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Degree of Scaffolding: Learning Objective Metadata: A Prototype Learning System Design for Integrating GIS into a Civil Engineering Curriculum

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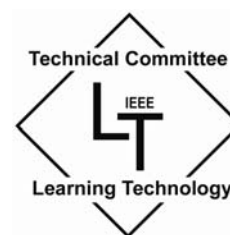


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From the editor..

Welcome to the April 2004 issue of Learning Technology.

This issue contains special section on "Learning objects in an e-learning context", guest edited by Prof. David Yang, National Kaohsiung Normal University, Taiwan, and assisted by Chun Yen Tsai, National Kaohsiung Normal University, Taiwan.

The call for participation for IEEE International Conference on Advanced Learning Technologies (ICALT2004), Joensuu Finland (August 30 - September 1, 2004) is now open. With more than 420 submissions, the Programme Committee has been able to select some very high quality papers for presentation. The proceedings of the ICALT 2004 will be published by IEEE Computer Society Press. The website of the conference (<http://lttf.ieee.org/icalt2004/>) contains registration form and other details.

You are also welcome to complete the FREE MEMBERSHIP FORM for Technical Committee on Learning Technology. Please complete the form at: <http://lttf.ieee.org/join.htm>.

Besides, if you are involved in research and/or implementation of any aspect of advanced learning technologies, I invite you to contribute your own work in progress, project reports, case studies, and events announcements in this newsletter. For more details, please refer author guidelines at http://lttf.ieee.org/learn_tech/authors.html.

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4th IEEE International Conference on Advanced Learning Technologies

(ICALT 2004)
August 30 - September 1, 2004
Joensuu, Finland
<http://lttf.ieee.org/icalt2004/>

Important Dates

May 31, 2004	Early bird registration
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Proceedings

All accepted Full and Short Papers and Poster Extended Summaries, will appear in a single volume to be published by the IEEE Computer Society Press. Extended versions of selected papers will be invited for a Special Issue of the Educational Technology & Society (ISSN 1436-4522) journal.

Keynote speakers

- Prof. Chee-Kit Looi, Nanyang Technological University, Singapore
- Prof. David E. Bloom, Harvard University, USA
- Prof. Henrik Hautop Lund, University of Southern Denmark, Denmark

Tutorials

- Measuring the Acquisition of Expertise: Considering the Possibilities (Prof. J. Michael Spector)
- Intelligent Web-based Computer-Supported Collaborative Learning (Prof. Vladan Devedzic)
- Implementation of the Shareable Content Object Reference Model (Dr. Michael W. Freeman)

Other highlights

- International Workshop on Technology for Education in Developing Countries
- International Conference on Educational Technology in Cultural Context
- Kids Club (engaging learning activities for kids of participants)
- Business day (academia-industry interaction)
- 3rd Summer school on educational technology (for PhD students)

Registration

Registration forms and other details are available at the conference website:
<http://lttf.ieee.org/icalt2004/>

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Guest Editorial

Special Theme on

Learning Objects in an e-learning Context

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With vigorous development of the Internet, e-learning system has become more and more popular. ADL proposes SCORM (Sharable Content Object Reference Model) specification that an XML-based metadata with physical files had been explored by many studies since 1997. The issue of Special Theme on Learning Technology Newsletter aims to collect early research opinions and report the development from the Learning Objects (LOs) in an e-learning context. We received over 40 articles and chose 18 articles for publication. Those articles show a variety of flavors for future research.

As we know that ADL SCORM has made its contribution on proposal of three major parts: definition of metadata specifications for reusability of learning object, Content Aggregation Model (CAM) of learning object, and simple sequencing of activity tree (AT) for adaptive learning. To enact the vision from ADL, researchers on this field have finished some successful and empirical results such as SCORM-compliant content repository, agent-supported learning environment, web-service technologies for distributed content repository, intelligent learning environment, data mining for adaptive learning, etc. This issue in April 2004 consists of three groups: (i). General issues across different domains; (ii). Special issues on interface design, agent-based learning environment, and domain model construction, and (iii). Experimental studies on SCORM-related e-learning context.

In the first group, Douglas Hamilton recommends insightful guidance for designing and developing reusable content objects for an online course in the article "*Creating Reusable Content: A practitioner's observations*". The article "*Considering Model-based Adaptivity for Learning Objects*" is proposed a hybrid model for using AHS (Adaptive Hypermedia System) and IMS SS by C. H. Wang & Tsai-Yen Li. Jorge Martínez-Peniche, Luz María Castañeda León, & Larisa Enríquez Vázquez in "*Developing learning objects: more than just labeling*", present tools for developing, indexing and searching content at different levels. The article "*Defining a Simple Sequence for RLOs*" is offered three layers of defining a simple sequence for RLOs (Reusable Learning Objects) by Jianhoa Chen, Salley Sawyer, joel McKinney, & Lu Zhang. The level 1 is to select RLOs and to assign priority number. The level 2 can be used by instructors to apply sequencing strategy. The level 3 can let students to take personalized courses. In "*The Collaboration of Learning Objects in a Grid Environment*" is designed for the problem for collaboration of LOs, a workflow framework by employing Grid Services Flow Language (GSFL) in a grid environment by Ching-Jing Liao.

In the article "*The potential for learning objects to support flexible learning in higher education*", Paul N. Semmens strongly acknowledge that learning objects will remain concepts of great promise and some benefit, but largely as yet unfulfilled potential for enhancing higher education student's online learning experiences unless some issues he raises would be resolved. Judy C. R. Tseng, Chuang-Kai Chiou, & Gwo-Jen Hwang in "*A Novel Approach of Learning Object Extraction and Management to Support Multiple Standards*" propose a unified learning platform to represent and translate teaching materials described with different standards. In the article "*Applying Data Mining in E-learning Environment*", Hsiao-Mei Huang & Cheng-Huang Wu offers the techniques for Applying Data Mining in E-learning Environment. Jessica Griffiths in "*Converting Existing Course Materials into Learning Objects via SCORM*" gives a case experience on how to converting existing course materials into learning objects via SCORM tools.

In the second group, three articles are classified in terms of technologies they use. Timothy K. Shih, C. Y. Chang, K. P. Shih, T. C. Kao, G. J. Yu, & T. S. Yu in “*Hard SCORM*” reveal their research laboratory product encoded as Hyper Tags, which is recognizable by the Hyper Pen. Hardcopy of textbook thus published via the use of an authoring tool. Essentially, navigation on this type of textbook by Hyper Pen has the same effect as browsing a website. In the article titled “*Agent-Based Web Learning System (ABWLS)*”, Yueh-Min Huang, Juei-Nan Chen, Kun-Te Wang, & Chih-Hsiung Fu develop an ABWLS, a convenient e-learning environment, which includes using software agent to provide intelligent services, give the proper presentation by a device’s capability, and reuse from learning resources through Web services. Fuhua Lin in “*Developing Domain Model Web Services For Agent-supported Distributed Learning Using PROTÉGÉ 2000*” tells his experience on constructing domain model web services by PROTÉGÉ 2000 for distributed learning.

The final group of articles gives emphasis on field study by different approaches from different domains. Show-Jane Yen in “*An Efficient Approach for the Maintenance of Frequent Sequences in a Web-based Training Environment*” makes effort on developing an algorithm for updating the frequent traversal sequences and does experimental results to show its power of the algorithm she creates. In the article “*SCORM-Compliant Adaptive and Personalized Learning Content Design*”, Huey-ing Liu & Chi-Min Huang focus on the design of SCORM compatible adaptive and personalized learning content, denoted as SAPContent. Poppy Pickard, Ken Fisher, & Ray Jones in “*Learning Objects for Introductory Computer Programming*” describes LondonMet experience on sharing pedagogical ideas and experiences, as well as learning objects at the computer programming course.

The last two case-study are “*Degree of Scaffolding as Learning Object Metadata: A Prototype Learning System Design for Integrating GIS into a Civil Engineering Curriculum*” by John M. Sullivan, Richard H. Hall, Ronaldo Luna, Michael G. Hilgers, Aaron J. Taylor, & Matt R. Buechler and “*WWW-Based Courseware in Global Competition Advancement — the IE ADES Pilot Project*” by I-Shan Haung, Pei-Chann Chang, & Yun-Kung Chung. The former adopts progressive scaffolding as it relates to SCORM compliant learning objects, within the context of the design of an application for integrating Geographic Information Systems (GIS) into the civil engineering curriculum at the University of Missouri – Rolla. The latter focuses on the SCORM functions for designing multimedia learning materials. The article “*An Implementation of a LO Repository with Version Control*” by Aapo Mäkelä, Kirsti la-Mutka, & Jari Peltonen is developed a separated index for implementing the search. Thus, updating the repository takes a little more time while the index must be updated and synchronized with the content metadata. However, the version control solution results in the significant speedup of the queries, which are the most common activities for the users.

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Creating Reusable Content: A practitioner's observations

One critical aspect of instructional design is taking into account the differing information conveying characteristics of the media to be used. For example, knowing that video is not suitable for presenting large amounts of text, a designer might compensate by incorporating a separate text component or by using audio with on-screen bullet points. As a result of my long experience as an instructional designer, I am accustomed to identifying and compensating for the strengths and weaknesses of the media to be used in a specific project. Recently I was called upon to design and develop reusable content objects for an online course--*Introduction to ADL and the SCORM*. In the process of this work I encountered several characteristics specific to the design of reusable content objects and developed techniques for addressing these factors.

In this paper I will describe what I observed and briefly present the techniques I developed. The issues had their origins in questions such as these:

- Which, if any, of your related content objects has the learner seen?
- How might you bring learners up to speed on a topic without repeating information across many topics?
- How do you address such things as navigation and visual continuity when you cannot know how your materials will be presented in very different LMS environments?
- How do you create materials that can work together when they are together, yet stand alone in other contexts?

Here are some of the techniques I used.

Catch-up

Writers have developed many rhetorical devices for handling situations where a viewer or reader may or may not have seen earlier installments of a series. Characters and previous events must be subtly re-introduced early in each installment. For example, instead of explicitly noting that “Douglas was a nurse who hated his job” an author would be better served by weaving it into the dialog. Similarly, learning object designers should develop a repertoire of devices for bringing incoming learners up-to-speed without losing learners who “saw the last episode.”

Organizers

Designers have long used visual organizers to tie together various parts of their material. The challenge with reusable objects is to provide central organization where objects can't link to each-other. To address this I employed a graphic that recurs within related materials, showing not only the whole but also where the current topic fits in. (fig. 1, 2) This allows learners to see where they are within a set of related concepts whether or not they have access to the other topics. If they do view other related materials, strong visual cues are used to tie the graphics together in the learner's mind.

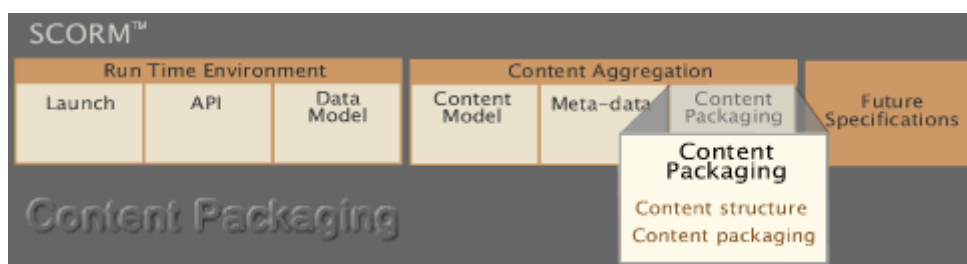


Figure 1. Organizer graphic shows relationship of current topic to whole.

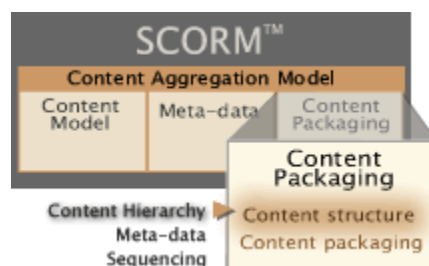


Figure 2. Detailed view visually tied to overview graphic

Separate content and assessments

Assessments are necessarily specific to a certain population or assessment need, whereas a good presentation of content might be appropriate across various populations and purposes, as long as an assessment is not directly incorporated into the topic. With the arrival of robust sequencing capabilities, it should be possible to reuse content while separately providing different assessments for different purposes. Anticipating this, I made the decision not to incorporate assessments directly into my topics.

Navigation confusion

Learning Management Systems necessarily feature their own navigation and menu structure. There is a high potential for learner confusion between these LMS features and any navigation within a reusable content object. (fig. 3a, b) My strategy for minimizing this confusion was to make my navigation somewhat unconventional and to give it strong visual ties to my material making it less likely to be mistaken for LMS navigation. Even so, confusion between two sets of next and back buttons is by far the most common feedback I receive, demonstrating that I am far from solving this issue. One possibility is to open content objects in another window, but for this project I was reluctant to forego having important LMS functions always available.

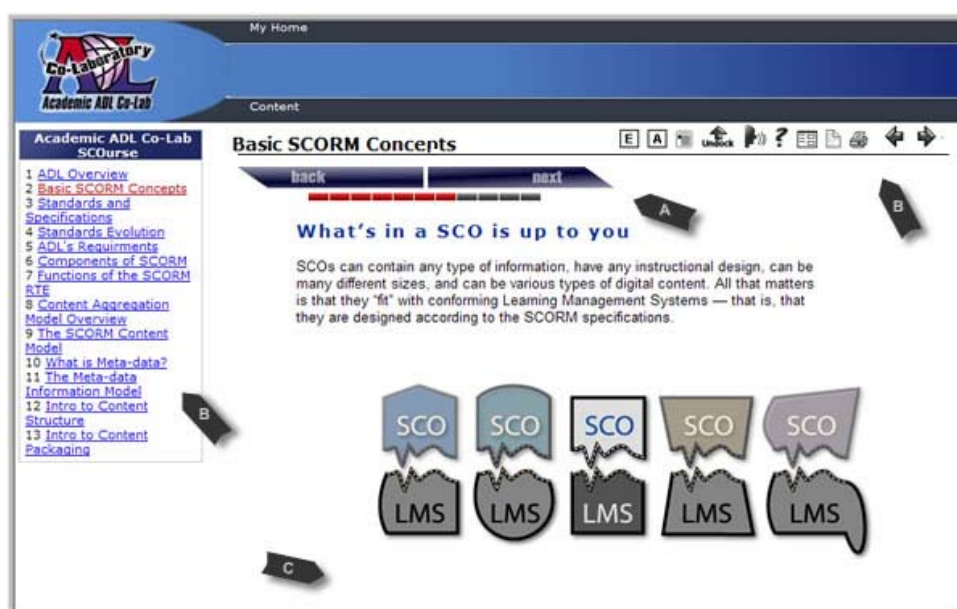


Figure 3. Content object in an LMS environment. (a) Content object navigation (b) LMS navigation and controls (c) No clear visual delineation below and to the right of embedded content.

Visual design

It is impossible to know much about future contexts for the reusable material you design. Will it open as part of a page containing global navigation and menus, as a figure in an online document, or in its own window without any navigation? Will the interface be highly graphical or very plain? Will learners see all of your topics in a logical order?

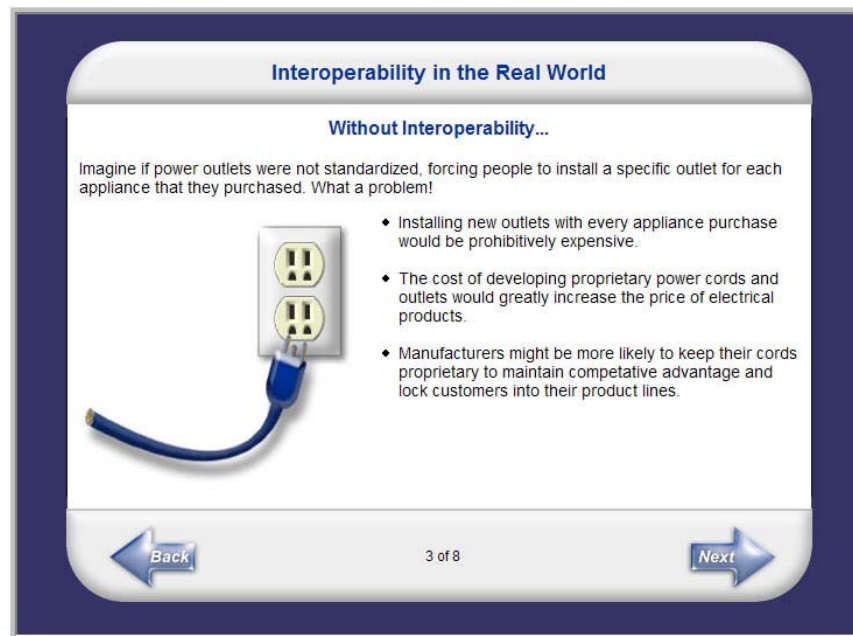


Figure 4. Content object in its own window, showing the design's strong visual "box."

I used several techniques to address these issues. Rather than putting the content in its own visual box, to eventually be placed within other unpredictable boxes when reused, I sought to create a “floating” design that could exist visually in many contexts. (fig. 3c, 4) I paid special attention to maintaining common design elements across topics so they would feel like they belonged together when viewed together, but could also stand alone.

Right-sized SCOs

Finding the optimal “granularity” of reusable content is a continual challenge. Cover too much and your content becomes less reusable, cover too little and it stops making sense. My (admittedly subjective) rule-of-thumb is that a content object should be “big” enough to make sense, but not so big it *only* makes sense in its original context. Keep in mind that as the size decreases (in theory making the content more reusable), both the design challenge and the importance of addressing it increases.

Every medium offers design challenges related to its information conveying characteristics. Because designing reusable content objects is relatively new, many of the techniques for effective design have yet to be discovered by those of us who are actively engaged in their design. Although technological solutions for some of these issues are in the offing, the instructional design community must still work to effectively address these challenges if the medium is to reach its full potential. It is my hope that by describing the issues I have encountered and the techniques I have devised in my development work, I will have contributed to the advancement of the art of designing reusable content.

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Considering Model-based Adaptivity for Learning Objects

Adaptivity for Learning Objects: Adaptive Hypermedia and Simple Sequencing

Adaptive Hypermedia (AH) and IMS Simple Sequencing (SS) are different approaches but both intend to attain a similar goal: tailored content for learning, just as Abdullah et al. discussed in [1]. However, these two distinct approaches have their own merits and defects. For SS, it takes the conformity with learning objects (LO) as the prime principle, and thus become the main approach to achieve dynamic presentation under the paradigm of using LOs to wrap up learning materials. But due to the absence of explicit domain and user models, SS cannot perform adaptivity in terms of learners' cognition, such as prior knowledge, learning styles, etc. On the other hand, AH systems focus on constructing explicit models that represent various aspects of information related to decision making, such as user's prior knowledge, preferences, learning domain, pedagogical knowledge, etc. Therefore, AH systems could perform elaborate decision making based on these models. However, issues like interoperability and reusability remain challenging to researchers in the AH field.

Here we discuss and present our observation on the issue of *model-based adaptivity* (i.e. *AH-oriented approach*) for learning objects. That is, we will consider how to bridge the gap between the AH and LO paradigms as described below.

Why Models?

Why should we consider domain and user models for the LO paradigm? We illustrate the need with two points: (1) to support in-depth adaptivity with respect to learners' cognition (2) to apply technologies developed for intelligent tutoring.

First, an evident cultural difference should be noticed. AH systems take *cognitive effect* as the main concern. For example, *adaptive navigation support* aims to share learners' cognitive load and prevent learners from disorientation. To handle cognitive issues, appropriate domain and user models are necessary. Dependency relations of domain concepts, users' proficiencies on topics and users' behavioral patterns are fundamental information to be modeled in general. On the other hand, a typical LO paradigm does not address these issues much¹. The presence of SS gradually changes the scenario. But SS still cannot perform adaptivity related to subtle cognitive effects due to the lack of corresponding models.

Second, model-based approach could benefit by various intelligent technologies. Some could be applied to LO paradigm seamlessly. A promising instance is to adopt course sequencing techniques to generate adaptive presentation in a systematic manner [4]. We will discuss this approach in the next section. Besides, it is also possible to apply machine learning techniques, e.g. theory refinement methods, Bayesian methods, etc. to automate the process of decision making [2]. Especially, when the scale of web-based learning is quite large, "hard-wired" sequencing rules employed by the SS approach might become inflexible and unmanageable. Instead of relying on the laborious process of authoring hand-coded sequencing rules, AI tools based on machine learning or data mining techniques would be hopeful to induce required knowledge as models.

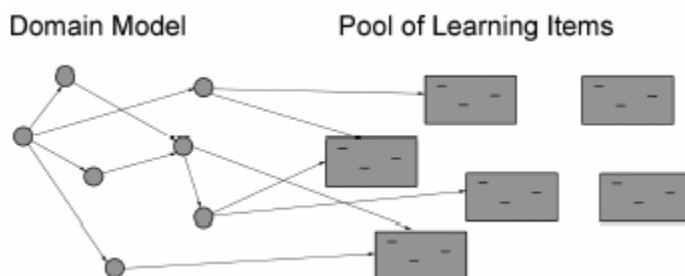


Figure 1. Bridging the gap between the domain model and learning items, adopted from [4].

