**Lidia BAJENARU, PhD Student**
**National Institute for Research & Development in Informatics**
**E-mail: lidia.bajenaru@ici.ro**
**Professor Ion SMEUREANU, PhD**
**The Bucharest University of Economic Studies**
**E-mail: smeurean@ase.ro**

# AN ONTOLOGY BASED APPROACH FOR MODELING E-LEARNING IN HEALTHCARE HUMAN RESOURCE MANAGEMENT

**Abstract:** *The paper proposes to use ontologies for modeling e-learning process in organizing the educational information in Healthcare Human Resource Management in Romania (HHRM), in order to use existing health workforce data and information systems for decision making and human resource management and support. One of the main objectives of this e-learning system is related to the need for training the managers in charge with the health care system management in order to increase the system's quality and safety. The main benefit of the proposed e-learning method for the Romanian health care system is a tailored training system adapted to the needs of the professionals working in different areas of the management in a high degree hospital. This will be achieved by implementation of a modern e-learning technologies and specific ontologies. The proposed model particularity consists in implementation of domain specific ontologies using Protégé environment using a personal methodology according to the student's knowledge profile. The settling of the students' profile is based on processing their entry data to allow the training process personalization, automatically generated by the intelligent system. The student's profile is identified by integrating a static and a dynamic model. Due to this methodology, students will be able to receive the learning material by an e-learning system, according to their level of knowledge, preferences and interests: a personalized model – driven approach.*

**Keywords**: *E-learning, student model, domain ontology, human resource management, ontology, personalization, semantic web.*

**JEL Classification: D83, M12, I19**

## 1. Introduction

The e-learning initiative is part of the European Community strategy. Learning is the most indispensable activity in the current knowledge society,

characterized by industrial change, globalization, increased competition, technological revolution of information, transfer of knowledge.

Training has become a really global business. Due to the development of communication technology and the Internet, continuous training methodology takes new forms. Learning is being delivered by web, to become more flexible and accessible (Smeureanu 2011). E-learning training offers educational content delivered in an electronic form via Internet, wherever those who need it are. At the Lisbon European Council a major strategic goal has been settled: *"to become the most competitive and dynamic knowledge-driven economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion"* (Designing tomorrow's education 2000).

The e-learning goal is to "break" the barriers of time and space by the automation of learning (Pandit 2010). The term „Semantic Web" built a new WWW architecture that supports content with formal semantics, offering new possibilities for searching and navigating through the cyberspace. People and machine agents exchange information on the basis of semantic (Berners-Lee 1999). So the Semantic Web is an innovative technology that underlies the new requirements e-learning.

One of the main objectives of this proposed e-learning system is related to the need for training the managers in charge with the healthcare system management in order to increase the system's quality and safety. This system consist of a personalized e-learning process for those who intend to occupy a managerial position in a complex university hospital. The main benefit of the proposed e-learning method for the Romanian healthcare system is a tailored training system adapted to the needs of the professionals working in different areas of the management in a high degree hospital. This training method is intended to build the capacity of healthcare leaders and managers to use existing health workforce data and information systems for decision making and human resource management and support.

The e-learning system is based on semantic web technology and proposes an ontological approach to achieve personalization and reuse of educational materials. The aim of personalization is to provide learning materials tailored to personal characteristics and educational goals of the student.

The idea of personalization may be interpreted and implemented in different ways. A number of projects have focused primarily on the concept of learning style (e.g. European project 3DE Design, Development and Delivery - Electronic Environment for Educational Multimedia or context-student / user's profile (e.g. European LIP project Learning in Process).

The main contribution of this paper is to propose a student model, a domain model, an ontology-based learning path personalized in an e-learning system targeting members in HHRM. Ontologies are used to model educational domains and to build, organize and update specific learning resources (e.g. student profiles, learning paths, learning objects). We tried to eliminate one of the main

problems of educational domains - the lack of personalized knowledge for students.

To achieve this, we consider the elements of the system, namely the target group to whom it is addressed and the field of interest. This e-learning system addresses a staff management team in an university hospital, which require verification, updating knowledge, according to their profile, with notions imposed by the requirements of their professional position.

The knowledge domain offered to students consists of basic HRM notions and specific information related to the healthcare system.

The model looks for student progress, updating student known concepts and decisions with new information they should know.

This paper offers an ontology model in the e-learning system to structure the educational content in the domain of HHRM. HHRM objective is to provide adequate number of healthcare workers who have appropriate knowledge, skills and qualifications, and who perform the right tasks, in the right place, at the right time, in order to meet public health goals (Bajenaru 2014).

Human Resource Management (HRM) refers to the staff management and administration, with the goal to improve the organizational structure by increasing the performance of the organization's members, including the strategies developed by the organization on personal leadership and aligning it to the global strategies development of the organization.

The vast range of Web information makes difficult for a student in the target group to find personalized information to its training requirements.

We propose an effective method to improve the learning system by providing a personalized learning path, created using a student model, ontology and advanced educational strategies for the medical staff, with the aim to improve knowledge and support better human resources management.

