2.3 Knowledge Management Systems

Much the same as with the definition of knowledge, there are several definitions of Knowledge Management Systems (KMS) in literature [Alavi & Leidner, 2001] [Gray, 2000] [McDermott, 1999] [Mertens & Griese, 2000] [Neumann et al., 1998] [Staab et al., 2001]. Some focus more on information technology some focus on communication or people. Therefore, the following definition is used in this thesis [Maier, 2002 p76]:

> *"A knowledge management system (KMS) is an ICT [Information and Communication Technologies] system in the sense of an application system or an ICT platform that combines and integrates functions for the contextualized handling of both, explicit and tacit knowledge, throughout the organization or that part of the organization that is targeted by a KM initiative. A KMS supports networks of knowledge workers in the creation, construction, identification capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search and last but not least the application of knowledge the aim of which is to support the dynamics of organizational learning and organization effectiveness."*

Summarising, KMS are applications used to support the process of

- information retrieval,
- information extraction,
- adding information.

2.3.1 Technologies and Applications forming a KMS

KMSs consist of many heterogeneous tools and applications connected to already existing relevant information sources and IT systems within a company [Föcker & Goesmann, 1999] like

- **ERP Systems**

  Product data is often stored in Enterprise Resource Planning Systems (ERP). An ERP system consists of general modules for purchase, production planning and control, inventory, etc. Special modules are also available for industry dependent applications or special tasks like the

planning of particular business processes.
(For special interests see Scheer & Habermann, 2000.)

- **CRM Systems**
  Customer Relationship Management Systems (CRM) supports the sales people by allowing the storage of all customer related data. CRM is the process that identifies customers, creates customer knowledge, builds customer relationships, and shapes customers' perception of the organisation and its solutions [Srivastava et al., 1999].
- **Document Management Systems**
  Document Management Systems (DMS) provide the structured storage of document oriented information. Unstructured information within documents can be indexed and keywords can be assigned to documents. Most DMS's offer powerful search and versioning functionality. [Campbell, 2008]
- **Databases / Data Warehouses / Data Mining**
  Most structured information are held in databases. Although most databases offer powerful interfaces, Knowledge Management Systems should use interfaces of the applications instead of accessing the data directly.
  Data Warehouses are subject-oriented collection of data optimised and adapted for support of management decision processes [Inmon, 1992]. So-called "multidimensional" data bases and business intelligence tools are often used to provide special views of the data adapted to requirements of the company management [Gray & Watson, 1998]. Data Mining means extracting knowledge from large amounts of data [Han & Kamber, 2006]. The aim is to find coherencies to support the management in developing new strategies.
- **Identity Management / User Directories**
  The personnel data of a company is often stored in so-called directories, for example, in X.509 directories available via Lightweight Directory Access Protocol (LDAP). For that purpose, many organisations are using the "human resources" modules of an ERP- or Workflow Management System [Scheer & Habermann, 2000]. In addition all user rights and roles are stored within identity management systems. If the provisioning of user rights is based on rules, these rules and the conditions for the rules are stored in the directory. [Greenblatt, 2001]

- **Workflow Management Systems**

  Workflow Management Systems (WfMS) can be used to implement the main business processes of an organisation. A WfMS contains the following important information:

  - formal description of the business processes;
  - status and outcome of a business process.

  Current processes can be monitored and their status is always available. Completed processes store their results in process variables and documents. Result documents can also be stored directly in a DMS.

- **Groupware**

  Teamwork may be supported by groupware. Most groupware systems use a "bulletin board" as a communication infrastructure. Information, documents and applications can be attached to this bulletin board. Document databases and discussion forums and mixtures of these may be implemented in a groupware system. Groupware supports modelling and the practical use of business processes using its own programming or script language.

- **Intranet**

  Information networks only available for users within an organisation, supporting internal communication processes and using internet technology are called intranets .

  There are two types of information available in an intranet:

  - Static information (e.g., stored in HTML files on standard web servers) can be administrated using Content Management Systems (CMS).
  - Dynamic information is generated at runtime using different information sources. Within these sources there are databases, other IT systems (e.g., DMS, ERP, and CRM systems), and static information (e.g., logos, icons and other pictures).

