AeLF: Mixing Adaptive Learning System with Learning Management System

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ABSTRACT

Several educational institutes use e-Learning platforms especially Learning Management System (LMSs) to manage the learning process. Adaptive Learning System (ALSs) supports the learning process using adaptive guidance and possibly personnalized content. The AeLF offers a new framework that brings the two systems together. This is done by a single sign-on, a User Model, an Experience Learner Tracker, a Domain Model and an Adaptive Engine. Authors can create structured course material and define the pedagogical rules through a graphical interface. The experiences learner tracker can detect all the interaction learner/system and a supple adaptation engine offers almost any type of adaptation a learner might want. This article presents the architecture of the AeLF environment, and describes the all its components.

Keywords:

Adaptation, adaptive learning systems, adaptive learning management system, learning content, adaptation engine

1. INTRODUCTION

Toward the last twenty years, two complementary technologies have been introduced in the world of the modern learning: e-Learning platforms (LMS[1] and MOOC[2]) and Adaptive Learning Systems (ALS).

LMS (such as Moodle[3], Blackboard[4], Sakai[5], etc.) is an integrated system which supports the learning process and administration. It presents an important package of services and features enhancing e-Learning. An LMS supports teachers in developing e-learning courses that students can enroll in. In addition, it allows the use of external learning materials (resources/activities) and the reuse of already developed learning materials . An LMS can support creating and serving tests, grading assignments, publishing course material.It can also allow a synchronous and /or an asynchronous communication between users (teachers, students or administrators) through chat rooms, discussion forums, etc.

Nevertheless this category of systems doesnt support the adaptation and personalization of courses; typically they present exactly the same course for every learner without consideration of the learners individual characteristics, situation, and needs[16]. Such a one-size-fits-all approach often leads to frustration, difficulties in learning, and a high dropout rate[23][34]

ALS supports the learning itself, by means of personalized access to course material. It allows selecting dynamically the most relevant learning object in order to present them at the right time and in the right direction for every learner. By taking individual learning differences and contexts into account, the ALS can improve learning outcomes, require less effort, reduce time required, and result in higher learner satisfaction. An ALS can, for example, adapt learning material/activities to a learners prior knowledge [7] [36], preferred learning style [33] [28] [17], affective states [35][13], and so on. Furthermore, this system can take advantage of nearby objects or people who might be able to help in the learning process [14][25], consider the characteristics of the learners environment, and take into account the features of the device a learner is using [21].

LMS is most advantageous for the institute (university, company),whereas ALS is most advantageous for the learner.But the AeLF (Adaptive e-Learning Framework) brings the world of LMSs and ALSs together in order to offer a powerful life-long e-learning solution. The AeLF is based on our experience with ALS-CP [1] developed in IRF-SIC Laboratory at the Faculty of science in Ibn Zohr University Agadir (Morocco). This new system allows integrating into LMS the main features of adaptation and personalization used in the ALS. In this paper, the all architecture of AeLF will be presented, including a description of each components of

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[1]Learning Management System

[2]Massive Open Online Course

[3]http://www.moodle.org/

[4]http://www.blackboard.com/

[5]https://www.sakaiproject.org/

its system and a full explanation of how adaptation can be brought about in the LMS using the AeLF.

This paper is outlined as follow: In the beginning, the background of Adaptive systems and the difference between AeLF and other previous systems will be presented. Afterwards, we explore the architecture of AeLF and we describe all its components and the capability of this work to achieve the adaptativity required in LMS. Finally the conclusion and the planned future work are presented in the last section.

2. OVERVIEW OF ADAPTIVITY IN LEARNINIG ENVIROMMENTS

This part will be devoted to the presentation of a general overview of adaptation in online learning environments. Then we will list the different approaches explored in the literature followed to make the LMS an adaptive systems.

