Web Services Architecture for M-Learning

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Abstract: The academic environment is undergoing a major shift, as increasing numbers of schools are ready to offer courses using mobile technology for economic and other reasons both from an instructor and student perspective. The mobile learning (m-learning) approach would necessitate changes in pedagogy, educational roles, curricular content, and classroom practices. In addition, it would also require different system architecture because it would demand massive integration of software systems. This paper presents a method for exploiting web services architecture for m-learning.

Keywords: Mobile education, e-learning, M-Learning, Web services

1. Introduction

Emerging technologies are leading to the development of many new opportunities to guide and enhance learning that were unimaginable even a few years ago. There are already about one million courses on the internet, 30,000 of them compiling with a scientific definition of online, 22,000 of these are listed on the telecampus portal, with many of them making didactic use of the World Wide Web (Anonymous 1998). The e-learning includes online learning, web-based training, virtual universities and classrooms, digital collaboration and technology assisted distance learning. The WebCT kernel alone was used by 5 million students in more than an hundred thousands courses, developed by 40,000 university and college faculty at over 1,000 institutions in 50 countries. The acceptance of e-Learning or web-based learning is due to growing availability of commercially available Learning Management Systems (LMSs) such as WebCT, BlackBoard, Learning Space, IntraLearn , Top Class, eCollege, Click2learn, Authorware, LearnLinc ,Virtual-U, Web Course in a Box, UniLearn and WebBoard (Abernathy 2001).

Handheld computers, the wallet-sized organizational devices used by business professionals to keep track of appointments, contacts, e-mail, and the Internet, have found their way into classrooms. Using m-learning environment, teachers eliminate the need to write assignments on the chalkboard because they can "beam" instructions to students' handheld devices (Kaasinen, Aaltonen et al. 2000). With the advent of mobile devices such as portable handheld computers becoming the norm in business and in our daily lives, it is inevitable that the educational environment will realize that using these mobile devices on campus would enrich the learning experience of students (Abernathy 2001) (Ed 2001). Educators understand that mobile handheld computers and wireless connectivity at schools can enrich the learning experience of students. Using mobile devices such as Palm handheld computers connected to web servers on campus, students can truly experience the freedom and productivity of mobile handheld computing (Bunnell 2002). Wireless laptops, Palm devices and graphing calculators will free teachers and students, turning any place into a classroom Students can access real-time information about their class curriculum, school events, after school sports and even test scores. An m-learning architecture based tool would enable students and teachers to quickly and easily access course curriculum and data whenever and wherever they need to. Time-crunched students and professionals place high value on the ability to access data anytime anywhere -- and wireless access is the future for all types of data transmission (Daniel and Cox 2002). Palm handheld-based learning programs would help students to solve and submit student homework assignments with lot of flexibility and may create a better learning experience in and outside the classroom. By the end of 2003, predicts Stamford, CT-based Gartner, 107 million Americans will own a Web-enabled cellular phone and 8 million will have a Web-enabled PDA (Training 2002) (Guardo, Arjona et al. 2001).

The paper presents the details of web services architecture that could be used for m-learning. The proposed architecture would provide students and teachers the opportunity to obtain any and all class related material on their Palm handheld computers through a web services architecture. The paper presents an architecture that can help to develop “one stop” oriented integrated software. Integrated software will provide an access to a central

home page that allows for synchronous group meetings, instant messaging, and a gateway to other real-time audio/video applications such as Microsoft NetMeeting, Netscape CoolTalk, or CU-See-Me.

2. M-Learning – A new paradigm in education

As our society is entering a knowledge-based, Internet/Web-driven economy, college education becomes a necessity for any individual who wants to be competitive and successful, regardless of his or her age, gender, and race (Fisher, 1997; Holstein, 1997). Over the last two decades the number of American college students over age 40 has more than tripled. Two-thirds of the older students are women; some of them have returned to school after their children are grown, giving them time to develop a career ("Older Students," 1996). Today, most full-time college students work part-time; many part-time students work full time, commute, and often have families to support. Students have found that going to college in the traditional way is difficult. They need innovative ways to help them study and work more efficiently in this competitive world (Zhao, 1999). To meet student needs, many universities offer self-, or i-paced, online courses on the Web with related technologies and applications software; studies indicate that i-paced online learning can be effective (Shea and Boser, 2001). M-learning is one more step in the same direction (Abernathy 2001).

The evolution in education and training at a distance can be characterized as a move from d-Learning (distance learning) to e-Learning (electronic learning) to m-Learning (mobile learning). With the successful development of Bluetooth, WAP (Wireless Application Protocol), GPRS (General Packet Radio System) and UMTS (Universal Mobile telecommunications System), the technological structures for wireless telephony and wireless computing are now firmly in place. M-learning, or mobile learning, involves delivery of digitized content to either wireless phones hooked into laptops or personal digital assistants (PDAs). The wireless technologies of the mobile revolution have seen the worldwide proliferation of wireless communication devices (Landers 2002). The idea behind m-learning is that it allows on-the-go professionals to connect to training courses anytime and anywhere. M-learning can include anything from job aids and courseware downloaded on personal digital assistant to Net-based, instructor-facilitated training via laptop (Abernathy 2001). M-Learning, allows users to access IT courseware modules via the Palm operating system. The Microsoft and Cisco certification courses, covering telecommunications fundamentals, TCP/IP, UNIX and JavaScript, are already available in m-learning format (Report 2000). Mobile technology enables schools to extend learning beyond the walls of classrooms. Palm handhelds can be loaded with applications, such as financial calculators, reference books, literature books, coursework organizers, and word processors etc. The schools have already started experimenting with this technology to develop new ways to enhance the educational experience of its students and the teaching experience for its faculty. Stanford University Law School has recently experimented with Palm devices; other PDA applications are also in place around campus, with positive results. Washington's American University is implementing a plan to become the first totally wireless university (Reuters 2002). The University of South Dakota is supplying Palm Pilots to first-year law and medical students (Ed 2001)