¹ More precisely, SCORM focus on "ilities" not QoL (quality of learning) [7]

	Global domain model & LO (without SS)	Global domain model & SS
Methods employed	<i>Domain model superposed</i>	<i>Domain model superposed</i>
Primitive learning item	<i>LO</i>	<i>Activity Tree</i>
Sensitivity	<i>High</i>	<i>Low</i>
Complexity of implementation	<i>Simple</i>	<i>Complex</i>

Table 1. The comparison of two kinds of integration.

Technical Issues

Though the areas of AH and LO are developed in parallel most of time, LO paradigm is not totally incompatible with AH systems. To achieve the integration, we notice two different situations: *LOs with or without SS*.

If we purely consider LOs without SS, the integration is easier. It is possible to package learning items up as LOs in an AH system. Brusilovsky et al. illustrated the separation of domain model and learning items in Figure 1 [4]. Nodes of the domain model represent abstract pieces of domain knowledge, i.e. concepts, or topics. Materials to be taught and learned reside in the pool of learning items. By using this scheme, learning items could be wrapped as LOs without doubt. This approach will not change the characteristics that an LO should have, such as reusability and interoperability. In other words, we can still exchange and reuse individual LOs.

A much more complex situation is to consider LOs associated with SS. This type of integration of AH and SS is a relatively new direction. In [5], Chen et al. propose a global domain model to organize a group of activity trees. By analyzing prerequisites and contributed capabilities of each activity tree, the system intends to import more cognitive and pedagogical concerns into the SS approach. We observe that this approach could also be reduced to the scheme illustrated in Figure 1 conceptually, in which each “learning item” in the pool refers to an activity tree instead of an LO. However, constructing a global domain model to organize a crowd of activity trees may fall short in practice. Though there is no strict definition of what should be an “activity” of the activity tree, but the *granularity* of an activity tree is likely to be large enough as a complete course in general. Under this scenario, the power of superposing a global model on-top of activity trees seems relatively weak, because learners may not receive needed adaptation at the best time. The system could detect and give adaptation *only* after the learner finish a learning session—a whole activity tree. Before that, static sequencing rules determine every thing. In other words, the *sensitivity* of adaptation is related to the size of chunks (i.e. the granularity of activity trees).

The comparison of these two kinds of integration is summarized in Table 1. No matter which situation is considered, once the linkage between the domain model and learning items is established, we could use overlay modeling technique to represent learners’ prior knowledge as a subset of the domain model. Furthermore, various techniques could be used to generate adaptive presentations adapted to learners’ prior knowledge and goal.

Reusability of Models

It is obvious that without a suitable standard, or if standardization is not feasible, we cannot exchange domain or user models properly. For domain-independent information about learner traits, the standard is available, such as [6]. But in current AH systems, some modeled relations and features highly depend on the application context or the learning domain. So it is inherently difficult to exchange every aspects of information. Nevertheless, reusing such domain-dependant information still could be made possible via other means if we can properly define relations between different domains, e.g. the method of distributed user modeling [3].

Conclusions

LO and AH address issues on computer-based learning from different aspects respectively. The LO paradigm successfully sets up a standard to exchange learning materials, and lower the cost of developing courseware, while AH develops substantial techniques to enhance learning.

The integration of these two areas would be quite beneficial for disseminating effective learning experiences. Since LO paradigm is very young, the exploration of the integration of AH and LO paradigm is still at the beginning. To bridge the gap, more efforts from both technical and educational aspects are required further.

Acknowledgement

The first author would like to thank Prof. Jin-Tan Yang at National Kaohsiung Normal University for offering discussion and interaction on learning objects issues.

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Developing learning objects: more than just labelling

Introduction

The primary purpose that the UNAM is seeking, is to increase access to the quantity and quality of learning content, and to avoid wasteful replications of effort by making that content usable in a variety of contexts. At the moment the main strategies are among the development and use of learning objects. Thus we decided to work on building an online learning object public repository.

In order to give answer to the purpose, we decided to work on standards and with opened technologies, we considered that the common standards for things such as content meta-data, content packaging, content sequencing, interoperability, etc., are requisites for the success for the future of learning. Then, how are we going to integrate the standards into our plans for the future as well as into our current projects?

Therefore, the first step we took was to create a first prototype that allowed identifying consistent methodologies, architectures and specifications with the raised necessities.

Our goals

The Educational Services Coordination at UNAM has been helping teachers and schools developing digital educational materials for over four years. Along these years we have been gathering these resources in order to promote them and enhance their production among other schools. We also have had the opportunity to see many groups having similar needs and developing similar materials. On the other side, we also have had the opportunity to work with other educational and research institutions that either have useful materials that we do not have or, are going through the same situation we are. Considering all these arguments is that we decided to work on building an online learning object public repository and to invite other institutions interested on participating.

Desiderable aspects for materials

Content must be:

- produced, in order to create content repositories
- benefit from existing content
- easily adaptable for specific needs
- able to be reused

but technically speaking, it must also be :

- interoperable
- re-usable
- manageable
- accessible
- durable

Thus, we thought about learning resources, considering both, Wiley's (2002) and L'Allier's (1997) definitions for learning objects, focusing on designing materials that could:

- support learning and teaching processes
- promote web knowledge
- promote knowledge construction and distribution
- impact on curricular and instructional designing
- promote technological management
- be easily stored, classified and found
- benefit from existing materials and
- be transfered among different platforms

Implying that their structure must be based on labels and standards.

Methodology

Considering the people we want to attend; we decided to design a public online repository with the following characteristics:

- Different levels of content.
- Tools for developing, indexing and searching content at different levels.
- Building and sharing online repositories.

In order to achieve these goals, we adopted several strategies.

Goals	Strategies
Different levels of content.	<ul style="list-style-type: none">◆ Comprehend the learning object definition.◆ Identify and classify existing resources.◆ Enhance incorporation and production of learning objects.◆ Select the metadata to be incorporated on learning objects.
Tools for developing, indexing and searching content at different levels.	<ul style="list-style-type: none">◆ Design the tools' technological architecture.◆ Analyze and select technologies to be used by the tools developed.◆ Develop authoring and searching tools in order to develop and reuse objects.
Building and sharing online repositories.	<ul style="list-style-type: none">◆ Design the repository's technological architecture.◆ Develop general prototypes.

Results

Until now, we have worked on the first two goals and the first six strategies.

◆ Different levels

- Comprehend the learning object definition.

Digital resources that are used and needed by teachers and students have a broad range of complexity; from the basic level where we can find raw data, to a whole online course; where there are specific objectives to be met and inserted in a specific context. This way we considered to adopt Autodesk's model for knowledge structure, shown on the following figure:

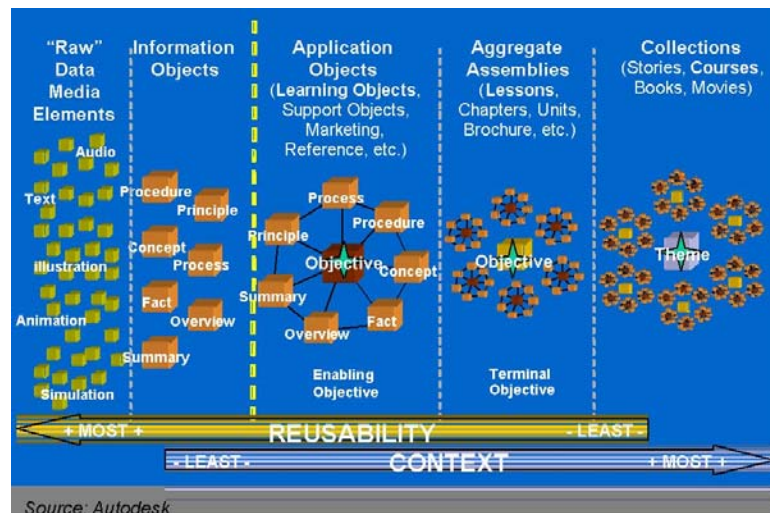


Figure 1

As a reinforcement for the use of the model, we also constructed several examples; all of them reusing existing materials.

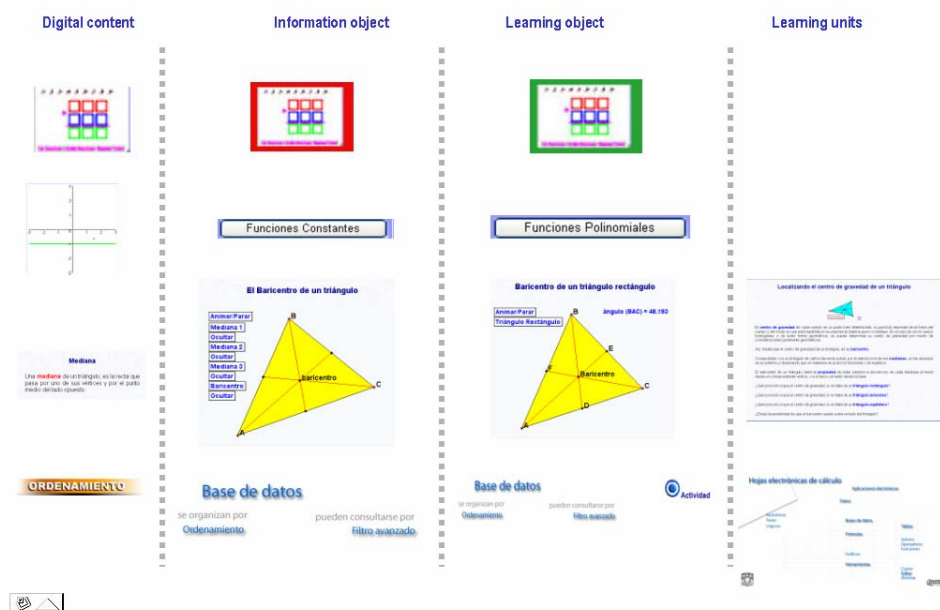


Figure 2

- Enhance incorporation and production of learning objects.

Another strategy to involve teachers in developing learning objects is through training. We have designed an online (and face-to-face) course which in addition to introduce the concept; it also introduces in the exercise of labeling digital content. The url where this course is hosted is

<http://hydra.dgsca.unam.mx/walc>

- Select metadata to be incorporated on learning objects.

Even though there are 9 categories that classify metadata yet we do not completely agree on all of the elements to be considered moreover, if we think about the levels mentioned above, not all elements apply to all levels. That is why we decided, for a first version, to select several metadata from all that are proposed.

- ◆ Tools for developing, indexing and searching content at different levels.
 - Design the tool's technological architecture

For this phase we considered the following: object-oriented code (JAVA), XML for the metadata, and a complete web services front-end API (Application Programming Interface, based on SOAP-compliant interface).

The hardware and software installed are UNIX and LINUX server platform; Apache v.2.0 Web servers; Jakarta Tomcat v. 4 o 5 Application server; Jars libraries and connector MOD_JK v.2; PostgreSQL, v. 7.2 Database servers and Java v.2.0.

- Authoring and labeling tools

In order to have a dynamic repository, growing and enriched by all users; we “reused” part of our own strategy for content building, which it is based on templates but, because the authoring tool must also consider the different levels mentioned above, we had to adapt it and develop different templates for the different levels.

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Defining a Simple Sequence for RLOs

Introduction

The idea of reusable learning objects (RLOs) originated as an element within a new type of computer-based instruction grounded in the object-oriented paradigm of computer science. Object-orientation highly values the creation of components (called “objects”) that can be reused (Dahl and Nygaard, 1966). As early as the mid 90’s, it was recognized that Web based learning systems lacked the support of a common framework. One of the efforts to solve this problem was initiated by Cisco Systems (Barritt and Lewis, 2000). Cisco proposed the so called Reusable Information Strategy to move from creating and delivering large inflexible training courses, to database driven objects that could be reused, searched, and modified independently from their delivery media. Additionally, the Department of Defense along with some other Federal and private sector organizations initiated efforts to develop common specifications and standards for technology-based learning. These efforts led to the development of a suite of technical standards referred to as Sharable Content Object Reference Model (SCORM). The value of SCORM is that it incorporates many of emerging standards and/or specifications into one common reference model.

While these initiatives tried to develop the range of technology standards necessary to support reusable learning object based systems, there was little discussion around theories of pedagogy or Instructional Design concerns as they applied to RLOs. One problem that emerged was that there was no specification in the standards on how to sequence these RLOs in ways that would enable a learner to attain a particular learning goal.

According to the definition given by Barritt and Lewis (2000), a RLO is based on a single objective, derived from a specific job task known as a Reusable Information Object (RIO). Each RIO is built upon an objective that supports the RLO’s objective. Therefore, the RLO-RIO structure is a two hierarchy. In reality, a RLO is not the higher layer. It can be grouped into a larger hierarchy depending on the author, business requirements and packaging of the "offering" on the learning management system. A possible hierarchy is listed as below:

- Curriculum
 - Unit
 - Module
 - Lesson (RLO)
 - Topic/Page (RIO)

When lessons are selected for grouping into a module, they have to be grouped in a way that makes instructional sense, or in instructional design terminology, should be “sequenced” based upon the needs and prior knowledge the learner brings into the learning environment. Appropriately sequenced RLOs enable an instructional designer to develop a personalized learning experience, which is one of the ultimate objectives of developing RLOs.

In this research, a layered sequencing model implemented in XML is proposed to deal with the problem.

A Layered Sequencing Model and Its Implementation

In a layered sequencing model, the first level is created by giving RLOs a priority number while the second layer is created by giving the RLOs a sequencing strategy or strategies. The first level is created when the instructor selects several lessons (RLOs) for grouping into a module and then gives each RLO a priority number. The priority numbers follow a numerical order. Therefore, a smaller priority number, such as a one or two, indicates that those RLOs should be sequenced in front of an RLO with larger priority numbers, such as a twelve or a thirteen. If there is no sequence requirement in some RLOs, these RLOs will share the same priority numbers. With this layer of specified sequencing, instructors can define some intrinsic relationship among RLOs.

The second level of sequencing is specified when instructors have completed selecting RLOs, and are ready to deliver the assembled modules, or lessons. At this level, an instructor can implement various instructional strategies discussed in the SCORM photoshop sequencing examples (ADL, 2000) such as No Sequencing rules;

Linear; Linear Choice; Knowledge Paced; Remediation. Competency Assessment can be implemented over RLOs with the same priority numbers. The layered sequencing model is illustrated in Figure 1.

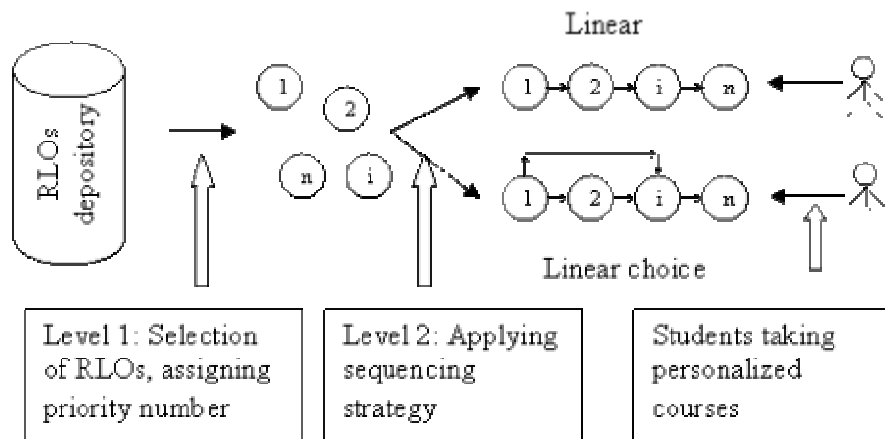


Figure 1. The Layered Sequencing Model

This process of setting two levels of specified sequencing gives instructors the flexibility to define the exact sequence they prefer in a module or a course in order to meet stated learning objectives and at the same time enables instructors to ensure that the course or module meets an individual student's personalized learning style through applying different sequencing strategies. Another advantage this model provides is a platform to discover an optimal learning style for a group of students.

The implementation of the layered sequencing model can be achieved by defining an XML file. The file is not part of any RLOs; it is associated with a module, or a course, when sequencing becomes meaningful.

An example of implementing a layered sequencing model using XML is shown in

Figure 2. According to the example, the linear sequencing strategy is applied only to lessons 4, 5, and 6. The possible sequence for students to follow could be: 1 2 3, 4, 5, 6, or 1, 2, 3, 4, 6, 5 etc.

```
<item identifier="MODULE1">
  <title>Module 1 -- Basics</title>
  <item identifier="LESSON1" priority="1">
    <title>Lesson 1 -- Introduction</title>
  </item>
  <item identifier="LESSON2" priority="2">
    <title>Lesson 2 -- How to start a word</title>
  </item>
  <item identifier="LESSON3" priority="3">
    <title>Lesson 3 -- How to open a word documentation</title>
  </item>
  <item identifier="LESSON4" priority="5">
    <title>Lesson 4 -- How to how to insert a table</title>
  </item>
  <item identifier="LESSON5" priority="5">
    <title>Lesson 5 -- How to insert a picture</title>
  </item>
  <item identifier="LESSON6" priority="5">
    <title>Lesson 6 -- How to close a documentation</title>
  </item>
  <sequencing>
    <strategy value="LINEAR"/>
  </sequencing>
</item>
```

Figure 2. Linear Sequencing specification for Module 1

Discussion and Conclusion

In this research, the importance of applying instructional theories towards reusable learning objects, especially the issue of achieving the most effective sequence for students is explored. A layered sequencing model is proposed. The sequencing model allows a description of the inherent relationships among reusable learning objects, while not compromising its capability to deliver the objects in designated sequencing strategies. The model also has the potential to provide a platform for discovering the optimal learning style for a group of students. The effectiveness of this model is being implemented and tested in the MIS 105 Introduction to Computers course offered by MIS Department at Northern State University, in South Dakota.

Acknowledge: This research has been developed under Bush Grant, Northern State University.

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The Collaboration of Learning Objects in a Grid Environment

Introduction

There are two problems existed in the e-Learning objects given as follows:

1. The interoperability among the different e-Learning systems. Though there are several XML-based standards like IMS [1], SCORM [3], ULF [5], etc., to define and describe for the e-Learning materials to be learning objects (LOs), so that the different LOs can be exchanged and reused among the different e-Learning platforms. But the communication and interaction is still lack among the LOs.
2. The relationship among LOs cannot be bound, so that service-level agreements are short to control for the collaboration of the working flow.

To solve the problem for collaboration of LOs, a workflow framework by employing Grid Services Flow Language (GSFL) in a grid environment is proposed in this paper. GSFL is proposed by Krishnan et al. [2] to solve the description of workflow of different dynamic grid services. It is XML based and solving the problems of peer-to-peer interaction among grid services and lifecycle management of grid services. The main idea of our method uses the notification ability in the GSFL to reach the interaction among the LOs.

The Workflow Framework of LOs Composition

Globus Toolkit 3 [4] is used to build up the environment for grid services which connected several computers, packed the LOs distributed among different learning platforms with different operating system into service types, and then mapping these LOs to be the standard grid services. The workflow framework of LOs composition in a learning grid is shown in Figure 1. The LO services supported by different content creators can not only be physically located at different location, but also hosting in heterogeneous platforms. Each node contains the LO services represents a virtual organization which can own platform architecture, operating system, software, hardware, and organization policy itself. The different LO services can collaborate by employing GSFL. The grid engine makes each LO service can register here, so that the service requester can bind services. LO services in the learning grid can be dynamically generated, searched, destroyed, and bound. The host of each node in the learning grid also can be the service registry to search the services. All of the client users can connect to the grid engine of a learning grid to access the collaborative services by the generated GSFL document.

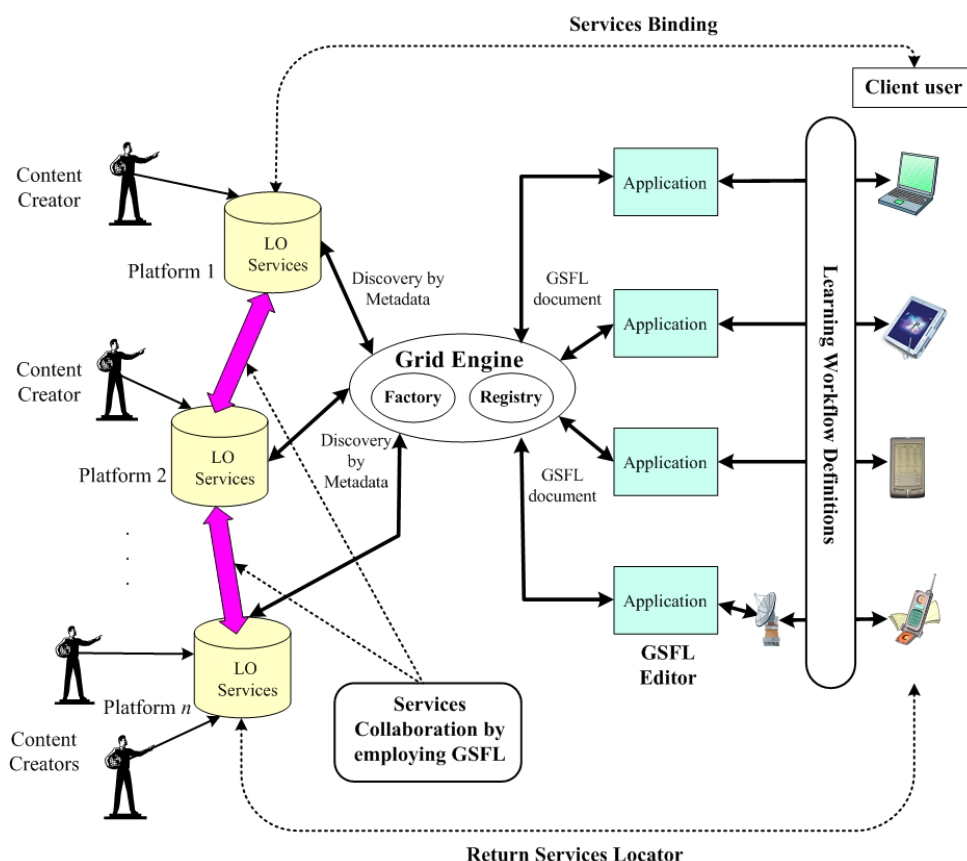


Figure 1. The workflow framework of LOs composition in a learning grid.

