The Hard SCORM LMS: Reading SCORM Courseware on Hardcopy Textbooks

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ABSTRACT

The Sharable Content Object Reference Model (SCORM) includes a representation of distance learning contents and a behavior definition of how users should interact with the contents. Usually, SCORM-Compliant systems are developed based on Web browsers or Java program. We developed a system which allows users to read SCORM-Compliant course materials on hardcopy papers while an OCR-like pen device is used as an interaction mechanism. A computer, a PDA, or a cellular phone can be used in conjunction with the pen device for multimedia presentations. Our project is called the Hard SCORM. Therefore, users can read textbooks in a traditional manner while behavior of reading is incorporated with the SCORM specification.

1. INTRODUCTION

In line with the blossom of Web-based learning and real-time instruction delivery, distance learning technologies brings to our education society a new perspective of future education. One interesting issue in distance learning is that interactions can be made between the instructor (could be a computer) and students, in different spatiotemporal domains. With advanced communication technology and intelligent agents (i.e., computer programs), students learn in an interactive manner through self-regulation-based distance learning systems. Human-computer interaction becomes an essential discussion issue. We believe that, not everyone uses computer, even it is so popular everywhere. An obvious example is senior people. It is possible that they still prefer reading on hardcopy books. How do we, as an engineer, bridge the gap between the physical world and the virtual world on computers, in terms of creating convenient devices and software for easy distance learning? Essentially, advanced hardware and communication technologies need to be used in conjunction with distance learning platforms. Fortunately, there are consumer available products based on OCR (Optical Character Reader) technology. OCR can be a pen-like device allowing users to scan through textbooks. Examples of such a pen device were also integrated with electronic dictionary. In our project, we call these types of pen devices the Hyper Pens. The name of Hyper Pen comes from the fact that a hyper jump is performed from one is using the device in the physical world for reading, to a virtual world in a electronic device which pronounces a vocabulary, or even shows motion pictures on a computer. One contribution of this paper is to bridge the gap between the physical and the virtual worlds, by providing such a Hyper Pen associated distance learning platform for senior people to learning from computer in a seamless manner.

Among the institutes involved in distance learning standards, the Advanced Distributed Learning (ADL) initiative (http://www.adlnet.org/) combines several specifications and proposed the Sharable Content Object Reference Model (SCORM). Since its announcement in 2000, the standard proposal is recognized by the e-Learning community. The main contributors of SCORM include the IMS Global Learning Consortium, Inc. (http://www.imsglobal.org/), the Aviation Industry CBT (Computer-Based Training) Committee (AICC) (http://www.aicc.org/), the Alliance of Remote Instructional Authoring & Distribution Networks for Europe (ARIADNE) (http://www.ariadne.eu-org/), and the Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standards Committee (LTSC) (http://ltsc.ieee.org/). The purpose of a SCORM run-time environment is to establish a standard protocol for the courseware to talk to its underlying Learning Management System (LMS), which is a machine and OS independent platform. The specification of SCORM run-time environment includes the procedures and responsibilities for courseware to communicate with a LMS, a set of standard application program interfaces (APIs) to serve the communication, and a data model which describes the message passed between the courseware and the LMS.

Typically, the Learning Management System is installed in a central server, where all of the course materials and student profiles are stored. Since students login to the server from the client side, it is necessary

Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies (ICALT'05)
0-7695-2338-2/05 $20.00 © 2005 IEEE

to install a learning system on a client computer either through a pre-installed program or a mobile agent. The decentralized installation avoids service traffic overload if the computation power of the central server is limited. The procedure of viewing a courseware starts from a launch process by the LMS. After that, controls are passed to the courseware (could be a Sharable Content Object/SCO). An initialization is issued by an SCO, followed by a series of invocations to API, which is handled through an API adapter in the client computer. In some cases, Java Scripts are used in an SCO to enable the interactions between the user and the courseware. The Java scripts call proper API functions, which check statuses of the learning process. Before the SCO is closed, the SCO must call the termination API function to terminate the communication with the LMS. While the courseware is presented, the associated multimedia data are retrieved and presented by a Web browser on the client site.

