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Contextual adaptability platform for mobile and ubiquitous learning: a step towards a pervasive learning environment

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ABSTRACT

The evolution and convergence of wireless technologies, mobile devices and sensors, has caused profound mutation in applications. Applications for e-learning are no exception to this trend; the mobile, ubiquitous and ambient learning have appeared next to the e-learning. Far from being simple extensions of distance learning, they pose several challenges. Most of learning content used in learning platforms are built to be consumed on broadband networks and powerful terminals. However, technological advances have allowed their consumption over low flow wireless networks, and terminals with limited resources. Consequently, there is a strong need for learning content adaptation systems. Within this article we study the learning pervasive environment that provides an access to information and activities through different context. We define the different dimensions of this context and describe our platform for dynamic adaptation of learning content that representing a brick of MADAR-Learning project.

KEYWORDS

m-learning, u-learning, p-learning, context-aware, Adaptation of Content, MPEG-21 DIA UED.

1 INTRODUCTION

Since the 90s, the web began to be exploited by users with desktop computers that are equipped with large screens. Thus, over the years, the increasing power of computers and strong demand for multimedia application has seen the integration of new formats of multimedia content to the web. In parallel with the evolution of applications, the number of objects with computing capabilities, software, data, is becoming increasingly important to mobile phone functions, PDAs, car embedded computers, entertainment systems, toys, portable devices, etc [3]. With this technological development and more specifically the emergence of mobile phones that are quickly integrated into our daily lives, a new form of communication has been developed, through what we call "mobile computing", allowing access to information anywhere and anytime. This trend accelerated with the advent of communicating watches, clothes, vehicles, campus, household appliances or intelligent furniture. The user is increasingly surrounded by objects that have the characteristics of a computer. Therefore, the technological evolution has not stopped in mobile computing but it continues to computing that MarkWeiser named "Ubiquitous Computing" [1] and which mark an even more important widening of the communication means by integrating a generalized way the digital chips and interfaces in objects and spaces.

This dissolution of digital in objects, spaces and bodies allowing us to observe a number of trends (figure 1). We have moved from a period when human activity must be adapt to the computer location (one computer, many people), to a period when the computer is the alter ego of the man (one person, one computer), for enter a period where the user is the central element and

where it is up to the machines to organize themselves around the man (one person, many computers) [6].

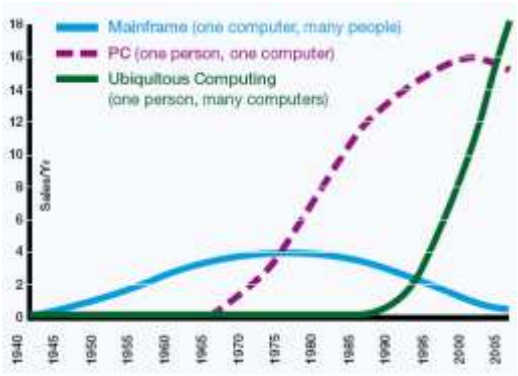


Figure 1. The three waves of computing [21]

This is the principle of pervasive computing that puts man at the center of a commonality of objects and machines that communicate not only with this one but between it also, for provide the adequate information in a transparent manner to the user [2].

This all without digital limit, leads us to analyze how in a radically changing environment, we can provide to the user the appropriate content to its context. For treating this research problem, we began this article by introducing technological changes. The first section of this article discusses our application field; it is distance learning that follows the evolution of new information technologies and communication. We then present our vision in MADAR-learning project which consists not to exclude the e-learning when the mobile, ubiquitous and pervasive learning will emerge [8]. In our point of view, it's important to provide coexistence with their new learning environment. However, this coexistence is not systematic. Allowing learner access to learning content through any environment, require good conditions for execution and represents a major challenge. It requires in a first step, the study of the various constraints posed by the environments of new technological generations that represent the context and design of system and architecture for adaptation. This architecture is presented in the second section of this article.