2.1 Adaptivity in learning enviroments

The crucial criterion to providing a responsive learning environment that engages motivates and inspires learners, and through this leads to higher learner satisfaction, is **Adaptation**.

Adaptation and personnalization, allows the system to present the most relevant and interesting learning objet, while it avoids learning materials that only deal with knowledge the learner already acquired, or that is outside the learner's reach at the current time (but it may display that material later, after the learner has learned the necessary prerequisite knowledge). Educational institutes that use learning environments realize more and more that personalization is a key to creating acceptance of the technology for Technology Enhanced Learning (TEL) by the users.

Personnalization in courses is attained through adaptive learning technologies. These latter provide an environment that intelligently adjusts and adapts to a learners needs by offering pertinent information, instructional materials, feedback and recommendations founded on ones unique individual characteristics and situation [15]. Research has brought forward several adaptive learning solutions.

If we look at the wide field of adaptive learning solution, which are not only designed for adaptive lessons but for other adaptive applications as well. The most famous systems include ELM-ART[5], KBS-Hyperbook [20],AHA![4][10], Interbook[7], GRAPPLE[9][11] and APeLS[8].

The outstanding ELM-ART (Episodic Learner Model, the Adaptive Remote Tutor) adaptive Lisp course for Brusilovsky has not only traced the way for further developments but also became a standard for adaptive link annotations through a traffic light metaphor. By using green, red, grey and yellow colors the ELM-ART can indicate the recommendation of links to content pages. Many later systems, including AeLF have inherited this metaphor.

Instead of a single Lisp course offered by ELM-ART Brusilovsky has created Interbook for providing a platform that could be used for various courses. An author would essentially redact text content in Microsoft Word which is used as the authoring tools for Interbook. Each outcome concept is associated with a fragment of text (paragraphs or sections) which would be marked as being a

prerequisite for other concepts. The content writing in Word will be converted into an adaptive e-learning course just in a press of a button.

The system adaptivity is always based on information about all its users. For this reason the user modeling is a key to success of any adaptive system. Practically user modeling is founded on rules that translate user actions in to user information which can be exploited later. Visiting a course page, to read a text or watch a video, means that you study a concept. That information can be confirmed through a test. Its also used to confirm that you fill prerequisites for learning other concepts. We will see this in AeLF as well.

Knowledge levels of short concepts also totalize to knowledge about chapters and whole courses. Its as if the knowledge of a chapter is being built from the knowledge of underlying sections, and knowledge of the sections being built from the knowledge of the paragraphs or the underlying pages. This approach may provide the false impression that an adaptive system certainly recognizes what goes on in the users mind, with absolute certitude.

However another approach to user modeling, via Bayesian Networks is taken by KBS-Hyperbook for example. The interactions user/system amend the confession of the system that the user acquired certain knowledge. To deal with positive / negative signs of the users knowledge, preferences, interests or any other type of information in Bayesian Networks is easy even in systems that simply employ event-condition-action rules to update knowledge progress.

In the latest versions of AHA! (Adaptive Hypermedia Architecture) an author can define arbitrary adaptation rules and arbitrary presentation. Arbitrary adaptation rules in which the user model can update the rules allows using any model or interpretation of the information about the users. Besides, the content in AHA! is authored in HTML, and also delivered as HTML page contrary to the use of Microsoft Word for authoring in Interbooks. So that authors friendly with HTML can provide an AHA! outcome with any look and feel they desire. So as to manage the complexity of supporting arbitrary presentation and arbitrary adaptation rules AHA! had to distinguish the authoring of the content and presentation from the authoring of the adaptation.

ELM-ART, Interbook and AHA! are examples of systems that support learning process. The learner receives guidance through link annotation and through the conditional fragments. Other support for the process of navigation and the use of services can be found for instance in GRAPPLE and APeLS.

