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A COOPERATIVE MULTI-AGENT APPROACH FOR THE ANNOTATION OF ADAPTIVE CONTENT FOR E-LEARNING

Samir Bourekkache[1], Okba Kazar[1], Nabila Benharkat[2], Laid Kahloul[1]

[1]LINFI Laboratory, Computer Science Department, Biskra University, Biskra, Algeria
bourekkache_samir@yahoo.com, kazarokba@yahoo.fr, kahloul2006@yahoo.fr
[2]IRIS Laboratory, lyon university, France
Nabila.benharkat@insa-lyon.fr

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The creation of learning content is a main task in any E-learning environment. The constraints of minimizing the time required for developing a learning content and for increasing its scientific quality, have been a principal aim, in the last decade. Thus, several approaches and methods were proposed to reach this aim. Moreover, the intellectual and social characteristics, as well as the learning styles of individuals, can be very different. These differences lead persons to adapt the learning content by taking into account the learners profiles and their objectives. It is indispensable to annotate the learning content using additional information about the learner and

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the learning content. Therefore, we develop a cooperative system, where several authors work in a cooperative manner, to create and edit educational content using multi-agent system. The contribution of our system is the hybridization of adaptation techniques with those of cooperation and indexing (annotation) of the learning content to meet the diversity and individual needs of the learners.

1 Introduction

In recent years, researchers have exploited information and communication technology (ICT) as a mean to improve deeply our ways of communication and learning. This emerging technology reveals a new way of learning known as distance learning or E-Learning. In E-learning environments, the learning process becomes more sophisticated, faster and more efficient and minimizes problems, economy of transport costs and accommodation, always available, no specific schedule of learning, flexibility and interactivity... etc. The platforms of E-learning should provide a set of features to be adaptable with new methods: ease of use, reuse and adaptation of the learning content, take into account the needs and levels of learners (backgrounds, objectives, levels of abilities…etc), personalized content, contextual representation of user's information.

In distance learning, there is often no human tutor and so the learner simply works sequentially through the learning content. Usually, the development of an efficient and adequate learning content is difficult, expensive, takes a long time and a crucial task to help the delivery of the accurate content in each case. For these reasons we propose a cooperative method where the learning content is developed by several cooperative authors (teachers). The cooperation reduces the time of the development process and increases the learning content quality. On another level, we propose a predefined structure (organization) of the content, which helps the learners to realize their courses efficiently. We create two types of content: Main Content (this content must be read by all the learners) and Reference Content (used for special cases or to enhance the comprehension of the main content). The main objective of the system is to assist and help a group of authors to create an efficient educational content by offering the possibility to use the annotations for the created content. Multi-agent system seems to be an excellent choice for the applications in open systems like Internet. The annotation of leaning content was proposed in many research papers (Tatyana, 2011; Kabel *et al.*, 2004; Hyun-Sook *et al.*, 2012). The annotations will be used to find the personal path of learning (set of contents) for each learner (personalized learning), and they facilitate discovery and reuse of the content stored in the database.

2 Related works

Several works have performed the indexing of learning documents using annotation or ontologies. In (Tatyana, 2011), the author tried to develop an adaptive content to ensure the reuse and well-organized personalized learning content. The author proposed a conceptual model to find external content, this latter will be added to the learning resources and described semantically. In the case of changing the learning content by any user (learner or teacher), the system finds, manipulates, annotates, and organize the new learning content. The authors of (Michael *et al.*, 2002) defined the contents as a set of layers (five layers). Each layer represents a level and a kind of concepts. Moreover each layer is associated by the used methods for efficient learning and by the possible languages for descriptions. In (Nassim *et al.*, 2012), the authors defined the ontologies to mark up the learning objects structure in order to allow the machines to understand these learning objects. They based on several kinds of structuring relations: `Prev`, `Next`, `IsPartOf`, `HasPart`, `References`, `IsReferencedBy`, `IsBasedOn`, `IsRequiredBy`. The authors proposed in (Hammache *et al.*, 2006) an approach based on the use of the indexing of collection of documents using ontology of domain. Also they used semantic links between documents or fragments of documents of the collection to allow the inference of all relevant documents.

3 Metadata

Metadata can be defined as a data about other data. It is added in the E-learning resources because it can provide a common nomenclature enabling learning resources to be described in a common way (Niwattanakul *et al.*, 2006). Moreover, the metadata is used to describe learning content to make them more easily identifiable (accessible) and manipulated (reusable, adaptable) by the educational system. The LOM standard, learning object metadata, (Rosa Maria, 2011) specifies the syntax and the semantics of educational metadata and defines the attributes necessary for a proper and complete description of educational contents. LOM is organized in nine categories (Harnandez *et al.*, 2008): General, Lifecycle, Meta-data, Technique, Pedagogy, Fees, Relationship, Annotation, and Classification. For a given application, one can limit the number of attributes adapted to the specific context of use. In our system, we use general description, relationship and the annotation of the content.

