IT based Knowledge Management

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Abstract

Knowledge Management can be seen from various perspectives: Human Resource Management helps us to encourage people to share their knowledge. From Artificial Intelligence we can learn how knowledge can be presented in a formal way as a basis for knowledge processing. Information Technology in general has provided several approaches to support and improve a successful knowledge management in an organisation.

The paper first clarifies the notions knowledge and knowledge management and reviews various techniques for knowledge representation: text, picture, logic formulas, rules or networks. A formal representation of knowledge using rules opens the door for knowledge processing. The relationships between knowledge processing and knowledge management will be outlined. Knowledge networks or topic maps will be highlighted since they offer new possibilities for knowledge management: knowledge networks enable a semantic search for knowledge. Unlike common search engine a semantic search considers the relationships between the search term and other notions.

The overview on information technology based knowledge management will include wiki systems as well. So called semantic wiki systems allow a semi-formal knowledge representation and may therefore become powerful tools for an efficient knowledge management.

The paper argues that knowledge management should be an integrated part of any engineering or business degree program. Graduates should not only be able to use knowledge management systems but should be the driving force in implementing such systems. It will be shown that knowledge and the management of knowledge is discussed in various lectures in our degree programme Business Informatics. Moreover knowledge management is not a theoretical issue only, applied knowledge management is used for co-operative learning.

Keywords: knowledge management, knowledge processing, knowledge in engineering and business education, higher education,

Introduction

Knowledge is not only a buzzword related to knowledge management or knowledge society but it is a widely used notion in everyday life as well as in academic life.

- But what is knowledge?
- What is knowledge management?
- How can information technology support our handling of knowledge?

The paper discusses these questions. Although our society has become a knowledge society the notion *knowledge* is rarely discussed in degree programmes. We start taking a closer look onto the term knowledge. Based on a definition or explanation of knowledge various kinds of *knowledge representations* are presented. A formal knowledge representation opens the door for (an automated) knowledge processing as this is in the focus of artificial intelligence. *Knowledge management* has been in the focus of business administration for many years. Knowledge has become a productivity factor and a working knowledge management can put an organisation into a comfortable position within the global competition: If you know what to do your decisions will be the right ones. Information technology has provided methods and tools for the management of knowledge since the very beginning. Thus, we look at techniques which have been used for knowledge management for a long time and introduce some new developments like knowledge networks or wiki systems. Wiki Systems have become well known since the launch of wikipedia. It is argued that extended wiki systems, so called semantic wiki systems, will become powerful knowledge management systems within the next few years.

Finally we look at the degree programmes at the Wismar Business School and the Faculty of Engineering at Hochschule Wismar and discuss the role of knowledge and knowledge management in the degree programmes offered by the faculties. As a result it will be recommended to include knowledge management as a topic into any academic education in order to prepare our graduates for their future in a knowledge society.

Good to know: knowledge

Everybody has to apply his or her or his knowledge almost every minute day in and day out. Especially in education knowledge is a widely used word. We say that students have to show their knowledge in oral or written exams. But what is knowledge? The Illustrated Oxford Dictionary (1998) gives several explanations:

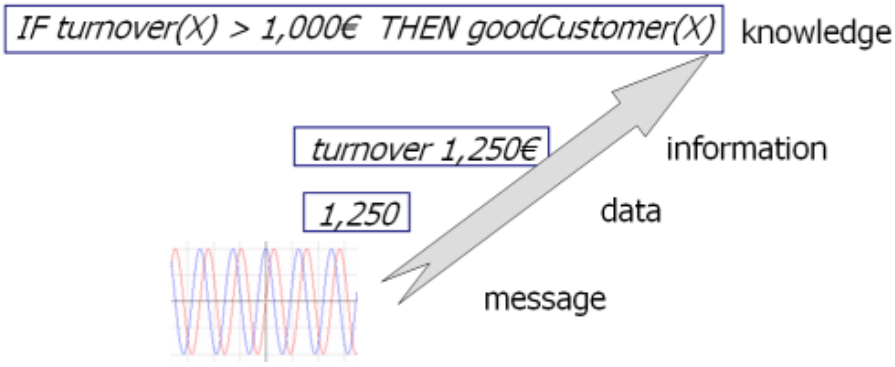
"1 a (usu. fool. by of) awareness or familiarity gained by experience (of a person, fact, or thing) (Have no knowledge of that). b a person's range of information (is not within his knowledge). 2 a (usu. foll. by of) a theoretical or practical understanding of a subject, language, etc. (has a good knowledge of Greek). b the sum of what is known (every branch of knowledge). 3 Philos. true, justified belief; certain understanding, as opposed to opinion." [1]

The second and third points are of special interest: the second explanation of the term knowledge is the one education deals with. During their studies students extend their knowledge (theoretical or practical) of various topics. The third point is related to logic. Knowledge is more than an opinion, it can be proofed or at least justified and therefore knowledge is always true: If we know something then we act according to that knowledge. Naturally knowledge can change due to new information. This does not imply that the knowledge itself becomes false. Instead the knowledge has extended including the fact that the former information cannot be applied any more.

