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A Dynamic Composition of an Adaptive Course

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***Abstract*—**The number of framework conceived for e-learning constantly increase, unfortunately the creators of learning materials and educational institutions engaged in e-formation adopt a "proprietor" approach, where the developed products (courses, activities, exercises, etc.) can be exploited only in the framework where they were conceived, their uses in the other learning environments requires a greedy adaptation in terms of time and effort. Each one proposes courses whose organization, contents, modes of interaction and presentations are unique for all learners, unfortunately the latter are heterogeneous and are not interested by the same information, but only by services or documents adapted to their needs. Currently the new tendency for the framework conceived for e-learning, is the interoperability of learning materials, several standards exist (DCMI (Dublin Core Metadata Initiative)[2], LOM (Learning Objects Meta data)[1], SCORM (Shareable Content Object Reference Model)[6][7][8], ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe)[9], CANCORE (Canadian Core Learning Resource Metadata Application Profiles)[3]), they converge all to the idea of learning objects. They are also interested in the adaptation of the learning materials according to the learners' profile. This article proposes an approach for the composition of courses adapted to the various profiles (knowledge, preferences, objectives) of learners, based on two ontologies (domain to teach and educational) and the learning objects.

***Keywords*—** Adaptive educational hypermedia systems (AEHS), E-learning, Learner's model, Learning objects, Metadata, Ontology.

I. Introduction

TODAY on the Web the learning documents (courses, exercises, case studies…, etc) are in exponential growth, the objective of the new e-learning framework is the re-use of its resources for the composition of others adaptable to learner's profile learning materials. There are several works which were interested in the adaptation of learning materials, we can mention the project ELM-ART [18], InterBook [4], which are based on the adaptive hypermedia systems. Other projects like CANDLE (Collaborative and Network Distributed Learning Environment) [10], Karina [15], Sibyl [15], are based on the virtual documents. Learning Environment) [10], Karina [15], Sibyl [15], are based on the virtual documents. The objective of our work is to develop a module which composes a course or a teaching aid dynamically the objectives of the learners.

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The structure of this article is as follows: The first section introduces the subject. The second section presents the course concept, its fragments and its various educational roles. The third section presents the ontologies used; the ontology of the domain to teach (it describes the domain concepts and the relations existing between them) and the educational ontology (it contains the various concepts, describing the course designer know how). The fourth section presents the learner's profile, which includes the characteristics used for the course adaptation. The fifth section presents the various fragments and the various metadata used to describe their contents. The sixth section presents the methodology used to achieve our goal (the dynamic and adaptable composition). Finally a conclusion and future works are given.

II. The Course Concept

A course is a set of chosen resources to present a matter or a knowledge, it is defined by the teaching (or training) objectives with a precise finality. Nkambou [14] defines a course as being a structured document including a set of retained objectives and a set of links to educational resources or fragments. Every fragment plays a very determined educational role; it can be (a conclusion, an introduction, an example or an exercise of assessment, etc.). The Fig. 1 represents the structure of a course.

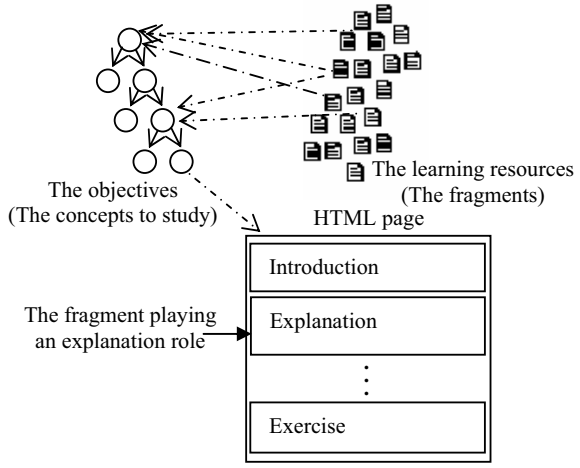

Fig. 1 The course's structure

III. The Ontologies

To compose an adaptive course, our approach calls upon two essential ontologies, that of the domain concerned and that of education.