  Another important source of information within an intranet can be a discussion or news forum. To enhance the well-known intranet platforms, new technologies arose referred to as Web 2.0 [O'Reilly, 2005]. So-called "blogs" (abbreviation for web logs) allow keeping a web-based diary. Some people use these blogs for announcing new products, strategies and other

relevant information. It is practically the same with applications to organise photos, videos, sound and other multimedia files.

- **IT-Management Systems / Helpdesk**

  To provide a basis for IT-Management, companies require structured documentation of the entire IT infrastructure. Ideally, the relationship between the business processes and the IT infrastructure should also be documented (of great value for Knowledge Management).

  Helpdesk systems are a kind of specialised KMSs combined with a small workflow system. They are intended to support members of the helpdesk team to find answers to questions which are submitted by employees as a so-called “Trouble Ticket” (TT). This TT can be exchanged within the helpdesk team until a solution is found and the calling employee is satisfied.

- **Email**

  A substantial part of communication is handled by email systems (Heuer, 2003]. Therefore a lot of valuable information is stored in email archives. In addition, emails can be classified automatically (e.g., using email addresses, emails can be classified in “internal communication”, “customer communication”, “partner communication” like suppliers or consultants).

- **Calendar**

  Electronic calendars can be used to find out whether an employee is available at a certain time frame on condition that every appointment is registered and up-to-date.

- **Wiki**

  A special working method becomes popular in the last three years: Wiki. Wiki wiki is a hawaiian word for “fast”. The wiki technology can be used in Intranets and in the Internet. Most wikis are server based software applications which allow the users to create, edit and link pages in an easy way. Wiks are suitable as easy to use collaboration systems. [Klobas, 2006] [Wikipedia: wiki]

- **Project Management Systems**

  Project Management Systems (PMS) can be used to document vision statements, goals, objectives, initiatives and dependencies to resources. Also the schedule of the project containing milestones, tasks and responsible

project members can be managed. All these information can be consolidated to project reports which show the status of current projects. Therefore, the PMS create graphical representations for an easy to read overview (e.g., so-called Gantt charts with traffic light based status information of tasks).

- **Internal Company Digital Documents / Reporting**
  - Regularly produced reports. These reports often contain essential information used for reporting to upper levels within the hierarchy of the company.
  - Organisational diagrams (Organigrams) and organisation handbooks giving a structural overview of an organisation. However, they tend to become out of date very quickly due to a frequent change of structures and responsibilities in big organisations. Furthermore, the update process is not supported, because all personnel data is of course stored in the main IT systems and there is no bridge to these structural diagrams. A much more difficult problem is the difference between the structure, the power and the communication paths in the diagram and the reality.
- **Search and Retrieval**

  Popular search engines from the internet can be used to search within a company's intranet. In addition, retrieval functions are available in most IT systems. A special function enabling the "meta-search" in all internal IT systems could help to increase the quality of retrieved results as well as the user acceptance. This meta-search submits the users' request to all connected IT systems using their search interfaces and combine the returned results to an overview that is displayed to the user. In literature this strategy is also called "Enterprise Search" [Demartini, 2007] [Riehn, 2008].

We could believe now that all (explicit) knowledge of a company could be stored in such systems as described above. The "meta-search" approach shows the complexity of Knowledge Management in practice: Even if all the above-mentioned systems provide access to the stored data via (non-standardised) interfaces, it is a extraordinary effort to integrate all these IT systems into a KMS.

In addition, this integration must provide semantic coherencies. For instance (see example in Figure 2.3-1), a search result within a CRM system returns an employee's User ID. Then the personnel data has to be derived from a user directory. The Identity Management system assigns a role to the user. The responsibilities of this role are described in the organisational handbook. A workflow definition describes the condition of involving the user in a business process. The basis of a specific decision was a discussion with colleagues via email stored in the email archive. Results of that specific process are part of a document stored in a DMS. Further data of that process are stored in an ERP system (e.g. products have been shipped to distributors and the payment did not come in up to now), and so on and so forth. How this chain of coherencies can be modelled?

