An Implementation Tool for the Expertise Model using CommonKADS Methodology

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***Abstract*— Our work is a part of the manufacturing monitoring systems, using the model of knowledge creation for the realization of industrial diagnosis dependability aspects. Knowledge capital has an important role in organizations, particularly in the industrial sector based on knowledge. The aim of this work consists in outsourcing tacit knowledge into explicit knowledge at the thermal power plant of Jijel city in Algeria. For our analysis, we used the methodology ''CommonKADS'' of knowledge acquisition, which is standard for the development of knowledge-based systems in Europe; but, the weak points are (i) the lack of an implementation tool for this method, (ii) weak modeling language CML (Conceptual Modeling Language), because it is a semi-formal language, and (iii) lack of inference (the role of knowledge-based). Therefore, we proposed the expert system generator G2 as a computerized model of expertise for this methodology; it is a highly efficient development assistant of knowledge-based systems. This comes from the fact that it contains a natural and formal language. It is structured and allows the definition of all the elements of the methodology CommonKADS, it offers possibilities more than an inference engine. The studied thermal power plant is using an online monitoring system; it makes the detection of signs that show abnormalities using alarms. We have proposed a knowledge-based system that follows the detection to diagnose in real-time the process that ensures good continuity of production and availability of inputs, and results in quality of monitoring equipment and rapid diagnosis. Saved expertise should allow a better fit of interventions. Our contribution is in the conduct and support the diagnosis of a production system. The proposal is a tool for implementing CommonKADS, based on improvement of its weaknesses.**

Keywords-knowledge acquisition; CommonKADS; industrial diagnostic model of expertise; language CML; G2; knowledge-based system.

I. INTRODUCTION

The knowledge management is an important need, whether a company is conscious or not. It should allow locating and making visible the tacit knowledge of experts, to be able to keep, access and update, and disseminate best use of knowledge. Engineering knowledge is not simply a means of extracting expert knowledge, but it includes methods and techniques of knowledge acquisition, modeling, representation and use [1]. We chose the CommonKADS methodology [2] because it provides a framework for modeling the knowledge level. The issue is that there is a conflict between former expert without a degree and new graduate recruited employee in our companies in Algeria. Experts resolve problems rapidly using their know-how acquired over the years of accumulated experience and, the graduate employees aren't reactive and make the time to explore guides, plans, etc. The latter cannot take advantage of experts because they do not have the same background. To break these barriers, the company should externalize the tacit knowledge hidden in the minds of experts; this is the aim of our work. In the next sections, a short review of methods of knowledge management systems shows the differences between them, then, a description of CommonKADS method and its weaknesses are presented, jointly with proposals. The ameliorated CommonKADS is applied to thermal power plant to give best results of externalization of tacit knowledge.

II. METHODS OF DEVELOPMENT OF KNOWLEDGE SYSTEMS

The pioneer in the methods of knowledge capitalization is SKANDIA [13], introduced by the Swedish insurance company SKANDIA. Its strategy is to focus on human resources and their capacity to innovate and bring wealth to a business. CYGMA is a method dedicated to profession memory, in the framework of a design task, while REX and MKSM are methods which do not focus on a kind of corporate memory and do not restrict to a kind of task [12]. REX relies on the building of pieces of experience, stemming from several kinds of sources (human, documents, databases); such pieces can be retrieved in answer to natural language request. MKSM [12] takes inspiration form the complex system theory for offering a theoretical analysis of organization knowledge, considered as a complex system. The modeling phases proposed by MKSM are close to CommonKADS notions. All three methods were applied to several industrial applications. Criteria for comparing them more precisely could be: (i) the complexity level of the method application, (ii) the kind of corporate memory it enables to build, (iii) the kind of task it restricts to, (iv) the number and features of effective applications built with them, and (v) evaluation of such applications by their end-users.

III. THE METHOD COMMONKADS

This methodology is one of the results of the ESPRIT projects KADS-I and KADS-II [12]. It relies on the premise that knowledge sharing is based on the communication of knowledge and recreation. Therefore, knowledge management means sharing knowledge among multiple

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individuals. The primary objective of the method is to assist in the knowledge modeling of an expert or group of experts in order to make a decision support knowledge-based system. CommonKADS uses more of the three categories listed above, six models to analyze the knowledge: organization, task, agent, communication, knowledge and design.