A. The Ontology of the Domain

The ontology of the domain gathers the concepts of the studied domain and the relations, which connect them; we are interested to the domain of the Pascal programming language, the Fig. 2 represents the set of the concepts used, and the Sub concept relation that join them.

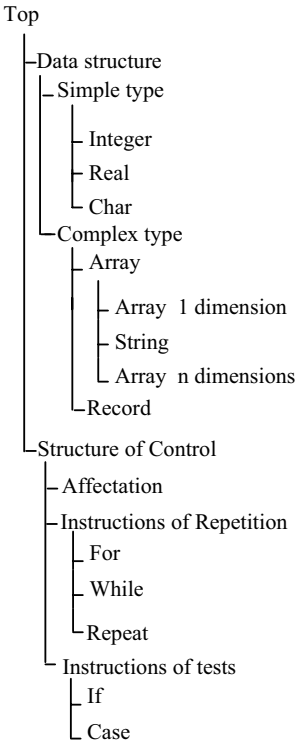

Fig. 2 The domain ontology concepts

B. The Educational Ontology

It regroups the educational concepts that are used for the annotation of the fragments (the educational resources). The Fig. 3 represents a part of the educational ontology used, it includes the concept "Educational role" which represents the different educational roles played by a fragment in a course, and the concept "Type of media" which defines the type of media used for the transmission of this educational role [15].

And the organization rules that are used to organize the disposition of the fragments in the course. The Fig. 4 represents a teaching rule of general order [15] that is valid whatever the context. For example "an introduction to a given concept precedes all other instruction concerning the same concept".

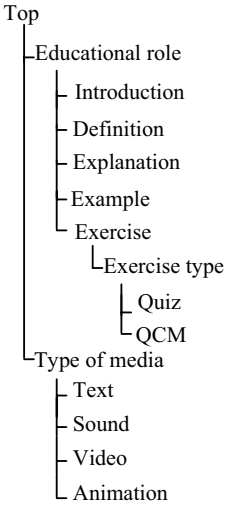

Fig. 3 Educational ontology concepts

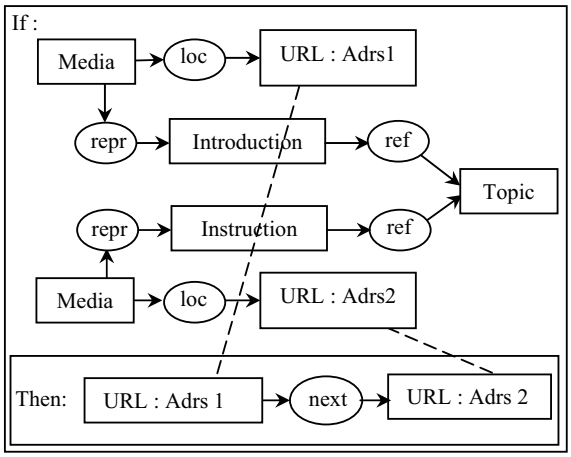

Fig. 4 A teaching rule of a general nature

IV. The Learner's Profile

The adaptation of a document or an application for a particular learner, requires the availability of information on this last, and the evaluation of the relevance of the available objects (text fragments, video, etc.), in order to help the system make the best choices. The user's model is a "source of knowledge, a data base on the user" [12]. More precisely, it is a set of persistent and relevant data, which characterizes a user or a particular group of users. Such model contains characteristics on the knowledge, the preferences and the objectives of the learners.

