Streaming mLearning Objects via Data Resolution and Web Services to Mobile Devices: Design Guidelines and System Architecture Model

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1 Abstract

Mobile technologies—PDAs, cellular/smart phones, PC tablets, hand-held computers, wearable computer devices, etc.—allow for connection to both internet-based learning/training resources, as well as other people. Users of mobile technology can manage the administration of their learning via personal journals and interaction with virtual learning environments. The ability to instantly download performance support resources and instantly publish ones behaviors/actions, observation, and data will empower users to become investigators and active learners that are responsible for their own knowledge acquisition and decision making. Further investigation that results in the design and implementation of guidelines is needed in order to successfully and effectively employ mobile technologies for education/training and performance support within blended learning environments, across various communities of practice, composed of learners having various skill levels. Moreover, existing technical specifications and standards such as—wireless network technology, web services, Sharable Content Object Reference Model (SCORM) 2004, Content Object Repository Discovery and Registration Architecture (CORDRA), and S1000D (technical data publication standards)—require investigation in their application to technically make available instruction and performance support resources via mobile technologies. Specifically, this paper will offer guidelines as well as a system architecture model that could potentially identify both SCORM conformant and technical publication objects via a content/data resolution server using web services to deliver objects for mLearning and performance support via mobile technology devices. Additionally, a prototype will be developed to demonstrate the capability to stream SCORM 2004 conformant objects from data repositories—using web services—to various mobile technology devices.

2 Mobile Technologies to Support mLearning

Both mobile and game technologies are increasingly topics of research for the development of resources that can remotely support learning and training. This increase is partly fueled by the realization that Generation-Xers (Gen-Xers) and Generation-Ys (Gen-Ys or Millennials) live in a digital world whose culture is constantly being shaped by mobile and game technologies, just as much, if not more than PC applications. Many education and training settings are trying to implement such technology to reach and engage this digital population in real time with meaningful performance-based learning/training. Other influences for this increased research activity are the need for immediate training and performance support on the spot and just in time. Examples include but are not limited to:

- Mobile devices that are use by a disaster recovery team to display just in time information and data capture that is relevant to disaster recovery.
- Ubiquitous collaborative learning via cell phones or PC tablets that allow the learner to play an active role in both the knowledge building process and decision making anywhere, anytime.
- PDA's are used as an essential device in dental education and clinical practice for knowledge capture and decision making.
- Experiential learning through mobile gaming or mobile simulations.
- Mobile technologies can provide situated learning by extending the learning/training environment beyond the classroom into authentic and appropriate contexts of use.
- Learning and performance support that provides information and training onsite and just in time.

The challenge of mobile technologies is to understand and explore how best they can be used to support learning, training, and performance support. The use of mobile technologies should not be viewed as isolated activities; instead, they should be viewed as richly ubiquitous, networked, and effective collaborative devices having a presence in the classroom, during a maintenance activity aboard ship, or helping to diagnose and triage victims during a disaster recovery effort.

2.1 Moving Forward with Mobile Technologies

Empirical based findings, best practices, and lessons learned regarding mLearning and their respective instructional strategies offer a foundation to investigate mobile technologies and appropriate instructional strategies for knowledge capture and adaptive decision making that result in performance based outcomes. Though mobile and gaming technology research and its application to learning and training is in its infancy, the existing research increasingly shows its potential to offer the learner empowering opportunities not only to learn by doing, but to develop meta-level reflections on strategies for learning and decision making (see, Kirriemuir & McFarlane 2003; Squire 2003; Gee 2003).

3 Support for Blended Data Systems

3.1 Standards and Specifications Overview

3.1.1 SCORM 2004

"The Advanced Distributed Learning's Sharable Content Object Reference Model (SCORM) aims to foster creation of reusable learning content as "instructional objects" within a common technical framework for computer-based and Web-based learning. SCORM describes that technical framework by providing a harmonized set of guidelines, specifications, and standards based on the work of several distinct e-learning specifications and standards bodies" (ADL, 2004).

