ISSN 2229-5518

Computer environment for human learning using ontology

Adil KORCHI

Laboratory of Signals, Systems and Components, Faculty of Science, and Technology, University Sidi Mohamed Ben Abdellah, Fez, Morocco, E-mail : adil.korchi@gmail.com

Fayçal MESSAOUDI

Laboratory of Research in Management, Finance, Audit and Organizations (LAMAFAO) National School of Business and Management, Sidi Mohamed Ben Abdellah Fès University – Morocco, E-mail : faycal.messaoudi@usmba.ac.ma

El houssine MABROUK

Laboratory of Organic Chemistry, Faculty of Science, Dhar El Mahraz, Regional Academy of Education and Training, Fez-Meknes, Provincial Directorate of Fes, Allal Loudiyi High School, E-mail : abounadah@yahoo.fr

Lahcen Oughdir

Department of Mathematics, Physics and Informatics, National School of Applied Sciences, University of Sidi Mohamed Ben Abdellah, Fez, Morocco, E-mail : lahcen.oughdir@usmba.ac.ma

Abstract

In this manuscript we are interested in the implementation and use of ontologies in the computer environment for human learning (CEHL) field, which draws its strength from semantic web technologies. This interest also relates to the valuation of the CEHL that have; over time ; lost their value in the eyes of people seeking to learn through the web.

To overcome these problems, we have opted for a solution that consists in determining the characteristics that influence a learner in any learning situation in order to model him/her. Such modeling can lead to the use of new concepts and learning techniques that put the learner at the heart of the pedagogical situation. To this end, we used ontologies and one of the semantic web power wich is the framework "Jena" that we have implemented in our learning system in order to use inference engine to links between the elements of our ontology. The rules of inference defined beforehand is to infer logical consequences from a set of facts or axioms explicitly proved to answer the different requests issued by the system.

The purpose of the Jena API implementation and the use of its inference engine was to make CEHL more effective in learning tasks so that it facilitates learning for the learner while respecting their profile. who has strengths and weaknesses, with a view to accommodation according to his behavior, interaction, skills and knowledge, and then self-evaluating the learner during his learning sequence for more effective learning. After that, we create a CEHL system called “PERFECT-LEARN” which use a set of computer software able to interact with the created ontology in order to adapt profile to the desired learning setting while respecting the preferences of the latter in order to offer an apprenticeship responding to the learner’s needs.

Keywords— Learner model, Modeling, CEHL, Ontology, Learning process, PERFECT-LEARN, Learner characteristics, Ontological engineering, Jena-API.

1 Introduction

CEHL has emerged to foster apprenticeship for people who are in a real learning situation which is controlled and guided by a system that can put the learner in a real active situation of apprenticeship so that he/she can build his knowledges.

However, the major problem of CEHL affects the learners as well as his/her knowledges that must be represented into the system which have the particularity to evolve from the point of view of their knowledges during their interaction with the computer environment (Balacheff, 99).

Research in CEHL is multi-disciplinary and they can involve various problems that find their application in several areas of computer science field. Indeed, the work done in the systems on the learner’s modeling, in particular to ensure a better adaptation, made it possible today to take into account the user in the design of the intelligent interfaces and then his modeling which constitutes a very active field of research that has resulted in the integration and use of Ontological Engineering (OE) in CEHL which participates in the advancement of research in this field.

In addition, Ontological Engineering can be used to model the knowledge of a domain and to allow the user or the machine to reason about this modeling which uses the key parameters that really influence the apprenticeship sequences in order to propose a learner model adapted to the characteristics of the CEHL which are semantically anchored and can support learners through the evaluation of his/her behavior, interaction, skills and learner knowledge.

In the first section of this paper, we will discuss some existing work on e-learning systems, and then give a description of the proposed PERFECT-LEARN system. In the second part, we will present the characteristics of the proposed system, functionalities and strengths. Then we will detail the implementation of the ontological module and finally, we will describe the architecture of the system.

2 Some existing E-learning systems

Many researchers (professors and doctoral students) are interested in E-learning. Most of these people have created one or more platforms that can make a difference for students who want to learn, we were interested in two projects because they are very close to ours, and which are the following ones :

2.1 ALS-CPL system :

The project "ALS-CPL" (Battou, 2012) is a prototype to test and validate the learning adaptation process according to the preferences of the learner. This project proposes a granular approach of pedagogical objects in order to adapt the context into IT Environments of Human Learning.

It is, in fact, automatic generation of courses tailored to a particular learner, from a set of pedagogical resources and according to his needs, preferences and prerequisites. Pedagogical resources currently referred to as pedagogical objects are indexed using standards pedagogical metadata such as LOM and SCORM. These pedagogical objects, which constitute the content to be learned, are assembled from pedagogical grains and then combined to constitute individual training courses with hypermedia type presentation.

