Personalized e-Learning in a Re-Usable Way:
A Proposed GIS System Design – The Architecture

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Abstract: For e-Learning, learning objects and XML not only present advanced technologies, but also promise an approach to create online instruction quickly and economically. Although it is unlikely that a global library of learning objects, which follows some open standards, will be formed in near future, developing a campus-wide instructional system based on learning objects for courseware design and delivery is still possible. The main goal of this study is to develop a reusable and adaptive e-Learning system with XML schemas forming the basic framework. This system shows that it is possible to achieve flexibility, reusability, interoperability, and personalization of learning content in such a XML environment. This study describes the detailed design of the e-Learning system. The first section describes the architecture of this system. The second section deals with the design of the learning management system.

Key words: E-Learning, learning management system, content packaging, courseware authoring, E-learning architecture, GIS authoring

INTRODUCTION

A crucial area to consider is the effectiveness of an e-Learning system. The goal is not to deliver course content as a book online or as a single-track sequence of facts but to provide an interactive and adaptive delivery[1]. With a powerful smart-engine permitted by today's technology, courses may be delivered that are pro-active and modify their presentation to the student's learning style, pace and media preferences. A flexible web-based delivery model enables users of varying backgrounds, skill levels, languages or abilities to receive quality courses that are individually designed to meet their needs. At the same time, a tool for creating courses and for managing the entire system is essential[2]. The design of the underlying architecture of such a delivery system demands careful planning.

GIS Learning Management Systems (GLMS), form the infrastructure of a GIS e-learning system. GLMS are a dynamic platform that support the tracking of users (learners), assessing performance, deployment of content, providing administrative functions such as access to user records, as well as providing an environment for chat rooms, threaded discussions, and synchronous learning 58 environments[3]. GLMS often interface with existing enterprise resource planning software applications. The products of many leading LMS providers include features such as robust functionality, highly scalable, easy implementation, and strong content partnerships[4]. These features are especially important when designing a GLMS in order to accommodate the growing number of e-learners.

THE SYSTEM ARCHITECTURE

The overall architecture of the proposed e-Learning system is presented in Fig. 1. This system assumes a Web-based infrastructure as a basis for its technical implementation. Therefore, learners interact with the e-Learning system through browsers in the client side, and get the learning materials in the format of HTML. In the server side, the XML documents, conforming to the schemas that we define in[5], are used to store all information about learning content, instruction as a run-time environment, administers the XML documents to response to the structures, and learner profiles[6]. The GIS Learning Management System (GLMS) is working learner's requirements. It involves a suite of functionalities designed to deliver, track, report, and manage learning content, learner progress and learner interactions.

The GLMS is developed to support the idea of composing larger units of instruction, such as a whole course, from relatively small, reusable learning objects. Learning objects by themselves have no specific context. As figure 1 shows, learning objects are normally separate knowledge objects with metadata, which are stored in a repository. When combined with other learning objects, it is the content packaging file that provides the context and allows a GLMS to manage the learning experience. Resources can thus be reused in multiple contexts.

This means that learning objects do not determine by themselves how to navigate through an aggregation representing a unit of instruction[7]. Instead, sequencing
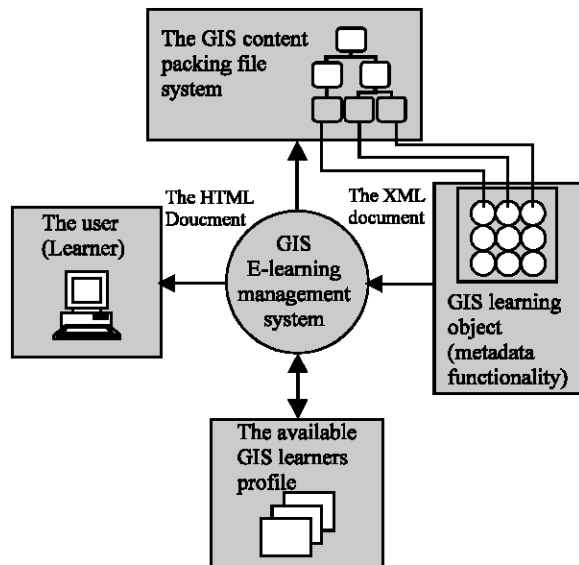
Fig. 1: The architecture of the proposed GIS E- learning system

and navigation are determined by rules defined within the content packaging file and interpreted by the GLMS. The GLMS merely processes the explicitly defined rules and itself has no knowledge about how the content is organized. By importing the content packaging file and following the defined rules, the GLMS has the ability to determine what and when to deliver, and tracks the learner's progress through the learning content. This allows course developers to specify sequencing attributes and rules and navigation behaviour while maintaining the possibility of reusing learning objects within multiple aggregation contexts. In the proposed system, the attributes and rules that are used to guide the navigation behaviour of the GLMS include the following:

The difficulty range of learning content: Normally, one instruction course may include some basic and some advanced knowledge, which are suitable for the requirements of different learners. For example, in a calculus class, the instruction content for students in Mathematics department should not be the same as that for students majoring in English. At some points of the instruction, several navigation paths need to be distinguished by the difficulty range; therefore learners with different background may reach the knowledge levels that fit their requirements.