## 2. Semantic Web and Ontologies

Searching for the student’s desired information on the web is a real problem due of the enormous amount of information. So with the emergence of the new technologies: semantic Web, information is interpreted not only by men but also of machines (Semantic Web). Thus search engine users more powerful and returns the desired information. The specific basic architecture and semantic web technology development is governed by the W3C (World Wide Web Consortium) – an international institution that oversees web standards used in the Internet.

The Semantic Web is a group of methods and technologies which allow machines to understand the meaning of information on the World Wide Web. It offers to developers new web-based technology applications that provide a more intelligent access to information on the web. In the context of the Semantic Web,

there are some aspects which offer reusability, sharing and interoperability among Web applications.

According to Berners-Lee, the structure of the semantic web is given by the existence of multiple layers of structure representation: (1) Extensible Markup Language (XML) - is the data structure, (2) Resource Description Framework (RDF) - is the data meaning, (3) Ontology - a formal agreement on what data mean, (4) Logic - allows intelligent reasoning with meaningful data (Berners-Lee 1999).

Stojanovic et al. (Stojanovic et al. 2001) illustrate how the Semantic web could be used to implement an e-learning scenario. Ontologies can be used to describe: (1) the content of learning materials, (2) the pedagogical context (such as introduction, analysis, discussion), and (3) the structure (the overall set of relations among parts of a course such as previous, next, is -part-of, references and so on). This three-fold ontology can be used to personalize access to learning materials.

Among the advantages of Semantic Web for e-learning, we emphasize: learning materials which are connected by ontology are offered on the web. This enables a student training program to be adapted by a semantic query for what he wants in a personalized manner, allowing the content to be determined by the student needs and aims. Ontology is the link between student needs and learning material characteristics.

The term ontology has been defined by Gruber (Gruber 1995), as the explicit specification of a conceptualization which facilitates the exchange of knowledge in a domain (that refers to the shared understanding of some domain interest).

Ontology is used to describe the meaning of shared formal vocabulary used into an interest domain (Stojanovic 2004). Ontology may be viewed as a declarative model of a domain that defines and represents the concepts existing in that domain, their attributes and relationships among them. It is typically represented as a knowledge base which then becomes available to different applications that need to use and/or share it.

Now, the development of a large number of applications in different fields, such as management, natural language processing, e-commerce, intelligent integration information, database design and integration, bio-informatics, education, etc. are based on ontologies.

Fernández-López and colleagues have identified the ontology development process and the ontology lifecycle in the framework of Methontology (Fernández-López et al.1997). Our proposed e-learning system is based on this methodology. Among the tools that provide support to ontology development process activities, a new generation of ontology-engineering environments, we mention some of them: Protégé (Noy et al. 2000), WebODE and OntoEdit. These tools have been designed to integrate ontology's technology in real information systems.

The information explosion of the Internet has led to the creation of ontology languages for the usage on Web features. Among all languages created,

those that are accepted are now actively RDF, RDF Schema and OWL. RDF (Klyne et al. 2004) was developed by the W3C as a semantic network based language for describing web resources. Ontology Web Language (OWL) (Allemang et al .2002) has been proposed as a W3C recommendation in 2004.

Ontology components are used in the semantic web, as a form of knowledge representation about the world. Ontologies generally describe: classes, attributes, individuals, relations.

Using ontologies to model knowledge in a particular field - like HHRM domain, is a key issue for the integration of information from different sources, learning objects, links, websites, to meet the needs of students correlated with their characteristics and profile (Niculescu et al. 2009).

## 3. Related work

### Student Modeling

The proposed e-learning system aims to address a number of unmet needs in HHRM training by adopting and implementing new concepts: focus on student personalization and student profile modeling, representation and knowledge education management. It proposes to implement the personalization concept and to demonstrate that the learning personalization requires new solutions for several aspects like: profile identification, students' knowledge, learning style, learning goal, training level, student's goal and context, knowledge formalization, student's competences, student skills level assessment and feedback.

The approach of the student modeling presented in this paper is based on adaptive web-based educational systems. The student model drives what should be further done about student training. This model is built incrementally by the system using data sources from the student (on the forms provided by the system) and from the interaction student-system. It provides the essential information about each considered student.

This adaptive system creates and maintains an up-to-date student model, and collects data for this model from various sources. This process is known as student modeling. Student modeling and adaptation are two sides of the same coin. The amount and nature of information represented depend largely on the type of adjustment that the system must deliver.

The proposed personalization model involves three main domains: (1) learning modeling process, (2) student modeling and (3) digital content modeling. The student model is based on the use of Information Management System (IMS) standard, which offers a conceptual framework for all three mentioned areas of expertise (IMS 2003). This choice was based on a global evaluation of the existing e-learning standards (e.g. SCORM, IEEE, and IMS).

For the proposed e-learning system, the personalization by name recognition, self-described personalization and cognitive-based personalization will be merged and inter-related. The cognitive data acquisition will be made using MCQ (multiple choice questions).

Several issues will be taken into account to specify the student model: (1) personalization requirements taken from student knowledge profile that results from his/her studies, (2) IMS standard recommendations, (3) optimized choice of learning style according to the students' cognitive features.

One of the most actual trends is to use the student model in particular to establish his profile and to guide the learning process according to it (Wilson et al. 2002).

