E-learning by Experience - How CBR can help

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Abstract : - The integration of e-learning platforms with Case-Based Reasoning (CBR) leads to distance learning systems where real occurrences are available to illustrate theory with practice. However, CBR systems may be completely different from each other due to their architecture, development platform, case description, etc. So, a way of querying and integrating different case sources is required. Besides that, examples must match theoretical topics, student profile and, if possible, be susceptible of observation in virtual reality environments. The paper describes some aspects of these problems and presents the general architecture of *MKM - Maintenance Knowledge Manager* - an e-learning and CBR based system devoted to the maintenance field.

Key-Words: - e-learning; CBR; maintenance; system integration.

1 Introduction

An intelligent platform for distance-learning that guides the student, selects real, adequate and relevant examples and, when possible, provides a virtual environment for experimentation, is the aim of *MKM - Maintenance Knowledge Manager*.

The conception of such a system involves knowledge management and learning theories, pedagogical aspects and, of course, complex technical problems. One of them is, for sure, the integration of distinct systems and technologies that quickly give to this project a big dimension.

The paper defines the type of knowledge we're particularly interested in, and why; a basic theory of learning is also described in section 2. Section 3 shows how computer systems can retain pre-acquired knowledge in the form of experiences. Section 4 gives an overview of MKM, its basic components, how CBR (and *ITS - Intelligent Tutoring Systems*) can help, and how active experimentation, present in one of the learning cycle phases, can be simulated. Section 5 gives a brief conclusion.

2 Knowledge and Learning

2.1 Knowledge

According to Polanvi, Nonaka and Takeushi, cited in [1], knowledge can be divided into two types:

1. *Tacit knowledge* refers to the experiences and the capability of innovation of the organization staff;
2. *Explicit knowledge* refers to procedures and databases.

The former contains two components: the *know-how*, of technical type, is created by personal experiences and is associated with intuition; the second is of cognitive nature - desires and emotions - and it's related to initiative.

The expression Knowledge Management designates a methodology that allows organizations to create extra value based on their own experiences, documentation, data, information and staff. This is a kind of synergy resulting from the integration of various knowledge types.

According to [2] a general model of knowledge management is composed of four phases: *Creation*, *Retention*, *Utilization* and *Divulgation* (Fig.1).

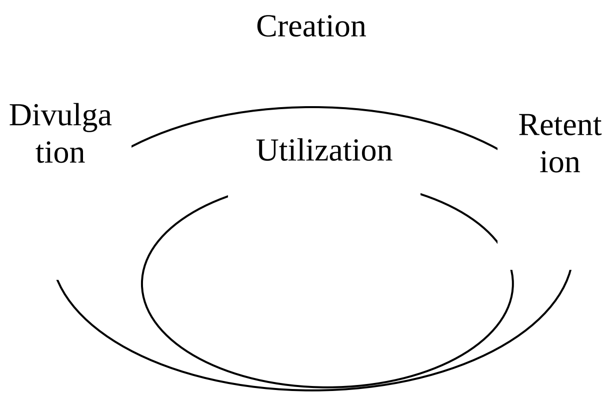

Fig. 1: The knowledge management cycle

In this cycle the divulgation phase plays a central role. In fact, a basic difference between the information era and the knowledge era can be resumed in the following phrase: *Information era – accumulate knowledge and it will be kept; knowledge era – share it and it will be multiplied* [2]. According to [3], knowledge is the most important factor of success for individuals and organizations. The theme *Towards the Knowledge Society* of the IFIP 2002 conference [4], reveals that in fact the information society is progressively giving its place to a (new) knowledge society.

2.2 Learning

Learning is the process by which information turns into knowledge. There are many theories that try to explain how learning happens and in what phases this process can be divided. Piaget opened a path for learning understanding and many author's [5] [6] [7] followed him. The concept of learning cycle emerged.

Somewhat divergent, theories agree in the following point: knowledge acquisition involves the creation of abstract concepts and active experimentation.

According to [6], a general model of learning is composed of four stages: *Concrete Experience*, *Reflective Observation*, *Abstract Conceptualization* and *Active Experimentation (*Fig. 2).