Davenport and Prusak (1998) characterize knowledge as "*information combined with experience, context, interpretation, and reflection. It is a high-value form of information that is ready to apply to decisions and actions*" and therefore underlines as well that knowledge is something we can apply.

From the computer science or the informatics perspective knowledge is based on information, information is based on data, and data is based on a message, see figure 1. A message is build by a sequence of signals. (So far no other ways of sending and receiving messages are known.) A message is physical: If the sequence of signals follow some rules (a structure, a so called syntax) then the message carries data. In informatics we mostly use digital characters carried by some physical message that might be optical (from CD; DVD) or electromagnetic (from chips, disks). Other messages (written text, photographs, sound) can be transformed into digital characters as well.

Figure 1: From a message to knowledge



A data like 1,230 is only a data, in this case a number and it is not yet information. In Informatics we speak about information if the data and its meaning for the receiver are known: If we know that 1,230 is a daily turnover in Euro then we have some information. We view on knowledge as applied information, i.e. information becomes knowledge if we can apply the information. Application can be performed by a human being or even by a machine.

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Knowledge Management can be best motivated and explained by the statement:

"*If only X knew what X knows*".

Looking into the literature and especially into the internet many values for X can be found, like Siemens, HP, we, your company, you. The aim of knowledge management is to make knowledge available whenever and wherever it is needed. This is the more technical background. In the field of business administration knowledge management is defined as a concept for the development of an organisation:

"*Knowledge management is a formal, structured initiative to improve the creation, distribution, or use of knowledge in an organization." It "is a formal process of turning corporate knowledge into corporate value*", Davenport and Prusak (1998).

Since knowledge management has become a buzzword it is also characterized as "*an umbrella term for making more efficient use of the human knowledge that exists within an organization. Knowledge management is the 21st century equivalent of information management*"[1]. A working knowledge management makes organisations more effective and efficient and helps an organisation to survive in the global competition.

Knowledge Representation

In order to be able to share knowledge a representation of knowledge is required. Especially in education knowledge always has been put down in text or pictures. Although computer started as number crunchers the processing of text and later on of pictures has become widely used. Knowledge is stored in a computer as text or picture, see figure 2. The article itself is stored knowledge: at least for those who can read and understand the text. We call it a formal knowledge representation if a machine can apply the knowledge, e.g. can handle the knowledge or "understand" it.

[1] www.pcmag.com/encyclopedia/ visited 2009-07-02

Figure 2: Pictures can represent knowledge[2]

Texts and pictures are not formal representations of knowledge in the sense a computer can handle. Artificial intelligence has focussed on a formal representation of knowledge since formal knowledge representation is the basis for any knowledge processing. Techniques like formal logic or semantic networks are used and will be discussed later.

If someone needs knowledge in order to solve a problem he or she has to assimilate the knowledge provided by someone else either in a direct conversation or via a certain representation. Even in a direct communication knowledge will be represented: an oral representation of knowledge sometimes based on a written representation. Even this article is a representation of knowledge. Knowledge can be represented in different ways and the kind of representation should meet the capabilities of the receiver. For a human being informal knowledge representation is often the better alternative although informal representation could lead to misunderstanding or ambiguities. Vice versa a formal knowledge representation can avoid ambiguities but may be more complicated. A formal presentation of knowledge goes far behind an ordinary text: A formal knowledge representation has to express knowledge in such a way that even a computer can work with it, that the computer can “understand” the knowledge. Taking the definition of knowledge into account the computer has to be able to apply the knowledge.

In the area of artificial intelligence several approaches for a formal representation of knowledge have been developed including various types of logic, an object oriented style called frames, or different types of semantic networks. All these approaches use an explicit knowledge representation, whereas self learning systems like artificial neural networks store their knowledge implicitly: Artificial neural networks learn by examples but unfortunately it can not be explained why an artificial neural network acts in a certain way.

Here we focus on two explicit and formal knowledge representations. Both are commonly used in real world applications:

- Rules, especially business rules
- Semantic networks, nowadays called knowledge networks

Business Rules

Knowledge can be represented in a formal way by using if—then statements, so called rules: IF the turnover of a customer is more than 1,000 THEN he is a good customer.

