A COOPERATIVE APPROACH TO CORPORATE MEMORY MODELING

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Abstract : Nowadays, the importance of Knowledge Management is growing in organizational contexts. Corporate Memory is an appropriate tool to represent organizational knowledge. This work presents an ontology-based approach to Corporate Memory modeling. In it, the members of an organization act as 'knowledge builders' and they construct the Corporate Memory co-operatively. Furthermore, the employees who take part of the Corporate Memory construction process are allowed to use their own terminology, even for requesting information about the Corporate Memory until a specific instant.

Keywords: Knowledge Management, Ontology, Corporate Memory, Mereology, Reusable Component.

1. INTRODUCTION

Nowadays, Knowledge Management (KM) is one of the key factors in organizations since the current trend is to evolve from employees to 'knowledge workers' ([6]; [18]). The fact is that organizations are realizing that knowledge increases the value of their products and services in addition to providing a competitive advantage. According to [24], the objectives of KM in an organization are to promote knowledge growth, knowledge communication and knowledge preservation in the organization. There are various types of significant knowledge for an organization. Thus, we should mention the identification of critical knowledge functions and the knowledge of who knows what in the organization as the most important factors. This knowledge must be kept in some way in the organization and that is why the concept of Corporate Memory (CM) arises.

The know-how knowledge is usually distributed inside an organization, so in order to facilitate its access and reuse it must be integrated coherently, that is, expressed as a CM. This has been considered as a key element for performing Knowledge Management because it facilitates knowledge conservation, distribution, and reuse.

In recent literature we can find many definitions for CM. The authors in [26] defines a CM as an "explicit, disembodied, persistent representation of knowledge and information in an organization" while [20] does it as "the collective data and knowledge resources of a company, including project experiences, problem solving expertise, etc". In [2] a CM is understood as "a

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container that integrates contextual information, documents and unstructured information, facilitating its use, sharing and reuse". Its main function would be to improve the organizations' competitiveness through the way their own knowledge is managed. Some authors consider the CM as a link mechanism between past and future knowledge in relation to the processes and activities that take place inside organizations. In particular [25] defines CM as "the means through which all the operative knowledge accumulated in the past is put in the present to be used in the activities performed in the organization".

In [8], the authors came up to the concept of Corporate Memory through the concept of activity in an enterprise. For these authors, a CM is comprised of a set of activities and an activity is defined as in [15]: "what people do, hour after hour, day after day: finally, employees achieve all these works because they know they can do them, they think they have to do them, all of this doings involving specific know-how as simple as they could be".

Regarding the activitities involved in KM as a process, according to [10] the following ones can be enumerated: i) identification and mapping of intellectual goods belonging to the organization, ii) generation of knew knowledge that will permit gaining a competitive advantage, iii) compilation of amounts of organizational information in an accesible way, and, iv) sharing best of practice and technology, including groupware techniques and the intranets.

In [23], the CM management is described as comprised of six processes: detection of needs, building, distribution, use, evaluation and evolution of the CM. Our work addresses four of these steps: knowledge construction, knowledge distribution, use of the knowledge and maintenance of the knowledge. Our approach to the problem has been carried out through a distributed perspective, that is, we have defined a system to manage Distributed Corporate Memories which facilitates knowledge sharing and collaboration between groups of people which can be at different geographic locations.

The technology used to represent the knowledge in our work has been the ontology, element that has been considered to be necessary to perform an appropriate Knowledge Management ([4];[22]). An ontology is commonly viewed as a specification of a domain knowledge conceptualization [27]. We can find domain ontologies (for example, a virus ontology in medicine) and enterprise ontologies (description of an enterprise model). Both of them can and must be included in a corporate memory. In our approach, each group of people generates an ontology concerning the previously mentioned significant (for the organization) knowledge of the group. This ontology represents a part of the organization, which must be shared with the rest of groups that belong to the same organization or to other collaborating organizations. To allow this knowledge sharing, we must proceed to integrate the knowledge from each ontology (one for each group). The cooperative building of knowledge pieces is an emergent topic and there are also different projects working on it such as KA^2 [3], Chimaera [17] or PROMPT [14].

The structure of this article is the following. Section 2 introduces some ground concepts of our approach, as well as how the system faces the steps of Corporate Memory and Knowledge Management. In Section 3, we explain the ontological model followed to represent the knowledge of each group of the organization. Section 4 describes the main characteristics of the system implemented. Section 5 presents a practical example of an application domain through which the system has been validated. Finally, we make some final conclusions in Section 6.

2. KNOWLEDGE MANAGEMENT AND CORPORATE MEMORIES

The main processes in KM can be described as in [10]: “identifying and mapping intellectual assets within the organization, generating new knowledge for competitive advantage within the organization, making vast amounts of corporate information accessible, sharing of best practices, and technology that enables all the above, including Groupware and intranets”. Therefore, it cannot be seen as a product but as a process which has to be implemented over a period of time. As it is pointed out in [4], this process has “as much to do with human relationships as it does with business practice and information technology”.

Distributed Knowledge Management Systems (DKMSs) are increasing their significance rapidly due to the growing importance of knowledge distribution. An example of a DKMS is a Corporate Memory (CM). A CM integrates contextual information, documents and unstructured information, facilitating its access, sharing and reuse. Its main function is to enhance the organization’s competitiveness by the way it manages its knowledge [1].