This technology provides students and teachers the opportunity to obtain any and all class-related material on their Palm handheld computers through a simple process of point-and-connect using infrared. The intersection of mobile computing and e-learning includes anytime, anywhere resources; strong search capabilities; rich interaction; powerful support for effective learning; and performance-based assessment (Abernathy 2001).

There are two familiar approaches to the issue of mobile learning. The first points out that since the dominant mode of access to the Internet will soon be through wireless devices, e-learning simply becomes m-learning, without any particular changes in content. The new approach stresses that m-learning will characteristically aim at specific kinds of knowledge, namely knowledge that is location-dependent and situation-dependent. The way e-learning is changing to m-learning is shown in Figures 1 and 2 (Landers 2002).

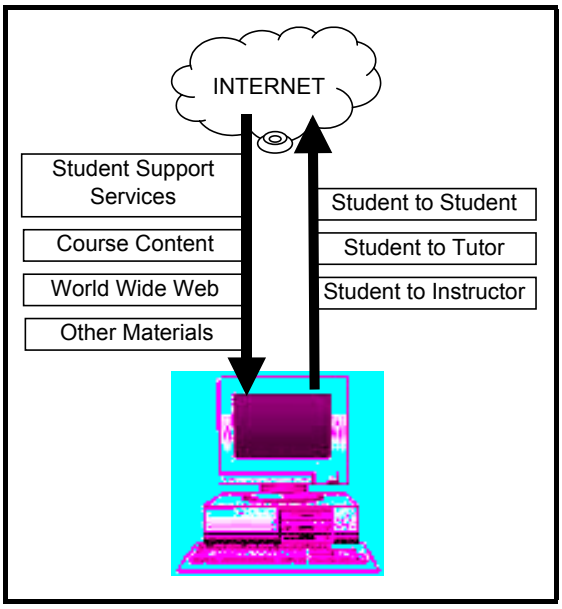

Figure 1: Wired Virtual Learning Environment of Today

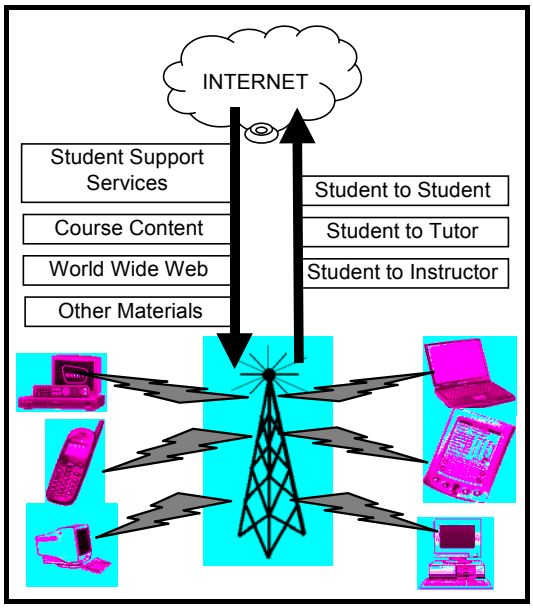

Figure 2: Wired Virtual Learning Environment of Tomorrow

The application of new, mostly mobile, technologies to distance learning involves new problems that require new and innovative solutions from both pedagogical and technological points of view. The same system that provides teacher-student communication provokes an excessive demand on teacher's response capacity, thus changing the pedagogical tools (Elena, Miguel et al. 2001).