A. The Knowledge

The learner's knowledge appears as the most used characteristic in an adaptive education system; it represents the learner's background to a given domain. The simplest way to manage the knowledge is to memorize what the learner

knows or doesn't know. This information can be obtained explicitly from the user or implicitly by the system on the basis of inference rules. The knowledge is a variable parameter; indeed, the user learns new information every day. In order to be the most precise possible and the most coherent with the state of mind of the user, it is important that the adaptive system takes into account the changes and modify the user's knowledge model. Several models exist for learner's knowledge representation. We can mention the two most used ones:

A.1 The Stereotype

It is a generic model, which corresponds to a digest of the most representative characteristics of a group - or a class – of individuals, which we can describe as default values. The stereotype can be used just as it is, or from a point of view of a model individualization [16].

A.2 The Overlay Model

The overlay model can exist only if the system has a domain model. It associates a value for each concept of the domain. Each value estimates the level of learner's knowledge for the concept. The overlay model is easy to update, but often difficult to initialise. The actions of the learner are analysed in order to increase or reduce his knowledge level for each concept of the domain [4].

B. The Preferences

Learner may prefer an interface rather than another, a technique of particular adaptation (masking, annotation, etc.), or a particular author, a type of literature (Romance, science fiction, etc.). The preferences are used by the system for adaptation, selection of stereotypes, or to infer the user assumptions [11], they also make it possible to combine various individual users' models to extract new models, which will be used as a basis when new members arrive [5].

C. The Objectives

Learners are accustomed to reach only part of the information space – set of fragments -, which depends mainly on their objectives [5][17]. The objective is a state, which the user hopes to reach, and the plans describe the stages to arrive there. The tasks' models are very suitable to model these plans and consequently the objectives of the users.

V. The Fragments (The Learning Resources)

The learning resources are syntactically and semantically well described by the metadata (data which describe data), so that the system can choose the relevant resources to the preferences and the intellectual abilities of learners. Several standards exist for the semantic indexing of teaching resources. We can quote:

1) The standard DCMI (Dublin Core Metadata Initiative) [2], which provides a common core of semantics for the resources description. It includes 15 descriptive elements, which treat with the Contents (Description, Subject, Source, Coverage, Type, Relation), the intellectual Property (Creator, Contributor, Publisher, Rights), the Version (Date, Format, Identifier, Language).

2) Standard ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe) [9]. The project is centred on the development of tools and methodologies for the production, the management and the re-use of learning elements on computer. It adopts three types of descriptors for the learning resources indexing:

   a. **General information** (To identify, Authors, Date, Language, etc.).
   b. **Semantic attributes** (Learning goal, Main concept, other concept, etc.).
   c. **Educational attributes** (standard Document, Format, Level, Difficulty, Duration, ect.).

3) The standard LOM (Learning Objects Metadata) [1], which comes from the IEEE. It is built from Dublin Core, and supplements it by extensions specific to the educational field. The LOM specifies the syntax and the semantics of the educational metadata. It proposes nine categories for indexing the learning resources, each category is decomposed into several sub categories:

   a. General
   b. Lifecycle
   c. Meta-MetaData
   d. Technical
   e. Educational
   f. Rights
   g. Relation
   h. Annotation
   i. Classification

VI. The Methodology

To compose an adaptive course, we adopted an approach inspired from the "learning objects". It consists in choosing among the various learning objects, which are the most relevant to the learners' profiles (knowledge, preferences), and organize them according to chosen teaching strategies, to achieve the learner's objective. This approach is based on the following stages:

The annotation of the learning resources.
The determination of the concepts to be treated.
The selection and the filtering of the learning resources.
The resources organization.
The learner's evaluation.

A. The Annotation of the Learning Resources

This stage allows the annotation of each learning resource by the concepts of the two ontologies (domain to teach and educational). The annotations express the semantic relations between the resources and the concepts of the ontologies. In our approach, we used various courses in Pascal programming language, we cut them out in several fragments, and each

fragment is annotated by the concepts of the two ontologies. Fig. 5 represents the annotation process adopted. Each resource is characterized by:

1) The educational role that it plays, expressed by the relation "**RolePlayed**".
2) The concept that it treats, expressed by the relation "**Subject**".
3) The concepts necessary for its comprehension, expressed by the relation "**PrerequisiteConcept**".
4) Its difficulty level, expressed by the property "**DifficultyLevel**", which takes one of the values beginner, average, expert.
5) The type of media used expressed by the property "**TypeMedia**" which takes one of the values text, sound, video, animation.
6) Its estimated minimal comprehension duration expressed by the property "**Duration**".