How do communication technology and the Hard SCORM project benefit distance learning? With a vision to frontier learning and advanced computer technology, while we aim to provide environments which allow easy access of learning materials, we target five paradigms of using our systems:

1. **Using PC in a classroom:** In a typical computer classroom, the instructor may deliver course contents through a PC. This paradigm allows in-class lecture and on-line exam to be conducted.
2. **Reading from PDA on a bus:** While a student is taking a bus or subway, one can review highlights of a lecture. PDA and Smart Phone integrated with GPRS, 802.11 or other advanced communication technologies serve the purpose.
3. **Reading through Hyper Pen in vacation:** While one family is taking a vacation, if it is necessary of reading an after class exercise, the student is able to use hardcopy hyper book and a Hyper Pen. Feedback of the Hard SCORM LMS can be integrated with LED outputs on a Hyper Pen, or via a synthesis speech technology (i.e., pre-recorded MP3) on Hyper Pen.
4. **Using Hyper Pen with guidance from a PC at home:** While a student is writing his homework, one will use Hyper Pen and PC at home. This paradigm allows the digital and the physical worlds to be bridged. The student can even use references such as video tutorials, without loosing the comfortable reading on hardcopy textbooks.
5. **Using Hyper Pen with PDA in library:** When a student goes to library, a PDA or Smart Phone is carried. With GPRS connections, the students can use Hyper Pen and PDA to check out on-line references.

Our systems enable a comprehensive pervasive learning environment, which is the dream paradise of future distance learning. The paradise allows "learning anywhere." However, it is the decision of an individual learning to decide what learning devices to be used. Thus, an efficient system that can encourage students to learn under a natural atmosphere is a must. This is the optimal goal of our research.

The pervasive learning society enabled by our system relies on a sophisticated software platform and advanced mobile devices. With the availability of advanced communication protocols/infrastructures (i.e., wireless LAN and Bluetooth) and devices (i.e., Hyper Pen, Smart Phone and PDA), the development of our SCORM-compliant distance learning platform is easier.

2. THE HARD SCORM TAGS

In order to allow Hyper Pen and LMS to communicate, we need to define a set of Hard SCORM tags, which can be recognized by Hyper Pen. The definition of Hard SCORM tags should consider effective interaction and fit with the navigation and sequencing specification of SCORM. Hyper Tags are divided into four categories:

- **Navigation Tags:** Navigations are controlled by using navigation tags.
  - <P p_i> **Page Tag** is associated with a SCO page number, p_i, which indicates current navigation focus. Activation of the tag changes the status of an activity tree.
  - <→> **Next Page Tag** allows a navigation to move forward to the next SCO page and change the status of an activity tree.
  - <←> **Previous Page Tag** is similar to the Next Page Tag.
  - <Exit> **Exit Tag** allows a navigation to exit from the current SCO.
- **Reference Tags**: Multimedia resources can be used as references, which is trigger by reference tags.
  - <Video i> **Video Reference Tag** shows a video.
  - <Audio i> **Audio Reference Tag** presents an audio clip.
  - <URL i> **URL Reference Tag** launches a website.
  - <Flash i> **Flash Reference Tag** brings out a Flash animation.
- **Answer Tags:** Answers in a test can be recorded by a SCORM LMS.

- <1> | <2> | <3> | <4> | <5> **Multiple-Choice Tag** allows a learner to give an answer.
- <Yes> | <No> | <Y> | <N> **True-False Tag** is similar to the Multiple-Choice Tag.
- <___> **Fill-in-Blank Tag** allows a learner to give an answer to LMS. A popup window is used.

- **Auxiliary Tags:** These tags turn on/off or control Hard SCORM.
  - <Start> **Start Tag** turns on Hard SCORM.
  - <End> **End Tag** turns off Hard SCORM.
  - <Pause> **Pause Tag** suspends Hard SCORM.
  - <Continue> **Continue Tag** resumes Hard SCORM.
  - <Status> **Learner Status Tag** provides status parameters to learners as an output.

Figure 1: Using Hard SCORM LMS

A formal definition of the functionalities and system response actions of these tags are also defined. The definition uses a set of icons for the tags. The activation of these tags will change SCORM variables in an activity tree while the LMS is running. Note that, the LMS is implemented on a PC, which serves as a backend server of Hard SCORM LMS. The Hyper Pen is connected to PC. Wireless communication will be used in the near future to enhance the flexibility of Hard SCORM. Figure 1 shows a section of Hyper Pen navigation on a textbook. The student is using a Hyper Pen to read textbook. A PDA is used to see multimedia presentations (such as video). And a backend computer had audio message to guide the student. Audio signal enforces the student to follow the sequence and navigation definition of a SCORM-compliant courseware.