GRAPPLE (Generic Responsive Adaptive Personalized Learning Environment) is a life-long learning solution based on the adaptive hypermedia system AHA!. The GRAPPLE is being developed and integrated with the major LMSs, using a service-oriented architecture approach. The main components of GRAPPLE are GUMF (GRAPPLE User Modeling Framework) which represents the learner in the system, GAT (GRAPPLE Authoring Tool)- which is used by teachers to create the conceptual and pedagogical structures of a course- and to associate content with concepts, and the adaptive engine GALE (GRAPPLE Adaptive Learning Environment). The role of the GALE is to provide adaptive content to each learner based on the GUMF and pedagogical rules generated by GAT.

In the same spirit APeLS (Adaptive Personalized eLearning Service) ,created by Conlan and Wide, is a multi-model, metadata driven adaptive e-learning system that can integrate adaptive fonctionnality in LMS. APeLS puts the content, narrative, and learner into distinct models. The adaptive engine which is used in APeLS is a rule-based engine that provides a model for personalized courses based on a narrative and the learner model.

So far, we havent given a full overview of the introduction of adaptive functionality in online-learning.We have only mentioned a few influential developments. In the next part we will introduce different approaches explored in the literature used to integrate ALS in LMS.

2.2 Adaptivity from ALS to LMS

Adaptation in online learning environments is often considered as a problem of providing adaptive course sequencing, see e.g. [18] also of supporting by e-learning standards such as SCOORM[6] and IMS LD[7].In the AeLF we approach the question of adaptation from the viewpoint of ALS. Brusilovsky [5][6] defined a taxonomy of adaptive techniques and methodes used in ALS and Paterno[27] updated it, (see [3]). The figure 1 below shows these methods and techniques. Others methods and techniques can be identified from the literature (see c.g [24]), but they are merely variants of the elements presented in this taxonomy. View the lack of space we will
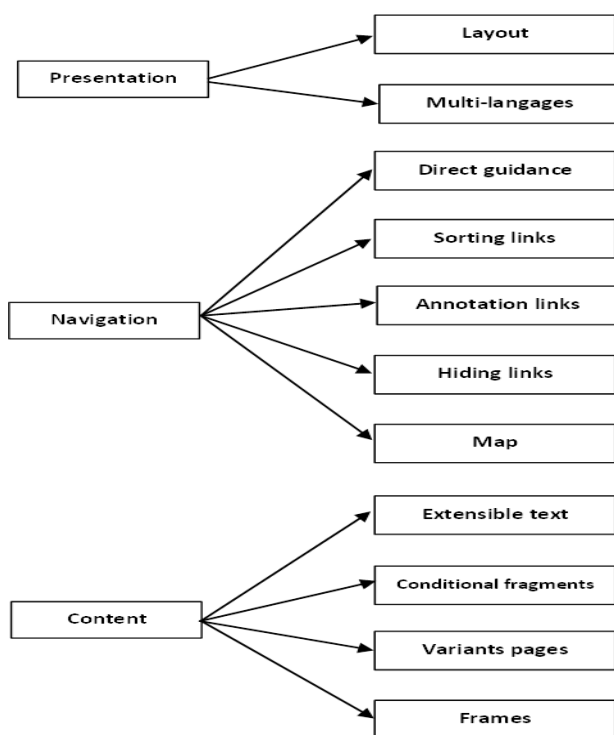

Fig. 1. Methods and techniques of Adaptation in ALS

not explain its all. By cons, we will set out the different approaches

explored in the literatures allowing to integrate these methods and techniques in LMS. These are the following approches :

(1) **LMS extensibility**,
(2) **Modifying LMS source code**,
(3) **e-Learning Standards**,
(4) **A framework communicating with LMS**,
(5) **LMS customization**.

