Learning Resource Authoring Techniques in Mobile Platform

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ABSTRACT

Education and training provision to mobile terminals is called m-Learning. It allows learning experience to be delivered at the precise place and time when it is required. M-Learning is applicable in academicals, in enterprises, in expert system applications, and in tourism. These applications construct interactive learning experience from digital content. Our research scopes content, which is supported by mobile terminals, synchronized multimedia integrated language (SMIL), adaptive multi-rate wideband audio, 3gpp video, and still image formats such as JPEG, GIF, and PNG. Web-base learning experience on mobile terminal do not provides platform independence and depends significantly of mobile browser, of the terminal itself, and of the learning resource complexity. The learning resource authoring techniques and authoring task obligations are proposed as content adaptation principles to achieve terminal independence.

Keywords

m-Learning, SMIL, learning resource, content authoring

INTRODUCTION

Businesses recognized the benefits of the mobile terminals to increase sales, mobile carriers and content providers prompting the market to respond with a wide set of services. 3G and next-generation converged mobile devices opens new opportunities, adds multiple features to the mobile telecommunications experience. The worldwide market for converged mobile devices topped 80 million units in 2006, up an impressive 42 percent over 2005 shipments. In the fourth quarter of 2006, vendors shipped a total of 23.5 million devices, 33.5 percent more than the same quarter a year ago. It enhances opportunity of m-Learning as part of an integrated global educational strategy and allows learning experiences to be delivered at the precise place and time when they are required. It offers a powerful and practical solution to many learning and training challenges, such as in collaborative projects and fieldwork, as a classroom alternative to books or computers, knowledge distribution for widely dispersed learners, promotional and awareness campaigns, and just-in-time employee training.

Previous Work: The usage of mobile technology in educational has been studied by multiple research projects (Keegan 2002, Daniele et al. 2003, Georgiev et al. 2004, Anderson et al. 2004, Attewell 2005). In the past a lot of effort has been devoted to investigate deployment approaches of mobile learning environments. It is important that their experience concludes any m-Learning deployment as inefficient activity once it begins from scratch. Significant effort is required to implement management of learning experience especially if e-Learning architectures exist and standardized by (IEEE 1484.11.2, SCORM 2004). Previous projects specifies m-Learning environment in terms of learning management processes executed on learning management system (LMS), mobile learner terminals, learning resources and their delivery over cellular network or similar wireless solution.

Our previous research (Kolesnikova 2007) investigates possibility to re-use existed e-Learning infrastructure for m-Learning. Proposed approach allows direct re-usage of LMS architecture developed by IEEE, scopes learner terminal to mobile and smart phones, and denotes distribution media to be Multimedia Messaging Service (MMS) or Packet-Switched Streaming Service (PSS). All these factors require adaptation or possible re-work of content associated with learning resources in order to suite requirements of mobile terminals. The resource adaptation can be carried out in a number of different points in the content life-cycle such as applying adaptation at server-side, in-network, client-side through the usage of additional terminal software layer for content rendering (Attewell 2005), and authoring with device independence principles (IEEE 1484.11.2). The our previous research indicates client-side and authoring as most perspective when once open multimedia technology standardized by 3GPP Forum is accepted as authoring methodology for m-Learning resources.

Author Contribution: This publication interest is focused on the authoring perspective of m-Learning resource adaptation, authoring task obligations and device independence principles, and focuses on the quality of learner experience. The paper also considers open issue highlighted in our previous publication (Kolesnikova 2007) such as communicability problems of Synchronized Multimedia Integration Language (SMIL). Any communicable learning resource is responsible to submit learner interactions to LMS. This is implemented on top of ECMA Script and SOAP messaging software but mobile SMIL players lack these features. SMIL has definite advantage over any other Web-based content description language since it contains methods for client-side resource adaptation, bandwidth management, and allows synchronizing independent multimedia objects, and rendering of rich multimedia content (voice, video) while browsers requires a special software

plug-ins (e.g. Windows Media). SMIL-based learning resources are used in many m-Learning applications. These applications includes components that define different aspects of a content structure, which should be considered at authoring stage. This paper denotes these exclusive m-Learning application specific authoring principles.

