Research on New Generation e-Learning System for Ubiquitous Learning

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ABSTRACT: ***After years of research on ubiquitous learning, there is a trend of incorporating ubiquitous learning into mainstream of education. This demands new generation e-Learning system for learning anywhere, at any time, with any device. The paper introduces our on-going research efforts in the field. In the work, the concept called Ubiquitous Learning Object (ULO) is proposed, and the functions on a ULO can be extended flexibly with API implemented in web service. Besides, ULO is designed according to knowledge point of a course according to pedagogical requirements in ubiquitous learning environment. With the concept of ULO, a metadata model called Semantic-oriented Ubiquitous Learning Object Model (SULOM) is designed, and the model provides foundation for the realization of new type of courseware which can be delivered to different terminals adaptively. Now, the concept of ULO and the model of SULOM have been realized based on Fedora (an open source system), and the aforementioned approaches have be initially validated.***

KEYWORDS: ***Ubiquitous learning; Ubiquitous Learning Object; Semantic-oriented Ubiquitous Learning Object; Course Ontology***

I. BACKGROUND

With the development of wireless and embedded technologies, the research on Ubiquitous Learning (u-Learning) has become a hot topic worldwide. Taking research in this field in Europe as an example, there have been many large-scale and impacting research activities on u-Learning since 2000, which can be classified into three stages: (1) The exploration stage. In this stage, the main issue is how to present learning resources on mobile terminals, such as projects of **Error! Reference source not found.**,[2], etc. In the latter project, 400 e-Learning courses were converted into m-Learning courses by NKI of Norway. (2) Developing stage. In this stage, u-Learning mode and pedagogical theory became the focuses of research, such as projects of [3][4], etc., and these projects focused on social applications of u-Learning and theory of effective learning in ubiquitous learning environment. (3) At present, the stage of how to merge u-Learning into mainstream of education, such as projects of [5],[6]etc., and these projects are different from ones aforementioned [7][8].

Compared with traditional e-learning, u-Learning brings new research topics because of different learning devices, learning contexts and new learning concepts, for example, the learning content in u-Learning environment must be made adaptively according to the requirements of mobile terminals[9]. The literature [10] focused on designing appropriate learning contents for PDAs, and the literature [11] focused on designing multi-media learning contents for mobile phones. Therefore, it is important to create new u-Learning systems which can facilitate the process of merging u-Learning into mainstream of education. From the perspective of e-learning facilities, it can be divided into Learning Content Management System (LCMS), Learning Management System (LMS) and distributed e-learning facilities, which is usually expanded based on the functions provided by these two kinds of system [12],[13]. U-Learning enhances the requirements on evolutional learning facilities, and there have been some studies in this direction, such as mobile learning systems listed in [14]. Among these e-learning facilities, LCMS has become more and more important, and researches in LCMS have been developing towards a reusable, semantic and knowledge-oriented direction. Because of intrinsic characteristics of u-Learning, the research on learning content facilities is of increasing significance, and technologies in this area include learning object (such as LOM, Dublin Core and some new metadata standards), object-oriented organization of learning resources (such as the standard of SCORM[15]), and semantic-oriented learning resources management.[16],[17],[18]

The paper focuses on creating new generation e-Learning system for ubiquitous learning with bottom-up method. We introduce the key concepts of the system, and also introduce our research work at present. Section 2 introduces the concept of ULO. Section 3 discusses SULOM model, which is designed to satisfy the requirements of u-Learning, and confirms the corresponding elements. In section 4, we put forward the method to realize semantic relations hierarchically and to create learning resources ubiquitously. Section 5 introduces the status of our research on the system realization based on the concept of ULO, the model of SULOM, and a prototype system, called SULOMS has been realized, and further research is also introduced.