[2] quarksteilchen.deviantart.com/art/IKEA-Gehstakk-71351744 visited 2009-07-02

A rule is a special logical formula of the predicate calculus where all the variables are universal quantified and the formula does not contain an existential quantification. In formal logic the example will be written as follows:

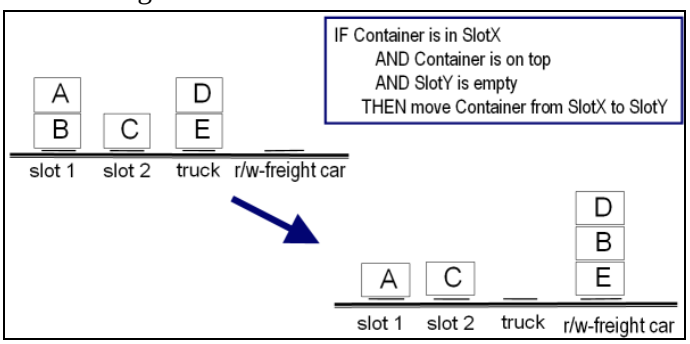
$\forall x \forall y\ turnover(x,y) \wedge (y>1{,}000) \rightarrow is\_good\_customer(x)$
$\forall x \forall y\ head(x) \wedge deputy(x,y) \wedge absent(x) \rightarrow signs\_documents(y)$

The second formula expresses the knowledge that if the head is not available and there is a deputy then the deputy will sign the documents. In simplified rule notation it is written as:

IF head(X) AND deputy(X,Y) AND absent(x) THEN signs_documents(Y).

Based on the formal knowledge representation and based on some facts about the head, the deputy, and the absence it can be automatically concluded who will sign the documents. Figure 3 shows another example where the rule is a very general one but is sufficient to solve simple container transhipment problems.

Figure 3: rules represent knowledge

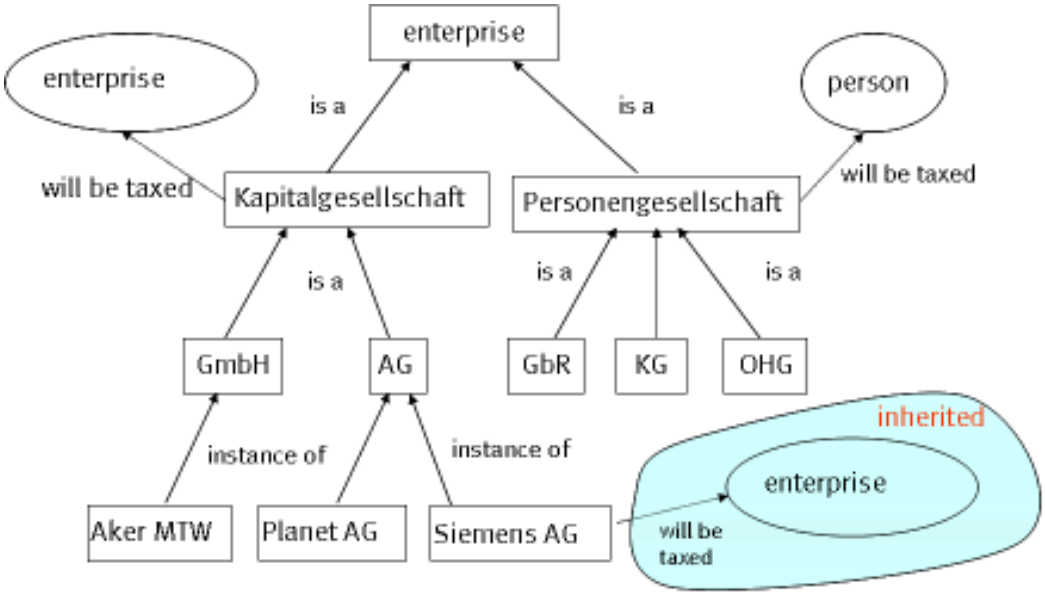


The Business Rules concept uses rules as the formal knowledge representation and applies it to business problems like e.g. business logic or customer relationship management. Business Rules Management Systems (BRMS) can handle large rule bases and offer more flexible solutions than other business software: If changes are necessary due to market developments or new regulations only the knowledge expressed in a set of rules has to be changed or extended. No changes in the software itself are necessary.

Semantic Networks

Another rather old technique represents knowledge as a network: a so called semantic network. From a mathematical point of view it is a graph consisting of nodes and edges. The nodes are entities or concepts and the edges represent relationships between the nodes. A concept hierarchy is a special type of semantic network which has been widely used in artificial intelligence. The hierarchy is built by concept nodes and two relationships: “is a” defines a subset relationship and “instance of” defines a membership. Additional information can be expressed by attribute nodes whereas the edges define the semantics of those attributes. Figure 4 defines the knowledge about German enterprises in a concept hierarchy. The area at the bottom right demonstrates that the Siemens AG inherits the property “enterprise will be taxed”. Thus again knowledge can be processed and new knowledge can be concluded from existing one.

