CONTEXT-AWARE ADAPTATION PROCESS TO BUILD UNITS OF LEARNING BASED ON IMS-LD STANDARD

Sergio Gómez, Carolina Mejía, David Huerva, Ramón Fabregat

Institute of Informatics Applications, Universitat de Girona
Girona/Spain
{sergiog, carolina, dhuervad}@eia.udg.edu, ramon.fabregat@udg.es

Abstract

Mobile and ubiquitous computing are changing the way how the students are learning. Heterogeneity of learner preferences in learning processes using Learning Management Systems (LMS) is a problem that researchers have been focused in the last few years. With the existence of different devices to access, technologies to interact, learning styles, competences to acquire, among others, the interest and motivation among students can be lost if personalization processes are not defined. Nowadays, the adaptation of learning contents considering these characteristics has become a research area to generate solutions for heterogeneity issues. Decide which variables can be addressed in adaptive processes to define how the contents in a LMS can be presented according to user preferences is one of the main challenges to design instructional models for e-learning courses. In order to build a context-aware content adaptation process on learning designs, a model that integrates different tools to provide adaptive contents when the learners perform different learning activities following the structure of a unit of learning (UoL) is proposed. This UoL meets the specification of the standard IMS-Learning Design (IMS-LD). To obtain this model some existing tools such as specifications and content transcoding technologies that can be used to achieve the adaptation of contents considering different context features such as access device, location, access time, performance of the network connection, interaction preferences, mood, etc., are used. Also, some elements of the IMS-LD standard that allow adaptive conditions to be defined are considered, in order to set up properties of learning content to be presented according to context features and device capabilities captured from learners.

Keywords - mobile learning, ubiquitous learning, adaptive hypermedia systems, adaptive content delivery, learning design.

1 INTRODUCTION

With the increasing use of diverse mobile devices that allow people to access the information anytime and anywhere, the computer science acquired a different perspective marked by Weiser's vision, who introduced the term of ubiquitous computing (ubicomp) [1], which defines a seamlessly integration between systems in the environment that aids people in their everyday activities. Under this concept, new technology has been embedded in many everyday objects and places such as furniture, clothes, museums, theaters, roads, vehicles, etc., to provide people with necessary tools and processes that allow them to do their activities by means of a relaxing interaction with the environment.

Education also has been involved in this perception. Nowadays, it can be considered different learning activities by means of face-to-face and computer-mediated instruction environments. Activities such as listen and watch different audio and video contents provided as informative or self-assessment contents, do homework discussing with classmates about different topics presented in different downloadable media on a course homepage, send out bulk SMSs to inform learners about different events (new files available on subjects' webpages, evaluation dates, forum discussions opened, etc.), upload explaining videos about how to use tools in real world to ensure learners can recall instruction on different process when and where they need it, and other activities have been proposed enhancing learners and teachers experience. This is due to the constant growth in the use of different devices that offer various means to acquire knowledge.

In the last two decades there has been a huge increase in the number of different mobile devices available in market that present different technological characteristics and offer a variety of possibilities to access the information. With ubiquitous computing, integration of this variety and

ISBN:978-84-612-9802-0

systems are tried to be carried out by means of building applications that any device can use, in order to let the users access the same information using the device of their preference.

Mobile devices have been the type of objects with greatest index of usability, because these devices join several tools and services that can be accessed anytime. In addition, they satisfy the nomadicity needs that people have while they are moving and normally carrying everyday tasks to any place.

Considering access device and other learner characteristics in a learning process is currently a research line of interest to propose different mechanisms of learning contents adaptation. Nowdays, the research in the development of LMSs is oriented to adaptation processes construction considering different traits of users like: learning profiles, interests, competences, knowledge levels, and others described in [2]. The goal of this research is to define optimal ways that the contents and the services, available in this type of systems, should be presented to learners and teachers (main actors of learning and instruction processes). Our interest in this proposal is to consider different user characteristics related with the context such as access device, browser, connection technology, time of access, location of the user, physical conditions of environment, etc.

To deliver context-aware adaptive contents, a model that join together existing tools such as standards, specifications and content transcoding technologies is defined. To propose it, heterogeneity related to user context (access devices, places, variable time and physical environment, etc.) was considered.

