KNOWLEDGE MANAGEMENT APPROACH FOR GAS TURBINES MAINTENANCE

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Résumé : L’objectif des dirigeants d’entreprises est d’augmenter la productivité par l’amélioration des organisations en réutilisant les connaissances (savoirs et savoirs faire) ainsi que les compétences. Il est donc important de disposer en plus d’une bonne gestion du personnel d’un système permettant de fournir aux utilisateurs à temps l’information utile dont ils ont besoin et sous une forme exploitable. Ceci implique la constitution et la valorisation d’un capital de connaissances. L’étude proposée dans ce papier est orientée vers la proposition d’un modèle de connaissances décrit par une ontologie et le processus de raisonnement associé fondé sur la technique de raisonnement à partir de cas, ce qui aboutit à un outil « DIAGTURB » d’aide au diagnostic et à la maintenance de pannes dans les turbines à gaz .

Summary : The objective of enterprises leaders, is to increase productivity while improving the organization by a reuse of knowledge (know, know-how) and competences developed during the time. Therefore an important aspect in addition to a good personnel management to have a system permitting to provide to users the useful information if need be, as soon as possible and in an exploitable way. It implies constitution as well as valorisation of knowledge capital. We are therefore facing to a knowledge capitalization process. This study is oriented to propose a knowledge model using ontology and a reasoning process based on CBR technique, that lead to “DIAGTURB” a tool for helping users to make decisions in diagnostic and maintenance of gas turbines.

Mots clés : Knowledge management, domain ontology, fault diagnosis, maintenance, case based reasoning.

Knowledge Management Approach for Gas Turbines maintenance

The diagnosis has for objective to determine the state of equipment or a process from observations [5]. It evaluate if the equipment functioning is correct, graduated, faltering and to determine the components that are breakdown or that require a maintenance action. Diagnosis is an intelligent act which is hardly programmable with classic techniques. Several studies have been made for the development of the diagnosis methods based on artificial intelligence (AI) methods and techniques. Expert systems [5] provide a useful means to acquire diagnosis knowledge directly from key personnel (experts) and transform their expertise into production rules. However the knowledge acquisition and verification processes are difficult and complicated and sometimes experienced technicians even have no idea of how to express their strategies explicitly and accurately. Rule induction and neural network [10] are the means that can be applied to find out fault classification knowledge using previous known examples. These methods are demonstrated robust but requires a sufficiently large training set to ensure promising outcome. Case based reasoning (CBR) [1] offers another alternative to implement systems of intelligent diagnosis for real applications. This alternative is motivated by the idea that the similar situations lead to similar outcomes. The main strength lies in the fact that it enables directly reusing concrete examples in history and consequently eases the knowledge acquisition bottleneck. It also creates the opportunity of learning from experiences but skipping the step of data training.

CBR techniques are of particular application value for diagnosis in real industrial environments where the acquirement of adequate training examples in advance is mostly not realistic if not possible.

Because of fundamental importance of the gas turbines maintenance operation, we are interested in this study to explore CBR techniques to develop a tool for gas turbines diagnosis.

The paper is organized as follows: section 1 gives an overview of knowledge management. Concepts. In section 2 we explain ontology conception and implementation as well as CBR process adapted to diagnose gas turbines. We conclude our work in the section 3.

1- KNOWLEDGE MANAGEMENT

Facing the needs increased of the enterprises to preserve and to share knowledge of their employees, knowledge management began to occupy, since the beginning of the years 90, a more and more important place in the enterprises [13]. Several definitions of the concept of knowledge management have been proposed in the literature: [13]; [6]; [7]. Two extreme ways exist to conceive knowledge management systems. On one hand it is considered like a simple process of communication that can be improved with certain tools (electronic mail service, Groupware, Intranet, workflow, System hypertext, etc). On the other hand it is about capitalizing knowledge with the help of a corporate memory by analogy with the human mind that allows us to construct on past experiences and to avoid the repetition of errors; the corporate memory must capture the information of the different sources of an organization and make it available to do different tasks.

According to our perception knowledge management can be defined as: “a set of tools used for structuring and preserving a capital of knowledge in an organization, facilitate access to these knowledge and sharing it while assuring the survival of this capital by the update and the creation of new knowledge”.

According to Grundstein [7], generic processes of knowledge management answer the problematic of knowledge capitalization This problematic is characterized by five facets and their interactions : to mark the crucial knowledge, preserving, valorising, actualizing and managing this knowledge, each of the facets refer to some processes intended to solve the problems concerned: Identify, localize, Modelling, conserving, diffuse, exploit, evaluate, organize ,….etc.

