A process pattern for knowledge management within museums

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1 Introduction

In the museums there are professionals within various fields. As long as these people are active their knowledge is kept in the organization. But as soon as they change position, museum or retire this valuable knowledge is lost. Of course, this is an awful waste of knowledge in any organization, but especially in a museum dealing with our culture heritage. Knowledge about a collection, e.g., may be lost forever if there is no way to store the knowledge for the future.

In the project KMM, Knowledge Management in Museums, we are working with the task to store knowledge regarding our culture heritage. Usually, information and not knowledge is stored in the museums' databases. Besides, these databases are mainly designed for internal use and cannot meet the new demands from the society. The goal with the KMM project is to establish a common museum IT infrastructure and this infrastructure should be able to improve the educational use of museum knowledge, e.g. for schools. The project is a collaboration of, for the moment, five museums, municipalities, private companies, and the universities in Uppsala and Luleå.

It is not trivial to organize, aggregate and store the knowledge in the museums so it can be utilized by people outside the institutions. In this article we propose a process pattern for this knowledge management. The process pattern describes an approach for developing appropriate software. First we shortly describe knowledge management, knowledge systems and knowledge engineering. Then we relate the life cycles for knowledge management and knowledge engineering and present the process pattern. The article ends with a conclusion and discussion.

2 Knowledge Management

Knowledge management, KM, can be defined as management of organisational knowledge for creating business value and generating a competitive advantage (Tiwana, 2000). KM involves people, organisational processes, and technology (Awad & Ghaziri, 2004). Usually, when speaking about KM the aim is to increase companies' profit. But KM can also be applied in organisations and institutions where profit is of no interest, which is the case for, e.g., museums and schools in Sweden. The purpose with KM in the school organization can be to facilitate the students' learning, increase the parents' participation, and support teachers (Edman, 2005). For museums it is vital to store information about the objects within the museums, but also knowledge about the cultural heritage. It is important to see the distinction between information and knowledge; knowledge is an understanding of information. This understanding can be based on studies and experiences. Capturing and storing knowledge from the museums' personnel together with other expertise in IT systems has, so far, not been in focus in Swedish museums.

The *knowledge management life cycle* can be seen as a four-step process; capturing, sharing, and applying knowledge, and then creating new knowledge (Liebowitz, 2001), see *Figure 1*. The life cycle is focused on the problems the KM system should solve, suitable development strategies and the process used to build the system (Awad & Ghaziri, 2004). As mentioned, one goal with KM is to create new knowledge. Nonaka and Takeuchi describe knowledge creation and transformation as a knowledge spiral (1995). Creation of organizational knowledge develops through a continuous and dynamic interaction between tacit and explicit knowledge.

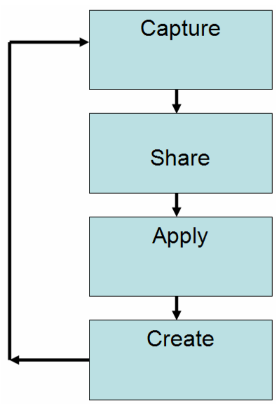

Figure 1. The KM life cycle.

3 Knowledge systems and knowledge engineering

Most of the systems on the market are information systems, i.e., they handle facts and information but not knowledge. A *knowledge system*[1], though, can process knowledge. This system type is especially suitable for storing and processing knowledge within a special subject, also called domain. The reason is that a knowledge system can perform problem solving based on knowledge within a restricted domain. A knowledge system comprises mainly a knowledgebase, an inference engine and a user interface, see *Figure 2*.

In the static part of the knowledgebase, general domain knowledge may be represented as facts, heuristic rules for reasoning within the domain, meta-rules, i.e., rules about rules, structured objects, and decision tables (Awad, Ghaziri, 2004). Information about the current session is stored in the dynamic part of the knowledgebase. During problem solving the inference engine uses the user's input together with the knowledgebase to reach a conclusion, which may, e.g., be a classification of an object or a presentation of knowledge related to an object and tailored to the current user. Usually, a knowledge system is able to explain its conclusions. The explanation mechanism generates explanations based upon both the static and the case-based dynamic part of the knowledgebase.