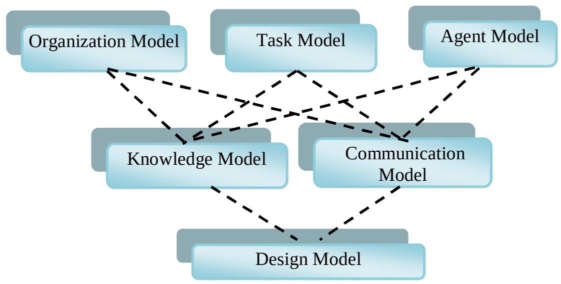

Figure 1. CommonKADS models.

- Organization model: It supports the analysis of major features of an organization, in order to discover problems and opportunities for knowledge systems.
- Task model: It analyzes the global task layout, its inputs and outputs, preconditions and performance criteria, as well as needed resources and competences.
- Agent model: Agents are executors of tasks. An agent can be human, an information system, etc.
- Communication model: It models communicative transaction between the agents involved in a task.
- Knowledge model: Its purpose is to explain in details the types and structures of the knowledge used in performing a task.
- Design model: The CommonKADS models together constitute the knowledge system.

There are several works using CommonKADs method; Recordel [9] found that CommonKADS provides a good starting point for modeling multi-agent systems as they are made to create knowledge-based systems. Therefore, extensions for CommonKADS [9] have been proposed for modeling multi-agent systems, as CoMoMAS and MAS-CommonKADS. The combination of CommonKADS with System Dynamics [10] provide effectiveness in fostering learning and transferring knowledge since such combination, integrates all important elements of an organisation's strategy and operations. CommonKADS was used by Zhang [11] to develop a learner model to give a user advice based on his knowledge to help the teacher and the learner in their tasks. In the next sections, we will illustrate the use of CommonKADS to save expertise of experts to share and to reuse it, to minimize professional mistakes, knowing dangers and risks in thermal power, and to mitigate or even better inhibit conflicts between experts and new graduate employees.

IV. APPLICATION OF COMMONKADS TO AN ALGERIAN THERMAL POWER PLANT

We applied CommonKADS to an Algerian thermal power plant. Organizational models, tasks, agents are shown in successsive sections. An extract of data sheme is presented in the class diagram in UML language [12] (Fig. 2). The principle of monitoring and diagnosis is illustrated in the diagram activity in UML language (Fig. 3).

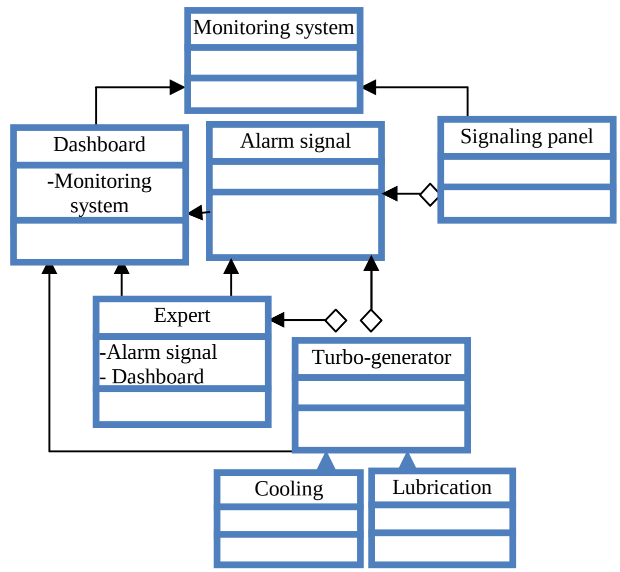

Figure 2. Class diagram of monitoring system.

