore, it presents requirements for a (IT) KM-system that addresses the identified issues.

Therefore, the chapter integrates goals and problems of KM from literature that is used to deduce requirements of a "complete" KM-system. Moreover, non-functional requirements and problems of existing KM-systems are taken into consideration.

6.2 Preconditions/Foundations for KM (-Systems)

Chapter 3 examines necessary preconditions and foundations of KM in general and KM-systems in specific. While all of the presented preconditions and foundations are very important, the issues of "We want to do KM and know the reasons why" together with truthfulness are the two most important ones.

Overall, the chapter illustrates that the success of a KM initiative ultimately depends on a wide range of organizational and cultural issues. As a KM-system can only support KM, it needs to consider these issues, whereas the KM initiative itself needs to establish an integrated view that includes these preconditions together with the proposed KM-system.

6.3 What Is Already Available – Existing Solutions

The next chapter analyzes three interesting examples of KM-systems, namely CYMANTIX.NET, Oracle, and Lotus/IBM software. As I had the privilege of having been a member of the development team of CYMANTIX.NET, this is the solution I know best. However, CYMANTIX.NET, though an interesting and flexible solution, lacks many features. On the other hand, the Oracle solution consists of many relevant technologies but does not provide a complete set of features and functions. Finally, the Lotus/IBM solution represented by the Lotus Discovery System plus Lotus Notes and other additional systems demonstrates the availability of elaborate KM-systems. However, it does not address all the requirements identified.

As the examined systems indeed are representative for current state of the art elaborate KM-systems, and since none address all identified requirements, the need for a "complete" KM-system seems obvious.

6.4 What Should Be Done – The Solution

The main chapter of this thesis presents the proposed solution, a "complete" KM-system that supports every aspect of a "complete" and holistic KM initiative. Consequently, the chapter starts with discussing principles the solution has to adhere to and continues with a presentation of the KM-system itself. Afterwards, the relationship of eLearning & KM (in form of the proposed solution) is examined, implementation considerations are discussed, and finally an evaluation is presented.

The described principles consist of technological guidelines such as integrating Groupware features and organizational issues that either help to ensure that future users are integrated (for example, participatory design) or address general topics (for example, differentiating long-term from short-term effects). Nevertheless, all these principles together are necessary to design, implement, and introduce a superior KM-system.

The next section illustrates the features and functions of the proposed solution that primarily consists of three major building blocks: The central user interface, the virtual information pool, and IT automation - Together forming the core of the presented KM-system, accompanied by other relevant aspects such as a powerful and flexible permission system and workflow support. While the presented architecture is a result of its own, all other aspects such as requirements, preconditions, principles, etc. culminate in this solution that takes all these issues, such as cultural and organizational ones, well into account.

Following the presentation of the proposed solution, the thesis discusses the relationship of eLearning and KM in the context of the proposed solution. As eLearning is lacking an exact definition and literature is containing hardly any discussion of the relationship to KM, the text deduces opinions of experts in these fields and argues that both are very similar but tend to have a different focus. Finally, the section proposes to integrate eLearning in the proposed KM-system in the case of educational organizations.

Section 5.4 discusses implementation issues, such as including planning & implementing the solution and examining its effects on the exemplified university problems. The central aspects are to adhere to the principles identified during all phases and to plan for a phased rollout of the system that allows for adjustments according to feedback and usage statistics. The section continues to present how the solution offers comprehensive support for the exemplified university problems by means of IT.

The final section of the chapter contains an evaluation of the solution. As there is no actual implementation, this is a difficult and complex task. However, the evaluation consists of three parts, namely examining the three major building blocks, comparing the system to the examined existing ones, and discussing how the solution addresses all the requirements identified. Consequently, all these parts of the evaluation prove the technological feasibility, identify that such a system does not yet exist, and that the goals and problems of KM are addressed.

6.5 Conclusion

Summing up, this thesis examines the relationship of KM and IT and proposes a "complete" KM-system to address the whole range of KM related problems based on a holistic view that lays emphasis on combining economical and sociological aspects while maintaining a strong IT focus. Consequently, the result is a unique KM-system that indeed takes all aspects of KM into consideration and not only adheres to IT solutions with a KM "complexion", as they are available today.

The identification of the goals and problems of KM, the presentation of the requirements of KM-systems, the preconditions and foundations of KM (-systems) and principles a KM-system has to comply is heavily influenced by cultural, organizational, and economical aspects. The examination of the existing systems illustrates the current state of commercial systems and allows comparing the proposed solution with them.

There are some issues this thesis chooses not to discuss to the extent possible. The exemplified problems of a university are sound and plausible, yet they are not backed by literature. At the same time, not all possible relationships between KM and economics theory have been investigated, although doing so most probably would not have affected the results in a significant way. Furthermore, this thesis concentrated on analyzing all important identified requirements, however, not every single technology known has been made part of the process. Finally, this thesis presents a KM-system on a relatively sound and valid foundation, yet it does not contain significant contributions to the serious problem of the fuzzy and unclear definitions in the field of KM.