In this approach, student's achievements records are based on the two aspects:

a) knowledge of the student's "background" (collected through a pre-assessment test) and

b) knowledge gained during the training process.

In general, the student model definition consists of answers to the following questions:

- "Who" - identification, evolution / history of the student's knowledge
- "What" - goals, plans, attitudes, capabilities, knowledge, benefits sought through training
- "How" - how is captured and maintained the model
- "Why"? – how are the data used in the model (assisting, sending a feedback)

All these techniques (to determine the student's current knowledge and objectives of training) lead to the construction of the student's model, which may be designed in a simple manner (as "static model" created once the onset of the training process, which does not change during student-system interaction) and more complex (as a "dynamic model" updated as the student progresses, accumulates new knowledge and achieves results in learning process) (Gomes et al. 2006).

The method we propose is to use both models: static and dynamic. The static model contains the following: personal identification data, cognitive profile, educational data and preferences. These do not change during learning. Personal data contain biographical information which are obtained from enrolment by a recording form. The student's cognitive characteristics may be identified by Ross and Witkin tests (Souto et al. 2003).

The student's cognitive style and experience level are required for providing appropriate tailored training content. The pedagogical data define the student's characteristics and include personal features: learning style, learning approach. Favorite student data contain his/her preferences regarding personalization. These are obtained from the system.

The dynamic model includes two sets of data: data on student performance and data on knowledge. All the results on performance data are stored in portfolio

stores. Data are collected continuously for updated data model. These data are derived from student-system interaction.

Knowledge domain ontology contains concepts referring to ongoing student progress on the concepts and skills specified for each item, describing concepts and skills relevant to the course, which the student must acquire by the end of the course. The student set defined for this type of course, target group and area, underly personalized approach e-learning system (Saraipa et al. 2012).

This proposed e-learning process requires a part of student modeling process, the definition of the process of adaptation / personalization, in order to obtain as a result a learning environment or experience more flexible and adapted by the learning experience and students' specificities. Student needs will be identified through this process (Brusilovsky et al. 2007) and will be met by delivering tailored education, providing learning adapted resources (Treviranus et al. 2008).

Students' interests are the most important part of the student profile in information retrieval systems and adaptive filtering, dealing with large volumes of information. The student model will take into account the features found when viewing the student as an individual person's knowledge, background, interests, goals and learning style.

The student's goal and interests are his aim to get immediately the needed information in an adaptive system. The student's background refers to a set of features of knowledge/experience from previous experiences.

The student's traits define the student' individual cognitive and learning styles (Riding et al. 1998). Learning styles defines the manner the student prefers to learn.

Student's profile was implemented with the Protégé environment (Protégé) (Figure 1, Figure 2).

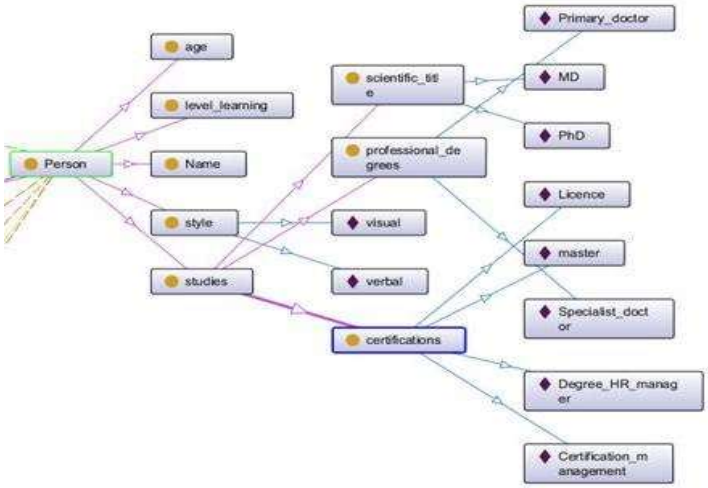


**Figure 1. Graph of student's profile**

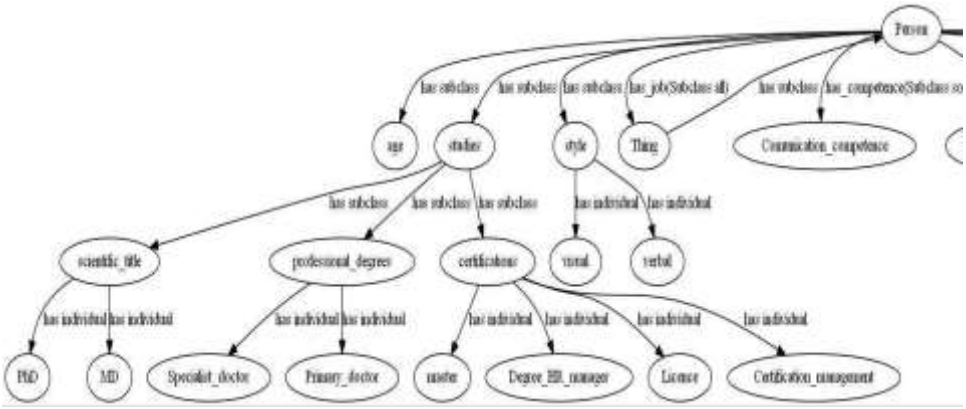


**Figure 2. Part of the student's profile ontology**

## The personalized approach in e-learning process

The proposed personalized e-learning system is an intelligent system with the following features:

- it uses a conceptual model of the considered domain – an Ontology
- a modeling based on the student's knowledge
- a knowledge-based analysis of student answers
- learning material generates dynamic and personalized web pages
- intelligent assistance

In developing learning specifications for this system, basic concepts of IMS standards (IMS Learning Design) have been adapted (IMS 2003), allowing the application and innovation of a variety of teaching methods and the interoperability of educational resources.