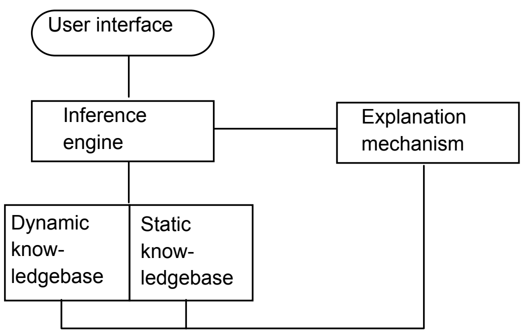

Figure 2. A knowledge system.

[1] Also called knowledge-based systems.

Some heuristic rules from a knowledgebase categorizing time periods for statues[2] are presented in *Figure 3 and 4*. A rule consists of a conclusion and premises, where the premises state the prerequisites needed to be able to show the conclusion. If the system does not have information whether the prerequisites are fulfilled the user is asked about them, e.g. if the persons in the statuary have beard, see rule 115. The confidence in the conclusion is described in parenthesis. It is often the case that a heuristic rule does not categorically describe that the conclusion is true or false.

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Rule 100
Statuary is archaic (with possibility) IF
    Eyes = "protruding" AND
    Eyes = "big"

Rule 101
Statuary is archaic (with some certainty) IF
    Posture = "stand at attention with left foot in front"
:
Rule 115
Statuary is archaic (definitely not) IF
    Beard = "yes"
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Figure 3. Example of heuristic rules regarding archaic statuary.

The rules 100 – 115 describe together how to categorize a statuary as archaic. All rules related to the conclusion "archaic" are investigated in the reasoning and the evaluation of the conclusion is based on a way to deal with degrees of certainty. There are different ways to compute the evaluation, e.g. using probabilities and Bayes theorem, or certainty factors (Negnevitsky, 2002). A scale of different degrees can be seen in *Figure 5*.

A rule may support a special conclusion, and another one can decrease the belief of it. In *Figure 3* rule 100 and 101 increase the belief in the conclusion "archaic" and rule 115 decreases it. Not all rules may be fulfilled and these don't influence the conclusion at all.

[2] Based on a prototype developed by students in a master course, Knowledge Management, within Computer Science.

Rule 130
Statue is elder archaic (with some certainty) IF
    Statuary is archaic (at least with probability) AND
    Facial expression = "visible feelings" AND
    Feelings = "slight smile"

Rule 131
Statue is elder archaic (with some certainty) IF
    Statuary is archaic (at least with probability) AND
    Facial expression = "expressionless"

Rule 132
Statue is elder archaic (with some certainty) IF
    Statuary is archaic (at least with probability) AND
    Hair = "long" AND
    Hair-style = "beaded tresses and wavy tresses"

Rule 133
Statue is elder archaic (with some certainty) IF
    Statuary is archaic (at least with probability) AND
    Backbone = "straight"

:

Figure 4. Example of heuristic rules regarding elder archaic statues.

With high probability
With probability
With possibility
With some certainty
Cannot be excluded
Probably not
Definitely not

Figure 5. Different degrees of certainty.

The conclusion of a group of rules (e.g. rules 100 – 115) can be utilised in the execution of other rules. In *Figure 4* all the rules have a first premise utilizing the result from the rules in *Figure 3*. The evaluation of the conclusion "archaic" has to be at least probable if the rules 130 – 133 should be applicable.

The process of developing knowledge systems is called *knowledge engineering*, KE. The *knowledge engineering life cycle* involves identifying and capturing knowledge, representing and encoding this knowledge followed by testing and evaluating the implemented knowledge system, see *Figure 6*.

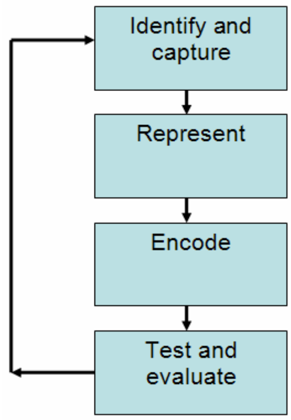

Figure 6. The KE life cycle.

4 A process pattern for knowledge management

It is obvious that the included knowledge is the clue to success in a system supporting KM. In the KM life cycle the capturing process deals with finding and storing the appropriate knowledge, which is an extensive work. Methods from knowledge engineering are suitable here. A suggestion is to combine the life cycles for KM and KE, where the capturing process in KM is replaced by the KE process, which is more detailed (Liebowitz, 2001).