2 E-LEARNING TO P-LEARNING: EVOLUTION OF LEARNING PARADIGMS

The e-learning was born to address the constraints of classical learning (spatiotemporal constraints, difficulties to involve pedagogical approaches in class …) and exploiting the new information technologies [9]. The coupling of technology to learning has created several pedagogical and Technical needs in E-learning [10]: Among these needs, we give the three issues of technical challenges [11] [12]: Accessibility for facilitating learning resources discovery, Reusability of the same content according to the context and Durability of learning resources. Two major e-learning pedagogical challenges are raised according to various existing learning currents: Collaborative learning based on constructivist, psycho-cognitive and socio-cognitive theories, and personalization of the learning process according to the learner's profile and characteristics [9].

Many standards were established to fulfill technical and pedagogical needs, We cite as example, the learning object indexation and structuring [13], and learning participants profile design [14]. However, research in e-learning is still traditional based on the transmission of knowledge without exploiting the strengths of the new context of distance learners. The implementation of constructivist, cognitive and their successors of approaches, who have not found a context of implementation en the class, are still absent until now for e-leaning [9]. Thanks to technology, who played the role of communication medium and transmission of knowledge, it has provided new opportunities for the application of cognitive and constructivist approaches and successors, particularly social constructivism and situated learning who are encouraged by mobile and ubiquitous learning [15]. Even though the mobile and ubiquitous learning brought new opportunities, however, we find ourselves

again in front of the same challenges that we noted in e-learning (Reusability, Accessibility, Durability, personalization…) given the diversity of Means of access to learning platform, and adds several technical and pedagogical challenges to overcome.

The integration of mobile technologies in the learning process was responsible for several technical requirements: Device with Small screen[16] [17] [18], variety of hardware and software features[19] [20], variable and limited bandwidth, disconnection, mobility [41]…, In addition to these technical problems pedagogical challenges remain fertile fields of research and include different areas [2]: Learning in real contexts, collaborative learning [4], possibility of more creativity and more autonomy: Mobile technologies have provided the learner the flexibility of learning regardless of time and space. This autonomy and flexibility provide the learner and the author more capability of innovation and creativity of innovation and creativity, and requires taking into account the preferences of the learner.

Until now, due to the existence of a set of challenges only the application of mobile and ubiquitous technology in education does not ensure effectively the expectations of learners. An obligatory passage to another mode of learning has become necessary. By consequently, a new form of learning is established called p-learning (Pervasive Learning). Among many proposed definitions for pervasive learning we found: « Pervasive Learning refers to an environment for the student where the computer becomes completely transparent and where the machine adapts to human needs. Access is everywhere, no matter the location of the equipment. This dimension calls for new paradigms to reduce the gap between the mechanical representation and human relations in a communicating space. The learner is at the center of an ecosystem that allows learning through a network of services and access. The user structure his learning through human interaction / network that takes into account the ubiquity of a spatial, temporal and cognitive multi dimension, as well as multiple channels and multiple access methods tailored to the learner »[5]. By consequence, pervasive learning takes part in an experience of immersion as mediator between the learner's mental (e.g., needs, preferences, prior knowledge), physical (e.g., objects, other learners close by) and virtual (e.g., content accessible with mobile devices) contexts. Where these contexts overlap and form a single entity is addressed here as pervasive learning environment [41].

The Context has a variety of definitions in the pervasive computing literature (Chen & Kotz [22], Strang & Linnhoff-Popien [23], daCosta, Yamin & Geyer [24]). The definition of context which is the most widely used was given by Dey [25] saying that: «Context is any information that can be used to characterize the situation of entities (i.e. whether a person, place or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves ». From this definition, in our MADAR-learning project we specify the context in four dimensions; the device context, the network context, the learner context (learner profile and preferences) and environment context [9]. Each dimension contains much information that constitutes the context parameters (figure 2):

Fig.2. Context of learning adaptation [2]