The comprehensiveness range of learning content: For the learners with similar background and requirement, the studying capability of those learners may still be different.

When studying the same topics, some learners may need more detailed explanation and more examples than others. The navigation paths with different comprehensiveness ranges will allow the learners with diverse studying capabilities to follow the most appropriate learning content.

The result of the tests: In an instruction course, some tests should be set to evaluate the performance of the learners. The result of tests is used in two ways. First, it may be used to determine whether the learners are good enough to skip some prerequisite knowledge. Second, the result is used to evaluate the learner's studying capacity. This may help the GLMS to decide whether the content with more examples and detailed explanation should be served to learners. Following those rules, course developers may develop instruction courses without considering the GLMS that they use. Through defining the content packaging file that conforms to the schema, they can freely design courses with different navigation paths, which will fit the requirements of different learners. Moreover, if the same content packaging schema is adopted by other systems, which may also interpret the rules, defined in the packaging files, these instruction courses can be easily reused in those systems.

In summary, the development of a reusable and adaptive e-Learning system involves two important parts. The first part is mainly concerned with learning content development, including a library of learning objects, metadata, content packaging file, and learner models. In the second part, it is necessary to establish a run-time environment for the learning materials. In this research, a Learning Management System is especially designed for the proposed e-Learning system.

THE GIS LEARNING MANAGEMENT SYSTEM DESIGN

A GIS Learning Management System (GLMS) is a single, integrated software tool based on standard technology platforms that will fit with the existing infrastructure of e-Learning. With the rapid growth of the Internet and the development of e-Learning technology standards, many designers of e-Learning system now use the term LMS to replace Computer Managed Instruction (CMI) so as to include new functionalities and capabilities not historically associated with CMI systems. The new features in LMS enable one to have more ability to assess, plan, deliver, manage, and improve e-Learning in a Web-based environment. With the open standards in place, a LMS developed by any organization can be used to handle learning materials from different resources. The
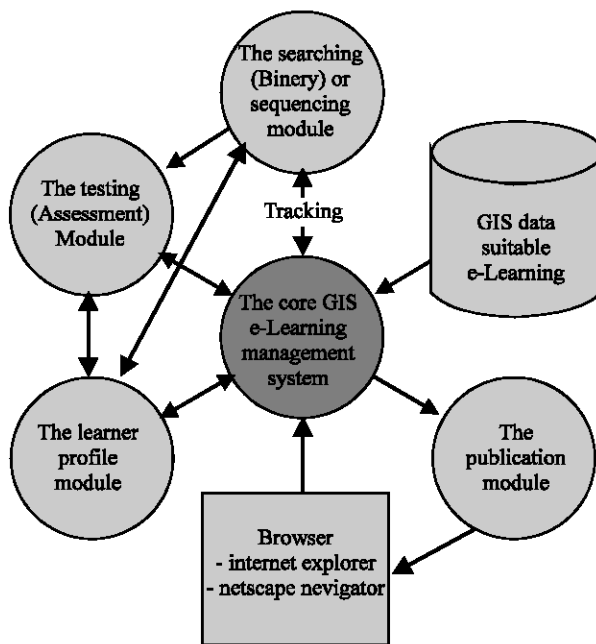
Fig. 2: The GLMS modules

term GLMS can apply to very simple course management systems or highly complex enterprise-wide distributed environments. However, the basic functions of a GLMS can be summarized as follows:

- Select and tailor learning materials to meet learners' needs;
- Establish learning path and sequence;
- Monitor and correspond with individual progress;
- Assign exercises and quizzes, and evaluate learner's performance;
- Manage and update learner information;
- Integrate learning materials from multiple sources

In this project, a specific GIS Learning Management System is designed to provide a run-time environment for our e-Learning system. As Fig. 2 shows, the components that make up this GLMS include six modules: the Core GIS e-Learning Management Module, the Sequencing Module, Testing (Assessment) Module, Learners Profiles Module and the Publication Module. Every module provides some specific functionality. This section gives a brief description of how each module works and interacts with other modules.