Figure 4: Knowledge about types of German enterprises described by a semantic network



IT based Knowledge Management

As expressed earlier knowledge management is an important factor for an organisation. An efficient knowledge management can save a lot of working time. Working time which otherwise had to be spent for searching for knowledge or has been wasted for doing things twice. The bigger an organisation is the more important becomes an efficient knowledge management. But Smaller and Medium sized Enterprises (SME) need knowledge management as well: Experiences made in projects as well as business knowledge have to be shared among changing staff members.

Obviously information technology can not guarantee an efficient knowledge management since experiences and knowledge has to be provided by human beings. Information technology can help the employees or may even encourage them to express and therefore share their knowledge. How can information technology achieve this? In recent years several techniques have been developed. We will review the knowledge network approach which is strongly related to the term topic map. Afterwards the wiki approach will discussed as another possibility to get or to share knowledge.

Knowledge Networks

Knowledge networks are based on the semantic networks concept: nodes represent items or concepts and edges define relationships between the concepts. Moreover a node is not only a single term but an object oriented description of that concept.

Knowledge networks allow a semantic search. Google or similar search engines only find pages which definitely contain the search word – syntactic search. A semantic search offers even results not containing the search word but which are nevertheless strongly related to the search word.

A knowledge network of ThyssenKrupp contains information about the more than 900 companies of the TyssenKrupp group, see figure 5. The knowledge network was developed by the German company intelligent views GmbH using their software K-Infinity. A graphical editor is used for the development of a network, see figure 6.

Figure 5: Knowledge network of the ThyssenKrupp enterprise[3]

[3] http://base.thyssenkrupp.com , visited 2010-05-08.

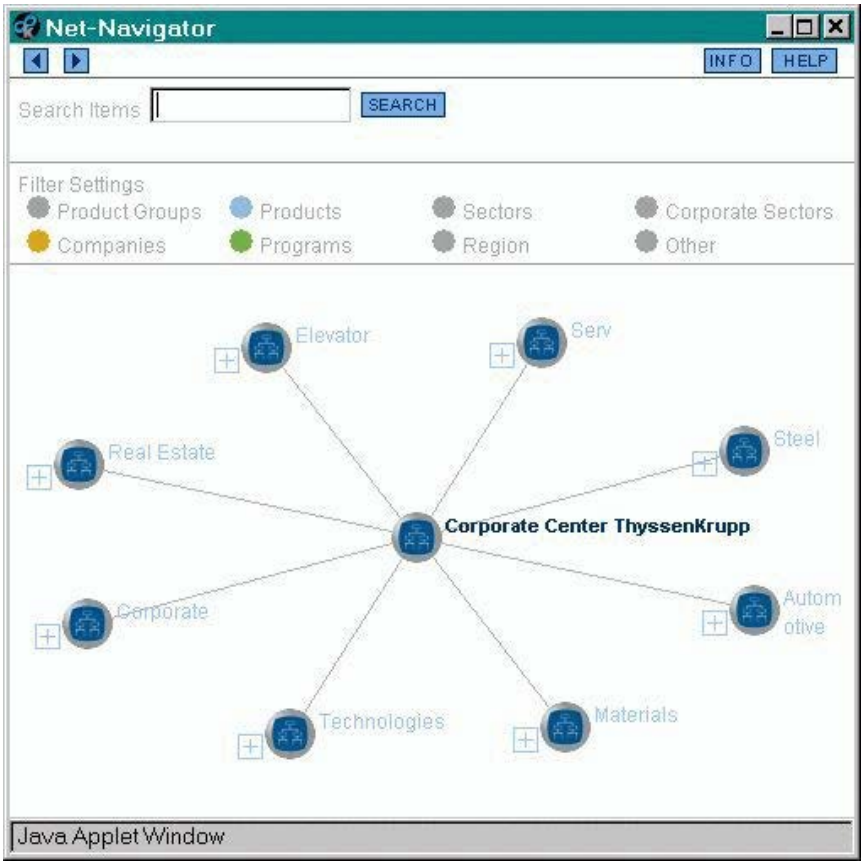
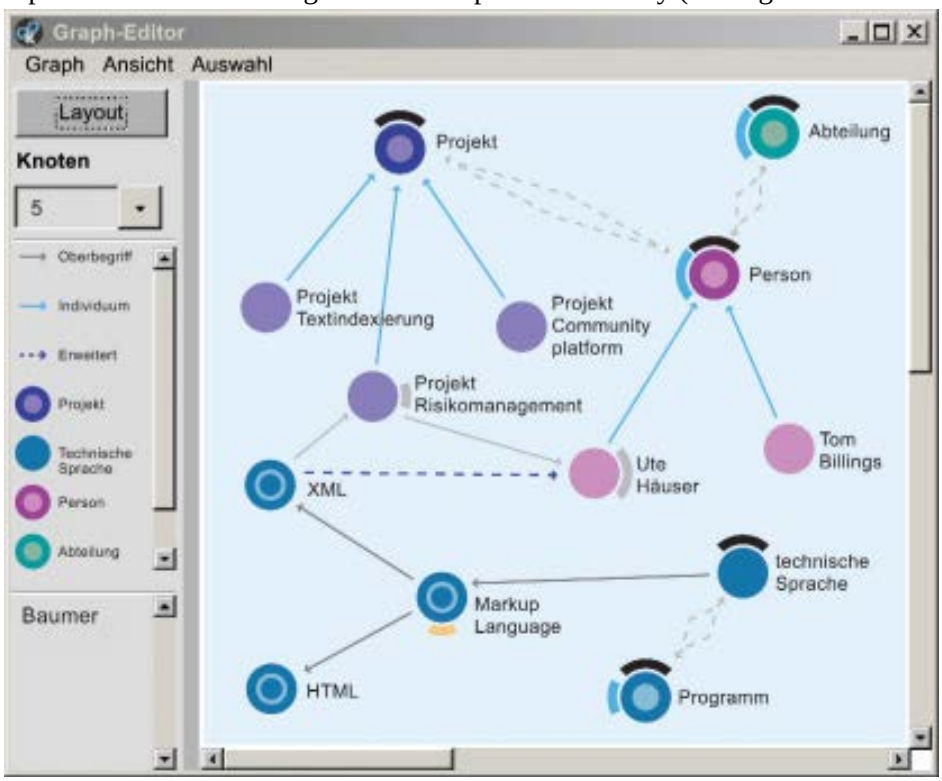