Our first attempt on the implementation is to recognize Hyper Tags as text forms, since OCR-based technology is well-developed. However, text-based tags mix the tags with text instructions. Our next step of implementation will use technologies from content-based image retrieval, which allows graphical tags to be recognized. Thus, clearness of text-based instructions is improved.

3. DESIGN AND IMPLEMENTATION

The implementation of Hard SCORM LMS can use any language and OS. However, web service framework is extremely suitable because it reduces the overhead of service requester and service provider. The architectures proposed in [1, 3, 5] also use Web services. With the help of standard definition, it reduces the effort to construct the Web Service Description (WSD) for communication parties. To integrate web service architecture into SCORM deems easier comparing with some other standards. The reason is that SCORM is XML-based. Web service architecture is also an XML-based message framework. As a result, the current data model and API functions definition of SCORM is easy to be integrated with web service architecture. Figure 2 shows a revised SCORM RTE architecture for supporting various learning devices.

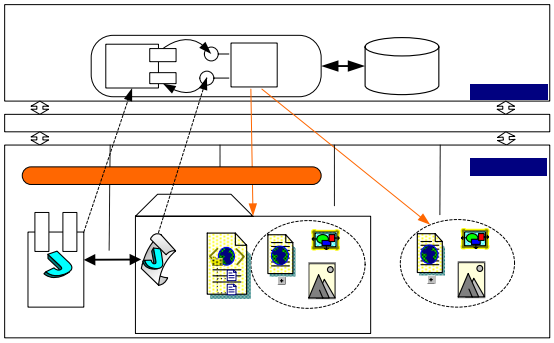

Figure 2: Revised SCORM RTE for Multiple Devices

As defined in the SCORM RTE specification, the LMS servers are able to launch SCOs and assets (i.e., basic learning objects) for learners to view learning content. The LMS server also needs to control learners' navigation behavior. SCORM APIs are converted or opened as web services. The transmission protocol can be either HTTP or SOAP. Traditional invocation of SCORM APIs can also be supported with the help of Web Service Gateway (WSG). In addition, a special component is added for mobile devices known as the sequencing cache engine.

The SCORM Web Service API is a replacement of the original SCORM API. The services can be acquired through SOAP messages from various clients. The basic operations of the original SCORM APIs are supported by SCORM Web Services. As a result, SCORM Web Services supports the operations such as administration, session management, sequencing control, learning content delivery, etc. However, with the advantages of web service architecture, these services are easily extended according to the domain specific services provided by each LMS server. To ease the implementation of SCORM API adopters, a WSG (Web Service Gateway) for SCORM API is also introduced. The WSG is shown in Figure 3. With the help of WSG and the LMS RTE, other LMS servers which do not support web service can also use WSG to wrap the original information into a SOAP message and send out the request to SCORM web service. After the service has processed the request, the responded SOAP message result can be unwrapped by WSG and sent back to the original API instance.

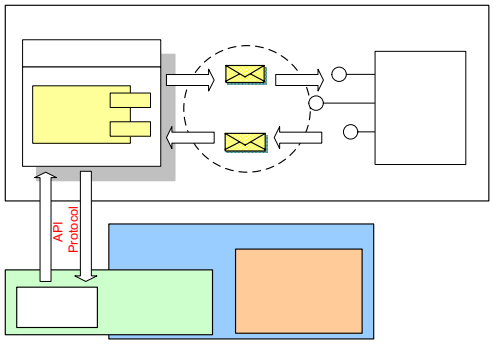

Figure 3: The Web Service Gateway

The ECMA Script in the current SCORM definition is the SCORM RTE APIs launcher. The ECMA Script is also known as Java Script which is used to write browser based control. In SCORM, ECMA Script will interact with SCORM API instance which is a Java Applet to communicate with the backend LMS server. In our framework, however, the SCORM API instance is not the only way to communicate with the LMS server. It is also possible to use ECMA script to create message and send to the SCORM web services thus achieve the purpose of communication with LMS server. This is a good solution for some platform which does not support Java Applet. To enable ECMA Script to request for SCORM web services directly, the original script needs to be modified due to the difference of communication modal. Web services normally are designed to support asynchronous communication which means that the client might not get the instant response from the SCORM web services. Therefore, the original script communication modal requires some modification.