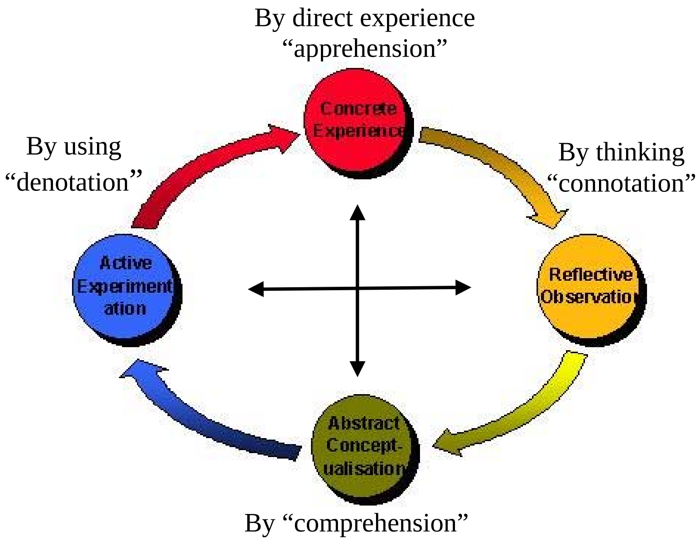

Figure 2: Kolb's learning cycle

In this cycle the paths are not rigid. For instance, it's not needed to follow the complete cycle to reach the Active Experimentation phase. Kolb believes that it is possible to drop a phase not compromising the final target of "learning".

3 Knowlegde Manipulation

3.1 CBR

How can experiences be represented?

Case Based Reasoning (CBR) is a paradigm of the Artificial Intelligence (AI) field of Computer Science that resides on the invocation of past occurrences to solve new ones classified as similar to them. The CBR paradigm was created at the Yale University (U.S.A.) in 1982/83 with Schank's pioneer work [8] and the CYRUS system [9].

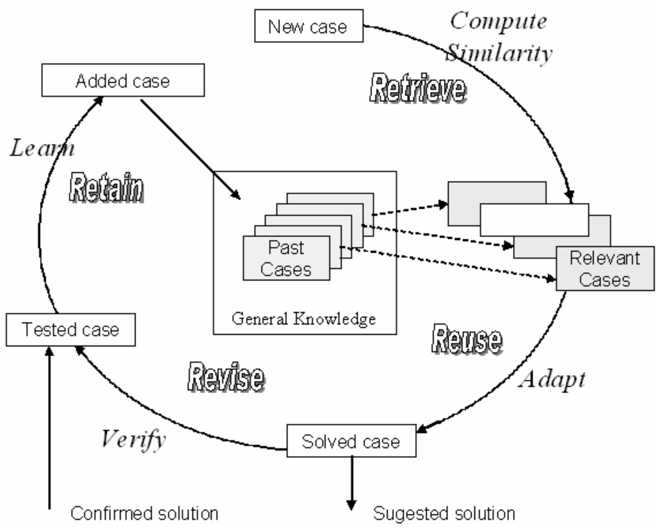

Figure 3: The CBR cycle [10]

When compared to rule-based expert systems, CBR system maintenance is much easier, historical data becomes implicitly available along the system lifetime and knowledge tends to adapt itself to the personnel day-to-day experiences and reality. The CBR operation cycle comprises four basic phases:

1. Retrieve: Select from the case library the past cases that seem to be relevant to solve the present one;
2. Reuse the selected cases to derive a solution;
3. Revise the solution(s): this phase implies an external teacher - in our case, the technical staff - or simulation tool to test each purposed solution;
4. Retain, in the Case Library, all or part of the new case (including its solution) if it seems that it may help to solve future cases, contains something new or teaches a lesson.

The CBR cycle provides an excellent support for organization's knowledge by keeping concrete experiences in the form of cases available for querying and simultaneously providing solutions to new problems derived from those of past (and known) cases.

3.2 Case querying

In [7] Race says that “Other people’s knowledge is just information” and transforming information into knowledge implies information querying. SQL is the standard language for information querying. In the CBR field, CBR-Works from Empolis, for instance - a development environment for CBR systems - provides CQL, a Case Query Language [11]. CBR-Works allows the quick development of HTML pages where a query case can be described. CQL is then used to return the more similar cases from the Case Library (fig.4).

send_query 1 0.5
objects "Work Orders"
"Converter" : true,
"Year" : 1995,
"Power" : 64,
"Funtion" : “X-Ray Machine”.

Fig.4 – Example of a query in CQL format

However, CQL is not a standard: querying different CBR systems implies using distinct approaches as CBR based systems may be completely different, varying from complex academic prototypes to standard applications based on development systems.

Besides that, if one tries to integrate knowledge supported by distinct CBR systems in a single knowledge base, then a case-exchanging support must be found.

3.3 Case exchanging

KQML - Knowledge Query and Manipulation Language - is a language for information and knowledge exchange developed by ARPA KSE [12]. Fig.5 shows an example.

(ask-one
:sender joe
:content (PROBLEM IBM ?problem)
:receiver CBR-Agent
:reply-with ibm-problem-list
:language CQL
:ontology NYSE-TICKS)

Fig. 5 : KQML query example

4 Maintenance Knowledge Manager

4.1 Overview

The integration of e-learning platforms with Case-Based Reasoning (CBR) leads to distance learning platforms where real facts and examples are available to illustrate theory with practice.