For the KMM project we utilize this suggested combination of the life cycles for KM and KE but with a further elaboration of the KE part, see *Figure 7*. The reason for the elaboration is to point out that working with knowledge engineering is a form of evolutionary prototyping; identifying new knowledge, working with the structuring and the representation of it, storing it in the system and then test it, over and over again. It is often the case that one has to reiterate one, two or more processes.

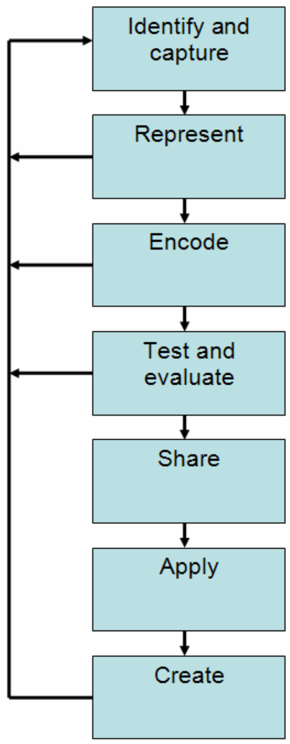

Figure 7. A combination of the knowledge management and knowledge engineering life cycles.

The IT system supporting KM is developed in the KE part of the life cycle, i.e. from "identifying" to "testing". The processes following, i.e. "share", "apply", and "create", deal with how the system can be utilized.

The life cycle in *Figure 7* is used as a basis for a process pattern for KM in museums. A process pattern can be defined as "a collection of general techniques, actions, and/or tasks (activities) for developing object-oriented software" (Ambler, 1998). Interesting to note is that a process pattern describes what should be done, but not exactly how it should be performed.

The proposed process pattern can be seen in Figure 8. Note that for every subprocess it is possible to describe a separate process pattern. In the KMM project we develop the software in accordance to this process pattern. In the process "identify and capture" the focus is on the museum personnel who has knowledge about the collections together with other experts with supplementing knowledge. Moreover, the expertise that museum pedagogues and teachers have is involved. This refers to how the material can be presented and utilized so learning can be facilitated. The different knowledge sources form a *pedagogical context*, comprising domain context, pedagogical context, and user context (Edman & Bengtsson, 2006).

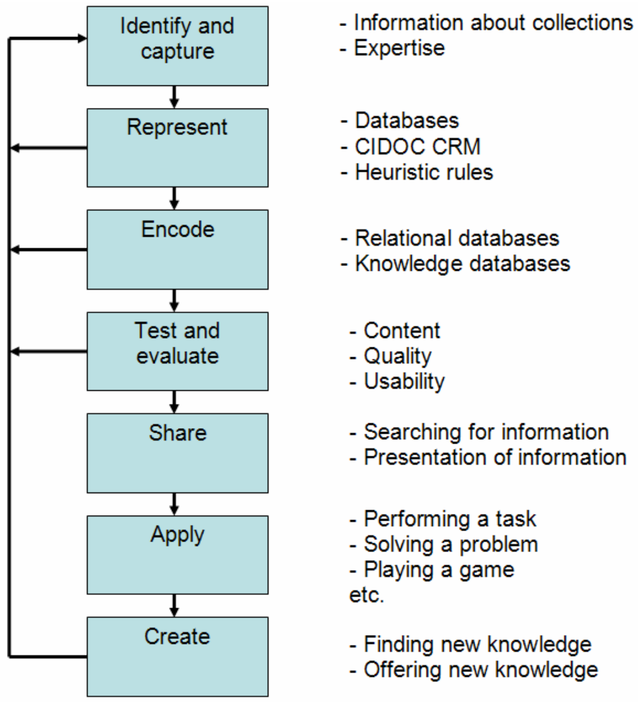

Figure 8. The process pattern for KM in museums.

In the "representation" process the different knowledge sources are organized and represented in a formal way. Much information is already stored in the museums' databases. For the representation of the domain context we will utilize the ontology CIDOC Conceptual Reference Model, CIDOC CRM, developed for culture heritage documentations[3]. Regarding the representation of pedagogical and user contexts heuristic rules will be used.