2.2.1 LMS extensibility. The idea of this approche is to incorporate an extension module (plug-in) that can provide features of adaptivity based on the profile of each learner. Several studies have been based on this approach, including the work of the author Sabine Graf [29], Gert Sauerstein [31] and Andre Scherl [2]. Based on this approach, the author Graf [29] integrated sorting adaptive link in the LMS Moodle. The author Sauerstein [31] incorporated annotation links through a traffic light metaphor in Moodle. Finally, Scherl [2] implemented other features namely adaptive navigation map, annotation links and direct guidance also in Moodle.

2.2.2 Modifying LMS source code. This approche is mainly concerns the Open Source LMS. This important feature of this category allows developers to access the source code, read it, understand it and modify it according to the objectives. In this vision, the author Jantke [22] integrated a PHP script to the source code Moodle in order to add some adaptive features to this platform. Among these, we cite the display of adequate resources to the learner or group of learners and the hide of the non adequate ones based on their interactions. Thus, the automatically reassign of learners to groups in response to their individual behaviors and success in the context of learning.

2.2.3 e-Learning Standards. The approach described in this section relates to the use of e-Learning standards and norms, such as: IMS-LD[8], IMS QTI[9], SCORM[10], xAPI[11]...etc, as a way to individualize courses for each learner enrolled in LMS. These standards can be operated in two different views. The first point of view is to use *the standards as a means for creating adaptive learning scenarios*. These can be imported and run in the LMS to deliver learners with individualized learning experiences. This vision is supported by Santos[30]. While the second view affirms *that standards are means of information on the experiences and state of learning of each learner*. This vision is supported by the author Moisa [26]. Moisa's work consiste to use SCORM and xAPI as a provider of information on the learning progress of each learner. These informations will be processed via adaptive learning algorithms in order to individualize content according to the characteristics of each learner.

2.2.4 A framework communicating with LMS. This approach, which we have adopted in this work, concerne the use of a framework as an adaptivity services producer communicating with the LMS. Adaptation via this approach is not delivered directly from the framework, but it's delivered via the interface of LMS. In literature, the frameworks of adaptation are generally composed of different models communicating each other. Among them, we identify the model of the learner, the domain model and an adaptation engine that reconciles these different models to present an individualized learning path for each student at the time of execution.

Communication between the framework and the LMS is provided either via a communication API, web services or http requests. The approach presented in this part was supported by several authors namely Conlan with the framework APeLS [8] and Paul De Bra with the framework GRAPPLE [11].

2.2.5 LMS customization. The main idea of the LMS customization approach is the adaptation of courses in the LMS without the need to develop new modules, or design entirely new solutions. This approach essentially consists of two steps: **(i)** *categorization of learners according to homogeneous groups with respect to different criteria such as: learning style, cognitive level ... etc;* **(ii)** *the development of educational resources tailored to each group.* Among the authors who have adopted this approach, we quote the author Despotovic-Zrakic[12] and the author Surjono[19].

In the next section we are interested to present the architecture of the proposed system and its capacity to achieve adaptativity in LMS.

3. AELF:A SOLUTION FOR ADAPTIVE LMS

In this section, we present the main contributions of the paper. First we clearly demonstrate the infrastructure of the AeLF and then we describe each components of its system. The infrastructure design of the proposed system consists of by five central components Figure 2.

This figure show the main components of and the subcomponents of the AeLF. Below, we give detailed descriptions of each components and a clear explanation of its features and interactions between them.

3.1 The AeLF User Model

One of the most important questions in adaptive learning is how the system can provide a rich representation of the learner. AeLF uses a common distributed learner model: AUM (AeLF User Model). In order to make learners an actor in the construction of their model, the AUM is open for editing and viewing by both the system and the learners themselves. Therefore it holds information and makes it more reliable and more representative of the learner. Three kind of information are considered in the AUM: personal (name, email address, phone, picture, etc.), preferences (language preferences, favorite colors, the preferred type of educational content, etc.) and Knowledge of learner that is described in relation to each domain model. This component grows dynamically as learners progress in their course. The AUM consists of two main parts:

— **Static model**: which contains the data indicated by the learner in their first connection to the system. This part can be updated by the learner at any time of their learning throughout a questionnaire delivered by the system.