2.1 M-Learning - A paradigm shift

The use of information and communication technologies in education and training has undergone several paradigm shifts over the last three decades (Bransford et al., 1999). E-learning (learning supported by digital "electronic" tools and media) and *m-learning* (e-learning using mobile devices and wireless transmission) have emerged. Handheld devices are emerging as one of the most promising technologies for supporting learning and particularly collaborative learning scenarios; mainly because they offer new opportunities for individuals who require mobile computer solutions that other devices cannot provide. M-learning is a new paradigm that creates a new learning environment. Mobile learning is unique because learners can access the course material, instructions, and other course related applications anytime and anywhere. This increases daily attention to learning material, makes learning pervasive, and may boost the learner's motivation for lifelong learning. Moving from stationary to mobile learning allows ad hoc collaboration and informal interaction between students (BRA, 2002, Wierzbicki, 2002). Mobile-learning is learning supported by mobile devices, ubiquitous communications technology, and intelligent user interfaces. The unique elements of mobile learning are; the facility to communicate with individuals or learning communities, either transient or well established, at any time or location; the ability to provide learning content dynamically dependent on a learner's location, wider context and the device being used by a learner, and the ability to record discrete acts of a learners 'learning episode', as they move through space and time, for later use and to provide recorded elements of previous learning episodes at any time or location (Rekkedal, 1999, Sariola, et al.,2001, Szucs, et al., 2001, Kynäslahti, 2001, Szucs, Wagner, and Holmberg, 2001). It is envisioned that with m-learning, the boundaries between the social arena and the formal learning arena, the classroom, diminish as students also take mobile telephone into use in classrooms. The teacher is put in a position in which the information that exists within the four walls of the classroom competes with information from 'outside' the classroom - beyond the teacher's control. Thus, the classroom culture is bound to change (Rekkedal, 1999, Koschmann, 2001, Bransford, et al., 1999, Gay, et al., 2002). We also hold the view that learning is an individual process that can be supported by adequate interaction and/or collaboration in groups (Askeland 2001). Mobile learning technologies present a challenge to the school – a challenge to access and utilize alternative learning arenas (Rekkedal, 1999). Mobile

technologies are referred to as handhelds, Personal Digital Assistants (PDAs) or Pocket PCs (PPCs) (Quinn, 2000, Sariola et al. 2001, Nyíri 2002).

Handheld mobile computing devices allow for exploratory activities not bound to a special location, for example field trips, without losing the potential for taking electronics notes and retrieving information of various types. Such notes, ranging from data collections and digital images to handwritten annotations, can be easily exchanged and downloaded. If combined with wireless transmission, these activities can be continuously monitored and coordinated between places. But even in classrooms and training settings with more or less fixed locations, the use of mobile and wireless technologies may lead to substantial changes as this can bring the technology to the background and to set the focus more on inter-personal relations and on the task at hand (Roschelle et al., 2002). A number of evaluation studies among distance and online learners demonstrate that students emphasize flexibility (Rekkedal, 1998, 1999). The various other shifts that may take place in m-learning environment are illustrated in following tables:

Table 1: Various Pedagogical and other Changes for M- Learning Environment

Pedagogical Changes	
Current e-Learning Methods	**M-Learning (Wireless)**
More Text-based and Graphic based instructions	More Voice, Graphics and Animation based instructions
Lecture in classroom or in internet labs	Learning occurring in the field or while mobile

Instructor to Student Communication	
Current e-Learning Methods	**M-Learning (Wireless)**
Time-delayed e-mail (students need to check e-mails or web sites for communication)	Instant Announcement of e-mail delivery (As soon as e-mail or communication arrives, students are informed through instant messaging
Passive communication	Instant communication
asynchronous	Interactive
	Spontaneous

Student to Student Communication	
Current e-Learning Methods	**M-Learning (Wireless)**
Face-to-Face	Flexible
Audio-teleconference is quite common	Audio-teleconference and Video-teleconference both would be possible
e-mail-to-e-mail	24/7 instantaneous
Private Location	No geographic boundaries
travel time to reach to internet site	no travel time since wireless internet connectivity
Dedicated time for any group meeting	Flexible timings on 24/7 basis
Poor communication due to group consciousness	Rich communication, due to one-to-one communication, reduced inhibitions

Feedback to Students	
Current e-Learning Methods	**M-Learning (Wireless)**
1-to-1 basis	
Asynchronous and at times delayed	Asynchronous and Synchronous both
Mass/standardized instruction	customized instruction
Benchmark-based grading	Performance & Improvement-based grading
Simulations & lab-based experiments	Real-life cases and on the site experiments
paper-based	less paper, less printing, less cost

Assignments & Tests	
Current e-Learning Methods	**M-Learning (Wireless)**
in-class	any location
Dedicated time	24/7 Instantaneous
Restricted amount of time	any amount of time
standard test	individualized tests
poor feedback	Richer Feedback
delayed feedback	instant feedback
fixed-length tests	flexible-length/number of questions
More text-based tests and assignments	More audio and visual animation based tests and assignments In-Field tests /experiments

Presentations, Exams and Assignments

Current e-Learning Methods	**M-Learning (Wireless)**
Theoretical and text based	Practical oriented exams direct on site hands-on based
Observe and monitoring in lab	Observe in the field and monitoring from remote location
class-based presentations	1-to-1 presentations with much richer communication
Use of one language	Auto translation for delivery of instructions in many languages (languages translator)
Individualized, component-based group work	Simultaneous collaborative group work
paper-based assignment delivery	electronic-based assignment delivery
hand-delivery of assignments at a particular place and time	E-delivery of assignments at any place and time
Instructor's time used to deliver lectures	Instructor's time used to offer individualized instructions and help

The convergence of computing and communication is a process that is turning phones and mobile terminals into powerful multimedia units. The XML-based Synchronized Multimedia Integration Language (SMIL), for instance, would be very useful for the distribution of sophisticated multimedia content. These forms of interactive multimedia offer new possibilities to learn, think, and communicate. The future online interactive m-learning based courses will have more multi-media based materials, tests and assignments. The present web-based asynchronous delivery method normally involves primarily text based material. This would change with the new m-learning paradigm. It should also be emphasized that we assume that the m-learning students normally will have access to a desktop or laptop computer with Internet connection for offline learning. This means that the equipment and technologies used when students are mobile are additions to the students' basic equipment used when studying at home or at work.