The ontological representation of proposed e-learning system can be seen in Figure 3.

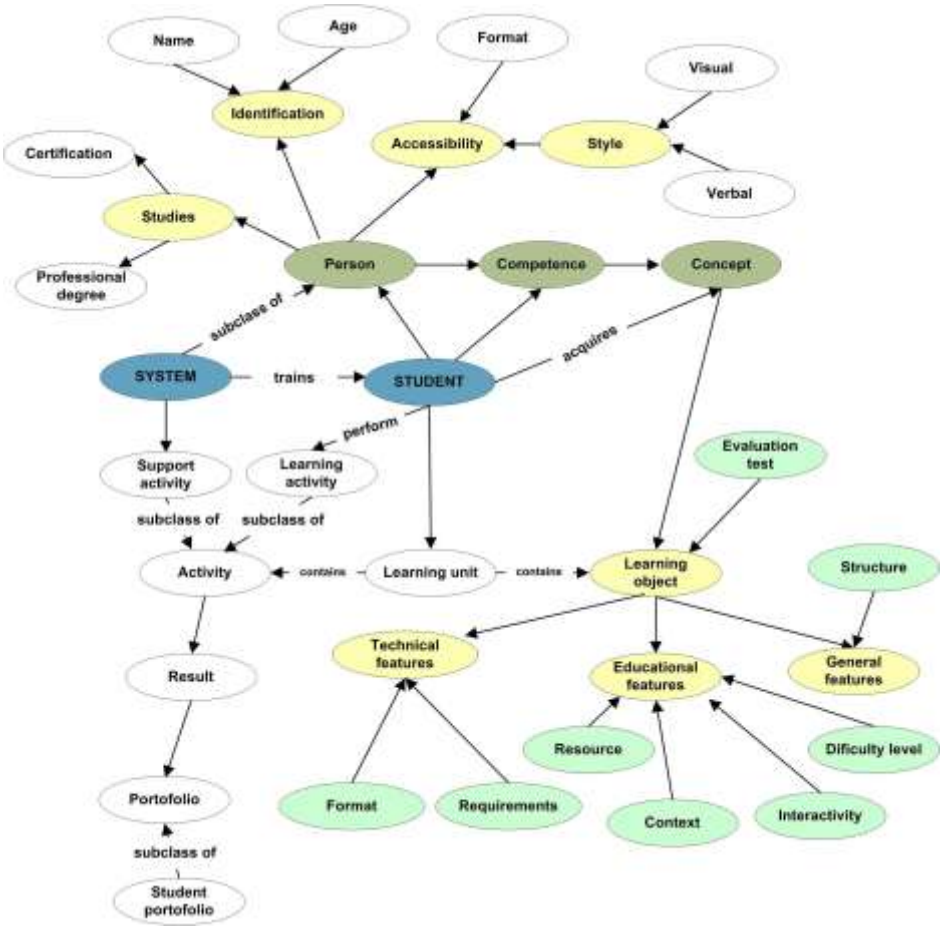


**Figure 3. Personalized e-learning system ontology**

UML (Unified Modeling Language) classes that describe the proposed system by showing the system's classes and the relationships among objects can be seen in Figure 3.

Next we present the scenario of the e-learning process.

After the student is registered for the training session he gets a pretest to be completed before beginning training. After scoring the test, the student's profile is supplemented with additional data (dynamic model).

The scenario learning path based on the level of knowledge of the student and his requirements should allow the students to access the content of a particular field of knowledge - in our case, the specific desired job, necessary to complete their specific knowledge.

The e-learning system will present a menu of options on how to customize and the presentation of the course. The system prefigures student profile after completing a form with personal data (static model) and data about learning style.