— **Dynamic model**: the information stored in is updated only by the AeLF and very dependent on the results and interactions of the learner with the content displayed (by the LMS interface).

As outflow, of the form (Figure3), an XML file is generated. We propose later a part of an AUM file.

```
1   <?xml version="1.0" encoding="iso-8859-1"?>
2   <!DOCTYPE learner SYSTEM "learner.dtd">
3   <learner>
4       <statique>
5       <identification>
6           <fistName>Aimad</fistName>
7           <lastName>QAZDAR</lastName>
```
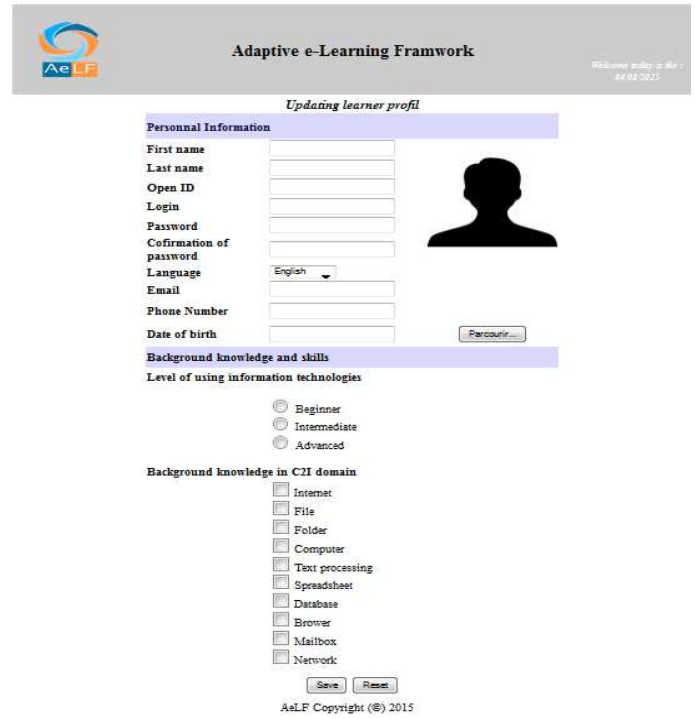

Fig. 3. The AUM updating learner profil.

```
8           <email>aimad.qazdar@gmail.com</email>
9       </identification>
10      <securite>
11       <openId>
12        https://plus.google.com/u/0/103398311087175068349/
                 posts
13       </openId>
14       <login>a.qazdar</login>
15       <password>g112345hjhdkllml</password>
16      </securite>
17      ....
18      </statique>
19      <dynamique>
20      <concepts>
21      <concept>
22       <id>Cl</id>
23       <etat>required</etat>
24       <cumul>16</cumul>
25       <pourcentageAcc>80</pourcentageAcc>
26      </concept>
27       ...
28      </concepts>
29       ...
30      </dynamique>
31   </learner>
```

3.2 The AeLF Domain Model

The AeLF Domain Model (ADM) is described by its faculty in the representation of concepts to learn, the resources available to learners and the structuring of several elements of the domain. The ADM has been separated into three parts:

— **Content Repository**: it contains resources that deal with domain concepts. These resources can be presented as an introduction, definition, example, exercise, paragraph, comment, etc. Each of these resources is described by a single multimedia brick
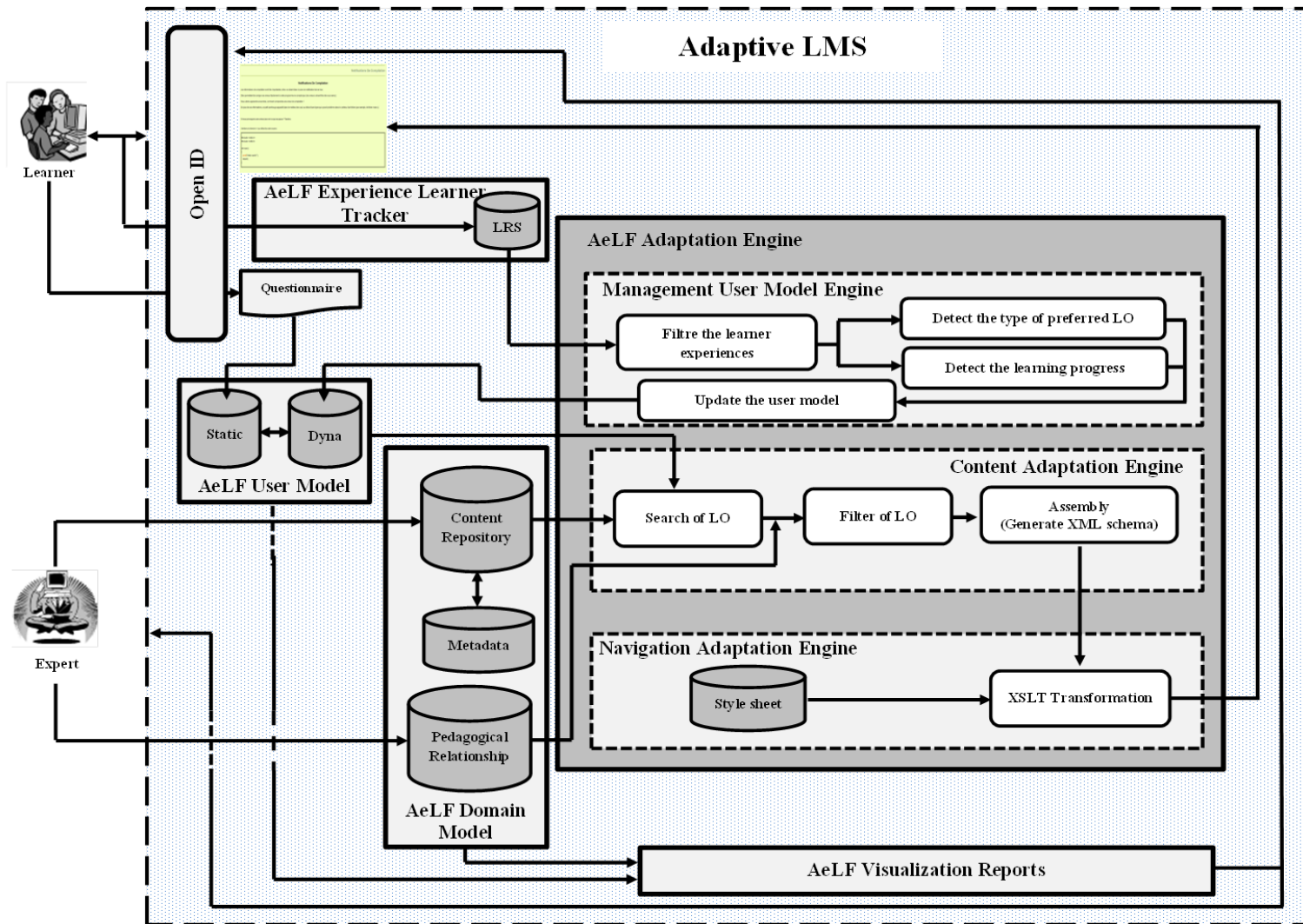
Fig. 2.   The overall AeLF infrastructure.

and can be presented in different formats: text, image, sound, video, simulation, and animation.

—**Meta-Data** : it stores various metadata to describe the different fragments. We used some elements of the LOM standard. Among these metadata we quote: id, title, language, format description, keyword, type of interactivity (active, transmissive, collaborative, communicative, not defined), the level of difficulty (easy, medAUM, hard), semantic density (very low, low, average, high, very high) and learning time etc.