When heterogeneity is not considered, it is possible that development of a diversity of independent solutions may want to solve the problem since different points of view and in consequence, if neither e-learning standards nor specifications are used, could limit the usability, the interoperability and even restrict the implementation of adaptation processes.

However, different existing organizations (IMS Global Learning Consortium [3], IEEE [4], ADL [5], etc.) in charge of the educative standards definition have created some specifications that consider: the construction of educative contents, the storage of personal characteristics of the students, the definition of competitions, the generation of evaluation structures and the development of instructional designs, in summary each one of the elements involved in the instructional process. These specifications generally do not adjust to a unique pedagogical model and facilitate the exchange of information between different interested entities: people, institutions or systems.

Furthermore, some others organizations (Open Mobile Alliance (OMA) [6], World Wide Web Consortium (W3C) [7], etc) are in charge of specifications definition associated to control, interact, access and other characteristics related to mobile technologies including: global user adoption of mobile data services, interoperability across devices and delivering web content to mobile devices.

In the proposed model, the specification of the IEEE-LOM [8] standard is considered to characterize learning resources by means of defining a metadata file that helps describing their properties, and the IMS-LD [9] standard because it defines a structure that let different elements to be considered in the design of pedagogical models over different LMSs. Also, the OMA Standard Transcoding Interface (OMA-STI) [10] that let define content transformation indications, and the WURFL [11] specification that allow device information to be detected in order to deliver suitable adaptive contents according with device capabilities are considered.

The analysis of the context characteristics and the elements that participate in the design of pedagogical models in a LMS, are the focus of this paper by means of proposing a mechanism to build adaptive instructional designs based on the context. This proposal is based on the identification of different user context adaptation variables which are not considered currently in the design of “Units of Learning”.

The paper is structured as follows. Second section describes what the context is, how it is conceived in mobile learning (m-learning) and which characteristics comprise it. In third section the properties of an UoL (following IMS-LD guidelines), which can be used to implement adaptation processes, are described. The fourth section details properties considered in proposed adaptive content delivery mechanisms. In fifth section the proposal of a context-aware adaptation process to deliver different types of mobile contents in a UoL is presented. Finally some conclusions and future work are remarked.

2 CONTEXT-AWARE ADAPTATION

Technological characteristics of devices and other before mentioned parameters like: location, time, physical environment, among others, are part of what is denominated as context, that according to [12] can be defined as “any information that can be used to characterize the situation of an entity”, understanding the term “entity” as anything relevant participating in the interaction between an user and a system, such as a person, a place, or an object including the user and the system.

The term context-awareness denotes the properties implicit in a system that considers the characteristics of the context. In mobile and ubiquitous computing this term is commonly used because of the purpose of the applications that can be developed and the different entities that interact in order to present useful tools and services according to user needs and situations. Emphasis of how the context is considered as a necessity is explained in [13]. It argues that context in mobile applications can be used not only for locating users and providing them with suitable information, but also for supporting the system’s selection of appropriate interaction techniques and providing users with useful tools.

Briefly [12], remarks that a system can be considered “context-aware” if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task.

In e-learning, as different learning activities are defined either for learners and teachers, this concept can be applied in learning tools development, architecture design, technologies application and specifications definition in order to design and implement processes to adapt these activities by means of contents and services that are displayed to both learners in their learning process and teachers monitoring their instruction process.

2.1 Context in m-learning

While m-learning encompasses all kinds of activities where learning happens out of a formal classroom situation, the term m-learning could be referred specifically to learning that is facilitated and enhanced by the use of digital mobile devices and that can be carried and used anywhere and anytime. In [14] it is defined as **“**learning that can take place anytime, anywhere with the help of a mobile computer device. And this device must be capable of presenting learning content and providing wireless two-way communication between teacher(s) and student(s).”

In practice, m-learning involves teaching and learning activities and makes the most of being mobile considering location, immediate access, connection, and acknowledges learning that occurs beyond formal learning settings, in places such as the workplace, home, and outdoors. According to this, it can be stated that m-learning makes use of context to facilitate performing learning activities out of a formal classroom situation.

According to that statement, in m-learning the design of applications and adaptation mechanisms should be based on identifying variables that affect users in two different types of context, one related to the structure of a pedagogical model, considering the learning paths which students follow in order to acquire the knowledge, and other related to ubiquitous environment in which learners and teachers operate performing and implementing those activities respectively. In [15] these two contexts are identified as learning context and mobile context and it describe the properties of both:

- *Learning context*: It is characterized mostly by students, learning objects and learning paths to follow a specific instructional model.
- *Mobile context*: It mainly summarizes aspects of space and time of the user situation.