Figure 6: Graph editor for a knowledge network as part of k-Infinity (Intelligent Views 2009)

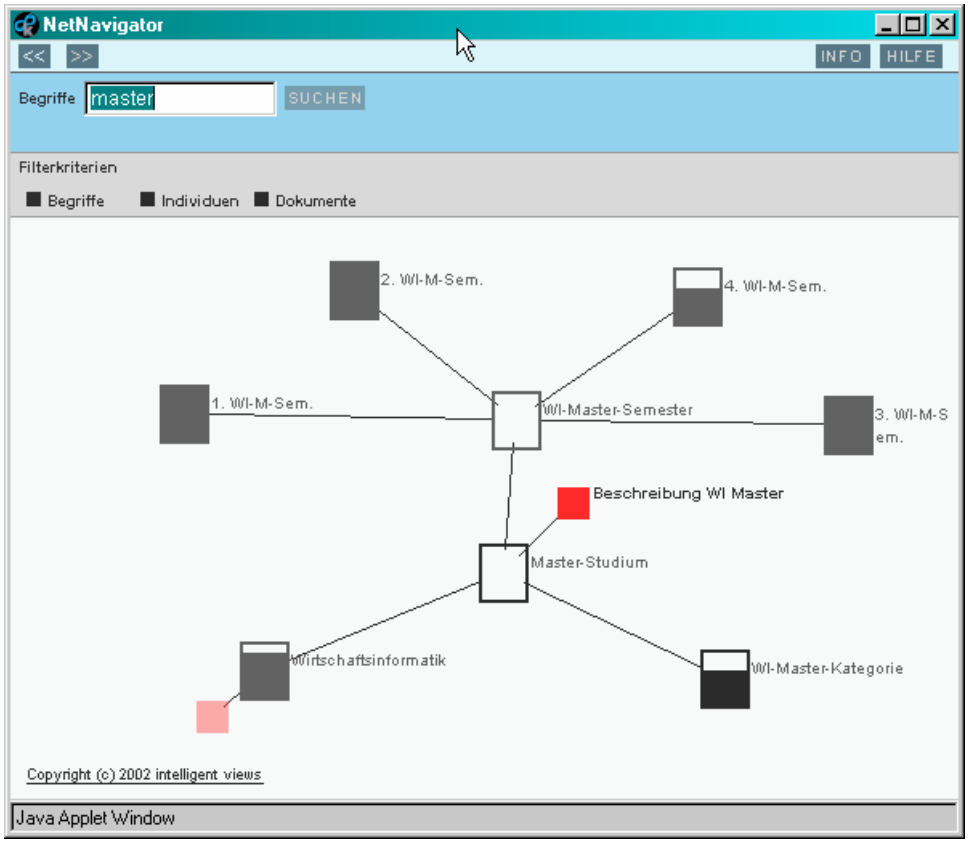


We used the K-Infinity software and developed two small knowledge networks:

- The degree programmes in Business Informatics (Bachelor and Master)
- The administration of the university

The work was done within the project TOMAHS –TOpic MAps for Hochschul (university) - Structures [5]. The knowledge network for the business informatics degree programmes consist of about 400 nodes: modules, lecturers, subjects etc. For every node an accompanying web page was developed which contains further information, mainly text, about the node's topic.