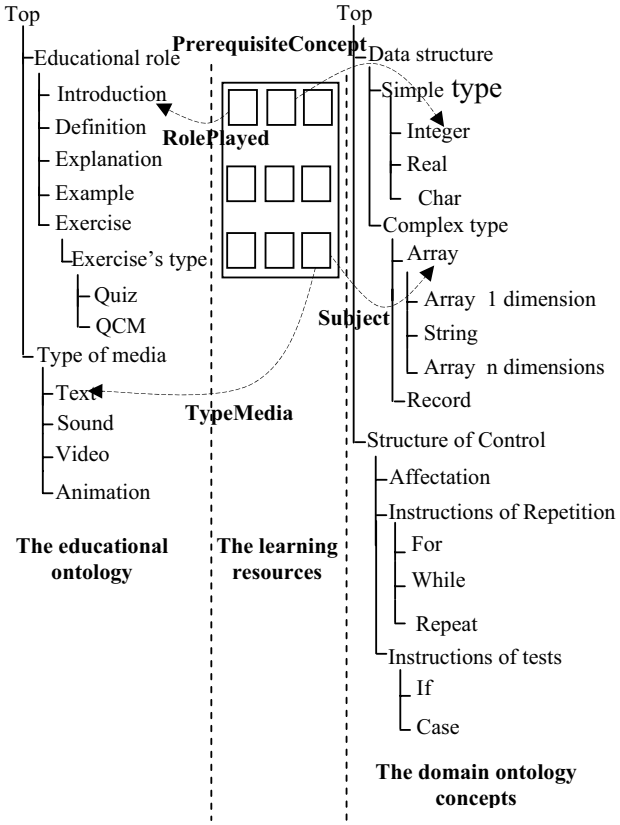

Fig. 5 The annotation of the learning resources

B. The Determination of the Concepts to be Treated

The learner determines its objective by choosing from the domain's ontology, the set of concepts that interest him. In this stage the learner's choice is supplemented by adding from the domain's ontology all the concepts that are necessary to achieve his goal. Concepts will be retained or removed according to the used pedagogical rules, the learner's knowledge, and the relations that connect the domain's concepts. Among the rules, we used:

Rule1: A concept is retained only if all its prerequisite concepts are acquired by the learner.

Rule2: If the concept selected has prerequisite concepts, not acquired by the learner, the system must add them.

C. The Selection and the Filtering of the Resources

This stage allows choosing for each concept selected the relevant resources to the learners' profiles. A teaching resource is relevant for a given concept, if its difficulty level is identical to the level of the learner's knowledge for this concept, and it satisfies the learner's preferences. Among the preferences that we used in this approach we will quote:

1) The types of media, the learner prefers (text, sound, video, animation).
2) The authors, the learner prefers consulting.
3) The types of exercises, the learner prefers to do (QCM, QUIZ).

To select the relevant resources we followed the following steps:

Firstly (Fig. 6), from the learners' profiles, we associate for each concept selected the correspondent learner's knowledge level.