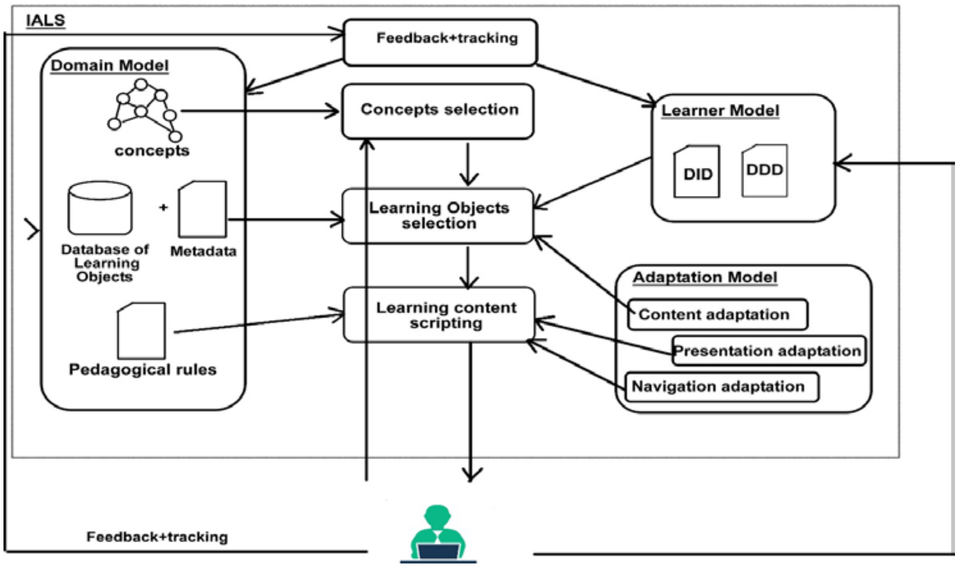

Fig. 1. Adaptive Content generation process of ALS-CPL system

The design of this project focused on three main aspects from the hypermedia paradigm and two other aspects of adaptive systems. The first three are the content, the navigation structure and the presentation for the purpose of constructing a conceptual model of the domain, and an application-specific navigation and presentation model. The last two are learner modeling and adaptation.

The methodology used for this design is based on the UML language on the one hand, and on the other hand on the UML-based Hypermedia Design Method (UHDM) adaptive hypermedia design approach. The UHDM method consists of constructing seven models of analysis and design. The seven main artifacts related to this method consist in determining the following models:

- The use case model that captures the requirements of the system;
- The conceptual model for the content (domain model);
- The model of the learner;
- The navigation adaptation model which includes a model of space and navigation structure;
- The presentation adaptation model that includes static and dynamic models related to how the content will be presented to the learner;
- The content adaptation model;
- The adaptation model.

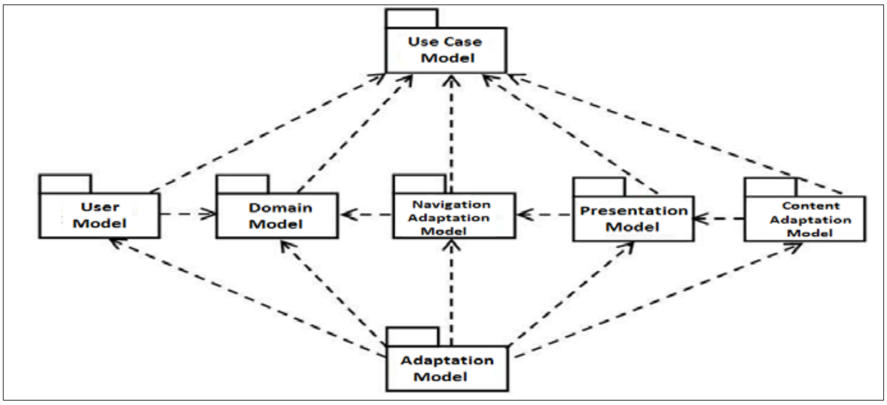

Fig. 2. Design and Analysis Models (Inspired from Koch (Koch, 2000)

2.2 MANHALI system :

Manhali is an adaptive learning management system that provides new methods for analyzing and evaluating learner behavior, and determining its online learning style in order to achieve a learner profile in order to improve the learning situation by placing the learner at the center of the training process. (El Haddioui, 2012)

Manhali allows:

- Graphical interface adaptation according learner's machine configuration.
- Adaptation of the pedagogical content to the competences of the learner in the field taught.
- Pedagogical strategies adaptation according to learner behavior and learning style.

MANHALI interacts with learner profiles that allow the analysis and assessment of learner behavior based on indicators of interaction between the learner and the system, and also on the use of educational tools of the platform. It also provides tools for determining the learning style of learners.

The Manhali architecture separates the system into multipart to simplify the collective work of system design, development and maintenance as well as the administration of Manhali learning platforms.

In the Manhali system, there are four parts: data, interaction messages, template and processing.

The data: We store all system data (learner data, training, statistics ...) on a single database.

Interaction messages: it is between the system and users are stored in language files, these files are simple text documents that do not contain any PHP script to simplify the work of translators even if they are not computer scientists.

The template: Styles, images, and themes are totally separate from other parts of the system.

Processing: we find the PHP files of the system processing. Thanks to this architecture, several people can participate in the project simultaneously: translators, Web designers, developers and users.

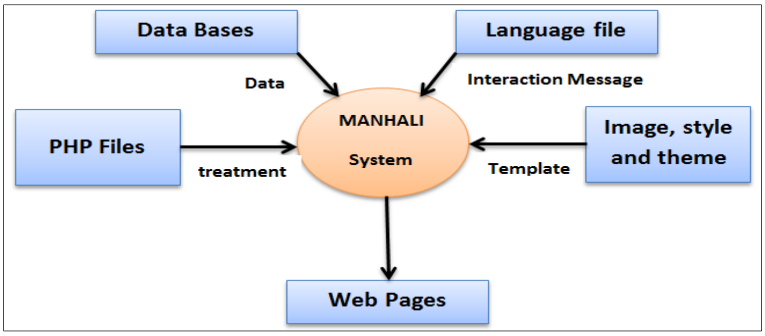

Fig. 3. Functional diagram of Manhali System

Finally, we can say that the Manhali system proposes new methods to analyze and evaluate the behavior of the learner, and determine his or her online learning style in order to obtain as a result a learner profile which allows to improve the learning situation by placing the learner at the center of the training process while the ALS-CPL system is able from a set of elementary and granular resources, their semantic descriptions and the learner profile, to generate adapted resources (lessons, exercises, etc.) with a web browser interface.

2.3 The proposed E-Learning System "PERFECT-LEARN"

We have proposed an online learning system called "PERFECT-LEARN". This system focuses on the learner in the first place and determines his profile as a set of relevant information to adapt learning situation to his behavior, knowledge, skills, interactions....