—**Pedagogical Relationship** : it stores all relationship between concepts. We chose to use two most important relationships :

—**IS-PREREQUISITES-OF**: the prerequisites indicate relationship such as the acquisition of a concept B is subjugated to the mastery of the concept A that precedes it.

—**IS-COMPOSED-OF** : the composition relationship means that the description of the parent node is performed with the aid of the description of its components. Example a concept A is composed of the following concepts B, C and D.

As output, of the form (Figure4), an XML file is generated. We present follow a part of the metadata XML file.

```xml
<?xml version="1.0" encoding="iso−8859−1"?>
 <!DOCTYPE learner SYSTEM "metadata.dtd">
  <metadata>
   <general>
    <identifiant>Def_Informatique_1</identifiant>
    <intitule>D finition de l informatique</intitule>
    <langue>fr</langue>
    <description>
     cette ressource defini le concept d informatique
    </description>
    <keyword>informatique; information; traitement</keyword>
   </general>
   <lifecycle>
    <version>1.0</version>
    <statut>final</statut>
    <owner>
     <name> Chihab Cherkaoui</name>
     <email>ccherkaoui@gmail.com</email>
    </owner>
```

```
20        <preparedBy >
21            <name>Aimad  QAZDAR</name>
22            <email>aimad.qazdar@gmail</email>
23        </preparedBy>
24        <revisedBy>
25            <name>Brahim  Er-Raha</name>
26            <email>erraha@gmail.com</email>
27        </revised>
28        ...
29     </lifecycle>
30  </metadata>
```


Fig. 4.   The ADM editing learning ressource metadata.

3.3   The AeLF Experience Learner Tracker

The main role of the AeLF Experience Learner Tracker (AELT) is to catch all the interaction between the learner and the LMS. The AELT is based on the standards xAPI. The xAPI describes the interaction as statements. Every single is comprised of an actor, an action, and an object. I (actor) did (action) this (object). All these statements will be stored in LRS (Learning Recording system)[32]. All information recorded in the LRS will be operated by the Adaptive Engine to update automatically the dynamic part of the AUM.

3.4   The AeLF Adaptation Engine

The AeLF Adaption Engine (AAE) is the core of the AeLF. It deals with the automatic production of adaptive content that will be presented later to the learner through the LMS interface. This component has three sub-components: (1) the Management User Model Engine (MUME), (2) the Content Adaptation Engine (CAE) and (3) the Navigation Adaptation Engine (NAE). Every single contains a set of rules to enable the adaptation:

—**The Management User Model Engine (MUME)**: the role of this component is to filter the experiences of the learner, to detect the types of favorite OP and the learning progress. Finally it permits to update the dynamic part of the AUM.

—**The Content Adaptation Engine (CAE)**: this component is used to produce individualized content based on the AUM of each learner. It allows providing a similar content, additional content, and alternating or hiding the contents. First of all it allows searching the LO based on their metadata and the AUM. Then it filters the LO based on predefined pedagogical relationships. The filter process is explained in Figure 5.
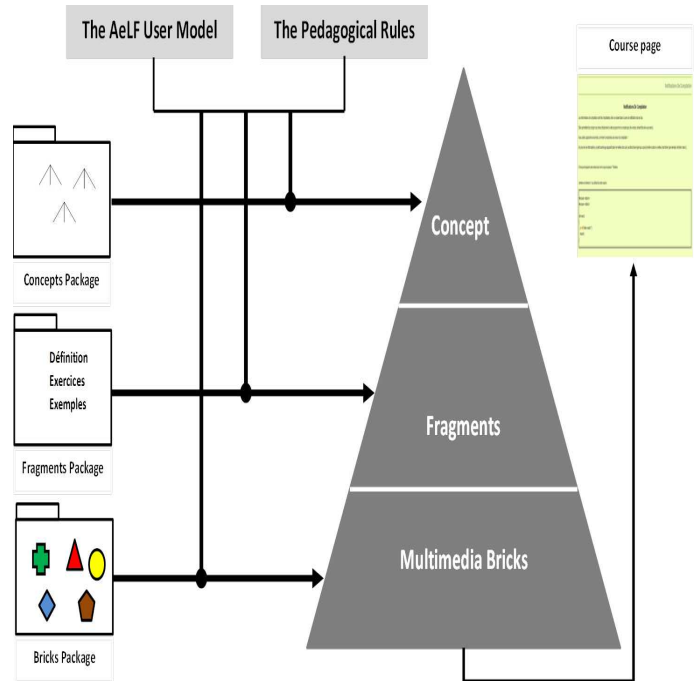