3.1.2 AECEMA S1000D

S1000D is an International Specification for Technical Publications utilizing a Common Source Data Base (CSDB) and is used for the procurement and production of technical publications. These comprehensive technical publications cover all aspects of creating, maintaining and publishing a technical information data set. Web technology and graphics standards are included as well as a capability to integrate with the other standards based processes used in project procurements. Whilst the title restricts its use to technical documentation it has been demonstrated that the principles of the specification can easily be applied to non-technical documentation (i.e., the incorporation of technical data into training content). The specification adopts and profiles ISO and WWW standards. Information generated is in neutral format, which means it can be used on disparate IT systems—is interoperable. It is this feature together with the modular approach to data creation and storage that makes the specification so acceptable to the wider international community. (S1000D Brochure)

3.1.3 CORDRA

CORDRA™ (Content Object Repository Discovery and Registration Architecture) is an open model for how to build systems than can share and reuse learning content. CORDRA is just one of many international activities that are focused on the development and deployment of tools and systems that enable discovery, management and sharing of learning content. The CORDRA project has its roots in the ADL's SCORM initiative, but the model will not be restricted to SCORM content. The project is currently a collaborative activity among a number of interested organizations—to include DoD, whose draft instruction 1322.XX.00 states that all DoD components shall maintain all distributed learning content in repositories that are searchable and accessible. CORDRA facilitates object searches and accessibility.

From a community perspective, users deserve simple models and means to seamlessly find and access appropriate learning content. Keys to reaching these goals are providing the appropriate infrastructure and removing barriers (both technical and policy) that limit interoperability among systems as well as between systems and users. The various ongoing international projects address parts of the content discovery and sharing problem through their particular approaches.

3.2 The Delivery of Objects Via Web Services and Wireless Technologies

Emerging technical standards and specifications such as wireless network technology, SCORM 2004, CORDRA, and S1000D can permit the 2-way interchange of reusable content objects among common-source data repositories that store both technical data and training/learning content. Learning content and technical data resource blending is both fiscally and strategically advantageous. The goal is to develop technical and training content from an integrated data environment that relies on data request and data

resolution Web Services in conjunction with XSLT processing applications to deliver technical data or training content objects to the appropriate communities of use.. (see Figure 1). This blended approach will also create potentials for the reuse of diverse data objects to enable the development and production of technical manuals and respective courseware as though from single source materials. Configuring training/learning content from the authoritative technical data will create possibilities for data aware distribution environments. These linked data environments could enable systematic, cascading notifications of recommended changes to training/learning content when critical updates are made to authoritative source data objects. Automated content data configuration systems will help insure that all data consumers will have access to the most current content data whether it is in the form of technical manuals or associated training and educational resources.

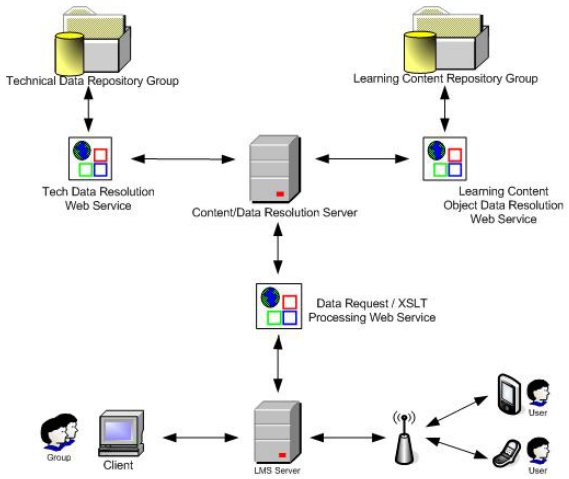

Figure 1: Data Flow and Resolution to Deliver Learning and Technical Objects to Mobile Technology End Users.

4 Methodology

Investigate the various types of mobile technologies: PDAs, cell/smart phones, PC tablets, hand-held computers, ultra portable computer devices, etc., and their appropriate application in various education/training and performance support environments. This investigation will include the analysis of integrating mobile technologies with emerging learning content (i.e., SCORM 2004) and technical data (i.e., S1000D) specifications to integrate into a distributed learning environment. Specifically, guidelines will be developed based on theories and applied research in the areas of cognitive sciences, learning, gaming/simulation, and learning objects as well as existing studies from mobile technologies' research and use cases. The following analysis and product development based will be structured around current mobile technology research, lessons learned, and best practices.

4.1 Literature Review

Review of literature was focused around the following research questions:

- What types of training and/or performance support can be effectively delivered via a PDA that are consistent with the identified learning environment?
- What are the technology and media capabilities and/or limitations within PDAs relevant to learning and performance support?
- What limitations, if any, exist for use of adult instructional strategies? Are there any that are particularly well suited for PDA use?
- How is the mobile technology training/performance support integrated within the identified learning environment, taking into consideration the identified learning environment's business rules and system architecture?