4 General architecture of the system

The following figure shows the architecture of our system that helps the teachers (authors) engaged in a learning platform for distance learning to create,

index and annotate (in a cooperative manner) the learning content to be taught.

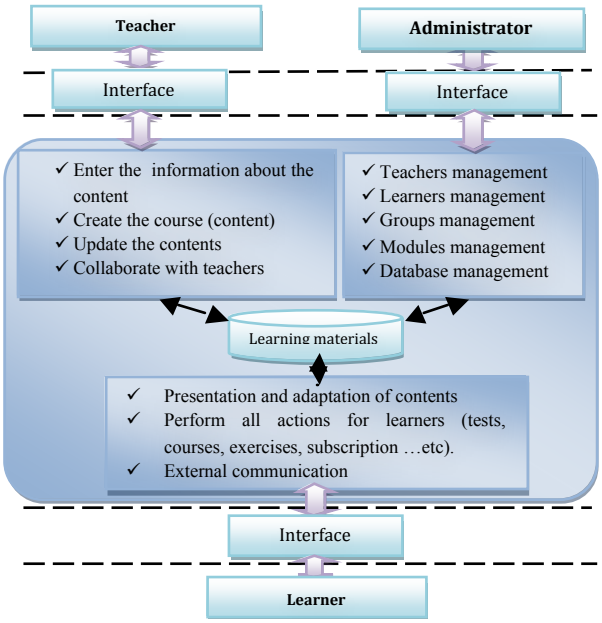

Fig. 1 - General architecture of the system.

In our System, there are three actors: the learner, the teacher and the administrator. In our case, we are interested in the teachers who create the learning content and provide all the information needed for the annotation of the content, and then we will annotate automatically these contents using the information given by the group of the teachers.

5 The learning content

The teachers create, in collaborative manner, the main content that will be given to the learners. Moreover, the teachers supply a set of references (additional learning content) for more explanation, more details, explanation in other styles and different terms. So we have two kinds of documents: MainDoc and RefDoc, this is the first level of annotation. The process of creating and annotation of the learning content has three main steps:

5.1 First step

In this step the administration members define the domain (context) of the learning process ex: computing, learning English, law, agriculture …etc. Also,

our system provides to the teachers a form of subscription that contains the information about the teachers (name, age, diplomats, actual profession, experience... etc). The administrator accepts or refuses the subscriptions of the teachers. In case of academic learning, the group of authors is the set of teachers in the association (university, school, enterprise, company…etc). If it is not academic formation, the administrator invites the teachers to participate in the learning process.

5.2 Second step

In this step, the teachers divide the domain to sub-domains for example: the "domain" is Computing, the sub-domains are: operating system, artificial intelligence, programming languages …etc. Then every teacher chooses one sub-domain to participate in it, and so we will have for each sub domain a group of teachers. Also they will select the chief of every group.

5.3 Third step

In this level, the teachers of a sub-domain group create the main content of their sub domain (so called MainDoc) which is the learning content given to the all learners. This MainDoc must be created by all the teachers of the group and they must use the same sub-domain vocabulary. The sub-domain vocabulary is created by the teachers with the assistance of our system.

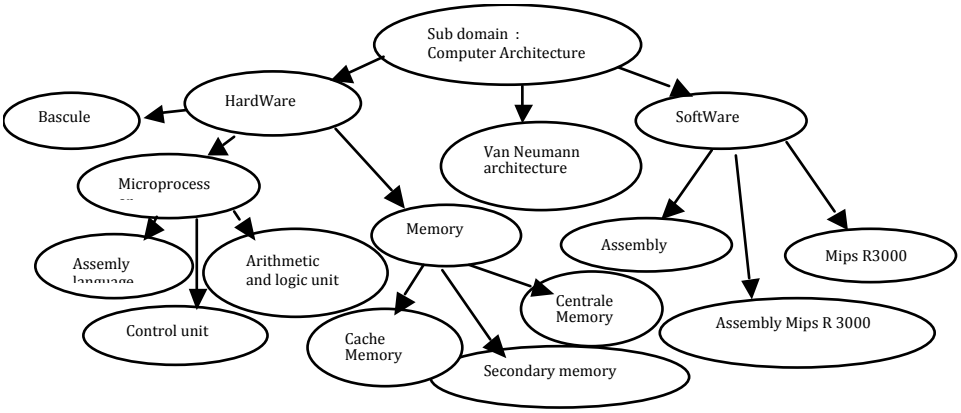

Fig. 2 - An example of subdomain vocabulary

We represent the subdomain vocabulary using XML to simplify the verification of the used vocabulary in the content. The MainDoc uses the sub domain vocabulary to unify its terms. This will be ensured by the verifying of the

MainDoc with the annotation of the RefDoc. The chief puts the first content, and then the teachers can change and update this content in a cooperative way to have a relevant content for the majority of learners. The MainDoc contains required information to understand the sub-domain (not very general and not very detailed).