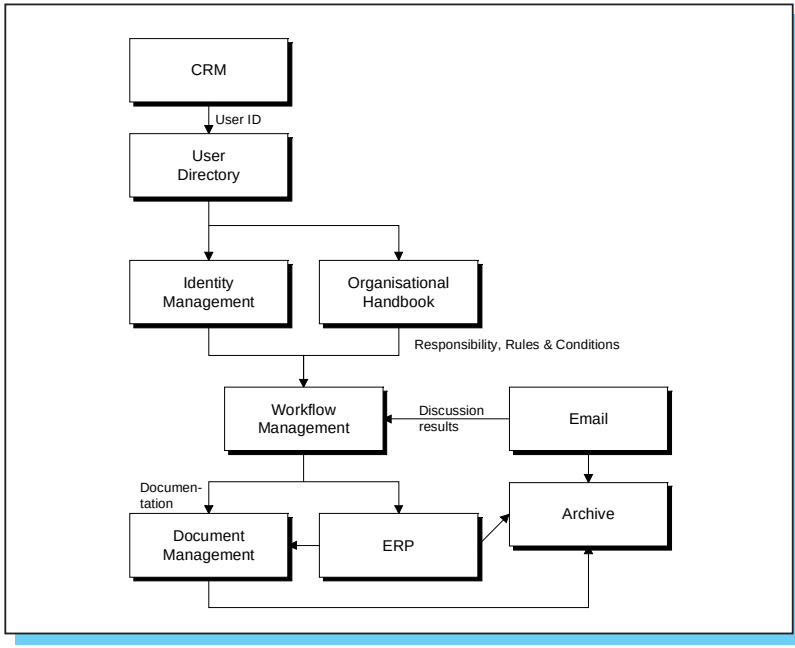

Figure 2.3-1 Example of integrated IT Systems in one search

Semantic coherencies can be simplified and described as “context”. Technically, simplified “context” means the relationships to further information with type descriptions of these relationships.

As an example we can store the content of a machine operating manual as a simple text file. An engineer or mechanic reading the document should understand all details of the manual. For people without this special knowledge, the document contains unknown terms. We can add a glossary for all technical terms. This is an easy form of context relationships only concerning single words. If there is a complicated instruction like “use a torque wrench and tighten the screw with 25 Nm” the glossary describes what a “torque wrench” is but a photo could be helpful. Also a manual “how to handle a torque wrench” is very useful for people never used this tool. So we have two further relationships.

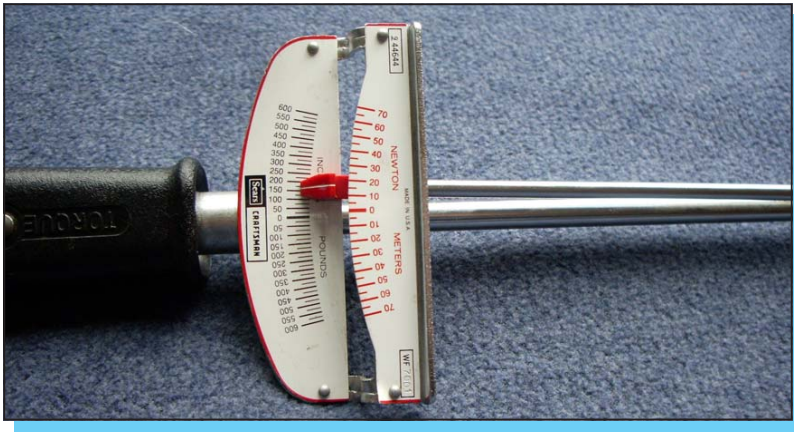

Figure 2.3-2 Photo of a torque wrench [Wikipedia: torque wrench]

How could those relationships be mapped in HTML, for example? A possible solution is the positing of hyperlinks between different documents. For example, to build up a glossary is an easy task with hyperlinks. The relationship “word means” could be added automatically before delivering the document to the user, using filtering and document scan technology. If now all possible relationships between information units would be added in this way, we would get an large number of information links and systems. All documents would have to go through these applications before documents are presented to users.

Within Wiki systems, for example, authors has to provide these links by using so-called “wiki-words”. If a wiki-word did not exist, the system adds a new page for this word. The reader of a page containing wiki-words can follow these links and is able to read and change the corresponding page. Some wiki implementations show links to wiki-words automatically. Therefore, a glossary or an encyclopedia could be built in an easy way using wikis. Unfortunately, more complex relationships between objects of interest are not provided within wiki systems. Most wikis support the “describe” relation only – unlike so-called “Semantic Wikis” that use extensions for providing semantic functionality (see Section 3.1).