In this work, we assume that an organization is divided into different groups. Each group is comprised of people and a group can be characterized by its number of members. Groups can have one or more members, so that those can be described as non empty sets of persons. From a functional point of view, a group can be a department of the organization or a group of people in charge of some specific tasks or responsibilities in the organization because not all the organizations or enterprises are organized in the same manner. Therefore, our notion of group was conceived to be flexible enough to be applied to a variety of types of organization structure.

The concept of ‘group’ is not new in the context of Corporate Memories. It has already appeared in literature, for instance in [12], "a CM is a repository of knowledge and know-how of a set of individuals working in a particular firm”. Our concept of CM is not restricted to a unique organization but it is also applicable to a co-operative enterprise. For us, a co-operative enterprise can be seen as a collection of groups of people belonging to one or more organizations, so that those groups can and must work co-operatively.

Figure 1 shows our concept of co-operative organization as well as the division of the organization in the terms that this work has been focused on. In this particular case, there are two organizations divided into groups. Each organization is comprised of two groups and each one has a manager. Organization 1 and Organization 2 have made an agreement for collaborating in doing some project. Therefore, the co-operative organization is comprised of four working groups and the corporate memory for this organization must cover the knowledge generated by the four groups. The manager has only local significance and there must be a decision about who is going to be the manager of the organization. The graphic on the right side of Figure 1 represents the internal structure of a group in the organization. A group is defined as a set of employees and an administrator who manages the group.

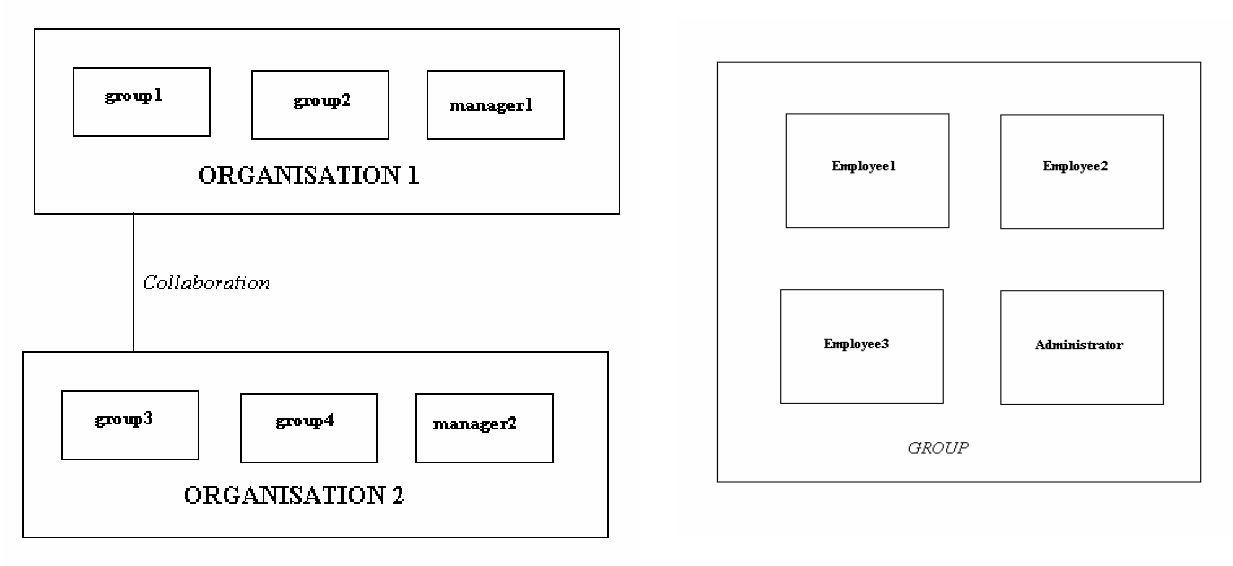

Figure 1. A co-operative organization

2.1 Corporate Memory Management

As we pointed out before in this paper, the management of a Corporate Memory is comprised of six main steps: detection of needs in the organization, construction of the CM, diffusion of the CM, use of the CM, and evaluation and evolution of the CM [9]. The first step is out of the scope of this work since it requires an exhaustive analysis of the organization in order to establish its needs and our approach tries to be generic and organization independent. The rest of steps have been dealt with in our work. In the following sub-sections, we present how our system performs the mentioned steps.

2.1.1 Construction

The Corporate Memory is built from the knowledge that exists in the organization. There is an agreement in the KM community about the nature of knowledge. According to [6], the knowledge has a double nature: explicit and tacit. Explicit knowledge is the knowledge that can be explained verbally or written down easily. On the other hand, tacit knowledge is the knowledge that cannot be made explicit due to different reasons, such as the impossibility of making certain knowledge available for others, (i.e., the incapacity of externalizing it in order to make it explicit).

We can find four different patterns for the creation of knowledge in an organization [21]:

- Socialization: Sharing tacit knowledge between individuals. The knowledge remains tacit without being transformed into explicit. This kind of pattern is not very interesting for the organization because of its tacit nature. (Tacit → Tacit)
- Articulation: Someone transforms tacit knowledge into explicit knowledge. (Tacit → Explicit)

- Synthesis: Combination of explicit knowledge to create new explicit knowledge. (Explicit → Explicit)
- Internalization: Process of transforming explicit knowledge into tacit knowledge. (Explicit → Tacit).