The architecture of PERFECT-LEARN system reflects the organization of the various elements that it includes (software, hardware, humans and information) and the relations between them. This structure is achieved following a set of strategic decisions made during the design of this system to allow an exemplary adaptation of the profile to different learning situations.

This adaptation can be achieved with the complicity of Ontological engineering. This will play a very important role in the sharing of knowledge and the adaptation of pedagogical content between humans and computers and between computers as well as the sharing and reuse of concepts through computational semantics. Ontologies that are widely used for learner modeling are in themselves a data model representative of a set of concepts in a domain, as well as relationships.

In PERFECT-LEARN system, we chose to represent the learner with 6 elements that provided us with the information needed to create an ontological model able to represent the learner in coordination with his profile ; which are : personal information of the learner - his behavior - his domain skills - his knowledge - his learning's style - his interaction.

The choice of these elements was made possible by a survey of teachers in some high schools, university professors and teachers in continuing education for adults. These teachers are not representative of all teachers. Nevertheless, they gave their personal opinion on the notions that we handle a testimony of their practices and the practices of the colleagues with whom they work.

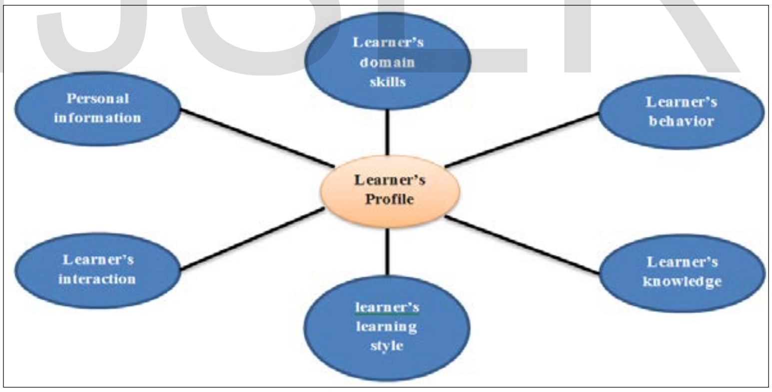

Fig. 4. Elements of the learner in PERFECT-LEARN

2.4 Why use ontologies

On the semantic web, ontologies are used as software components to solve the problem of heterogeneity of data sources distributed on the web, promoting their sharing and intelligent reuse by different semantic software agents.

In the context of this manuscript, ontologies are used for the model, control and organize learner's data. However, their construction and their management are too delicate tasks that require expertise in areas of knowledge they represent, and in ontological engineering.

To model complex knowledge about resources, the Web-OWL ontology language provides the constructors needed to define heavy ontologies. This language allows the definition of different axioms on concepts and properties to further clarify their formal semantics. The use of ontologies that contain ontological axioms for resource description allows logical systems to reason with descriptive data and to infer new data.

On the semantic web, the resources are fully distributed but identifiable by their URIs, linked and described with a set of RDF-data that is a multi-graph-RDF searchable on a web-wide SPARQL. The result of a SPARQL query is an XML document, called SPARQL-results document, valid against an XML schema provided by the SPARQL specification. This document can be used by semantic software agents to perform various application tasks on web resources. The syntactic interoperability offered by the core technologies of web hypertext is a prerequisite for semantic interoperability, which is currently possible thanks to the new technologies introduced by the semantic web. Information on the semantic web is not only produced to be presented to users but its unambiguous interpretation allows its use in an interoperable way by semantic software agents and thus development of new services and semantic applications to evolve the current web to a more programmable and dynamic web.

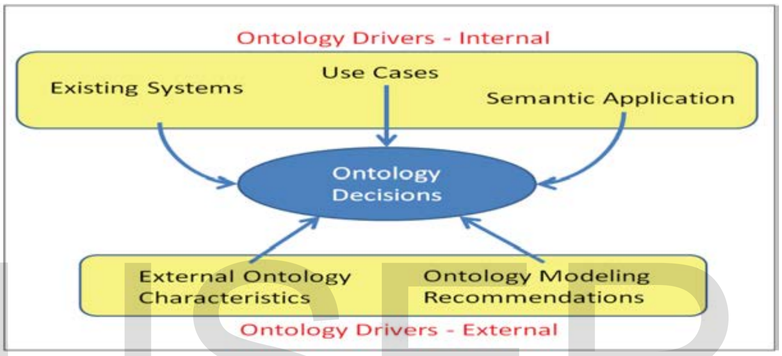

Fig. 5. Ontology decision drivers

We tried to realize a learning system using the forces of the semantic web and in which we created ontology that will participate and control all learning process such as :

- Detection of learner's behavior
- Determination of learner's skills
- Determination of learner Knowledge
- Determination detection of learning style

3 Characteristics of PERFECT-LEARN system

In this paper, we propose a new learning profile that takes into account the learner's behavior, his domain skills and his learning style. The management of this profile will contain new methods and processes for the analysis and evaluation of behavior, as well as learner style determination, behavioral evaluation. In order to adapt the profile to the characteristics of the learner. The proposed learner model contains some personal information's such as name, first name, email, date of birth and registration data.

For the characteristics of the learner such as learning style, behavior, interaction, we have chosen to create processes that will help us to determine them and then manage them according to well-defined procedures. These processes are as follows:

3.1 Determination process of the learner's behavior

The behavior of the learner in PERFECT-LEARN system is deduced from 4 indicators and which are:

- The number of connections to the platform;
- The number of courses consulted;
- The total time spent in the platform;
- The number of past assessment tests;

For each indicator, we calculate the percentage of number of activities performed by the learner on the total number of activities performed by all active learners. The active learner is the learner who has accessed the platform at least once.