According to that, in m-learning, learning activities can be settled in both learning context and mobile context if they are executed by learners or teachers considering different learning environments (indoor or outdoor), diverse mobile access devices, different execution times and different situations of the physical environment (weather, illumination, noise level, etc.). Taking into consideration these characteristics it can be defined different parameters in m-learning adaptation processes that can be taken into account when the context is considered.

2.2 Characteristics of context

Appropriate classification of the characteristics that can be considered as part of the context is proposed in [13] (see Table 1). It describes five parameters (User, Place, Artefact, Time and Physical

environment) in which context characteristics can be categorized in order to define an ontology framework that let modeling the context to build mobile applications.

Table1. Parameters and characteristics of context

Parameters	Characteristics
User	profile, preferences, goals, tasks, activities, actions, mood, etc.
Place	location, orientation, space (public, private, social, informative), etc.
Artefact	physical properties, digital properties, interaction interfaces, etc.
Time	hour, day, weekday, month, season, year, etc
Physical environment	weather condition, illumination, noise level, overcrowding, etc

When the context is integrated in adaptation processes development, it is important to consider such external variables that would be involved in the interaction between the users and the LMS, particularly with the contents. We defined this integration as "context-aware adaptation" and it refers to an adaptation process that considers the characteristics of the mobile and ubiquitous computing. According with [16] when the context is considered, context-aware features are useful to:

- Present information and services to user,
- Automatically execute a service for user, and
- Tag information to support later retrieval.

In the case of the LMSs, considering these context parameters will let defining which variables can be considered to build an adaptation process. In our proposal we consider artefact, place, time and physical environment parameters as first approach to adapt learning contents.

3 PROPERTIES OF AN IMS-LD UNIT OF LEARNING

Through learning design authors can represent pedagogical models by means of defining learning activities as a procedural structure identifying different objectives that learners have to achieve and considering different activities that teachers define in order to guide and follow the learners' learning process. Also, authors can define which learning tools are used to complete those activities and the environments which include these tools and different services to facilitate that the activities can be performed. Nowadays, with the existence of different types of learning (face-to-face, computer-mediated, blended, etc.), environments definition and learning possibilities using different tools and services have increased, even more when context and mobile learning are considered offering alternatives not identified yet.

To support pedagogical diversity and innovation the standard IMS Learning Design [9] defines a framework that promotes the exchange and interoperability of e-learning materials. With this specification a generic and flexible language is provided. This language is designed to enable many different pedagogies to be expressed. This language has the advantage over alternatives in that only one set of learning design and runtime tools then need to be implemented in order to support the desired wide range of pedagogies.

The IMS-LD states that "regardless of the pedagogy involved, in practice every learning design came down to: a Method prescribing various Activities for learner and staff Roles in a certain order, and each activity refers to a collection of specific objects and services needed to perform those activities."

The relation of these elements participating in an IMS-LD is depicted in Figure 1. The standard describes this relation as the structure of a theater play, in which there are several scenarios (executions) with different acts that can be played and that involve different actors with several roles (students or teachers). Also there are activities that actors perform in different environments, using different resources and tools. The result of this structure is a package called "Unit of Learning" (UoL) with specific adaptive properties which are explained in next sections. UoL is a term very known in e-

learning and is used to refer any delimited educative or training piece like a course, a module, a lesson, etc.