MKM - Maintenance Knowledge Manager - is such a system, devoted to the maintenance field. The basic idea about MKM is shown in Fig.6.

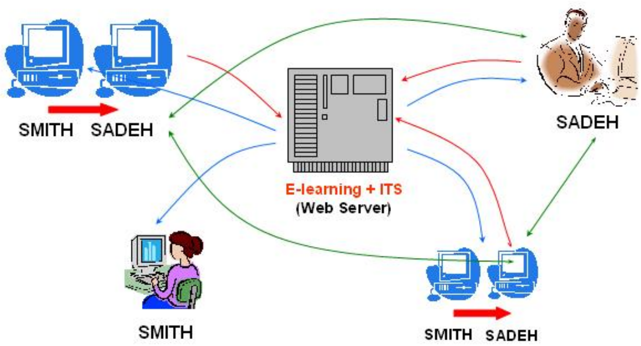

Fig.6: MKM in operation

MKM consists of one or more Maintenance Information Systems such as SMITH [18] and fault diagnosis CBR systems such as SADEH [19], CBR-Works based systems, etc. located at different facilities of the same or distinct organizations. CBR systems may acquire knowledge from information systems usually based on automatic procedures for data analysis. CBR systems can then be used to supply real examples in a distance learning environment.

In this scenario information systems deal with confidential data and so may be accessed by local staff only. In the example SADEH acquires cases from SMITH by importing and processing information such as work orders and historical data. As above-mentioned other information and CBR systems may also intervene, as the MKM architecture is modular. Integrating other systems is a matter of developing interfaces and protocols.

4.2 Architecture

Fig.8 shows the purposed architecture for the main MKM system. This architecture is derived from [13]. Fig.9 complements it by showing its multi-agent platform.

In this context, an (intelligent) agent is a piece of program that perceives its environment and acts on it by taking decisions. In Fig.8 there are three types of agents: CBR, Router and Example Manager.

The Example Manager agent is responsible for obtaining the best examples from the connected CBR systems and to choose the ones that correctly illustrate the subjects to teach. First it has to translate the query to be sent to the connected CBR systems into some querying language, pass it to the Router Agent and wait for a sign from that agent to query one intermediate CBR system that will act as appraiser, evaluating the best answers from the connected CBR systems. After getting a reply from the CBR systems it parses it back to KQML format and sends it to be processed by the other ITS agents.

The Router agent acts as a connector between all the CBR systems and the Example Manager, managing all the messages, guaranteeing their uniqueness and correct delivering. The Router Agent receives the query that has to be sent from the Example Manager Agent and replicates it for all the CBR Agents connected to him. When all of them answer back it should add the result as new cases in the appraiser CBR System for a final evaluation. Fig.7 shows how to add a case with CQL..

add_case
defcase get_slots confirmed
creator "XPTO (IS)" date(2006 7 10)
objects
"Appraiser" get_slots
"Price":_Price_,
"Engine":_Engine_,
"Miles" : _Ml_,
print_name "default" get_slots.

Fig. 7 – Adding a new case using CQL

The CBR Agent must query the CBR system it his responsible for, previously knowing some technical details about it. It also must collect the results and send them back to the Router Agent. These results should be restricted to a reasonable number of answers not to overload the system.

4.3 e-leaning and ITS

In MKM cases are to be used as examples of the presented subjects. Basically, theory can be presented by any "classical" e-learning platform. But the learning process can be improved if the platform is complemented with *ITS - Intelligent Tutoring System* - whose role may be, among others, matching exercises, problems and examples to the student skills and difficulties.

The ITS of fig.9 is based on [14] [15] and includes the Example Manager Agent (also represented in fig.8).

The main parts of this architecture are:

1) The Domain Agent (1) that knows and controls the subjects to be presented to the student. Messages can be exchanged between it, the Student Role Manager (5) and the Interface Agent
2) The Exercise Manager (2) that selects exercises and evaluates answers. It can interrogate the Student Role Manager in order to adapt a problem to the student profile or determine its update based on performance evaluations. It can also exchange messages with the Interface Agent (6) to record the steps followed by the student when solving a problem or situation.