In our approach, we are only interested in knowledge expressed in an explicit manner, because it is the unique type of knowledge that can be directly (i.e., without processing) shareable, accessible for and reusable by people within the same group or organization. The knowledge is created by the employees of the organization, who are members of one or more groups of the (co-operative) organization. All the knowledge is made explicit by some specialized applications integrated in our system, so becoming shareable and reusable in an easier way. Our choice for internally representing knowledge has been the ontology as we stated above and the ontological model followed to develop this system is described further in this paper. In summary, the knowledge is created by employees and put into the CM by the system through ontologies because of the good properties of ontologies for facilitating CM Management. These allow for knowledge sharing and reuse, in addition to the ontology characteristic of permitting a formal representation of knowledge. This ontology feature is another key factor when deciding which representation technology is the most appropriate for knowledge modeling.

To end with the creation of knowledge, we should mention the facilities to express knowledge offered by the system. The basic knowledge element is the concept, which can be a logical or physical entity in the organization. Examples of organization-relevant concepts are department, employee, process, etc. These concepts have attributes (i.e., properties) that make them different from other concepts, that is, a concept is partly characterized by its attributes, although it is also characterized by its relationships with other concepts of the corporate memory. In this work, two types of attributes are considered:

- Specific attributes: These are the attributes a concept has by its nature.
- Inherited attributes: These attributes are derived from relationships with other concepts.

Concerning the relationships a concept may have, we contemplate three types of inter-concept relationships:

- CLASS-OF: It means that a concept ‘is a class of’ another concept. For instance, an employee ‘is a class of’ person. This kind of relationship is useful to establish the hierarchies at different levels in the organization and it implies attribute inheritance. A concept is a classification of another concept attending to one or more attributes of the parent concept. This non-empty set of attributes of the parent concept by which the classification is made is called the ‘specialization’ that every CLASS-OF relationship induces.
- PART-OF: It means that a concept ‘is a part of’ another concept’. For instance, an employee ‘is a part of’ a department. Partonomies are useful to express structural divisions in the organization or in elements of the organization (departments, processes, etc).
- AFTER: It means that a concept ‘occurs after’ another concept. For instance, the process of evolution of knowledge ‘occurs after’ the process of evaluation of the knowledge. This kind of relationship is important in an organization to establish temporal links between processes. For example, if we are modeling the resolution process of a failure, there can be different tasks to perform in order to fix it. This process will involve a task execution order that may be established by using this kind of relationship.

2.1.2 Distribution

This aspect concerns the distribution of knowledge to the staff of the organization. In particular, the purpose is to know who is allowed to know what in the organization. If the distribution is made automatically this will occur as soon as new knowledge is available or after a request for knowledge actualization is made. However, the distribution process has two groups of elements that take part in it. The first group is comprised of the groups (or employees) who have new knowledge to introduce in the corporate memory, that is, people who can communicate some organization-relevant knowledge in some way to the rest of the organization. The system must capture this knowledge first in order to make it available for the rest of the community (the co-operative organization in this case). The second group is formed by the rest of the mentioned community, namely, people who must be interested in having access to the new knowledge available in the organization. Therefore, knowledge distribution can be regarded from two perspectives: knowledge collection versus new knowledge access.

Knowledge collection is a more critical factor for us, so it must be performed on a 'as Soon as possible' basis, that is, when the system detects or assumes the existence of new knowledge, it must be retrieved. Thus, when employees are generating knowledge for the organization and other employees want to check for the existing knowledge, the system must retrieve the new knowledge in order to provide the best possible knowledge to the employees who request for that knowledge. The discussion about knowledge collection can be moved to a different domain, namely, knowledge distribution, which is concerning with how and when employees have access to the knowledge. An employee will be able to receive the new knowledge included in the corporate memory of the organization by requesting for it. Therefore, this process can be seen as a passive knowledge distribution. The knowledge created by the employees of the organization is stored in a knowledge server and the system provides a web-based access to the corporate memory via Internet/Intranet.

2.1.3 Use

A corporate memory management system must provide a simple and comfortable use for the employees of the organization. In other words, the exploitation process of the system must be conceived to be friendly with the system users (i.e., the employees of a (co-operative) organization). This implies to provide a well-documented system and friendly, intuitive user interfaces without forgetting that we are providing a web-based access to the knowledge. Another aim of our work was to display the information graphically. The exploitation of our system is briefly explained in Section 4, where the system's modus operandi is illustrated through a practical example.

According to those requirements, the system has been designed to have a very flexible knowledge visualization, allowing the users to see what they want at each instant. To be more precise, the following visualization options are facilitated by the system:

- Complete corporate memory: This option shows the hierarchy defined by the corporate memory at a specific instant.
- Concept exploration: This option allows the user to visualize a specific concept, in terms of attributes and relationships with other concepts belonging to the corporate memory.
- Expanding taxonomic hierarchies: This option visualizes the existing taxonomies with respect to a specific set of attributes of a concept.

2.1.4 Maintenance

We can bring the processes of evaluation and evolution of the corporate memory together into the process of maintenance of the CM, although we can discuss about them independently. The evaluation of the CM means to make an estimation about the usefulness of the CM for the organization from different points of view. The objective of this process is to assess the improvements originated by the introduction of the CM in the organization. The evaluation of the CM is out of the scope of this work because this process is organization-dependent. However, we think that the exchange of know-how within the organization will be always a benefit for it.