II. THE CONCEPT OF ULO

To satisfy the requirements of various terminals in u-Learning environment, a mechanism for learning resource delivering, repurposing, and managing is required. In our research, the concept named ULO is proposed, which is designed in accordance with object-oriented principle. ULO is composed of two parts, one is data portion and the other is behavior portion. In data portion, all metadata and media-data is used to describe knowledge point of a course, and accordingly, features of knowledge are annotated with metadata. In behavior portion, web service technology is used to provide extensible capability for functions on a special ULO.

To design ULO, three principles are proposed in our research: (1) Ubiquitous principle. ULO should provide capability for extracting learning resource adaptively in

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different u-Learning scenarios; (2) Reusable principle. ULO should provide support to record refined semantic relationships among different ULOs, which is used to facilitate sharing and repurposing learning-resource based on semantic technology; (3) Usable principle. The systems based on ULO should provide high availability for users, which can be realized through reasonable metadata design for ULO. To promote systems' availability based on ULO, every item of metadata in ULO should be considered carefully. With these principles, the design of ULO absorbs advantages of existing e-Learning specifications, such as LOM, DC and CanCore, while it is optimized according to the new requirements in u-Learning environment.

With the considerations aforementioned, the metadata of a ULO has been classified into two levels: one level is used to describe the overall features of a ULO, while the other level is used to describe features of media related to the ULO, which can be used to provide system's adaptive capability. The design can facilitate learning resources delivering, re-using, sharing in u-Learning environment. The structure of data partition of ULO is described in figure 1, which is mainly composed of three parts, metadata for u-Learning object, metadata for media, and metadata for refined relationships among ubiquitous learning objects. The refined relationships among ULOs are used to facilitate ULO sharing based on semantic technology, and also, it can be used to provide capability for automatic or semi-automatic courseware creation.

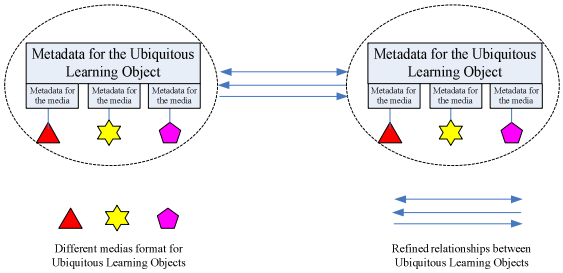

Figure1. Data Partition of U-Learning Object

Compared with the data portion, behavior portion provided for every ULO is more important and it is the key for understanding difference between ULO and learning object in traditional e-Learning system. The behavioral features of ULO should have the following characteristics:

(1) The behaviors of a ULO can be customized according to the carried media in the ULO. Because media in a ULO are organized based on knowledge point, they could be represented in different media formats, such as text, audio, picture, video, etc. Due to varied networking status, different physical characteristics of terminals, and various preferences of users in u-Learning environment, the capability of extracting and delivering media adaptively from a ULO according to a special situation is strongly needed. According to our research, it needs two kinds of adaptive behaviors: one is realized based on media format selection, and the other is realized with media transformation, such as transferring a big picture to a smaller one.

(2) The behaviors of a ULO can be extended according to different scenarios. Because of various kinds of ULOs, media formats in a ULO, and different contexts for a ULO, it demands capability of configuring behaviors of a ULO online. This is realized through web service technology which can be used to modify behaviors of a ULO while it is working.

The capability of desired behaviors of ULO in the system is explained in Figure 2.

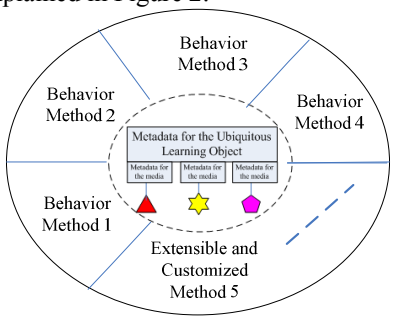

Figure2. Behavior of Ubiquitous Learning Object

The aforementioned concept of ULO is the foundation for new generation e-Learning system, and it needs runtime environment for the realization of ULO aforementioned. In our research work, the runtime environment for extensible and configurable ULO behavior is realized based on Fedora [19] which is an open source project for general data object..