For example, to calculate the score of the first indicator, the following formula (1.1) is used:

$$Score\_Connexion = \frac{Nbr\_Cnx\_Learner}{Tot\_Nbr\_Cnx} \times 100 \quad (1.1)$$

Where :

- Nbr_Cnx_Learner is the number of connections to the platform of this learner;
- Tot_Nbr_Cnx is the total number of active learner connections in the same domain.

The following table shows the indicators, variables and formulas ((1.1), (1.2), (1.3), (1.4)) that we have chosen for the representation of the behavior of the learner.

Indicator	Variable	Formula	
Number of Connections to the Platform	Score_Cnx	$Score\_Connexion = \frac{Nbr\_Cnx\_Learner}{Tot\_Nbr\_Cnx} \times 100$	(1.1)
Number of courses viewed	Scor_Cours_View	$Score\_Conn\_View = \frac{Nbr\_Cours\_View}{Nbr\_Tot\_View} \times 100$	(1.2)
Total Time Spent in the Platform	Tot_T_Sp_Platf	$Tot\_T\_Sp\_Platf = \frac{Spend\_T\_Learn}{Tot\_T\_Spend} \times 100$	(1.3)
Past Number of Evaluation Tests	Score_Test	$Score\_Test = \frac{Nbr\_Test\_Learn}{Nbr\_Tot\_Test} \times 100$	(1.4)

Table 1. Indicators, Variables and formulas of the behavioral calculation indicators.

To evaluate the behavior and detect the behavioral changes of the learner, he is given a final score calculated from the following formula (1.5) to compare these changes according to a range of dates. The final score of the behavior is the average of the confirmed scores obtained by a learner from the confirmed indicators. The indicator and the score is not confirmed only when the activity is already carried out by one-tenth (1/10) of all active learners.

$$Score\_Learn = \frac{Scor\_confirm}{Nbr\_Indic\_confirm} \times 100 \quad (1.5)$$

The learners are then classified according to this formula (1.6) into 5 grades (A, B, C, D and E) according to the final score of the behavior in order to allow the personalization of the pedagogical content with a view to its adaptation for each learner profile.

The behavior grade is determined from (1.6) the following GRADE coefficient:

$$Grade = \frac{Score\_Learn \times Nbr\_Actif\_Learn}{100} \quad (1.6)$$

Where « Score_Learn » is the score obtained by the learner and « Nbr_Actif_Learn » is the number of active learners in the platform.

The result indicates the rank according to the following table:

Coefficient "GRADE"	Grade assigned
Less than 0,5	E
Between 0,5 et 1	D
Between 1 et 2	C
Between 2 et 4	B
More than 4	A

Table 2. Determination of behavior's grade

3.2 Process of determining learner's skills

A learner's skills are his know-how. Some researchers believe that in order to estimate learner skills, systems must have two assessment tools, homework and tests through which learners' skills can be verified. PERFECT-LEARN system automatically manages assessment methods to detect, the level of the learner (self-assessment process) that relies on the assessment test. The evaluation parameters will be saved; within the system; in the profile data.

The following table shows how the system affects levels to learners.

Score obtained in the evaluation test	Level of Competence assigned
Between 25 and 33	Level 1
Between 12 and 24	Level 2
Between 0 and 11	Level 3

Table 3. Determining the Learner's Level of Competency

3.3 Learner Knowledge Determination Process

The knowledge of the learner: It is his cognitive baggage. It can be general, theoretical or practical. For a possible evolution in the learning process, the learner's knowledge is also updated through the self-assessment process.

The knowledge of the learner is calculated from the rules set in the system and which concerns the evaluation test.

We assigned each test question a score according to the degree of difficulty (for the learner's knowledge level detection process). Thus, the score obtained in each test provides the system with the level of knowledge of each learner.

	Score obtained	Knowledge level of Learner
Test	Less than 14	Low level
	Between 14 and 35	Average level
	More than 35	Good level

Table 4. Determination of Learner Level of Knowledge

3.4 Learning style and the process of its detection

The learning style is one of the main individual differences that play an important role in the training process. The learning style encompasses all the preferences that characterize an individual in a learning situation.

The purpose of learning style determination is to achieve a better learning profile that improves the learning situation and can only succeed if the system adapts learning to the learner's current needs through controls of the proposed ontology.

The methods of determining the learning style are numerous, for example: Oculometric technology which remains very expensive. We have limited the learning style process in the following:

The system calculates the number of the types of instructional media used by the learner and classifies them in that order.

For example: the learner connects to the platform and consults the teaching materials: Video (8 times), PDF (6 times), Web Page (3 times) and PowerPoint presentation (1 time). The system will interact with its learning style and will classify; in his private space; these resources according to the number of times visited.

The learner connects a second time and consults the teaching materials: Video (4 times), PDF (2 times), Web Page (6 times) and PowerPoint presentation (0 times). Thus, the system will detect these changes and will classify the media as follows:

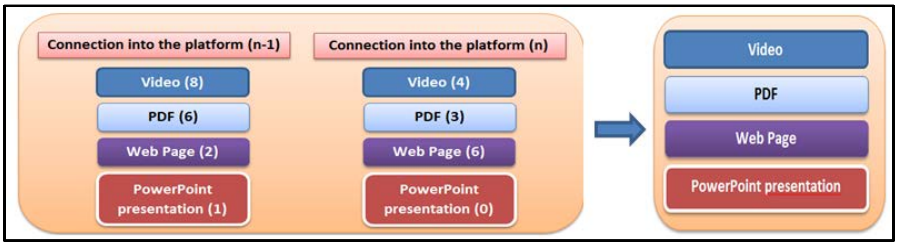

Fig. 6. Determination of Learner's Learning Style

This ranking has been designed for ease of navigation and to make the application more ergonomic.

