# Knowledge Management for Fault Diagnosis of Gas Turbines Using Case Based Reasoning

Fouzia Anguel, Badji Mokhtar Annaba University, BP 12, 23000 Annaba, Algeria, <u>fanguel@yahoo.fr</u> Mokhtar Sellami, Badji Mokhtar Annaba University, BP 12, 23000 Annaba, Algeria, <u>sellami@lri-annaba.net</u>

#### Abstract

Fault diagnosis of industrial equipments becomes increasingly important. Developing a fast and reliable diagnosis system presents a challenge issue in many complex industrial systems. The major difficulties therein arise from the unavailability of experienced technicians for support. This study is oriented to explore a knowledge management approach by capitalizing the expertise which serves on one hand, to build an ontology used in gas turbines maintenance domain, and on the other hand, to develop a case based reasoning tool for helping users to make decisions in diagnostic and maintenance.

**Keywords:** Knowledge management, domain ontology, fault diagnosis, case based reasoning.

#### 1. Introduction

Construction of automatic maintenance systems, especially diagnosis systems is one of means to optimize reliability and availability of equipments. Indeed, 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.

We believe that 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.

The paper is organized as follows: section 2 gives an overview of knowledge management. Concepts of ontology, CBR and gas turbines are given in the section 3, followed by the explanation of the gait adopted for the conception and the implementation of the ontology as well as an explanation of the use of the principle of CBR for the diagnosis in gas turbines in section 4. We conclude our work in the section 5.

#### 2. 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, localise, Modelling, conserving, diffuse, exploit, evaluate, organize ....etc.

# 3. Modelling knowledge

#### 3.1 Ontology

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].

The following definition has been given to the ontology in [4] "to make ontology, is to decide of the individuals who exist, the concepts and properties that characterize them and the relations that link them". So, the ontology contains the terminological primitives of the domain (the conceptual vocabulary structured in a set of concepts and a set of existing relations between these concepts).

#### 3.2 Case based reasoning (CBR)

The processes that make up case-based reasoning can be seen as a reflection of a particular type of human reasoning. In many situations, the problems that human beings encounter are solved with a human equivalent of CBR. When a person encounters a new situation or problem, he or she will often refer to a past experience of a similar problem. This previous experience may be one that they have had or one that another person has experienced. If the experience originates from another person, the case will have been added to the (human) memory through either an oral or a written account of that experience. The idea of CBR is intuitively appealing because it is similar to human problem solving behaviour. Therefore, CBR involves reasoning from prior examples [1]: retaining a memory of previous problems and their solutions and solving new problems by reference to that knowledge.

Descended of the research in artificial intelligence on the problems resolution, this principle of resolution can be described as follows [8]: Generally, a case-based reasoner will be presented with a problem, either by a user or by a program or system. The case-based reasoner then searches its memory of past cases (called the case base) and attempts to find a case that has the same problem specification as the case under analysis. If the reasoner cannot find an identical case in its case base, it will attempt to find a case or multiple cases that most closely match the current case.

In situations where a previous identical case is retrieved, assuming that its solution was successful, it can be offered as a solution to the current problem. In the more likely situation that the case retrieved is not identical to the current case, an adaptation phase occurs. During adaptation, differences between the current and retrieved cases are first identified and then the solution associated with the case retrieved is modified, taking these differences into account. The solution returned in response to the current problem specification may then be tried in the appropriate domain setting.

At the highest level of abstraction, a case-based reasoning system can be viewed as a black box (Fig. 1) that incorporates the reasoning mechanism and the following external facets:

- The input specification or problem case.

- The output that defines a suggested solution to the problem.

- The memory of past cases, the case base, that are referenced by the reasoning mechanism.

In many practical applications, the reuse and revise stages (Fig 1) are sometimes difficult to distinguish, and several researchers use a single adaptation stage that replaces and combines them. However, adaptation in CBR systems is still an open question because it is a complicated process that tries to manipulate case solutions [12]. Usually, this requires the development of a causal model between the problem space (i.e., the problem specification) and the solution space (i.e., the solution features) of the related cases.