- How can training and technical data be integrated into a hybrid product for delivery via mobile technologies?
- What are the existing mobile technologies "best practices" that can be applied to the identified learning environment?
- What is the potential for importing legacy content into the mobile technologies for use in the identified learning environment?
- What existing mobile technology applications can readily integrate with the identified learning architecture to maximize the potential for content delivery via mobile technologies?
- What are the change agency issues that surround the adoption of mobile technology use within the identified learning environment?

4.2 Analysis

1. Investigate a cost model for infrastructure, technology, and services for integrating mobile technologies into a distributed learning environment.
2. Investigate the usability requirements of all stakeholders—both those creating the content and using the technology—involved in the development and use of mobile technologies within a distributed learning environment. Specific areas to investigate include:
    - Appropriate ISD theories for mobile technology content development
    - Appropriate design and use of mobile technologies for both education/training and performance support
    - Technological (e.g., web services, data resolution, data repositories) considerations for implementing mobile technologies within a distributed learning environment
3. Determine which mobile technologies and respective instructional strategies are best suited for which training and learning task to support mLearning.

5 System Architecture Design Issues

5.1 The Mobile SCORM LMS Issue

Limitations in current mobile technologies prohibit the standard LMS deployment of SCORM compliant content to mobile devices under the terms of the SCORM RTE Specification. Deployment of SCORM compliant content to mobile technologies will require highly specialized mobile SCORM LMS development.

The conceptualization and engineering of methodologies to cope with the deployment and rendering of SCORM compliant content on mobile devices, or any other platform, lie beyond the domain of SCORM compliant content development. Content developers are bound by elaborate yet technologically unsophisticated specifications. The SCORM 2004 Content Aggregation Model (SCORM CAM) and the SCORM 2004 Sequencing and Navigation Specification (SCORM S&N) apply more to content development concerns.

The task to deliver SCORM compliant content to mobile devices falls under the realm of LMS development. The SCORM 2004 Run Time Environment Specification (SCORM RTE) is the primary reference for LMS developers.

The SCORM RTE is a much more technologically demanding specification than the CAM or S&N specifications. It requires familiarity with Object Oriented Programming (OOP), the W3C Document Object Model (DOM), Hypertext Transfer Protocol (HTTP) and data modeling to be fully understood.

The ADL SCORM RTE assumes PC-based rendering of content objects delivered (or served) by a compliant LMS. The SCORM RTE Specification offers no support or guidelines for the implementation of the SCORM RTE within the realm of mobile technologies.

However, it is possible to demonstrate the ability to successfully render and track SCORM 2004 compliant content on mobile devices in non-standard ways. It is possible to address the limitations of individual

mobile device OS and browsers by developing integral, client-side SCORM conformant viewer applications for each mobile OS platform. Pocket SCORM is the example of this technology.

5.2 The SCORM RTE "As Is Situation"

Research into SCORM RTE compliant content for mobile devices reveals a number of special circumstances that make the strict implementation of the ADL SCORM Application Programming Interface (API) on mobile devices a task fraught with barriers.

Perhaps the single greatest obstacle is the lack of uniform support for the most common technologies promoted by the SCORM RTE Specification. The strategies used by LMS developers to establish data communications between SCOs and the LMS invariably fail when deployed on mobile devices.

Lack of complete support for the foundational technologies that enable the SCORM RTE among device OS and mobile browsers currently prohibits the development of universal, cross-platform, open-source solutions to accommodate the ADL SCORM RTE. However, there are other means to accommodate SCORM compliant content on mobile devices. As mentioned, Pocket SCORM represents one such solution now available for the Pocket PC. This will be discussed later in the document.

However, enabling technologies for mobile devices and browsers are evolving by leaps and bounds. It is not unreasonable to speculate that the inhibiting issues may be overcome by the mobile OS and browser developers in the near future. The gravity of the consequences of these issues for all communities of mobile content developers makes this eventuality even more likely.

The limitations for ADL SCORM in mobile browsers fall into two basic categories:

- General Lack of support for advanced DHTML scripting and the W3C Document Object Model (DOM)
- Lack of cross platform support for Java and/or Active X Components

Perhaps the greatest handicap to the SCORM on mobile devices is the limited support for advanced DHTML in mobile browsers. As a practical matter, the SCORM API requires the use of advanced scripting and DHTML objects in HTML pages. It should also be noted that the ADL offers no support, guidelines or specification for the implementation of the API within mobile technology platforms.