2.2 The teacher-student relationship in M-Learning environment

Mobile technology is changing the basic paradigms of when, where, and how school instruction can be delivered. The implications for the teacher-student relationship, standards, assessments, accountability, and traditional geographic boundaries are fundamental issues with which state and local boards of education will have to wrestle (Mioduser, et al., 2000). The teacher-student relationship has always been, and will continue to be of value. What will eventually happen in the mobile learning model is a 'blended learning' - an intelligent combination of e-learning and instructor-led training. The student will have access to multimedia learning tools, and all the information available on the Internet. The teacher will act as a guide to the student on how best to use these tools to get the information that is required. Constructivism is the main pedagogy used in online learning. This approach is used in the form of discussions, constructivist activity and conferencing to enable the learner to build an understanding and the meaning of the issues and to construct new knowledge on the basis of information (O'Reilly and Morgan, 1999, Mioduser, et al., 2000).

For effective teaching in am m-learning environment, teachers and students both need to understand the nature of the social relations, the quality of the interaction, and of

communication will ensure communicative competence, which includes the exchange of information, knowledge, experience, and development of skills. Teachers need to understand the complex relationships of cognitive tasks, socio-emotional aspects of learning, and the social context of learning, in order to create those social spaces for reflective learning by students. Online learning and specifically m-learning is very different from the traditional face-to-face instructor-led teaching method. The m-learning model is compared with traditional method of learning and is shown in figure 3 and figure 4. As shown in these figures, the learning space or classroom concept of traditional method is changed in m-learning environment. This certainly will have effects on student-teacher relationship and social issues.