The single most important result of this thesis is the architecture of the proposed KM-system and has been the focus of two papers by the author, one has been presented at the ECKM 2003 (see Hüttenegger [53]), while the other has appeared in the EJKM issue of December 2003 (see Hüttenegger [54]). While the presented architecture is an actual result of this thesis, the whole approach represents the vision of presenting a KM-system that addresses **all** issues KM faces and, thus, extends what IT can do for KM, in focusing on economical, sociological, and organizational aspects.

Another important result of this thesis is the examination of the relationship between eLearning and KM. As this relationship is hardly discussed in literature at all, the presented arguments illustrate what appears to experts in these fields and what can be deduced from those opinions.

Finally, the evaluation of the proposed solution proves the technological viability, highlighting differences when compared to existing solutions, and evaluating to what extent it addressed the goals and problems of KM. Although the existing systems already provide a wide range of features and functions, they lack important functionality to comprise a "complete" KM-system, as proposed by this thesis.

6.6 Future Areas of Research

This thesis illustrates that many fields of science are related to KM and are conducting relevant research. However, these activities are not coordinated in any way and, thus, KM is not benefiting by these research activities to the extent possible. While there are many relevant fields (most of them mentioned in the first chapter), the most important ones are economics (management), sociology, philosophy, cognitive research, and technology (as it provides supporting systems and due to the focus of this thesis).

6.6.1 Narrowing Down the Field of KM

One of the most important issues of future research is to narrow down what KM actually stands for, by developing a sound theory and a widely accepted definition. Because of the fact that most researchers have an economics **or** technology background, this issue may well prove difficult to solve. However, the combination of efforts with other disciplines will remain difficult, as long as the current situation of not widely excepted weak definitions persists.

Perhaps it might even become necessary to reduce the scope of KM, as there are not many boundaries that define its extents. Furthermore, the lack of understanding the phenomenon of the human consciousness will most probably prevent any exact definition and understanding of knowledge, thus, making it impossible to define KM in an exact way.

Summing up, the field of KM is widespread and diverse at the moment. Either it needs to focus and define KM in a more exact way, or it faces the risk of becoming another hype that fades away (regrettably signs in this direction already exist).

6.6.2 Computer Science Issues

From an IT point of view, things are not that complicated, as the technologies that are used for KM-systems are not very different from the rest. However, the broad application of AI technology demonstrates that KM-systems use cutting-edge technology. At the same time, this fact illustrates the importance of currently conducted research.

One of the most important and promising areas of IT related to KM is AI technology used for speech mining, image similarity, and video analysis. While speech mining is maturing rapidly, image similarity and video analysis are only applicable for specialized tasks. However, recent advances in all these fields promise interesting results that will allow KM-systems to enlarge the potential information they can process and provide.

Another important field is that of generating, maintaining, adapting, and using taxonomies, linguistic ontologies, and ontologies in general. While many applications handling taxonomies and linguistic ontologies already exist, pure ontologies mostly are used and cannot be generated or maintained in general. Although it seems uncertain where related research will lead to, almost every

result will allow a KM-system "to do a better job" and make the system appear more intelligent.

Of course, there are many other relevant areas of research and numerous results will be integrated in KM-systems to come, thus helping to improve existing ones. For example, at the moment one interesting research project is being conducted in England, which tries to warn a project team as soon as they are about to make a second decision on a topic they already discussed.

6.7 Vision for the Field of KM

In this final section I want to present my vision for the field of KM. While this thesis demonstrates that a "complete" KM-system supporting a "complete" and holistic KM initiative already offers a huge set of features and functions, many issues are not supported properly by IT at the moment.

Of course, there are many interesting and relevant ideas that have certain relevance for KM such as the semantic web, computers communicating directly with the brain, having systems that "know" the current situation of an individual and act accordingly. However, they do not seem to address the most important aspect I have in mind.

In my eyes the single most important advance in the field of KM would be to have means to extract knowledge from whatever artifact contains it and being able to transfer this knowledge to any person interested.

Bibliography

[1] Adelmann, Holger and Jashapara, Ashok: *Embedding knowledge management into business processes: The use of threaded discussion forums and knowledge objects at AstraZeneca.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 13–23, MCIL 2003.

[2] Alavi, Maryam and Leidner, Dorothy E.: *Knowledge Management Systems: Issues, Challenges, and Benefits.* Communications of AIS Vol. 1, Article 7, February 1999.

[3] Alavi, Maryam and Leidner, Dorothy E.: *Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues.* MIS Quarterly, Vol. 25, pp. 107–136, 2001.

[4] Allee, Verna: *eLearning is Not Knowledge Management* http://-www.linezine.com/2.1/features/vaenkm.htm, published Fall 2000, visited October 23, 2003.