The Collaboration of Learning Objects

GSFL is based on XML, the whole document is packaged by several tags which consist of definition tag, imports, service providers, activity model, composition model, and lifecycle model to describe the workflow. In the following, an example is given to describe the workflow among the LOs composition by employing GSFL in details. Four LOs services, one word everyday, one sentence everyday, life English, and assessment, are used to integrate as a collective dictionary service, so that the learner can not only learn a word, but also learn the relevant sentences, life phraseology, and several assessment questions at the same time. In this example, four LOs services, OneWordEveryday, OneSentenceEveryday, LifeEnglish, and Assessment are composed as a target collaborative service by the GSFL definitions, so that the data of word meaning, sample sentence, life phraseology and assessment questions can be got in precedence. The final results are sent to learner by the definition of data flow. This example is showed in Figure 2.

The workflow startup when a program receiving the request. There are four different LOs services building up from heterogeneous platforms in this example. It is corresponding to the first service entered to call out coming from the port (Exported Port) that is released, namely OneWordEveryday service. The input data is one word, sending the meaning of this word to the OneSentenceEveryday service through OutputDataA, receiving by InputDataB. Then OutputDataB of the OneSentenceEveryday service gets the example sentence of that word sending to the LifeEnglish service, receiving by InputDataC. At the same time, the contents sent by data flow are the summary of first and second services which contain word meaning and example sentence. After that, OutputDataC of the LifeEnglish service gets the materials of life terms combining two materials mentioned in advance send to Assessment service, and receive under the care of InputDataD. Finally, because the assessment service is the last procedure of the workflow, so that InputDataD is responsible for obtaining the relevant assessment questions of the word adding to the end of the data flow and pass back to callers directly.

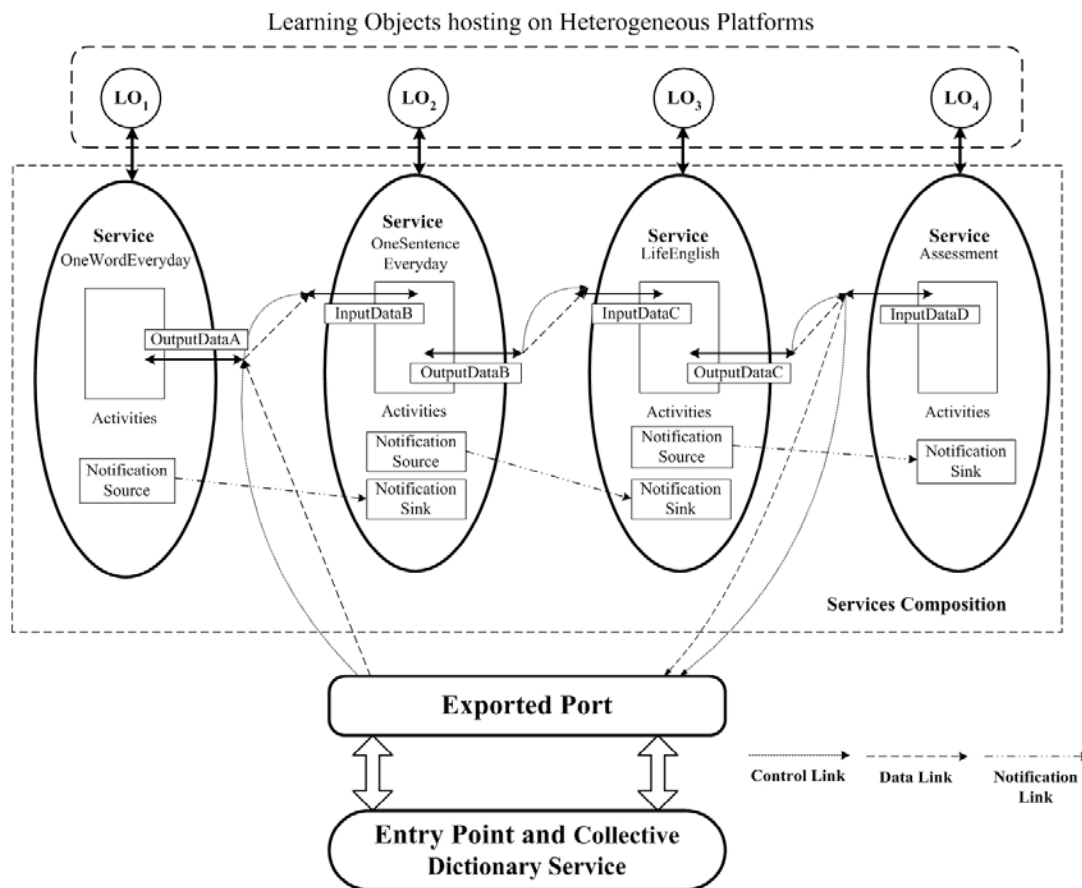


Figure 2. The workflow among four pervasive learning objects composition

A sample is given to describe how to employ GSFL in defining workflow of LOs composition in this example, part listing of the document is illustrated in Figure 3. We can see that serviceProvider defines four different services which are OneWordEveryday, OneSentenceEveryday, LifeEnglish, and Assessment. Then the activityModel is used to defined six relevant operations. After that, the compositionModel defines ExportModel and NotificationModel where ExportModel defines control flow and data flow, and NotificationModel defines mass data transformation type among grid services. Finally, the lifecycleModel defines the precedence of grid services generation.


```

- <definitions name="GSFLforLO" scope="session" targetNamespace="http://grid.mis.cycu.edu.tw/gsfl">
  <!-- List of Service Providers -->
  + <serviceProvider name="OneWordEveryday" type="OneWordEverydayServiceType">
  + <serviceProvider name="OneSentenceEveryday" type="OneSentenceEverydayServiceType">
  + <serviceProvider name="LifeEnglish" type="LifeEnglishServiceType">
  + <serviceProvider name="Assessment" type="AssessmentType">
  <!-- List of activities -->
  - <activityModel>
  + <activity name="OutputDataA">
  + <activity name="InputDataB">
  + <activity name="OutputDataB">
  + <activity name="InputDataC">
  + <activity name="OutputDataC">
  + <activity name="InputDataD">
  </activityModel>
  <!-- The composition model -->
  - <compositionModel>
  - <exportModel>
  - <exportedActivity>
    <exportedActivityInfo name="FlowOfABC" portType="exportPortType" />
    - <controlModel controlIn="OutputDataA">
      <controlLink label="link0" source="OutputDataA" target="InputDataB" />
      <controlLink label="link1" source="OutputDataB" target="InputDataC" />
      <controlLink label="link2" source="OutputDataC" target="InputDataD" />
    </controlModel>
    - <dataModel dataInTo="OutputDataA" dataOutFrom="InputDataD">
      <dataLink label="link0" source="OutputDataA" sink="InputDataB" />
      <dataLink label="link1" source="OutputDataB" sink="InputDataC" />
      <dataLink label="link1" source="OutputDataC" sink="InputDataD" />
    </dataModel>
  </exportedActivity>
  </exportModel>
  - <notificationModel>
    <notificationLink label="link0" source="OneWordEveryday" sink="OneSentenceEveryday" topic="AtoB" />
    <notificationLink label="link1" source="OneSentenceEveryday" sink="LifeEnglish" topic="BtoC" />
    <notificationLink label="link1" source="LifeEnglish" sink="Assessment" topic="CtoD" />
  </notificationModel>
  </compositionModel>
  <!-- Lifecycle for the services -->
  + <lifecycleModel>
</definitions>

```

Figure 3. A sample of the GSFL document.

Conclusions

The collaboration of LOs in a grid environment is proposed in this paper. GSFL is employing to describe the workflow for the composition of learning objects distributed in heterogeneous environment. The collaboration method not only solve the difficulties of sharing learning resources distributed on different e-Learning platforms, but also makes the LOs collaborative and reusable effectively. Different LOs services can interact themselves, and the lifecycle of services can be managed well.

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- [4] The Globus Alliance, <http://www.globus.org/>
- [5] ULF, <http://www.saba.com>

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The potential for learning objects to support flexible learning in higher education

1. Introduction

In the past, the ability to provide quality education was associated with teachers engaging in high degrees of social and personal interaction with learners (Oliver, 2002). In fact, debate continues over the amount students really learn through online instruction as compared to the amount they learn in traditional teacher-led classrooms. Some comparative studies conclude by positively favoring eLearning, while some still regard conventional classrooms as the more effective of the two learning environments. Other studies reveal there is little or no significant difference in the amount students learn regardless of which mode of learning is undertaken (Russell, 1999). However, eLearning is generally reputed to be less expensive to conduct than classroom-based teaching and learning practices. This economic advantage, combined with its ability to offer a vast amount of digital educational content for learners to access whenever they wish, makes the prospect of adopting an eLearning initiative now very attractive (Strother, 2002).

Yet despite its hype and promoted benefits, the large and complex eLearning field has experienced considerable problems. These have included high development costs, not always having the desired cost-saving ability and poor usability levels in implemented systems. The issue of poor usability levels suggests some eLearning developments have focused too heavily on making use of the latest technologies and have not been designed with end-users, i.e. the learners, in mind. There is also the issue of ensuring ICT is used in ways that actually improve the learning process. Such problems have contributed to many eLearning tools not meeting the expectations set for them.

2. The need for 'lifelong learning' in higher education

The changing needs for higher education in society have widened the demography of student populations. Growing numbers of vocations and workplaces are insisting their workers possess sound problem solving skills and are able to think critically (van Dam, 2002). This has led to an ever-increasing number of mature-age people returning to academic studies. Traditional forms of teaching and learning, where courses and classes are lecturer-driven, targeted at young adult students and designed to run for specific periods of time, are often no longer appropriate or convenient for such learners to undertake. Furthermore, many of these students are less likely to spend time on campus or see academic study as the primary priority in their life.

Subsequently, many tertiary institutes are now considering adopting eLearning systems as a means of conducting more efficient, learner-centric and flexibly paced education services - thereby promoting 'lifelong learning' for students of all ages (Trondsen, 1998). This would not only better accommodate demographically diverse student groups, but also offer higher education to students who are motivated to learn but are geographically remote or simply in preference to learning independently from direct human interaction.

3. Instructor-based and learner-based learning paradigms

Opinions regarding the degree to which online learning technologies have influenced teaching and learning practices in higher education often vary. Eilif Trondsen (1998) claimed there had been a significant transition towards using more (technologically driven) learner-centric paradigms instead of traditional instructor-lead teaching practices. Distinguishing between the instructor-based and learner-based paradigms is inevitably a matter of perspective. It is apparent that the move is to think of teaching from a learner's perspective. When discussing learner-centric models, it is important to acknowledge the continued involvement and contribution of the teacher. They remain important due to their ability to, for example, provide expert consultation when required and direct learners to (on- and offline) resources of interest. Furthermore, the choice to shift to using a more learner-based teaching paradigm is still governed by the respective instructor(s). This leads to the (more accurately worded) notion of *learner-centric teaching*.

The use of ICT undoubtedly lends itself well to learner-centric teaching. Students can be more directly responsible for their own learning by using it to access and inquire about a variety of information sources, forms and types as needed. Teachers can shift from their conventional instructor role to a more mentor-like

involvement in the student's learning environment (Oliver, 2002). Yet it is important to regard eLearning simply as a tool. To be most effective, it must be used in the right way and for the right purpose.

ICT advancement has seen wireless communication emerge to spawn the term *mobile learning* (mLearning), as well as facilitating the development of learning games and exploratory simulations that are very 'media rich'. However, such technologies should not be expected to fully replace the inter-personal skills of teachers that are needed to successfully dialogue with their students. Online learning tools, such as the learning management system (LMS) WebCT, should be continued to be used for supplementing and value-adding existing teaching materials – rather than totally superseding them.

Attempts to harness the benefits of advancing technology, as well as the push to discover more cost-effective ways to create and deliver (reusable) learning material, have resulted in the emergence of **learning objects**. To illustrate the significance and relevancy of learning object-based technology for eLearning in higher education, the remainder of this paper is devoted to discussing the learning object paradigm in more detail.

4. The concept of learning objects

In its most basic form, the underlying rationale of learning objects relates to firstly breaking educational material down into modular 'chunks' (objects), where each object can then have its defining properties described (or tagged) using metadata constructs. Once an object has been properly tagged, it can be effectively searched for, identified and retrieved when required. Then it is most common for independent objects to be combined with other objects or assembled into sequences (learning paths) to support more customized, and hopefully more rewarding, online learning experiences.

Although learning objects have no single, universally accepted definition, the most frequently referenced definition for them is the Institute of Electrical and Electronics Engineers' (IEEE) definition. In 2002, the IEEE's Learning Technology Standards Committee's (LTSC) defined a learning object as 'any entity, digital or non-digital, that may be used for learning, education or training'. When considering this definition, it is of paramount importance to note the wording '*any entity*'. This is because it implies any form of teaching and learning material, regardless of whether it is digitized in electronic form or not, can comply with this extremely broad definition and still be regarded as a learning object.

It is the notion of reusability, and being reusable across different educational contexts, which is causing the heavy focus on learning objects at present (South & Monson, 2000). More specifically, the benefits of achieving learning object-reusability relate to the (time and financial) savings that come from only needing to develop educational content once in learning object form (Duval et al., 2003). In theory, objects could then be shared and distributed over wide computer networks (with minimal alterations) as required by students and learners.

Yet there is still considerable debate over the reusability properties of learning objects (Mortimer, 2002). At the most primitive level, the theoretical concept of implementing learning objects is fairly elementary - as static objects can simply be shared between applications. But this does not comply with what most existing systems implementing learning object approaches are reputed to do, which is actually recontextualize the content according to individual learner's needs. Indeed, the establishment of architectures necessary for performing the desired individualization of learning content has not been a trivial task (Wiley, 2001). A fundamental reason for this is because most existing learning content cannot be scaled and reused in multiple contexts. It is typically static in nature, having been developed for a single, specific teaching purpose (Hannafin et al., 2000). As a result, much of today's digitized learning content has just been repurposed for online delivery without capitalizing on the opportunities afforded by modern ICT (van Dam, 2002).

It is evident that adhering to learning object-based approaches for developing online learning content is now widely perceived to create more efficient and effective eLearning systems. However, it is also obvious that significant opportunity exists for more research and development into the learning object paradigm to facilitate it reaching its full potential. The remaining discussion in this section highlights some of the main issues currently associated with learning objects that require further research and development.

4.1. Instructional design issues for learning objects

In the past, eLearning systems that adopted the learning object approach for delivering educational content have typically presented materials to students in straight-forward, predefined and inflexible sequences (Bannan-Ritland et al., 2000). As a result, such systems were limited in their ability to deliver adaptive learning

experiences to individual learners. Subsequently, there is now interest in thinking beyond the traditional forms of systems design and considering instructional design issues specifically for learning objects.

Proper instructional designing could facilitate identifying and using what is actually 'in' a learning object more effectively, thereby maximizing the object's intrinsic value. Yet the establishment of an instructional standard that could be universally adhered to by learning object developers is proving very difficult (Barron, 2002).

4.2. The importance of metadata

Another critical component of learning object development is to have each object effectively describe its own semantics and defining characteristics. Regardless of how it is understood or interpreted by those that create and describe information resources, the most basic concept of *metadata* invariably relates to 'recording data about data'.

Once a learning object is tagged using metadata descriptors, it is deemed possible to then adopt a competency-based eLearning approach. This is because such approaches involve presenting each system user with particular learning objects, which (based on the object's tag attributes) aim to address the learner's identified competency gaps (Longmire, 2000).

The move from delivering content-centric curricula to providing CBL is associated with the move from instructor-centric to more learner-centric teaching practices (see section 3) (Oliver, 2002). Instead of following traditional course-like training, CBL is designed to address either knowledge or performance gaps identified in individual learners (Tuso & Longmire, 2000). This coincides with one of the eLearning field's major promises: delivering content that is targeted specifically at student's needs in an attempt to maximize the effectiveness of the learning experience they receive online.

However, like the work directed towards establishing a common instructional design standard for learning objects (see section 4.1), a great deal of complexity has been encountered when attempts have been made to develop a universal metadata schema for cataloging learning objects. At the time of writing this paper, no singular accepted metadata standard exists for consistently tagging the properties of learning objects.

4.3. The need for standardized protocols

Efforts have been made towards developing standards and specifications for eLearning-based technologies (atleast) since the late 1990's (Friesen, 2003). Yet despite the endeavors of many collaborative efforts to define common learning object standards, such as the Instructional Management System (IMS) Global Learning Consortium and the IEEE, there is no universally accepted protocol for ensuring their interoperability and reusability at present.

Nilsen and Trondsen (1999) acknowledge that the development of any effective interoperable technical standards as an extremely challenging task, as multiple components of the eLearning industry must be addressed. A selection of the areas they have identified as requiring consideration are:

- Technically-oriented standards for ensuring platform independence;
- A categorization system for classifying content into meaningful and easily accessible forms;
- A categorization system for pedagogical approaches - meaning instructional content will need to include an indication of its complexity and sophistication;
- Standards for testing learner's comprehension of instructional content and
- Systems for tracking the actual users of instructional content.

5. Conclusion

There is no doubt that eLearning and ICT have become integral parts of higher education. When it is perceived and adopted as a tool for establishing effective teaching and learning, eLearning can facilitate the widening demographics of student populations, accommodate the growing need to conduct distance education and streamline many existing teaching practices.

The modular representation of educational material in learning object form does have genuine potential for supporting flexible modes of learning where students are more responsible for their own learning. Yet despite their reputed benefit of more personalized learning experiences, a 'reality gap' (Edmonds & Barron, 2002) is evident between the promise of learning object technology and the reality of their role in most existing eLearning implementations. While they remain significant, it is important not to over-hype the current learning object technologies or their impact and influence on online teaching and learning.

Systematic investigation into this paradigm has revealed many lingering uncertainties relating to the creation, use, flexibility and scalability of learning objects that still need investigation, clarification and development. For instance, there is presently call to develop the following for learning objects:

- A consistent instructional design - to facilitate their interoperability and ability to be effectively sequenced in learning paths;
- An ('open', easily obtainable and usable) metadata standard - for consistently describing learning object characteristics and
- A technical standard - to ensure their platform independence and interoperability between learning environments.

Until further developments in the areas identified in this paper succeed, eLearning and, more specifically, learning objects will remain concepts of great promise and some benefit, but largely as yet unfulfilled potential for enhancing higher education student's online learning experiences.

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A Novel Approach of Learning Object Extraction and Management to Support Multiple Standards

Introduction

In recent years, several standards, such as SCORM [7-8], IEEE LOM [3-4] and IMS [5-6], were proposed for describing the structures and contents of teaching materials. As shown in Figure1, subject materials of a course are regarded as a package consisting of a collection of learning units and a manifest. Each learning unit contains one or more learning objects, and the information of the learning objects are described in the manifest.

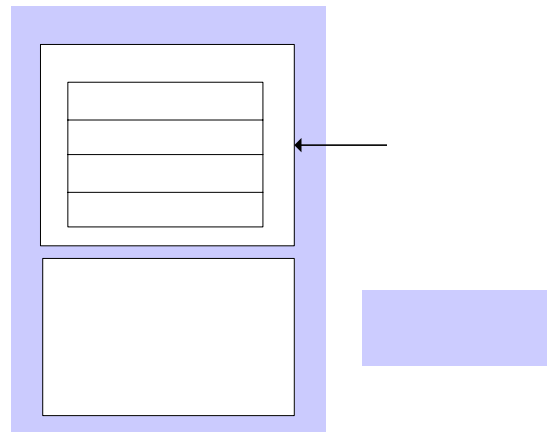


Figure 1. IMS Content Packaging scope

Components of a teaching material are recognized by the specified *vocabularies*, called metadata set. For example, part of the metadata set of Dublin Core [1-2] are given as follows:

- *Title*: a name given to the resource.
- *Creator*: an entity primarily responsible for making the content of the resource.
- *Subject*: a topic of the content of the resource.
- *Description*: an account of the content of the resource.
- *Publisher*: an entity responsible for making the resource available.
- *Contributor*: an entity responsible for making contributions to the content of the resource.
- *Date*: a date of an event in the lifecycle of the resource.