LEARNER PERSPECTIVE THROUGH M-LEARNING

In present, the face of learner is different from children to senior citizens to business managers on-the-go. Mobile terminals are likely to be used for entertainment, for business-related purposes, and others services. Mobile learners have immediate context-directed intention to search specific pieces of knowledge that are relevant for them. They are not interesting in length courses and training sessions. The device hardware limitation and nature of mobile environments prevents from absorbing lengthy content. Learners expects from m-Learning interactive learning experience, which is called m-Learning application.

Academicals: M-Learning attempts between basic technological and pedagogical problems. In the past, educational process was constrained within blackboard and the teacher was the main source of knowledge. With the advent of mobile technology the learning concept is a change to the positive size. From a pedagogical perspective, mobile learning supports a new dimension in the educational process: the ability for any-time and any-place learning. M-Learning applications should not replace convenient face-to-face or instructor-led training, but mainly facilitates learning, coaching and related management processes. M-Learning serves teacher-student relationship known as legacy application from e-Learning era. Academicals environment propose the m-Learning as a method that supports learners in different levels of the educational process, e.g. during preparation his examination, reviewing his knowledge. The research on usage of mobile Internet by students (Kolesnikova 2007) supports the m-Learning deployment for academicals. More than 50% of students used mobile connectivity for information searching, entertainment, on-line learning and messaging. Messaging is most popular service among others. Nowadays, mobilized students connect Internet through mobile terminals and consume large amounts of multimedia content at anytime and anywhere.

Enterprises: M-Learning changes the primary context of teacher-student relationship from academicals to enterprises, where application helps workers to meet their job requirements and update their knowledge continually. Improve performance and productivity with m-Learning is one of the main integration into employees training. Mobile learning is a valuable solution for many occupations in non-traditional office environments. Enterprises has the series of temporary workplaces, it may be the nature of a job to requires the worker to move from place to place, as in factory work, package delivery, field service, or the health-care profession. Having the option of m-Learning it allows workers to get into the professional field more quickly or more globally to learn on the job. M-Learning offers variety of tools and activities to improve the employees' skills, either to progress at work or to find new employment.

Expert system: Mobility makes expertise available to decision makers and technicians who need answers quickly, provides expert system applications. Expert system is designed for the population who needs to know everything interesting in a short time. Mobile terminals enable on-demand access to in-depth knowledge of specific subjects. These knowledge-based applications of artificial intelligence have enhanced productivity in business, science, engineering, and military and in a ubiquitous life. This system can be used by anybody interested to study whatever one likes.

Tourism: The usage of mobile devices equipped by location-based services gives possibility to implement location aware application for tourism and traveling (Rabin et al. 2006). This application broadcasts real-time information prepared according to the user's position, and personal interests. Tourists are limited in their activities by queue information, daily opening times and ticket availability. If such information could be collected from one central point, it would allow the visitor to quickly eliminate unsuitable activities. It would be far more convenient to have your whole day planned out for you and updated automatically should any of the circumstances change. The other major problem faced by tourists is knowledge of their surroundings.

M-Learning applications uses a representation of knowledge differently then face-to-face, instructor-led training. Learning resources are learning content in a form of digital content and are assembled to hierarchical structures, which introduce a common approach used by the instructional design community to present the complex relationship of a learning material where each element is loosely depicted as a meaningful learning resource (SCORM 2004). The applications listed above require own learning resource organization that should be considered at authoring. The levels of hierarchy and learning resource granularity are not described by the applications such terms needs to be resolved by content developer. The authoring procedure is supported by (IEEE 1484.11.1) that mandate patterns for content organization: atomic, collection, network, hierarchy and linear. Atomic organization implies that learning experience is constructed of indivisible learning resource. Collection is the set of learning resources without specified relationship between them; learner can only

indicates a desire to jump directly to specific learning resource. Network defines relationship between learning resources and do not specify any order of learning experience but it offers choice of related resources in contrast to collection where all resources is available. The hierarchical also known as tree structure defines obvious parent-child relation between learning resources. Finally, the linear organizes learning resources in fully ordered manner, where learner has freedom to choose next or previous learning resource. These content organization patterns are tools used by content developers to authorize m-Learning applications. Content developers are looking on two perspectives in m-Learning: the type of interactive learning experience is called m-Learning application, and the learner terminal context. The learner terminal context is a combination of hardware and software that allows learner to perceive and interact with m-Learning application.