[5] Altman, Edward, Chen, Yu, and Low, Wai Chong: *Semantic Exploration of Lecture Videos.* Proceedings of the 10th ACM international conference on Multimedia, Juan-les-Pins, France, pp. 416–417, ACM Press 2002.

[6] Ambrose, Paul J., Ramaprasad, Arkalgud, and Rai, Arun: *Information System, Knowledge Work and the IS Professional: Implications for Human Resources Management.* Proceedings of the 1998 ACM SIGCPR conference on Computer personnel research (CPR 98), Boston, pp. 78–81, ACM Press 1998.

[7] Anklam, Patti: *Technical Communications as Knowledge Management: Evolution of a Profession.* Proceedings on the 17th annual international conference on Computer documentation, New Orleans, pp. 36–44, ACM Press 1999.

[8] Babilon, Maria: *The Evolution of Knowledge Management within NCR Corporation.* Proceedings of the 16th annual international conference on Computer documentation, Quebec, pp. 1–4, ACM Press 1998.

[9] Banerjee, Sujata and Mittal, Vibhu O.: *On the Use of Linguistic Ontologies for Accessing and Indexing Distributed Digital Libraries.* Proceedings of the 1st Annual Conference on the Theory and Practice of Digi-

tal Libraries, College Station, Texas 1994, Texas A&M University (available from http://www.csdl.tamu.edu/DL94/paper/banerjee.html visited December 2, 2003).

[10] Basili, Victor R., Caldiera, Gianluigi, and Rombach, Dieter H.: *The Experience Factory.* In Encyclopedia of Software Engineering, Vol. 1, pp. 476–496, John Wiley & Sons, 1994.

[11] Basili, V., Shull, F., and Lanubile, F.: *Using Experiments to Build a Body of Knowledge.* Proceedings of the 3rd International PSI Conference, Novosibirsk, Russia, pp. 265–282, 1999 (available from http://-www.cs.umd.edu/~basili/psi99.pdf visited December 2, 2003).

[12] Bettoni, Marco, Braun, Ann, and Weber, Wolfgang: *What motivates cooperation and sharing in Communities of Practice?* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 67–72, MCIL 2003.

[13] Bircham, Heather: *Extracting knowledge for organisational decision-making: The impact of question structure.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 85–92, MCIL 2003.

[14] Brachos, Dimitros A., Soderquist, Klas Eric, and Prastacos, Gregory P.: *Knowledge sharing networks' (KSNs) critical success factors: A comprehensive study of knowledge work.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 111–120, MCIL 2003.

[15] Brook Hall, Timothy: *Curriculum Development Critical Success Factors for eLearning Implementation.* Proceedings of the International Conference on Computers in Education (ICCE'02), Auckland, pp. 1544–1545, IEEE 2002.

[16] Brown, Eric, Srinivasan, Savitha, Coden, Anni, Ponceleon, Dulce, Cooper, James, Amir, Arnon, and Pieper, Jan: *Towards speech as a knowledge resource.* Proceedings of the 10th International Conference on Information and Knowledge Management, Atlanta, pp. 526–528, ACM Press 2001.

[17] Budin, Aban: *Knowledge Management in Library Resources for Distance Learning.* master thesis, University of Krems 2001.

[18] Carlstedt, Anna and Nordborg, Mats: *An Evaluation of Topic Maps.* master thesis, Göteborg University 2002 (available from http://-www.cling.gu.se/~cl8matsn/uppsats.pdf visited December 2, 2003).

[19] Cegarra Navarro, Juan G. and Dewhurst, Frank W.: *The shared organisational context and unlearning as a prior step in the creation of intellectual capital: An empirical investigation.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 147–155, MCIL 2003.

[20] Chawathe, Sudarshan, Garcia-Molina, Hector, Hammer, Joachim, Ireland, Kelly, Papakonstantinou, Yannis, Ullman, Jeffrey, and Widom, Jennifer: *The TSIMMIS Project: Integration of Heterogeneous Information Sources.* Proceedings of IPSJ Conference, Tokyo, pp. 7–18, 1994.

[21] Chen, Shizhong, Duan, Yanquing, Edwards, John S., and Lehaney, Brian: *An investigation on SMEs' inter-organisational knowledge transfer needs.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 171–179, MCIL 2003.

[22] Coakes, Elayne, Bradburn, Anton, Shearer, James, and Burke, Terry: *Knowledge creation and sharing mechanisms: From heads to heads.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 181–189, MCIL 2003.

[23] Cochrane, Ednea M. and Ong, Cindy: *Customer retention by integrating knowledge management, CRM, and data mining: An holistic system thinking approach.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 191–199, MCIL 2003.