Figure 2.3-3 illustrates an imaginable KMS architecture [Maier, 2002].

The layer “Knowledge Repository” is responsible for building the semantic coherencies described here. In this layer, ontologies offer very flexible possibilities to represent relationships between real objects. (Ontologies and methods for constructing complex models are described in Section 2.2.) Objects of the ontology are related to knowledge elements (coming from several data sources) using Meta-Knowledge. The knowledge repository may be developed as a knowledge network, for example, but has to be maintained manually. Among others, this includes the task of describing relations between objects in the knowledge network and objects in data sources, for example, by adding and linking keywords in the knowledge network and tagging documents within the document management system using these keywords (as illustrated in Figure 2.3-4).

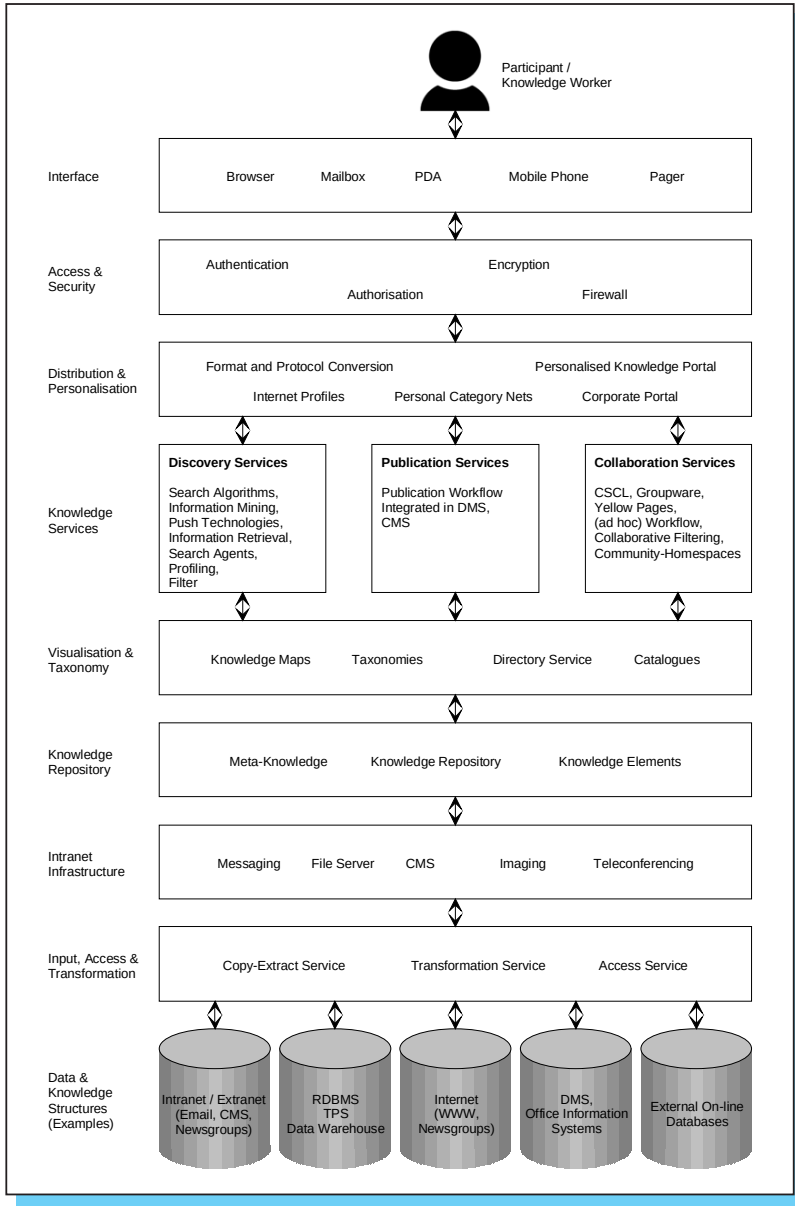

Figure 2.3-3 Elements of a KMS [Maier, 2002]