3. PLATFORM FOR DYNAMIC ADAPTATION OF LEARNING CONTENT FOR PERVASIVE LEARNING ENVIRONMENTS

The main objective of our work is to propose an adaptation system for learning content to

enable transparent adaptation and facilitate the migration to future pervasive learning environment. A process of adaptation is defined by the set of operation necessary to ensure optimal use of the learning resource in a given context. The success and effectiveness of this adaptation process are highly dependent on the amount of knowledge about both the context of the learner and content that must be adapted. Generally, Content adaptation solutions can determine the identity and characteristics of a particular device by using the header fields of HTTP requests. They use "User-Agent" which contains information about the browser, the operating system and sometimes material information. And « Accept header » that contains the list of formats supported by the device. However the available information in the HTTP header is not sufficient for a detailed description about device features. For this propose, to design the platform of adaption of learning object in MADAR-learning project, we started by Designing an acquisition and context management module which is the main module in a pervasive learning environment [elha08] [elha09]. The rest of the necessary functions of the platform are summarized in: Decision making and execution of the decision. Figure 2 represents our adaptation system that is positioned as an intermediate layer between the learner context level and the database level; suppliers of electronic adaptation services.

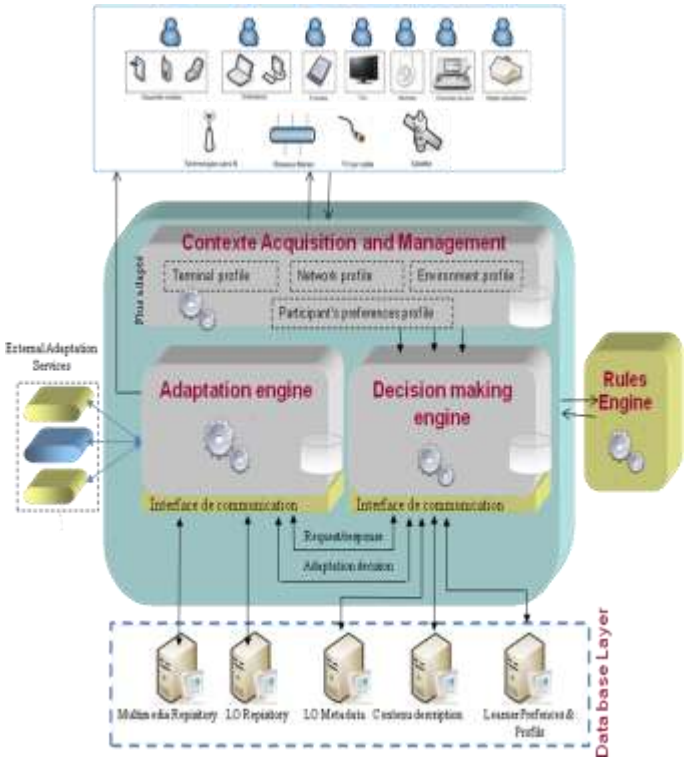
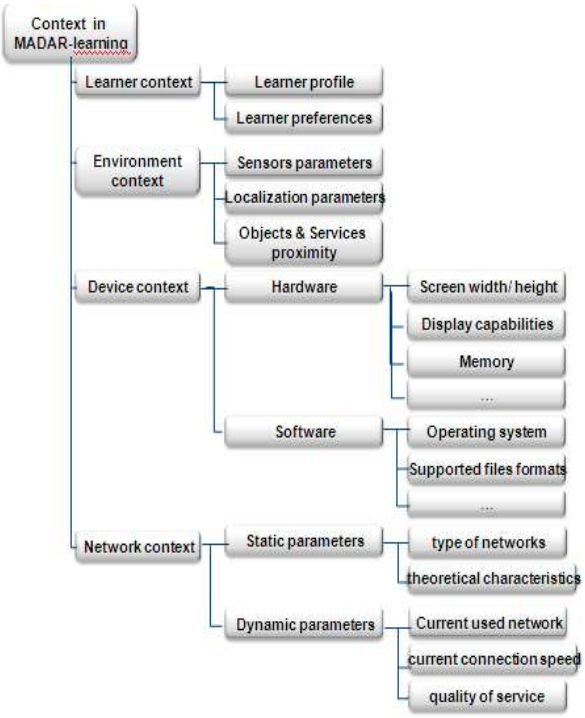


Fig. 2. Platform architecture for dynamic adaptation to the context

3.1 Learner context level

The learning context is the target level that represents information about learner, the device used, the network connection and parameters of the environment from this learner. Each dimension of this level of context is associated with a set of parameters:



Device context: A wide variety of devices can play the role of terminals exist such as personal digital assistants (PDA), laptops, mobile phones, TVs, e-books, games consoles etc. However, since these devices have different features, we propose to adapt contents according to the particular characteristics of each type of device. We classify those characteristics into two types of information: hardware information (Type of terminal (PC, PDA, mobile phone), mark, model, memory, audio characteristics, screen type, screen size, screen resolution, processor…) and software information (Name of the operating system, operating system version, applications, audio format, video format, pictures format, types of protocol, …).