Figure 7: Topic Map of a degree programme created using K-Infinity [4]



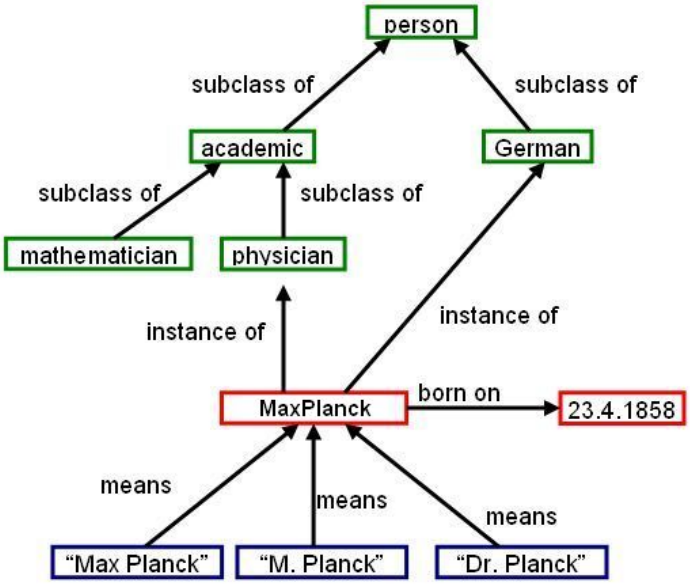
The TOMAHS project has shown the following results:

- A topic map is a powerful tool to share knowledge by showing the relationship between notions. Required knowledge can be found very fast.
- The development of a knowledge network as a backbone of the topic map requires a lot of man power and is by no means an easy task.
- A knowledge engineer is essential who collects the knowledge and transforms it into the formal representation.
- It is almost impossible that all the staff members take an active part in the network development process, since an understanding of informatics is required.

Sometimes the notions knowledge network, topic map, and ontology are used as synonyms. We see a topic map is a graphical representation of a knowledge network: The distance between two nodes reflects the semantic distance of the notions. A topic map can be used for the visualisation of various approaches. Similar to a knowledge network an ontology can be represented as a topic map as well. An ontology is a conceptualisation of a domain and reflects an agreement of a group of people. It has a formal specification mostly based on an XML notation. Ontologies are used for knowledge management, knowledge portals, in semantic web, digital libraries or e-learning systems.
„*People can't share knowledge if they don't speak a common language*"[2]. An ontology defines the common language as a basis of understanding.

The small ontology in figure 8 defines the relationships of the object MaxPlanck. It is a concept hierarchy where synonyms are defined as well. Therefore it defines a common language.

Figure 8: Small part of an ontology [11]



Wiki Systems

Wiki systems have been used for more than ten years. The idea is simple: A wiki system is a hypertext system mostly based on the World Wide Web where the user can not only read the pages but may edit the web page online as well. Wiki has become widely known due to the wikipedia. Although the use of wikipedia as a source for scientific work is put into question it even is used widely by many academics to get a first impression of a previously rather unknown topic.

Figure 9: wiki definition in wikipedia

But the wiki approach consists of much more systems than wikipedia. Wiki systems are used for software development projects (e.g. trac) or used as part of learn management systems like Stud.IP or moodle. In the same way as wikipedia is a platform for sharing worldwide knowledge a wiki in a learn management systems is a platform for sharing knowledge among participants in a lecture. In an enterprise a wiki system can be used to share the organisational knowledge. Examples can be found in Mader 2008 [7].

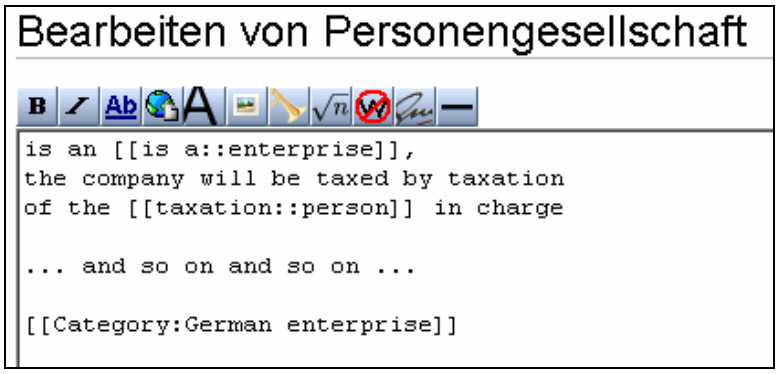
However, wiki systems are a collection of pages containing links. There is no other structure and therefore a search engine in a wiki system performs a syntactic search only. The main advantage

of a wiki system is its openness: it encourages everybody to participate in the management of knowledge. More likely that such a system has the newest knowledge available.