Concerning the evolution of the corporate memory, [10] stated that it depends on the results of the evaluation process. This is obvious because if the organization estimates that the corporate memory is useless for its purpose, there will be no need for maintaining the CM working. Maintaining a CM implies to add new knowledge when it is generated, to remove obsolete knowledge from the CM and to solve coherence and consistency problems which are intrinsic problems of co-operative work. The removal of obsolete knowledge can be made by the system manager, who can and must decide when some knowledge has become obsolete. Another possibility is that the obsolete knowledge is replaced by new knowledge belonging to the same user or group.

The addition of new knowledge to the system has been explained in the sub-section about knowledge creation, but we do not have explained what happens when the new knowledge is inconsistent with other existing knowledge in the corporate memory. The system we present here has a user-oriented philosophy for managing the knowledge a specific user is going to receive. That is, our knowledge integration approach makes it available to the user the integration of the knowledge kept in the system that is consistent with his/her own knowledge.

3.THE ONTOLOGICAL BASIS OF THE SYSTEM

In this work, an ontology is seen as a specification of a domain knowledge conceptualization. Ontologies are represented here by means of *multiple hierarchical restricted domains* (MHRD) in a similar sense of that employed by other authors (see, for instance, [11]). The notion of **Partial, Hierarchical, Multiple and Restricted Domain** (PHMRD) [16] has been utilized for this work. A PHMRD can be specified as a set of concepts which are defined through a set of attributes. In PMHRD's, we contemplate three types of permitted relationships among whatever two concepts: taxonomic (allowing for multiple inheritance), mereological and temporal ones. Taxonomic relationships are assumed to hold all the irreflexive, the antisymmetric and the transitive properties, while mereological relationships are assumed to hold all of them except for the transitive one [5].

Regarding temporal concept relationships, these hold the same properties as taxonomic relationships. In order to implement this type of relationships, the FTCN model, as employed in [7], has been used. This model has been introduced to formalize the computational representation of general situations in which an arbitrary number of events are specified. A FTCN is a couple $<X,L>$, where $X= \{X_0, X_1, ..., X_n\}$ is a finite set of variables and $L= \{L_{ij} \mid i, j \leq n\}$ represents a finite set of binary fuzzy constraints. The variable X_0 represents a precise origin, in our case, when the time is supposed to start (i.e. when the first process of the temporal chain starts). Therefore, each constraint L_{0i} defines the absolute value of X_i. By translating this into the organization domain, if X_i stands for the occurrence of a specific process, L_{0i} will define the fuzzy time at which the process starts.

In this work, we have made use of possibility distributions for the FCTN model. In particular, the trapezoidal one has been employed, because of its good properties for our goal. We can characterize a trapezoidal distribution by four parameters: $\pi_j = (\alpha, \beta, \gamma, \delta)$:

- Base of the distribution: Set of values $t \in \tau$ such that $\pi_j(t) > 0$. It gives all the possible values.
- Kernel of the distribution: Set of values $t \in \tau$ *such that* $\pi_j(t) = 1$. It gives the completely possible values.

The left hand side of Figure 2 shows a generic trapezoidal distribution, while the right part of it shows the fuzzy number associated to an event whose occurrence time is "approximately at 8:00". Arithmetic operations on this distribution are reduced to apply them to the base and kernel, as follows:

$$1.\,Addition\colon (\alpha_1,\beta_1,\gamma_1,\delta_1)\oplus(\alpha_2,\beta_2,\gamma_2,\delta_2)=(\alpha_1+\alpha_2,\beta_1+\beta_2,\gamma_1+\gamma_2,\delta_1+\delta_2)$$

$$2.\,Intersection(\alpha_1,\beta_1,\gamma_1,\delta_1)\cap(\alpha_2,\beta_2,\gamma_2,\delta_2)=(max\{\alpha_1,\alpha_2\},max\{\beta_1,\beta_2\},min\{\gamma_1,\gamma_2\},min\{\delta_1,\delta_2\})$$

Once we have introduced the complete network, the next task it to minimize it in order to find the minimal network that meets the original constraints. This will help us to calculate the estimated occurrence time of each process, which will be its absolute value from X_0, L_{0i}, as we stated previously. The algorithm that we have used detects inconsistency in the network and produces a minimal network as well. The body of such an algorithm is the following:

```
begin
  for k := 0 to n do
    for  i := 0 to n do
      for j:= 0 to n do
        Lij:=Lij∩(Lik⊕Lkj);
        if Lij = π∅ then exit "inconsistency"
end
```

We assume that the system is supplied with ontologies without inconsistencies in order to avoid the evaluation of them once they have been built. For it, and given that each ontology can be built in a particular way, users in charge of dealing directly with the (ontological) internal knowledge representation in our approach (i.e., employees of the KM department) must introduce their own ontologies by using a specific format for the ontology file. In this work, we refer to users as people belonging to the organization that are using the KM system presented here. The specification of this pseudo-language can be resumed as follows. It is comprised of the concepts which are part of the ontology. Each concept is defined through its attributes, its name and its parent concepts, either mereological, taxonomic or temporal ones. The successfully parsing of the ontologies defined according to this model is granted to be consistent.

Concerning the characteristics of the integration process, inconsistencies between (a part of) the knowledge corresponding to a group's ontology at a given instant (we refer to this ontology from now as $O_i(t)$) and the knowledge of the ontology obtained by the integration process until that instant (we refer to this ontology from now as $O_{int}(t)$) could appear. In this case, the knowledge from $O_i(t)$ would be assumed as the valid one, because we have considered the fact that $O_{int}(t)$ might have been checked by the owner group during the construction of their own ontology.