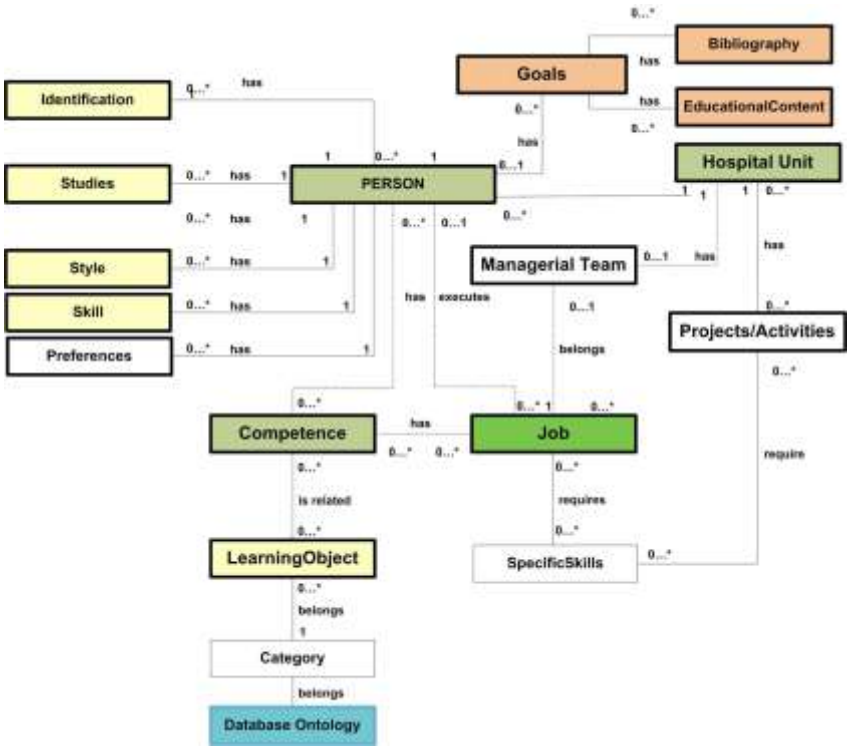


**Figure 4. UML e-learning process representation**

The system consists in: the unit of learning - depending on the score obtained in the test, the student' profile and other related information (level - beginner, intermediate, advanced). The student goes through the unit and gets the

results (assessment test for every module.) The system validates interim results, offers or not to grant students the right to continue the sequence of activities and update the student's profile. The system analyzes the student's profile keyword (e.g. learning style) and offers dynamic information (specific links, references etc.).

The system compares individual results to the questions (benchmark testing) to the necessary knowledge on the field, providing in the end of the training process feedback to the student, offering suggestions (recommendations) for additional training.

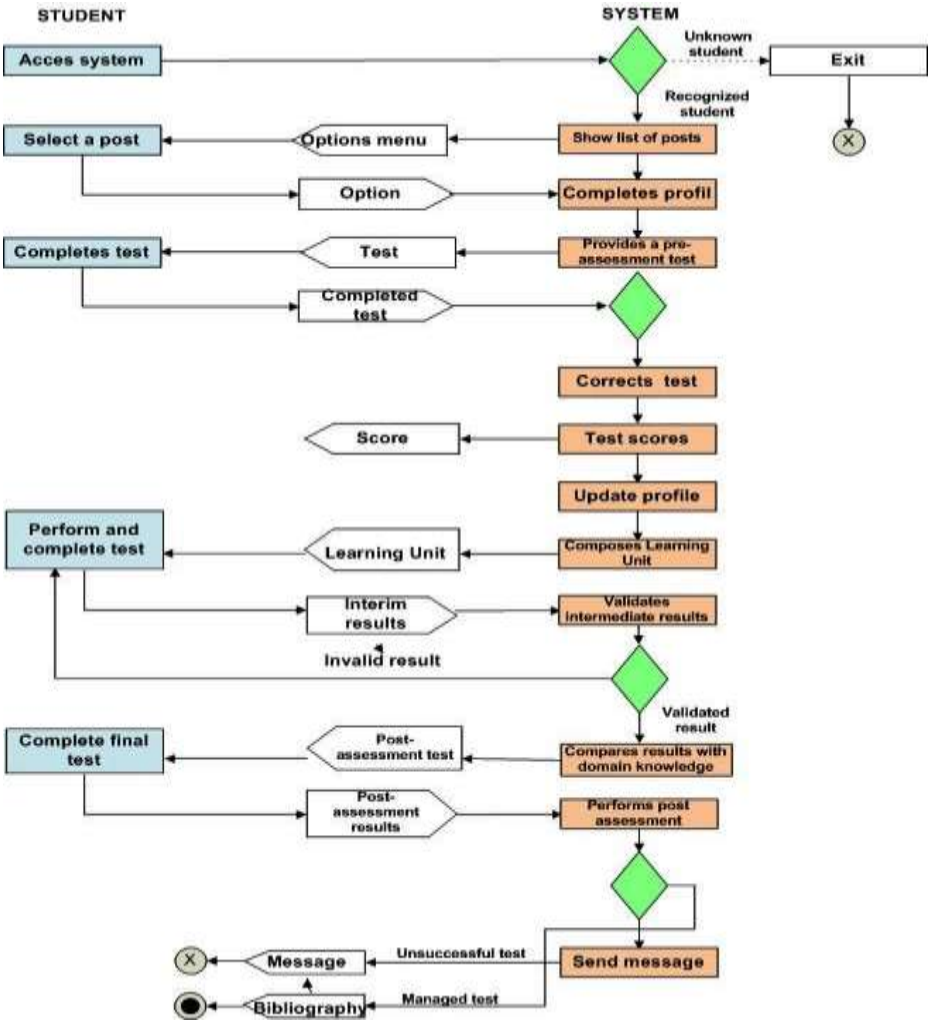


**Figure 5. Scheme of the e-learning activities scenario**

Assessment tests and dynamic information (specific links, references etc.) learning objects metadata enable a suitable choice of the learning objects as a personalized learning path. The UML activities diagram based IMS model is shown in Figure 5.