Fig 1. Case based reasoning phases [12]

The feasibility of the CBR for the decision support where the experience of past situations is reused to manage new situations, has been shown in the survey of the decision making process [8]. The deepening of this mechanism (CBR) brings us to see behind a knowledge management process. In fact, the CBR and the knowledge management follow the same objective of acquisition and reuse of experience or knowledge.

#### 3.3 domain analyze

Communications of the IBIMA Volume 10, 2009 ISSN: 1943-7765 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. The diagnosis takes support on two complementary analyses, one consists to a functional decomposition of the equipment, and a second consists to an analysis of failure style: for every failure, the expert identifies the symptom, the origins that provoke it and the actions that lead to its reparation.

# 3.4 The Gas turbines

The gas turbine [14] is a motor machine with rotary movement and internal combustion, provided with an air compressor and a combustion chamber in measure to produce a fluid under pressure and with very high temperature. This fluid, while relaxing in the floors of the turbine, produces the mechanical energy to the outside.

Because of the importance of the gas turbines in the process of the economic development, maintenance operation of these equipments is of a fundamental importance. It permits to reduce the inactivity time of equipments that is very expensive.

# 4. Steps of Work

# 4.1. Domain ontology for diagnosis and maintenance of gas turbines

After studying the maintenance process of gas turbines and the practice of experts in this domain we developed the ontology of maintenance domain. The role of this ontology is to describe the installation to maintain which is a gas turbine with all its components and all its information concerning its functioning method.

*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" [15] (Fig2). Protégé is used as a tool of knowledge acquisition describing the considered installation. The ontology resulted can be exploited by other systems.

# 4.2. Case based reasoning system

In our study we focused two phases of CBR cycle: 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 ( $w_i = 1$  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( $t_i$ , $s_i$ ) that indicates the variation of values

Communications of the IBIMA Volume 10, 2009 ISSN: 1943-7765 between the descriptors. So the similarity is calculated as follows:

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 a phase of adaptation. 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

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

refers to the last phase of the dBR cycle "Retain", on the other hand the facet <sup>*i*</sup> 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. We proceed thus until one of the proposed solution is kept or the operator applies his own solution that must be described so that it will be memorized with its problem in the case base.