	Content Organization patterns				
	atomic	collection	network	hierarchy	linear
academicals		x	x	x	x
enterprise		x	x	x	x
expert system	x	x	x		
tourism	x	x			

Table 2. Rrecommendations to authoring for content organization patterns in context of quality in m-Learning applications.

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Learning mobile terminal context

M-Learning applications are useful only if learners can view learning experiences reliably without dependency to their learner terminal context. Previous projects (Keegan 2002, Daniele et al. 2003, Georgiev et al. 2004, Anderson et al. 2004) implements terminal independency through the usage of common web-based technologies, the web-browser, its plug-ins and ECMA Script assumes major responsibilities. It has been denoted by (Attewell 2005, Kolesnikova 2007) that Web-base learning experience on mobile terminal do not provides platform independence and depends significantly of mobile browser, of the terminal itself, and of the learning resource complexity. Alternative solution was proposed by (Kolesnikova 2007) for m-Learning, where SMIL and open multimedia technologies provides appropriate level of platform independence through client-side resource adaptation.

The usage of SMIL affects the learner terminal context, requires component for user interface provision, learning resource rendering, and communication protocols with LMS. Let us consider Fig. 1 that depicts learner terminal in terms of functions (navigation control, renderer, delivery, communication) denoted by (SCORM 2004) and their interaction with LMS through mobile gateway (m-GW). Our previous research investigates possibility to re-use existed LMS architecture developed by IEEE in m-Learning applications. LMS provides their services to m-Learning environment thought m-GW. M-GW is the server side software: servlet or web-server script that adapts IEEE compliant LMS interface to mobile platform. The learner terminal is multimedia enabled mobile or smart phone. During our research, we have used Nokia mobile terminals based on S40 3rd edition and Nokia S60 3rd edition software platforms.

The learner terminal is the primary entry point to choose, subscribe learning experiences and enables the means for learner to indicate the desire to navigate thought learning resources in a particular manner. These functions are available via user interface (UI) provided by the navigation control. None of existed learning standards specifies implementation principles for UI. We used mobile profile of xHTML to implement UI as a solution for m-Learning applications. UI is developed with device independence recommendation by UAProf and provided by simple web-browser capable of rendering text or images, no needs for ECMA Script support. Navigation control applies to navigation between learning resources, and does not address the ability to define sequencing or navigation within learning resources. However, any learning resource may optionally implement UI for triggering navigation within the resource or outside through anchor element specified by SMIL Basic Linking module.

The navigation control delegates learner interactions to LMS in form of HTTP GET request, where URI points the navigation service on m-GW, and defines navigation event to choose particular learning resource, deliver next or pervious resources in learning experience. LMS handles the request accordingly and delivers learning resource to terminal. The learning resources delivery function has been denoted by (Kolesnikova 2007) and includes MMS or PSS services. MMS encapsulates content associated with learning resource to single

multipart object and pushes it to terminal messaging subsystem – inbox. PSS streams content directly from LMS over HTTP for text, still images, and over RTP for video and audio content.
The main terminal function is learning resource renderer. It enables learning experience from delivered learning resources. Modern mobile and smart phones have embedded software for rendering SMIL-based learning resources as well as add-on software is available e.g. Helix Player, InterObject. M-Learning applications classify learning experience to interactivity level required from learner. It should be distinguished active, explosive and mixed experiences. Active learning is supported by content that directly induces productive actions by learner, explosive learning occurs when the learner absorbing the exposed content and mixed strategy is a blend of active and explosive types. Mobile terminal capabilities such as input system, screen resolution and software components limit usage of active learning but provides great ability to deploy explosive and mixed learning where dynamic multimedia content assumes major role. Interactive learning experience is ensured by communicability property that defines the capability of learning resource to transmit information about learner's actions. Communicable resources are responsible tracking of learner's interactions, gather competition status, and communicates them back LMS for performance evaluation and control order of learning resource delivery. For interoperability reasons, LMS describes primary communication interface to be IEEE 1484.11.2. Deployment of learning resource based on IEEE 1484.11.2 assumes availability of ECMA Script and SOAP messaging software. In mobile environments, we cannot guarantee that learner will have terminal with these features especially they integration to SMIL player. Therefore, learning resource communicability is achieved via HTTP GET and POST methods The authoring should take into account that SMIL-based content can only submit data and not able to receive response back.