As different vocabularies are used by different standards to describe the same notation, it is difficult to share and reuse those teaching materials. To cope with this problem, a unified platform to support multiple standards is proposed in the following section.

Unified Web-based Learning Platform

Most teaching material standards are based on XML (eXtensible Markup Language), an expression language for web documents. XML was proposed by W3C (World Wide Web Consortium) in 1998, and has become the most popular description language for web documents.

To develop the Unified Web-based Learning Platform, the metadata sets of multiple standards are collected to form a unified metadata set, and the original metadata sets are treated as subsets of the unified metadata set. After specifying the relationships for vocabulary translations, original descriptions of teaching materials are translated to a unified standard described by XSL (Extensible Stylesheet Language), which is a language for formatting objects and transforming XML documents. XSL includes XML vocabularies for format descriptions, and specifies the styling of an XML document by using XSLT (XSL Transformations), which is designed for use as part of XSL, to describe how the document is transformed into another XML document that uses the formatting vocabulary.

The vocabularies of multiple standards are kept in the Metadata Set documents. If a metadata set is updated, we only need to modify the corresponding Metadata Set document. That is, new standards can be easily added to the unified platform by simply modifying the metadata sets.

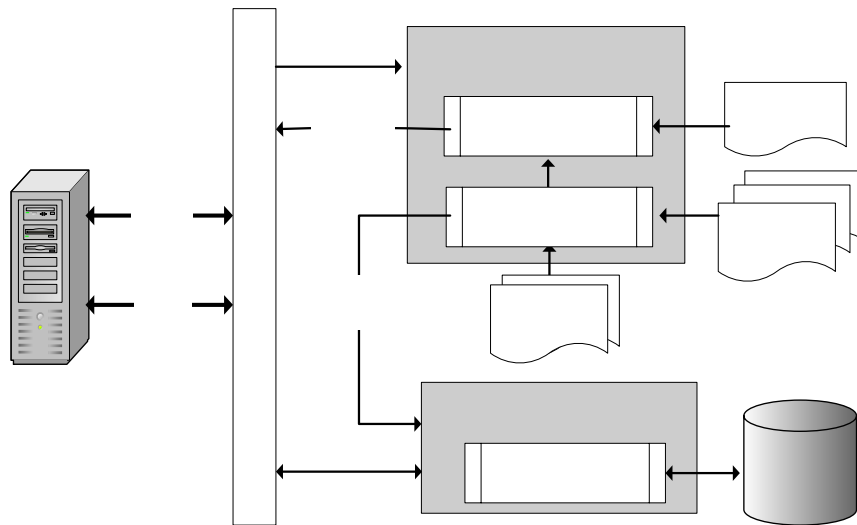


Figure 2. Architecture of UniWeLP

Users can query for teaching material information by invoking the Teaching Material Management module, which consists of two function units:

- ◆ *Presentation of teaching material information:* This function unit is capable of translating teaching material among different standards, and extracting the information and components from teaching materials for reuse.
- ◆ *Components management:* This function unit provides an interface for updating and inquiring extracted learning objects stored in the database.

Teaching Material Translation module first extracts the information of the teaching materials by invoking the Parse analyzer to create an XML document tree, and then translates the contents to the unified format based on the mapping relationships given in the metadata set by employing the XSLT Processor.

Development of Learning Object Extraction and Management System

Based on the novel approach, a Learning Object Extraction and Management system has been implemented. Figure 3 depicts detailed information of the teaching materials, such as standard adopted, standard version and teaching material structure, by invoking the information extraction function of the system.

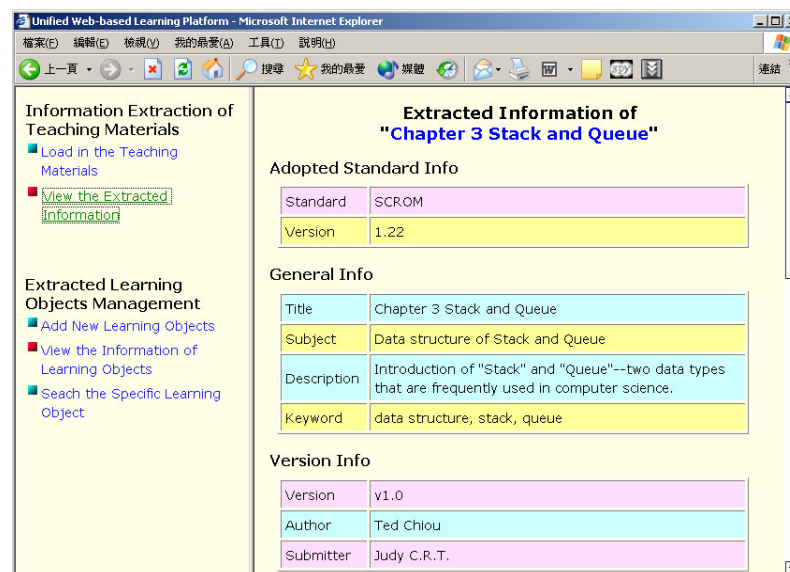


Figure 3. Example of information extraction function

Control
Code

HTML

Page
r

Figure 4 depicts the management function of the system. The users can search for any extracted learning object by giving a set of features.

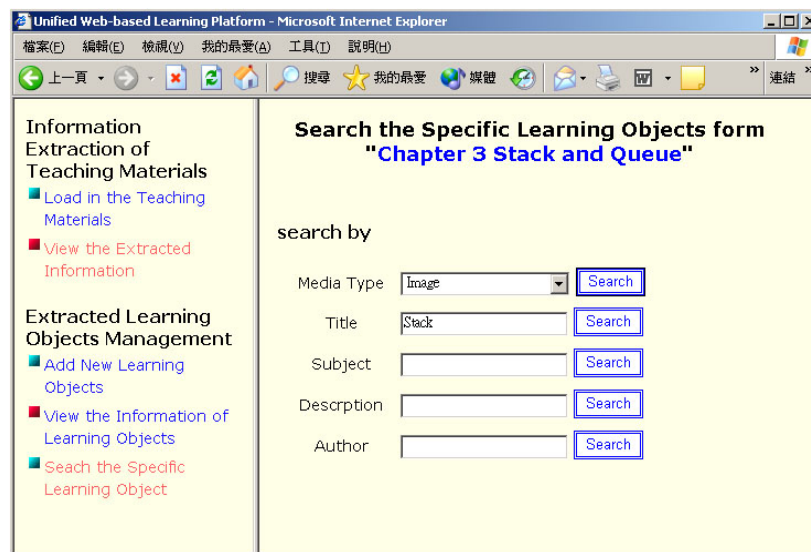


Figure 4. Example of management function

Conclusions

In this paper, we propose a unified learning platform to represent and translate teaching materials described with different standards. Based on the platform, a learning object extraction and management system has been implemented to support multiple teaching material standards, and hence the teaching materials can be shared and reused. Now, we are trying to extend the unified standard to include more detailed information of teaching materials and test bank, such that the information concerning learning diagnosis and guidance can be described and shared.

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Applying Data Mining in E-learning Environment

Introduction

Teaching on the Internet can not only conquer the limit of time and space, but also let students have more choices in time and location. Adaptive learning and collaborative learning are popular learning models on e-learning. E-learning is featured in self-directed and self-paced learning process. Learner can decide what to learn and when to learn. In this situation, e-learners have more opportunities to learn what they need to learn based on learners' individual differences. As a result, it reaches the target of personalization. Collaborative learning supplies great opportunities for students to work together to accomplish shared learning goals and objectives.

Data mining is the process of discovering interesting patterns in databases that are useful in decision-making [7]. It has been used to analyze log file data to understand access patterns of WWW users [4]. Classification and clustering are one of the mostly in common used tasks in the data mining techniques. Classification is a process of learning a function that maps a data item into one of several predefined classes [3]. Clustering model is also called a segmentation model, which one tasks a set of instances in a database and partitions them into a finite set of categories or clusters, such that the instances within a cluster are similar [1][2][6].

Because Web Logs may contain huge amount of students learning portfolios, we can analyze students' learning performance according to the learning activities such as login time, test scores, discussions, assignments and etc in the courseware [5] by data mining. We develop a classification model by decision tree and a clustering model that can achieve the goal of adaptive learning and collaborative learning in this paper. Integrating data mining and e-learning through the model can predict and describe the students' learning performance. Thus, data mining is a great tool to help teachers in designing instructional strategies.

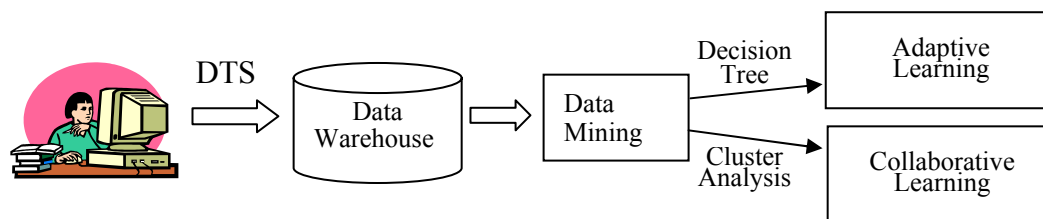


Figure1. Framework and Steps of the research framework

Framework of the research

Figure 1 is the framework and steps of this paper. First of all, we obtain the Web Logs from courseware such as, Web CT, Learning Space and TopLearn [5]. Here we employ TopLearn distance learning system as data sources. Students' learning behavior has been recorded on TopLearn. In order to extract the data that is interesting and useful for teachers who want to understand students' learning situation, Microsoft SQL Server 2000 Data Transformation Service (DTS) package can be applied to extract, clean, integrate, and delete the inconsistent ones. Then data were loaded into the data warehouse that specifically created for the purpose of analysis rather than to support daily business transactions.

These processes ensure the correctness and quality of data. After the data warehouse is built, we use data mining skill such as Microsoft SQL Server 2000 Analysis Service, SPSS Clementine, and Support Vector Machines to analyze data by decision tree and clustering. We exploit the courseware record, like test scores in the data warehouse, to be the training data set that is used to identify the maximally distinguishing attributes associated with classes or clusters of data. Once the classes are identified, new examples can be analyzed and appropriately categorized. Hence, course material could be determined by different levels for students and achieve the goal of adaptive course sequencing based on individual differences. By applying the decision tree analysis to detect when and what the students may have a learning bottleneck, and then teachers can use those results to give the students who have problems in learning with the correct remedial instructions at the right time.

Clustering is also called unsupervised classification. The aim is to divide the data tuples into non-predefined classes. Cluster has two main characteristics: first, similar to one another within the same cluster. Second, dissimilar to other clusters. Clustering is to reduce the differences between groups and help each other in the same group, so employing the cluster analysis to group students for collaborative learning. In general, thread discussions in a courseware record a lot of learning processes, so we can use the keywords to cluster and build the clustering model to distinguish from similar interest as a group. It can avoid the huge variations between groups and increase the learning efficiency, especially for theme-based learning. Also, classification and clustering models will be automatic refreshed when the new records come. Then, it can provide the latest information for both students and teachers and reach the goal of adaptive learning and collaborative learning as well.

Discussion and Conclusion

In recent years, due to prosperous growth of Internet, e-learning begins to gradually applying in learning. By applying new technologies and tools, teachers can understand the students' learning performance easily via learning portfolio. To analyze students' learning behavior and provide the adaptive learning, data mining was conducted to build a classification model. Thus, course sequence will be fit to his or her own level for every student. In other words, students can learn by personalization.

Establishing the clustering model is one way to achieve the goal of collaborative learning. It not only gives the teachers a reference about how to group, but also decreases the differences between groups. Each group has its high similarities, so students' level will be closer. It could help students be more confident and learn happier. The application procedures of the framework could be empirically tested in future research.

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Converting Existing Course Materials into Learning Objects via SCORM: An Initial Study

This project report describes an initial and on-going study into the development of SCORM-compliant Learning Objects (LOs) for use on a module taught at the University of Glamorgan. The module has already run for one term through the traditional lecture-tutorial method of teaching; the aim is to translate the existing materials into LOs to support the next intake of students. It is intended that the LOs will be stored in a database to be added to the University's Virtual Learning Environment, Blackboard, for students to access during their own study time.

Whilst ADL [1] set out comprehensive guidelines to build Shareable Content Objects, this project aims to build Learning Objects initially using a more pedagogically influenced framework before refinement for SCORM compliance. There are very few LO case studies where the developers have used a pedagogic structure for their LOs. Most have instead concentrated on the content packaging and metadata technical specifications.

The most appropriate definition of a Learning Object for this study is Cisco's classification: 'A Learning Object is based on a single objective, built from a collection of static or interactive content and instructional practice activities' [2]. Unlike many other definitions, Cisco specifically mentions structure and the idea that content may be interactive. While it does not explicitly mention reusability, the term 'collection' implies that the constituent elements of the LO would be selected from a store of content and practice items. The individual components are grouped within a larger encapsulating LO, all of which would be tagged and stored. The size of an LO is constrained to a single objective and is not determined by a length of time.

Since the Cisco definition of an LO already implies structure and an element of granularity, it makes sense to look to the Cisco structural framework for a standard design format. In the Cisco framework, the LO is a Lesson within a Module, comprising of 7 +/-2 content items or Topics. Wrapped around the Topics is an overview, a summary, practice item and an assessment of the overall Lesson. The Topics are one of five types; Concept, Fact, Procedure, Process and Principle, each with their own particular structure of subtopics [3]. Practice and assessment items may also be placed within the subtopic structures.

Since the Cisco strategy is aimed at business training, the UDRIPS teaching and learning specification model is applied in order to ensure pedagogical value. Developed at the University of Glamorgan, UDRIPS is a CBL development model and method derived from software engineering and pedagogic theory principles [4]. Addressing key questions from both the developer and student's perspective, UDRIPS stands for **U**niversal **D**efinitions, **R**ules, **I**llustrative examples, **P**roblem solving and **S**ummary. These elements were applied to the Cisco subtopics.

The result was a series of ten LOs, whose structure was laid out in individual structure charts detailing name, pre-requisites, Topics, subtopic structural components and their corresponding UDRIPS element. While not all UDRIPS elements are present in the Topics, Problem Solving and Summary elements could be mapped to the LO's practice, assessment and summary items, or they could be added to the Cisco framework. Further work will determine if refinement of either model is required.

At this stage, it was necessary to explore SCORM compliance before any further, more detailed development. The JISC funded project, RELOAD (<http://www.reload.ac.uk>) focuses on the development of tools based on emerging learning technology interoperability specifications. The tools are ideal for this project where lecturers and tutors wishing to convert their material to LOs may be unfamiliar with standards and specifications. An initial test was performed using the RELOAD Editor, which enables users to organise, aggregate and package their own learning objects in standard IMS and SCORM content packages tagged with metadata. Five HTML pages were created, each with similar content to that planned for the LOs that included a Director movie, text, and graphics. The Editor generates the appropriate .xml files, resulting in ready-to-use LOs, compliant to IMS Content Packaging 1.1.3, IMS Metadata 1.2.2 and ADL SCORM 1.2.

Following these successful initial studies, the next stage of the project will be to design and develop the content of the planned LOs according to their designated Topic type. In order to maintain the rich pedagogical value offered by Cisco and UDRIPS, this phase will take into consideration multimedia learning and retention ideas such as Dual Coding Theory and Cognitive Load Theory [5, 6]. The complete pages will be evaluated and refined before packaging and metadata implementation by the RELOAD Editor. The finalised LOs will be tested and evaluated in the next run of the module, where students will answer a questionnaire on their use and perceived benefit of the LOs. An evaluation of the integration of the LOs into the VLE will determine the ease of transfer from development to use. It is hoped this project will have an influence in persuading sceptics and beginners on the School of Computing staff to develop and re-use Learning Objects.

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Hard SCORM

1. Background

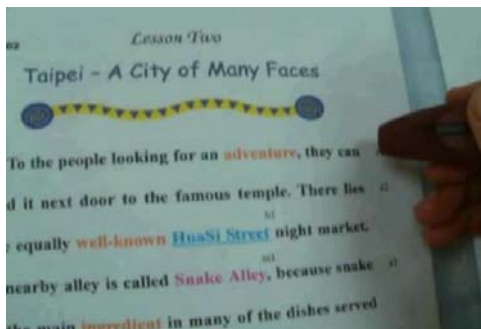
One way to push distance learning to its next level of success is standardization of digital contents. The Sharable Content Object Reference Model (SCORM) was introduced by the Advanced Distributed Learning Initiative (ADL) (<http://www.adlnet.org/>). As an official partner of the Academic ADL Co-Lab (<http://www.academiccolab.org/>), we are developing a project (<http://www.mine.tku.edu.tw/scorm/>) which looks at SCORM from an experimental perspective. Even Web technology and internet are popular, as a realistic situation among several virtual universities, textbooks are still widely used. The fact is that people still prefer reading books instead of facing to screens. Recently, OCR-based technology is integrated with a pen device, which is used on ordinary paper as an input device. Imaging that, with wireless communication technology, people can use an ordinary-like *Hyper Pen* in reading SCORM-based learning objects. As a backend support, a computer server manages the interaction, the learning activity, the progress, and the exams. We argue that the most important contribution of this research project is on the integration of devices, which marry the physical and the digital worlds. Yet, distance learning standard should be followed. We are developing an authoring tool and a learning management system following the SCORM specification. The authoring tool automatically places *Hyper Tags*, which is recognizable by the Hyper Pen. Hardcopy of textbook is thus published via the use of our authoring tool. Essentially, navigation on this type of textbook by Hyper Pen has the same effect as browsing a website. We call this new definition of hyper-interaction and SCORM-based sequencing standard the *Hard SCORM*.

2. Navigation and Sequencing via Hyper Tags

To develop an efficient system that can encourage students to learn under a natural atmosphere is our primary goal. Thus, the definition of Hyper Tags should consider effective interaction and fit with the navigation and sequencing standard of SCORM. Hyper Tags can be 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.
 - **[Attempt s_i] Attempt Tag** allows a navigation to indicate the status, s_i , of attempt.
 - **[Objective s_i] Objective Tag** allows a navigation to indicate the status, s_i , of learning objective.
 - **[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] Video Reference Tag** shows a video.
 - **[Audio] Audio Reference Tag** presents an audio clip.
 - **[URL] URL Reference Tag** launches a website.
- **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 used².
- **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.



developed. However, text-based tags mix 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. Summary

Our approach to use Hyper Pen in distance learning is a beginning. With the advanced technology used in cellular phones, it is possible that, in the near future, a high school student can carry a cellular phone with a Bluetooth earphone, which is associated with a wireless Hyper Pen. Via WAP and GPRS technologies, students can read hardcopy textbook anywhere with multimedia instructions as supplementation, while his/her learning behavior is recorded and analyzed by a powerful backend server. We believe that, the era of wireless and mobile learning will further bring the success of distance education to another dimension.

Acknowledgement

We will like to thank the following people for their help on the implementation of the Hard SCORM Project: Wen-Chih Chang, Nigel H. Lin, Wen-Chieh Ko, Hsuan-Pu Chang, Freya H.W. Lin, and D. H. Wang.

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² When a user is using a Hyper Pen on reading, a PDA or a PC can be used as an auxiliary device to present multimedia contents or enter answers.

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Agent-Based Web Learning System

1. Introduction

ABWLS (Agent-Based Web Learning System) is an integrated e-learning system that provides teachers creating curriculum contents, utilizing sharable learning resources, and offering students an intelligent web learning environment associated with the diversification of presentation versions to various devices.

2. The Architecture of Agent-Based Web Learning System

The framework of ABWLS is decomposed into five important modules: LCMS (Learning Content Management System), WSMS (Web Services Management System), Database, LMS (Learning Management System) and Agent, as presented in Figure 3.