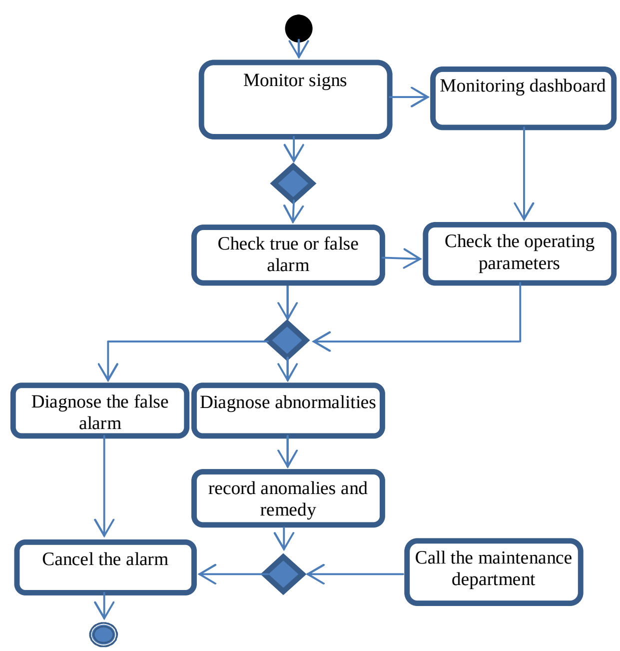

Figure 3. Activity diagram quarter production service of thermal power.

A. Organizational model

Identifying problems in the organization and solution-oriented knowledge opportunities are the first steps. During the next decade, the working age population will begin to decline when experts retire. Exporting know-how (tacit knowledge) is critical to the future of a company expertise.

TABLE I. KNOWLEDGE PROBLEMS AND THEIR PROPOSED SOLUTIONS

Problems and opportunities	✓ Lack of coordination between the division operation and maintenance division ✓ Lack of knowledge sharing between managers of company (experts) and new operating engineers. ✓ Response time in case of abnormality is very slow, which causes downtimes.
Organizational context	Mission ✓ Produces electric power of 630 MW. ✓ Ensures good continuity of production and the availability of means of production. ✓ Monitor the economic parameters and improve equipment performance. ✓ Training employees under the responsibility of the expert
Solutions	Externalization of tacit knowledge into explicit knowledge through direct interviews with experts in order to build a knowledge-based system, based on experience to ensure the transition to generations of younger workers.

B. The knowledge model

The knowledge model proposed in the CommonKADS methodology allows specifying the types, structures and roles of knowledge. This model contains three kinds of knowledge, namely, knowledge of the domain, inference, and task.

a) The knowledge domain

The S-lubrication concept has attributes which can take values. For each attribute, we define a type-of-value (value-type), such as the type-sealing system. It is a symbolic variable and takes two values (sealed or unsealed) (Fig. 4).

```
CML2 CONCEPT S-lubrication;
Description
"Lubrication system to power the turbine bearings and alternator''
ATTRIBUTES:
D-Huil: real;
T-Huil: real;
Pr-Huil: real;
Res-huil: real;
Pr-Eau-ref: real;
Fuit: symbol;
State operation: symbol;
Sealing system: symbol;
END CONCEPT S-lubrication;
```

Figure 4. The concept S-lubrication in CML2 language.

```
CML2    value-type ::= sealing-system;

        Type: VARIABLE;
        value-List: {sealed, unsealed}
        End value-type [sealing-system];
```

Figure 5. Value-sealing-system in CML2 language.

```
CML2    BINARY-RELATION group-turbo-altrnat-alarm-signal;
        DESCRIPTION:
        "The relationship between lubrication system and alarm
        signals";
        ARGUMENT-1: groupe-turbo-alternat;
        CARDINALITY; 1;
        ARGUMENT-2: Alarm signals;
        CARDINALITY; 1..*;
        END BINARY-RELATION conduccion-maquinaria;
```

Figure 6. The relationship between group-turbine generator and alarm signals in CML2 language.

b) The task knowledge

The second step in building the knowledge model is knowledge of the task; therefore, the task identification is very important. The task will support the knowledge-based system of the diagnosis failure. The knowledge model of the task has to define the task and the method to achieve it.