III. THE MODEL OF SULOM

To realize the above concept of ULO, it is necessary to carry out more work in both data portion and behavior portion. With the further research on data portion, we put forward a model called Semantic-oriented Ubiquitous Learning Object Model (SULOM), and elements of these metadata are described in figure 3 and figure 4.

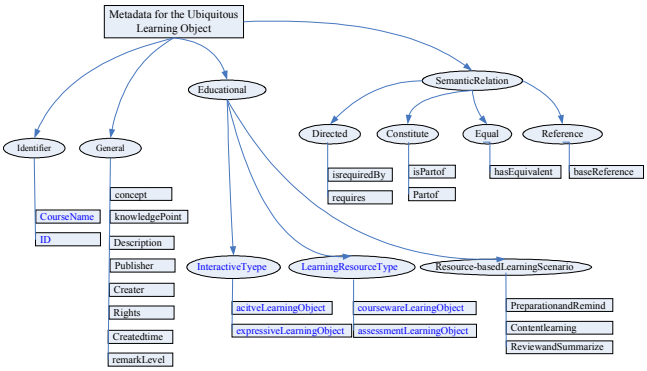

Figure3. Metadata for U-Learning Objects

First, we describe the metadata elements for describing overall features of a ULO which is depicted in figure 3. These elements are organized into three categories. One is used to identify basal elements for a ULO, and the second is used to describe educational scenarios and is suitable for u-Learning, and the third is used to describe semantic relationships among ULOs. Details of these elements will be

introduced by referring to figure 3, and these elements are categorized into four sub-classes, which are “Identifier”, “General”, “Educational”, and “Semantic Relation”:

(1) “Identifier”. There are two elements in this sub-class, and they are “courseName” and “ID”, which are used to identify ULO in system. In order to build resource-based learning environment for u-Learning, all ULOs in system will be assigned a “courseName”, which is usually the name of a curriculum.

(2) “General”. The sub-class is used to identify general information of a ULO, and there are eight elements in this sub-class. The elements of “concept” and “knowledge” are used to mark concept and special knowledge under the concept of the ULO respectively. The elements of “description”, “publisher”, “description” “creator” “rights” and “createdTime” are used to describe some other information of a ULO. The last element, which is called “remarkLevel”, is used to remark the level of a ULO, and the value should be updated by upper assessment mechanism supported by machine automatically or by human collaboratively;

(3) “Educational”. The sub-class is used to identify educational scenarios for a ULO, and there are three further sub-classes in this class. Among them, “interactiveType” is used to identify interactive type of a ULO, “learningResourceType” is used to identify a ULO type, the value of which may be “coursewareLearingObject” or “assessmentLearningObject”, and the last is “resouce-basedLearningScenario”, which is used to identify suitable educational scenarios of a ULO. According to our research, there are two kinds of scenarios in resource-based learning, one is content-learning（“contentLearning”）, and the other is refinement-learning(“preparationAndRemind” ,“reviewAndSummarize”). Among these two kinds of scenarios, refinement-learning is more suitable for m-Learning or u-Learning;

(4) “Semantic Relation”. The sub-class is used to annotate semantic relationships among ULOs, and in order to promote usability of the system, semantic relationships in the developing system are realized through hierarchy methods, which will be introduced in detail in Section 4. With this method, normalization of semantic relationship is guided by Course Ontology in the uppermost level, while complicated semantic relationships are carried out by Semantic-based Courseware Structure. With these considerations, the semantic relationships among ULOs can be refined to just four kinds, namely, “directed”, “constitute”, “equal” and “reference”, and among these four kinds of relationships, the relationship of “reference” is designed to be used for refining and simplifying complicated upper relationships to simplified ones.