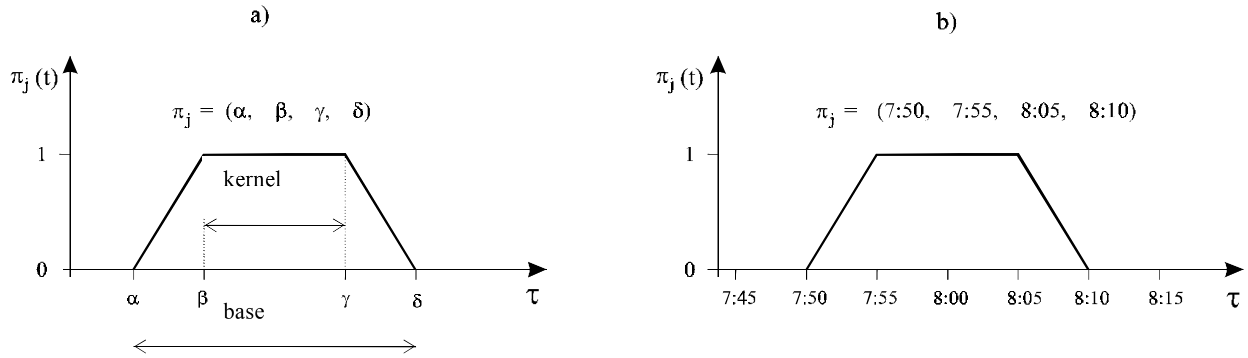

Figure 2. An example of trapezoidal distribution

The author in [16] states that the reuse of ontologies has important advantages in Knowledge-based Systems research. We agree with that statement because it is easier to generate knowledge from different source ontologies (belonging to the groups) than generating it from scratch (i.e., starting from having no information at all).

As we mentioned previously in this article, the aim of this work was the design and implementation of a tool for building distributed corporate memories from the knowledge supplied by a set of groups of people. In order to achieve this goal, the system must be able to solve some possible consistency conflicts between the candidate ontologies to be integrated until a specific instant. In particular, each time that a group adds or modifies knowledge to its private ontology, such knowledge will have to be incorporated into $O_{int}(t)$. It is also remarkable that more than one group might decide to send its knowledge contribution to $O_{int}(t)$ at the same time. This made it necessary that the system was able to distinguish amongst pieces of knowledge belonging to different groups. In this sense, a group-oriented integration principle has been followed, which basically states that 'the knowledge in $O_{int}(t)$ at a specific instant will have to be consistent with that included in every private group ontology ($O_i(t)$) for every previous instant'.

In order to obtain the integration of the knowledge specified in groups' ontologies (i.e., the ontologies that belong to groups who are members of the same co-operative organization), the following algorithms have been followed [13]:

Ontological_Integration

Let $O_i(t)$ be the i-th ontology that is intended to be incorporated into $O_{int}(t)$; n = number of ontologies to integrate.

i = 1

While i ≤ n do

If inconsistent($O_i(t)$,$O_{int}(t)$) or compatible($O_i(t)$,$O_{int}(t)$) or there is a previous version of $O_i(t)$ in $O_{int}(t)$) then erase the inconsistent or compatible ontology with $O_i(t)$, as well as the previous version of $O_i(t)$ (if there were any)

End-if

Ontological_Inclusion($O_i(t)$,$O_{int}(t)$) (this algorithm is defined below).

End-while

where

inconsistent(x,y) is true if and only if there are at least 2 concepts, written C1 and C2, one belonging to $O_i(t)$ and the other to $O_{int}(t)$, such that one of the following conditions holds:

(i) They both have the same name, the concepts do not have any attribute in common and their respective parent/children concepts (if there were any) have the same attributes.

(ii) They both have the same attributes, there is no other concept, which is parent of one of them, with the same attributes than the attributes of any parent of the other concept. The same property holds for the children.

(iii) Temporally_inconsistent_concepts(C1, C2).

compatible(x,y) is true if and only if (not(inconsistent(x,y) and equivalent(x,y)));

equivalent(x,y) is true if and only if for each concept belonging to x(y), there exists another from y(x) such that both of them have the same attributes and parent/children concepts and they are not temporally inconsistent concepts.

Temporally_inconsistent_concepts(c(t),c'(t)) is true if there is a concept c''(t) which belongs to the same ontology as c(t), whose name is the same as the name of c'(t) and there is a concept c'''(t) which belongs to the same ontology as c'(t), whose name is the same as the name of c(t) such that one of the following conditions holds:

a) c(t) is a temporal parent concept of c''(t) and c'''(t) is a temporal parent concept of c'(t)
b) c(t) is a temporal child concept of c''(t) and c'''(t) is a temporal child concept of c'(t)

Ontological_Inclusion

Let $O_j(t)$ be the j-th ontology that is intended to be incorporated into $O_{int}(t)$; m = number of mereological children of $O_{int}(t)$; *topic* is the topic which the final user requests information about; $O_i(t)$ is the ontology whose root is to*pic-according to-group i* in $O_{int}(t)$.

