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A Framework for the Successful Introduction of KM Using CBR and Semantic Web Technologies

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Abstract: This document describes our current work on developing a framework which supports organizations in the successful implementation of Knowledge Management (KM). It follows the holistic approach of a KM introduction by considering technological, organizational and human aspects, as well as the organizational culture in equal measure. The framework provides recommendations based on Case-Based Reasoning (CBR) techniques and Semantic Web technologies. It supports the four processes of Aamodt & Plaza's CBR-cycle. The best practice cases for a successful KM implementation are structured by the use of an ontology.

Key Words: Case-Based Reasoning, Knowledge Management, Semantic Web

Category: H.3.3

1 Introduction

Nowadays, most organizations are aware of the importance of KM for their daily business [DP98]. But to be aware of KM is very different from introducing and using it. KM introduction is not easy at all and has to overcome several technical and organizational barriers. Moreover the introduction of KM necessarily has to focus on organizational, technical and human aspects and should in no case be regarded isolated for one specific aspect. In addition, already existing organizational structures, technical infrastructures and processes should be considered. Since many KM projects fail as a result of an insufficient know-how about conceptions for KM strategies, it is important to have a strategy showing the way how to proceed. One way to deal with that fact is to learn from the KM implementation experience of others. This can be done by analyzing best practice cases for the successful implementation of KM and to adapt those experiences to the own organization. The problem of this approach is, that the existing best practice case descriptions are usually not well structured or not directly applicable to the own organization's needs. Furthermore, there is no existing public available computer-supported knowledge base for the introduction of KM which can easily be queried for typical KM implementation problems. The holistic and integrated approach of the KM implementation and recommendation framework described in this paper will cover these problems by supporting organizations in the successful introduction of KM by the use of CBR and Semantic Web Technologies.

Expected Benefits of using CBR in this context are described as follows:

- In consideration of the fact that in practice problem areas are often not completely understood, even experts can't provide consistent rules for problem solving. In this regard, especially CBR systems often provide an acceptable quality of results, because of providing an open architecture for modeling knowledge.
- CBR systems guarantee a better utilization of the existing experience than, for instance, traditional database systems by providing similarity-based searching and fuzzy querying about the captured knowledge.
- CBR systems typically approach human problem solving by processing a fuzzy specification of the user query and successively refining that query (interactive dialog with the user) until an appropriate solution is found. Moreover the CBR approach is better able to respond to the real user needs through considering user-specific weights.

The motivation for bringing together mature technologies from CBR with technologies from the Semantic Web is based on the assumption, that the two different technologies have complementary strengths, from which we expect synergy effects [BS03]. In addition to the benefits of approved methods like CBR, an ontology-based case base would provide among other things, the integration of a traditional case base with a knowledge model, an ontology-based querying/ query refinement as well as a more flexible, refinable and maintainable case base. The framework will be realized by a web-based system providing organizational and technological recommendations, based on best practice cases with regard to a successful implementation of KM. The best practice cases are structured by the use of an ontology. The paper is structured as follows: The next section gives an overview on the components of the framework to be developed. After that, the components of the KM Implementation and Recommendation Framework (KMIR) to be developed are described in detail along the processes of the adapted CBR-cycle. Finally the paper concludes with a summarization and an overview on future work.

2 Working Agenda

In order to support organizations in the implementation of KM, we intend to develop a holistic and integrated KM Implementation and Recommendation Framework KMIR), which is based on (a slightly modified version of) the Case-based Reasoning Cycle from Aamodt & Plaza [AP94]. The framework will consist of the following components which are later described in the following section along the processes of an adapted CBR cycle (cf. Figure 1):

1. a **case base** containing KM best practice cases structured by the use of an ontology
2. a **web-based self-description component** supporting the organization to describe its organizational profile, strategic, normative and operational goals, as well as organizational, technological or human based

knowledge problems which they would like to solve in the context of implementing KM

3. a **matching component** for retrieving most similar cases with regard to the described profile of an organization
4. a **recommendations component** providing recommendations about how to introduce KM based on retrieved most similar cases
5. a **learning component** capturing new best practice cases and refining existing cases
6. an **expert interface** for importing current research results into the case base, i.e. new technical solutions and methods