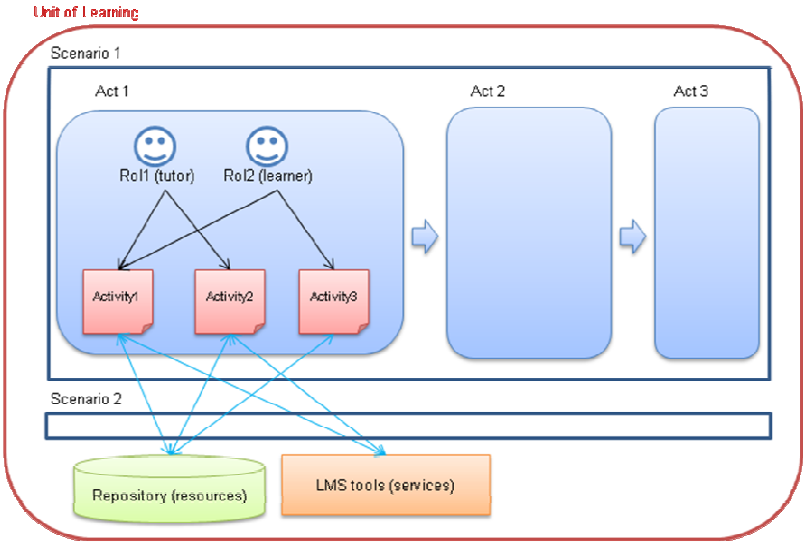

Figure 1. Relationship of the main elements in an IMS-LD

IMS-LD specification is a standard that defines the guidelines to build this UoL. It defines UoL as "the smallest unit providing learning events for learners, satisfying one or more inter-related learning objectives", and provides the elements that contains: a manifest file (an XML file that represents the complete structure of the UoL), a instruccional design, the definition of resources, optional sub-manifest and physical files.

The instructional design is the key element in a UoL and is basically what it is tried to be modeled; the other elements are necessary and complementary parts. In literature the term used to refer to instructional design is "learning design" and according to the specification it means: "a description of a method enabling learners to attain certain learning objectives by performing certain learning activities in a certain order in the context of a certain learning environment".

In order to build a UoL, IMS-LD describes and implements learning activities based on different pedagogical methodologies, including group work and collaborative learning. In addition, it lets to coordinate multiple learners and roles within a model unique-student or multi-student. It let manage the use of learning contents with collaboration services and also it support models delivery including blended learning (face-to-face instruction combined with computer-mediated instruction).

With the purpose of make possible the implementation of the specification in different LMSs, IMS-LD can be built in three different levels: level A, level B and level C, providing different schemes of XML for each level that can be integrated considering the purpose wanted for a certain LMS. The level A offers the necessary vocabulary to express a general learning process, including learning paths. It considers the definition of different user roles in the process (e.g. teacher and student), several learning and support activities that these roles perform and diverse environments in order to establish which learning resources and services can be used in those activities. The level B, adds the possibility of defining conditions to evaluate different expressions based on properties of the individual user or the roles in order to enable the personalization. Finally, the level C allow notifications mechanism to be defined (i.e. messages as answers to events execution).

Another important characteristic in UoL building is the relation and integration with other specifications like: IMS Content Packaging [19] for distribution of UoLs, the IMS/LOM Metadata [20] for characterization of the resources, IMS Learner Information Package [21] for characterization of the students, among others. This property adds interoperability and durability to the different proposed models in order to obtain adaptive UoLs.

To conclude, the use of conditions and properties of level B allow the authors of learning designs to consider different variables of adaptation in order to let them schematize a pedagogical model on a LMS. In [17] the integration of different specifications and standards in an IMS-LD is presented. That work describes how can be developed learning designs addressing variables of adaptation according to the learning profile and competitions of the student. Continuing with the capacities of the standard in

[18] is presented how the use of conditions can be used to generate level B learning designs to adapt resources according to the student's learning profile.

4 ADAPTIVE MOBILE CONTENTS DELIVERY

Building content adaptation processes are necessary when mobile environments in a pedagogical model are considered in order to perform learning activities that ease knowledge acquirement and help enhance learner experience on particular devices. These processes commonly consist in learning content transformation and services adjustment. Generally this transformation is a content transcoding/recoding process which let personalize the file format or the properties of the resources according to different parameters settled based on clients requests or device capabilities.

Regarding to the place where the adaptation is established and performed, W3C [22] has categorized three types of content adaptation: server-side approach, proxy-based approach and client-side approach. Due to the lack of computing power and bandwidth, the transcoding possibilities of the client side approach is very limited.

Server side approach is able to overcome the problems that the client side approach has. When a web server employs some types of device detection together with a device feature repository, it can then send optimized content to the requesting device based on its capabilities.

Proxy side adaptation is where the content is altered as it passes through one or more network components. For example, network operators can compress images before they are passed over the net to the mobile device.

Considering transformation processes and the server-side and proxy-based categories of content adaptation, some projects that propose different context-aware adaptation models are presented.