Depending on the profile and responsibilities of each management team member, they will have access to the e-learning platform, in order to obtain a personalized learning program based on a specific ontology, as well as to get bibliographies complying with their learning requirements.

## The Domain Model

The particular domain knowledge in our case is the human resources management in an university hospital in Romania, which has both elements (concepts) of general nature and particular to the specific health field. Concepts which must be acquired by the student in this e-learning process are organized into an ontology that represents the domain knowledge.

Knowledge modeling is a process of structured field modeling, which breaks down the body of knowledge in the respective field into a set of domain knowledge elements. These elements are named "concepts" and represent the mean elementary pieces of knowledge or information. The knowledge will be represented at different levels of abstraction, the lowest level being learning objects (LO). Learning objects must be indexed to allow the system to know which ones and how a given subject can be used in learning. This information is obtained from the second level of abstraction of knowledge represented by metadata.

The third level of abstraction (ontology) is used for the domain concepts and their relationships. A domain concept can be exposed by one or more LO. Learning objects (LO), based on IMS standard is a key concept in the project; they constitute the basic building blocks with which one can customize the content of the training materials provided to an individual student.

The implementation of our system ontology involved setting vocabulary, classes, relations between data and primitive data types, inference rules of the type if-then-else. Another important issue was the content sequencing, that is the order they are given knowledge (objects LO) to meet the students' needs.

## The ontology of the prototype

The ontological system underpinning e-learning in HHRM aims: to contain a complete and systematic knowledge base about the competences of the target group, to provide knowledge about competences, to enable the application of available knowledge to serve the set purpose. Based on the results of this stage, students will be able to grasp with better competence the evaluation of health services provided by hospital.

The document that were the basis for the implementation of ontological system concepts with Protégé open source editor are "A Practical Guide To Building OWL Ontologies Using Protégé 4 and CO-ODE" (Horridge 2011).

The HRM e-learning process concepts' partial hierarchy is shown in Figure 6.

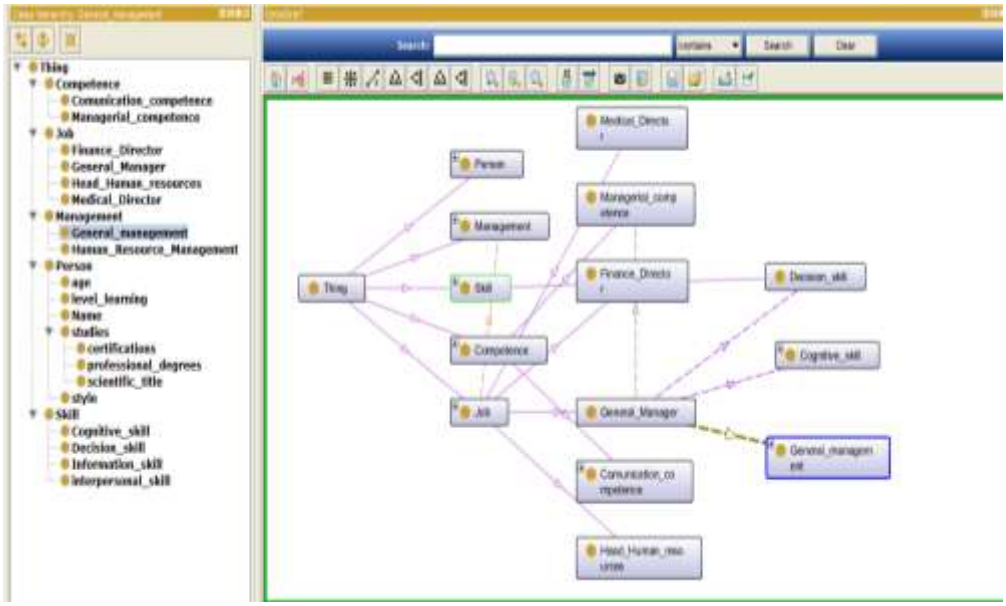


**Figure 6. Basic concepts of ontological e-learning system and their relationships**

During the knowledge acquisition phase, we collected all relevant information required for ontology conceptualization. The sources for the knowledge base were managers of a university hospital, and electronic documents to be captured an also the target group requirements.

The ontology represented by concepts, relationships and properties need to be extended with integrity rules and inference. Inference rules allow explicit knowledge's job. The knowledge base consists of information and students' skills, jobs and their competences and general and specific HRM concepts from an university hospital.

The representation of domain concepts in a structured and understandable form is done using Description Logics (Knowledge representation formalism Description Logics) (Figures 7, 8). The conceptualization phase will develop the ontology model.


**Figure 7. The concept "General_Manager" definition**

The ontology contains a conceptual system of the approach domain and rules for interpretation and use these concepts (Fig.8).

After completing the ontology, the result may be implemented into an e-learning system and used by students from HRM in the public healthcare system, in order to create and refine in a dynamic manner the management competences necessary in a general hospital activity.