	turbines.pprj, Protege i i	tes (.pont and .)				
<u>File Edit Project Window Tools Help</u>						
	44					protégé
Classes 🔲 Slots 📮 Forms 🔶 Instanc	ces 📕 Queries					
CLASS BROWSER	CLASS EDITOR	a haaa i (instance s				N 26 Y
	ror class. Composant-ue	s-base (inistance c	IT.STANDARD-CEASS)			
Class Hierarchy 😕 🗮 🗶 🔻	Name		Documentation		Constraints	P4 🛧 🔹 🔹
SYSTEM-CLASS	composant-de-base					
🔻 😑 eléments-de-bae	Role					
▶ ● système	Concrete 😑	•				
composant     composant de base						0 0 ¥ * - +
composuri recondusc     carter d'entrée d'air	Template Slots	Canalization	Time		Office: E.	~~~
Palier de butée	(  designation	required sir S	tring		Other Fa	Cets
enceinte acoustique	(=) fonction principale	single C	lass with superclass Fonctio	ns		
composant auxiliaire	(=) fonction secondaire	single C	lass with superclass Fonctio	ns		
<ul> <li>réservoir d'huile</li> </ul>	mode de pannes	multiple C	lass with superclass panne			
pompe	se- compose- de	required sir S multiple	uning lass with superclass sous- c	×c		
V e Instrument	<ul> <li>surveillé par</li> </ul>	multiple C	lass with superclass Instrum	ent		
manomètre     thormon rum in		se- comp	ose- de (in <u>stance of :</u>	STANDARD-SLOT		
sonde de vitesse		- comp	, interest of the	,		
Source on the second seco		Name	Di	ocumentation		Template Value 🎢 👎
Fonctions		se- compose-	de pe	ermet d'identifier les diff arties ou sous composa	erentes ant du	
▶ ● panne		Value Type	ec	emposant considéré		
Alarme     Concert RèPC		Class	-			
		L				Default Values 1
		Allowed Sup	erclass 🔏 🧉 🧉 C	ardinality		
		sous- comp	oosant 🗌	required	at least	
Superclasses • •				multiple	at most	Bomain
composant						
				10000		
🔏 diaturbines Protégé 3.3.1 (file:\C:\dia	turbines.pprj, Protégé Fi	les (.pont and .j	pins))			<b>- - ×</b>
Image: Second state     Second state       Image: Second state     <	turbines.pprj, Protégé Fi	les (.pont and .j	pins))			
≤     diaturbines     Protégé 3.3.1     (file:\C:\diaturbines       Elle     Edit     Project     Window     Tools       Help     □     □     □     □	turbines.pprj, Protégé Fi 🖄 🗳 💝	les (.pont and .j	pins))			_ ₽ ×
Image: Set in the set of th	turbines.pprj, Protégé Fi 🛃 🤣 😒 ces 🗖 Queries	les (.pont and .j	pins))			protégé
Idiaturbines     Protégé 3.3.1     (file:\C:\diation       Ele     Edit     Project     Vindow     Tools       Heip     Image: State of the s	turbines.pprj, Protégé Fi	les (.pont and .j	oins))			protégé
Idiaturbines       Protégé 3.3.1       (file:\C:\diata         Ele       Edit       Project       Vándow       Tools       Help         Image: State	turbines.pprj, Protégé Fi	les (.pont and .j	DARD-CLASS)			protégé
Idiaturbines       Protégé 3.3.1       (file:\C:\diata         Elle       Edit       Project       \Underwidth{\Underwidth{U}}_ndow       Tools       Help         Image: State in the s	turbines.pprj, Protégé Fi	les (.pont and .j (instance of :STAND	)ARD-CLASS)		Constraints	د او کې د او کې د او کې
Idiaturbines       Protégé 3.3.1       (file:\C:\diata         Ele       Edit       Project       \Underwidth Mindow       Tools       Help         Image: Sold state       Ima	turbines.pprj, Protégé Fi	les (.pont and .j (instance of :STAND	)) )ARD-CLASS) Documentation		Constraints	
Idiaturbines       Protégé 3.3.1       (file:\C:\diata         Ele       Edit       Project       \Underwidth Mindow       Tools       Help         Image: Sold state       Ima	turbines.pprj, Protégé Fi	les (.pont and .j	)) )ARD-CLASS) Documentation		Constraints	
*% Idiaturbines: Protégé 3.3.1 (file:\C:\diaturbines: Protégé 3.3.1 (file:\C:\diaturbine: Leip)         Ele       Edit Project: \Qindow Tools: Help         Classes       State: Forme Instance         CLASS BROWSER       Forme Instance         For Project: Instance       diaturbine         Classes Hierarchy       A V V V         :THING       :SYSTEM-CLASS         Image: Instance       Image: Imam	turbines.pprj, Protégé Fi	les (, pont and , , (instance of :STAND	)ARD-CLASS)		Constraints	
** (diaturbines: Protégé 3.3.1 (file:\C:\diaturbines: Protégé 3.3.1 (file:\C:\diaturbine: Colosses)       (file:\C:\diaturbine: Classes)         Classes       State       Forms       Instance         CLASS BROWSER       For Project:       diaturbine       Classes       State         Classes       State       Forms       Instance         CLASS BROWSER       For Project:       diaturbine         Class Biterarchy       A V V V       V       V         : THING       SYSTEM-CLASS       V       V         • Gements-de-base       • exysteme       • composant       • composant         • Composant       • composant-de-base       • Composant-de-base       • Composant-de-base	turbines.pprj, Protégé Fi	les (, pont and , j (instance of :STAND	ARD-CLASS)		Constraints	