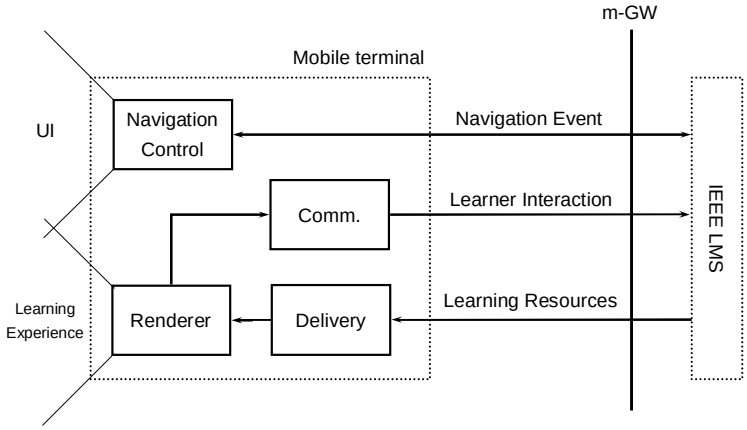

Figure 1. Learner terminal functions.

LEARNING CONTENT AUTHORING IN MOBILE PLATFORM

One of objectives in m-Learning applications is to obtain as much metadata as possible automatically, based on the learner context. This enables targeted retrieval of learning experiences when resources are provided to learners. New requirements for personalized adaptive learning include development of semantic-based and context-aware systems, adaptive to context and learner needs, and exhibits a seamless interaction with its surroundings. Learning content authoring techniques needs to be considered from multiple points of view: learner behavior, content communicability and authoring tools.

Learner behaviour model in m-Learning

While the learner interacts with m-Learning application it passes through elementary states: registration, personalization, login session, learner attempt, learner session, and communication session. These states are called the temporary model, and developed by IEEE 1484.11.1. Any IEEE complaint LMS supports its temporal model for any interactive learning experience. The chosen authoring methodology for m-Learning experience and software limitations in mobile terminals affects significantly to this model. Specifics of learner behavior in mobile environment should be considered at authoring of learning experience and UI design. The difference of IEEE compliant LMS temporal models and actual mobile learner behavior are shown on the Figure 2.
Learner begins with the registration process within m-Learning application. Many applications defines registration as essential procedure especially if continues tracking of learning activities or learner scoring is required, there is needs to perform billing or authentication. Learner registration allows monitoring the progress through learning experience. Often creation and learner account activation is required in order persist his MSISDN, especially if delivery media is MMS. The registration procedure is the issue of xHTML UI

development. UI designer should follow up best practice for mobile Web development presented in (Robin et al. 2006). The registration should not be long, contains not much pages, requires multiple free text input, and account confirmation procedure over e-mail.
M-Learning experience considered successful if it is capable to adapt for learner context and obey individual preferences. Therefore, personalization precedes any learner interaction with learning application. The personalization logically consists of preparatory, educational settings and detection of learner context. The preparatory is learner diagnostic and includes pre-tests, learning-style tests, attitudinal surveys and the gathering of pre-requisite data about the learner experience with mobile terminals and embedded software, many applications verifies job qualification and etc. This data is useful as it can prevent wasteful time on educational process, where the user probably already knows the material. It also allows shaping the learning experience towards that particular learner. The education setting is indented to gather learner essential requirements for educational process. The main steps are familiarization factors with learner's language skills, knowledge on the subjects, experiences and practices, competences, interest, goals, previous activity, and agenda. Finally, m-Learning environment should be able to detect learner contexts such as location and time information, capabilities of learner terminal since learner terminal features might evolve depends on the context. Similar to the registration procedure, m-Learning implements personalization as xHTML-base UI and same practice to optimize UI for mobile terminal should be used. Often registration and personalization are implemented as single multi-page registration form. However, learner context discovery operation needs to be automated by m-GW, based on principles of HTTP content negotiation, on HTTP headers to identify terminal profile, or on UAProf solutions.