The formula (2.1) for calculating the learning style is as follows:

$$\text{Learning Style} = nbr\_Teach\_M\_Use\_Cnx\_(n-1) + nbr\_Teach\_M\_Use\_Cnx\_(n) \quad (2.1)$$

Where :

nbr_Teach_M_Use_Cnx is number of times that learner has consulted a specific type of pedagogical courses. "N-1" is the last connection to the system, "n" is the current connection.

3.5 The interaction of the learner and his process

The learner is an integral part of the interaction; otherwise he would not be a learner. It is therefore the exchange that the learner can have with a learning environment and that can be long, medium or fast.

If the created system detects that the learner spends too much time in one of the learning materials made available (PDF documents, Web document, ...), then he must propose more adequate supports like slideshows or small video sequences ... or even smaller course materials for better learning.

Each resource is assigned the maximum time of its consultation. If the learner respects it, the system affects him a quick interaction. Otherwise, the system compares the learner's consultation time with the predefined time for the same resource and assigns one of the two remaining interactions, namely: medium or slow interaction.

The time allocated to each resource was set by a domain expert.

For example : By default, we assigned to the normal resource "Grammar level 1 section 1" a consultation time equal to 3 minutes. If the learner consults it in less than or equal to 3 minutes then the system concludes that the learner's interaction is fast and therefore, the system will not change the type of media the learner started with learning session.

3.6 The assessment of the learner and his process

We preferred to add another important element : the learner assessment which is in fact a process that acknowledges a positive impact in an online learning environment. This assessment consists of verifying what has been learned, understood and retained by the learner. It is a question of checking one's achievements as part of a progression, judging one's work according to the given criteria, estimating one's skills, situating it in relation to one's skills and determining in the end, one's level of production.

We first thought of adopting the Cronbach's alpha coefficient which is a statistical index varying between 0 and 1, which makes it possible to evaluate the homogeneity (consistency or internal consistency) of an evaluation or measurement instrument. composed of a set of items, all of which should contribute to apprehending the same "underlying" entity (or dimension): the level of knowledge or competence on a given theme; the level of aptitude, attitude, motivation, interest in a particular field or object, but given its complexity we have opted for a method of learner evaluation, which creates a process that works as follows:

Special questions in the form of multiple choice questions are offered to the learner after 6 connections to the learning system. This test is optional for the moment but can be made mandatory later. The score obtained will allow the system to change the learning strategies used for this learner if there is a remarkable decrease. It should be noted that this module is not fully validated because of the complexity of its implementation and that it will undoubtedly be the subject of future research.

After having studied different types of profiles as well as the elements that characterize them as well as the different processes that characterize the adaptation of learning for the learner, and in order to lead to a modeling that respects what has been evoked, we arrive the ontology construction phase that will concretize the implementation.

4 Construction of the learning ontology

Fig. 7 gives an overview of proposed Learner ontology. In order to implement it in the designed learning system, we have represented it in PROTEGE (an open-source ontology editor) to recover the XML (Extensible Markup Language) file and the graph associated with it. Fig. 8 schematizes this graph.

This ontology proposes a modeling way comprising several concepts linked semantically to each other as it is shown :

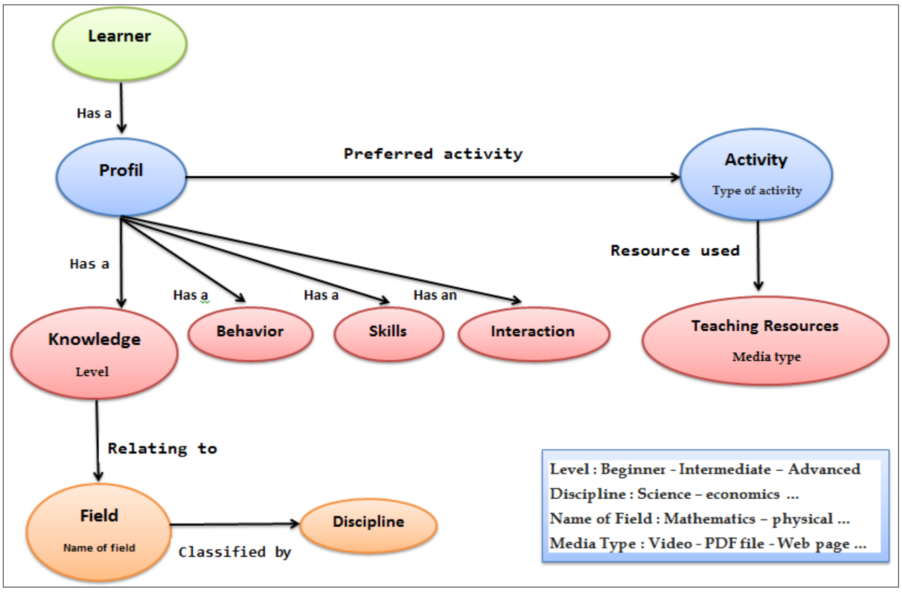

Fig. 7. Learner ontology graph elaborated

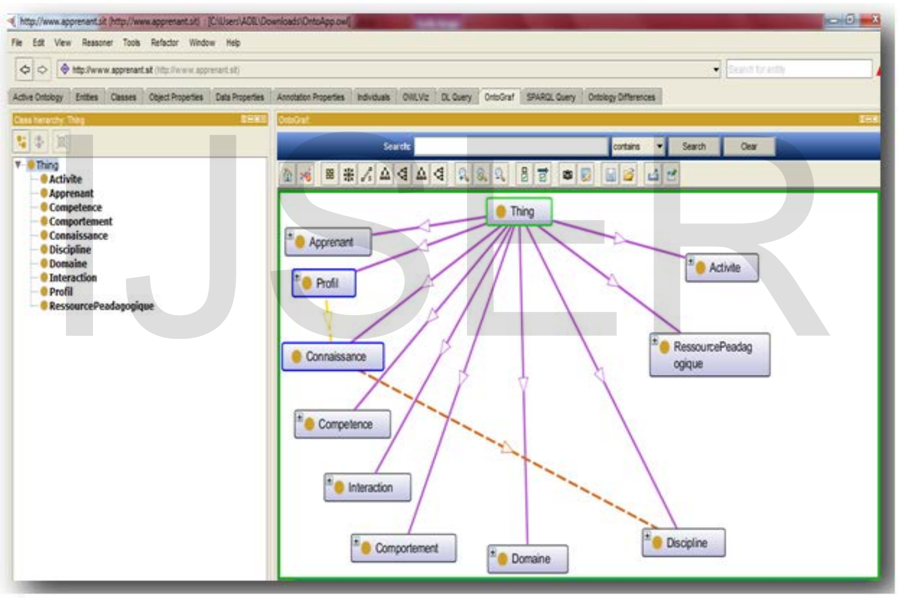

Fig. 8. Learner ontology graph elaborated in Protege editor.