In [23] a multi-agent server-side architecture is presented that capture the characteristics of the user access device and automatically online courses undertaken by students as well as their learning environment are adapted using online transformation services. In [24] a functional architecture based on adaptation algorithms that analyze the information obtained from learner context on a server. The information considered let to present customized intelligent contents based on: access time, location, network type and mobile device profile. In MASHA [25] also a multi-agent architecture is defined and it allow information of the user behavior to be collected, at the moment the user accesses web pages using different mobile devices, in order to create a global profile that let recommend web pages adapted according to the analysis of that profile or other profiles of users who have used the same access devices. In [26] an Adaptive Mobile Learning Management System evaluates the student preferences about his/her learning style to adjust educational resources on user interfaces over mobile devices.

In [27] a content adaptation proxy transcoding mechanism is proposed, which deals with network and CPU demand in an integrated form and aims to improve the system's potential service capability. [28] propose a proxy server content provider that receive context information from the user client device and executes algorithms that computes the optimal version of resources that is renderable with the current client device and network characteristics.

The majority of works done in m-learning area have been focused on addressing context characteristics of access devices, and other "technological characteristics" such as browser, connection technology, server state, etc. Nevertheless, the term context as it was mentioned can consider many other characteristics as it was showed in table 1.

5 CONTEXT-AWARE ADAPTATION PROCESS

Considering the parameters of the context explained in the background section and the categorization of the levels defined in the IMS-LD standard to obtain adaptive UoL, we could identify different variables that can be considered to design the adaptation process in learning designs.

5.1 Modules

Context-aware adaptation process proposed includes three main modules: i) context variables detection, ii) evaluation and contents loading and iii) adaptive content delivery. The relation of the elements and processes performed by these modules are explained later in this section. In Figure 2

the relationship of the three modules is illustrated. All modules perform required tasks at the server level and in modules i) y iii) communication with users (who make content visualization requests) is established. We have focused on the server-side content adaptation approach. The benefits are that in server the characteristics of all learning contents can be stored, both transcoding processes execution and user interaction with LMS can be performed at the same time, well-communication with other servers can be established, among others. Server technological characteristics can vary but they are still better than client's platforms.

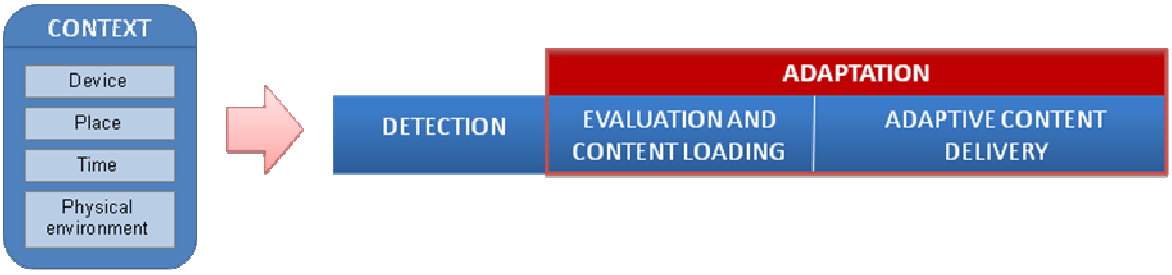

Figure 2. Main modules of the adaptation process

The context characteristics we consider in the adaptation process are: artefact (which we will call "device"), place, time and physical environment. As first approach, in the adaptation process, only technological characteristics of the parameter "device" were selected and from that selection different resource types that can be adapted to device capabilities were analyzed.

To design the proposed model a set of different client platforms that are used in m-learning environments are considered, and therefore a set of properties and characteristics of different contents were also evaluated. Learning activities in mobile environment need to consider different access objects and different materials that can be delivered. When learning paths are followed both learners and teachers can change the access device anytime and that can generate a set of modifications in the contents that can be accessed. We consider some the most commons used devices:

- Mobile phones
- PDAs (personal digital assistants),
- Personal digital media players (e.g. iPods, MP3 players),
- Smart phones,
- Laptop computers,
- Tablet personal computers,
- Ultra-Mobile Personal Computers

The laptop computers, tablet personal computers and ultra-mobile personal computers can also be used to facilitate mobile learning, however, characteristics such as small screen, lack of standard keyboard and pocket-sized nature were considered to resolve content transformation in the adaptation process.