The metadata for media is the key for the realization of adaptive u-Learning system, and a sub-class metadata called “pervasive” is designed for this purpose. In the sub-class, there are some basic metadata items, such as “size”, "format”, and “duration”. Also, there are two other kind further sub-classes, one is used to identify ubiquitous features (“pervasiveIdentifier”) and the other is used to identify display requirements (“displayReq”). The item “pervasiveIdentifier” is used to mark two categories of learning resources which are classified according to the capability of terminal (“PCorWirelesslearning-based” or “MobileorUbiquitouslearning-based”). This item is used to provide classification for two category terminals, one is for PC or PC-like terminals, and the other is for portable terminals, such as PDA, mobile phone, etc. The item “displayReq” is used to provide support for screen size and display resolution of terminals.

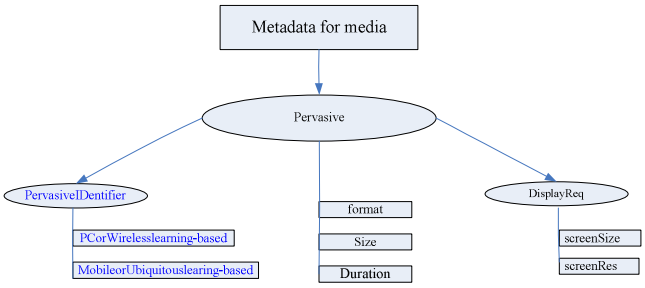

Figure4. Metadata for Media of ULO.

IV. METHOD AND PRINCIPLE TO REALIZE ULO AND SEMANTIC RELATIONSHIPS AMONG ULOS

How to build ULOs of a course and how to annotate semantic relations among ULOs are the keys for the realization of system based on the concept of ULO. A course organization process is proposed to realize system using semantic level as guiding ideology. As shown in figure 5, relationships among ULOs originally come from course ontology, and semantic relations in the system are distributed in three layers: Course Ontology Layer, Semantic-based Course Structure Layer and ULO Layer.

(1) Course ontology is composed of basic concepts and relations among them according to a curriculum. It standardizes the basic relations of ULOs and has mandatory power to guide the semantic relations in other two layers.

(2) Semantic-based Course Structure Layer is the bridge of semantic relations in course ontology and relations in ULOs. It is a carrier of a course structure. Based on this design, semantic course structure is a three-dimensional and directed graph with central node (also known as root node). In figure 5, the nodes in the directed graph represent knowledge in a course, and the relationships among these nodes come from three channels, the basic semantic relations among concepts within course structure (usually is “composeOf”), constraints guided by course ontology, and additional semantic relations among knowledge defined by teachers or resources providers according to their viewpoints. In terms of levels, the semantic course structure can also be considered as a tree based on knowledge, which has a root node. The leaf-nodes of the tree correspond to specific knowledge points, which can be expressed and managed in ULOs. Corresponding to the demand of ULO sizes, the depth of the tree can be modified (increased or decreased), which is decided by the characters of resources binding up by leaf-

nodes. According to a concretion, knowledge is too small to be syncopated. The interface among leaf-nodes and their father nodes is called Mapping Interface.

(3) ULO Layer is used as a carrier to express knowledge in Semantic Course Structure Layer, and learning resource is attached in ULOs. At the same time, based on the semantic relations conveying from course ontology and new relations generated from semantic course structure, the ULO Layer identifies the relations among ULOs of a course. As previously mentioned, there exists a relation reducing process, within which complex relationships in Course Ontology Layer and Semantic-based Course Structure Layer are reduced into four kinds of basic relationships in ULO Layer. The design approach is adopted to enhance the usability of system.