We were aware from the beginning of the research that the complexity of learner modeling in a CEHL based on ontologies did not lie in the creation of the ontology itself, but in its implementation in the system in order to interact with the different processes that characterize the apprenticeship we wish to achieve, and this for several considerations:

1. The first one was about the behavior of the learner, because it is a machine that cannot detect anything without the help of the processes we are going to implement for that purpose.

2. The same issue arose for the interaction of the learner during a learning session and for which we thought to implement the tool for detecting the time spent in one of the learning supports.
3. The problem of methods and techniques choice for handling data relating to a learner arose, as well as the exchanges that the learning system can have with the elaborated ontological graph (Onto-app.owl).

The following section explains how to implement some of critical components for learner's modeling in the proposed system. It also reveals the methods and techniques used to integrate and exploit the elaborate ontology.

5 Architecture of the developed system "PERFECT-LEARN"

"PERFECT-LEARN" application is developed with the NetBeans development environment, and for its deployment we used the web server GlassFish and this by generating an archive file associated with the Web application where the application is saved and the resources it needs. The overall architecture of the system is as follows (Fig. 8).

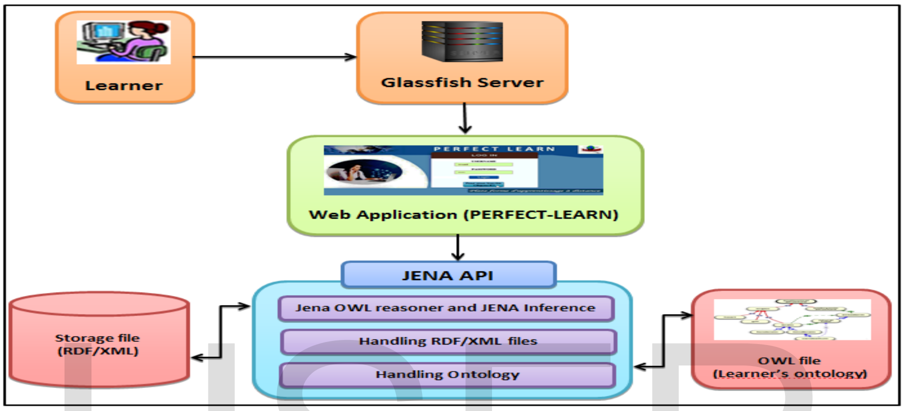

Fig. 9. Overall architecture of PERFECT-LEARN system.

The prototype proposed in Fig. 9 is a tool for easily exploring the different logical structures of a set of documents in XML and RDF/XML format (RDF/XML is a syntax defined by the World Wide Web Consortium (W3C) to express an RDF graph as an XML document). It is built entirely in Java using a set of JENA APIs to manage access to RDF/XML documents. The latter offer tools for describing data and which can be of any type. (Korchi & al., 2017)

The JENA Framework (an open source Semantic Web framework for Java. It provides an API to extract data from and write to RDF graphs) is designed in a modular architecture. It offers several modules to meet the different needs of efficient manipulation of RDF data as well as those of ontology. (Korchi & al., 2017)

The JENA inference subsystem is designed to allow a range of inference engines or reasoners to be plugged into Jena. Such engines are used to derive additional RDF assertions which are entailed from some base RDF together with any optional ontology information and the axioms and rules associated with the reasoner. The primary use of this mechanism is to support the use of languages such as RDFS (Resource Description Framework Schema) and OWL which allow additional facts to be inferred from instance data and class descriptions. However, the machinery is designed to be quite general and, in particular, it includes a generic rule engine that can be used for many RDF processing or transformation tasks.

The overall structure of the inference machinery is illustrated below (Fig. 10).

The JENA Framework is designed according to a modular architecture. It offers several modules (TDB, SDB, ARQ, Fuseki, ...) to meet the different needs of effective data manipulation-RDF as well as ontology.

The JENA inference subsystem is designed to allow a range of inference engines or reasoners to be plugged into Jena. Such engines are used to derive additional RDF assertions which are entailed from some base RDF together with any optional ontology information and the axioms and rules associated with the reasoner. (Korchi & al., 2017)

The following figure gives us an overview of the architecture of this Framework.