Fig. 5.   The assembling courses process.

Finally the CAE organizes and brings these LOs in an XML file that will be transferred later to the Navigation Adaptative Engine.

—**The Navigation Adaptation Engine (NAE)**: by combining the XML file with style sheets the presentation of the link anchors can be adapted. This realizes the direct guidance, the link annotation, and it can also realize the link hiding. Although NAE can use any number of arbitrary colors we typically use the color red to indicate non-recommended link, green for the recommended unvisited link, gray for the recommended visited and yellow for the current link.

3.5   The AeLF Visualization Report

The interaction of users with AeLF through the LMS interface results in large amounts of data that can be visualized for both authors and learners. The AeLF Visualization Report (AVR) is a part of the AeLF which is used by teachers and learners to view progress reports in order to observe learners progress and understand the learning processes. The AVR is not described in this paper.

As AeLF aims at supporting life-long learning it provides an architecture through which different LMSs can interact with a distributed user model (AUM. AUM is used by AAE as an extra source of user information on which adaptation is based. The top left of Figure 2. shows the Open ID identity provider [12] which is not developed within the AeLF project. In order to have life-long learning support the learner should have an identity that can be used everywhere: on different LMSs and on AeLF. Moving to a different university, an institute or a company can be done without losing the user model stored in the shared AUM service.

When a learner interacts for the first time with the system, the list of concepts learned in the AUM is empty. The concepts stored in the IDM without preconditions and have not been acquired by the learner will initialize the list of active concepts. This allows deciding on the objective of the session. Some elements of the AUM can impact this decision. This impact comes from the background knowledge and skills of the learner represented in the AUM like use of information technology level (beginner, intermediate, Expert), or the background knowledge built from a set of concepts about the domain in study, such as the C2I domain (file, folder, computer, text processing , spreadsheet , database, navigator, and mailbox, etc..). Each decision is controlled by some pedagogical rules.

The selection of one or more concept(s) related with other information depends in particular on the representations of the learner, especially the sequence that will be derived after in fragments. If, for example, the AUM indicates that the learner prefers to study by examples, the sequence will contain more examples. For exercises, the difficulty level will rely on information extracted from the AUM corresponding to her/his level (Beginner, Intermediate, and Advanced). This sequence corresponds to a prototypical sequence of fragments to complete the selected learning concept. Depending on the AUM, the system associates a multimedia brick with each fragment of this sequence. If the AUM indicates for example that the learner prefers pictures and videos, the system will promote anything that is multimedia. If she/he prefers reading on the screen, the text associated with fragments will be used to create a course page.

4. CONCLUSION AND FUTURE WORK

As the e-learning platforms (LMS and MOOC) have become used more and more as learning environments in several educational institutes, the lack of adaptation in these systems has become an issue.

In this paper, we showed the structure of AeLF as a new framework of adaptivity in LMSs. We also described all its components and features like Single Sign-On. Finally we explained the process used in AeLF to turn a static course in LMS to an adaptive course.

It is clear that to arrive at the expected system several issues remain to be addressed. Our proposed solution continues along these lines to try to finish a first functional prototype which will be tested and validated.

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[12]http://openid.net/

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