For i = 1 to m do

If compatible($O_i(t)$,$O_j(t)$) or inconsistent($O_i(t)$,$O_j(t)$) then delete $O_i(t)$ from $O_{int}(t)$

End-for

Add Oj(t) to $O_{int}(t)$ as a mereological child concept, so that its root is *topic-according to-group j*

4.GENERAL DESCRIPTION OF THE SYSTEM

The aim of the designed and implemented application was to develop a system and framework for managing a corporate memory that allowed an organization to take advantage of the knowledge supplied by the (internal or collaborating) groups belonging to the organization. The starting point of the system is a set of organization groups working in an intranet/internet and generating knowledge co-operatively but independently one group from another. In other words, this co-operation is totally transparent for each group because they do not know whether their knowledge is shared with other groups' one. A group is never allowed to see the knowledge created by another group directly nor modify other groups' work, but each group receives the global benefits from all the groups' (knowledge) contributions represented by ontologies. The system differentiates among two types of users, namely:

- *Group*: This is an organization working division unit, that is, a collective of people who generates knowledge for the system in such a way that other groups are able to look it up. Any group combine its own contribution with that of other groups of the same (co-operative) organization.

- *Manager*: This is the figure in charge of keeping the system working correctly. Another responsibility left to the manager is the management of groups as well as the knowledge to be maintained in the system.

A similar approach could be used for groups management. We could see each group as an organization, and we could split each group into two or more different types of users. We propose the following types of users in a specific group:

- *Employee*: This is a system worker, that is, a person who generates knowledge for the group(s) (s)he belongs to in such a way that other employees are able to look it up. Any employee may combine his/her own contribution with that of other employees from his/her same groups.
- *Administrator*: This is the figure in charge of managing the employees and the knowledge concerning a specific group.

4.1 Architecture and implementation of the system

The solution we have adopted is to use a client/server architecture, where a group corresponds to a client and the corporate memory is kept in the server. Therefore, the software developed has two different parts, one for the client and another for the server. Knowledge integration is produced when an employee or group applies for it. It may happen that at that specific moment there exist some employees working on the generation of new knowledge they consider interesting for the organization such as new best practices or new versions of previous existing knowledge, so the knowledge of the corporate memory could have become obsolete. This represented a design problem we had to face, because there were two possibilities to choose: integrating the known system's knowledge until the moment the request is made, or actualizing the system's knowledge. We have decided to adopt in our prototype the second one because one of our goals was to maximize the quality of the information our users receive from the system.

However, this solution implies to keep track of the active users. Each time that an employee wants to have a look at the state of the corporate memory, the system checks a user register in order to know if its knowledge needs to be actualized. In case there is any possible new knowledge, it must be retrieved to increase the quality of the corporate memory. We needed to add new elements to our first architecture, so becoming more complex. Finally, the process of knowledge integration is briefly described as follows: Checking whether the knowledge in the corporate memory is up to date. If it is not, actualize it. Finally, supply the employee with the requested knowledge.

An employee can actualize the corporate memory, either because (s)he wishes to do it (by using the "Actualize corporate memory" option) or by an automatic actualization operation due to another employee's request. Once the knowledge has been integrated, the following step is to personalize the information. At this stage, the user has the chance for redefining the terminology that is assigned to the concepts belonging to the derived ontology. Then, the user will have better information about the topic than the one (s)he previously had when the request was made. Therefore, (s)he will be able to decide the terminology more accurately. Users are offered the possibility of changing the name that has been given to a concept by the process. The new name could be the one assigned by another user, who must have taken part in the integration process, or a different one that the user thinks to be more appropriate.

Attending to the properties and requisites that we have established in previous sections, a tool has been implemented in JAVA. Besides the client/server application, there is a web version that allows users to see the state of the corporate memory at a given instant.

5.A PRACTICAL EXAMPLE

The example we present in this section is based on an ontology built by last (fifth) year students at our university. The purpose was to build a co-operative enterprise and design a corporate memory model for it. We are not going to display the whole ontology but we are going to constraint our presentation to a general overview of the model, going (at first levels), in depth in the technical support area of the enterprise. The domain subject to study in this work was the film projectors industry. For it, several interviews with some domain experts were carried out before coming up with the model whose first levels are shown in Figure 3. This model has been got after integrating the (partial) models through the system we present in this paper. The complete model will be accessible at our group web page in the next months.

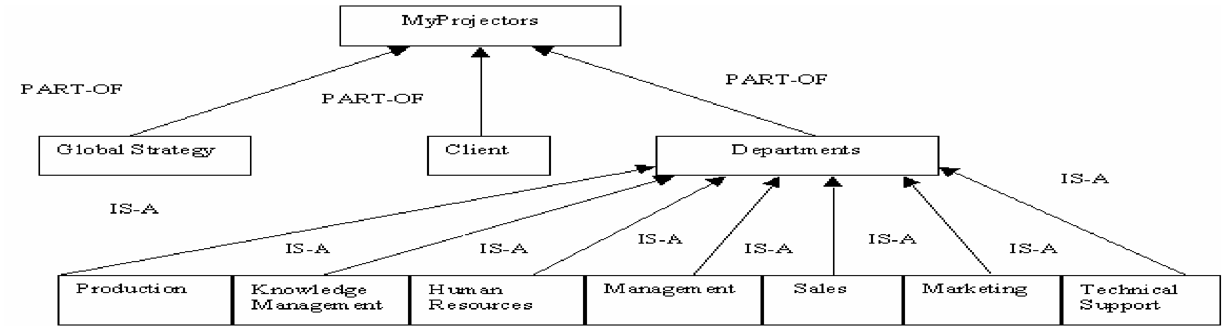

Figure 3. MyProjectors ontology

Figure 4 shows the part of the company that we have centered our efforts on, namely, the technical support department. We can see the knowledge schema about this department is divided into four parts: technical staff; the strategy of the department to face their working situations such as behavioral rules, working guidelines, etc; knowledge about the type of failures a projector can suffer from (diagnosis, treatments and best practices which help the technical staff to perform their job in a more efficient way); and suggestions about the company or the department.