5.2.1 An Immature Rendering Environment

Mobile devices are a comparatively immature content rendering platform. As previously noted, the lack of standardized support for the SCORM RTE foundational technologies creates an unfriendly environment for the LMS delivery and client rendering of SCORM compliant content on mobile devices in accordance with the SCORM RTE specification. This means that it is highly unlikely that a single solution can be formulated for the delivery of SCORM compliant content across the spectrum of mobile device OS and Web browsers at this time.

Follow these links to view detailed information on the support for capabilities of the two predominant mobile browsers for Palm OS and Pocket PC:

- http://kb.palmone.com/SRVS/CGI-BIN/WEBCGI.EXE/,/?St=32,E=0000000000100175381,K=5710,Sxi=4,new,t=printsolution,case=obj(31514)
- http://msdn.microsoft.com/library/default.asp?url=/library/en-us/wcepie/html/cerefPocketInternetExplorer.asp

Please note that our research indicates that, although not stated, the Palm browser support for DHTML is limited, as it is for Pocket IE.

5.2.2 Palm OS

Our research does not indicate the existence of a SCORM conformant RTE for the Palm OS. However, because Pocket SCORM architecture is built upon Web Services and platform independent protocols such as SOAP, it may be possible to devise a client-side SCORM viewer application module for Palm OS devices that can be integrated into the existing Pocket SCORM RTE server-side architecture. Creation of such an application may represent a significant development effort.

5.3 A Viable Alternative: Pocket SCORM

Pocket SCORM is a modular remote LMS and mobile client viewer solution. It operates through a custom Pocket SCORM RTE that mirrors the conventions of the ADL SCORM RTE. The Pocket SCORM RTE accommodates the special needs of MS Windows-based mobile devices. Although it is similar in many respects, by necessity, the Pocket SCORM RTE is not fully ADL SCORM RTE compliant.

While it may not strictly comply with the ADL SCORM RTE, Pocket SCORM is recognized and to a degree endorsed by ADL. Pocket SCORM provides a sophisticated and elegant means to deliver and track user data from SCORM 2004 compliant content

6 Prototypes

Applying the a) results from the analyses—guidelines for which instructional strategies best support mLearning via mobile technologies, and b) system architecture design and respective model a prototype will be developed to demonstrate the capability to deploy SCORM 2004 conformant objects from data repositories through XML Web Services to mobile devices.

7 Conclusions

Until the methodologies required for the instantiation of the SCORM API on mobile clients are fully supported by mobile browsers and Operating Systems, we are prevented from deploying standard SCORM LMS navigation and CMI user data functionalities in mobile environments as specified by the SCORM RTE.

This circumstance necessitates the research and development of conformant LMS adaptations of the SCORM RTE in mobile learning environments across the range of target Operating Systems.

At the same time, the lag in technology affords a great opportunity to plan the infrastructure and programming methodologies that will enhance a standardized ADL Mobile SCORM RTE when it eventually becomes a viable option—as it seems almost certain that it will.

This effort has produced a wealth of strategic information that will greatly enhance future efforts when conditions permit implementations currently rendered impractical within mobile technologies.

8 References

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9 Curriculum Vitas

Heather A. Katz, Ph.D., Senior Instructional Technologist and Researcher
Dr. Katz has over 13 years experience in the field of education and instructional technology with a concentration in the application of cognitive sciences to electronic learning environments. Dr. Katz has designed e-learning for K-16, government, and corporate audiences to include both technical and ISD development. Her current research endeavors involve data—technical and training—integration, content management, reusable object models, mLearning, and mobile technologies as they apply to enterprise strategies. Dr. Katz was the project lead and primary author of foundational research that was used to develop the U.S. Navy's Content Object Model. She is a contributing author for the U.S. Specification Implementation Group Training Subproject White Paper that raises issues and recommendations regarding the harmonization of the S1000D and the ADL SCROM. Dr. Katz is a member of the AICC ISD Working Group that is devising recommendations for the extension of the LOM. She is the former Department Head of the Interactive Medical Multimedia Department within the Visual Information Directorate at the U.S. Naval Medical Education and Training Command. Dr. Katz is a former adjunct professor and has designed and instructed both undergraduate and graduate level courses in the educational, instructional technology, and computer disciplines.

Stephen Worsham, Senior Programmer
Mr. Worsham has over 20 years experience in the fields of computer programming and training with a concentration in the development of interoperable and open architecture development tools and data resolution systems. He has designed SCORM conformant proprietary software for the development of training courseware that delivers interoperable and open architecture source files. Mr. Worsham's current development endeavors include the design of interoperable system architectures that utilize web and data resolutions services to deliver both learning content and technical data objects to end users.