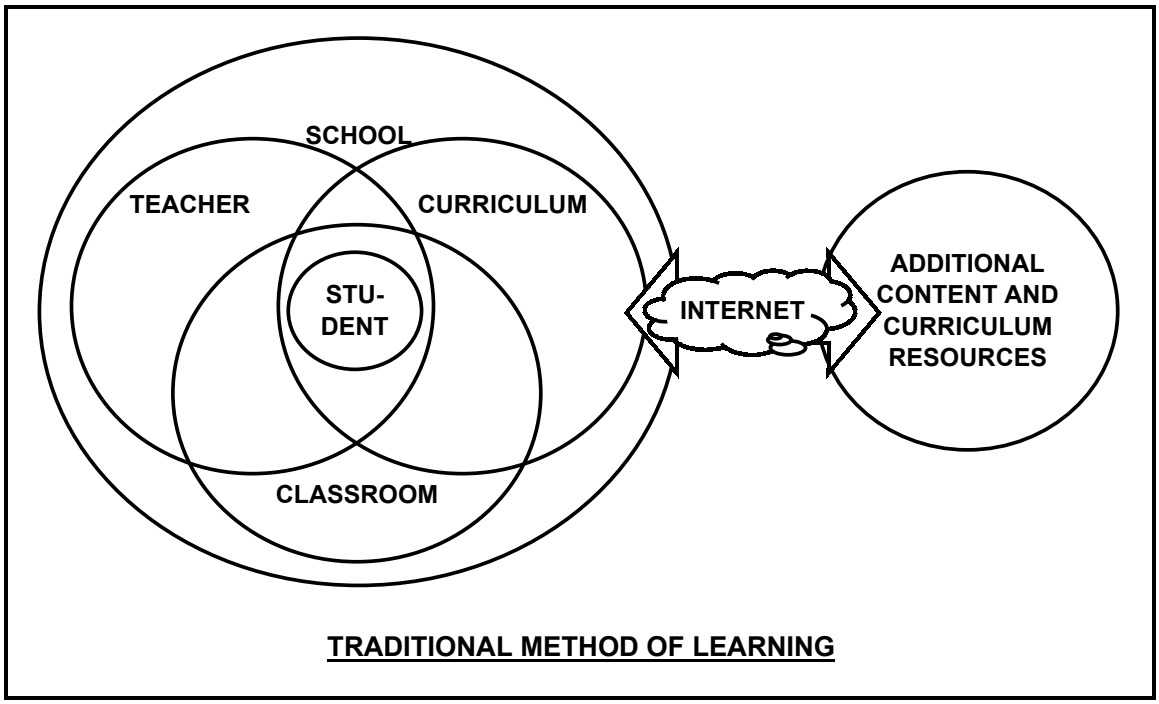

Figure 3: Traditional method of learning

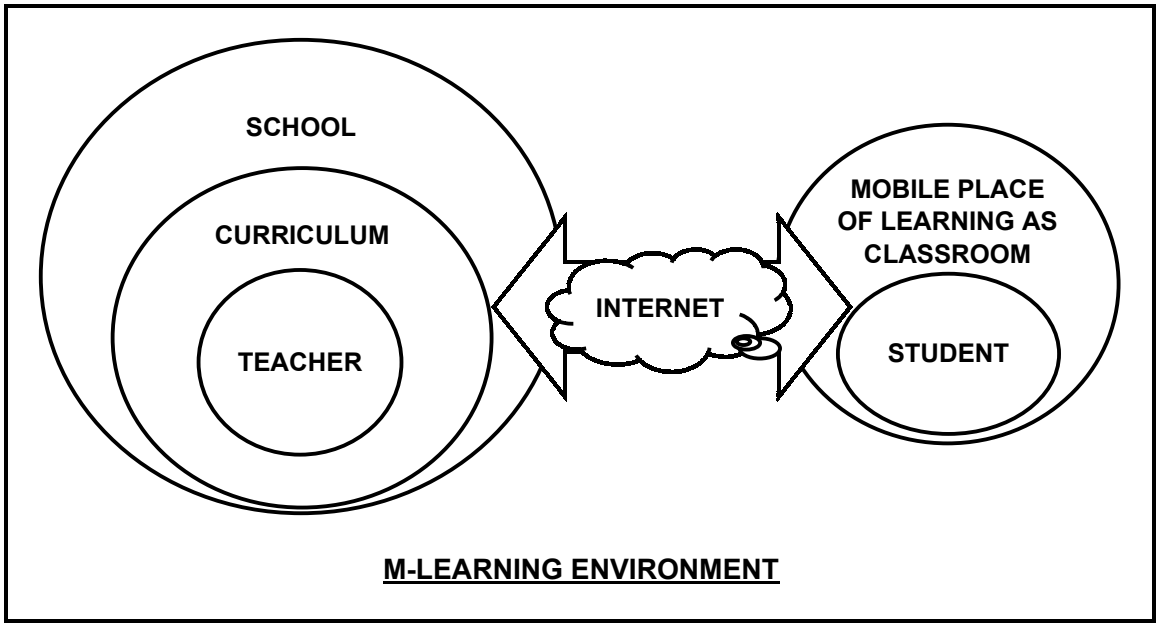

Figure 4: M-Learning model

Learning is a complex activity that puts students' motivation and physical condition to the test. Teaching resources, teacher skills, and curriculum all play a vital role in a students' learning process. The power dynamics of online education and particularly

m-learning will be altered (Mioduser, et al., 2000). The 'space' in which the students are learning is their own space, not a classroom. The time of study is the student's own choice, not the school's. The major resource for generating new insights is not the teacher but the combined intellectual resources of the student group and the resources available on the Internet. Power rests more in the student group than in the teacher (LaRose, and Whitten, 2000).

Students perceive the benefits of m-learning as, ease of access to continuing professional development. The authors conducted a short survey of teachers and students to know their experiences with online- and specifically m-learning as compared to the traditional face-to-face method of learning. The students expressed that their experiences with the m-learning environment were more communication-rich and more effective. However, the teachers' perspective of the same experience was very different. The majority of teachers opined that teaching online is more time demanding than teaching face-to-face. In addition, teachers miss the social engineering component of student-teacher relationships (Bonk, and King, 1998, Higgison, 2000).

Another aspect of the m-learning environment will be a shift in the learning paradigm. There are many aspects of the college experience that are significant to the development of a student into what we consider a well-rounded, college-educated individual. It is for this reason that colleges have Student Development and Student Services offices, to provide educational, cultural, social, and other activities to complement student learning and round out the college experience. In a m-learning environment, building such developmental components in a learning experience is a challenge (Higgison, 2000).

From a modal perspective of online mobile delivery, the shift is toward learning communities with less emphasis on the tutor as 'sage on the stage' and more on the guiding and facilitative functions. Online communication lends itself to dialogue and negotiation as it allows both the student and the teacher to test understanding, which might be evidenced offline in the form of body language or signs of attention. Online, the teacher does not know what a student does or does not understand unless they asks. Some research into email communication for learning purposes has found that the lack of relatively "immediate" response to students' emails is a major de-motivating factor (Ting-Toomey 1999; Carroll, 1987 in Ting-Toomey, 1999). Given this, online tutors cannot assume to fully understand phenomenon like "silence" and other related issues such as humor. It would be wiser to check and ask. This can be done in the online group environment, or behind the scenes in individual emails, faxes, or telephone calls. Asking learners to reply, or to give the reason for their silence, should be done regularly, but with tact and explanations as to why the subject was raised (quality control, checking all is well, etc). Learners are often not aware of the impact of their silence on other participants in the group or on the tutoring/learning process. To avoid issues causing a block to learning in an online or m-learning environment, teachers and facilitators need to address a number of issues (McKenzie, 2000).

- Teachers should give due consideration in designing contents in multiple formats ensuring access to disabled, blind and the visually impaired students.
- The learning materials should be based on multiple perspectives and ways of doing things.
- Teachers should making rules, norms, expectations, learning content and skills explicit; explain the reasons for doing things; check to see that students have really understood and what is expected of them.
- Teachers should suggest where students could get appropriate help, including online resources.

3. Web services architecture for M-Learning

Web services are the next big thing in distributed computing. Unlike existing distributed technologies (such as CORBA, J2EE, COM, and DCE), Web services are descendants of text processing systems rather than binary communication protocols (Mateosian 2002). XML is derived from document processing technologies, not distributed computing technologies. Web services are asynchronous messages that exchange XML documents across a network. Web services also are responsible for mapping the XML documents into and out of executable programs, objects, databases, and legacy applications. The executable programs are not part of the definition because they are not included within the specifications that define the core Web services technologies. Web services are not executable. They are instead

a collection of XML applications mapped into and out of executable programs. The core Web services standards - SOAP, WSDL, and UDDI - have received widespread adoption and generated tremendous interest (Bunnell 2002).