Knowledge capitalization process consist in marking the crucial knowledge (know and know-how) that are necessary to the processes of decision. So it’s important to identify; then to formalize and model the explicit knowledge in order to memorize them. One of the proposed methods is the construction of the ontology [4].

2- "DIAGTURB" ARCHITECTURE

2.1- domain model

After studying gas turbines maintenance process and the practice of experts in this domain we proposed a model that represents domain knowledge with an ontology. The role of this ontology is to describe concepts of gas turbines with all its components and all its information concerning its functioning method as: compressor, rotor, combustor, instrument, failure,..etc To obtain this ontology we have followed four steps :

Step1: we focused our work on the identification of knowledge requiring an operation of capitalization (to Mark). We collected the crucial knowledge of the domain from the existing technical documentation (books, handbooks of manufacturers…) and with the help of key personnel (operator of maintenance, expert of the domain). The result of this stage is a set of knowledge judged crucial in the domain of the maintenance.

Step2: From the collected knowledge, we identify precisely the concepts and their relationships which constitute our ontology. Concepts are of various types: classes, properties and instances. We consider as classes equipments and their decompositions (e.g. instrument, thermocouple, pump, filter…). We associated every equipment with knowledge describing its characteristics which are considered as properties or slots (e.g. temperature, pressure, vibration, frequency…).

Other knowledge are also selected to specify relations between concepts. Some of these relations are:

Is-a: this relation allows leading taxonomy of concepts (e.g. thermocouple "is –a" instrument).

Part-of: this relation makes possible to determine subcomponents of a component. Every equipment is decomposed in sub-equipments which can be decomposed in elementary components (e.g. inlet guide vanes IGVs, inducer, impeller, a diffuser a scroll "part_of" centrifugal compressor). In addition, other relations are formalized describing functioning method of equipments (their main role and secondary functions, e.g. supervise, control…).We precise for every equipment the breakdowns style in other words the categories or failure kinds of this equipment (have-failure relation).

Step3: On the other hand another category of knowledge that we judged essential in this study and which are represented in our ontology consist on describing the procedures in the process of maintenance by describing some cases of dysfunction. The case is composed of two different parts that contains the description of the case through a set of symptoms (parameters or variable on the equipments) and its solution. These cases constitute the case base in our CBR system. For the mechanism of reasoning we associate to the set of variables the similarity measures that are based on the distance and the associated weight.

Step4: we have constructed the instance base of the designed ontology using a powerful ontology editor "Protégé"(protégé 3.3.1) [15] (Fig1, Fig2). Protégé is used as a tool of knowledge acquisition describing the considered installation. The ontology resulted can be exploited by other systems.

2.2- CBR PROCESS

Case Based Reasoning (CBR) is an approach to problem solving and learning, by reusing the solutions to similar problems stored as cases in a Case Base [1]. A general CBR cycle may be described by five processes [12]: develop the representation cases, retrieve the most similar case or cases, reuse the information and knowledge in that case to solve the problem, revise the proposed solution and retain the parts of this experience likely to be useful for future problem solving.

In our study we focused two phases of CBR cycle: develop (describe) the new case and retrieve sources cases. Initially and following a demand of intervention we start by describing the problem by an equivalent case. So, the maintenance operator fills in a form. This form is composed of a hierarchy of questions with multiple answers permitting to localize the problem in term of system, equipment, component, and the nature of the problem: electric, mechanical problem... and to have some parameters on the failed components. From this form we extract the pertinent descriptors of the case. Once the target case (new case) is elaborated we retrieve the sources cases. In a first time the case base is filtered to k the cases sources that have the same nature of the problem represented by the target case. On this set of cases we compare by calculating the degree of similarity of the target case (T) with the different cases sources (S). For the calculation of similarity, we consider that the descriptors of cases (p descriptors) have the same importance (wi =1 for all descriptors). We take in account the presence or the absence of the descriptor (sim presence: 0 / 1 for absent or present) as well as the local similarity of the descriptors sim(ti,si) that indicates the variation of values between the descriptors. So the similarity is calculated as follows:

$$Sim(T,S)= \frac{\sum_{i=1}^{p} w_i \, sim_{presence} \, sim(ti,si)}{\sum_{i=1}^{p} w_i}$$

Then we reuse the solutions of the sources problems considered like similar to the target problem. The solution can be modified while changing the parameters and we speak here of adaptation phase. In some cases the solution is proposed without change. The operator of the maintenance executes the proposed procedure for reparation. If the result is satisfactory this new case is memorized in the case base and therefore in the ontology what refers to the last phase of the CBR cycle "Retain", on the other hand the facet “Actualize” is appeared here from our knowledge management system else if the proposed solution is not satisfactory we proposed the solution of the least similar case than the precedent one.

