Learner-Centric Context-Aware Mobile Learning

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Abstract—Mobile learning is gaining a lot of interest in recent years mainly for its convenience and boundless way of learning. It is convenient because mobile devices are used not only for communicating but also for accessing the Internet, purchasing goods, exchanging information, and organizing our everyday life. It is boundless since it extends e-Learning and removes space boundaries offering anytime anywhere learning experience. Mobile devices have the potential to be used as powerful learning tools in different learning contexts, however this poses new challenges that are associated with their ability to cope technically with the available multimedia learning material. Our main focus in this paper is to discuss issues related to the design and implementation of a mobile learning system. Our proposal comes from a web-based framework accompanied with ontology and tuned to solve mobile-environment challenges, hence, making it a highly cross-platform solution.

Index Terms — Context-awareness, educational technology, m-Learning, mobile aided learning, ontology.

I. INTRODUCTION

THE rapid development and technological advancements of wireless technologies in addition to the increasing number of mobile users paved the way for 'mobile learning' as a complement of e-Learning [1]. Mobile learning (or m-Learning) is the achievement of e-Learning on mobile computing devices (e.g. cell-phones, Personal Digital Assistants (PDAs), and Pocket PCs) offering anytime anywhere learning. M-Learning poses new challenges to be taken into account. This is mainly due to device capabilities (e.g. screen size, power and memory limitations, and navigation tools), limitations of mobile communication channels (in terms of bandwidth and associated cost) in addition to the special requirements of mobile learners [2]. However, the highly personalized nature of digital mobile devices provides an excellent platform for the development of

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contextual, learner-centric learning experiences. In this paper we emphasize the importance of considering learning over mobile technology, and suggest an ontology based approach for developing learner-centric m-learning. Many approaches have been proposed to develop mobile learning systems taking into account the adaptivity of learning [3] and the learning environment context [2]. Our architecture extends these two learning dimensions, it is designed with the following main goals: Providing each user with a personalized learning experience, constructing an adaptive model of learning systems that takes into account the constraints associated with mobile environments, making use of learning practices already deployed in e-Learning systems and adopting them in m-Learning systems, and finally deploying web technologies as an infrastructure to facilitate mobile learning. The system allows each user to build a personalized learning experience that fits his constraints in terms of preferences, speed of learning, consumed time, and background information. The system takes into consideration the device capabilities while searching for appropriate learning objects for presentation, hence adding reusability to learning objects.

II. ONTOLOGY-BASED M-LEARNING

The proposed architecture is built around an ontology backbone that defines both the learning domain and support technology (device and network settings) at the semantic level. The use of ontologies facilitates context acquisition and enables a standard-based learning object metadata annotation. The system uses a set of ontological rules to achieve personalized context aware learning by integrating knowledge embedded in both ontologies. The reasoning process is driven by the user interaction taking into account the task at hand, learner profile, and the device-network environment. The output of the reasoning process is the extraction of metadata that will allow discovery and adaptation of learning objects. Many adaptability dimensions are investigated in this paper. These are mainly related to user and device adaptations. Thus the ontology used in this work aims at communicating contextual information and delivering just the right amount of knowledge learners can consume on the fly using their mobile devices.

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III. SYSTEM ARCHITECTURE

The architecture depicted in Fig. 1 exhibits three layers namely the context layer, the semantic layer, and the resource repository layer. The context layer deals with attributes related to the learner, used device, and network connectivity. The semantic layer consists mainly of an ontology reasoning component which uses the contextual information sensed by the context acquisition and management module from the user interaction to drive the reasoning process. The semantic layer uses Apache server to provide the necessary environment to run PHP scripts using the PHP Zend engine as well as to act as a web server. PHP language is used as the main development language for the learning web constructor. In order to formulate the output, Cascading Stylesheets (CSS) are used. The learning resources repository layer includes repositories for learning objects, ontologies, learners' profile, and device profiles. This layer is implemented using MySQL (Database Management System).

In order to cope with the variety of contexts and the heterogeneous technological environments, the proposed system articulates five functional dimensions that are: content, learner model, mobile device, network connectivity, and coordination dimensions.

The content dimension is characterized by the metadata generated while invoking the set of ontological rules. It is composed of two main parts: XML (Extensible Markup Language) ontology and Learning Objects (LOs) repository. Learning object attributes such as LO identifier, described concept, estimated learning time, LO relationship to other LOs as described in the domain ontology, multimedia nature of embedded content, semantic density of the content, are described in XML [1] adopting the IEEE-LTSC LOM (Learning Object Metadata) standard. Examples of Learning Objects are HTML files, multimedia contents, PDF documents, and PowerPoint slides. Learning objects are stored in a database that is read-only as far as clients (learners) are concerned. The LO authoring could be performed by a separate process and is considered out of the scope of this paper. The learner model dimension is built from the repository of learner profiles and experiences. It contains information about the user, his/her learning style and the course progression. In addition, it contains the time allocated and consumed for the learning session and topics covered. Devices are categorized in three main categories according to multimedia support: PDA, mobile phone, and pocket PCs (and tablet PCs). Each category has specific characteristics. Laptops and tablet PCs have no limitations on multimedia support. Mobile phones facilitate short text and small images. PDAs however support short text, video, audio, and images. Static information about the multimedia capabilities of each category is stored in the device profiles repository. The connectivity dimension defines the type and constraints related to the network connection by which different components of the system communicate. Currently, mobile systems only support real-time communication in their web