■ ■ × Protégé > × × > × × > × × > × × > × × > × × > × × > × ×
*** Idiaturbines: Protégé 3.3.1 (file:\C:\diaturbines: Protégé 3.3.1 (file:\C:\diaturbine: Colesses)       Staturbine: Colesses)         CLASS BROWSER       Forms Instance         For Project: Instance       diaturbine         Class BROWSER       Forms Instance         For Project: Instance       diaturbine         Class BROWSER       Instance         For Project: Instance       diaturbine         Class Billerarchy       Instance         Instance       Staturbine         Class Billerarchy       Instance         Instance       Instance         Instance<	turbines.pprj, Protégé Fi	les (, pont and , j (instance of :STAND	DARD-CLASS) Documentation Type		Constraints Other Fa	■ Protégé       >     >       >     >       >     >       >     >       >     >       >     >
Idiaturbines       Protégé 3.3.1       (file:\C:\diaturbine         Ele       Ell       Protégé 3.3.1       (file:\C:\diaturbine         CLASS BROWSER       Forms       Instance         For Project:       diaturbine       Classes       Staturbine         Class Hierarchy       A V X X       V         • SYSTEM-CLASS       • eléments-de-base       • système         • composant       • composant duxiliaire       • instrument         • sous-composant       • sous-composant       • sous-composant	turbines.pprj, Protégé Fi	les (.pont and .j (instance of :STANC Cardinality required etc	DARD-CLASS) Documentation Type tring tase with supervisor 50-47-		Constraints Other Fa	■ ■ × Protégé > × × × <p< th=""></p<>
Idiaturbines       Protégé 3.3.1       (file:\C:\diaturbines         Ele       Elt       Protégé 3.3.1       (file:\C:\diaturbines         Ele       Elt       Protégé 3.3.1       (file:\C:\diaturbines)         Classes       Stats       Forms       Instance         Image: Stats       Classes       Stats       Image: Stats       Image: Stats         Image: Stats       Stats       Stats       Image: Stats       Image: Stats       Image: Stats         Image: Stats       Stats       Stats       Image: Stats       I	turbines.pprj, Protégé Fi Cueries CLASS EDITOR For Class: © composant Name Composant Role Concrete © Template Slots Name © designation © fonction principale © fonction secondaria.	Ies ( , pont and . , (instance of :STAND Cardinality	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass with superclass Fonctio	ns	Constraints Other Fa	[□ ×     ]     [□ ×     ]     [□ ×     ]     [□ ×     ]     [□ ×     ]     ]     [□ ×     ]     [□ ×     ]     ]     [□ ×     ]     [□ ×     ]     ]     [□ ×     ]     [□ ×     ]     ]     [□ ×     ]     [□ ×     ]     ]     [□ ×     ]     [□
Idiaturbines       Protégé 3.3.1       (file:\C:\diaturbine)         Ele       Ell       Protégé 3.3.1       (file:\C:\diaturbine)         Ele       Ell       Protégé 3.3.1       (file:\C:\diaturbine)         Classes       Slots       Forms       Instance         Classes       Slots       Slots       Forms         Sous-composant       Slots       Slots       Foreclons         Sous-composant       Slots       Foreclons       Foreclons         Sous-composant       Slots       Foreclons       Foreclons         Sous-composant       Foreclons       Foreclons       Foreclons         Sous-composant       Foreclons       Foreclons       Foreclons         Sous-composant       Foreclons       Foreclons       For	turbines.pprj, Protégé Fi Cueries  CLASS EDITOR  For Class: Composant  Role Concete Template Slots  Template Slots  Maine  Gonction principale  Fonction secondaire  Fonction s	(instance of :STAND (instance of :STAND Cardinality required simS required simS cardinality captive condaints incling secondaints	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass wit	ns ns DARD-SLOT)	Constraints Other Fa	×
Idiaturbines       Protégé 3.3.1       (file:\C:\diaturbines         Ele       Edit       Project       Vándow       Tools       Help         Image: Solar State       Forms       Instance         Classes       Slots       Forms       Instance         Striling       Composant       Composant       Slots         Sours-composant       Sours-composant       Sours-composant       Fonctions         Sours-composant       Sours-composant       Fonctions       Fonctions         Sours-composant       Sours-composant       Fonctions       Fonctions         Sours-composant       Alarme       Alarme       Composant-Composant         Souro-composant       Sours-composant	turbines.pprj, Protégé Fi Cueries  CLASS EDITOR  For Class: Composant  Name Composant  Role Concrete  Template Slots  Mame designation  fonction principale	Ies (, pont and .) (Instance of :STAND Cardinality required sim. C sequired sim. C required sim. C cardinale Canction secondal	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass with superclass Fonctio lass with superclass Fonctio (istance of :STAN) (; STANDARD-SLOT)	ns ns DARD-SLOT)	Constraints Other Fa	. • ×