The rush toward mobile services reflects a shift in the nature of computing: rather than a device-centric world with a PC at the center, the consensus is that we are moving toward a mobile person- (or identity-) centric universe where a multitude of devices (PCs, laptops, PDAs, phones, tablets, etc…) can access user-specific data from any location (Mateosian 2002) (Bunnell 2002). Fortunately, with the emergence of Web services the task may become easier. Web services are the next wave of distributed enterprise computing. They provide a layer of interoperability that allows applications to be described, published, located, and invoked irrespective of underlying architectures. Web services are driving the next generation of mobile computing applications by providing a thick abstraction layer that masks the operating systems for any given device from the developer (Dostan 2001). Web services architecture is a set of emerging protocols and standards. It offers a different approach to enterprise integration and development. Architecturally, Web services are typically made available by use of a common transport mechanism, namely SOAP, through which agreements and binding can be universally facilitated. The directory, or repository, is accomplished through UDDI. The interface is described in WSDL, and the transport is managed seamlessly using SOAP, allowing users to communicate with the outside application regardless of what platform, system, or standards are being used behind the scenes (Gottschalk, Graham et al. 2002) (Editorial 2002) (Gibbs 2002). This concept is visually represented in Figure 5.

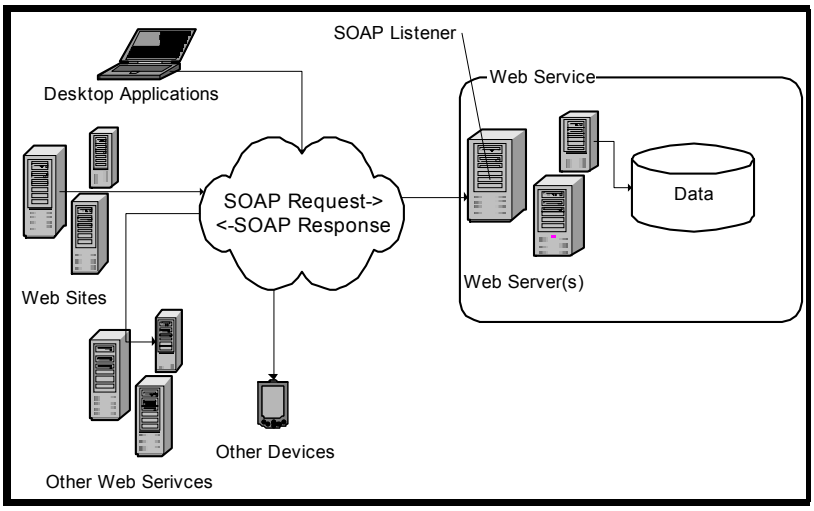

Figure 5: Logical architecture of a web service built on the flexible services architecture

Developers can build standard interfaces to existing and new systems using SOAP and they can describe the process of accessing the data using WSDL. These let each user access data in another user's database without custom programming on an application-by-application basis. The re-use of Web services functionality cuts development time. A developer only has to identify the user's data to access and link to the corresponding WSDL interface, using existing development tools. Presently, web service models are using four standards: Soap, WSDL, XML, and the UDDI protocol. These comprise the basic capabilities necessary to build the discrete elements of a services-oriented architecture (Gottschalk, Graham et al. 2002). Web services architecture will offer many benefits in systems design such as: encouraging modular system architecture; changing underlying program logic without greatly affecting interfaces; hiding underlying system complexity via standard interfaces; extending and enhancing legacy systems without changing underlying code; and offering platform- and vendor-neutral applications. Largely due to these many benefits, web services are gaining momentum (Dostan 2001).

4. Flexible services architecture for M-Learning

The designing principle for m-learning architecture has to be on the premise that the technology and the developing tools had to be integrated within the principles of the open,

component based, modular architecture which will permit the reusability of the modules in various training scenarios and operations, with wide acceptable standards, are to be used to permit the interoperability with the existing hardware and software (Elena, Miguel et al. 2001).

In accessing a course from a wireless handheld device, the system would know how to assemble the objects that can be downloaded and then send them to the handheld device. In addition, e-learning information intended for a handheld unit must be formatted to suit that device. Considering the above principles for designing architecture, the authors propose the web services oriented Flexible Services Architecture shown in Figure 6 for an m-learning environment (Miller, Sharma et al. 2002).