Secondly (Fig. 7), we classified for each concept, the learning resources, according to their levels of difficulties and the preferences of the learner.

```
<Top Name= PascalLanguage>
  <HaveSubConcept>
    <Concept Name="Data Structure" Level="Expert">
    <Concept Name="Structure of control" Level="Beginner">
      <HaveSubConcept>
        <Concept Name="Affectation" Level="Average"/>
        <Concept Name="Instructions of Repetition" Level="Beginner">
          <HaveSubConcept>
            <Concept Name="For" Level="Average"/>
            <Concept Name="While" Leval="Beginner"/>
            <Concept Name="Repeat" Level="Beginner"/>
          </HaveSubConcept>
        </Concept>
        <Concept Name="Instructions of tests" Level="Average">
          <HaveSubConcept>
            <Concept Name="If" Level="Average"/>
            <Concept Name="Case" Leval="Beginner"/>
          </HaveSubConcept>
        </Concept>
      </HaveSubConcept>
    </Concept>
  </HaveSubConcept>
</Top>
```

Fig. 6 The representation of the levels of knowledge for each concept retained in XML

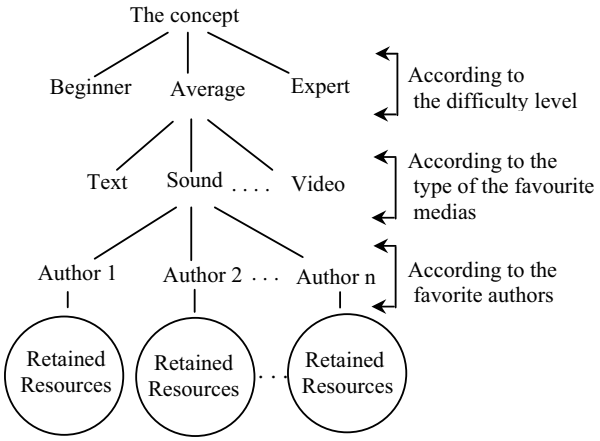

Fig. 7 The classification of learning resources.

D. The Resources Organization

After the selection stage, each concept will have as many resources as they are educational role for this concept, for example: introduction's resources, example's resource, exercise's resources, etc... This stage allows ordering the various learning resources, by using the teaching rules or the presentation's styles preferred by the learners.

E. The Learners' Evaluation

During each training session, the learner can acquire new knowledge, as it can improve them, for example it can pass from a beginner level to an average level, or from an average level to an expert level. These changes must be evaluated and recorded in the learners' profiles. In our approach the model used for the learner's knowledge representation, is the overlay model [13], where the domain's concepts are represented in a hierarchical form. Each concept can take one of the following values (unknown, beginner, average and expert). To evaluate this knowledge, we associated for each concept several test's resources that the learner must consult. Knowledge can be estimated quantitatively by numerical values or qualitatively like in the case of our approach, the knowledge's level takes one of the values, unknown, beginner, average and expert. The evaluation of each concept is carried out by the following rules [10]:

1) The rule R1, allows the evaluation of concepts which do have not sub concepts, it is expressed like this:

R1: $\exists$ n $\in$ N, *evaluation*(d, u, n).

For the other concepts their evaluation is deduced by inferences, for example:

2) The rule R2, evaluates a concept with "Unknown" because all its sub concepts are evaluated with "Unknown". It is expressed like this:

R2:$\forall$ c$\in$ D
(*direct-subconcept*(d, c) $\wedge$ *evaluation*(c, u, unknown)) $\Rightarrow$ *evaluation*(d, u, unknown).

3) The rule R3 evaluates with "beginner" a concept which all its sub concepts are evaluated "beginner" or "unknown" with at least one of sub concept is evaluated with "beginner". It is expressed like this:

R3:$\forall$ c$\in$ D
(*direct-subconcept*(d,c1)$\wedge$*evaluation*(c1,u,beginner)$\vee$ *evaluation*(c1, u, unknown)),
$\exists$ c2 $\in$ D (*direct-subconcept*(d, c2) $\wedge$ *evaluation*(c2, u, beginner)) $\Rightarrow$ *evaluation*(d, u, beginner).

Where:
D: The set of the domain's concepts organized hierarchically.
N: The set of knowledge's levels possible.
U: The set of the learners.
direct-subconcept(D, C): mean that the concept C is a direct sub concept of concept D.
evaluation(D, U, N): mean that the concept D is evaluated to level N for the user U.