Fig. 1. The three level architecture of M-Learning System.

browsers. Therefore, all system components are designed to communicate in real-time. Finally, the coordination dimension, which embeds the learning web constructor, maps the content to the presentation. It consists of five main processing stages: input, construct, exclude, order, and output. In the first stage, the system prompts the user for a username/password for authentication, time allocated for learning, and a search keyword which is used for building the learning web. These inputs are referred to as explicit inputs and are simply the user answers to the direct questions initiated by the web interface as explained above. Also, at this stage, the system will collect some implicit inputs such as the type of used device (mobile phone, PDA, laptop) and topics covered. The implicit inputs are collected without a direct interaction from the user. For instance, the device type is inferred from the HTTP header, and background information of covered modules can be inferred from learner profile. Secondly, the system constructs the reduced relevant ontology based on the LO repository. In the third stage, the system excludes unsuitable content due to user or device restrictions (e.g. time, screen resolution, multimedia support, etc.). Then, it orders the content left to produce the learning web. Finally, it produces the output to the user which consists of an ordered list of suitable learning objects according to the context and the search keyword (as a table of contents). Moreover, the system output will be HTML files embedded with multimedia contents (if any) which are dynamically created according to the learner request and the context. Therefore, the client layer

will be completely handled by the web browser [3]-[4].

IV. CASE STUDY

Consider a situation where a student is at a conference session and his presentation is the next in the schedule. Within a very short time, he would like to revise how to handle the Question-and-Answer (Q&A) session. Using his PDA, he logged in to the system and requested information about presentations in general and handling Q&A sessions in particular. Fig. 2 shows a portion of a simple ontology for communication fundamentals. Each concept contains text and may contain image, video, and other multimedia files.

Once logged-in, the system extracts the learner's profile from the repository layer. It also identifies the device type based on a string matching in a field of the HTTP request header as mentioned before. Based on the device type identification, the system will retrieve associated device capabilities from the repository layer. Thus, all constraints related to the user and the device are clearly identified, stored in a database, and associated to the current learning session. Then the system matches the user query with concepts in the ontology. For our case study, this results into two types of matches: Effective Presentations and O&A session. The next processing stage consists of extracting all sub-concepts of the obtained two matches. Hence, Research and preparation, Presentation aids, Presentation process, Q&A session, and Fundamentals of persuasion are extracted because they are sub-concepts of Effective Presentations concept. In addition, the sub-concepts of Q&A session are extracted. These are: when & how to open the floor, Handling challenging questions, and Handling challenging audience. At this stage, the learning web is constructed as illustrated in Fig. 3(a). The next step excludes and removes unsuitable content based on device constraints and the learner profile. To perform this process every concept is examined in order to remove any content that the device cannot handle or the user does not prefer to receive based on his/her preferences. The system will then examine the learning web to check whether the selected learning content fits within the learning time allocated by the learner. Let us assume that the constructed learning web exceeded the allocated time provided by the user. Consequently, the system will refine the result including only sub-concept of 'Q&A session' which is the term with most depth as shown in Fig. 3(b). The final step is to order the selected learning objects using the LOs' relations' constraints. The output result is a set of ordered links to HTML documents to be presented to the user as illustrated in Fig. 3(c) [4]. A detailed description of mapping and ordering ontologies to learning webs can be found in [1], [5], [6].

V. CONCLUSION

This paper shows the design and implementation of a dynamic and adaptive mobile learning system. It is based on

Fig. 3. Learning web processing steps.



Fig. 2. 'Communication fundamentals' ontology.







current open-source publicly available web technologies such as: HTML, CSS, XML, PHP, and MySQL. This used infrastructure provides a highly cross-platform solution with no special software to be installed on the client's device. The only requirements are a web browser with a mean to connect to the Internet which is available to most handheld devices nowadays. In addition, the proposed system does not perform heavy processing on the client side. The client is only responsible for handling the reception and presentation of simple standard HTML files embedded with multimedia content, if any, while the server carry the rest of the processing.

Constructing the learning web consists of five main stages: input learner's query and preferences, construct LO ontology, exclude undesirable and device-incompatible content, order learning objects, and finally output a browsable learning sequence. The first stage captures both user inputs and constraints related to the learner and/or the used device. We then construct the reduced relevant ontology based on LO repository. Third, the system excludes unsuitable content due to user and/or device restrictions (e.g. time, screen resolution, multimedia support etc.). Then, learning content is ordered to produce a learning web. Finally, the system produces the output to the user in terms of an ordered browsable sequence of suitable content offering "just enough, just in time, and just for me" learning experience [7]. Our future work will investigate the integration of our implementation with the web to form a mobile version of the web.

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