[24] Currier, Sarah and Campbell, Lorna M.: *Learning Technologies Critical Success Factors for eLearning Implementation: Educational Technology Interoperability Standards.* Proceedings of the International Conference on Computers in Education (ICCE'02), Auckland, pp. 1542–1543, IEEE 2002.

[25] D'Amore, Raymond, Helm, Daniel, Valley, Gary, and Damianos, Laurie: *Expertise sharing and community detection.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 221–231, MCIL 2003.

[26] Davenport, T. H. and Prusak, L.: *Working Knowledge: How Organizations Manage What They Know.* Boston Harvard Business School Press, 1998.

[27] Dienes, Zoltan and Perner, Josef: *A Theory of Implicit and Explicit Knowledge.* Cambridge University Press, 1998.

[28] Lotus Discovery Server: http://www.lotus.com/products/discserver.nsf, visited December 2, 2003.

[29] Doernhoefer, Mark: *Surfing the Net for Software Engineering Notes.* ACM SIGSOFT Software Engineering Notes Vol. 27, Issue 3, pp. 24–33, ACM Press 2002.

[30] Döring-Katerkamp, Uwe and Trojan, Jörg: *Einzelergebnisse der Umfrage "Wissensmanagement in der Praxis".* in German, http://www.ifem.org/-www/mitarbeiteraktivierung/wmpraxisquantitativ.pdf, visited December 2, 2003.

[31] Workshop on Knowledge Management ECIS'98: Articles on Knowledge Management, CEA Cadarache, http://www.mcxapc.org/inserts/ateliers/-liens/ecis98.htm, visited December 2, 2003.

[32] Edwards, Deborah L. and Mahling, Dirk E.: *Toward Knowledge Management Systems in the Legal Domain.* Proceedings of the international ACM SIGGROUP conference on Supporting group work (GROUP 97), Phoenix, pp. 158–166, ACM Press 1997.

[33] Eppler, Dr. Martin J., Seifried, Patrick M., and Röpnack Axel: *Improving Knowledge Intensive Processes through an Enterprise Knowledge Medium.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 222–130, ACM Press 1999.

[34] Essers, Juup and Schreinemakers, Jos: *The Conception of Knowledge and Information in Knowledge Management.* In: J.F. Schreinemakers (ed.) *Knowledge Management: Organization, Competence and Methodology – Advances in Knowledge Management Vol. 1. Proc. 4th Int. ISMICK Symposium.* Würzburg, pp. 93–104, 1996.

[35] Ezingeard, Jean-Noël, Leigh, Simon, and Chandler-Wilde, Rebecca: *Knowledge Management at Ernst & Young UK: Generating Value through Knowledge Flows.* Proceedings of the 21st international conference on Information systems, Brisbane, pp. 807–822, Association for Information Systems, Atlanta, 2000.

[36] Fagrell, Henrik, Forsberg, Kerstin, and Sanneblad, Johann: *FieldWise: A Mobile Knowledge Management Architecture.* Proceeding of the ACM 2000 Conference on Computer supported cooperative work, Philadelphia, pp. 211–220, ACM Press 2000.

[37] Fehér Peter: *Knowing the knowledge organisations.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 345–355, MCIL 2003.

[38] Firestone, J. M.: *Estimating Benefits of Knowledge Management Initiatives: Concepts, Methodology, and Tools.* Journal of the KMCI, Vol. 1, No. 3, 2001 (available from : http://www.kmci.org/KI_Journal/Articles/-VolumeOne/Number_3/KMBenefitEstimationrev1.PDF, visited December 2, 2003).

[39] Fischer, Stephan: *Course and Exercise Sequencing Using Metadata in Adaptive Hypermedia Learning Systems.* Journal of Educational Resources in Computing Vol. 1, No.1, Article No. 5, ACM Press 2001.

[40] Fürnkranz, Johannes: *A Study using n-gram Features for Text Categorization.* Technical Report of the Austrian Research Institute for Artificial Intelligence, Vienna 1998.

[41] Golebiowska, Joanna, Dieng-Kuntz, Rose, Corby, Olivier, and Mousseau, Didier: *Building and Exploiting Ontologies for an Automobile Project Memory.* Proceedings of the International Conference on Knowledge Capture, Victoria, British Columbia, pp. 52–59, ACM Press 2001.

[42] Greif, Irene: *Panel: Everyone is talking about Knowledge Management.* Proceedings of the 1998 ACM conference on Computer supported cooperative work (CSCW 98), Seattle, pp. 405–406, ACM Press 1998.

[43] Grützner, Ines, Angkasaputra, Niniek, and Pfahl, Dieter: *A systematic approach to produce small courseware modules for combined learning and knowledge management environments.* Proceedings of the 14th international conference on Software engineering and knowledge engineering (SEKE'02), Ischia, pp. 533–539, ACM Press 2002.

[44] Grey, Denham, Moderator Summary by Beller, Stephen: *KM101 Summary* April 2001 (from http://www.nhds.com/download/dikuw.htm, visited December 2, 2003).