In general, the whole Learning Management System is developed based on servlets, which accept requests from a client (via the Web server), performs some tasks, and returns the results. These servlets implement the following functions:

- Verify the learner's identification, and then load the learner's background information;
- Check the current progress of the learner, load the content packaging file, and select the proper learning objects according to the learner's need and performance;
- Transform learning content to the appropriate formats, such as HTML or PDF, by using some standard XSLT files;
- Load proper quizzes to evaluate learner's performance;
- Update learner's information along with learner's performance.

The GIS Learning Management Module (GLMS): Learning Management Module is the central part of the GLMS. It mainly contains a series of interfaces between the server and the client, and implements the basic functions that a server should provide. In order to get a better understanding of the details of this module, a brief knowledge about server and servlet is required. In the client/server architecture, the server manages the data resource: it stores, retrieves, and protects data. The services provided by conventional Web servers are mainly restricted to the delivery of files. For this reason, if more complex services are required, a powerful interface is needed between the actual application and the HTTP server. One of the basic interfaces is the Servlet API. Sun developed this application programming interface to provide Java programs on the server with a simple and flexible basis on which to run. Like CGI, the programmer can use the API to access environment variables and write the response to the request in a stream. In addition to that, the API provides cookie support and session management. It is left open whether the application on the server runs in the same process as the server or a different process.

In a nutshell the Learning Management Module is used to wait for client HTTP requests. When these requests arrive the module does whatever is needed to serve the requests by invoking the appropriate applications to provide the necessary content to the learners. Therefore the basic performance of this module includes the following functions:

- It provides an interface for the learners to log into the e-Learning system;
- When the status of learners is validated, the module sets up a session between the client and the server. Therefore, the system may begin to track the learner's progress. Moreover, it also loads the content packaging file and the learner's profile information for future use;

- When a request arrives from the learner, it checks and decides if a certain request belongs to another module. If so, it invokes the right module to handle this request;
- The result of every request is sent to the Delivery Module, where the XML documents are transformed into HTML documents and provided to the learner.

The searching (binary) or sequencing module: Most Web sites deliver content essentially one-way: from the server to the user. Occasionally the user, for example when ordering something online, which is then posted back to the server, enters information. But for the most part, Web servers do not keep track of what the user is doing with the content until a specific request is made. However, a GLMS, on the other hand, must track a learner progress, assess a learner's performance, and then select the next appropriate learning content. This involves gathering learner's profiles information, monitoring key interactions and performance within the content and then determining what the student should next experience. The Searching (Binary) or Sequencing Module implements this functionality. When the Searching (Binary) or Sequencing Module is invoked, it imports the content packaging file and gets the learner's information from the Learner Profile Module. Based on the rules defined in the content packaging file and learner's information, the module will select the next appropriate learning objects. Every time such a selection is made, Learners Profiles Module should update the learner's profile information. The Searching (Binary) or sequencing module provides a way for the system to find the appropriate learning objects by keywords. The course developers or learners can use this module to retrieve learning objects that they need for course design or learning. According to the keywords input by users, the module compares the keywords with the <keyword> elements in each learning objects and return a series of learning object that fit the requirement.

The Testing (Assessment) Module: The Testing (Assessment) Module implements two functions:

- When a quiz is invoked, this module finds the proper quiz file or forms a quiz file dynamically from the learning objects' <test> elements. Associated with this file, the quiz applet file is sent to the client side, which runs in the browser to show the quiz content. After the learner finishes the quiz, the result of the test is sent back to the GLMS.
- After getting the test result, this module updates the learner's profile information to include the result of the quiz. Moreover, the module changes the status of the learner's studying capability according to the scores.

The learners profiles module: The Learners Profiles Module keeps updating the learner's progress and performance. This information may dynamically form a content menu for learners. Moreover, it also provides learner information to other modules that need the information to make a proper decision or choice.

The publication module: The Delivery Module includes a set of standard XSL files, which transform the XML files into HTML files. Every time when some content needs to be presented to the learners, this module invokes the right XSL file for transformation. Therefore, the content can eventually appear in the right format on the browser of client side.

CONCLUSIONS

The major features of this e-Learning system can be summarized as follows:

- The whole system is developed based on reusable learning objects. The GLMS always tries to find the appropriate learning objects for learners.
- The system can provide individually tailored learning content and process. The combination and sequencing of learning objects are accomplished and adjusted dynamically according to the learner's performance and requirement.
- The learning objects can be reused in different instruction contexts.
- The learning content can be transformed to other forms of layout with standard styles.

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