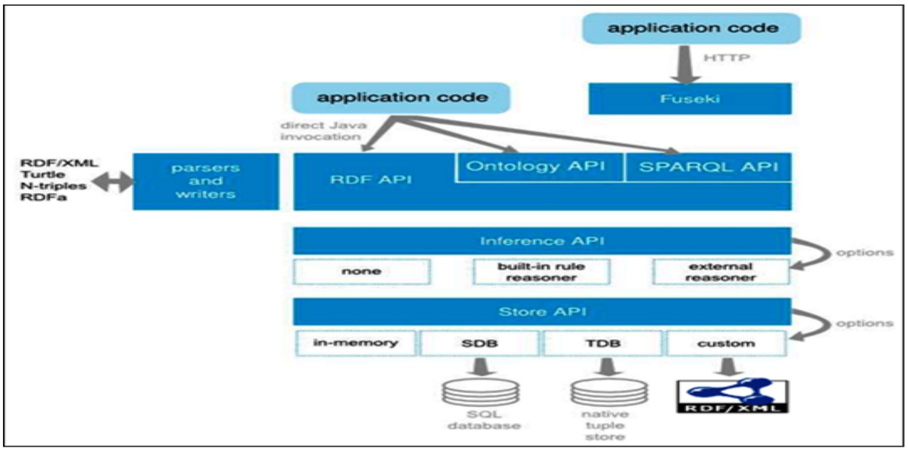

Fig. 10. Overview of the JENA Framework Architecture

5.1 Ontology Access Techniques

In order to concretize the proposed approach, we had to use the created ontology in "PERFECT-LEARN" system. To do this, it had to be loaded from the JAVA code (using the JENA API) :

The central point of ontology access is the "OWLOntologyManager", which is used to create, load and access ontologies.

"OWLOntologyManager object" is created first to be used to load the ontology. Then "loadOntologyFromOntologyDocument( ) method", which takes the ontology local path as its parameter, it loads it into the ontology variable.

For the storage of learner information, we create an RDF file for every learner to facilitate data management and retrieval via the loaded ontology. The system can then manage any activity and records it in order to present it and exploit it. The query language SPARQL is present through its query engine ARQ RDF files to run this engine. (Korchi & al., 2017)

5.2 Some examples of code used in our application that call ontology

Creating an Ontology Model for an OWL-DL Ontology with an RDFS Reasoner

```
Model m = ModelFactory.createOntologyModel(OntModelSpec.OWL_DL_MEM_RDFS_INF);
Model model =ModelFactory.createMemModelMaker().createModel(null);

OWL file read.

InputStream in = (InputStream) FileManager.get().readModel( m, inputFileName );
if (in == null)
throw new NotFoundException("Not found: "+inputFileName) ;
return load(in, "RDF/XML") ;
InputStream in = (InputStream) FileManager.get().readModel(model, inputFileName
);
if (in == null) { throw new IllegalArgumentException("File: " + inputFileName
+ " not found"); }
model.read(in, "RDF/XML");
```

The RDF code that the application generates to store the information of a new learner in ontological file.

```
public static void LearnerToOntologyfile
(String nom, String prenom ,String eta, String domain, String niveau,
String Passe_test, String login, String pass)
{
String ins="http://localhost:8080/APA/OntoApp.owl#";
String foaf="http://xmlns.com/foaf/0.1/";
String rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#";
Model model = ModelFactory.createDefaultModel();
model.setNsPrefix("foaf", foaf);
model.setNsPrefix("apa", ins);
model.setNsPrefix("rdf", rdf);
Resource reso1 = model.createResource(ins+"Apprenant");
Resource reso2 = model.createResource(foaf+prenom);
Resource reso3 = model.createResource(eta);
Resource reso4 = model.createResource(domain);
```

5.3 Interfaces of PERFECT-LEARN system

The developed system is in the form of a website. The first page allows the learner to register or to authenticate. If the learner authenticates, the system queries the RDF file for that learner as well as the ontology file for authenticity of the information provided by the learner. Once this information is validated, the learner is informed by the system of his level, his interaction and offers him the opportunity to pass a test to update his level or start a learning session depending on the type of preferred medium. The learner then has the choice to pass a level test for a possible update of his level, either to start his learning sequence by choosing the type of pedagogical support with which he wishes to learn. Once this operation is done, he has only to choose the course that the system proposes him in coordination with his level.

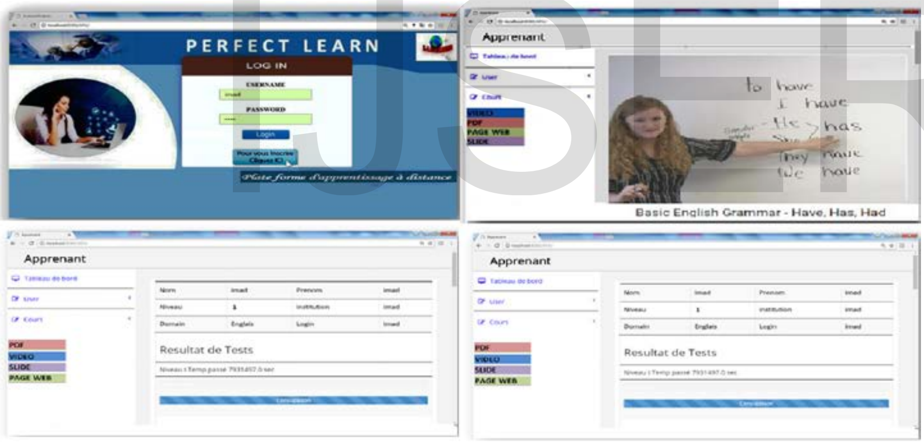

Fig. 11. Some interfaces of the system PERFECT-LEARN

The PERFECT-LEARN administrator ensures the maintenance of the system, manages access rights, adds questions, users and also educational resources such as videos by creating links to external systems and resources, etc.

As a summary, we can say that PERFECT-LEARN is a learning environment controlled and guided by ontologies. This environment has put the learner in an active learning situation by proposing educational content appropriate to his preferences. The detection of the learner's interaction is also a crucial parameter for the learner since it allows him to learn in a specific.

JENA's API techniques allowed us to better interact with the ontology and made it easier for us to get the data into PERFECT-LEARN while using resources that helped us to determine the behavior, interaction, style learning of the learner, the classification of pedagogical supports according to the order of preferences and this, in the formats that include ontologies.

The developed PERFECT-LEARN application can be incorporated into an e-learning platform as a CEHL. It can also be used autonomously.