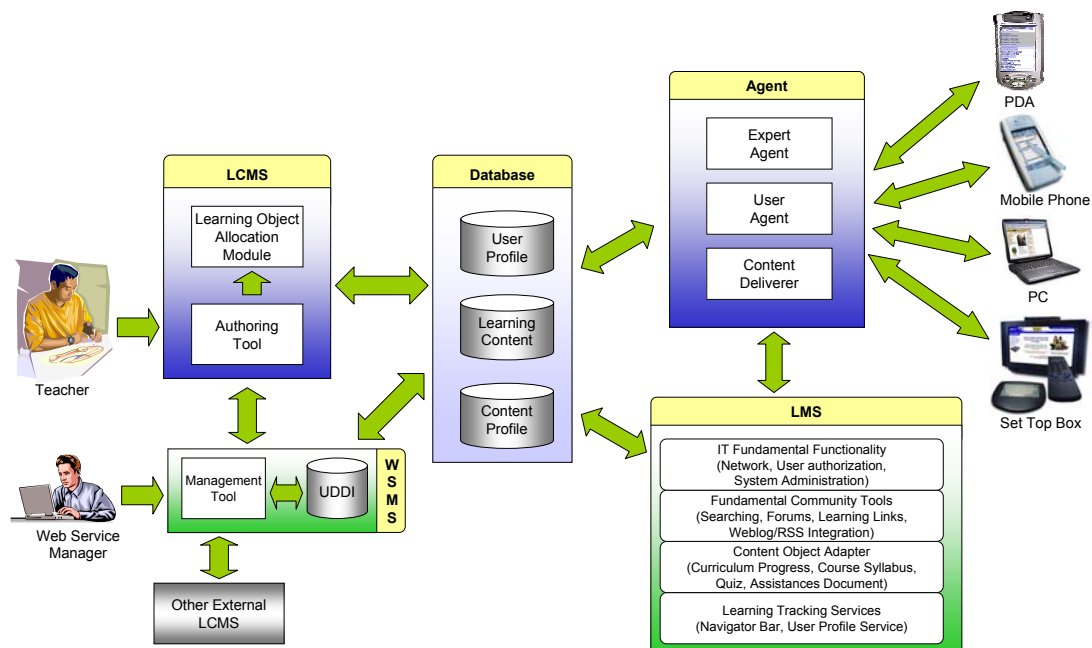


Figure 3. Agent-Based Web Learning System Architecture

LCMS (Learning Content Management System)

The LCMS mainly aims at providing a convenient editing tool for teacher to fabricate an integrated course. Furthermore, in order to utilize all kinds of learning contents in different standards such as IMS [2] and SCORM, [3] it incorporates plug-and-play compatibility. The LCMS can transform the learning contents to fit in the content with SCORM standard via a simple and easy editing tool. Since the learning material can be used by the scenario of SCORM standard, it can correspond with a reusable component to be reused by the other teachers.

- *Authoring Tool.* It is mainly composed of four components in terms of functionality. First, it provides a teacher a convenient tool to edit SCO (Sharable Content Object). The SCO is alike the “sub-section” in a course. Second, the teacher can search UDDI (Universal Description, Discovery and Integration), through *Web Services Management Tool*, to find out the reusable SCOs. Sometimes, those SCOs have been prepared by some other instructors who want to contribute these learning resources. In case of locating the SCOs, the teacher may pass over these sections and include them to be parts of his learning content. Third, the teacher can also announce that the SCOs he accomplished to be sharable learning resources, and then these SCOs can be used by other instructors. Finally, it combines the SCOs into a manifest file that is corresponding to a “section” in a course.

- *Learning Object Allocation Module.* After finishing the manifest files, the teacher has to map out the relationships between these manifest files. The module will provide the *Expert Agent* to guide the student achieving entire course scheme afterward.

WSMS (Web Services Management System)

WSMS (Web Services Management system) is for managing Web services resources and provides a consistent and secure mechanism. Through Web services technology, teacher can locate the learning resources from the content provider according to UDDI search results, and then include these learning objects to be parts of curriculum materials (shown in Figure 4).

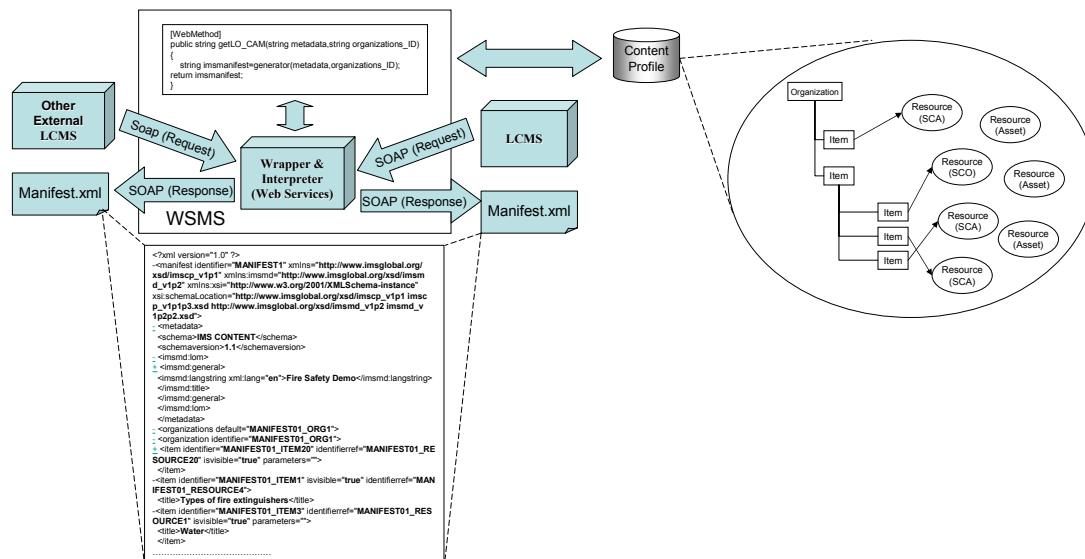


Figure 4. Web Services Management System Conceptual Diagram

Database

- **Content Profile.** It is arranged to record the related information of learning content. Content Profile contains three kinds of file to record the information — SCO.xml, Manifest.xml, and Course.xml (shown in Figure 5). The file structure of SCO.xml and Course.xml follows the scenario of IEEE LOM (Learning Object Metadata) [1] which is a collection of specifications adopted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility, and reusability of Web-based learning content. Based on IMS Content Packaging Specification [2], the related learning resources are packaged into Manifest.xml file. The scope of manifest is very flexible. A manifest can describe a part of a course, an entire course, a collection of courses, or just a collection of content that is to be shipped from one system to another.

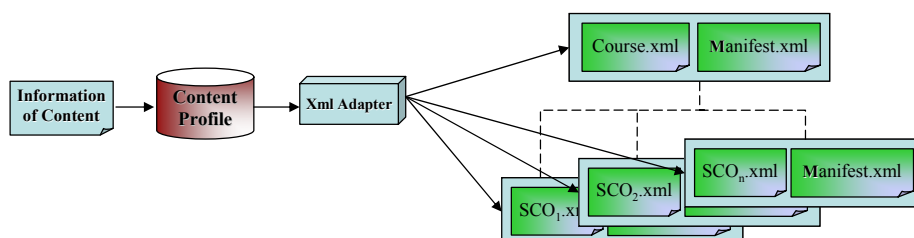


Figure 5. Content Profile Conceptual Diagram

- **Learning Content.** It is designed for storing learning resources including document, photograph, video, audio, hyperlink, and some other kinds of learning materials. The storage arrangement is referred to

SCORM CAM Content Package [3] which focuses on defining interoperability between systems. We package up the learning assets with .zip file in order to unpack from the other LMS (Learning Management System).

- *User Profile*. In order to observe each student's learning status and guide him to achieve his learning goal, we design a *User Agent* to record these relevant information, and then put these data into User Profile database. Due to that each LMS (Learning Management System) needs to record different users' behaviors and statuses, we mainly construct three elements to record user's profile as shown in Table 1. The first element <userdata> notes down user's profile information, such as name, age, birthday, gender, e-mail address, years of education, classification of learning direction, and partner list. The second element <learningitem> records the relevant data of each learning section, such as course ID, section ID, last login time, the total browsing time of this section, and the frequency of browsing times. The final element <assessment> registers learning assessment data, such as section ID, testing scores, the threshold of a section, pretest learning resources, and posttest learning resources.

Table 1. The List of User Profile

XML Tag	Attribute/Subitem	Parameter
<userdata>	name, age, birthday, gender, e-mail, educationYears, classification, partner	<i>Read</i>
<learningitem>	courseID, sectionID, lastTime, stayTime, frequency	<i>Read/Write</i>
<assessment>	<i>sectionID, score, threshold, pretest, posttest</i>	<i>Read/Write</i>

LMS (Learning Management System)

The purpose of LMS is to provide a virtual environment for students with the functions of online learning, online discussion, performing learning activities, taking assessments, recording learning history, showing achieved percentage of scheduled progress, etc. LMS can approximately be classified into four functional modules: (1) IT Fundamental Functionality (Network, User authorization, System Administration), (2) Fundamental Community Tools (Searching, Forums, Learning Links, Weblog/RSS Integration), (3) Content Object Adapter (Curriculum Progress, Course Syllabus, Quiz, Assistances Document), (4) Learning Tracking Services (Navigator Bar, User Profile Service).

Agent

- *Expert Agent*. Teachers can use *Learning Object Allocation Module* to map externally entire course learning sequence. Subsequently, ABWLS will dispose of an expert agent to serve a student who wants to study this course. The expert agent will guide the student's learning sequence depending on his learning results. Besides, the expert agent will provide auxiliary learning resources whenever the student gets unsatisfied learning result.
- *User Agent*. It records student's learning behaviors via navigation bar interface. After the user agent acquiring these tracking data, it will place into *User Profile* database.
- *Content Deliverer*. Due to the convenience of pervasive information environment, many people use various computing devices to progress the e-learning activities. However, some computing devices suffer from the limited resources and can not accommodate enriched information content. Therefore, the information content has to be tailored into different kinds of presentation versions depending on the variety of computing devices. Hence, we employ content deliverer to be a translator between the learning resources and the presentation devices.

3. Conclusions

ABWLS provides a convenient e-learning environment, which includes using software agent to provide intelligent services, giving the proper presentation by a device's capability, and reusing learning resources

through Web services. The future work of this study may explore individual user's learning behaviors using data mining methodologies.

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Developing Domain Model Web Services For Agent-supported Distributed Learning Using PROTÉGÉ 2000

Introduction

The integration of Web services and agents simplify the complexity of development, saves time and the most important of all, makes distributed learning environments feasible and practical [1]. However, currently there is a lack of domain models that support e-Learning in a language and platform-independent manner. It is desirable to develop a conceptual model and knowledge base that can be accessed in a language and platform independent manner. It will facilitate developing intelligent software agents for generating and delivering personalized courses to learners, to connect to a remote or local knowledge base will allow the course agents of instructors to create new courses from a central repository that is kept up to date with relevant information, and it has the potential to allow students' learning agents to connect to the same repository to perform further research or view the most current version of the content.

Web services are Web-based enterprise applications that use open, XML-based standards and transport protocols to exchange data with calling clients [2]. In the process, they leverage an emerging group of standards that govern their description and interaction, including SOAP (Simple Object Access Protocol), UDDI (Universal Discovery and Description Initiative), XML (Extensible Markup Language), and WSDL (Web Services Description Language). Web Services are a middleware that enables and simplifies web application-to-application connectivity. They expose business processes in order to perform a function via HTTP. Since Web Services are based on standards they facilitate interoperability between systems, and they are platform independent.

Knowledge-based systems and services are expensive to build, test and maintain, and there are several technical problems that stand in the way of shared, reusable knowledge-based software, including hardware platforms, programming languages, and network protocols [3].

“Recently the notion of ‘ontology-driven information systems’ (ODIS) has been proposed that opens up new ways of thinking about ontologies and IS in conjunction with each other and covers both the structural and the temporal dimensions of information systems” [4]. Ontologies can guide the development of new e-Learning courses by helping agents choose appropriate course materials, content, and testing questions depending on their needs. Ontologies are essentially knowledge artifacts with a certain level of abstraction, and therefore, courses can be generated from the ontology through specialization and combination. “It also appears that the emerging paradigms such as web services and the semantic web will enable the large-scale development, deployment, and sharing of ontologies and ontology-driven information systems” [4].

With the advent of Web Services and the Java programming languages these technical problems are becoming less of a hindrance. Since Java can run on any platform in which there is a Java Virtual Machine, it is now possible to build a platform independent Web Service and client to access the Web Service, using standard protocols as HTTP.

The goal

The goal of this research is to develop a set of ontology Web Services that facilitate retrieval of information for the purposes of developing intelligent software agents for e-Learning systems. The use of ontology Web Services to connect to an e-Learning domain model, allows clients' agents to connect to the domain information and give the agents the ability to piece together new courses remotely, or locally from a central repository.

Methodology

We are using Protégé 2000 [5], a domain-modeling tool from Stanford University, to develop the domain models. Protégé generates a default form when the domain is created, which can then be further customized to suite the project visual preferences and requirements. Once the domain model and data entry forms have been created, the instances tab, which is a knowledge-acquisition tool, can be used to acquire instances of the classes

define in the ontology. Once the model has been populated with information, the Protégé library can be access using a Java API to retrieve that information for use in the Java Web Services.

We use Java 1.4 and Sun Microsystems Java Web Services Developer Pack (JWS DP) 1.3. [6] to develop the ontology Web Services component. Using JAX-RPC and other technologies within JWS DP we can easily generate the ties, stubs, and WSDL that facilitate the connection of the Web Service and focus on the business logic, which, in this case, is connecting to the Protégé 2000 domain model containing the e-Learning material.

An example

While the Protégé 2000 domain model is being developed and populated with information and we integrate the ontology Web Service on top of it, we are constructing a mechanism in place that facilitates adaptive course generation and delivery. The domain model is being populated with IEEE/ACM Software Engineering Body of Knowledge 1.0 (SEBOK) [7]. In the future other publications can be added. Figure 1 shows the e-Learning knowledgebase tree structure in Protégé 2000.

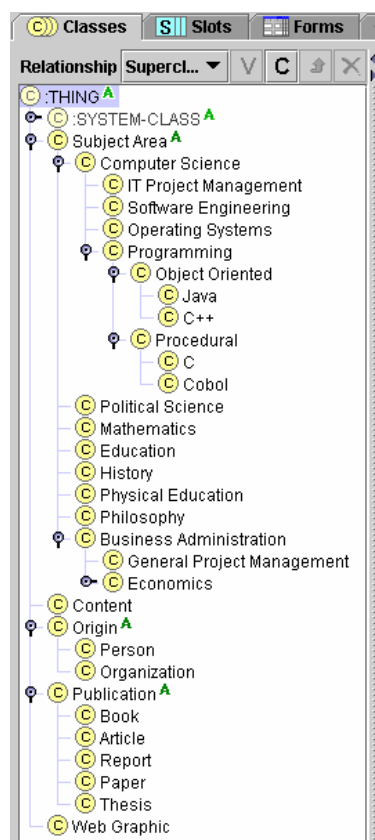


Figure 1: e-Learning knowledgebase tree structure in Protégé 2000

The WSDL can be used to register the Web Service with a UDDI server, if desired.

For example, “GetContentService” is used to retrieve an individual piece of content from the Protégé 2000 knowledgebase, based on a known protégé 2000 class ID. The client can call the client side auto-generated stub for this service, invoking the JAX-RPC command.

The service can be invoked and a server side business command will be executed to retrieve the matching content based on the input ID. From the WSDL (see Figure 2) for this service we know that it will return a Content Object (<complexType name=“Content”>) containing values for the attribute’s listed within the complexType node (i.e. text, and title).


```

<?xml version="1.0" encoding="UTF-8" ?>
<definitions name="GetContentService" targetNamespace="urn:Foo" xmlns:tns="urn:Foo" xmlns="http://schemas.xmlsoap.org/wsdl/"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/">
  <types>
    <schema targetNamespace="urn:Foo" xmlns:tns="urn:Foo" xmlns:soap11-enc="http://schemas.xmlsoap.org/soap/encoding/"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
      xmlns="http://www.w3.org/2001/XMLSchema">
      <import namespace="http://schemas.xmlsoap.org/soap/encoding/" />
      <complexType name="Content">
        <sequence>
          <element name="FOLLOWING_CONTENT_SLOT" type="string" />
          <element name="KEYWORDS_SLOT" type="string" />
          <element name="PREVIOUS_CONTENT_SLOT" type="string" />
          <element name="SECTION_SLOT" type="string" />
          <element name="SUBTITLE_SLOT" type="string" />
          <element name="TEXT_SLOT" type="string" />
          <element name="TITLE_SLOT" type="string" />
          <element name="classID" type="string" />
          <element name="followingContent" type="string" />
          <element name="images" type="tns:ArrayOfImage" />
          <element name="keywords" type="tns:ArrayOfstring" />
          <element name="owningPublication" type="string" />
          <element name="previousContent" type="string" />
          <element name="section" type="string" />
          <element name="subtitle" type="string" />
          <element name="text" type="string" />
          <element name="title" type="string" />
        </sequence>
      </complexType>
      <complexType name="ArrayOfImage">
        <complexContent>
          <restriction base="soap11-enc:Array">
            <attribute ref="soap11-enc:arrayType" wsdl:arrayType="tns:Image[]" />
          </restriction>
        </complexContent>
      </complexType>
      <complexType name="Image">
        <sequence>
          <element name="description" type="string" />
          <element name="relativePath" type="string" />
        </sequence>
      </complexType>
      <complexType name="ArrayOfstring">
        <complexContent>
          <restriction base="soap11-enc:Array">
            <attribute ref="soap11-enc:arrayType" wsdl:arrayType="string[]" />
          </restriction>
        </complexContent>
      </complexType>
    </schema>
  </types>
  <message name="GetContentIF_getContent">
    <part name="String_1" type="xsd:string" />
  </message>
  <message name="GetContentIF_getContentResponse">
    <part name="result" type="tns:Content" />
  </message>
  <portType name="GetContentIF">
    <operation name="getContent" parameterOrder="String_1">
      <input message="tns:GetContentIF_getContent" />
      <output message="tns:GetContentIF_getContentResponse" />
    </operation>
  </portType>
  <binding name="GetContentIFBinding" type="tns:GetContentIF">
    <operation name="getContent">
      <input>
        <soap:body encodingStyle="http://schemas.xmlsoap.org/soap/encoding/" use="encoded" namespace="urn:Foo" />
      </input>
      <output>
        <soap:body encodingStyle="http://schemas.xmlsoap.org/soap/encoding/" use="encoded" namespace="urn:Foo" />
      </output>
      <soap:operation soapAction="" />
    </operation>
    <soap:binding transport="http://schemas.xmlsoap.org/soap/http" style="rpc" />
  </binding>
  <service name="GetContentService">
    <port name="GetContentIFPort" binding="tns:GetContentIFBinding">
      <soap:address location="REPLACE_WITH_ACTUAL_URL" />
    </port>
  </service>
</definitions>

```

Figure 2: WSDL file for Web service "SearchContentService"

Conclusion

The research involved in this project includes determining how to model the domain within Protégé 2000 to suit the needs of developing intelligent agents for e-learning problem, and determining how to access the contents of the knowledge base, once populated, and search and retrieve information from the knowledge base. We are working on how to tie all the pieces together through an ontology Web Service, which includes developing the Web Service(s) itself, generating a WSDL file, and creating a Java client to access the Web Service(s).

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An Efficient Approach for the Maintenance of Frequent Sequences in a Web-based Training Environment

Introduction

Owing to the structure of a web system is designed by experts, there must be the relationships between every two pages which are linked together, and the structure of the web system is also a flow to guide the users for browsing. It is important to analyze the traversal paths traversed by all the users in a web-based training environment to understand the users' interests [1, 2, 4, 5].

A *user sequence* is a traversal path for a user in the web system. A *user sequence database* contains a set of user sequences traversed by all users in the system, which includes traversal path identifiers (TP), traversal pages and traversal-time. A user sequence u *supports* a traversal sequence s if s is contained in u . The *support* for a traversal sequence s is the number of user sequences that supports s . If the support for a traversal sequence s satisfies the user-specified *minimum support* threshold, then s is called *frequent traversal sequence*. The *length* of a traversal sequence s is the number of pages in the sequence. A traversal sequence of length k is called a *k-traversal sequence*, and a frequent traversal sequence of length k a *frequent k-traversal sequence*. Before generating the frequent traversal sequences, we need to generate the *candidate traversal sequences*, and scan the database to count the support for each candidate traversal sequence to decide if it is a frequent traversal sequence. A candidate traversal sequence of length k is called a *candidate k-traversal sequence*.

First, the new user sequences are inserted into the original database- D , and the obsolete user sequences which are deleted from D are marked. After the updating, we have the updated database UDB . Besides, we decompose UDB into three parts. The user sequences, which contain the deleted user sequences, are included in the first part which is called *deleted part*. The user sequences, which contain the inserted user sequences, are included in the second part which is called *inserted part*. The third part includes the user sequences in the original database except the deleted user sequences, which is called *original part*.

The algorithm for updating the frequent traversal sequences

Let L_k be the set of the frequent k -traversal sequences before updating the database, L'_k and C'_k be the set of the frequent k - traversal sequences and the candidate k - traversal sequences, respectively, after updating the database.

Our algorithm *MAFTP* partitions the updated database into some segments. The inserted part and the original part need to be partitioned individually. Suppose the segment length is set to n ($n \geq 1$). For the inserted parts, from the first user sequence to the n^{th} user sequence are in the first segment, and from the $((i-1) \times n + 1)^{th}$ user sequence to the $(i \times n)^{th}$ ($i \geq 2$) user sequence are in the i^{th} segment. If there are m segments in the inserted part, then from the first user sequence to the n^{th} user sequence in the original part are in $(m+1)^{th}$ segment, and so on.

Definition 1. Let traversal sequence $s = \langle s_1, s_2, \dots, s_n \rangle$ and user sequence $c = \langle c_1, c_2, \dots, c_m \rangle$. If there exists $i_1 < i_2 < \dots < i_n$, $1 \leq i_k \leq m$, such that $s_1 = c_{i_1}, \dots, s_n = c_{i_n}$, then the position of s in c is i_n . Otherwise, the position of s in c is 0.