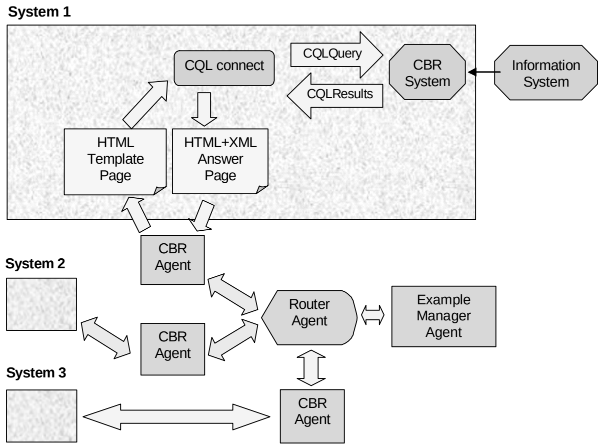

Fig. 8: Searching examples contained in CBR systems of different facilities

3) The Example Manager Agent (3) that selects examples (cases) to illustrate the subjects. In the MKM architecture these examples are extracted from the CBR systems that operate at distinct facilities. This agent acts as the bridge between Fig. 8 and 9. It exchanges messages with the Student Role Manager in order to adapt cases to the student profile or update it according to the purposed solution. It can also exchange messages with the Interface Agent (6) to track the student steps.
4) The Student Role Manager Agent (4) builds and maintains a knowledge base that models the cognitive state of the student. In each lesson startup it receives from agent (6) the login information from agent (6) and retrieves the student model. It then decides which strategy to follow.
5) The Interface Agent (6) controls what the student sees in his browser: all messages received or sent come and go thought this agent (5).
6) The Communication Manager Agent receives and sends messages from agents (1) to (4)

according to the needs of agent (6). It doesn't process them: it acts as a router leaving to agents (1) to (4) the interpretation tasks.

7) The student's browser shows web pages containing the theoretical subjects to teach, examples (JavaScript, for instance) and exercises (applets). The student is completely unaware of the complexity behind his lesson.
8) The Knowledge Base is a standard database that stores all the necessary data to feed the learning process, such as theory and exercises, student's data and his activities and results, necessary to determinate his knowledge level at each moment.

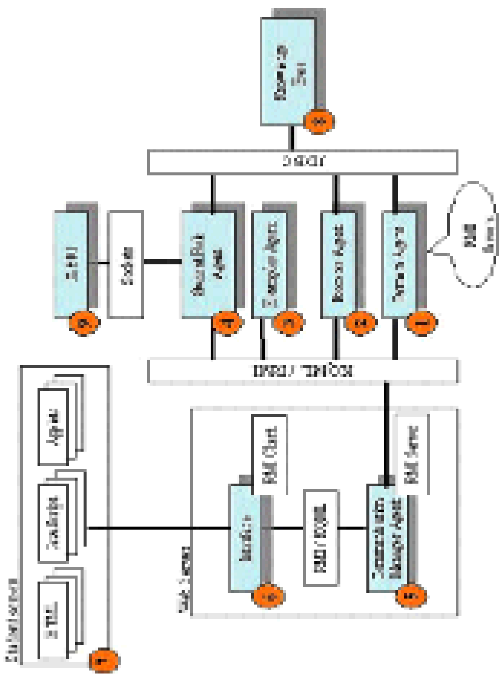

Fig.9: An ITS architecture to guide student's actions and select adequate real examples and cases

9) The X-BDI [16] is an environment that allows the formal description of the agent's initial mental states and the behaviour rules that establish how it will act.

The communication tasks between all the agents involved in this architecture represents a real problem: we are talking about a distributed architecture in which some agents must reside at the student side for interacting with him. The message format will be composed by two distinct layers:

1. The abstract layer represents the message that will travel trough the system from agent to agent;
2. The physical layer encapsulates the abstract layer and treats it as an object that can be easily transported across the network. Java - a well-known cross platform programming language - may be a solution along with RMI (Remote Method Invocation) [17] that allows objects to be sent from RMI clients to RMI servers.

4.4 Active Experimentation

Sophocles, once said "Though you think you know it, you have no certainty until you try it".

The use of virtual reality to present examples or to test concepts can give the ability to try what have been taught in a safe "real" environment completing the final stage of the learning cycle.

Fig.9: VRML - Simulating a control panel (RIDES / VIVID - University of Southern California , U.S.A.)

In this context VRML - *Virtual Reality Markup Language* and simulation provide a suitable support for such an environment. The student will be able to feel "inside" a production line, interact with equipment, adjust controls by "direct" manipulation, observe alarms, etc.

5 Conclusion

MKM is a system under development to be tested in the maintenance field. Systems like SMITH [18] - an information system based on the maintenance therology model - and SADEX [19] - a fault diagnosis system based on the CBR paradigm and fuzzy logic - have been developed by our research group and will play a central role in the whole scenario.

MKM integrates CBR, ITS and e-learning in a single system designed to help people learn with theory and practice, by providing real examples, guided lessons and virtual reality environments for active experimentation.

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