Access device properties *detection* is a key part of the content adaption processes proposed. Different specifications such as CC/PP [30], UAProf [31] and WURLF [11], defines the profiles of the devices in a XML structure that has data related to their technological capabilities (hardware, software, network, etc.). Moreover, the detection of variables like the place and the physical environment need entities ("sensors") that can be settled to be used in the environment and that can interact with the user, detecting her stage (location, orientation, space, lighting, noise level, weather conditions, etc) and capturing necessary information to adapt contents or services according to the situation.

After detection, context's variables and device's characteristics *evaluation* will allow *content loading* to be executed. These processes determine which contents' properties should be transformed in order to deliver adaptive contents to learners. Delivery constraints are identified in order to generate transcoding requests of the contents available. The loading and delivery process should be a transparent process for learners and teachers, and should be a process without delays because multiples contents and services are used in a unit of learning.

Different contents types were considered to proposed different scenarios in learning activities. In [29] a set of recommendations about how contents can be built were proposed with the purpose that authors and developers can follow to practice good m-learning. A report of the analysis of different elements (platforms, contents, support standards and delivery technologies) involved in the mobile learning process was elaborated as an approach in the definition of m-learning standards.

We make use of properties of the following resources evaluated in that report:

- Audio
- Video
- Still images
- Standard documents
- Web content
- Interactive Media

5.2 Adaptation Process

In a pedagogical model (in our case represented in the structure of a UoL) objectives achievement is obtained by evaluating conditions and properties defined in learning activities of a UoL. These properties belong to learners and teachers who are following learning or instruction paths respectively. In our proposal, we consider the user context to enhance the experience of interaction and extend the execution domain of proposed learning activities.

Figure 3 illustrate the procedure through the three modules of the adaptation process proposed. To interact with context-aware learning activities (contents and services) we consider mobile device detection, access time and the place and physical conditions where access occurs. In this way we are considering to solve the following questions related to the context: How and When access happen? Where access happen? and What environmental conditions exist?

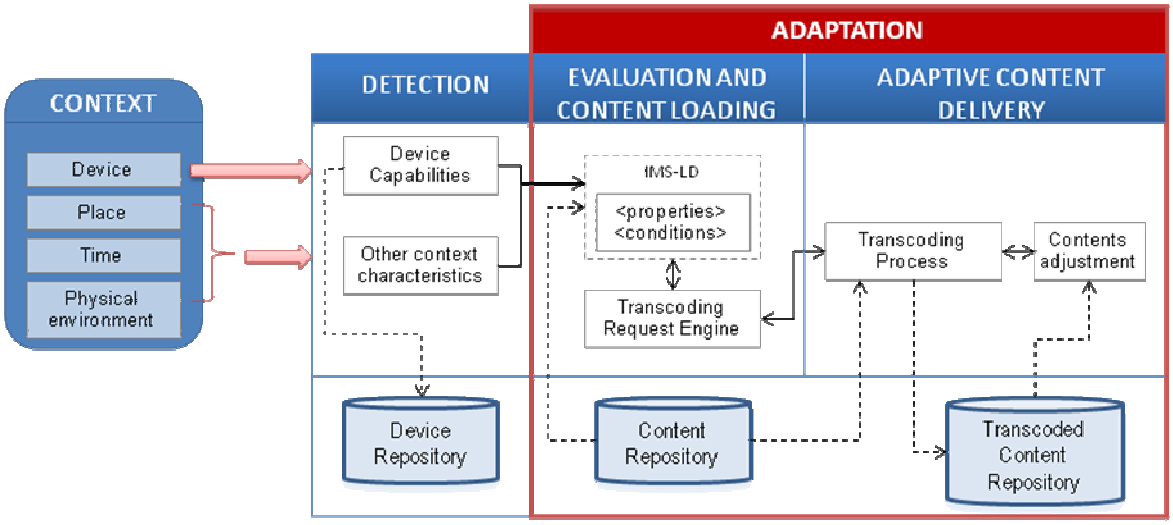

Figure 3. Context-aware adaptation process

As we mentioned, in the adaptation process only technological characteristics involved in the context parameter “device” were considered as first approach. WURFL specification is used to detect and get the characteristics of several existing mobile devices. WURFL is an XML configuration file that storage the technologies properties of different mobile devices and can be updated as new devices appear.