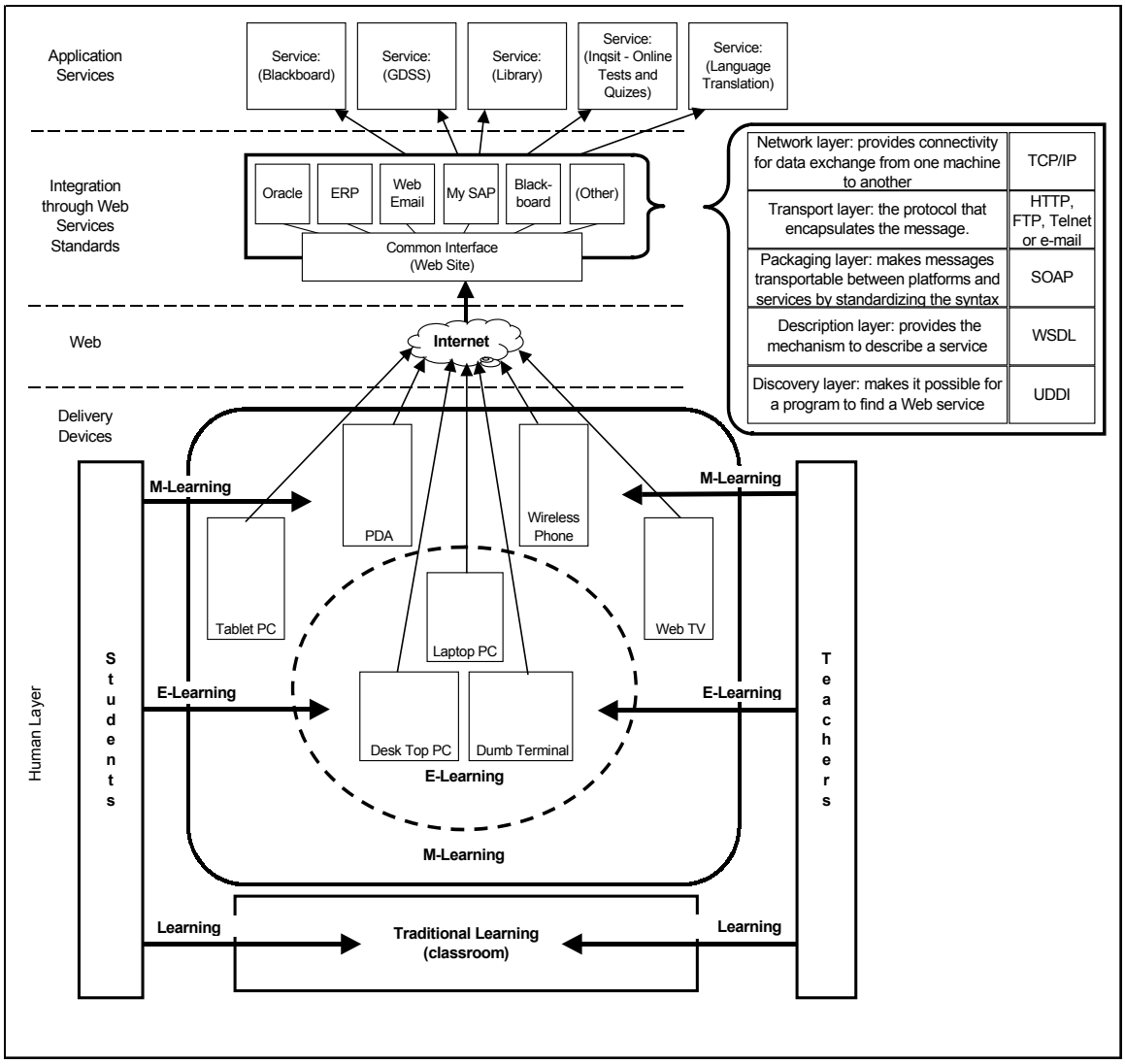

Figure 6: Flexible services architecture for web services

The goal of many schools is to develop a student-centered, network-centered, mobile computing oriented flexible environment that can allow students to access the content whenever they need it, in whatever form they need it. M-learning can include anything from job aids and courseware downloaded on personal digital assistant, to Net-based instructor-facilitated training via laptop. The proposed m-learning architecture that is web services architecture based is open, scalable, and global, with plug-and-play capabilities. With the goal of creating a plug-and-play m-learning applications environment that supports interoperability among different vendor solutions, the framework of the architecture is an open, standards-based model (Morgan 2002). A scalable architecture delivers appropriate performance as broadly as possible, while providing the flexibility to increase the level of sophistication of the overall learning solution as it matures. The

architecture also has the capability to integrate with all backend application systems — including library, various laboratories, knowledge management, and other information resources. The web services architecture provides modularity that becomes an essential element in providing a highly personalized experience based on pre-assessments or other selection criteria. M-learning can be as simple as providing a video or audio-on-demand for anyone who immediately needs to know something to improve his/her knowledge or performance. The proposed architecture will have four following layers whose details are given below.

4.1 Application layer

The application layer consist various services for students and instructors. These services are; library services, admission services, fee submission, grade sheet and language translation etc. All different applications. These services are created by instructors, and administrators for students use. The students are receivers of these services. The interaction between students and instructors and administrators is at the application layer. The other layers below application layer will be completely transparent to students.

4.2 The integration through web services standards layer

At this layer, the integration through web services would integrate all the contents and applications that may already be available in different formats. Web services architecture used for this type of purpose would cause the whole integration process to be similar to plug-and-play, and would provide enough flexibility to allow content independent of devices. The architecture ensures availability, scalability, and performance, as well as the ability to simultaneously deliver data, voice and video. It also manages security, quality of service and content distribution. The application integration layer provides access to all the internally built systems, authoring tools as well as the third party authoring tools supported by IT, such as DreamWeaver, Microsoft Word, OutStart, gForce, or PowerPoint. It enables e-learning providers to register entire learning applications as binary large objects (BLOBs) or to register structured objects. Structured learning authoring tools enable the author to assemble learning objects, including text, graphics, assessment items, executable files, videos, etc., into a lesson template.