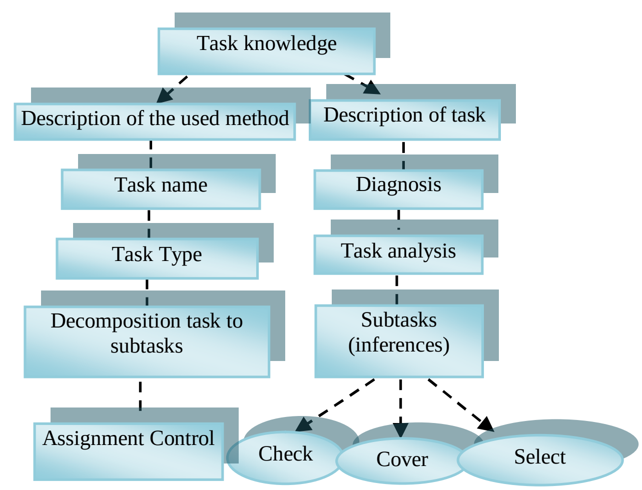

Figure 7. Knowledge model of the task.

c) The knowledge inference

Knowledge inference in a knowledge model describes the inferences, which is the lowest level of a functional decomposition. The last step of building a knowledge model is a description of each inference. Figure 8 shows the inference structure for fault diagnosis task. Inferences proposed in this model of knowledge are: Check, Cover, Select.

CML2 INFERENCE :: = Check;
ROLES:
INPUT: Alarm message;
OUTPUT: true alarm, false alarm;
STATIC:
Rules to check the alarm;
SPECIFICATION: "The entrance is an alarm signal in the form of a message that indicates a fault in the system. The output is a message " true" or "false alarm". »
END INFERENCE Check;

Figure 8. Description of the selected inference in CML2 language.

CML2 INFERENCE:: = cover;
ROLES:
INPUT: Alarm message = true alarm;
OUTPUT: All probable causes defined by the expert;
STATIC:
Procedure to cover causes;
SPECIFICATION: "The entrance is an alarm condition with" true" alarm. The set of hypotheses output (the likely causes of failure)."
END INFERENCE Check;

Figure 9. Description of cover inference in CML2.

CML2 INFERENCE:: = selected;
ROLES:
INPUT: probable causes;
OUTPUT: the most probable cause;
STATIC:
Procedure to select the cause;
SPECIFICATION: "Admission is assumptions. The output is the cause of failure"
END INFERENCE selected;

Figure 10. Description of the selected inference in CML2 language.

V. AN IMPLEMENTATION TOOL FOR THE EXPERTISE MODELUSING THE COMMONKADS METHODOLOGY

A. CML2 language

CML2 (Conceptual Modeling Language) is a semi-formal language and specific model of knowledge used by CommonKADS method.

B. Presentation of G2

G2 is a generator of high performance expert systems development assistance; it is used to support many applications involving various techniques of artificial intelligence: Diagnosis, alarm filtering optimization control and supervision.

C. Specific language of G2

The natural language of G2 is a formal and structured language; a developer can express instructions with familiar terms and syntax, because G2 is close to English, which is a benefit for a developer. The natural language of G2 offers:

- An interactive text editor to edit instructions for rules, procedures.
- An interactive graphics editor with:
  - Icons objects
  - Curves, plans, tables, tools
  - Buttons, dialog boxes
  - Message, etc.

D. The domain knowledge

Knowledge of the domain contains a domain schema, which describes schematically the types of knowledge and information to build a knowledge-based system.

1) Domain schema

A schema of concepts, attributes, types of values, relationships between concepts, types of rules and relations between values is defined.

2) Comparative study between CML2 and G2

A comparison is elaborated, according to some criteria, between modeling language of CommonKADS which is CML2 and the language of the generator of expert systems G2, which we used for implementing our human expert system after externalization of tacit knowledge from experience of experts of the thermal power plant.

a) Concepts

The object-oriented concept is the basis of development in G2. The object can represent something physical like a pump, a valve or something abstract like an event, a task, a message, etc.