Network context: This dimension represents the characteristics of network connection. We can classify it by two types of parameters. The first concerns the static ones that include the type of networks supported by device and its theoretical characteristics (theoretical download and upload speed …). The second concerns the dynamic parameters wherein the parameters change across the time (Current used network, current connection speed and the quality of service offered by the network).

Environment context: To be able to include authentic learning scenarios in the real-world, learning solutions should include parameters of learner's environment such us learner location [26], time, proximity to services or other devices or objects and other parameters such us temperature, motion, light and all environmental or activity context. We can classify environment parameters into tree classes: Objects and services proximity (Bluetooth, Wi-Fi RFID) [27], localization parameters (Cell ID, GPS) [28], and Sensors parameters (light sensors, temperature sensors, smoke detectors, motion sensors, and touch sensors).

Learner context: A learner context is both a learner profile and learner preferences profile that gathers information about the learner, such as his content preferences (text, audio, video...), and to the human machine interfaces preferences (text size, language preference, color choice...) etc.

3.2 Database layer

The main objective of our work is to propose an adaptation system for learning content to enable transparent adaptation and facilitate the migration to future pervasive learning environment. However, in the current context of technological convergence and the explosion of networks and mobile terminals, the consumption of learning object poses a mismatch between the media content that is likely to be represented with different content encoding formats at different quality levels [29], and context of use, which is the main obstacle to fulfilling the promise of pervasive learning. Detailed descriptions of content are needed and this must be arranged as a description of learning objects. This doesn't just imply the need of metadata about learning objects, but another level of description detailing the multimedia learning content.

MPEG-7 includes a rich set of descriptors and description schemes by both the content (audio and visual) and semantic / text [30]. The MPEG-7 descriptions of content may include [31]: Information of the storage features of the content (storage format, encoding), Structural information on spatial, temporal or spatio-temporal components of the content (scene cuts, segmentation in regions, region motion tracking), Information about low level features in the content (colors, textures, sound timbres, melody description), Conceptual information of the reality captured by the content (objects and events, interactions among objects), Information about how to browse the content in an efficient way (summaries, variations, spatial and frequency subbands,), Information about collections of objects, Information about the interaction of the user with the content (user preferences, usage history)...

The scope of action of MPEG-7 only applies to multimedia content. Therefore, to facilitate adaptation decisions we inserted in our project, a new multimedia content description layer annotate with MPEG-7, above proposed standards such as LOM model that is more focused on describing educational information. Thus, our project is based in database level of five repositories: Multimedia Repository, Learning Object Repository, Learning Object Metadata Repository and Learner profile that we annotate with the IMS-LIP.

3.3 Treatments layer

Our platform is designed in a model of multilevel distributed applications. The adaptation logic is divided into components according to the function assigned to each component. Three main components are identified: Context Acquisition & management, decision making engine and adaptation engine.

Context Acquisition & management

First, contextual Adaptability platform must have a mechanism to acquire and manage all information about the execution context that can have an impact on the content requested by the learner. Therefore, Context Acquisition & management module provide collection, annotation, automatic composition and management all context parameters. Therefore, for annotation it is essential to chose precisely a standardized format that will be used by this module. Several solutions exist as CC/PP [33], UAProf [20] and WURFL [32] for describing the characteristics of mobile devices [34] [35] [36].