Semantic Wiki

A semantic wiki system extends a wiki system and allows the definition of annotations. By these annotations the wiki pages become smarter: properties can be expressed or even relationships between wiki pages can be named and made explicit. Using the example shown in figure 4 a page of a semantic wiki system can define the property of an enterprise and the relationship as well. Figure 10 shows that annotations define the relationship ("is a") and the property ("taxation") visualised in figure 4.

Figure 10: Annotations in a semantic wiki for the term: Personengesellschaft (business partnership)



If the annotations are set up properly we can imagine that in this way a semantic network or even a knowledge network can be defined.

From a wiki to a knowledge network

If the concept of annotation is used for the definition of relationship all necessary information is available: the wiki page represents a node in a knowledge network and the annotation defines the relationship. A topic map can be drawn from the information. Thus, a system is required which can understand the annotations and represents the structure as a topic map. Unfortunately no such system has been known so far. Nevertheless the wiki system itself supports the process. In the Semantic Mediawiki system it is possible to export a set of pages as a RDF /XML file.

Figure 11: Annotations on the semantic wiki page for the term: MaxPlanck

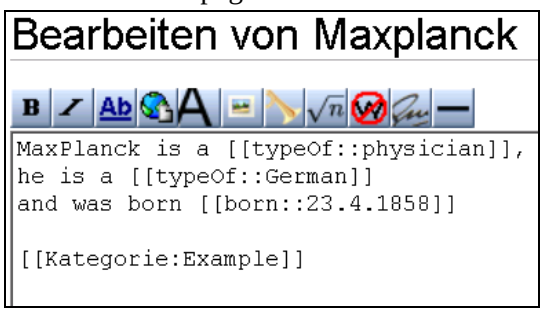


Figure 11 shows the annotation in order to implement the ontology of figure 8 into semantic wiki pages. Ones this has been done the pages can be exported as a RDF/XML file shown in figure 12. Instead of an RDF an OWL notation could be used as well. Nevertheless the next step on the way, see figure 13, to a graph representation is still missing.