Obtaining and considering device profiles can be performed using a device repository that allow device profiles to be stored in order to use them in the implementation of systems that consider the context. Some of the proposals explained in background use repositories in order to analyze device properties to deliver adaptive contents. Two of these repositories are SESAME [32] that stores UAProf profiles and the repository of WURLF that stores WURLF profiles respectively. We consider WURFL as best choice and according with the profile specification selected.

A. Evaluation and Content loading

Taking into account the information of a UoL explained in previous sections, we consider both properties and condition elements of level B of the IMS-LD in order to generate adaptive UoL. This leaves the possibility to integrate mechanisms, specifications and technologies of adaptation according with the variables of the context defined. However properties and conditions definition is a process that has to be undertaken in design phase. In [33] characteristics of context are considered to define conditions in a IMS-LD UoL to evaluate device and content properties in order to display the contents adjusted to evaluation results. Properties and conditions definition let refine the visibility of the activities and environment entities to different users and roles, specifically to their access devices

In order to accomplish adaptation in a UoL considering the parameters of the context, it is necessary to:

i) Tag resources available in the LMS using metadata schemes. We use IEEE-LOM standard to characterize resources, defining the most important elements of the metadata. These resources are stored in a content repository and are created by teachers, designers and developers, who also have to label them following the specification guidelines. The repository used to store contents was Fedora [34]. These repositories stores digital resources, let define multiples versions of one content and let associate metadata of different specifications establishing relations between resources.

ii) Define a set of properties to store context values from place, time and physical environment parameters captured in detection process, these values allow conditions to be evaluated according to learning activity objectives defined. In a pedagogical model, learning activities can consider different learning situations such as change the place where the activity has to be performed, organize different learning sessions in different values of time, propose outdoor or indoor activities where variables have to be analyzed, send messages to learners or teammates when some advice have to be notified, etc. These situations where learners and teachers participate have to be considered in order to achieve specific objectives.

iii) Define a set of conditions that allow context properties to be evaluated in order to execute show or hide actions to decide which resources, environments or learning activities have to be shown or hidden respectively, or change a property value if would be needed. The conditions consist of sentences IF/THEN/ELSE. Within IF block an expression that must generate a boolean result is evaluated. In order to execute the adaptation actions within THEN block when the result is true or the actions of ELSE block when the result is false.

To transform and adapt contents considering technological device capabilities, first statement have to be followed, tagging all the resources referenced in a UoL. Other statements are followed when place, time and physical environment parameters are captured.

The OMA-STI guidelines proposed by Open Mobile Alliance allow generating tools to start and end a content transformation process. To provide a standardized interface between LMSs and a transcoding platform, this specification presents different recoding criteria for media content files transformation based on specified transcoding parameters established and/or user equipment capabilities considered.

Parameters relation between content and device capabilities was defined in order to accomplish content adaptation process. Still image, audio and video contents were considered as first approach. Transcoding process can be performed with these types of content. Table 2 list the parameter relation identified from both WURLF capabilities and OMA-STI specification (all specific WURFL device capabilities identified were not listed because of paper size constraint).

Table 2. Parameter relation between OMA-STI and WURFL

OMA Image property name	WURFL group	WURFL capabilities
content-type	image_format	jpg, png, gif, …
size-limit	object_download	picture_directdownload_size_limit
width	display	max_image_width
height	display	max_image_height
colorScheme.scheme	image_format	greyscale
colorScheme.depth	image_format	colors
OMA Audio property name		
content-type	sound_format	mp3, wav, mmf, voices, …
size-limit	object_download	ringtone_directdownload_siz e_limit
bit-rate	sound_format	mp3, awb, …
channels	sound_format	midi_polyphonic, midi_monophonic, , …
sampling-rate	sound_format	mp3, …
sampling-resolution	sound_format	wav, au
OMA Video property name		
content-type	playback streaming	playback_3g2, playback_mp4, streaming_mp4, streaming_wmv, …
size-limit	playback streaming	playback_directdownload_size_limit, streaming_video_size_limit
videoVisual.codec	playback streaming	playback_wmv, playback_mp4, video_mov, …
videoVisual.width	object_download streaming	video_max_width, …
videoVisual.height	object_download streaming	video_max_height, …
videoVisual.bitrate	object_download streaming	streaming_video_max_bit_rate, …
videoVisual.framerate	object_download streaming	video_max_frame_rate, …
videoAudio.codec	playback streaming	playback_real_media, playback_mp4, playback_wmv, ...
videoAudio.channels	playback streaming	playback_real_media, playback_mp4, playback_wmv, ...
videoAudio.sampling-rate	playback streaming	playback_real_media, playback_mp4, playback_mov, ...
videoAudio.bit-rate	object_download streaming	streaming_video_max_audio_bit_ra te, …

B. Adaptive content delivery

After devices capabilities and resource in a UoL have been detected and referenced respectively, the *transcoder request engine* prepares requests of transformation to be carried out in the transcoding process. Different transcoding jobs with the new properties for each resource according to the evaluation of the device WURFL capabilities are defined.