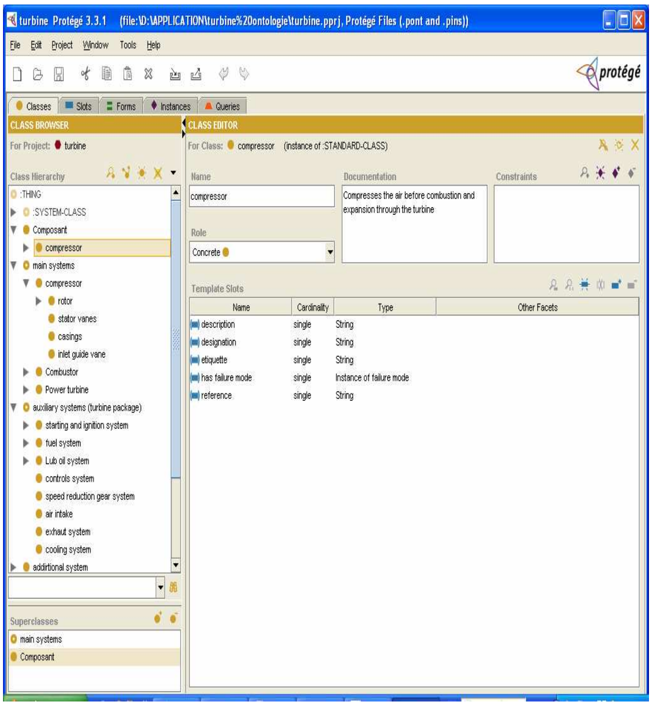

Fig 1 : Overview of ontology concepts

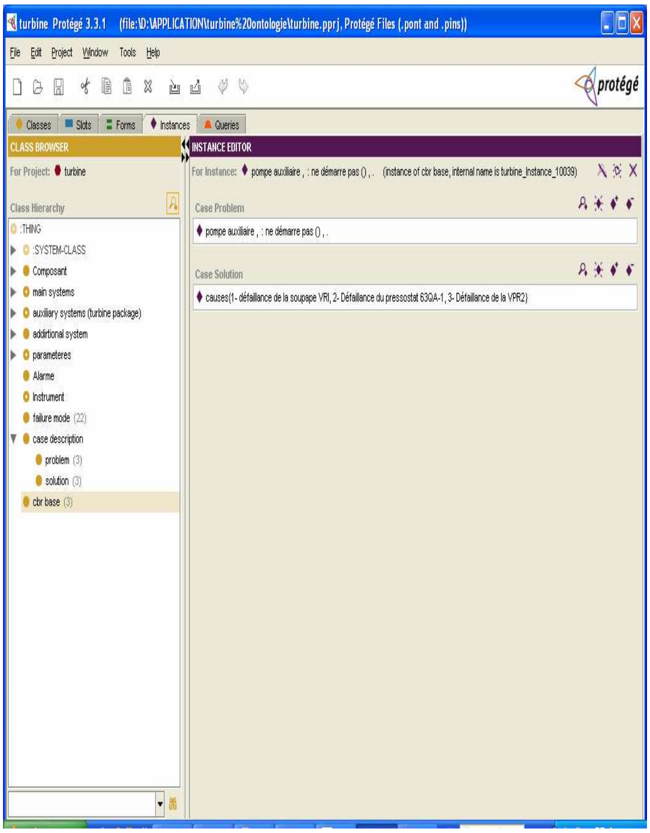

Fig 2 case example stored as instance on the ontology

3.CONCLUSION

In this study we have applied knowledge management approach to formalize domain knowledge with ontology. This ontology constitute the core of “Diagturb” : gas turbines diagnosis tool. “Diagturb” uses CBR techniques to find similar problem cases then gives its solution (failures causes, maintenance operations) this informations are used and adapted by maintenance operator to solve current problem. The new case (problem and solution are finally validated and added to cases base to enrich the system.

The validation of “Diagturb” by the experts showed that our ontology covers the entire domain. This ontology is extensible (modeling and instantiation). We note that cases base will be continuously update in order to cover higher number of failure cases. the validation and evaluation of this tool must be continued during its use in real situations.

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