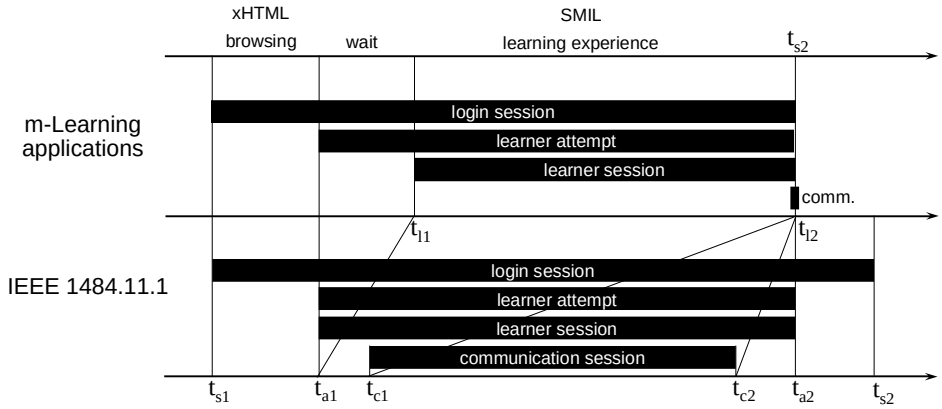

Figure 2. Learner behaviour model.

Registration and personalization are preconditions for actual learning, some m-Learning applications omits these steps to enable easy on-the-go access for learning experience. Any learner interaction with m-Learning application begins with login session. The login session is defined as period of time during which a learner is acknowledged by the LMS and m-GW. The session remains active when a learner begins a communication with environment at time t_{s1} until he terminates it at time t_{s2}. M-GW identifies t_{s1} when terminal navigation control function issues the first HTTP GET request to fetch instance of xHTML UI. Nature of mobile terminals does not allow m-GW to uniquely recognize session over at t_{s2} time. The gateway detects login session termination automatically based on his internal states, e.g. session time out is over, learner attempt is over or learner instantiates a new session.
Mobile learning experience is built of learner attempts. The attempt is denoted as tracked effort by a learner to satisfy learning objectives and requirements. The attempt is started at time t_{a1}, when learning activity is identified. The attempt is over at time t_{a2}, when objectives are met, in other words, learner has got learner experience and his interactions, and scores has recorded by LMS.
For non-communicable learning experience, it is denoted in (SCORM 2004) that learner attempt ends when the resource is taken away. Mobile terminal renderer function does not provide tools for m-GW to detect time when learning resource is withdrawn from the learner. Therefore, m-GW should inform LMS that learner attempt is over immediately when learning resource is successfully delivered to learner terminal.
Learner attempt spans a learning session. The learner session is depicted as time interval while learner interacts with learning resource, obtains learning experience. The learner session starts once the learner will be engaged with a learning resource and content has been launched in terminal renderer at time t_{l1}. IEEE compliant LMS do not distinguish among t_{l1} and t_{a1}, it defines learning resource launch as instant operation,

which is an incontestable fact with bandwidth capacity of fixed networks. Wireless and cellular networks have a measurably high latency, which leads to long retrieval time, especially for lengthy content. Simultaneously, mobile learner terminals implements navigation control and renderer functions as different software components: navigation is held through web-browser, renderer – SMIL player. For example, this problem is extremely visible in MMS delivery scenario. Learner initiates login session and triggers attempt through xHTML UI but learning resource is delivered to terminal inbox as MMS message. Learner needs explicitly instruct terminal messaging component to render the message content. These factors bring visible latency between t_{l1} and t_{a1} that should be considered on m-GW.