RefDoc is the second type of learning materials, it can be an explicative examples, explicative schemes, documents contain detailed explanation, resumes, different style of explanation, books, articles …etc. We will use the main annotation for the RefDoc (using LOM) we have chosen these criteria: The title (marked as the main index), keywords, the most repeated words in the document, and the degree of relevance (selected by the learner and the teacher). Also the teacher must give additional information about the RefDoc for example: type of RefDoc (example, schemes, book…etc), reference for which part of MainDoc, explanations of prerequisites, exercises with solutions, detailed or not, contains additional information or not, oriented to excellent learners or failed ones, quizzes …etc. These points will be also used as annotations of the RefDoc to help us in the searching process (retrieval of the appropriate reference documents).

In the RefDoc, the vocabulary used maybe different from the vocabulary used in MainDoc. Thus, we will create third annotation for the RefDoc about all the synonyms, for example:

- Computer architecture = Computer organization, computer structure
- Control unit = command unit, synchronisation unit, Schedule unit

These synonyms will be shown to the learners when they are reading the RefDoc. Moreover; these synonyms will be used to verify the existence of these synonyms in the MainDoc to change them to the sub-domain vocabulary, as well as it will help the retrieval of convenient RefDoc. The RefDoc is used in special cases:

- The learner fails (less than 50 %): here we search for RefDoc which has annotations: examples, schemes and exercises with solutions.
- The learner fails (less than 25%): we search for RefDoc which has annotations: more details, simple explanation, video audio courses…etc.
- The learner fails (less than 10 %): we search for RefDoc which has annotations: explanations of prerequisites, quizzes
- For the excellent student: we search for RefDoc which has annotation: more information, resumes, articles …etc
- When a student makes a research using keywords which exist in the sub domain: here we will use these keywords and all their synonyms.

6 Detailed architecture

The choice of using the agent is due to the success of the technology of multi-agent and the characteristics of the agent (autonomy, flexibility …etc) and the widespread use of this technology in the Web

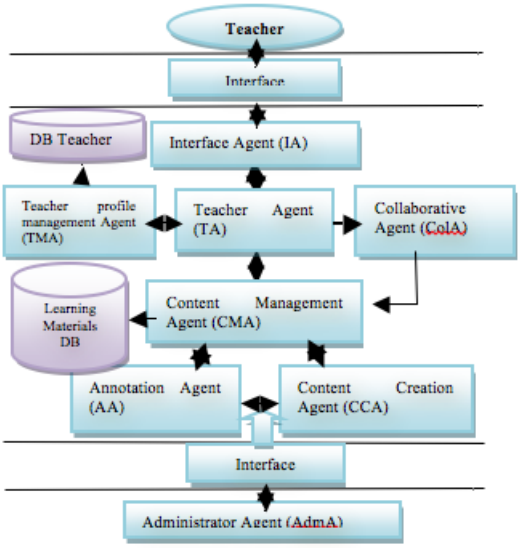

Fig. 3 - Detailed architecture of the system

6.1 Interface Agent (IA)

Interface Agent allows the teachers to interact with the system. The IA ensures the displaying of all what is designed for teachers (home page, announcements, registration form, and Management of the session of creating the contents).

6.2 Teacher Agent (TA)

The role of this agent is the preparation of all what is shown to the teacher through Interface Agent. TA sends the form of registration to the IA and sends the pages (information) to IA to display them to the teacher. Also when a teacher changes his profile the IA sends these new information to TA, this latter sends them to the TMA for storing in the database.

6.3 Teacher profile Management Agent (TMA)

This agent is specialized in management of the database of teachers' profiles. TMA receives the information of the new subscribed teachers from TA to create new profiles for the accepted teachers. Its main task is the storing and sending the information of the teachers.

6.4 Content Management Agent (CMA)

This agent performs the management of the learning content database. It stores the content with its annotations (descriptions or the set of synonyms) and prerequisites of each course, it provides the following services:

- It sends to the AA the annotations given by the teacher.
- It stores the created learning content with its annotations and synonyms.
- It searches about a RefDoc using the description and Synonyms.
- It sends to the learner the RefDoc and the synonyms used this RefDoc.
- It sends the RefDoc in case of failed or excellent learner using the annotation and the rules to find the relevant references.