In Figure 4, we can see the three different relationships between concepts: the knowledge about technical staff 'is a part of' the knowledge about the technical support department; the knowledge about adjustments 'is a class of' the knowledge about treatments of failures; the replacement of a bulb 'occurs after' a failure in the bulb has been diagnosed. The delay between the detection of the failure and the replacement of the bulb is represented as a fuzzy number, according to the temporal ontology representation described in Section 3. For example, the bulb is replaced between 5 and 10 minutes after the bulb failure has been diagnosed.

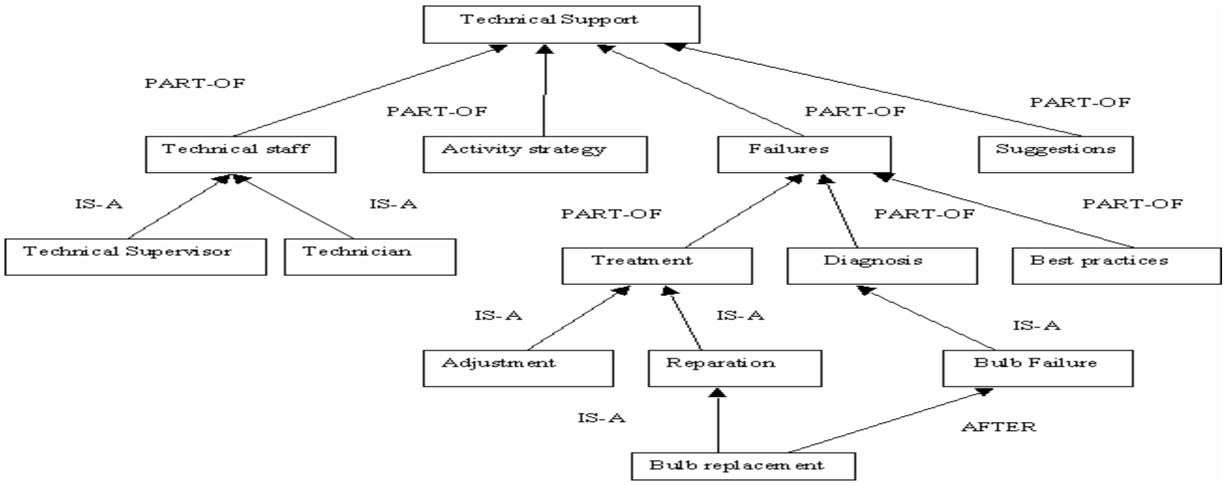

Figure 4. The technical support department

Finally, Figure 5 represents a screen snapshot of the system implemented. It is the part of the ontology that concerns the knowledge about the diagnosis process. We present here four possible families of reasons for project failure: sound, film, picture and bulb. We repeat that this model is not complete but only a brief introduction to what is feasible to do following our approach.

We can see the steps of corporate memory management in this example. We stated earlier in this section that we come up to this CM model after integrating different (partial) models. These (partial) models have been constructed by employees of the organization, in this case the students who simulated the (co-operative) organization. In this domain, employees are not supposed to know about ontologies or any other technology for representing knowledge. Therefore, the initial CM is constructed by the Knowledge Management department by using different techniques for extracting knowledge. A group can be seen as a department in this organization and the administrator of each group can be a member of the Knowledge Management department because they are in charge of introducing the knowledge into the CM when an employee makes a request for adding new knowledge to it. This is part of the distribution of the CM whose description is continued next.