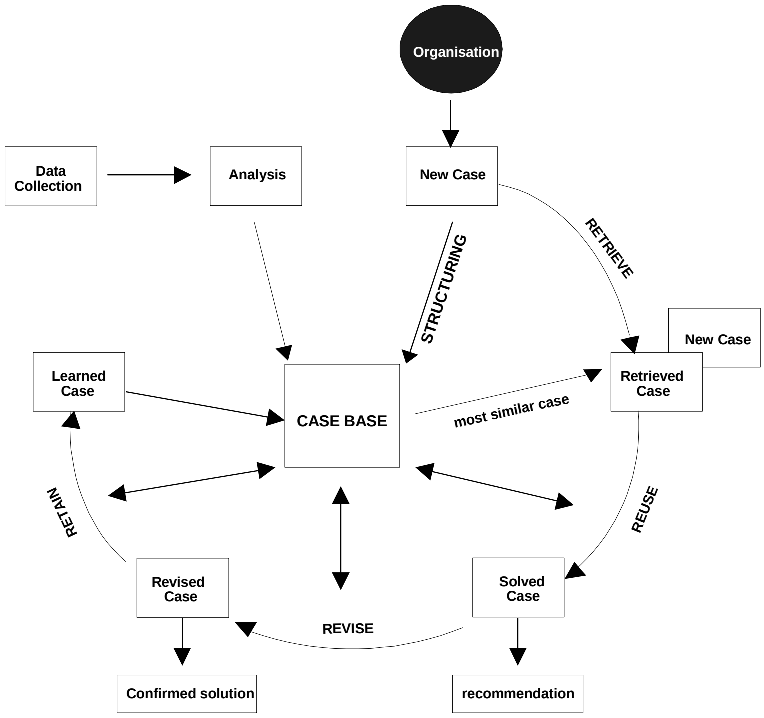

Figure 1: Adapted CBR Cycle (Source: [AP94])

3 Description of the KMIR Framework Components

3.1 Data Collection, Analysis, and Structuring

In order to create a first version of the case base, this preliminary step is concerned with: (1) on the one hand collecting episodic best practice cases of a successful KM introduction from different information sources, which are describing real events (i.e. [PRR03], [ES01], [SBS03]) and (2) on the other hand with designing prototypical cases by experts in order to capture innovative technical solutions, new methods and practices into the case base, that are not widely used in organizations and therefore guaranteeing the timeless and reusability of the whole framework. The best practice cases are analyzed considering organizational, technical and human aspects and finally structured and stored in an ontology. This can be done by either using the OI-Modeler, a tool for visually creating and maintaining ontologies, or by using a web-based Case Editing Component (CEC) (see Figure 2).

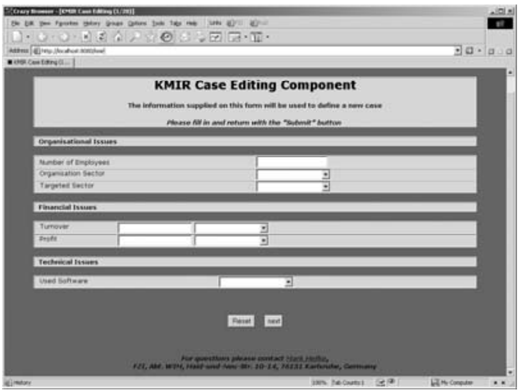

Figure 2: KMIR Case Editing Component

The OI-Modeler is a module of the open-source ontology management infrastructure KAON[1], which includes a comprehensive tool suite allowing easy ontology creation and management, as well as building of ontology-based applications. The CEC is realized by the use of Java Server Pages (JSP) and tag libraries which are directly connecting to the API of the above-mentioned KAON Toolset. This means that the new created case is directly stored as a set of in-stances, attributes and relations into the ontology (case base). Figure 3 depicts an excerpt of the KMIR ontology's conceptual level, which is used for structuring the best practice cases in the case base.

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[1] http://kaon.semanticweb.org