An object class defines the properties and behavior of objects (attributes icon, etc.). G2 contains several classes that can be defined and inherited by the classes defined by the user. G2 in any class that inherits from a class above should contain all the attributes of the parent class.

Figure 11 presents the notion of concept in the language CML2 of CommonKADS method and the specific language of G2:

CML2
concept = Concept degasser;
super-type-of: Centrale
[**disjoint**: **yes** | **no** ;]
[**complete**: **yes** | **no** ;]
[**sub-type-of**: Concept , ... ;]
[**has-parts**: has-part+]
[**part-of**: Concept , ... ;]
[**viewpoints**: viewpoint+]
[attributes]
[axioms]
end concept [Concept ;] .

G2 Notes	ok
Authors	Pks (July 6th 2011 12:41 p.m.)
Item configuration	none
Class name	degasser
Direct superior classes	power plant
Instance configuration	none
Change	none
Menu option	A final menu choice
Class inheritance path	none
Inherited attributes	none
Attribute initializations	none
Attributs display	inherited
stubs	inherited
Icon description	inherited

Figure 11. Presentation of the concept of language and language-specific CML2 and G2.

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b) *Attributes of concepts*

The attributes are the characteristics of an object. Each execution of an application under G2 is based on the behavior of objects and defined object classes.

CML2
CONCEPT degasser;
ATTRIBUTES:
Pr-deg:real;
T-deg:real;
N-deg:real;
T-deg:real;
END CONCEPT degasser;

G2
Pr-deg is given by a pression, initially is given by a pression;
T-deg is given by a temperature, initially is given by a temperature;

Figure 12. The attributes CML2 and G2.

c) *The type of values*

In G2, types of current values of attributes are more interesting than in CML2, and easier to be handled.

These values are recorded directly in the table object.

CML2
value-type::=**value-type** *Value-type*;
[terminology]
[**type**: **nominal** | **ordinal** ;]
< **Value-list**: { *Value* , ... } >
| < **value-specification**:
primitive-type | "Text" > :

G2
E1, E2: symbol;
t-deg, p-deg, n-deg:
quantity;

Figure 13. The types of values CML2 and G2.

d) *Relations between concepts*

G2 has two ways to define relationships between objects: connections and relationships, connections are used to represent a physical connection between objects. Relations are only created at runtime and have not a graphical representation, and they have no attributes. They can be specified one by one, one to many, or many to many.

CML2
binary-relation::=**binary-relation** *Relation*;
[terminology]
[**sub-type-of**: *Relation* , ... ;]
[**inverse**: *Relation*;]
argument-1: argument
argument-2: argument
[relation-type]
[attributes]
[axioms]
end binary-relation [*Relation* ;].

G2 Notes	Ok
First class	Groupe-turbo-alter
Second class	Paneau-signalisation
Relation name	In-communication-with
Inverse of relation	none
Type of relation	One-to-many
Relation is	no

Figure 14. Types of relationship CML2 and G2.

E. *The inference knowledge*

G2 is an inference engine developing an object referring to the rules associated to this object, uses backward chaining to find values and forward chaining rules if a value is received.

CML2
Inference::=**inference** *Inference*;
[terminology]
[**operation-type**: *Name*;]
roles:
input: *Dynamic-knowledge-role*; **output**: *Dynamic-knowledge-role* , ... ;
[**static**: *Static-knowledge-role* , ...;]
[specification]
end inference [*Inference*;].

G2
If the temperature of deg…
When ….
Unconditionally…
Initially……….

Figure 15. Presentation inference CML2 and G2.

F. *Communication model*

The communication model allows conceptual independent modeling of interactions between different agents involved in a task. The agent could be an expert, operator or a system of monitoring. Figure 16 illustrates communication between different agents at quarter production service.