************************************	turbines.pprj, Protégé Fi	les (, pont and . ) (instance of :STAND Cardinality Cardinality required air C sincle C nation secondal pade (instance C	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass swith superclass Fonctio (instance of :STANI (if:STANDARD-SLOT)	ns ns DARD-SLOT)	Constraints Other Fa	× <i>protégé</i> × × × × × ×
************************************	turbines.pprj, Protégé Fi	les (, pont and . ; (instance of :STAND Cardinality required sim. C single C nction secondai hale (instance c	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass with superclass Fonctio f (STANUARD-SLOT) ocumentation	ns ns DARD-SLOT) Template 1	Constraints Other Fa	×
************************************	turbines.pprj, Protégé Fi	Ites (.pont and .j (instance of :STANC Cardinality required airs. c sinale C nction secondai hale (instance c	DARD-CLASS) Documentation Type Tring lass with superclass Fonctio lass with superclass Fonctio lass with superclass Fonctio re (instance of :STANI rf :STANIDARD-SLOT) occumentation Situe la fonction principale ré ri e composant	ns ns DARD-SLOT) eilisée	Constraints Other Fa	
Idiaturbines       Protege 3.3.1       (file:\C:\diaturbines         Ele       Edit Project       \Underwork       Tools       Help         Cass       Stats       Forms       Instance         CLASS       Browser       Instance       Classes       Stats       Forms       Instance         CLASS       Browser       Instance       Classes       Stats       Forms       Instance         CLASS       Browser       Instance       Instance       Instance       Instance         Class       Brorecty       A **       *       *       *       *         Instrument       Instrument <th>turbines.pprj, Protégé Fi</th> <th>Ites (.pont and .j (Instance of :STANU Cardinality required sim. C sincle C nction secondai nale (instance c</th> <th>DARD-CLASS) Documentation Type Tring lass with superclass Fonctio lass with superclass Fonctio re (instance of :STANI re (instance of :ST</th> <th>ns ns DARD-SLOT) Template \</th> <th>Constraints Other Fa ∉alue A ≚</th> <th> ×</th>	turbines.pprj, Protégé Fi	Ites (.pont and .j (Instance of :STANU Cardinality required sim. C sincle C nction secondai nale (instance c	DARD-CLASS) Documentation Type Tring lass with superclass Fonctio lass with superclass Fonctio re (instance of :STANI re (instance of :ST	ns ns DARD-SLOT) Template \	Constraints Other Fa ∉alue A ≚	×
Idiaturbines       Protege 3.3.1       (file:\C:\diaturbines         Ele       Ele       Window       Tools         Ele       Ele       Image: Solar in the so	turbines.pprj, Protégé Fi Cueries CASS EUTOR For Class: © composant Name Composant Role Concrete © Template Slots Template Slots Name © designation © fonction principale © reference © fonction principale © fonction principale © fonction principale © fonction principale © fonction principale © fonction principale Value Type Class	(instance of :STANC (instance of :STANC Cordinality required sime: C sinction secondai pale (instance of instance of instance	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass with superclass Fonctio re (instance of :STANI of :STANDARD-SLOT) Documentation likiue la fonction principale ré r la composent	ns ns DARD SLOT) alisée	Constraints Other Fa	×
Idiaturbines       Protégé 3.3.1       (file:\C:\diaturbines         Ele       Ele       Vindow       Tools         Ele       Stats       Forms       Instance         Classes       Stats       Forms       Instance         Class BROWSER       Ele       Composant       Vindow         Class Biterarchy       A       V       V         O:SYSTEM-CLASS       •       eléments-de-base       •         •       •       composant duciliare       •         •       •       composant duciliare       •         •       •       composant duciliare       •         •       •       ocomposant       •         •       •       composant duciliare       •         •       •       ocomposant       •         •       •       ocomposant       •         •       •       ocomposant	turbines.pprj, Protégé Fi Cueries CASSEDITOR For Class: © composant Name composant Role Concrete © Template Stots Name designation © fonction principale Fonction principale Terference Fonction principale Value Type Class Allowed Superclass	(Instance of :STANC (Instance of :STANC Cardinality required air S required air S inclient secondal pale (Instance of pale (Instance of pale (Instance of pale) (Instance of pale)	ARD-CLASS) Documentation Type tring lass with superclass Fonctio lass with superclass Fonctio re (instance of :STANI rf :STANDARD-SLOT) Documentation Sigue Is fonction principale rf r le composant ardinality	ns ns DARD-SLOT) Template 1 Default Valt	Constraints Other Fa	