[45] Hagedorn, Kat: *Extracting Value from Automated Classification Tools.* March 2001 (from http://argus-acia.com/white_papers/classification.html, visited December 2, 2003).

[46] Hahn, Jungpil and Subramani, Mani R.: *A Framework of Knowledge Management Systems: Issues and Challenges for Theory and Practice.* Proceedings of the 21st international conference on Information systems, Brisbane, pp. 302–312, Association for Information Systems December 2000.

[47] Harris, Kathy: *Success or Failure in KM, CM, Collaboration and E-Learning.* February 2003, Gartner Group 2003 (downloaded from http://www.gartner.com/resources/113100/113103/113103.pdf on August 14, 2003).

[48] Henninger, Scott: *Developing Domain Knowledge Through the Reuse of Project Experiences.* Proceedings of the 1995 Symposium on Software reusability (SSR'95), Seattle, pp. 186–195, ACM Press 1995.

[49] Herschel, Richard T. Ph.D. and Nemati, Hamid R. Ph.D.: *CKOS and Knowledge Management: Exploring Opportunities for using Information Exchange Protocols.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 42–50, ACM Press 1999.

[50] Hess Michael: *Part I Knowledge Management and E-Learning in Security Police.* In: Kurt R. Spillmann, Andreas Wenger and Michel Hess (eds.) with the Assistance of Karin Fink *Vol. 12: Setting the 21st Century Agenda Proceedings of the 5th International Security Forum.* Bern, pp. 15–68, 2003 (downloaded from http://www.fsk.ethz.ch/documents/-Studies/volume_12/documents/ls_vol12_parti.pdf on August 14, 2003).

[51] Hoch, Rainer: *Using IR Techniques for Text Classification in Document Analysis.* Proceedings of the 17th annual international ACM-SIGIR conference on Research and development in information retrieval, Dublin, pp. 31–30, Springer-Verlag, New York, 1994.

[52] Hoffmann, Marcel, Loser, Kai-Uwe, Walter, Thomas, Herrmann, Thomas: *A Design Process for Embedding Knowledge Management in Everyday Work.* Proceedings of the international ACM SIGGROUP conference on Supporting group work, Phoenix, pp. 296–305, ACM Press 1999.

[53] Hüttenegger, Georg: *A Knowledge Management System Architecture.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 485–494, MCIL 2003.

[54] Hüttenegger, Georg: *Knowledge Management System Building Blocks.* Electronic Journal of Knowledge Management (EJKM), Vol. 1, Issue 2, MCIL 2003.

[55] ICSTI FORUM: Articles on Knowledge Networks. Quarterly Newsletter of the International Council for Scientific and Technical Information, http://-www.icsti.org/forum/32/, visited December 2, 2003.

[56] International Organization for Standardization (ISO): *ISO/IEC 13250:2002 Topic Maps (2nd Edition).* http://www.y12.doe.gov/-sgml/sc34/document/0322_files/iso13250-2nd-ed-v2.pdf, visited December 2, 2003.

[57] Jasek, Deborah: *Distance Learning Defined.* Texas Transportation Institute, http://transops.tamu.edu/documents/DistanceLearningDefined.pdf, visited December 2, 2003.

[58] Johannessen, Jon-Arild, Olaisen, Johann, and Olsen, Bjørn: *Mismanagement of tacit knowledge: Knowledge management, the danger of information technology, and what to do about it.* http://-program.forskningsradet.no/skikt/johannessen.php3, visited December 2, 2003.

[59] Jurisica, Igor and Nixon, Brian A.: *Building Quality into Case-Based Reasoning Systems.* Proceedings of the 10th International Conference on Advanced Information System Engineering (CAiSE'98), Pisa, pp. 363–380, Springer-Verlag, Heidelberg, 1998.

[60] Kaski, Samuel: *Data exploration using self-organising maps.* dissertation, Finish Academy of Technology, Espoo 1997.

[61] Kingsley, M.: *Measuring the Return on Knowledge Management.* http://-www.llrx.com/features/kmroi.htm, visited December 2, 2003.

[62] Knoeru, Krishna: *Real time project management using knowledge networks.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 583–592, MCIL 2003.

[63] KMCI discussion group to be found at: http://groups.yahoo.com/group/-kmci-Virtual-Chapter/ and http://www.kmci.org/.

[64] KPMG Consulting: *Knowledge Management: Research Report 1998.* downloaded from http://www.brint.com/papers/submit/knowmgmt.pdf March 14, 2002; visited December 2, 2003, published 1998.

[65] KPMG Consulting: *Knowledge Management: Research Report 2000.* downloaded from http://-www.kpmg.nl/Docs/Knowledge_Advisory_Services/-KPMG%20KM%20Research%20Report%202000.pdf March 14, 2002; visited December 2, 2003, published November 1999.