When it comes to the process "encode" the context in CIDOC CRM will be reproduced in relational databases. Moreover, the already existing museum databases (most often relational) are included. The heuristic rules are stored in knowledge databases.

[3] http://cidoc.ics.forth.gr/

The process “test and evaluate” is vital. Here the system’s content is tested by museum personnel and other experts. Furthermore, the securing of the data quality has to be taken care of, e.g. through validation and typing. Vast amount of money is spent on problems connected to data quality. For instance, “The Data Warehousing Institute estimates that poor quality customer data costs US businesses a staggering $611 billion a year” (Eckerson, 2002). Moreover, the usability of the system must be tested and evaluated by the user categories, i.e. the employees in the museums, different experts, and other interested persons, e.g. school children.

In the “share” process the users utilize the system’s knowledge. The different categories of people should be able to reach the system’s content. Thus, the users have to be able to search for information and the system should generate presentations of the related context tailored to the current user.

In the process denoted “apply” the knowledge reached in the “share” process is utilized and processed. To be able to learn and, hopefully, create new knowledge the user has to be active (cf. e.g. Edman & Bengtsson, 2006). Examples of activities related to systems in museums are writing essays, performing a task, solving some kind of problem, or participate in a game. For instance, knowledge regarding statues could be used to decide how old a specific statue is and also find out characteristics for a statue from a special period. In these cases, the user and the system co-operates since the user has to be able to answer the questions the system poses and some of these are not at all trivial (for more about co-operation cf. e.g. Edman, 2001). In these activities, together with other experiences, new knowledge may be found. Moreover, users with knowledge not yet in the system may be interested in supplementing with this knowledge. In the process “create” this new knowledge can be recognized and will then go through the KE processes to be included in the system.

5 Conclusion and discussion

The process pattern we are suggesting is based on a general knowledge management life cycle, emphasizing knowledge engineering, which is then related to museums. A well performed knowledge acquisition is vital for the development of KM systems, therefore utilizing well tested methods from knowledge engineering is recommended.

IT systems are tools in the knowledge management within organizations (Awad & Ghaziri, 2004). Based on our process pattern we develop a knowledge system in the knowledge engineering process. The system is a hybrid system combining the CIDOC CRM ontology and heuristic rules. CIDOC CRM mirrors the domain context and heuristic rules reproduce the pedagogical and users' context. The users are people within and outside the museums.

The system we are developing performs a knowledge-based reasoning utilizing both the ontology and heuristic knowledge. Through this reasoning the search for and presentation of the knowledge is performed. Moreover, a knowledge-based reasoning can be utilized for supporting the persons that are supplying the system with knowledge. The reasoning will take into account the context needed for a special object and delimit the possibilities when giving information. Moreover, through this technique the data quality can be investigated and, hopefully, secured. Bad data quality is a common problem in most database systems. The knowledge-based technique works for these tasks, which has been tested in a small scale by Chan and Gröndahl (2005). How well it works for a full ontology and a large database has to be tested.

A research issue is to investigate how well CIDOC CRM can support the reproduction of the culture heritage context, though it is developed for this reason. How to deal with knowledge representation is an old philosophical problem. The problem refers to the possibility to represent "all" relevant knowledge related to a subject and how this representation should be designed to be usable for reasoning. Ontology evaluation and validation have become a crucial problem for development of semantic technologies (Gangemi *et al*, 2006). Gangemi *et al* propose a meta-ontology and different types of measures for evaluation (*ibid*). If there are shortcomings in the ontology it is possible to utilize rules for the completion of the domain context (Bengtsson, 2005).

It is common to study knowledge management from an organizational perspective. This refers to, e.g., leadership, developing a knowledge culture, and alignment with strategic priorities (Debowski, 2006). Sources of organizational knowledge are individual knowledge and corporate knowledge, where the corporate knowledge can consist of libraries, archives and different types of computer based systems (*ibid*), such as, e.g., document handling systems, enterprise resource management systems, data warehouses, and decision support systems. Many articles and books can be found regarding knowledge management from the organizational view. Unfortunately, the process of capturing the current domain knowledge in a computer system is not thoroughly investigated and described. The research within the KMM project, though, emphasizes this.

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