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Chu Ting Cheung
Hong Va Leong
Qing Li (Eds.)

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Advances in Web-Based Learning

First International Conference, ICWL 2002
Hong Kong, China, August 17-19, 2002
Proceedings

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E-mail: csjfong@cityu.edu.hk

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Hong Va Leong
The Hong Kong Polytechnic University, Department of Computing
Hung Hom, Kowloon, Hong Kong
E-mail: {csronnie,cshleong}@comp.polyu.edu.hk

Qing Li
City University of Hong Kong,
Department of Computer Engineering and Information Technology
Kowloon Tong, Kowloon, Hong Kong
E-mail: itqli@cityu.edu.hk

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Message from the Conference Chair

The first International Conference on Web-Based Learning (ICWL) was organized by the Hong Kong Web Society, in cooperation with the City University of Hong Kong and Hong Kong Polytechnic University, and was hosted by VLDB 2002. Organizing ICWL 2002 was an exciting and very rewarding experience for me. The rapidly growing demand for e-learning is forcing educational institutions to expand in remote learning through the web in terms of technological and pedagogical development. The conference aims at providing an in-depth study of the technical, educational and management issues of web-based learning. The trend in education is to shift from a traditional teacher-centered learning environment to one that is student-centered.

ICWL 2002 included a regular track and an industrial track, consisting of both invited papers and submitted papers, selected from a collection of 75 submitted papers. The research papers presented in the conference will assist lecturers in effectively teaching their students in all kinds of various subjects through the web. A tutorial session was also offered to conference attendees for special web-based training.

I am thankful for the generous support of the conference sponsors: the City University of Hong Kong through Horace Ip, Hong Kong Polytechnic University through Keith Chan, Lingnan University through Irene Kwan, Hong Kong Pei Hua Education Foundation Limited, and the K.C. Wong Education Foundation. I would like to thank Qing Li and Weijia Jia of City University of Hong Kong for inviting 17 Mainland-China scholars to attend the conference. Li and Jia also reviewed presented papers at the conference for the purpose of publishing selected ones in the Journal of Distance Education Technologies. I appreciate very much the effort of Ronnie Cheung and Cherry Chan of Hong Kong Polytechnic University in organizing and operating the conference web-site, Hong Va Leong of Hong Kong Polytechnic University for contacting Springer-Verlag to arrange publication of the conference proceedings, Reggie Kwan and Jimmy Chan of the Open University of Hong Kong, and Anthony Fong of the City University of Hong Kong for organizing the conference industrial track with the publisher World Scientific, and T.Y. Cheung and Margaret Ng of the City University of Hong Kong for dealing with the conference logistics and local arrangements. Special thanks must go to all conference program committee members for reviewing submitted papers.

ICWL 2002 was also the first international conference organized by the Hong Kong Web Society. The society aims to facilitate web technology transfer among academic and industrial practitioners. The conference steering committee plans to hold the conference every year. On behalf of the Hong Kong Web Society, I am looking forward to your support of the conference next year.

August 2002 Joseph Fong

Message from the PC Co-Chairs

The development of Web-based learning has led to a revolution in traditional teaching methods. The rapidly growing demand for Web-Based Learning is forcing educational institutions to expand remote learning through the Web in terms of technological and pedagogical development. This conference aims at providing an in-depth study of the technical, pedagogical, and management issues of Web-based learning. The Hong Kong Web Society organized the first International Conference on Web-Based Learning (ICWL 2002) in conjunction with the City University of Hong Kong and Hong Kong Polytechnic University to provide a forum to bring together educators, researchers, technologists and implementors of Web-based learning from around the world to discuss the state of the art in this area.

The topics that were covered in the conference exhibit a very concise focus on the topics in Web-Based Learning. The ICWL 2002 conference included various sessions addressing issues such as: Virtual Classrooms, Virtual Laboratories/Universities, Distance Learning Architectures, Infrastructures for Web-Based Learning, Integrated and Collaborative Learning, Cyber Education Initiatives, Management of Learning Resources, Interactive e-Learning Systems, Knowledge Management for e-Learning, Database Architectures for e-Learning, and Multimedia Databases for Web-Based Learning.