Lemma 1. Suppose the position of traversal sequence $\langle s_1, s_2, \dots, s_u \rangle$ in user sequence c is p , and the position of traversal sequence $\langle s_2, \dots, s_u, s_v \rangle$ in user sequence c is q . If $q > p$, then the user sequence c supports the traversal sequence $\langle s_1, \dots, s_v \rangle$ and the position of the traversal sequence $\langle s_1, \dots, s_v \rangle$ in c is q .

MAFTP scans the inserted part of the updated database pass by pass. For the $(k/2)^{th}$ ($k=2, 4, 6, \dots$) pass, *MAFTP* generates L_k and L_{k+1} . For the i^{th} ($i \geq 1$) segment scan, *MAFTP* computes *i-segment support* for each candidate k -traversal sequence, which is the number of the user sequences that support this candidate traversal sequence in the i th segment. In this segment scan, *MAFTP* also records the position of each candidate k -traversal sequence, which is used to compute the *i-segment support* for each candidate $(k+1)$ -traversal sequence according to Lemma 1 without scanning the database.

Assume that *MAFTP* has scanned the i^{th} segment. The *current support* $CSs(i)$ for a traversal sequence s is defined as:

$$CSs(i) = 1\text{-segment support of } s + \dots + i\text{-segment support of } s \quad (1)$$

For each segment scan, we also compute the *maximum support* for each candidate traversal sequence so far. Let $a = \langle a_1, \dots, a_k \rangle$ and the i -segment support of page a_j be Si_j ($1 \leq j \leq k$). The initial maximum support $\max S_a(0)$ of a is defined as :

$$\max S_a(0) = \sum_{i=1}^{i=m} \min \{Si_1, \dots, Si_k\}, m \text{ is the number of the segments in the database} \quad (2)$$

According to expression (2), we can see that the *maximum support* of a traversal sequence s is never less than the support of s .

After scanning the i^{th} ($i \geq 1$) segment, because we have computed i -segment support of a , the maximum support of the k -traversal sequence a can be obtained by the following expression :

$$\max S_a(i) = \max S_a(i-1) - \min \{Si_1, \dots, Si_k\} + i\text{-segment support of } a \quad (3)$$

Lemma 2. *If the maximum support of a traversal sequence is less than the minimum support threshold, then the traversal sequence is not a frequent traversal sequence.*

Lemma 3. *If the maximum support of traversal sequence s is equal to the current support of s , and the current support is no less than the minimum support threshold, then s is a frequent traversal sequence and the support of s is equal to the current support of s .*

MAFTP needs to compute the maximum support and the current support for each candidate traversal sequence when a segment is scanned. According to Lemma 2 and Lemma 3, we can prune the candidate traversal sequences which can not be the frequent traversal sequences and find the frequent traversal sequences earlier.

First, the original part and the inserted part of UDB are scanned to find the set of frequent pages L_1' , and the segment supports of each page can be obtained.

In the following, we use this example presented in Table3 throughout this section and describe the steps for the $(k/2)^{\text{th}}$ pass ($k=2, 4, \dots$) of MAFTP.

Step 1. Generate C_k' from L_{k-1}' , and then compute the initial maximum support of each candidate k -traversal sequence. Finally, prune the candidate k -traversal sequences from C_k' , which cannot be the frequent k -traversal sequences according to Lemma 2.

Step 2. Generate C_{k+1}' from C_k' , and then compute the initial maximum support of each candidate $(k+1)$ -sequences. Finally, prune the candidate $(k+1)$ -sequences from C_{k+1}' , which cannot be the frequent $(k+1)$ -sequences according to Lemma 2.

Step 3. Decompose C_k' and C_{k+1}' into $ClassA_k$, $ClassB_k$, $ClassC_k$, and $ClassA_{k+1}$, $ClassB_{k+1}$, $ClassC_{k+1}$, respectively.

$$ClassA_k = \{Candi \mid Candi \in C_k' \cap L_k\}$$

$$ClassB_k = \{Candi \mid Candi \in C_k', Candi \text{ at least contains a page } x \notin P, \\ P \text{ is the set of pages in the original database}\}$$

$$ClassC_k = \{Candi \mid Candi \in C_k', Candi \notin ClassA_k \cup ClassB_k\}$$

Step 4. Scan the inserted and deleted part of UDB from the first segment to the last segment.

Step 4.1. For the i^{th} ($i \geq 1$) segment scan, MAFTP records the position of each candidate k -traversal sequence in each user sequence in the i^{th} segment, computes the maximum support and the current support for each candidate k -traversal sequence, and then prune the candidate k -traversal sequences which cannot be the frequent traversal sequences according to Lemma 2. Besides, if the pruned candidate k -traversal sequence is a subsequence of a candidate $(k+1)$ -traversal sequence s , then s is also pruned from C_{k+1}' .

Step 4.2. Compute the i -segment support, the maximum support and the current support for each candidate $(k+1)$ -traversal sequence, and then prune the candidate $(k+1)$ -traversal sequences which cannot be the frequent traversal sequences according to Lemma 2.

Step 5. Generate the frequent sequences from $ClassA_k$, $ClassB_k$, $ClassA_{k+1}$, and $ClassB_{k+1}$, and prune the candidates from the $ClassC_k$ and $ClassC_{k+1}$, which cannot be frequent sequences.

Step 6. Scan the original part of UDB from the first segment to the last segment. For each segment scan, record the position of each candidate k -traversal sequence $s \in ClassC_k$ in each user sequence in the segment, compute the position of each candidate $(k+1)$ -traversal sequence $s \in ClassC_{k+1}$ in each user sequence in the current segment, and compute the maximum support and the current support for each candidate. Finally, prune the candidates which cannot be the frequent traversal sequences according to Lemma 2. Besides, if the pruned candidate k -traversal sequence is a subsequence of a candidate $(k+1)$ -traversal sequence s , then s is also pruned from $ClassC_{k+1}$.

After scanning a segment, we can obtain the segment support of each candidate $s \in (ClassC_k \cup ClassC_{k+1})$, and compute the maximum support and the current support of s . If the maximum support of s is less than minimum support threshold, then the candidate s can be pruned. If the maximum support of s is equal to the current support of s , then we can determine if s is a frequent traversal sequence according to Lemma 3.

Experimental results

We evaluate the performance of *MAFTP* by inserting user sequences into and deleting user sequences from the three user sequence databases, and then comparing this algorithm with *FASTUP* algorithm [3]. Figure 1 shows the relative execution times for *FASTUP* and *MAFTP* after inserting user sequences into the three user sequence databases. Suppose the number of the user sequences in the original database is n . The number of inserted user sequences is ranging from $n \times 2\%$ to $n \times 12\%$. If the maximum length of the generated frequent traversal sequences is $maxlen$ after the database update, *FASTUP* need to take $maxlen$ passes over the database, but *MAFTP* just need to take $maxlen/2$ passes over the database. Hence, *FASTUP* takes much more database scans than *MAFTP*.

Besides, *FASTUP* just use subset principle, that is, all the $(k-1)$ -subsequences of a frequent k -sequence must be frequent, to prune the candidates. However, except for using the subset principle, *MAFTP* also use maximum support (Lemma 2) and Lemma 4 to prune the candidates, and use current support (Lemma 3) to find the frequent traversal sequences earlier without scanning all the segments. Hence, *MAFTP* can prune much more candidates than *FASTUP*. Figure 1 shows that our algorithm outperforms *FASTUP* algorithm, and the performance gap increases as the number of inserted user sequences increase, since the number of candidate traversal sequences increases such that it cannot prune the candidates efficiently for *FASTUP* algorithm.

Figure 2 shows the relative execution times for *FASTUP* and *MAFTP* after deleting user sequences from the three user sequence databases. The number of deleted user sequences is ranging from $n \times 2\%$ to $n \times 12\%$. Because *FASTUP* does not consider the incremental technique for database deletion, it is necessary to re-find the frequent traversal sequences for *FASTUP* algorithm. However, *MAFTP* still can use the discovered information and some Lemmas to reduce the number of candidate traversal sequences and the number of database scans. Figure 2 shows that *MAFTP* significantly outperforms *FASTUP* algorithm, and the performance gap decreases as the number of deleted user sequences increases, since the size of the user sequence database decreases and *FASTUP* just need to re-discover the frequent traversal sequences from a smaller database. However, *MAFTP* needs to scan the deleted user sequences to compute the supports for some candidates.

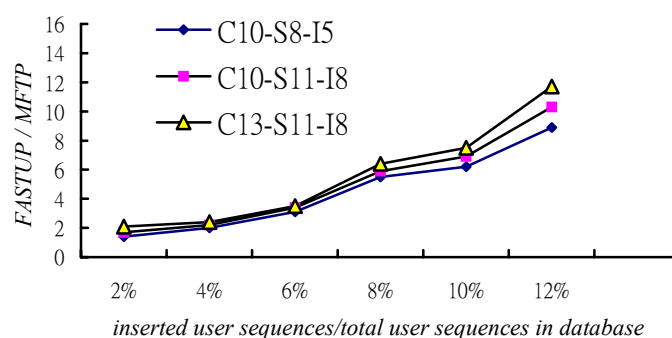


Figure 1. Relative execution time (*FASTUP*/*MAFTP*)

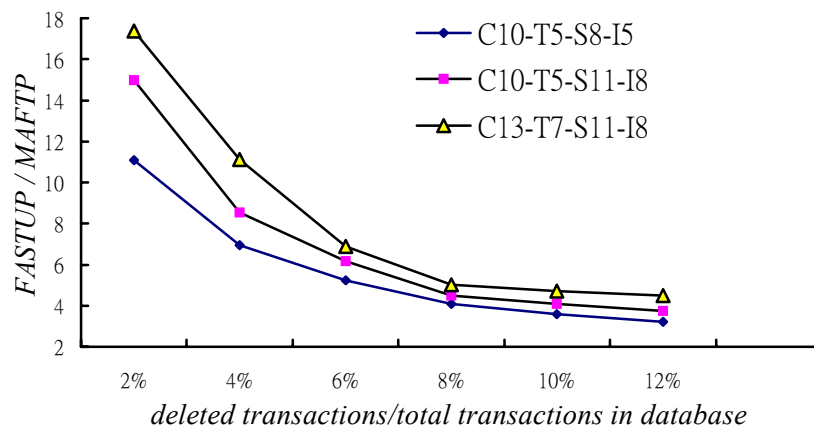


Figure 2. Relative execution time (*FASTUP/MAFTP*)

Figure 3 shows the relative execution times for *FASTUP* and *MAFTP* after deleting $n \times 4\%$ user sequences from and inserting $n \times 4\%$ user sequences into the three user sequence databases. Because *FASTUP* cannot use the discovered information to find new frequent traversal sequences after deleting $n \times 4\%$ user sequences, it needs to apply GSP algorithm to re-mine the new information from the three user sequence databases. After re-discovering the frequent traversal sequences, *FASTUP* needs to be performed again to find frequent traversal sequences after inserting $n \times 4\%$ user sequences into the three user sequence databases. Figure 3 shows that *MAFTP* also significantly outperforms *FASTUP* algorithm, because both database insertion and deletion can be processed by *MAFTP* at the same time, and *MAFTP* just needs to be performed once to discover all the new information.

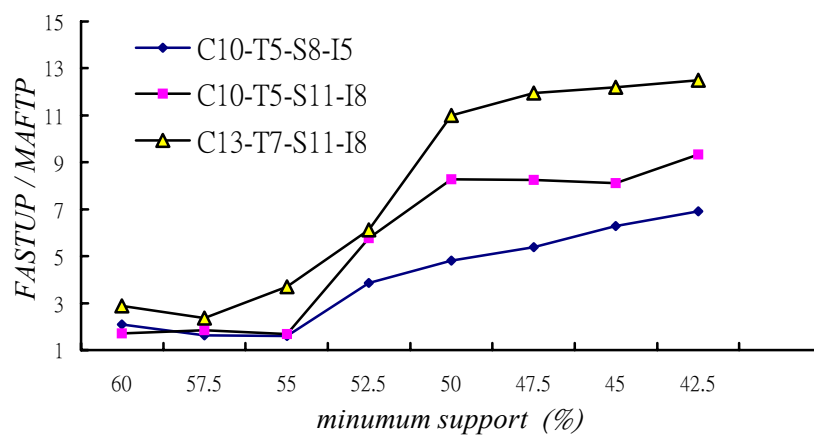


Figure 3. Relative execution time (*FASTUP/MAFTP*)

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SCORM-Compliant Adaptive And Personalized Learning Content Design

Introduction

Learning material is one of the key factors in leading to the success of learning system. The great advances in computer, communication and learning technologies fulfill the adaptive and personalized e-learning environment. In designing e-learning systems, accessibility, adaptability, affordability, manageability, reusability, durability and interoperability are primary concerns [1]. Standardizing learning material impose better accessibility, reusability, manageability and interoperability. Thus, this study focuses on the design of SCORM [2] compatible adaptive and personalized learning content, denoted as SAPContent.

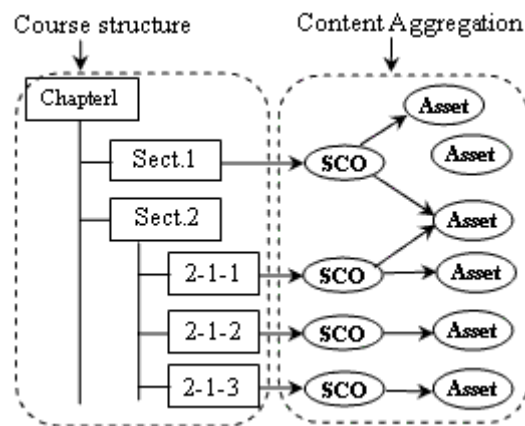


Fig. 1 Content model

We use the Content Aggregation Model (CAM) to define and package learning components. CAM structure consists of three parts: Content Model, Metadata and Content Packaging.

Content Model: Content model provide a reference model to organize the learning materials including: the decomposition of learning materials, the relation of learning components, and recomposing a course page as shown in Fig. 1. CAM contains three components: sharable content object (SCO), Asset and content aggregation. Asset is the basic and single-formed learning material, such as text, audio, etc. SCO is a meaningful sharable component composed by single or multiple assets. SCO is a basic learning object in SAPContent. Content aggregation defines the learning content structure. Through the structure defined in content aggregation, the system easily build up a larger learning resource.

Metadata: Metadata is used to describe the features of SCO, asset and content aggregation so as to speedup search, reuse and share.

Content packaging: Content packaging provides a standard mechanism to combine content model and metadata. In addition, it also supports the sharing and exchanging digital resources among different systems. The SAPContent uses a XML file –Manifest to pack courseware as shown in Fig. 2.

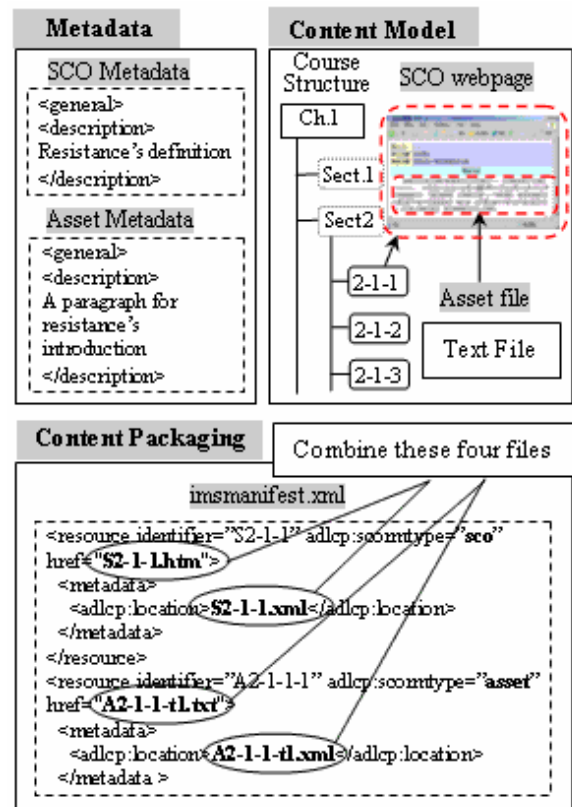


Fig. 2 A snapshot of content aggregation model in the SAPContent

Content attributes and metadata

To provide adaptability, SAPContent not only considers SCORM standard but also defines the following five attributes for learning contents:

- **Visibility:** Different learners have diverse backgrounds and abilities. Visibility attribute determines a learning object is visible or not.
- **Level:** To fit each learner's ability, level attribute defines the explanation and description degree for learning materials as shown in Fig. 3(a). The implementation of level is easily achieved via including different number of assets as shown in Fig. 3(b).
- **Difficulty:** Difficulty reveals that a learning object is easy to learn or not.
- **Relation:** Some learning objects hold specific relationship which also shows the appropriate learning sequence.
- **Necessity:** To reach a specific learning goal, some of the supplementary learning materials might be unnecessary.

Table 1 demonstrates the metadata for asset, SCO and content aggregation. Where the visibility of A2-1-1-2 = (F,T,T) represents asset A2-1-1-2 is invisible, visible and visible for L₁, L₂, and L₃, respectively.

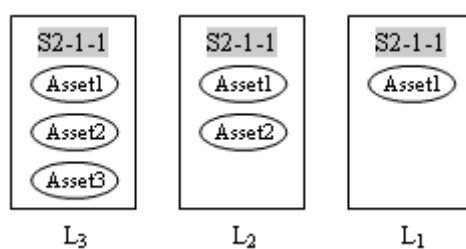
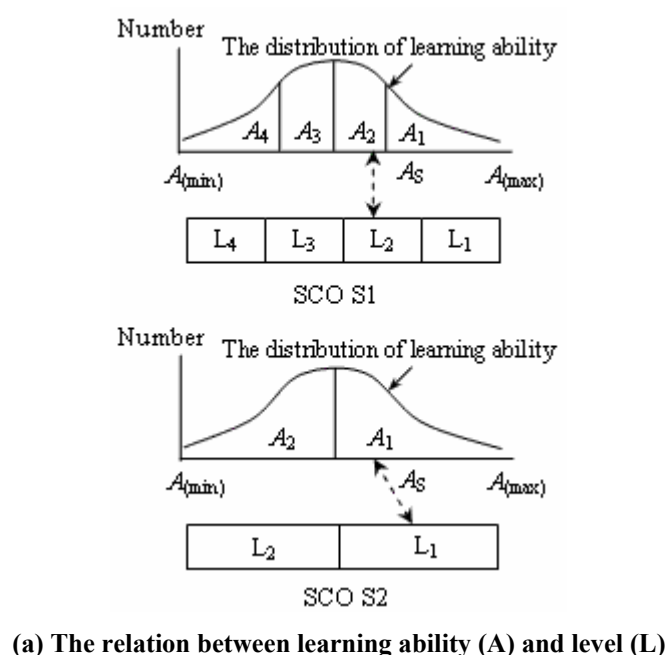


Fig. 3 Level attribute

Table 1 The metadata of asset, SCO and content aggregation

Content Aggregation Metadata	
Identifier	Content Aggregation's ID
SCOs	A list of used SCOs' IDs

SCO Metadata		
Identifier	SCO's ID	S2-1-1
Title	Unit title	Understand electric resistance
Assets	A list of used assets' IDs	A2-1-1-1 A2-1-1-2 A2-1-1-3
Difficulty	5 degrees (1~5)	2
Level	Explanation degrees	3

Relation	Related SCOs' IDs	S1-1-1
Description	Primary purpose of the SCO	Understand the definition and features of electric resistance

Asset Metadata		
Identifier	Visibility	Necessity
Asset's ID	T (visible) / F (invisible)	T (necessary) / F (unnecessary)
A2-1-1-1	(T,T,T)	T
A2-1-1-2	(F,T,T)	F
A2-1-1-3	(F,F,T)	F

SCORMize the learning process

The learning process of each student can be obtained via test evaluation and analysis of learning curve [3]. To provide sharable learning process information, SAPContent also SCORMizes the learning process of each student. SAPContent defines a basic sharable SCO for learning process to be the learning process of each basic learning unit. Figure 4 demonstrates the content aggregation of a class's learning process. Consider an example in Fig. 4, for student Kevin, the personal property contains his learning ability and average score. Each learning unit, denoted as Px-x-x, records his learning results for this unit including: learning score, ability, times and pass or not. Through a clear picture of each student's leaning process, SAPContent is capable of providing a adaptive and personalized learning environment to each learner. Table 2 lists the metadata of learning process. According to the collected information of learning process, SAPContent adapts each learner's learning environment as shown in Fig. 5.