Several solutions for m-learning adaptation architecture are based on CC/PP or WURFL for describing the characteristics of mobile devices. However, in the pervasive need the context does not only consist of mobile devices dimension, but of other dimensions, namely learner preferences, network characteristics (current used speed of the network) and information about the physical environment of the learner. These dimensions have to be described under the same standard description language that must be widely accepted to be manipulated by all sorts of machines and software. For this reason, we chose to use for annotation of the "Usage environment description" tools or "UED of the MPEG-21 DIA considered as the standardization initiative to represent a more complete context of content adaptation [38]. The UED allows the description of terminal capabilities, network characteristics, user preferences and characteristics of the natural environment [37].

Figure 3 displays the correspondence of context in MADAR-learning project with Usage environment descriptiontools MPEG-21.

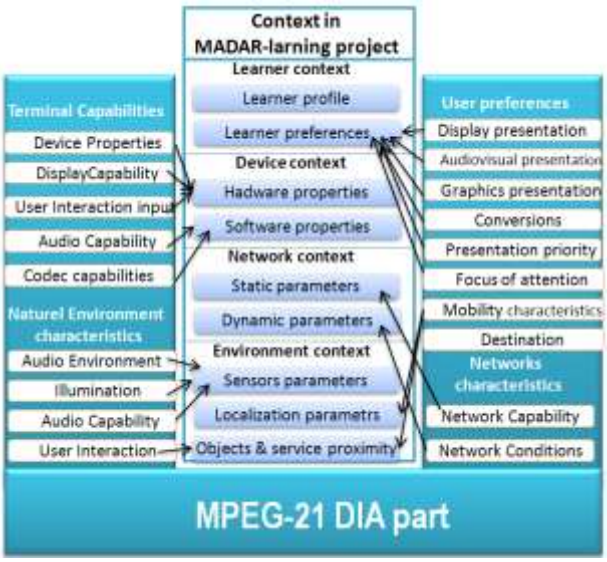


Fig. 3. Mapping of MADAR-learning context with MPEG-21 DIA part

Decision making engine:

The decision making engine is based on the three categories outputs; the first is recovered of Context Acquisition & management module and includes context parameters. The second is recovered of database layer and include: the MPEG-7 Metadata and the Learning Object Metadata. A third category concerns the conditions of implementation and consists of Universal Description Constraints and Terminal and network quality of service of the DIA part of MPEG-21[38]. The UCD description defines the constraints that may exist on certain parameters that must be met by the module "Decision making engine". By example, the flow rate (audio + video) should not exceed the available flow at the access layer or the rate of FEC redundancy must not exceed a certain threshold. It also defines the parameters that must be maximized (the PSNR of a video) or minimized (loss rates) [39]. The UCD is the link between "AdaptationQoS" and UED [48]. With this tool, different types of constraints that affect the adaptation process can be described using XML syntax.

To define what to adapt and to what it will be adapted, the Decision making engineuse the three categories and a rules engine to define rules of adaptation that will be sent to the adaptation engine. Rules may be charged, discharged or amended in memory without resetting the rules engine. Then, the rules engine optimizes the performance of rules by arranging the most efficient way possible.

Adaptation engine:

Based on rules provided by decision making engine, the adaptation engine selects the services necessary to adapt the learning content. The objective of this adaptation layer is to attach, detach, dynamically reconfigured, compose and combine the appropriate services that provide elementary adaptation operations to adapt learning resources, activities or situations based on adaptation rules. Adaptation engine contains also all generated rules during the user access session to the learning system, and delegate and allows adaptation to adaptation services (video adaptation, translation, audio processing, and change of layout). Types of adaptation can be: Transmode; Transcoder, Tradition, etc.

CONCLUSION

As we note through this paper, during the last decade there is an evolution of the used technologies in learning from the E-learning to the P-learning through M-learning. Each evolution, meets to a set of needs: E-learning has answered the question of any time, but partially to the other two basic needs: anywhere, any environment. The m-learning was coming with the advantage of mobility. The u-learning also was coming with the advantage of enhancing the mobility and the independence; He replied to anytime and anywhere paradigm. However, it was unable to provide a learning environment that can fully address the three needs (any time, anywhere, any environment). Therefore, the main objective of our work is to propose an adaptation system for learning content which is a necessary step for migration to future