6.5 Content Creation Agent (CCA)

This agent is specialized in creating the content, its services are:

- It receives the new content or its updates from CMA.
- It creates the content and sends it to AA to annotate it.
- It sends the structured updates to the CMA to update the content.
- It verifies if the used vocabulary is the same as the defined vocabulary.

6.6 Annotation Agent (AA)

This agent helps the CCA to create the content; it performs the annotation of the content. It behaves as follows:

- It receives the content from the CCA.
- It receives the Annotations of the learning content from CMA.
- It receives the set of synonyms of each course from CMA.
- It relates each annotation, description and synonyms with the appropriate course.
- It sends the final annotated content to CMA to store it in the database.

6.7 Collaborative Agent (ColA)

This agent helps the teachers to cooperate with each other. It informs the teachers by the modification of the content done by another teacher. It performs the modification or the addition of the annotations.

6.8 Administrator Agent (AdmA)

This agent is the responsible of the interface between the system and the human administrator, this administrator can cancel the registration of a teacher, remove a teacher. It can access to the all databases of the system.

7 Scenario of our system

In this section we will present the main scenarios of our educational system to express the behaviour of each agent in the whole system:

7.1 Opening a session of a teacher

The IA displays the home page of the teacher who will enter his username and password. The IA sends, to the TA, the information entered by the teacher with a request to open a session. TA sends this request plus password and username to the TMA to verify them. TMA will verify the correspondence between username and password given by the teacher with which are saved in the Teacher Database (teacher profile). If the check result is ("failure"), then the IA displays a message indicating the type of failure (incorrect password or identifier not existing); otherwise, the verification is done successfully, this agent will open the session. The IA will receive all necessary information to display them to the teacher.

7.2 Creation and indexing a pedagogical document

This task is the most important one, because it is the kernel of our system. In the case of creation of MainDoc, the CMA sends to the TA the subdomain vocabulary (the ontology which is used for the MainDoc). The teacher writes a part of the course, then he gives all the necessary information for the MainDoc (title, module, chapter …etc).When the teacher clicks on the button "create", the TA sends the content plus its necessary information to CMA. This latter sends them to the CCA to create the MainDoc (completes the organization of the document, adds the information to the content…etc) and sends it back to CMA to store the final content in the database. The MainDoc is not annotated because it will be given to all the learners. Therefore, the AA will not annotate it.

In the case of RefDoc, the CMA sends a demand to insert the information needed for the RefDoc to annotate it and to facilitate the process of researching. The first information is to which MainDoc is related this RefDoc, and the type of the RefDoc (an explicative examples, explicative schemes, documents contain detailed explanation, resumes, different style of explanation …etc). To annotate the RefDoc we use the main annotation (using the chosen criteria

of LOM: title, keywords …etc). The second information used for annotation (given by the teacher) is the synonyms used in the RefDoc (according to the MainDoc). Finally, the teacher defines to which rule of adaptation is related (rules defined in the section 3). In this level the necessary information of the RefDoc are ready. The TA sends this information plus the content to the CCA to create the learning content. CCA prepares the content and sends it to the AA to annotate the RefDoc. AA organizes the three types of the annotations (defined in the section 3) for the RefDoc and sends the final annotated RefDoc to CMA to store it in the Database.

8 Implementation

We have used the Java language for developing our prototype. The used environment is the "Eclipse" which is considered as IDE. The use of JADE (Java Agent Development Environment), enables the development of multi-agent systems. XML (eXtensible Mark-up language) is used to create and annotate the Content and the ontology of the subdomain vocabulary. Our system includes databases for storing information. MySQL is a relational database management system based on SQL (Structured Query Language). It works on almost of platforms, including Linux and Windows. JSP is a combination of Java code and HTML tags with special tags. The JSP allows to easily writing servlets. In this way, they provide a powerful technology to create dynamic pages.

Conclusion

In an educational environment, one must use several techniques and strategies to ensure that learners will understand the educational content. Thus, we must take into account that the learners have different backgrounds, different intellectual levels and heterogeneous abilities. Consequently, we should focus on the phase of the creation of educational content which is the essential part of the educational system to satisfy the needs of learners. In this paper, we have presented a cooperative and mutli-agents approach for the creation and indexing of pedagogical and adaptive content for E-learning. The creation of learning content by the authors requires two steps: the first step is the creation of the content: through an editor that facilitates the interaction between the teachers and the system. The second step is the content indexing: to facilitate the searching of relevant content. Finally, the benefits and using of the Semantic Web (ontologies, OWL, RDF) in our system can be considered as one of the most important future works. We plan to enrich and extend the platform by other features such as the functionality of the interface and integration of communication between the learner and the teacher.

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