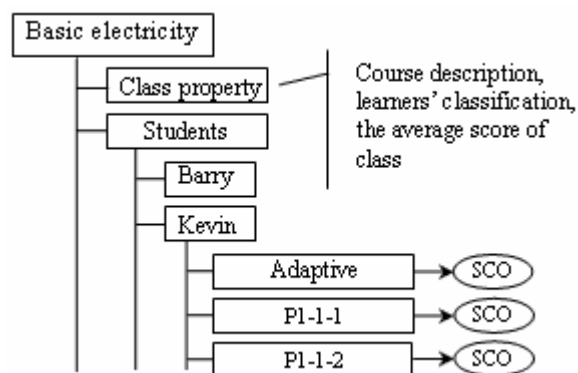


Fig. 4 The content aggregation of learning process

Table 2 The metadata of learning process

Learning Process Metadata			
Identifier	Learning unit's ID	P1-1-1	P2-1-1
Times	Unit learning times	1	1

Score	Unit score	80	60
Ability	Unit learning ability	40	30
Pass	T(pass) /F(fail)	T	F

Conclusion and future works

This work has proposed a SCORM compatible SAPContent capable of providing adaptive and personalized learning environment to users. SAPContent also SCORMizes the learning process to record the whole learning history for each student. Through the SCORMized learning process,

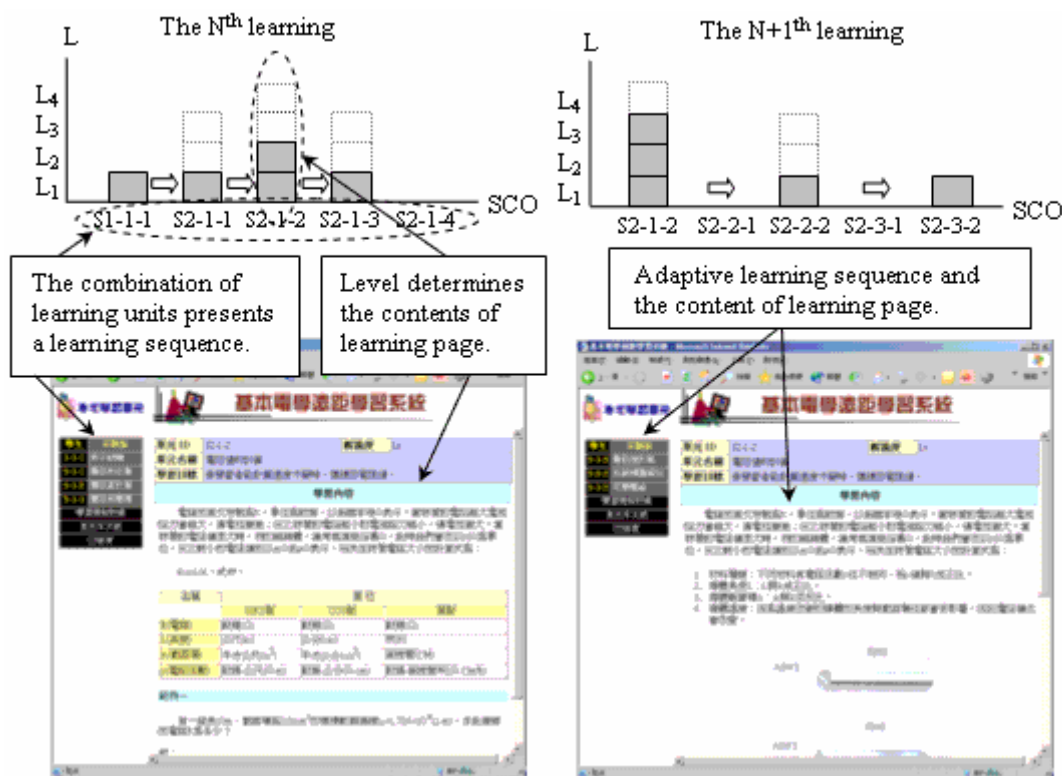


Fig. 5 A snapshot of adaptation processing of SAPContent

SAPContent obtains clear picture of each learner so as to provide personalized and adaptive learning environment. The idea of SAPContent has fulfilled via an online course – Basic Electricity. Real student experiment is undertaken and the collected initial results are excellent. Measurement results are still under collecting and analysis. In the future, the experiment results and analysis data will take into consideration to refine the SAPContent.

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Learning Objects for Introductory Computer Programming

This paper describes a project, which began two years ago at London Metropolitan University (LondonMet), the project was then extended to include Bolton Institute of Higher Education when one of the team took up a new post. Our work began with an urgent need to improve student success rates on introductory computer programming modules. Students needed to have a sound pedagogic resource to which they could return that would enable them to understand the different facets of the Java programming language. The most appropriate format for this resource was a set of Learning Objects (LOs) deployed on the web. During two years, this set of LOs has been used by over 1000 students at the two lead institutions and more recently by students from the University of Ulster; and they have been the subject of presentations at national and international conferences. Additionally, a link now exists with an international project with similar interests, Codewitz, to begin sharing objects. The expertise gained from designing these LOs has now been employed at LondonMet in Business and Polymers.

The aim of the project was to improve student success rates in introductory Java programming by moving away from a traditional delivery model to a blended learning model with a substantial e-learning component based around LOs managed by the virtual learning environment WebCT. The structural aspects of the Java language would form the subject matter for LOs, which would each address one learning outcome. The LOs were designed to use the principles of cohesion and de-coupling [1] by providing a succinct text based overview (Figure 1) from which additional links could provide animated explanations (Figure 2), simulations or quizzes giving immediate feedback.

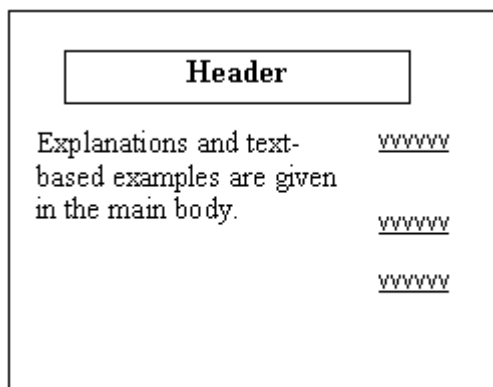


Figure 1 Showing expansion links

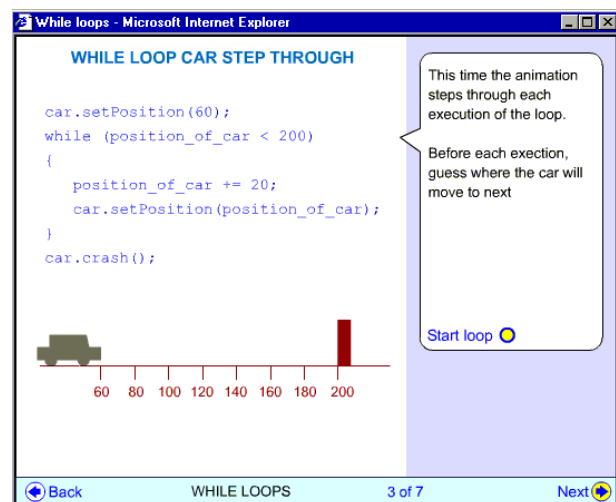


Figure 2 An animated explanation.

This design would facilitate re-engineering for any new contexts. LO development took place between a team of academics, the project's researcher and a multimedia developer responsible for Flash animations. In order to complement this visual approach student programming exercises were designed to produce a visual output. [2]. The new blend was received well by students, with increased pass rates and positive feedback (Figure 3) across both institutions. The average increase in pass rate measured against results in 2001-2 was 17% in 2002-3 and 20% in 2003-4.

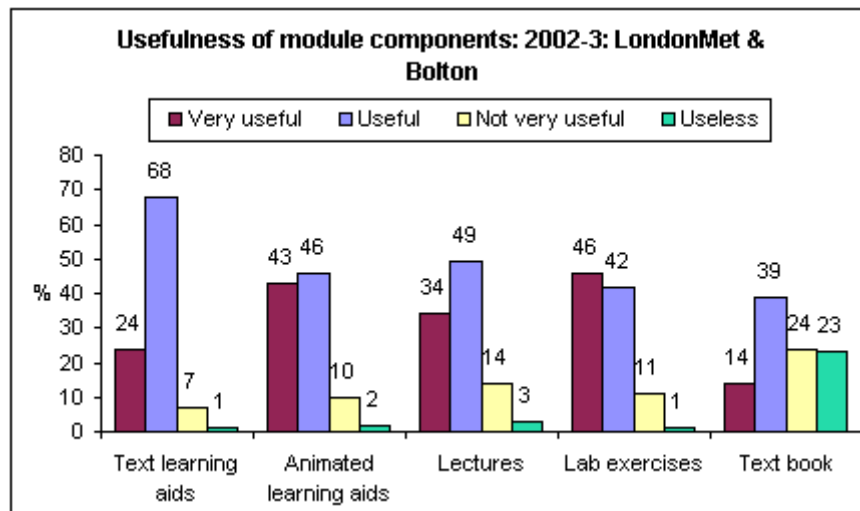


Figure 3 Student Questionnaire Feedback

Partly in response to feedback, in 2003-4 a new core text was introduced which used visual examples throughout. Some re-ordering took place together with the rewriting of some practical exercises to reflect the new examples from the book. Relatively little work was required on the LOs because of their generic design. Questionnaires issued at the end of this semester revealed that a slightly higher number of students found the LOs to be either useful or very useful (88% compared with 86% last year). Server statistics show that, after three semesters, LOs have been requested a total of 134,104 times. Access peaked during practical sessions, but about 25% of accesses were outside the hours of 9am to 6pm, indicating self-study. The results for this year show a further increase in pass rate. Also, a colleague from the University of Ulster reported obtaining very positive results from using the LOs in lectures.

LOs are unlikely to be reused if they are not easily available through a searchable online repository. LondonMet has recently become a member of the Codewitz consortium [3] in order to make the LOs developed available to a wider audience. Codewitz has created an international repository of LOs for programming, coordinated by Tampere Polytechnic in Finland. It is hoped that this reciprocal collaboration will increase the quantity and quality of available reusable resources and help to overcome the serious difficulties that students often have when starting to learn programming. The director of Codewitz, Esa Kujansuu, recently spoke at a LTSN-ICS symposium on "Learning Objects for Computing", held at LondonMet.

The initial design and development of the LOs for programming created a set of objects that had a similar format. This was refined through design reviews and resulted in a number of simple patterns, or templates, being developed. These templates were then reused to produce LOs for other programming topics. The development of these templates is an important feature of the project as they have encapsulated the design of a particular pedagogical process or sequence. Though they have yet to be properly documented, these templates exhibit some of the properties of software design patterns in that they "address a recurring design problem that arise in specific design situations and present a solution to it" [4]. The development of such patterns has resulted in extending reusability: not only are the LOs themselves reusable but the design is reusable as well. This has allowed our multimedia designers to employ the templates in different subject areas where similar pedagogical constructs are required. The templates are now being employed in areas as diverse as Business and Polymers.

The project has been successful in many ways: students have had the benefit of a rich learning resource which has provided significant help in their studies; the learning resources themselves have been reusable in different contexts; the learning object patterns have proved useful in other subject areas; and we have formed productive partnerships with other institutions with whom we hope to share pedagogical ideas and experiences, as well as learning objects.

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Degree of Scaffolding as Learning Object Metadata: A Prototype Learning System Design for Integrating GIS into a Civil Engineering Curriculum

Digital media and networking offer great potential as tools for enhancing classroom learning environments, both local and distant. One concept and related technological tool that can facilitate the effective application and distribution of digital educational resources is *learning objects* in combination with the SCORM (sharable content objects reference model) compliance framework. *Progressive scaffolding* is a learning design approach for educational systems that provides flexible guidance to students. We are in the process of utilizing this approach within a SCORM framework in the form of a multi-level instructional design. The associated metadata required by SCORM will describe the degree of scaffolding. This paper will discuss progressive scaffolding as it relates to SCORM compliant learning objects, within the context of the design of an application for integrating Geographic Information Systems (GIS) into the civil engineering curriculum at the University of Missouri – Rolla.

Learning Objects and SCORM Compliance

The goal of distributed learning networks is to provide a repository of sharable learning objects facilitated by information networks. Conceptually, this means that educators decompose their courses into a collection of fundamental elements, called *learning objects*, and make them available to an information network [1]. A learning object is a collection of web displayable material that has an associated learning objective. There are several goals to such a system. For the objects themselves, it is desired that they be *interoperable*, *accessible*, *durable*, and *reusable* [2].

Key to the success of a distributed learning environment is having a common architecture shared across the network to ensure the interoperability and accessibility of the learning objects. In 1999, Executive Order 131111 tasked the Department of Defense (DoD) “to develop common specifications and standards for technology-based learning” [3] resulting in the first draft of the *Sharable Content Object Reference Model* via the DoD’s Advanced Distributed Learning Initiative. The fundamental idea behind SCORM is to use XML to attach metadata tags to content objects. Using these tags, information networks can access and distribute learning objects to a variety of educational environments using *Learning Management Systems* (LMS).

Progressive Scaffolding

The term “Progressive scaffolding” is a term we use to refer to a systematic method of providing users with an optimal level of assistance. Within such a system, different levels or tiers of facilitation are provided to match the optimal levels of assistance required. The level could be set by the learner, an instructor, or automatically, based on learner response.

It’s important to note that, scaffolding, as defined within our framework, refers to guidance that supports the core content, which remains constant across differing levels of scaffolding. Therefore, degree of scaffolding, is not equivalent to difficulty of the content, rather it refers to the degree of supportive context provided.

As an initial exploration of progressive scaffolding, we carried out a usability study in which we varied degrees of scaffolding, where subjects were asked to produce a webpage using *Macromedia Dreamweaver®* with advanced features. Three levels of scaffolding were used: text, graphics, and video. A detailed qualitative and quantitative analysis of students’ performance with the system indicated that maximal performance occurred with students who used the scaffolds progressively and systematically. In general, these results indicated that providing students with a progressive set of scaffolding options can be a viable way to enhance learning [4, 5].

The purpose of our current project is to extend this work by creating multi-level sets of learning objects, which cover the same core content, but differ in the degree of associated scaffolding. The degree of scaffolding could then represent a dimension of metadata which would allow a given instructor or student to locate and implement content materials based on the degree of guidance included within the object.

We are in the process of designing and developing such a system for the creation of a learning system for teaching tools for implementing GIS within the context of civil engineering classes at the University of Missouri – Rolla.

Application: GIS for Civil Engineering

GIS is a computerized database management system that provides geographic access (capture, storage, retrieval, analysis and display) to spatial data. While the industry sector of civil engineering has begun the process of integrating GIS within itself, the academic world has been slower to respond. Since civil engineering is replete with uses for GIS functions, public agencies' (the civil engineer's primary employer) use of GIS technology is increasing rapidly. There exists a consequent need for civil engineers versed in GIS and able to apply GIS tools to civil engineering problems in innovative ways. The University of Missouri – Rolla was recently awarded a National Science Foundation Curriculum, Course, and Laboratory Improvement (NSF/CCLI) planning grant (Award No. DUE-0341016) to create a prototype of such a learning application. From the outset we are working to break content into sharable content objects, and to utilize progressive scaffolding as an important aspect of the object management design, as described above.

In this proof-of-concept project begun in February 2004, the learning system being developed for the civil engineering curriculum focuses on a geotechnical application. The prototype will consist of a comprehensive problem and an associated repository of learning objects organized using progressive scaffolding. Figure 1 is a flow chart representing a sequence of learning objectives associated with this problem that a student must navigate to achieve a comprehensive understanding of the problem. The overarching learning goal of the prototype system is to teach students how to use the GIS system to intuitively and efficiently solve the geotechnical problem. These objectives in combination with the digital material form the basis for constructing the learning objects. Examples of such digital content is seen in initial screen mock ups that represent two differing levels of scaffolding representing instruction in the process of opening a map in *Arcview®* GIS software. One of these is a portrayal of a video demo illustrating the process including some textual cues built into the video (Figure 2), and the other illustrates a pedagogical agent which is responding to an incorrect response on the part of the user (Figure 3).