Figure 12. RDF of the annotations in the MaxPlanck example

```
- <rdf:RDF>
    <!-- Ontology header -->
  - <owl:Ontology rdf:about="">
      <swivt:creationDate rdf:datatype="http://www.w3.org
      /2001/XMLSchema#dateTime">2009-07-10T17:04:57+02:00
      <owl:imports rdf:resource="http://semantic-mediawiki.org/sv
    </owl:Ontology>
    <!-- exported page data -->
  - <swivt:Subject rdf:about="http://kiwiki.wi.hs-wismar.de/kmwi
      <rdfs:label>Academic</rdfs:label>
      <swivt:page rdf:resource="http://kiwiki/kmwiki/index.php/Ac
      <rdfs:isDefinedBy rdf:resource="http://kiwiki/kmwiki/index.
      <rdf:type rdf:resource="http://kiwiki.wi.hs-wismar.de/kmwik
      <property:Is_a rdf:resource="http://kiwiki.wi.hs-wismar.de/
    </swivt:Subject>
  - <swivt:Subject rdf:about="http://kiwiki.wi.hs-wismar.de/kmwi
      <rdfs:label>German</rdfs:label>
      <swivt:page rdf:resource="http://kiwiki/kmwiki/index.php/Ge
      <rdfs:isDefinedBy rdf:resource="http://kiwiki/kmwiki/index.
      <rdf:type rdf:resource="http://kiwiki.wi.hs-wismar.de/kmwik
      <property:Is_a rdf:resource="http://kiwiki.wi.hs-wismar.de/
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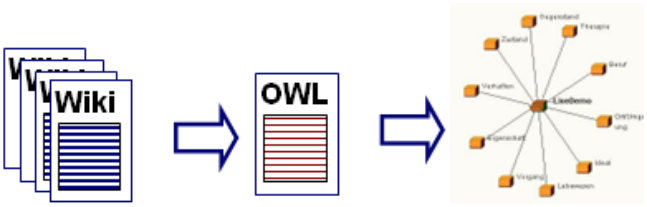
Figure 13. Steps from a semantic wiki to a topic map



A so called validator for the RDF/XML notation exists which checks such notations and can even produce a graph. The graph is rather clumsy and static and can not be seen as a graphical representation of a knowledge network. It is expected that in the near future a topic map can be generated automatically out of a set of wiki pages. The result will not be a fixed graph only: Part of the total graph will be shown and the user can interactively modify the view.

Knowledge and knowledge management in academic education

Various types of formal and semi-formal representation of knowledge have been introduced in the previous chapters. Will these concepts be discussed in academic education?

Knowledge is an important term in any academic education. The students have to learn and then to apply their learned knowledge. But is knowledge and knowledge management itself a topic in a lecture (course or module)? Our students in Business Informatics encounter the term knowledge in various modules: Knowledge representation using formal logic is a topic within the theoretical informatics module. Later on the module on artificial intelligence focuses on knowledge representation and especially knowledge processing. The business perspective of knowledge management is a topic in the module “information management”. As an optional subject the undergraduate students can choose a project work in knowledge extraction.

Graduate students can choose a special subject called knowledge management which consists of three modules: knowledge based systems, knowledge extraction / data mining and knowledge management (business perspective). The module on human resource management is strongly related to knowledge management as well.

The topics outlined in the paper are especially addressed in the module “knowledge based systems”. Here the students build and use knowledge management systems for a certain topic. It is used for learning and sharing the knowledge as well. All of our lectures are managed by a learn

management system (LMS) called Stud.IP. Every module managed in the LMS has a separate wiki system which again is used for co-operative work and knowledge sharing.

All the other degree programmes lack a topic on knowledge and knowledge management. While in the business administration courses knowledge management is at least handled from the management perspective the engineering courses do not offer any knowledge management topic at all. Basic courses related to electrical engineering include logic circuits; students therefore get a basic understanding of logic although this is a subset of propositional calculus only and can not be seen as a topic of knowledge management.

Table 1: Knowledge related topics in degree programmes of the Business and Engineering Faculty

Degree Programme	Degree	Module
Business Informatics	Bachelor	Theoretical Computer Science
		Artificial Intelligence
		Information Management
		Change Management
Business Informatics	Master	Knowledge Based Systems
		Data Mining
		Knowledge Management
Business Administration	Master	Business Management
		Change Management
		Sustainability Management
Digital Logistics	Master	Information Technology
		Business Intelligence
Multimedia Techniques	Bachelor	Propositional Logic
		Boolean Algebra
Multimedia Techniques	Master	Data Mining
Electrical Engineering	Bachelor	Boolean Algebra
Process Automation	Master	—
Mechanical Engineering	Bachelor	—
Ship's Operating Technology	Bachelor	—
Plant operation and Supply Technology	Bachelor	—

In the various degree programmes at the Wismar Business School (Business faculty) knowledge management is discussed as a management topic especially as a human resource management one. Only in the Business Informatics degree programme students learn about formal representation of knowledge and the management of knowledge using information technology. It can be seen in table 1 that especially the engineering degree programmes do not handle knowledge or knowledge management in their modules. Although Boolean algebra is a basic logic formalism it is not sufficient for a formal representation of knowledge. It can be assumed that a similar situation could be found at other universities as well.

It is expected that knowledge management is an implicit topic in various degree programmes: every student needs a kind of personal knowledge management and at least in exams knowledge has to be expressed explicitly. Project work as another example needs the exchange of knowledge among the team members. Although there may be more examples for knowledge management in academic education it still lacks an education in a (semi-) formal representation of knowledge using various techniques or tools of information technology.

Conclusion

It can be summarised that there are three current developments in IT based knowledge management:

- formal representation of knowledge using business rules,
- knowledge networks
- and semantic wiki systems.

Knowledge networks are powerful and can be visualised user friendly by topic maps. Moreover a semantic search is available which improves the search process as it finds answers a syntactic search cannot find. The high amount of work necessary to establish a knowledge network is a serious drawback.

Wiki systems are easy to use and encourage people to take part in the development and maintenance of such a system. Unfortunately up to now a wiki system cannot contain the same kind of knowledge representation a knowledge network can. Wiki systems are still text based and named relationships are unavailable, limiting the search to a syntactic one. Semantic wiki systems open the door to smarter wiki systems. Properties and relationships can be defined via annotations. This enables the automatic development of a topic map out of a wiki system. A formal definition using an XML based language like the OWL one can be used as an interface between the wiki system pages and a graphical representation as a topic map. Although no working system has been known so far it is expected that we will have graphical visualisations of wiki systems in the near future. These systems will provide better understanding of complicated topics since a network of terms and relationship is a condensed view on a topic and visualises the underlying structure.

(Business) Rules are definitely a formal representation of knowledge: Expert knowledge, workflows or business logic can be expressed by rules and can then be processed. Although rules are the more formal approach they are comprehensible and can therefore be used for documentation or the exchange of knowledge between human beings as well.

Students will have to deal with knowledge during their entire professional life. We are aware of the fact and try to explicitly incorporate the topic “knowledge” into our degree programmes. It is argued that knowledge and the management of knowledge especially formal representation of knowledge should be integrated into business and engineering degree programmes. A successful knowledge management based on appropriate information technology is a key issue for any organisation.

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