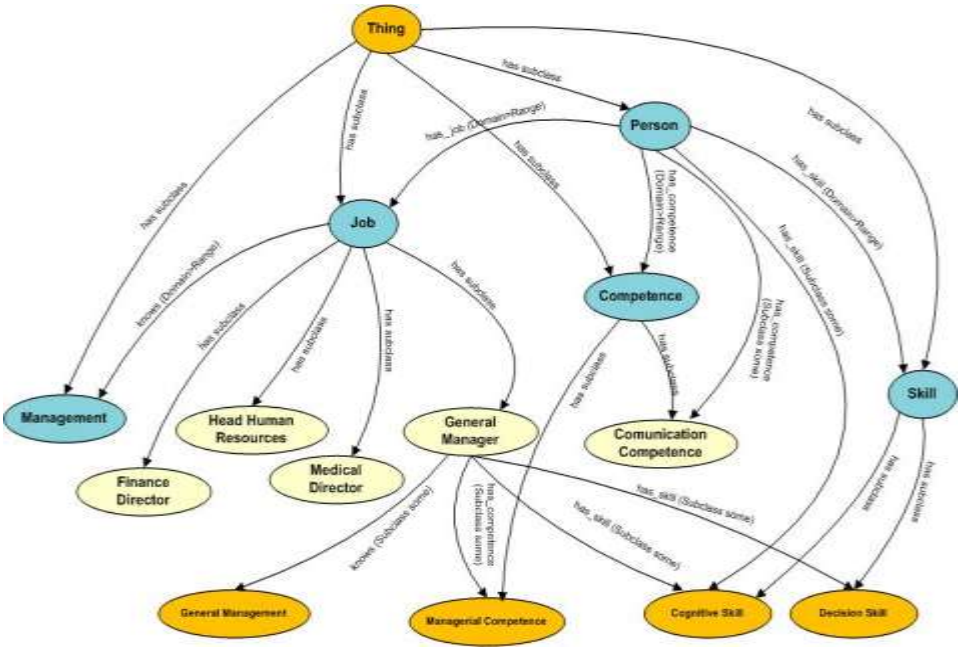


**Figure 8. An ontological representation for system concepts information**

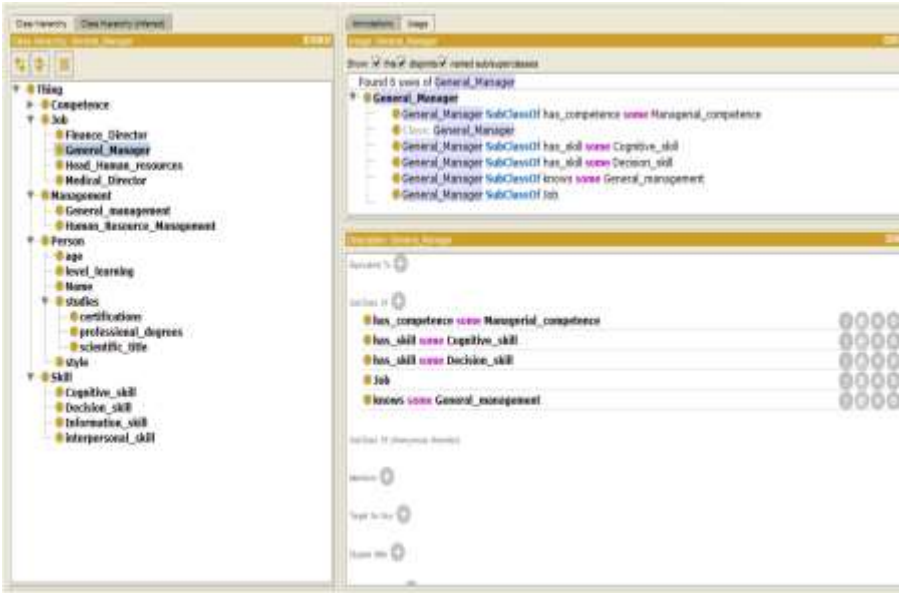


**Figure 9. Part of conceptualized structure of the proposed ontology**

E-learning for targeted students aims to improve performance, human resources competences and ability to assess the healthcare services provided by the hospital.

The improvement of e-learning system user's ability to accomplish their professional responsibilities will be considered as a first step of this learning/assessment process: the relationship between the hospital structure and staffing, the relation between the services demand and staffing, medical personnel migration, as well as methods to increase professional/hospital performance and motivation/stimulation of the medical staff.

## 4. Conclusions

This paper presents an approach of personalized e-learning process based on ontology. We presented student and domain modeling process and its implementation. Another important aspect of our work is the use of an ontology to map students' knowledge in course concepts, so that we can have better access to her / his progress and to adapt the content and navigation structure for a particular student. Future work involves experimentation of our system on a real exchange platform.

Both ontologies and standards specifications are used in knowledge representation in e-learning, which will facilitate the growth of intelligent systems.

Thus, all the specifications for e-learning development support, student modeling for generating accessibility to advanced and flexible e-learning services for all.

The purpose and originality of the project consists in the implementation of a new approach for the health system managers' continuous training, based on modern e-learning technologies and specific ontologies, in a complex area that needs urgent increase of efficiency and modernization, to respond to the public health requirements in the economic, social and political context of Romania in the new historical conditions of development and globalization.