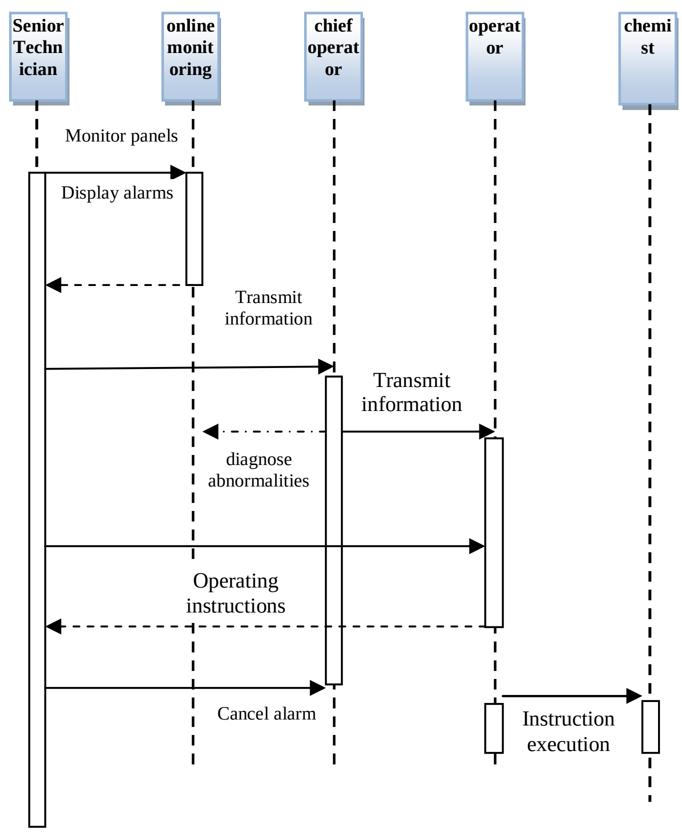

Figure 16. Communication model of agents.

VI. IMPLEMENTING KNOWLEDGE MODEL BY G2

A. The domain knowledge in G2

Domain objects are defined by icons. Each class object can have its own icon with, in this case the superclass is the central class, all elements inherit the characteristics of the superclass.

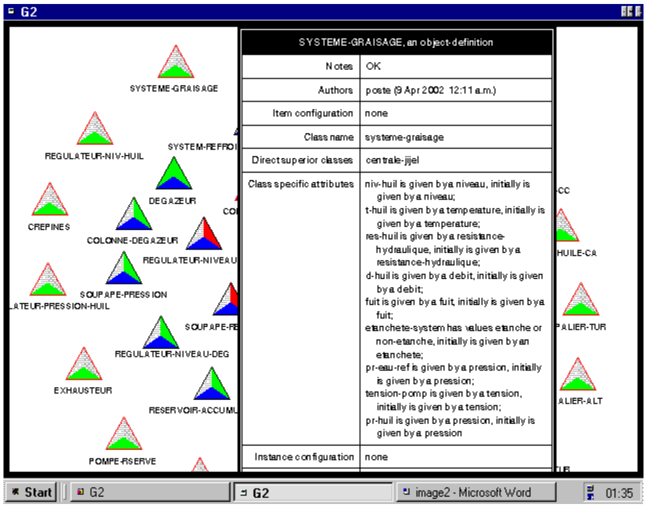

Figure 17. The attributes of the lubrication system in G2.

B. Variables

All objects of the same class have the same general structure, using the following variables. These variables are recorded directly in the object table, and can have a real-time representation.

Figure 18 refers to the alarm messages lubrication system.

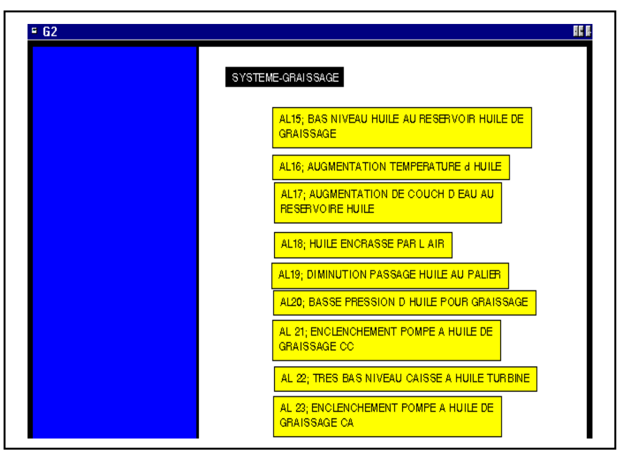

Figure 18. Variables used in the knowledge-based system in G2.