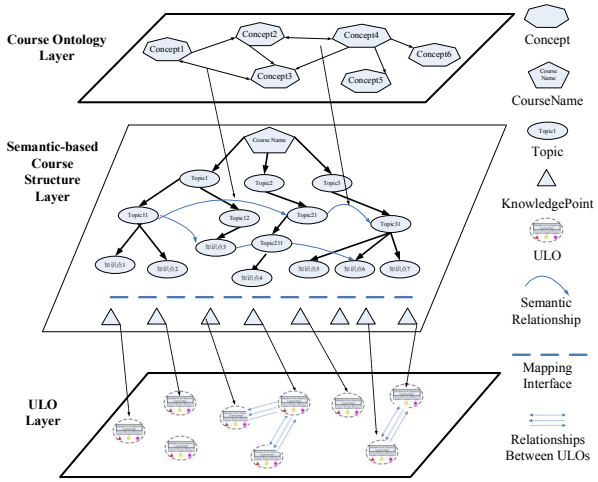

Figure5. Hierarchical semantic relationships of SULOM and the way to create ULOs

The process is demonstrated in figure 5, and the basic ideas of annotating semantic relations among ULOs in ULO Layer are described as follows.

(1) Generate semantic relations for ULOs related to similar topic: The semantic relations among ULOs related to similar concepts are described by four type relations, "directed" (require / required-by), "constitute" (par-of / is-part-of), "equal" (has-equivalent) and "reference" (base-reference) relations. Among the four types of relations, the base-reference relation is the basic relationship. ULOs annotated by these four relations are tightly coupled.

(2) Generate semantic relations for ULOs related to different topic: The semantic relationships defined in Semantic-based Course Structure Layer are the foundation for refining the relations among ULOs, which are generated from concepts. In order to establish relations of knowledge under different concepts, the relation paths of knowledge should be shown, and consequently, users can use the displayed paths to confirm the relations of knowledge related to different concepts. This is a refining process for relations among ULOs, within which the refined relationships are described by the above four relationships.

V. THE PROTOTYPE SYSTEM OF OUR RESEARACH

The concept of ULO, the model of SULOM and the way of ULO construction described above have been realized in Semantic-oriented U-Learning Object Management System (SULOMS), which is implemented with expansion of Fedora.

At present, five core modules of SULOMS system have been developed (refer to figure 6). They are ontology module, course structure management module, ULO module, adaptive module and mobile terminals module. (1) Course Ontology is managed in graph and parsed by Jena; (2) The course structure management module can be used to provide convenient access for teachers or resources providers when they build their own course structure and create ULOs under the course structure. This module is important for building ULOs and also is the foundation for creating semantic relationships in SULOMS; (3) ULO module is provided to enable resources providers (such as teachers, curriculum experts, etc.) to package learning resources in the way of ULO. Fedora uses Dublin Core to describe learning objects by default, and it has been expanded by our research team to load SULOM model. After that, the system can support creating, adding, deleting and modifying learning object of ULOs. These functions have been implemented now; (4) Adaptive module can be used to choose appropriate ULO dynamically for learners according to terminal characteristics, learner preferences and learner styles. In the module, the most important work is to identify adaptive rules based on various constraints, and this has been achieved in this research.

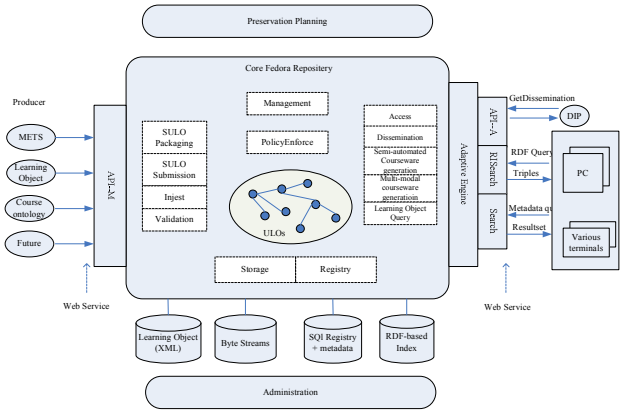

Figure6. The Architecture of SULOMS.