[66] Li, Chen, Yerneni, Ramana, Vassalos, Vasilis, Garcia-Molina, Hector, Papakonstantinou, Yannis, Ullman, Jeffrey, and Valiveti, Murty: *Capability Based Mediation in TSIMMIS.* SIGMOD 98 Demo, Seattle, June 1998.

[67] Magnini, Bernardo and Speranza, Manuela: *Merging Global and Specialized Linguistic Ontologies.* Proceedings of the Workshop Ontolex-2002 Ontologies and Lexical Knowledge Bases, LREC-2002, pp. 43–48, (downloaded from http://tcc.itc.it/research/textec/topics/multiwordnet/doc/-ontomerge_ontolex.pdf August 31, 2003).

[68] Mahe, Sylvain and Rieu, Chrinte: *Toward a Pull-Approach of Knowledge Management for Improving Enterprise Flexibility Responsiveness.* In: J.F. Schreinemakers and Jaean-Paul Bartès (ed.) *Knowledge Management: Organization, Competence and Methodology - Advances in Knowledge Management Vol. 2. Proc. 5th Int. ISMICK Symposium.* Würzburg, pp. 33–45, 1997.

[69] Malhotra, Y.: *Why Knowledge Management Systems Fail. Enablers and Constraints of Knowledge Management in Human Enterprises.* In: Handbook on Knowledge Management 1: Knowledge Matters, Springer, Heidelberg, Germany, pp. 577–599, 2002 (may also be found on: http://-www.brint.org/WhyKMSFail.htm, visited December 2, 2003).

[70] Marwick, Alan D.: *Knowledge Management Technology.* IBM Systems Journal Vol. 40, No. 4, pp. 814–830, 2001 (downloaded from http://-www.research.ibm.com/journal/sj/404/marwick.pdf on February 21, 2002; visited December 2, 2003).

[71] Maturana, Humberto R. and Varela, Francisco J.: *The Tree of Knowledge: The Biological Roots of Human Understanding.* Revised Edition, Shabhala, Boston, and London, 1992.

[72] McDermott, R.: *Why Information Technology Inspired But Cannot Deliver Knowledge Management.* California Management Review, Vol. 41, No. 4, pp. 103–117, 1999.

[73] McElroy, Mark W.: *The New Knowledge Management: Complexity, Learning, and Sustainable Innovation.* KMCI Press / Butterworth-Heinemann, 2003.

[74] Merali, Yasmin and Davies, John: *Knowledge Capture and Utilization in Virtual Communities.* Proceedings of the International Conference on Knowledge Capture, Victoria, British Columbia, pp. 92–99, ACM Press 2001.

[75] Minor, Mirjam and Wernicke, Mike: *Experience management with knowledge sharing agents.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 669–675, MCIL 2003.

[76] Mitchell, Tom M.: *Machine Learning.* McGraw-Hill, New York, 1997.

[77] Nickols, Fred: *The Knowledge in Knowledge Management (KM).* In: The Knowledge Management Yearbook, Butterworth-Heinemann, Boston, 2000 (may also be found on: http://home.att.net/~nickols/-Knowledge_in_KM.htm, visited December 2, 2003).

[78] Nonaka, I.: *A Dynamic Theory of Organizational Knowledge Creation.* Organization Science Vol. 5, No. 1, pp. 14–37, 1994.

[79] Nonaka, I. and Takeuchi, H.: *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation.* Oxford University Press, New York/Oxford, 1995.

[80] Osterloh, M. and Frey, B. S.: *Motivation, Knowledge Transfer, and Organisational Forms.* Organization Science Vol. 11, No. 5, pp. 538–550, 2000.

[81] Panteleyev, Michael G., Puzankov, Dmitry V., and Sazykin, Pavel V.: *Intelligent Educational Environments Based on the Semantic Web Technology.* Proceedings of the 2002 IEEE International Conference on Artificial Intelligence Systems (ICAIS'02), Russia, pp. 457–463, IEEE 2002.

[82] Papakonstantinou, Yannis, Abiteboul, Serge, and Garcia-Molina, Hector: *Object Fusion in Mediator Systems.* In VLDB Conference, Bombay, India, September 1996.

[83] Pepper, Steve: *The TAO of Topic Maps.* Proceedings of XML Europe 2000, GCA (available at http://www.ontopia.net/topicmaps/materials/-tao.html, visited December 2, 2003).

[84] Pepper, Steve and Grønmo, Geir: *Towards a General Theory of Scope.* http://www.ontopia.net/topicmaps/materials/scope.htm, visited December 2, 2003.

[85] Petrak, Johann: *Data Mining Methoden und Anwendungen.* in German, Technical Report Austrian Research Institute for Artificial Intelligence, Vienna 1997.