The learner session ends at time t_{l2} when learner finishes interactions with learning experience and corresponding learning resource are withdrawn. The learner session can have normal termination when learner fulfils learning objectives and requirement. Learner can also fail to meet objectives, abnormal situation occurs in network, or software crash. Termination of learner session leads termination of learner attempt only if the session ends to normal state. Failure of learning session will suspend attempt until learner successfully passes through learning experience again and again.

Previous section was mentioned that interactive learning experiences is constructed from communicable learning resources that are responsible tracking of learner's interactions, gather completion status, and communicates them back LMS for performance evaluation and control order of learning resource delivery. The active connection between content object and LMS is held within communication session, started when a new attempt begins and resource is launched on the learner terminal. IEEE compliant LMS assumes that communication session is implemented through IEEE 1484.11.2 API. Any communicable learning resource starts the communication session at time t_{c1} by calling "initialize" method and terminates as time at t_{c2} via "terminate" method. In m-Learning applications m-GW adapts this IEEE 1484.11.2 interface to mobile platform. It makes essential difference to communication session timeline. IEEE 1484.11.2 compliant learning resource communicates within the learning session. On mobile platform, learning resource starts communication at learner's discretion when learning session is over. M-Learning applications utilize SMIL Basic Linking Module to achieve learning resource communicability. At the end of learner session the learning resource supplies HTTP/GET request. This approach limits learning communication to simplex model where resources submit information about learner interactions and leads a communication session to be instant operation where t_{c1} equals to t_{c2} and equals t_{l2} termination time of learner session.

Data Model Element	Implement. approach				Applications				Description
	HTTP GET	HTTP POST	SMIL (in-net)	xHTML UI	academicals	enterprise	expert system	tourism	
Comments From Learner		x			x	x			Resource writes data to LMS via xHTML form.
Comments From LMS				x	x	x	x	x	Contains comments and annotations, shown as before or after learning session
Completion Status	x				x	x			Indicates where the learner has completed the experience.
Completion Threshold			x		x	x			Measures the learner progress, content authoring issue via presentation timeline
Credit				x	x				Indicates where learner will be credited
Entry				x	x	x	x	x	Amount of learner interaction with the resource
Exit	x				x	x	x	x	How or why learner terminates the session
Interaction		x			x	x			Resource writes data to LMS via xHTML form, used for assessment, quizzes, etc.
Learner Id				x	x	x	x	x	Identifies a learner
Learner Name				x	x	x	x	x	Learner name
Learner Preferences			x	x	x	x	x	x	Impl. as SMIL Content Control, UAProf, and HTTP negotiation
Location			x		x	x	x	x	Learning resource location

Maximum Time Allowed			x		x	x			Maximum time allowed for learning resource
Mode				x	x	x			Identifies a mode for resource: pre-test, evaluation, etc.
Objectives				x	x	x			Objectives, in m-Learning impl. as read-only for learner.
Progress measure	x		x		x	x			Measures the progress the learner has made.
Scaled parsing score	x								Identifies scaled learner score
Score	x				x	x			Identifies learner score
Session Time	x				x	x			Identifies the amount of time learner spend in the current learning session
Success status			x		x	x			Indicates, where the learner has master the resource
Time limit action			x		x	x			Indicates the action when maximum time is elapsed
Total time			x		x	x			Total time for learning experience

Table 2. IEEE 1484.11.1 data model variables, usage in m-Learning application, and implementation approaches.

Communicability in m-Learning resources

Interactive learning experience is built from communicable learning resources. Any communicable learning resource is responsible to transmit information about learner's actions to LMS. For interoperability reasons, LMS assumes the usage of ECMA Scripts and SOAP messaging for communication. The information about learner's action is defined as IEEE 1484.11.1 data model and must be also supported by any m-Learning resources to ensure interoperability across LMS from different vendors. The data model provides variables to communicate learner progress, the resource writes data to LMS, to control learner session timeline, and to obtain learning experience metadata, the resource reads data from LMS. The read and write access to data model variables is held within the communication session, which is initiated and terminated by learning resource.