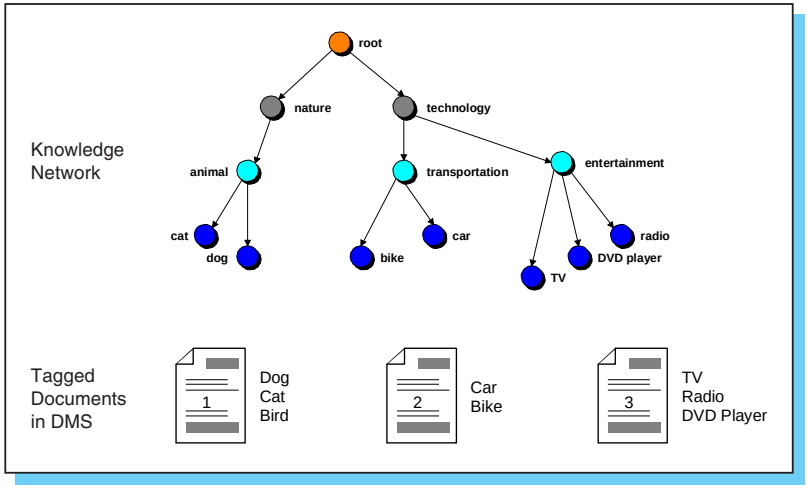

Figure 2.3-4 Knowledge Repository Layer Example

The layer "Visualisation & Taxonomy" of Figure 2.3-3 creates a classification (taxonomy) of the knowledge and provides varied visualisations. Figure 2.3-5 illustrates an example search result for the keyword "entertainment". Even though there is no relation between document no. 3 and the node "entertainment" it is shown as a result because it has relations to sub-concepts of "entertainment", by the tags associated to the document.

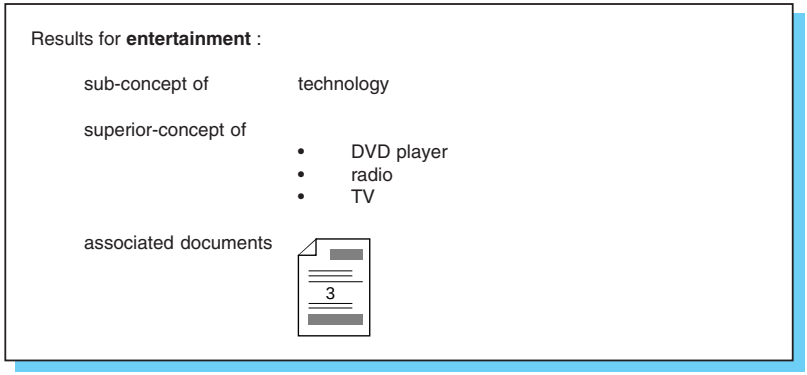

Figure 2.3-5 Visualisation Layer Example

2.3.2 Review of Some KMS

There are a huge amount of KMS on the market. Here the following four KMSs will be described concerning their strategies, principles and application domains:

- e:kms (empolis GmbH)
  [empolis web site];
- KnowledgeMiner (USU AG)
  [USU web site];
- Infocodex (MSI Dr. Waelti AG)
  [Infocodex web site];
- Knowledge Café (Altavier GmbH)
  [Altavier web site].

The choice made shows a variety of KMS approaches and depended on the availability of these systems for testing and background information. This represents a broad collection across the KMS systems on the market including a modular and highly adaptable All-Round system (e:kms), a system based on Document Management (Infocedex), an Intranet based system focused on typical Intranet applications (Knowledge Café) and a system to build and manage knowledge structures based on hugh amount of existing structured and un-structured information (KnowledgeMiner).

e:kms

empolis knowledge management suite (e:kms) is based on a modular model to be adaptable to individual company needs. It offers modules for document management (e:com), web content management (e:wcs), workflow management (e:ws), portal management (e:ps) and user administration (e:cs).

empolis represents the philosophy that for different existing search requirements an optimal search method has to be offered. e:kms provide a hierarchical search technique that increases the quality of results but also increase the cost of modelling and forces to focus on a special subject.