6 CONCLUSION

This manuscript discusses learner modeling and the adjustment of the learning process according to the learner profile. It also tries to go beyond traditional methods of knowledge modeling. We focused on developing a learner profile that supports the behavioral analysis of knowledge, the detection of learning styles, the preferences and the attitude of the learner. Subsequently, we addressed the realization of an adaptive learning system that adapts the pedagogical content to the learner's current needs while self-assessing the learner during the learning sequence through the use of ontologies and semantic web tools.

We recognize that the work done can evolve to meet the real learning needs of learners and we believe that the created ontology can help the system more and more, especially with the contribution of techniques and tools of the semantic Web to better design a CEHL with more satisfied learners.

But before finishing, we have to say that certainly the learners who have different behavior have passed tests to know their level in order to progress in their learning. They also used resources to learn and improve their knowledge. However, the questions that arise are :

- Do the results obtained in the tests really reflect the levels of the learners?
- Did learners really made progress in their learning when the system adjusts their private learning space by changing pedagogical supports?
- Did the learners who took too much time to consult the pedagogical supports have found learning difficulties? If so, they must be determined.
- What are the steps to be taken to ensure that learners who have progressed do not regress in their learning?
- Did the system detect the real behavior of learners?

The answers to his questions will be the subject of a future research.

Reference

1. ADIL, Korchi, AMRANI, E., et LAHCEN, Oughdir. ”*Modeling and Implementing Ontology for Managing Learners' Profiles*”. Int. J. Adv. Comput. Sci. Appl., 2017, vol. 8, no 8, p. 144-152.
2. BALACHEFF, Nicolas. ”*Cours de DEA EIAH*”. 1999.
3. BEHAZ, Amel et DJOUDI, Mahieddine. ”Approche de Modélisation d'un Apprenant à base d'Ontologie pour un Hypermédia adaptatif Pédagogique”. In : CIIA. 2009.
4. BATTOU, Amal. ”*Approche granulaire des objets pédagogiques en vue de l'adaptabilité dans le cadre des Environnements Informatiques pour l'Apprentissage Humain*”. 2012, toubkal.imist.ma
5. BURANARACH, Marut, SUPNITHI, Thepchai, THEIN, Ye Myat, et al. OAM: ”*An ontology application management framework for simplifying ontology-based semantic web application development. International Journal of Software Engineering and Knowledge Engineering*”, 2016, vol. 26, no 01, p. 115-145.
6. C.BREWSTER, H.ALANI, S.DASMAHAPATRA & Y.WILKS. ”*Data driven ontology evaluation*”. *In International Conference on Language Resources and Evaluation* (LREC, 2004), 24-30 May 2004, Lisbon, Portugal. 2004.
7. DE KOCH, Nora Parcus. ”*Software Engineering for Adaptive Hypermedia Systems-Reference Model, Modeling Techniques and Development*” Process. 2001.

8. De Vries, E. (2001) ”*Les logiciels d’apprentissage : panoplie ou éventail?* ” Revue Française de Pédagogie, 137, 105-116.
9. DIMITROVA, Vania, SELF, John, et BRNA, Paul. ”*The interactive maintenance of open learner models”*. In : Artificial intelligence in education. 1999. p. 405-412.
10. EL HADDIOUI, Ismail et KHALDI, Mohamed. ”*Learning style and behavior analysis: A study on the learning management system Manhali*”. International Journal of Computer Applications, 2012, vol. 56, no 4.
11. EL MEZOUARY, Ali, BATTOU, Amal, OHOUD, Mohsine Ben, et al. ”*The Educational Semantic Web and Associated Technologies for Adaptability in Adaptive Learning Systems*”. International Journal of Computer Applications, 2011, vol. 32, no 9.
12. FARIDA, Mme DAHMANI. ”*Modélisation basée ontologies pour l'apprentissage interactif-Application à l'évaluation des connaissances de l'apprenant*”. Thèse de doctorat, 2010, Université Mouloud Maameri de Tizi Ouzou.
13. FARQUHAR, Adam, FIKES, Richard, et RICE, James. ”*The ontolingua server: A tool for collaborative ontology construction.”* International journal of human-computer studies, 1997, vol. 46, no 6, p. 707-727.
14. IDDIR, O., & Rachid, A. O. (2014, November). ”*Information retrieval in educational structured documents adapted to learners needs*”. In ISKO-Maghreb: Concepts and Tools for knowledge Management (ISKO-Maghreb), 2014 4th International Symposium (pp. 1-8). IEEE.
15. I.AKHARRAZ, M.EL OUAAZiZi et N.CHENFOUR. ” *Apprentissage en ligne d’un cours d’algèbre guidé par des ontologies* ”. Congrès Méditerranéen des Telecommunications-CMT’12. Ecole Supérieure de Technologie de Fès. Fès-Maroc. pp.441-443. 22-24 Mars 2012.
16. MAMMASS, Driss. Amal Battou Ali El Mezouary Chihab Cherkaoui. ”*An Adaptive learning System Architecture based on a Granular Learning Object Framework”*. IJCA Journal, 2011.
17. PSYCHÉ, Valéry, MENDES, Olavo, et BOURDEAU, Jacqueline. ”*Apport de l'ingénierie ontologique aux environnements de formation à distance”*. Sciences et Technologies de l'Information et de la Communication pour l'Éducation et la Formation (STICEF), 2003, vol. 10, p. 89-126.
18. RISTOSKI, Petar et PAULHEIM, Heiko. ”*Semantic Web in data mining and knowledge discovery: A comprehensive survey*”. Web semantics: science, services and agents on the World Wide Web, 2016, vol. 36, p. 1-22.
19. Tom HEATH & C. BIZER. Linked Data: ”*Evolving the Web into a Global Data Space”* (1st edition). Synthesis Lectures on the Semantic Web: Theory and Technology, 1:1, 1-136. Morgan & Claypool. ISBN: 9781608454310. 2011.