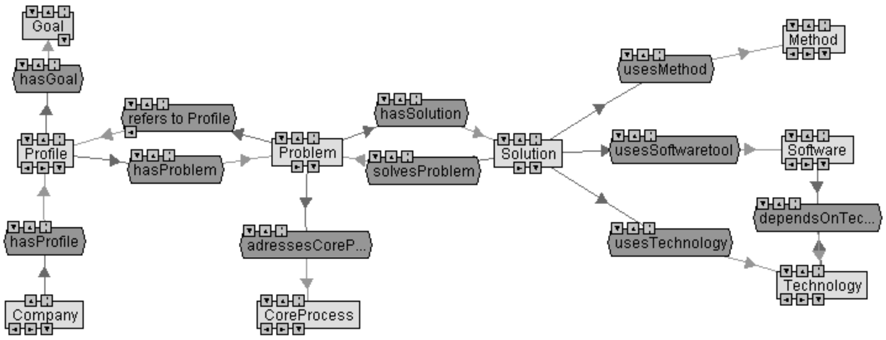

Figure 3: Excerpt of the KMIR ontology

Each best practice case describing a successful KM introduction is modelled as a "profile-instance" of the ontology. It consists on the one hand of a general description of the organization that has implemented KM, including the number of employees, the industrial sector, the organisational and technical infrastructure as well as general financial ratios and information about KM implementation costs and implementation time. This will be realized by modelling on the conceptual level the two main concepts "company" and "profile" that are linked together using the property "Company has Profile" as well as by further sub-concepts of these two concepts that are faded out in figure 3. On the other hand, the case base structures organisational, technical and human-based problems and barriers, which the companies had to solve while introducing KM, and how they managed to solve them. Therefore each modelled problem is linked to the profile by using the property "Profile has Problem" as well as to a solution by using the property "Problem has Solution" and the inverse property "Solution solves Problem". Problems can also address a specific core process of the Probst-Model (i.e. knowledge acquisition, knowledge sharing, etc.) [PRR03]. The modelled problems can be divided into sub-problems (by the use of a property "problem consists of/ is part of problem") because KM approaches are of course never identical, and the organizations have sometimes already existing partial solutions with regard to a specific knowledge problem that can then be extended. Another important point for dividing the problems into sub-problems is that the assigned solutions of different profiles can individually be combined to new solutions. The modelled solutions follow the above-mentioned holistic approach, meaning that a solution considers technical, organizational and human aspects which are additionally linked among each other by modelled properties for each link. This is necessary because the implementation of a KM system depends for instance on a specific technology and furthermore requires a methodology for the successful introduction as well as a cultural change in the organization. Technical KM solutions, which are implemented in the context of the KM introduction, are linked to the technology on which they depend, can consist of or depend on further solutions, or just be a part of a larger solution. Several other concepts of the ontology are furthermore divided into sub-concepts in order to have the possibility for more precisely specifying the top concepts which are viewable in figure 3.

3.2 Self-description Process

A web-based self-description component supports an organisation in describing its profile (size, industrial sector, organisational and technical infrastructure, economic aspects, etc.) as well as normative, strategic, and operational knowledge goals. Normative knowledge goals set the basic conditions for an innovative and knowledge-aware corporate culture, strategic goals specify the future competence portfolio of the organisation and operational goals translate normative and strategic demands into conversion-oriented and action-oriented sub-goals [PRR03]. Furthermore the organisation is able to define target costs for the implementation of a KM solution, to describe or select general knowledge problems and requirements, as well as technological, organisational and human-based problems and requirements. Moreover the self-description component provides means for assigning these problems and requirements to above-described KM core processes from Probst. Finally, the organisation is able to associate weights to all described aspects in order to attach more or less importance to them. The received profile from the self-description process is directly stored as a set of instances, attributes and relations into the ontology structuring the case base. The web-based self-description component is realized by the use of JSP and tag libraries connecting to the API of KAON.

3.3 Case Retrieval Process

For retrieving cases that are most similar to the new created profile achieved from the self-description process, a matching component matches the profile against already existing best practice cases from the case base. Due to the complexity of used ontology-specific similarity measures, the matching process is divided into two successive process steps, consisting of firstly identifying a basic set of similar cases using traditional similarity measures; and, based on these identified most similar cases, secondly applying ontology-specific similarity measures.

In order to achieve the basic set of matching best practice cases, the matching component is computing the similarity between attribute values (turnover, number of employees, implementation costs, etc.) of the profile description (a_{pd}) and of corresponding cases (a_{cb}) from the case base by using the following distance-based similarity measure:

$$sim\left(a_{pd}, a_{cb}\right) = 1 - \frac{\left|a_{pd} - a_{cb}\right|}{\max diff}$$

where $a_{pd}, a_{cb} \in A = \left[A\min, ..., A\max\right]$ and $\max diff = A\max - A\min$

Finally a weighted average determines the global similarity. Table 1 shows a simplified example for identifying the basic set using a distance-based similarity measure and weighted average (assuming max *diff* = 250 for “Organisation-Size” and max *diff* = 10000 for “Implementation Costs”).