C. The rules used to check alarm

These rules for inference check if alarmis true or false.

D. The procedures

G2 contains a procedural programming language; it provides procedures to perform sequential actions. These procedures for inference identify probable causes and appear as a message.

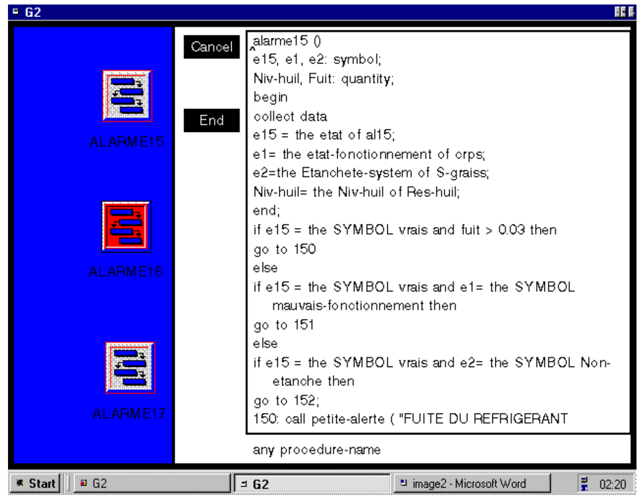

Figure 19. The procedures used for inference as identified in G2.

E. The results of the identified inference

The results of the inference are suggesting probable causes of a failure identified by the expert, as a message understood by the operating personnel.

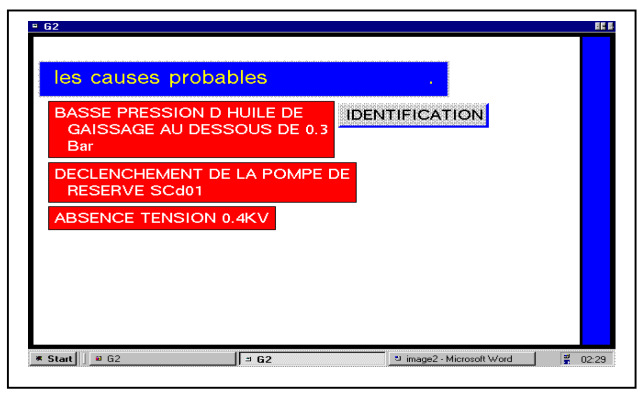

Figure 20. The output of the inference in G2.

VII. CONCLUSION

We developed a knowledge-based system under CommonKADS methodology for the application at the thermal power. The knowledge model specifies requirements knowledge/reasoning system knowledge base to implement. Then, we presented a tool that combines domain knowledge (concepts, attributes, relationships, values, variables) and knowledge inference (G2 contains an inference engine, rules, procedures, formulas, methods).

We found that CommonKADS is structured and offers a systematic development of based-knowledge systems, via many facilities in knowledge modeling. It is easy to understand its configuration, and ensures reusability. Otherwise, CommonKADS presents weaknesses, such as difficulties in the acquisition phase of knowledge, use of a semi-formal language CML2, which we replaced in our work with the natural language of the generator of expert systems G2.

We proposed to use the structured and natural language of G2 to define all the elements of the CommonKADS method for extracting better knowledge of an application, without using CML language which is a language with a semi-formal complexity in reasoning rules.

This broadens the scope of use of the method and builds a knowledge-based system more sophisticated.

We believe that this methodology will be used to keep formalization of the panel memory; achieving system diagnosis aid may be concretely useful to promote the sharing of knowledge between experts and all operating agents and manage the operational know-how of expert's field.

Our work emerges from several perspectives:

- The application of the methodology CommonKADS in real time.
- The generation of this method for all operating tasks and maintenance.
- The use of model expertise to optimize the process of preventive and predictive maintenance.
- Building a book of knowledge that provides a complete memory reproducing the know-how and skills of experts is useful for a company. Our solutions could be used by other manufacturing systems; cement and cylinder manufacturing, etc.

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