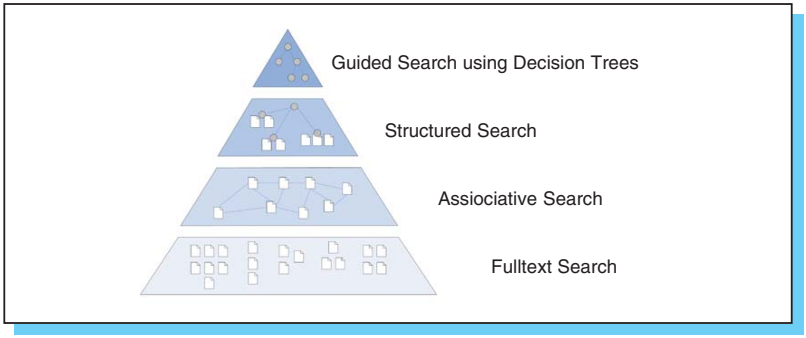

Figure 2.3-6 Hierarchy of Search Methods in e:kms

For searching in extremely huge amounts of unstructured information, a **full-text search** is used.

Searching in big unstructured information using natural language search queries is performed by applying an **associative search** method. The query can be interactively refined by user feedback to get results of high quality more quickly.

Natural language searches on structured and unstructured information based on ontologies is called **structured search**. It uses case-based reasoning technologies.

Guided searches using decision trees are used for searches when the query is hard to phrase. A decision tree guides a user to follow a sequence of decisions as for example the structured questions in helpdesk systems.

The meaning of associative search and structured search is like a semantic search. The associative search uses mathematical analysis methods. The knowledge used for structured search is modelled and explicitly defined. Associative and structured searches are capable of learning. This improves the results but is dependent on user feedback. Classification of documents will be enhanced by associative search. The structured search learns by use of case-based reasoning concept.

Using user profiles, an individual filtering of results can be used among others by rating of documents. For example, a standard search for “Golf” returns “golf club” and “VW-Golf”. Using “Sport” as filter the results can be conditioned.

Infocedex

Infocedex of MSI Dr. Waelti AG is more a Document Management System. It combines linguistical databases (for example WordNet of Princeton University or Eurovoc of the European Union) with a taxonomy tree and self-organised neuronal networks. This enables

- automatic recognition of content and logical ordering of documents in an overview map,
- automatic tagging of documents (adding meta-data like keywords), and
- an efficient cross-linguistic full text search using synonyms and similarity.

Words and terms of documents will be matched with a linguistic database, taken together in groups of synonyms and linked with the taxonomy tree. A vector space model of exact 100 dimensions will then be created. After projection into this model, the documents will be classified in logical overview maps by self-organised neuronal networks. Therefore no human interaction is needed.

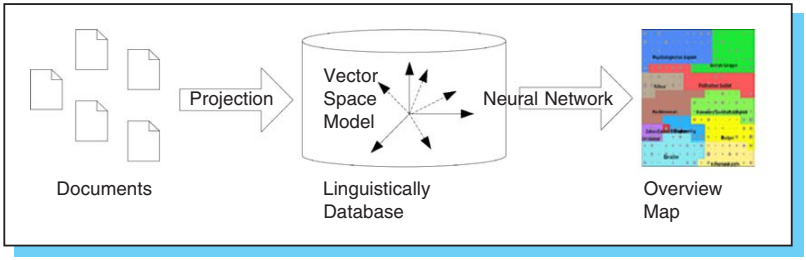

Figure 2.3-7 Automatic Creation of Overview Map by Infocodec

Knowledge Café

Altavier's Knowledge Café is a modular Intranet based software. It includes the following base modules: Glossar, GlobalSearch, MyNews, Online-Help and Yellow Pages. The Modules Knowledge Base, Discussion, Projects, Press, Communities, MyBookmarks, Content-Analyses, and Tree-Applet can be integrated into the base modules. Some of these modules will be described now:

- GlobalSearch offers additional search functionality across all modules.
- MyNews is an individual newsletter like blog but uses a push method to broadcast news.
- Yellow Pages offer a collection of user profiles for searching for reference persons.
- Knowledge Base supports creating, using and sharing documents.
- Discussion Base supports on-topic information exchange like forums.
- Project work will be supported by Groupware functionality like team calendars, email and resource management.
- A Press module provides employees with relevant information from newspaper and magazines. Like MyNews, it uses a push method.
- MyBookmarks enables to bookmark individual results of searching and navigating.
- Content-Analyses is an administration tool to create analyses and reports.
- The Tree-Applet is used for the visualisation of concepts and their relationships.