In the revised modal, the ECMA script must maintain message queues for the service requests and service responses. The process of this new modal is explained as following. A difference from the original ECMA script in SCORM is that, when there is a SCORM API call, the call is queued in the service queue which is maintained by a service request controller. The service request controller checks the service queue regularly on a time basis. When the service request controller finds there is a request which is queued, the request is pulled out from the service queue and then sent to the SOAP Request Composer. The SOAP Request Composer receives the request and wraps the message according to the WSDL of SCORM web service. After the request is wrapped as a standard form of SOAP message, it is sent to the Communication Controller, and Communication Controller actually send the request message to the requested SCORM web service of the web service provider. This also completes the request process of SCORM web service. Once the requested SCORM web service has completed the task, a response result is send back to the Communication Controller in a SOAP message format. This message is then sent to the SOAP Message Decomposer. The SOAP Message Decomposer unwraps and extracts the result from the response SOAP message. This result is then stored in the result queue. The result queue is maintained by Service Result Maintainer. The Service Result Maintainer checks the result queue regularly. Once it finds that there are results in the queue, it will pop-up the result and return to the requester. This is also ends the response process of SCORM web service.

The Hard SCORM LMS supports different learning devices including PC, PDA, cellular phone, and Hyper Pen. Figure 4 and 5 illustrate the user interfaces on PDA and Smart Phone (cellular phone running Windows CE).

Figure 4: SCORM LMS on PDA

A few important functions are implemented on the PDAs or Smart Phones. Object reflow will resize text, video, and image on PDA and Smart Phone to fit window sizes [2]. As a result, the reader only uses the

up-and-down scroll bar to read contents. The reader can add personal notes to the content, which can be uploaded to the central database. A cache mechanism is used. According to the definition of SCORM specification, a *cluster* represents a small aggregation of learning objects, which can be delivered and used in a learning activity. The memory size of each cluster is calculated. And a cache mechanism incorporates the definition of navigation sequences is implemented. The cache mechanism is very important, especially for devices with small memory capacity. In addition, we use SOAP for message transmission [4]. SOAP messages are passed between client devices (Web browser on PC, PDA, or cellular phone) and the central server. The underlying transmission protocol can use 802.11 or GPRS, which depends on particular hardware of a client device. Even the LMS is running on different devices, the activity tree (i.e., learning status) of each student is maintained by a central server. Thus, a student can use multiple devices with a continuous learning schedule. So far, we have tested a few PDAs (Dopod 700, HP iPAQ 5550, and AnexTEK SP230) and Smart Phones (Dopod 565 and Mio8390). On the other hand, the Hard SCORM LMS is running on Web browsers. Interested reader can visit our demonstration website (http://www.mine.tku.edu.tw/SCORM/).

Figure 5: SCORM LMS on Smart (cellular) Phone

The Hard SCORM LMS was developed and used. We ask two sets of users to try the system and give us suggestions. Two high school teachers in Taiwan use the system to teach English. Each student in a small group is allowed to use a PDA or a Smart Phone, while a Hyper Pen is connected to each school computer. According to their experience, most students are interested in using high-tech devices such as PDAs and Smart Phones for learning. Learning performance is improved, especially in English vocabulary. We also ask two professors in computer engineering to evaluate software performance of our system. Form their experience, using Hype Pen is not difficult and the accessing time is very short. Downloading lecture notes to PDAs and Smart Phones is still slow due to the transmission rate of GPRS. In addition, to follow the instruction delivered by audio from a computer is not friendly. One professor founds that when a PDA is used with the Hyper Pen, the interaction will be easier.

4. CONCLUSIONS

It is the first time that Hyper Pen device is used in a SCORM-based Learning Management System. We designed and implemented such a LMS, which is based on web service architecture. A few systems on mobile devices are also developed to be used in conjunction with the Hyper Pen. As an integrated system, the LMS supports students to use different devices to read the same course material consistently. Individual learner profiles are maintained in a central server. To allow an instructor to develop courseware, an authoring tool (not addressed in this article) was also developed. We are looking for a local telecommunication company to transfer our technology.

The contribution of this paper is to bridge the gap between reading in a traditional manner and learning by using electronic devices (such as PDAs). To realize the concept, SCORM is followed and Web service architecture is used. We believe that, with high-tech devices, ubiquitous distance learning will be an important issue in our education, especially for the young generation who use mobile devices constantly.

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