Previous sections conclude that SMIL-based learning resource uses Basic Linking Module and HTTP GET methods to achieve communicability. Any communicable SMIL presentation utilizes anchor element to write data model variable. In general, this element allows learner to access any networks resource identified by URI. Same approach is applicable to ensure communicability in m-Learning scenario, m-GW implements a service that access data model variables to LMS via IEEE 1484.11.2 compliant interface. URI defines the network path of this m-GW service and contains list of data model variables in dot-notation and values for them. SMIL player is not capable to automatically activate anchor element, learner action is required.

At learner discretion, the player supplies URI to web browser, which triggers HTTP GET request to m-GW. The gateway service writes data model variables to LMS. SMIL players cannot provide possibility to read data model variables but m-GW can read data model variables and inform learner about its status as xHTML content with the response on GET request. In some m-Learning application, xHTML carried within the response provides additional interaction, e.g. assignment, quiz that is implemented as HTTP POST method to m-GW. Applications should avoid free text input due to input system limitation, instead selection lists, radio buttons and other control that do not requires typing is used.

IEEE 1484.11.1 defines subset of data variables that guides learner session (e.g. maximum time allowed to experience the resource). Learning resource must read them before learner session is started. We implements this feature thought in-network resource adaptation, m-GW reads these variables from LMS and makes corresponding changes to SMIL presentation timeline before delivery.

The IEEE 1484.11.1 data model has been developed from pedagogical perspective. It should be supported by learning resources used for academicals and enterprise m-Learning applications. Some of the data model variables are useful in expert and tourism applications but it is optionally left for content developer decision.

Authoring tools

M-Learning applications build learning experience from digital content. The term digital content is a broad range, including discrete media types as still images, text, and vector graphic, as well as continuous media

types that are intrinsically time-based, such as video, audio and animation, Java games, Web 2.0 media boards, Web document, and Flash. Our research scopes SMIL as authoring language to depict learning experiences. SMIL is XML-based markup language, which allows content providers to describe of the spatial layout and temporal behavior of a presentation. It provides various markup elements and attributes for control runtime content choice and content delivery, for positioning of digital content on the visual rendering surface, for coordination and synchronization the presentation over timeline, and for inclusion of digital content.

M-Learning solutions are useful only if learners can view this digital content reliably. Therefore, m-Learning solution provider requires to utilize content supported by mobile terminals. The best result can be achieved if rendering of content is supported by embedded software supplied within the terminals. The previous publication (Kolesnikova 2007) studies the content types suitable to build solid m-Learning experience. Textual content is plain\text media files, still images are image/png, image/gif and image/jpeg, voice and music is encoded by adaptive multi-rate (AMR) codec to audio/amr or audio/amr-wb files, and video is video/3gpp.

The authoring procedure needs to consider variable display resolution of mobile terminals. It varies up to half-VGA and further, the current trend is QVGA (Forum Nokia). Therefore, non-scalable digital content should be developed to suite all resolutions or needs to be scaled at runtime for particular terminal. Modern terminal supports flexible display geometry by changing portrait to landscape mode at learner discretion. Usually, aspect ratio of portrait and landscape geometries differ each other (e.g. QVGA-portrait is 0.75, QVGA-landscape is 1.3). Let us consider the region R corresponds to portrait geometry of terminal display, region R´ is the rotate projection of R by 90 degree – landscape resolution. It is not possible to fit region R to R´ without cropping height, the R´ width needs to be cropped to fit R. The intersection of regions R´ and R denotes area A, which fits best to landscape and portrait layouts. Any non-scalable still images and video content do not loose quality if its dimension less or equal to area A while display geometry is changed. The dimension of area A needs to be denoted in relative values to suite multiple resolutions. The dimension of A relatively to region R and R´ is calculated by formula (1) and corresponds to (0.75, 1), (1, 0.75) for QVGA dimension. Sub-regions besides area A still used for rendering learning content but they location depends on display orientation.

$$A_R = \left(\frac{R'_h}{R_h} \quad 1 \right) \quad A_{R'} = \left(1 \quad \frac{R_w}{R'_w} \right) \qquad (1)$$

Wireless and cellular network have a measurable high latency, which leads to long retrieval time, especially for lengthy content. Mobile data communication cost money, where learners are charged by carrier for used bandwidth. Any digital content used in SMIL presentation need consider possibility of delivering over MMS, where message size is limited to 300Kb. The lengthy content also affect to quality of learning experience, especially if learner observes delays due to images scaling or requires constant scrolling to view text.