[86] Rapanotti, Lucia, Tosunoglu Blake, Canan, and Griffiths, Robert: *eTutorials with Voice Groupware: real-time conferencing to support computing students at a distance.* Proceedings of the 7th annual conference on Innovation and technology in computer science education (ITiCSE'02), Aarhus, pp. 116–120, ACM Press 2002.

[87] Rath, Holger H.: *The Topic Maps Handbook.* Version 1.1 February 6, 2003; http://www.empolis.com/download/docs/whitepapers/-empolistopicmapswhitepaper_eng.pdf, visited December 2, 2003.

[88] Romhardt, Kai: *"Die Organisation aus der Wissensperspektive – Möglichkeiten und Grenzen der Intervention".* dissertation in German, University of Geneva, 1998.

[89] Rollet, Herwig: *Aspekte des Wissensmanagements.* master thesis in German, Graz University of Technology, February 2000.

[90] Ruiz-Mercader, Josefa, Meroño-Cerdan, Angel, and Sabater-Sánchez, Ramón: *Learning in organisations and information technologies. Their impact on organisational performance in small businesses.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 775–785, MCIL 2003.

[91] Ruth, Stephen PhD., Theobald, Jeffrey, and Frizzell, Virgil PhD.: *A University-based Approach to the Diffusion of Knowledge Management Concepts and Practice.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 283–290, ACM Press 1999.

[92] Senge, Peter M.: *The Fifth Discipline: The Art & Practice of the Learning Organization.* Doubleday Currency, New York, 1990.

[93] Schmidt, Siegfried J. (ed.): *Der Diskurs des Radikalen Konstruktivismus.* in German (The Discourse of the Radical Constructivism), Suhrkamp Taschenbuch Verlag, Frankfurt/Main, 1987.

[94] Sharp, Peter, Eardley, Alan, and Shah, Hanifa: *Use of visual tools in the context of development of MaKE - A KM method.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 799–808, MCIL 2003.

[95] Shi, Hongchi, Revithis, Spyridon, and Chen, Su-Shing: *An Agent Enabling Personalized Learning in e-Learning Environments.* Proceedings of the 2002 ACM AAMS conference, Bologna, pp. 847–848, ACM Press 2002.

[96] Skok, Walter: *Knowledge Management: London Taxi Cabs Case Study.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 94–101, ACM Press 1999.

[97] Smolnik, S. and Nastansky, L.: *K-Discovery: Identification of Distributed Knowledge Structures in a Process-Oriented Groupware Environment.* Proceedings of Knowledge Technologies Conference 2001 (may also be found on: http://www2.gca.org/knowledgetechnologies/2001/-proceedings/Smolnik%20Paper.pdf, visited December 2, 2003).

[98] Spiegler, Isreal: *Knowledge Management: A new Idea or a Recycled Concept?* Communications of AIS Vol. 3, Article 14, June 2000.

[99] Stuart, Angela and O'Donnell, David: *Establishing a knowledge sharing culture in an R&D context: Can HR drive the agenda?* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 861–870, MCIL 2003.

[100] Sumner, Mary: *Knowledge Management: Theory and Practice.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 1–3, ACM Press 1999.

[101] Sunassee, Nakkiran N. and Sewry, David A.: *A Theoretical Framework for Knowledge Management Implementation.* Proceedings of the 2002 annual research conference of the South African institute of computer scientists and information technologists on Enablement through technology, Port Elizabeth, pp. 235–245, ACM Press 2002.

[102] Sveiby, Karl-Erik: *What is Knowledge Management?* http://-www.sveiby.com/articles/KnowledgeManagement.html, visited December 2, 2003.

[103] Swami, Sundaravalli, Venkitachalam, Narayanaswami, and Sangle, Purnima: *Enabling knowledge management by practicing and processing knowledge engineering.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 871–881, MCIL 2003.

[104] System Dynamics Homepage: http://sysdyn.clexchange.org/sd-intro/-home.html, visited December 2, 2003.

[105] TSIMMIS publications: http://www-db.stanford.edu/tsimmis/-publications.html, visited December 2, 2003.

[106] Trauth, Eileen M. Ph.D.: *Who Owns my Soul? The Paradox of Pursuing Organizational Knowledge in a Work Culture of Individualism.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 159–163, ACM Press 1999.

[107] Ferrán-Urdaneta, Carlos: *Teams or Communities? Organizational Structures for Knowledge Management.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 128–134, ACM Press 1999.

[108] Vandenbosch, B. and Ginzberg, M.J.: *Lotus Notes and Collaboration: Plus ça change.* Journal of Management Information Systems, Vol. 13, pp. 65–82, 1996.

[109] Vanhoenacker, Jurgen, Bryan, Prof. Dr. Anton, and Dedene, Prof. Dr. Guido: *Creating a Knowledge Management Architecture for Business Process Change.* Proceedings of the 1999 ACM SIGCPR conference on Computer personnel research, New Orleans, pp. 231–241, ACM Press 1999.