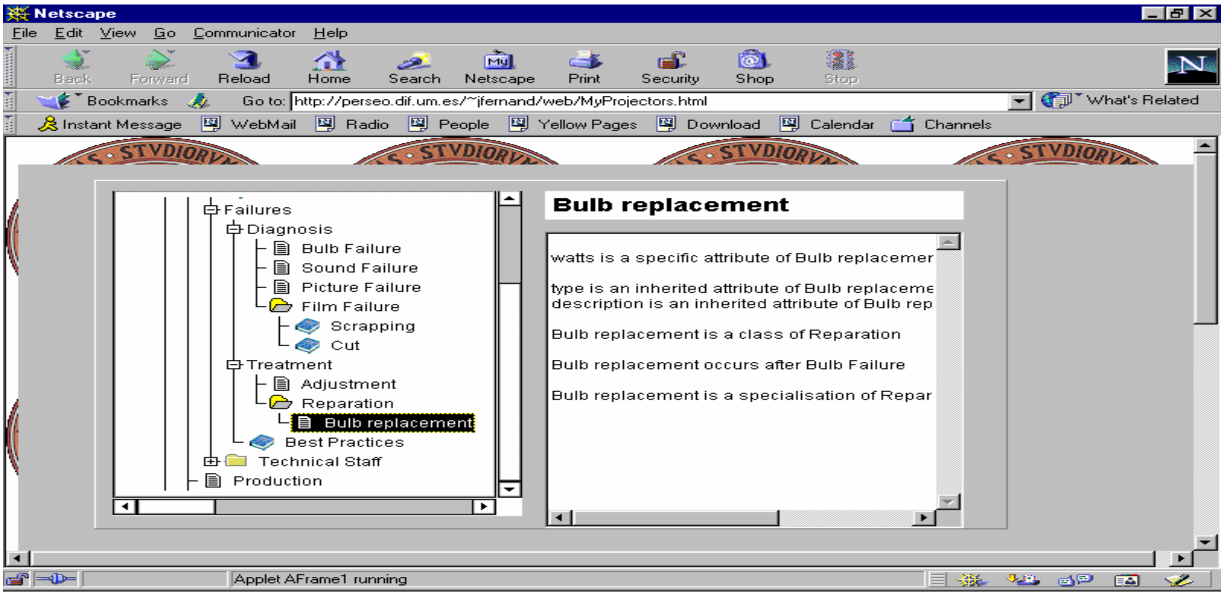

Figure 5. Using the tool for browsing the Corporate Memory

The model of the example represents a user request for checking the state of the CM. When this process is executed, the request goes to the administrator of his/her group, who is in charge of supplying the user with the best possible and accessible knowledge according to his/her preferences. Figure 5 shows the exploration of the concept 'Bulb replacement', and it represents a way of using the knowledge of the system for increasing the user's knowledge. The maintenance of the knowledge cannot be illustrated with this example because maintenance is a dynamic process while we are showing a snapshot of the system at a given instant.

6 Conclusions

Knowledge Management (KM) is an emergent topic in Artificial Intelligence and organizational environments. There is not any tool that provides a complete KM yet, but its current significance has encouraged the search for solutions capable of facilitating Knowledge Management. Thus, this work describes the design and implementation of a system through which employees of an organization can build, consult and maintain a Corporate Memory (CM) in a co-operative way. These (users) employees may be at different geographical locations (i.e. sites). The objective of a CM is to facilitate the sharing of the knowledge that exits within the organization in order to increase its productivity and competitiveness. The knowledge of employees is agreed to be the most important knowledge source for an organization but its main properties are its privacy and its tacit nature in most cases. The CM is an element that helps to make this knowledge public and explicit to other members of the organization. Our approach is similar to [27], where a CM is supposed to play two roles in the organization: passive (i.e., knowledge collector) and active (i.e., knowledge disseminator).

CM management implies to perform some key operations that have been detailed in this work. These include the construction of the CM from the knowledge which exists in the organization, its distribution to the staff of the organization, its use within the organizational frame, and the maintenance of the CM and the knowledge which is kept by the CM in order to ensure its correct temporal evolution. Some authors (see [26]) include information about external elements to the organization by splitting the CM into two: an external corporate memory and an internal one. Our approach is different since the way in which we construct the CM allows for the introduction of each piece of knowledge that is useful for the organization, independently of their (internal or external) origin.

Our approach covers the main processes in KM. The CM model represents an intellectual asset for the organization. In this approach, the generation of new knowledge is facilitated by the system, the corporate information is accessible and best practices can be shared by the members of the organization. Our CM model includes three different relationships (taxonomic, mereological and temporal), which allow employees to establish several kinds of relationships among the concepts they may be interested in. The definition of types of mechanisms for integrating knowledge facilitates one of the goals of a CM, namely, the reuse of knowledge to create new one in the context of organizations, so reducing the cost of obtaining it. This process is made through an adaptation of the terminology that is used for an employee's knowledge (formalized as an ontology) with respect to the global knowledge kept in the CM.

However, the selection of the most adequate terminology for the knowledge the user will receive depends on some parameters, particularly on two. The first one is the consistency of the knowledge that is intended to be introduced into the CM with the knowledge kept in the CM. The second parameter is the amount of knowledge which is contained in a specific piece of knowledge. An advantage of our approach is that the consistency of the knowledge of the CM is guaranteed due to the fact that each new (candidate) piece of knowledge to be included in the system is evaluated to check whether it is inconsistent with the current state of the system or not. In case there is any inconsistency between a new piece of knowledge of a user and his/her previous knowledge, the new piece of knowledge is considered to be the valid one and this one takes part of the integration process.

Collaborative knowledge building is not new. Thus, in [12], the authors have presented a system for collaborative construction of consensual knowledge bases. Such a system is based on the peer-reviewed journals: before introducing some piece of knowledge in a knowledge base, that piece must be submitted to and accepted by a given community. In order to achieve it, the definition of a protocol for submitting knowledge is provided. The consistency of the knowledge introduced into the CM is guaranteed by this principle and leads to the collaborative dialog among the experts. An important concern underlying this approach is that the community must use the same terminology. In our approach, a mechanism for synonym concepts management, that allows each agent to operate with its particular vocabulary, overcomes this problem. In order to solve the problem of synonym concepts, we use an approach close to that used by [28]. However, the way in which those conflicts are detected is different. In our approach, it is the system that is in charge of finding out which concepts are synonyms and which ones are not. This facility is not included in [28].

Finally, some remarks about future work should be made. We plan to extend the approach in order to contemplate more (real) situations that can exist in an organizational context. For example, the inclusion of new types of relationships, extending the ones available now (i.e., taxonomic, mereological and temporal) is interesting because it will contribute to make our system more realistic and adequate to organizational environments. More facilities concerning users' preferences is another desirable future feature of the system. Another suggestion about future work is the inclusion of multimedia contents, which could make it easier to employees the understanding of specific concepts that belong to a domain in which they have not much background knowledge.

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