The phase presented in this paper will be followed by defining complementary knowledge base of HHRM domain, ontology implementation into an e-learning system.

## REFERENCES

[1] **Allemang, D. Hendler, J. (2002),** ***Semantic Web for the Working. Modeling in RDF, RDFS and OWL;*** *Journal of Knowledge Management,* 6(1), 40-51;

[2] **Băjenaru, L., Borozan, A.-M., Smeureanu, I. (2014)**, ***An Ontology Based Approach for E-Learning in Health Human Resources Planning***; *Proceeding of the 13th International Conference on Informatics in Economy*, 352-357, ISSN: 2247-1480;

[3] **Berners-Lee, T. (1999),** ***Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by its Inventor***; *New York: HarperCollins Publishers;*

[4] **Brusilovsky P., Millán E. (2007),** ***Student Models for Adaptive Hypermedia and Adaptive Educational Systems; The Adaptive Web,*** *LNCS, Springer, Heidelberg,* vol. 4321, 3-53;

[5] ***Designing tomorrow's education***, *Communication from the Commission e-learning, European Union documentation*, 24 May 2000;

[6] **Fernández-López, M., Gómez-Pérez, A., Juristo, N. (1997),** ***Methontology: From Ontological Art towards Ontological Engineering***; Paper presented at the *Spring Symposium on Ontological Engineering of AAAI*, 33-40;

[7] **Gomes, P., Antunes, B., Rodrigues, L., Santos, A., Barbeira, J., Carvalho, R. (2006),** ***Using Ontologies for E-learning Personalization,*** *3rd E-Learning Conference*, http://elconf06.dei.uc.pt/pdfs/paper11.pdf;

[8] **Gruber, T.R. (1995),** ***Toward Principles for the Design of Ontologies Used for Knowledge Sharing***; International Workshop on Formal Ontology, Padova, Italy. In *International Journal of Human-Computer Studies*, Vol. 43, Issue 5-6 November / December, 907-928;

[9] **Horridge, M. (2011),** ***A Practical Guide to Building OWL Ontologies Using Protégé 4 and CO-ODE Tools Edition 1.3***, The University of Manchester;

[10] ***IMS Learning Design Best Practice and Implementation Guide***, IMS Global Learning Consortium, 20 January 2003, http://www.imsglobal.org;

[11] **Klyne, G., Carroll, J. J. (2004),** ***Resource Description Framework (RDF): Concepts and Abstract Syntax;*** *W3C Recommendation*, http://www.w3.org/TR/2004/REC-rdf-concepts-20040210;

[12] ***Knowledge representation formalism Description Logics***, http://dl.kr.org/;[

[13] **Niculescu, C., Trăuşan-Matu, S. (2009),** ***An Ontology-centered Approach for Designing an Interactive Competence Management System for IT Companies****; Informatica Economică*, vol. 13, no. 4;

[14] **Noy, N.F., Fergerson, R.W., Musen, M.A. (2000),** ***The Knowledge Model of Protégé-2000: Combining Interoperability and Flexibility***; *Proceedings of 2nd International Conference on Knowledge Engineering and Knowledge Management (EKAW'2000)*, Juan-Les-Pins, France, LNAI 1937, Springer-Verlag, 17-32;

[15] **Pandit, V.R. (2010),** ***E-Learning System Based on Semantic Web***; *International Conference on Emerging Trends on Engineering and Technology*, IEEE computer society;

[16] **Protégé**, http://protege.stanford.edu/;

[17] **Riding, R., Rayner, S. (1998),** ***Cognitive Styles and Learning Strategies: Understanding Style Differences in Learning and Behavior***; *David Fulton Publisher*, London;

[18] **Sarraipa, J., Baldiris, S., Fabregat, R., Jardim-Goncalves, R. (2012),** ***Knowledge Representation in Support of Adaptable E-learning Services for All;*** *Proceedings of the 4th International Conference on Software Development for Enhancing Accessibility and Fighting Info-exclusion*;

[19] **Semantic Web roadmap**, http://www.w3.org/DesignIssues/Semantic.html;

[20] **Smeureanu, I., Isaila, N. (2011),** ***Information Technology, Support for Innovation in Education Sciences*****;** *3rd World Conference on Educational Sciences*, vol. 15, 751–755;

[21] **Souto, M.A.M., et. al. (2003),** ***Towards an Adaptive Web Training Environment Based on Cognitive Style of Learning: an Empirical Approach***;

[22] **Stojanovic, L. (2004),** ***Methods and Tools for Ontology Evolution*****;** PhD thesis, Universitat Karlsruhe;

[23] **Stojanovic, L., Staab, S., Studer, R. (2001)**, ***E-learning Based on the Semantic Web***; *Proceedings of WebNet2001 - World Conference on the WWW and Internet*, Orlando, Florida, USA;

[24] **Treviranus, J., Roberts, V. (2008),** ***Meeting the Learning Needs of all Students through IT;*** *International Handbook of Information Technology in Primary and Secondary Education*, Springer US, 789-801;

[25] **Wilson, R., Villa, R. (2002),** ***Survey on Methods and Standards for Student Modelling;*** University of Strathclyde Glasgow, UK, IST-2001-33358.