[110] Vossen, Gerard A.: *Strategic Knowledge Acquisition.* In: J.F. Schreinemakers (ed.) *Knowledge Management: Organization, Competence and*

Methodology - Advances in Knowledge Management Vol. 1. Proc. 4th Int. ISMICK Symposium. Würzburg, pp. 237–246, 1996.

[111] Vroom, Regine W.: *Towards a toolbox for conceptual design engineering known as C-DET.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 937–947, MCIL 2003.

[112] Weber, Volker: *People, Places & Things.* in German, c't 20/2001 Magazin für Computer Technik, pp. 142–144, Heinz Heise, Hannover, 2001.

[113] Weggeman, Mathieu and Berends, Hans: *Facilitating Knowledge Sharing in Non-Hierarchical Workrelations.* In: J.F. Schreinemakers and Jaean-Paul Bartès (ed.) *Knowledge Management: Organization, Competence and Methodology - Advances in Knowledge Management Vol. 2. Proc. 5th Int. ISMICK Symposium.* Würzburg, pp. 57–69, 1997.

[114] Wiig, Karl M.: *The Intelligent Enterprise and Knowledge Management.* UNESCO's Encyclopedia of Life Support Systems, 1999 (Copyright 1999 Knowledge Research Institute).

[115] Williams, Roy: *Integrating Distributed Learning with just-in-context Knowledge Management.* Electronic journal of e-Learning, Vol. 1, Issue 1, pp. 45–50, MCIL 2003 (available at http://www.ejel.org/, visited December 2, 2003).

[116] Witten, I. H. and Frank, E.: *Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations.* Morgan Kaufmann, San Francisco, CA, 1999.

[117] Won, Kuan Yew and Aspinwall, Elaine: *Is knowledge management equivalent to information technology?* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 989–997, MCIL 2003.

[118] WordNet: information about and download from: http://-www.cogsci.princeton.edu/~wn/, visited December 2, 2003.

[119] Yoo, Youngjin, Ginzberg, Michael J., and Ahn, Joong Ho: *A cross-cultural Investigation of the Use of Knowledge Management Systems.* Proceeding of the 20th international conference on Information Systems, Atlanta, pp. 501–505, ACM Press 1999.

[120] Zerzour, Kamel and Marir, Farhi: *Knowledge management of surveillance video-content in an integrated descriptive object-oriented model.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 1007–1021, MCIL 2003.

CURRICULUM VITAE

Personal Information

Name: Georg Hüttenegger

Title: Master (*Diplom-Ingenieur*) in computer science

Date and Place of Birth: May 25, 1976, Eisenstadt

Nationality: Austria

Address: Khekgasse 39/4, 1230 Vienna

E-mail: georg@ist.org

Professional Experience

Since Dec 2001	Project manager and software architect/developer at WAVE Solutions Information Technology GmbH, Nordbergstrasse 13, 1090 Vienna Work focus: All aspects of transactional and non-transactional web applications such as the Online Banking Service of Bank Austria-Creditanstalt
Dec 1999 – Oct 2001	Software architect/developer at CYMANTIX Software GmbH, Darnautgasse 13, 1120 Vienna Work focus: Cross platform software development in the areas of middleware, user interface, and database of a KM software
Mar 2001 – Oct 2001	Member of the technical committee of the EU project CORMA (IST-12685) for CYMANTIX Software GmbH
Feb 1998 – Nov 1999	Software developer at Tecco Software Entwicklungs GmbH, Prinz Eugen Strasse 58, 1040 Vienna Work focus: Cross platform development, test, and documentation of a middleware system and a multi-tier system based on it

Education

Since Mar 2000	Enrolled at the Vienna University of Technology in the doctoral program

Oct 1999	Graduation from the Vienna University of Technology with a master's degree (*Diplom-Ingenieur*) in computer science
Oct 1995 – Oct 1999	Enrolled at the Vienna University of Technology in the "Informatik" (computer science/information technology) masters program
Jun 1994	Austrian high school graduation ("Matura")
Oct 1986 – Jun 1994	High school (BG/BRG/BORG Eisenstadt) in Eisenstadt, Austria
Oct 1982 – Jun 1986	Elementary school in Eisenstadt, Austria

Miscellaneous

Oct 1994 – Apr 1995	National service in the Austrian army

Research Interests

- Knowledge Management
- Distributed Systems
- Middleware Systems

Publications

- Hüttenegger, Georg: *Knowledge Management System Building Blocks.* Electronic Journal of Knowledge Management (EJKM), Vol. 1, Issue 2, MCIL 2003.
- Hüttenegger, Georg: *A Knowledge Management System Architecture.* Proceedings of the 4th European Conference on Knowledge Management (ECKM 2003), Oxford, pp. 485–494, MCIL 2003.

Vienna, 14th December 2003