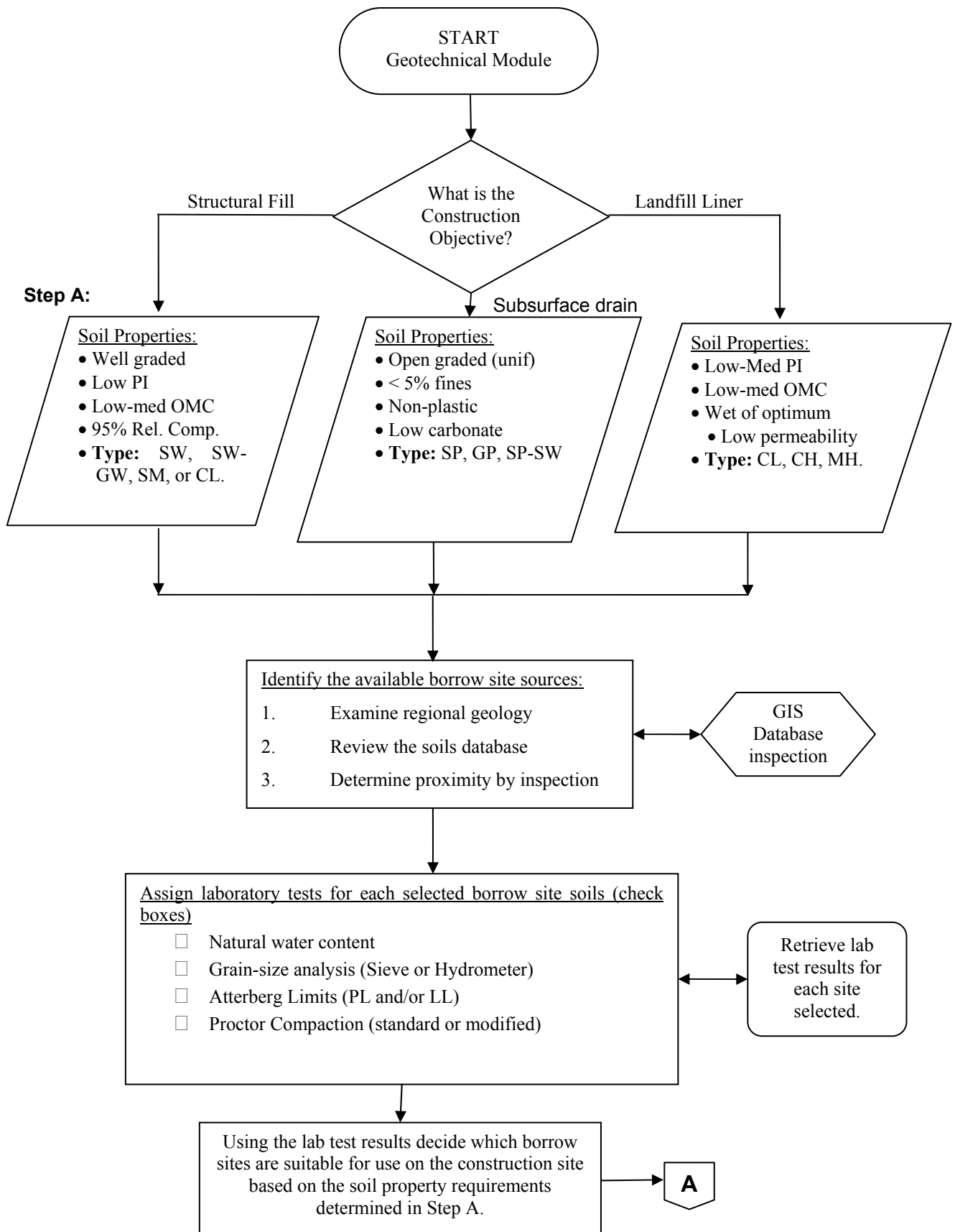


Figure 1. Portion of Flow Chart for Navigation of Learning System

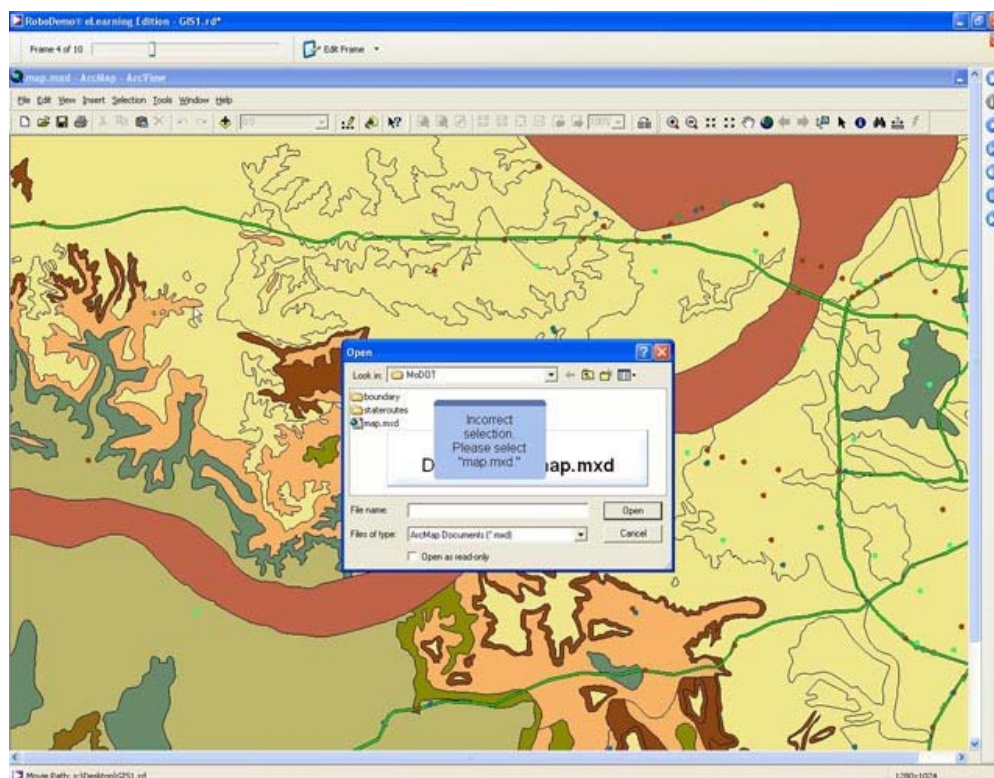


Figure 2. Screenshot of *Arcview@* with Interactive Video as Scaffolding

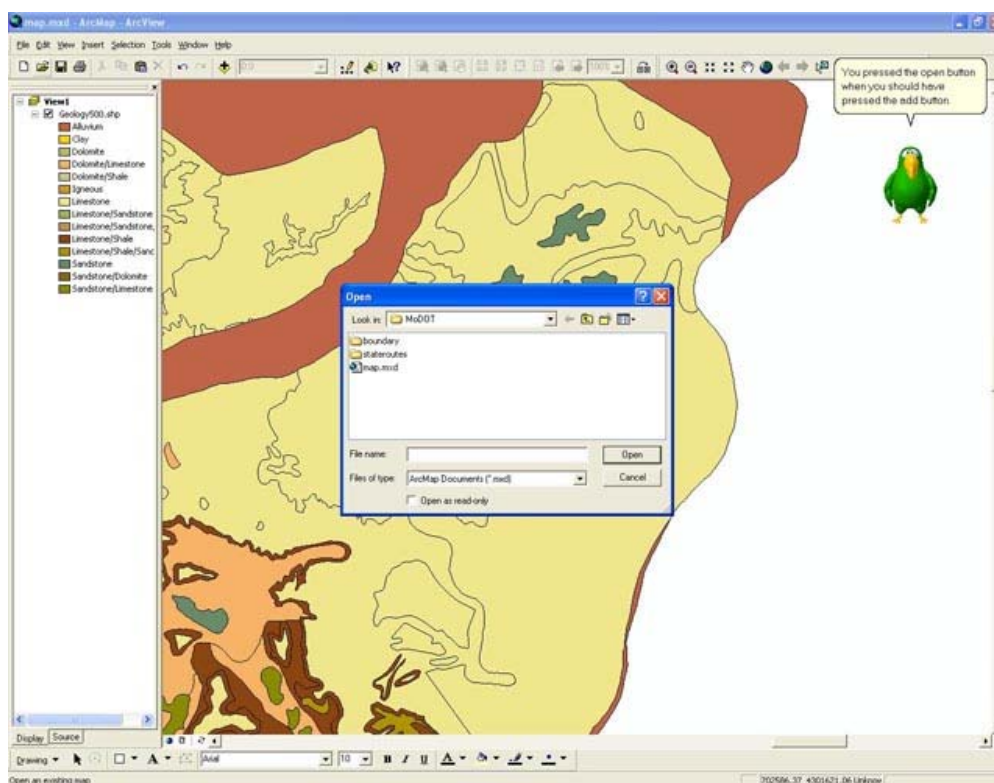


Figure 3. Screenshot of *Arcview@* with Pedagogical Agent as Scaffolding

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An Implementation of a LO Repository with Version Control

Introduction

Universities need both to incorporate new courses to the existing programs and to modify the old courses according to the new knowledge and development trends of the field. This means constant work in producing educational materials for the courses, especially in the rapidly developing field of computer science.

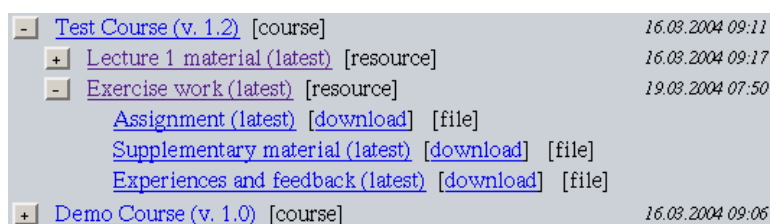
Open Source Courseware project [1] was launched to help with this problem 1) by creating a community to develop learning materials by open source principles and 2) by distributing the practical knowledge related to courses by organizing the courses distributively among several universities. The starting point for the project was a long-time tradition, similar to OpenCourseWare [4], to archive and publish course-related teaching materials on WWW. Since plain teaching materials are not enough to really transfer a course to another university, these are accompanied with process descriptions and experiences from the actual course implementations.

Although the IEEE Learning Object Metadata (LOM) [3] standard is most commonly used for materials designed for web-based learning, we found it suitable to be used also for courses with traditional teaching forms. It is essential that LOM provides description fields for material versions, since the materials are changing continuously and different sites may be interested in different versions. Surprisingly, the present repositories do not usually seem to consider this issue, and provide only the latest versions of the materials. Especially, when storing complete course packages, it is essential to provide teachers with a possibility to find and select learning materials and experience documents also from older courses.

In this paper, we introduce a material repository that uses a version control system to store both the metadata and the actual material content, as well as discuss some technical aspects of the repository.

Overview of the Learning Object Repository

As shown in Figure 1, our repository supports three aggregation levels of learning objects. These levels are nested; courses are divided into resources and resources compose of single files. The educational metadata is associated to courses and resources, and the technical information, i.e. location and size, is associated to the physical files. All resources contain also version information. Thus, in addition to the latest version, older versions can be accessed and modified.



-	Test Course (v. 1.2) [course]	16.03.2004 09:11
+	Lecture 1 material (latest) [resource]	16.03.2004 09:17
-	Exercise work (latest) [resource]	19.03.2004 07:50
	Assignment (latest) [download] [file]	
	Supplementary material (latest) [download] [file]	
	Experiences and feedback (latest) [download] [file]	
+	Demo Course (v. 1.0) [course]	16.03.2004 09:06

Figure 1. An example of the repository content

The user interface to the repository is web-based and provides possibilities for viewing, inserting, and modifying learning objects. Two search methods are supported: free text search and field-based search. The free text search returns the learning objects that have the queried keywords in any of their metadata fields. In the field-based approach, keyword search is restricted to the specified metadata fields.

Implementation of the repository system

The repository implementation uses CVS [2] version control system. All the learning objects and their metadata are stored into separate directories controlled by CVS. Each directory contains an XML formatted LOM file and the actual content file. Because each version of an object is stored as a new object, the total

amount of files is notably larger than in systems without knowledge of version history. Thus, it may become inefficient to implement queries on the repository data.

A possible, but slow solution to implement queries would be to use a method like XPath[5] to process every XML file and to return the learning objects that meet the search criteria. Our solution is to use a separate index to quickly locate the queried learning objects. The basis of the structure is an ordered list of words where each word is linked to a set of metadata fields. Each metadata field is further linked to a list of learning object references. This structure is illustrated in Figure 2, where the word “*exam*” occurs in the *general description*, *learning resource type* and *educational description* fields. The word “*exercise*” occurs only in the *general description* field. The index is updated every time when learning objects are inserted or modified.

Figure 3 illustrates the field-based search, when the keyword “*exam*” is searched from the *educational description* field. After selecting the metadata fields matching to the queried word, the system returns only the learning object references that are connected to the appropriate metadata field. Free text search returns all learning object references connected to any of the matching metadata fields. The index structure also allows the use of wildcard characters and different logical combinations of the search criteria.

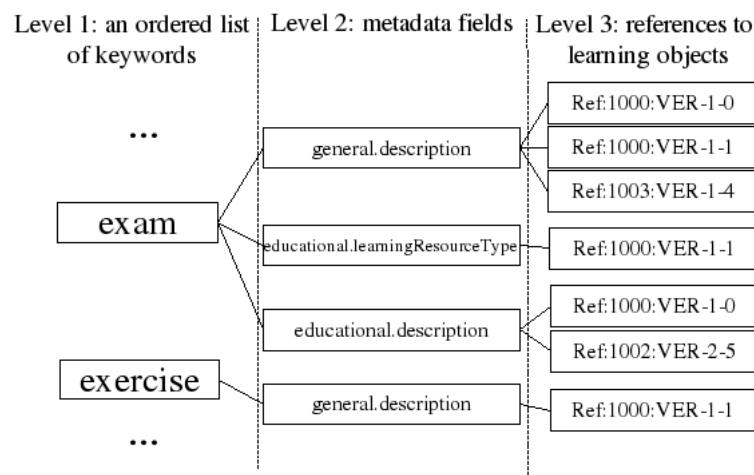


Figure 2. The structure of the metadata index.

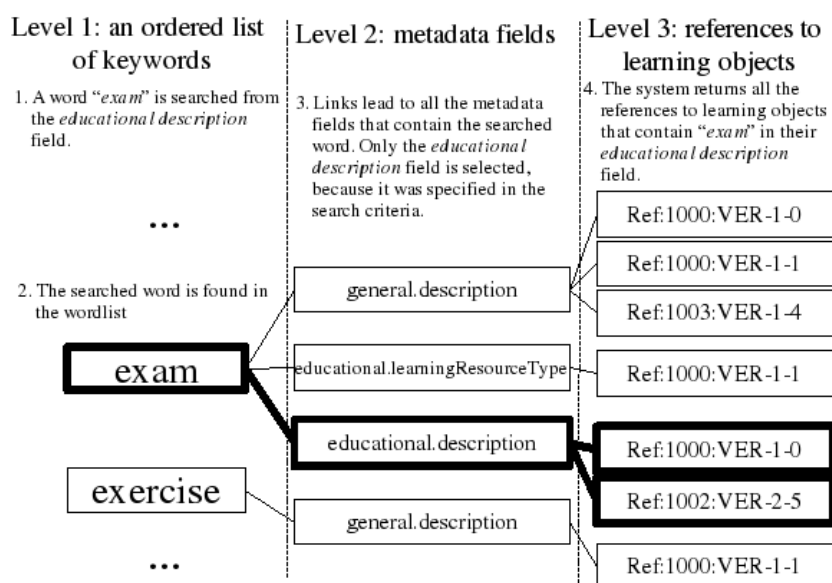


Figure 3. Implementing the field-based search.

Conclusion

Versioning provides users a possibility to search and use not only the latest but also the previous versions of the materials and course implementations. In the presented approach, all the metadata and the materials are stored as LOM compliant XML files to the version control system. The speed of this approach may not be as good as in those learning repository solutions that are implemented as relational database systems. Especially, making queries to this kind of a structure may be inefficient due to the large number of files. In our course repository, the solution is to use a separate index for implementing the search. Updating the repository takes a little more time, because the index must be updated and synchronized to the content metadata. However, the solution results in the significant speedup of the queries, which are the most common activities for the users.

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WWW-Based Courseware in Global Competition Advancement — the IE ADES Pilot Project

Motivation to the System Development

In Taiwan, almost all of businesses and industries have confronted the stress of global trade competition since Taiwan got into the WTO (World Trade Organization), thus how to improve the core productive competence of Taiwan firms is the primary destination for the survival in the trend of the trade globalization. One of the successful factors moving forward to the destination is to learn more advanced manufacturing/service knowledge without the limitation of working sites. The knowledge concerns with the ability of quickly responding to international market, the methods of reasonably reducing production/service costs and the tools of significantly increasing product quality. Unfortunately, Taiwan firms seem not to possess the knowledge well. Starting from the above respects, YZU decided to develop a distinguished WWW-based teaching environment from the traditional in-classroom-based one.

For the IE department of the YZU the authors are working, it has been planning to construct a WWW-based asynchronous distance education system (ADES) used to supply a training program special for improving the business productivity and international competition. The program contains the following four courses: (1) Logistics Information Techniques, (2) Engineering Economic Investment, (3) Computerized Production and Operations Management and (4) System Analysis and Design. These WWW-based teaching materials have been saved into the IE ADES platform developed with SCORM (Sharable Content Object Reference Model) specifications, which is a WWW-based learning information technique standards initiated by Advanced Distributed Learning (<http://www.adlnet.org>). The detailed implementation of the SCORM-based IE ADES will be introduced elsewhere because of the limited article space. This article does not focus on the concrete enabling SCORM constitutes, such as ASP.NET-based LMS (Learning Management System) and CMS (Content Management Service), but on the introduction of the above four WWW-based courseware into the IE ADES platform. Readers can see the following web site for LMS and CMS:

http://www.medvalue.net/live/medvalue/content/e83/e264/index_ger.html

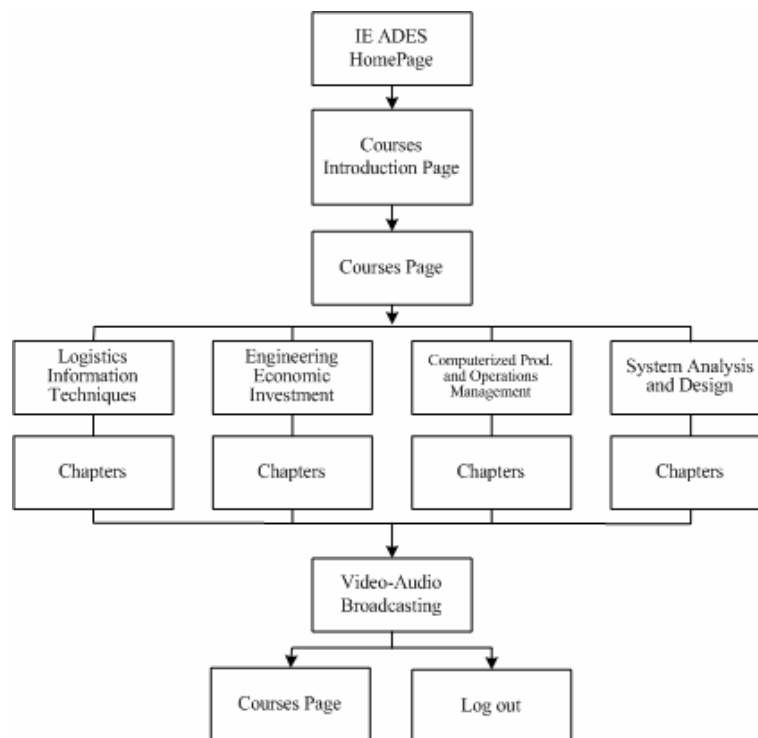


Figure 1. IE ADES courses management conceptual structure

System Architecture

The IE department has been developing its own ADES to provide spatial-temporal learners an easily accessed knowledge diffusion system. The ADES follows the “what you see is what you get” rules with Video-On-Demand (VOD) (i.e., click-based) retrieval and direct visualization of titles of training courses and their contents. A learner can first perform a search of the course title on his PC or browse through the all course titles on the IE department web site located at <http://www.yzu.edu.tw>. The conceptual courses management structure of IE ADES for WWW-based distance learning can be seen in Figure 1. Figure 2 shows a platform of a three-tier “browser/server/database” used to host the courses manager.

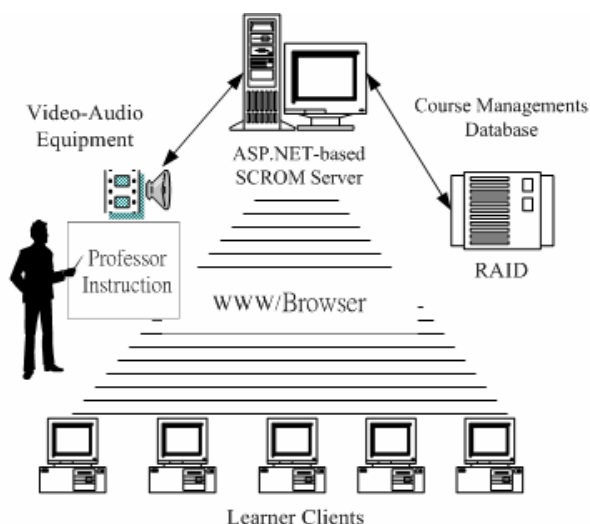


Figure 2. Three-tier architecture of browser/server/database for IE ADES

Server Description

Since both the practical education and response speed must be taken into account, IE ADES is broken down into two subsystems for separating static learning materials from dynamic explanation diagrams. The static learning material existing in the course management database is executed with ASP.NET on the instruction server PC for the WWW interruption prevention and the information transfer load alleviation. The dynamic explanation diagrams are performed with Macromedia Flash MX on the learner client PC for the prompt Flash film presentation and the WWW multimedia interactive effectiveness. The Macromedia Flash MX instrument also mediates the both subsystems. This lets IE ADES offer such a service with the learners' consent. The implementation cost of the server is low because all software instruments are the popular Microsoft products and the hardware is a P4 PC, as shown in Table 1.

Table 1. Tools of SCROM server

CPU	Pentium IV 2.66 G MHz
Memory	256MB SD RAM
Hard disk	80 G
Operating system	Microsoft Windows 2000 Server (Chinese Version)
Web server software	Microsoft Internet Information Server 5.0 (Chinese Version)
Data base	Microsoft Access 2000 (Chinese Version)
WWW design	Microsoft ASPNET (Chinese Version)
Interactive software	Macromedia Flash MX (Chinese Version)

Running Logic

When a learner arrives at the homepage of IE ADES made with the Flash tool (Figure 3), he/she will read the acknowledgement to Ministry of Education, Taiwan, for its partial financial support of the ADES development. Next, the learner can browse the four courses of the Global Competition Improvement Program, as shown in Figure 4.



Figure 3. Homepage of the IE ADES

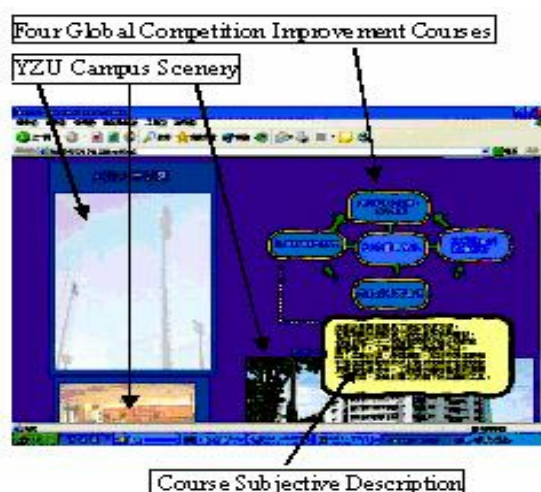


Figure 4. Course selection page

The learning profile of a student or a learner is a paramount record file that saves his/her learning performance and is used to adapt teaching-learning system for the performance improvement. If one wants to get into his profile, he must first have his own ID and password for reading his private learning profile (Figure 5). The profile contains the studying time and hours, homework grade, testing score and simple statistic data. Figure 6 is an interface of course functions where the Course Message Board posts the messages such as test dates and homework notice and the Course Selection displays a pull-down menu for browsing the courses.



Figure 5. Learning profile page

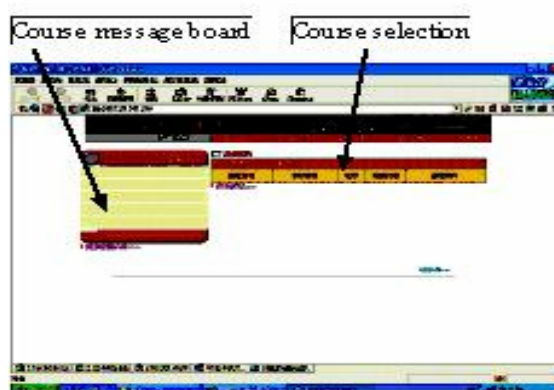


Figure 6. Course functions page

After a learner has found a course, the course's actual location also appears on the courses table. This feature lets the learner easily select the course chapter and its sections on the menu table, as shown in Figure 7. Each chapter consists of a set of sections that can be visualized as associated hypermedia learning subjects. Each section instructs a virtual learning material hierarchically composed of word text, mathematical formula, graphics, tables and other media types like XML documents. The hierarchy performs a very good way to direct learning and preparing for the learning materials of distinct courses such as liberal arts. These “comprehensive” functions attribute to the success of IE ADES design based on SCORM.



Figure 7. Virtual sections

More practical functions being added to IE ADES will let a learner get the information of other learners who are taking the same course. Specifically, the creation of an active learning and discussing index system provides the

dynamic learning supervision mechanism. This mechanism must not be set up in a traditional in-classroom if the diversified learner populations are taken into account.

Conclusions

This paper presented ideas and an organization of a WWW-based distance learning system designed primarily for teaching the global competition improvement courses, without losing the in-classroom advantage. The proposed IE ADES possesses the SCORM functions for designing multimedia learning materials, but they do not be introduced in this article because of the limited pages. In essence, the concepts of the integration including coupling educational content, mechanisms of adaptive hypermedia and distance learning process within IE ADES had been illustrated.

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Conference Announcements

IADIS International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2004)

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Lisbon, Portugal

<http://www.iadis.org/celda2004/>

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August 16-18, 2004

Sheraton Kauai Resort

Kauai, Hawaii, USA

<http://www.iasted.org/conferences/2004/hawaii/c428.htm>