M-Learning applications utilizes AMR compression scheme for voice and audio. This scheme is specially optimized for speech coding and defined by 3GPP Forum as standard solution for mobile terminals. In our research we used AMR-WB codec that provides excellent speech quality due to wider speech bandwidth of 50–7000 Hz compared to others. AMR-WB operates with various bit rates: 6.60, 8.85, 12.65, 14.25, 15.85, 18.25, 19.85, 23.05 and 23.85 kbit/s. The lowest bit rate providing excellent speech quality in a clean environment is 12.65 kbit/s, higher bit rates are useful in background noise conditions. Also lower bit rates of 6.60 and 8.85 provide reasonable quality especially if compared to narrow band codec.

SMIL players allow authoring to utilize PNG, GIF and JPEG files for graphical content. JPEG is most suitable format for photographs, painting of realistic scenes with smooth variations of tone and color. JPEG produces smaller files than GIF or PNG for photo-like images since it uses a lossy compression. PNG is a choice for images that contain text, line art, or other images with sharp transitions, these objects do not transform well into the frequency domain. Like a PNG, GIF are suitable used for sharp-edged line art with a limited number of colors but it takes advantage of small animations and low resolution film clips. The main GIF limitation is color pallet, it supports formation to 256 colors.

SMIL has definite advantage over any other content description language since it allows synchronizing independent multimedia objects, and rendering video content. SMIL player implementations on mobile and smart phone allow learning resource authoring to use video/3gpp. 3GP is a simplified version of the MPEG-4 Part 14 (MP4) container format designed to decrease storage and bandwidth requirements in order to accommodate mobile phones. It stores video streams as MPEG-4 Part 2 or H.263 or MPEG-4 Part 10 (AVC/H.264), and audio streams as AMR. It operates with various frame-per-second rates from 0.5 to maximum 15 fps and supports QCIF and sub-QCIF resolutions.

Content authoring procedure for mobile terminal is time consuming task where most effort goes to testing and verification activity. This effort can be minimized with help of special authoring tools, many device manufactures provides such tools for 3rd party developer. During our research, we have used mobile terminals

from Nokia to make the final verification on hardware platform. Primary authorization and testing was held on PC platform with tools supplied by Forum Nokia. We have used Nokia Multimedia Converter 2.0 to produce video and audio content in 3GP and AMR-WB formats. Developer's Suite for MMS 1.1 allows us to encapsulate content associated with learning resource to single multipart object and pushes it to terminal SDK for verification. Finally, S60 and S40 software platform terminal SDKs were used to ensure desired look and feel of learning resources.

CONCLUSION

M-Learning is depicted as part of an integrated global educational strategy and allows learning experiences to be delivered at the precise place and time when they are required. M-Learning applications serves teacher-student relationship known as academicals learning, enables enterprise employee to meet their job requirements, makes expertise available on-the-go through expert system applications and offers new dimension in tourism. M-Learning applications are useful only if learners can view learning experiences reliably without dependency to their learner terminal context. The learner terminal context is a combination of hardware and software that allows learner to perceive and interact with learning experience.

Learning content authoring techniques needs to be considered from multiple points of view: learner behavior, content communicability and authoring tools. Software limitation and mobile environment affects significantly to learner behavior that differs from the IEEE 1484.11.1 behavior. These specifics of learner behavior in mobile environment should be considered at authoring of learning experience. Content communicability is required to build interactive learning experience. M-Learning applications utilize SMIL Basic Linking Module to achieve learning resource communicability. Content authoring procedure for mobile terminal is time consuming task where most effort goes to testing and verification activity. This effort can be minimized with help of special authoring tools such as terminal SDKs, various multimedia converters and MMS development suites. The financial and technical aspects of m-Learning restrict its worldwide deployment. Nowadays, only medium enterprise can invest to m-Learning solutions.

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