4.3 The delivery devices layer

The delivery devices layer is used to deliver the content using internet enabled multiple devices a. The flexible services architecture support all-purpose personal communicator systems geared to societies "on the go" including multifunction cell phones, e-mail capability, PC, Web surfer, fax, video-television, picture phone, AM/FM radio, and global positioning systems. All-purpose devices that are compact, wireless, and use a single, lifetime identifier code so that a person can be reached anytime, anywhere, will capture the fancy of communications era consumers. The content can be customized automatically depending upon the type of device.

4.4 The human layer

The human layer consists of learners, administrators and instructors. This layer signifies that on one hand instructors and administrators will be creating services, therefore would have interface with application layer, and on other side, there would be a direct interaction between instructors and students for communication, feedback, or other learning components, thus there would be interface through end user layer.

To implement the above flexible services architecture for m-learning, the m-learning technology environment may include mobile device such as; pocket PC, mobile phone, and portable keyboard. This m-learning device will have the power of a desktop that gives access to Microsoft Pocket applications such as Internet Explorer, Outlook, Word, Excel and Microsoft media player. Among this software would be Microsoft Reader with a Clear Type kind of software. Microsoft Reader with a Clear Type kind of software program would be helpful to read e-books or content in *.lit file format (MS Reader file format). The software would also provide opportunity to read e-books, Pocket Dictionaries, etc. to downloaded from the Internet and synchronized to the Pocket PC via the PC. One can synchronize the device with one's desktop PC to read e-mail, view attachments, update the calendar and the device can easily connect to a mobile phone via cable, infrared, or wireless technology for online browsing. Learning content and the communication component of a learning environment include resources (articles on the web, references to other resource materials), online access to the discussion forum with the possibility quick access for reading in the Forum and writing

contributions, and e-mail for individual communication with instructor and fellow students and for submitting assignments. Assignments may be submitted as text-based e-mail, voice-based mail or as Word or Text or voice attachments.

Although, one can use the various readymade software packages available in the market for this purpose, however, the prototype of this framework is developed to demonstrate the powerful features of web services based architecture. The prototype web service code is written in the programming language C#. The communication is all done through SOAP, which is a subset of XML. The database used is SQL Server 2000 database, which is a relational database management system. The experience of developing this web service model is unique from other software development projects. The end user is usually known prior to development as well as the device/application that will be used. In this case, there was no specifically defined user, therefore multiple devices and consumers had to be considered. From a development standpoint, the challenge is to build a dictionary database. Setting up a database that can contain audio, video and text data, and to allow data to be retrieved quickly upon request is a challenge. The most difficult task of developing such a service is how to handle the multimedia files. One can store the multimedia files in the database as binary data, but every time somebody requests them, the program must build a temporary multimedia file, which is expensive from a processing standpoint. Also, if the consumer were using a cell phone, such multimedia files are unusable making this development effort pointless. To access data from a cell phone would require at least 2 interfaces, one for the cell phone, and one for a multimedia device. This opposes the idea of "transparency" where everybody accesses the service in the same way. The authors created "virtual files" for this purpose, and then passed around the URL to those files.

There could be number of different ways the m-learning model could be implemented.

1. Mobile Internet service
2. Online access via mobile telephone to the entire course
3. 'Download-on-demand' version

The authors are planning to experiment mobile internet service model. Using Mobile internet service model, students easily could access and download the entire course content anytime anywhere in their mobile device. The Mobile learning service can provide interactive and personalized content and applications to handheld device or Internet-enabled mobile phone real-time via wireless connection or desktop synchronization. Due to web services architecture and use of XML, it can deliver any format of file (html, pdf, reader, etc.) and the backend format will be transparent to the users. This allows the students to use the materials actively. The students would be able to 'make the materials their own' while studying and these functionalities may help students organizing the materials cognitively to support learning and remembering. Students can also download content for offline considerations such as studying mainly offline, communication and discussion with fellow students, group assignments, and communication with the instructor - including submission of assignments with correction and feedback.

5. Conclusion

M- learning offers a unique opportunity for teachers and students in different kinds of learning environment settings. The unique feature of this mode of learning is that it enhances flexibility for students; however, it demands new pedagogies, and new approaches to deliver a course. If appropriately facilitated, m-learning helps learners in a great way by providing virtual classrooms on their mobile devices. Teachers will ultimately spend more time for course-delivery and follow-up as compared to traditional classroom method. In addition, teachers will have to provide a rich learning resource and environment, which in turn, contributes to the quality of learning. To keep up with these changing phenomenon and to continue to effectively facilitate m-learning, it is imperative that online teachers learn about and adapt to the changing environments, when and where appropriate. Web services provide a means of integrating applications via the Internet. By using XML messaging to exchange data, Web services allow companies to link applications and conduct e-business regardless of the computing platforms or programming languages involved. Web services are quickly becoming the way to develop systems, for obvious reasons. They eliminate the major problems associated with network and distributed software, and they can provide a new source of revenue for companies that provide the service. The proposed web services based flexible services architecture could become a new direction for developing web services applications for mobile education.

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