Each job is done consecutively in the order that resources are referenced in the UoL in each learning activity. In the transcoding process new transformed contents are stored into transcoded content reporitory (that can be defined as a cache repository), which stores the jobs done for different access devices leaving all resources modified available in order to improve the user interaction with the LMS. In this way the number of transcoding jobs in the future will be decreasing as multiple devices are used to perform different learning activities.

To deliver the adapted content, capturing mobile markup language is necessary to perform the adjustment process of transformed contents using appropriate labels that can be used to display them on the device. Capturing this property from the device can be made from the WURFL element "preferred_markup". Browsing capability is one of the main properties that any system that support content adaptation processes has to consider. This capability has the information of the name of the markup that is best known to be rendered on the device. Having transformed contents in the repository, adjustments can be done to web content that has embedded the contents referenced in learning activities.

6 CONCLUSIONS AND FUTURE WORK

The contribution of the work is the generation of a content adaptation process that consider different context characteristics to facilitate performing mobile learning activities.

To carry out the context-aware adaptation process on an LMS, capturing technological characteristics of the "device" is presented as a first approach. It is considered as future work to implement mechanisms that allow more characteristics of the parameters of context (place, time and physical environment) to be captured in order to be used in the construction of a learning design.

A proposal that integrates concepts of the hypermedia multimedia systems, ubiquitous and mobile computing research lines is presented. Through construction of learning designs, context variables can be considered. Ubiquitous and mobile computing are areas that aim proposing solutions to situations and problems that had not been considered in the construction of systems, such as context-awareness.

Furthermore, the use of mechanisms to generate transcoded/recoded educational contents is presented and considered to implement content adaptation mechanisms after some properties and conditions have been processed in an unit of learning. We concluded that using them can facilitate the integration of an adaptation process to any architecture. Furthermore, they can aim to implement adaptation in run-time process when an IMS-LD that considers context is being played. Also to generate different versions of a resource that later can be stored in a repository.

7 ACKNOWLEDGEMENT

Authors would like to thank the Spanish Science and Education Ministry for the financial support of A2UN@ project (TIN2008-06862-C04-02/TSI). Also thanks to the Research Program of the University of Girona.

8 REFERENCES

[1] M. Weiser, "The computing for the 21st century". Scientific American, 265 (3), pp. 94-104, 1991.

[2] P. Brusilovky and E. Millán, "User Model for Adaptive Hypermedia and Adaptive Educational Systems", The Adaptive Web, LNCS 4321, P. Brusilovsky, A. Kobsa, and W. Nejdl, Eds. Berlin, Germany: Springer-Verlag, pp. 3-53, 2007.

[3] The IMS Global Learning Consortium website. [Online]. Available: http://www.imsglobal.org/.

[4] The IEEE website. [Online]. Available: http://www.ieee.org/portal/site.

[5] The ADL Advanced Distributed Learning website. [Online]. Available: http://www.adlnet.gov/index.cfm.

[6] The Open Mobile Alliance (OMA). [Online]. Available: http://www.openmobilealliance.org/.

[7] World Wide Web Consortium (W3C). [Online]. Available: http://www.w3.org/.

[8] Standard for Learning Object Metadata (LOM), IEEE 1484.12.1, 2002.

[9] Learning Design (LD) Specification, IMS Global Learning Consortium, Version 1.0 Final Specification, 2003.

[10] OMA - Standard Transcoding Interface Specification. [Online]. Available: http://www.openmobilealliance.org/technical/release_program/docs/CopyrightClick.aspx?pck=STI&file=V1_0-20050704-C/OMA-TS-STI-V1_0-20050704-C.pdf.

[11] The WURFL website. [Online]. Available: http://wurfl.sourceforge.net/.