VII. Conclusion

This module of composition was applied in the domain of Pascal programming language, comprising tens of concepts, to various profiles of learners. Each learner receives an adaptive course, according to his level, and his preferences. In the future we envisage to improve the ontologies used, by adding other concepts and other relations connecting them. For the teaching rules, we envisage to supplement them with more specific to the studied domain teaching rules.

References

[1] "Draft for Learning Object Metadata (LOM 6.1)", LTSC-IEEE P1484.12 LOM working group, 2001.
[2] "Dublin Core Metadata Element Set", version 1.0, September 1998.
[3] "Principles and positions one Learning Object Metada, 2003, document ISO SC36 N0430", The CanCore Subset Element, document ISO SC36 N0431, 2003.
[4] Brusilovsky P., Eklund J. and Schwarz E. "Web-based education for all: A tool for development adaptive courseware". Proceedings of Seventh International World Wide Web Conference, volume 30(1-7), pp.291-300. Computer Networks and ISDN Systems, 1998.
[5] Brusilovsky P., Schwarz E. and Weber G. ELM-ART: "An Intelligent Tutoring System on World Wide Web", International Third Conference one Intelligent Tutoring Systems, ITS-96, Montreal, 1996.
[6] Fletcher W., Handwork M., Herald S., "Sharable Content Object Reference Model (SCORM®), Content Aggregation Model (CAM)", Version 1.3, January 30, 2004.
[7] Fletcher W., Handwork M., Herald S., "Sharable Content Object Reference Model (SCORM®), Run-Time Environment (RTE)", Version 1.3, January 30, 2004.
[8] Fletcher W., Handwork M., Herald S., "Sharable Content Object Reference Model (SCORM®), SCORM Sequencing and Navigation", Version 1.3, January 30, 2004.
[9] Forte E., al., "Semantic and Pedagogic Interoperability Mechanisms in the ARIADNE Educational Repository", 1999.

[10] Iksal S., “Spécification Déclarative et Composition Sémantique pour des Documents Virtuels Personnalisables”, Thèse pour obtenir le grade de Docteur de l'EHESS à l'ENST Bretagne, 2002
[11] Kobsa A. “To use modelling: Recent work, prospects and hazards. In Schneider-Hufschmidt Mr., Kühme T. and Malinowski U., editors, Adaptive user Interfaces: Principles and Practice, North-Holland, Amsterdam, 1993.
[12] McTear M. F., “User modelling for adaptive computer systems: a survey recent developments”, Artificial Intelligence Review, 7: pp. 157-184, 1993.
[13] Murray T., “Authoring Knowledge based tutors: tools for content, instructional strategy, student model, and interface design”. Journal of the learning sciences, volume 7, 1998.
[14] Nkambou R. “Modélisation des connaissances de la matière dans un système tutoriel intelligent, modèles, outils et applications ”, thèse présentée à l’Université de Montréal, 1996.
[15] Ranwez S., “Composition Automatique de documents hypermédia adaptatifs à partir d’Ontologies et de Requête Intentionnelles de l’Utilisateur”. Informatique, Université de Montpellier II, Montpellier, France, 2000.
[16] Rich E., “Stereotypes and Use Modeling,” Chapter 2, pp, 35-51. Springer Verlag, 1989.
[17] Vassileva J., “A task-centered approach for user modeling in a hypermedia office documentation system”, in User Modeling and User-Adapted Interaction, Volume 6, pp.185-224, 1996.
[18] Weber G., Brusilovsky P. “ELM-ART: An Adaptive versatile sytem for Web-based instruction”. In P. Brusilovsky and C. Peylo (eds.), International Journal of Artificial Intelligence in Education 12 (4), Special Issue on Adaptive and Intelligent Web-based Educational Systems, pp 351-384, 2001.