************************************	turbines.pprj, Protégé Fi Cueries CLASS EDITOR For Class: Composant Name Composant Role Concrete C Template Slots Name Gonction principale Fonction principale Fonction principale Value Type Class Allowed Superclass Fonctions	(Instance of :STANC (Instance of :STANC Cardinality required sim. S required sim. S required sim. C nction secondal bale (Instance of pale (Instance of pale (Instance of pale (Instance of pale	ARD-CLASS) Documentation Type tring lass with superclass Fonctio ardinality required at lea	ns ns ns DARD-SLOT) Persuit Vali et 1	Constraints Other Fa	
************************************	turbines.pprj, Protégé Fi	(Instance of :STANE (Instance of :STANE Cardinality required sim. C sincle Cardinality required sim. C sincle Cardinality (Instance of sincle Cardinality required sim. C sincle Cardinality (Instance of sincle Cardinality (Instance of State (Instance of State) (Instance of State)	DARD-CLASS) Documentation Type tring lass with superclass Fonctio lass with superclass Fonctio lass with superclass Fonctio f (instance of :STAN f :STANDARD-SLOT) ocumentation dique la fonction principale ré r le composant ardinality required at leas multiple at leas	ns ns DARD-SLOT) alisée tt_1	Constraints Other Fa	
************************************	turbines.pprj, Protégé Fi	Ites (.pont and .) (Instance of :STANE Cardinality required air sinale Cardinality required air sinale Cardinality required air cardinality required air cardinality required air cardinality cardi	DARD-CLASS) Documentation  Type  Tring Isss with superclass Fonctio Isss with superclass Fonctio Isss with superclass Fonctio Isss with superclass Fonctio Iss with superc	ns ns DARD-SLOT) elisée st 1 bomain	Constraints Other Fa Value A ¥ ues A ¥ ues A ×	
************************************	turbines.pprj, Protégé Fi	Ites (.pont and .) (Instance of :STANE Cardinality required sim. C sinale C sinale C netion secondai hale (instance c sinale (instance c c c c c c c c c c c c c c c c c c c	DARD-CLASS) Documentation Type Tring Lass with superclass Fonctio Lass with superclass Fonctio Lass with superclass Fonctio Lass with superclass Fonctio re (instance of :STANI re (instance of :STANI re (instance of :STANI ardinality required at lea multiple at mo- werse Slot $\mathcal{R} \rightleftharpoons$	ns ns DARD-SLOT) alisée ttermine ttermi	Constraints Other Fa	(*********************************
Idiaturbines       Protege 3.3.1       (file:\C:\diaturbines         Ele       Edit Project       \Mindow       Tools       Help         Casses       Stats       Forms       Instance         CLASS       Browser       For Project:       Instance         CLASS       Browser       Instance         CLASS       Browser       Instance         CLASS       Browser       Instance         CLASS       Instructione       Instance         CLASS       Browser       Instrument         Image: Source       Instrument       Instrument         Image: Source       Image: Source       Image: Source         Image: Image: Source       Image: Source       Image: Source <t< th=""><th>turbines.pprj, Protégé Fi</th><th>Ites (, pont and , ) (Instance of :STANU Cardinality required sim. C sincle C nction secondai pale (instance c , A C C C c aximum In</th><th>DARD-CLASS) Documentation Type Tring lass with superclass Fonctio lass wit</th><th>ns ns DARD-SLOT) allsée st 1 perault Vali</th><th>Constraints Other Fa</th><th></th></t<>	turbines.pprj, Protégé Fi	Ites (, pont and , ) (Instance of :STANU Cardinality required sim. C sincle C nction secondai pale (instance c , A C C C c aximum In	DARD-CLASS) Documentation Type Tring lass with superclass Fonctio lass wit	ns ns DARD-SLOT) allsée st 1 perault Vali	Constraints Other Fa	
Idiaturbines       Protégé 3.3.1       (file:\C:\diaturbines         Ele       Edit Project       \Mindow       Tools       Help         Casses       Stats       Forms       Instance         CLASS       Browser       For Project:       Instance         CLASS       Browser       Instance         CLASS       Browser       Instance         CLASS       Browser       Instance         CLASS       Instructione       Instance         CLASS       Georgestrate-tode-base       Instrument         Instrument       Instrument       Instrument         Instrument	turbines.pprj, Protégé Fi	Instance of :STANE	DARD-CLASS) Documentation Type Tring Iass with superclass Fonctio Iass wit	ns ns DARD-SLOT) allsée tt 1 Default Vali st 1 Domain composa	Constraints Other Fa	■ ● × Protégé       A *       A *       A *       A *       A *       A *