KnowledgeMiner

USU AG's KnowledgeMiner is designed for searching documents concerning a question or to find again answers to questions that are answered already. This is a typical practice in helpdesk systems. Based on topic- and concept networks, KnowledgeMiner describes the semantic coherencies. The system involves related topics into the search and gives the user hints to refine the search.

Topic networks are held in Topic Maps and the concepts are stored as Semantic Networks. In a Topic Map, a subject / topic is the lowest entity. It consists of search terms and search conditions plus further information like synonyms. Structurally or

organisationally related topics are forming a topic network. A collection of topic networks consists of several topic networks (see Figure 2.3-8).

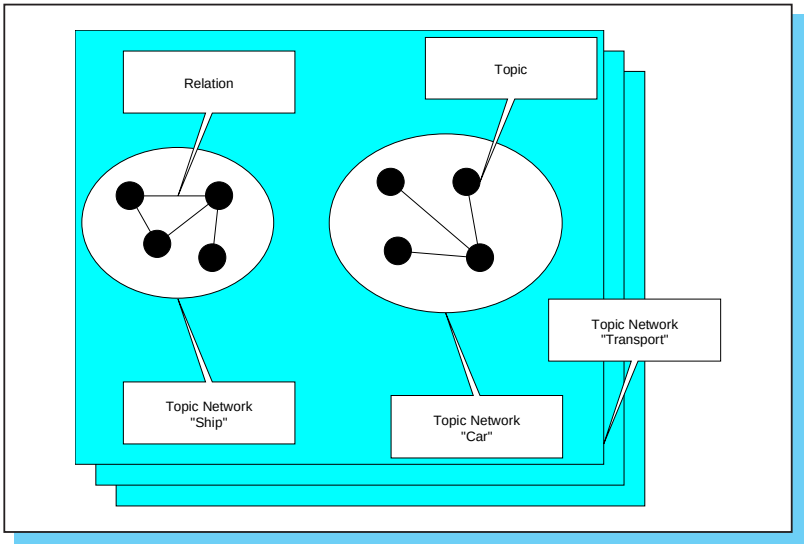

Figure 2.3-8 Example of a Collection of Topic Networks

Concept networks are optimised for automatical creation and processing using existing documents. They can learn by user interaction. They consist of concepts and relationships and are organised as collections of concept networks (see Figure 2.3-9). Relationships between concepts contain the context and synonyms in addition.

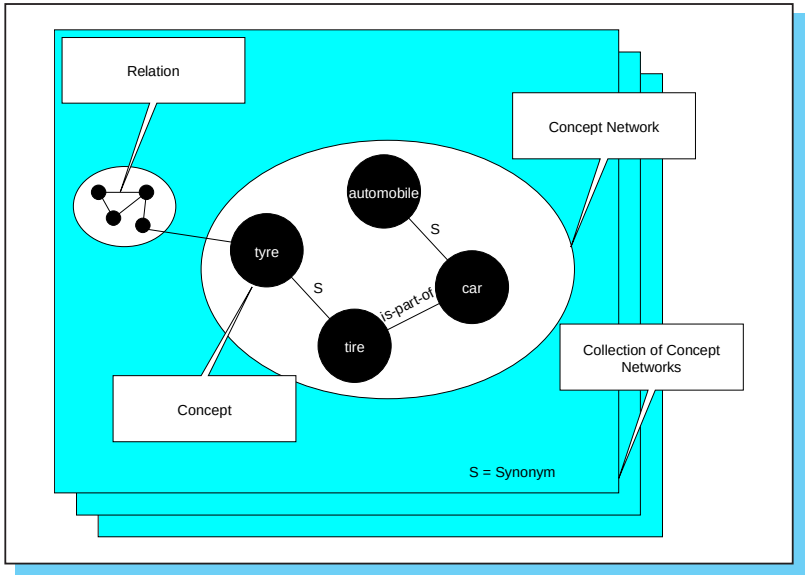

Figure 2.3-9 Example of a Collection of Concept Networks

A simple search in KnowledgeMiner is processed as follows (see Figure 2.3-10):

1. User types in a search query;
2. removal of stop words;
3. morphological forms referring to concepts of the user input are determined by text analysis;
4. searching for synonyms and their context for every concept of the user input;
5. involvement of morphological forms referring to synonyms found;
6. starting a search with all concepts involved.