Profile Description	Weight	Similarity	Case X (from case base)
Sector: IT	**6**	**1**	**Sector: IT**
Organisation-Size: 50	**4**	**0.8**	**Organisation-Size: 100**
Processes: defined	**2**	**1**	**Processes: defined**
Identified knowledge intensive processes: no	**1**	**0**	**Identified knowledge intensive processes: yes**
Planned implementation costs: 2000 €	**3**	**0.2**	**Implementation Costs: 10000 €**
Similarity: 1/16·[6·1+4·0.8+2·1+1·0+3·0.2]=0.7			

Table 1: Similarity Computation using Distance-Based Similarity and Weighted Average

In the second step of the matching process the created profile from the organisational description is matched against the achieved similar cases of the basic set, using ontology-specific similarity measures. That is to compute the similarity between (sets of) instances on the basis of their attribute values (***Attribute Similarity***), relations to other objects (***Relation Similarity***) as well as of their position in the concept taxonomy (***Taxonomy Similarity***) [MZ02]. Beyond comparing attribute values of instances using *Attribute Similarity*, *Relation Similarity* computes the similarity between (sets) of instances by considering if these instances have more or less common relations to other instances. For example, the requesting organisation has assigned a particular problem to one of the above-described core processes (i.e. knowledge acquisition). After that, the auditing component has stored the problem definition into the case base using a property "problem addresses core process". Now the matching component and thus the recommendations component only consider methods and solutions to the defined problem, that are also linked to this specific core process. *Taxonomic Similarity* identifies problem-solving methods and solutions, which base upon problem-solution pairs from best practice cases similar to defined problem(s) in the organization profile. For instance, a company is searching for an extension of its existing groupware by the use of Semantic Web Technologies in order to get better search results. The matching component identifies a similar groupware in the case base, which also served as a basis for such an extension by checking all instances of the corresponding concept "groupware" resp. of more general/specific ones and recommends the assigned solution to the requesting organization.

3.4 Recommendation Process

A recommendations component automatically provides recommendations to the requesting organization according to its defined problems, requirements and goals based on the identified most similar case(s). This will be done by on the one hand presenting to the organization one or more retrieved profile(s) from the matching process, that correspond to the profile from the self-description, including similar problems as well as associated solutions and methods to solve these problems. On the other hand the framework is able to present recommendations to the requesting organization that are combined of different similar cases to one general recommendation. In addition the recommendations component checks for each problem-solution pair further relations to other KM aspects (using the structure of the ontology) and generates from them additional recommendations to the requesting organization. In addition, the system combines the recommendation with an estimation of implementation costs and time. An example for a so called "holistic recommendation" would be that the recommendations component recommends the requesting organization the implementation of a KM tool X and furthermore combines it with a specific organizational method for a successful introduction of this tool, as well as with a required organizational culture.

3.5 Feedback Loop and Learning

In the Feedback Loop, successfully completed KM implementations of an organisation are added as a new best practice case into the case base. This will be done by structuring and capturing the adapted and reused best practice case(s) as a learned case into the case base. Therefore the Feedback Loop guarantees the timeless and reusability of the case base. A Learning Component will collect lessons learned regarding successful or inappropriate given recommendations in order to refine or extend the best practice cases as well as the general structure of the case base. This will be done by a web-based questioning of the requesting organizations concerning the experiences they made with the recommendations as well as by tracking the user behaviour using log files and from that changing the structure and content of the ontology representing the case base [SS02]. Using web-based questioning, the user has the opportunity to evaluate the recommendations with regard to their correctness and capability to solve a specific problem. The evaluation results directly flow into the learning component. The learning component uses the achieved results of the user feedback as well as the data from the user log for an internal ranking of the best practice cases in the case base. Based on ranked cases, the recommendations component is able to provide better recommendations to the requesting organisation (i.e by providing recommendations that were evaluated better than other ones in terms of solving a specific problem). On the other hand, worse evaluated recommendations with a low ranking can be either optimized or thrown out of the case base. Moreover, ontology-specific similarity measures are used in this context for supporting the maintenance of the general structure of the case base. A concrete approach is to identify, if two or more concepts are at least similar or even equal (*Concept Similarity)* and based on this to either subsume these concepts or to assign them using a property "concept is similar to concept".

4 Conclusion and Future Work

In this paper we described our current work on developing a framework which supports an organization in the successful implementation of KM by providing recommendations based on CBR techniques and the usage of Semantic Web Technologies. For the development of this framework an extensive collection, analysis and structuring of best practice cases from different information sources is necessary. The analysis, but also the structuring of the best practice cases directly focus on human, technical and organizational aspects in order to consider a holistic

KM approach. For the future we intend to further develop and after that to validate this implementation and recommendation framework under real-life conditions which might be realized in the context of a concrete project. Moreover we will include a component for determining the current KM maturity level of an organisation in order to better focus on the organization's needs with regard to a successful introduction of KM.

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