Fig2: overview of the ontology in Protégé

#### 5. Conclusion

We studied the process of diagnosis and maintenance of the gas turbines. We have oriented our work toward the construction of a knowledge management system. Knowledge in this system are preserved as an ontology that regroups knowledge of the domain, and a case base used for reasoning. This ontology is implanted on the ontology editor "protégé". We have developed a method for the resolution of the diagnosis problem based on CBR approach. The validation of our system of diagnosis and maintenance by the experts showed that our ontology covers the entire domain. This ontology is extensible (modeling and instantiation). Currently we enrich the case base in order to cover a higher number of failure cases. We note that the validation and evaluation of this tool must be continued during its use in real situations. In prospect we are going to add other functionalities to this system notably the aid of the distant experts in the process of maintenance.

#### 6. References

[1] Aha, J. "The omnipresence of case-based reasoning," in science and application, Knowledge–Based Systems 11 (5-6), pp 261-273,1998.

[2] Anguel, F., Sellami, M., «Une Approche de Diagnostic de Pannes Basée sur une Ontologie de Domaine et un Modèle de Raisonnement à Partir de Cas », in MCSEAI, April 28-30, 2008 – Oran, Algeria.

[3] Bachimont, B. «Engagement sémantique et engagement ontologique, » in Ingénierie des connaissances, évolutions récentes et nouveaux défis. (Eds) Paris: Eyrolles, pp 305-323,2000.

[4] Charlet, J. «L'ingénierie des connaissances, entre science de l'information et science de gestion ». Rapport de recherche SIC 805, http://archivesic.ccsd.cnrs.fr,2004.

[5] Chatain, J–N. « Diagnostic par système expert ». édition Hermes 234 p,1993.

[6] Ermine J-L. « Enjeux et démarches de gestion des connaissances ». Net\_Actes 2000.

[7] Grundstein M. « Vers un modèle global de knowledge management pour l'entreprise (MGKME) », Rapport de recherche RR 11, MGconseil . 19p,2005.

[8] Mille A.. « Raisonner à partir de l'expérience tracée (RàPET)- Définition, illustration et résonances avec le storytelling ». Dans Le livre storytelling : Concepts, outils, et applications, Eddie soulier, Ed hermès, lavoisier,2006.

[9] Meherwan P.Boyce, "Gas turbine engineering handbook", 3<sup>rd</sup> edition gulf professional publishing, Elseiver 2006, 955p.

[10] Olsson E., Funk P., Xiong N. "Fault diagnosis in industry using sensor reading and case based reasoning," in journal of intelligent & fuzzy systems 15 (2004), pp41-46

[11] Palade v., Danut Bocaniala C and Lakhmi J., "Computational Intelligence in Fault Diagnosis". Springer edition , 2006, 373 p

[12] Sankar, k.P, Simon C.K.S, "Foundations of soft case-based reasoning," Wiley Interscience publication, 2004, 299p.

[13] Tiwana, "A. Knowledge management toolkit", Springer edition, 1999, 610 p.

[14] http://fr.wikipedia.org/wiki/Turbine\_%C3%A0\_gaz

[15] <u>http://protege.stanford.edu</u>

Copyright © 2009 by the International Business Information Management Association (IBIMA). All rights reserved. Authors retain copyright for their manuscripts and provide this journal with a publication permission agreement as a part of IBIMA copyright agreement. IBIMA may not necessarily agree with the content of the manuscript. The content and proofreading of this manuscript as well as any errors are the sole responsibility of its author(s). No part or all of this work should be copied or reproduced in digital, hard, or any other format for commercial use without written permission. To purchase reprints of this article please e-mail: admin@ibima.org.