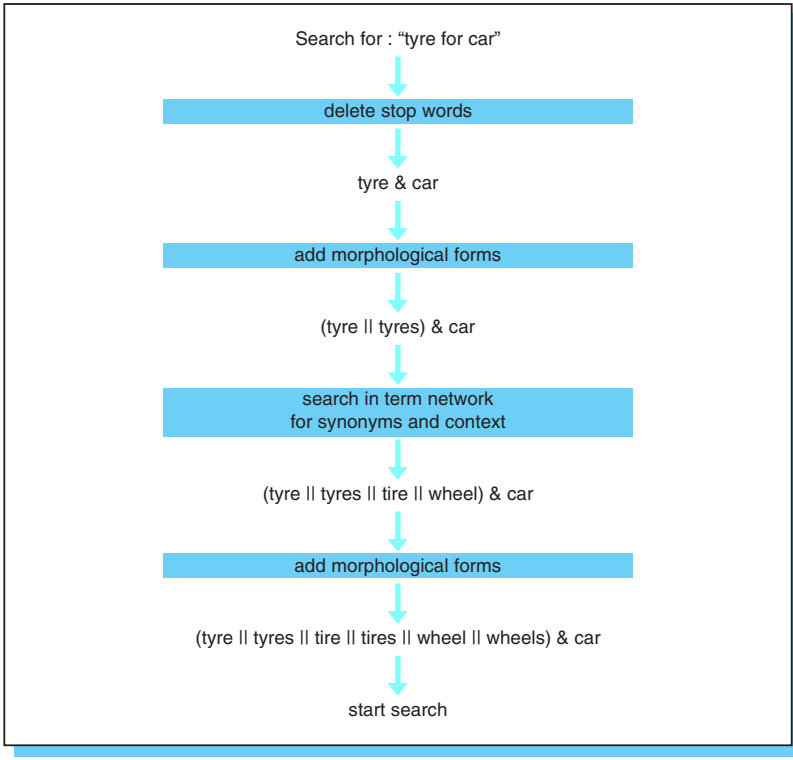

Figure 2.3-10 Processing a Search in KnowledgeMiner

The user now is able to improve the ranking by weighting the results. On the basis of the described functionality KnowledgeMiner can be predicated as capable of learning. Thereby, the quality of results will be increased during the usage and will be fitting better to the users need.

Comparison of the Four KMS

Figure 2.3-11 illustrates a feature list for all four KMSs described (+ = supported, - = not supported, ? = no information available).

Function	e:kms	Infocedex	Knowledge Cafe	Knowledge Miner
Knowledge Search (pull)				
User Profile	+	-	+	+
Thesaurus	?	-	+	+
Multilingual	+	+	+	?
Fulltext Search	+	+	+	+
Synonym Search	?	+	+	+
Semantic Search	+	+	?	+
Knowledge Delivery (push)				
Newsletter	?	-	+	+
Hints (important additional Information to search results)	?	-	?	?
Notification (on Changes of Knowledge Base)	?	-	?	+
Knowledge Representation and Visualisation				
Semantic Network	?	-	-	+
Neural Network	-	+	-	-
Ontologies	+	-	-	-
Topic Maps	+	-	-	+
Databases	+	+	+	-
Ranking	+	+	?	+
Graphical Navigation	+	+	+	?
Publication, Structuring and Cross-Linkage of Knowledge	+	+	+	+
Automatic Addition of Knowledge	+	+	?	+

Figure 2.3-11.a Comparison of the Four KMS

Function	e:kms	Infocedex	Knowledge Cafe	Knowledge Miner
Knowledge Communication and Cooperation				
Chat	?	-	-	-
Communities	?	-	+	-
E-Mail	?	?	+	?
Forum	?	-	+	-
Supporting Project Work	+	-	+	-
Administration of Knowledge Management Systems				
User Groups	+	?	+	+
Administration of User Rights	+	?	+	+
Analysis of Data for Creation of Knowledge Elements	?	?	+	+
Computer Based Teaching and Learning	-	-	-	-
Learning Ability of the System				
Evaluation of Results	+	?	+	+
Interactivity (e.g., by check back the user within queries)	+	?	+	+

Figure 2.3-11.b Comparison of the Four KMS (continued)