Further studies include: (1) realize hierarchical semantic annotating functions in the modules and among the modules mentioned above. At the same time, semantic operation API should be provided in ULO Layer, Semantic-based Course Structure Layer, and Course Ontology Layer in order to provide advanced functions; (2) Further improve the SULOMS system, and at the same time, integrate all learning resources in a course (English learning) into SULOMS system according to the ideas mentioned above, and we plan to conduct a preliminary application in undergraduate students in Beijing Normal University. All

these work aims to verify and improve the design of SULOMS, and to promote the practice of integrating u-Learning into mainstream of education.

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REFERENCES

[1]. The project "From e-Learning to m-Learning" http://learning.ericsson.net/mlearning2/project_one/index.html. 2000~2002.

[2]. The project "M-Learning: the next generation of learning".http://learning.ericsson.net/mlearning2/resources.shtml. 2004.

[3]. The project "m-Learning Project". http://www.m-Learning.org/archive/background.shtml. 2001~2004.

[4]. The project "MOBILearn" http://www.mobilearn.org/. 2002.7~2004.12.

[5]. The project "incorporation of m-Learning into mainstream education and training" http://learning.ericsson.net/mlearning2/resources/malta_paper_final.doc. 2006.

[6]. The project "MoLeNET" http://www.molenet.org.uk/. 2007.9.

[7]. Geoff Stead. Moving mobile into the mainstream Tribal Education: CTAD England, UK 2005. www.mlearn.org.za/CD/papers/Stead.pdf

[8]. Desmond Keegan. Incorporation of m-Learning into mainstream education and training. www.mlearn.org.za/CD/papers/keegan1.pdf. Retrieved at 2008-12-21

[9]. A. Bouzeghoub, K.N.Do and C.Lecocq. Contextual Adaption of learning resources. In the proceeding of IADIS International Conference M-Learning 2007. pp: 41-48.

[10]. Churchill, Daniel. Learning Objects for Educational Applications via PDA Technology. Journal of Interactive Learning Research, v19 n1 pp: 5-20 Jan 2008.

[11]. C.Bradley, R.Haynes, T.Boyle, et al. Multimedia Learning Objects for Mobiles. In the proceeding of IADIS International Conference M-Learning 2007. pp: 65-72.

[12]. Baker, Keith D.，Learning Objects and Process Interoperability，International Journal on E-Learning, v5 n1 pp: 167-172 spec iss Jan 2006

[13]. Watson, William R.; Watson, Sunnie Lee. An Argument for Clarity: What Are Learning Management Systems, What Are They Not, and What Should They Become. TechTrends: Linking Research and Practice to Improve Learning, v51 n2 pp: 28-34 Mar 2007

[14]. Evgeniya Georgieva. A Comparison Analysis of M-Learning Systems. International Conference on Computer Systems and Technologies - CompSysTech' 2006. IV pp 17-1 ~ 17-6

[15]. Nigel H. Lin, Timothy K. Shih. Pocket SCORM. Proceedings of ICDCSW.2004. Volume 7 pp:274 – 279.

[16]. Verbert, Katrien; Duval, Erik; Meire, Michael; et al. Ontology-Based Learning Content Repurposing: The ALOCoM Framework International Journal on E-Learning, v5 n1 pp: 67-74 spec iss Jan 2006

[17]. Wang, Hei-Chia; Hsu, Chien-Wei. Teaching-Material Design Center: An Ontology-Based System for Customizing Reusable e-Materials. Computers and Education, v46 n4 pp: 458-470 May 2006. http://www.eric.ed.gov.

[18]. K. Kozaki, Y. Kitamura and R. Mizoguchi. Development of Contents Management System Based on Light-Weight Ontology. Proc. of the 2007 IAENG International Conference on Internet Computing and Web Services, Hong Kong, 21-23 March, pp: 987-992, 2007.

[19]. http://www.fedora-commons.org/.