The conference committee received 75 submissions from academic researchers from 19 countries. Each paper was sent to at least three international reviewers. Papers were reviewed and selected based on their originality, significance, correctness, relevance, and clarity of presentation. Among the high-quality submissions, 34 papers were selected for presentation at the conference and are included in this volume. The conference also invited well-known international scholars to deliver the keynote speeches and take part in interesting panel discussions. We are delighted to include the invited keynote presentation *A Growing Book for Distance Learning* by Prof. Shi-Kuo Chang.

We would like to thank all the authors who submitted papers, as their effort is the foundation of the success of every conference. Through the efforts of Qing Li and Weijia Jia, the conference also invited well-known scholars from mainland China. Our thanks also go to the international program committee members for their invaluable input and advice. We are also grateful to our sponsors for their generous support. Special thanks go to Prof. T.Y. Cheung, our honorable conference chair, the local team led by Keith Chan (organizing chair), Cherry Chan (conference secretary) for coordinating with the authors, and Hong Va Leong who also helped with the editing of this volume.

We must also express our gratitude to the steering committee members. ICWL 2002 was successful because of the invaluable input and advice from the following steering committee members: Shi-Kuo Chang from the University of Pittsburgh, Joseph Fong from the Hong Kong Web Society, Qing Li from the City University of Hong Kong, Xiaoming Li from Beijing University, Maria Orlowska from the University of Queensland, and Timothy Shih from Tamkang University.

On behalf of the organizing and program committees of ICWL 2002 we trust you found the conference a fruitful experience and hope you had an enjoyable stay in Hong Kong.

August 2002 Ronnie Cheung, Weijia Jia, Reggie Kwan

First International Conference on Web-Based Learning (ICWL 2002) August 17–19, 2002, Hong Kong, China

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A Growing Book for Distance Learning

Shi-Kuo Chang

Department of Computer Science
University of Pittsburgh, Pittsburgh, USA
chang@cs.pitt.edu
http://www.cs.pitt.edu/~chang

Abstract. The Growing Book is an ever-expanding body of knowledge created by a team of experts. It is an electronic book co-developed by a group of teachers who are geographically dispersed throughout the world and collaborate in teaching and research. Since the course materials are constantly evolving, the Growing Book must be constantly updated. The Growing Book is used by each teacher both in the local classroom as well as in the distance learning environment and accessible by multilingual students. Each chapter of he Growing Book is owned by an instructor who may utilize different tools for distance learning, self learning and assessment. A macro university framework provides the experimental test bed to investigate how to design and manage the growing book so that it can be accessed by people with different linguistic skills for effective teaching and research. We describe the basic operations such as Match, Abstract, Weave and Customize, which can be used to extract and organize information from the multi-level, multimedia, multi-lingual book.

1 Introduction

A *Growing Book* is an electronic book co-developed by a group of teachers who are geographically dispersed throughout the world and collaborate in teaching and research. Since the course materials are constantly evolving, the Growing Book must be constantly updated and expanded. The Growing Book is used by each teacher both in the local classroom as well as in the world-wide distance learning environment. Therefore the Growing Book must be accessible by multi-lingual students. The chapters of the Growing Book are owned by different authors who may utilize and/or provide different tools for distance learning, self learning and assessment.

The Macro University provides an experimental test bed for the Growing Book. The Macro University is a distance learning framework consisting of three layers: the micro-university [2], the virtual university, and the macro university. A micro-university is a self-contained learning environment, usually on a single PC (or laptop, notebook, palmtop, PDA, etc.) for a single student interacting with a teacher. A micro-university is designed to serve a single individual, but of course many instances of

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the same micro-university can be created to serve many students. A virtual university is a collection of individualized learning environments so that students can engage in learning activities from home, remote locations, etc. A virtual university is usually owned and operated by an academic institution and therefore has more administrative functions than a micro-university. The Macro University is a framework such that many virtual universities can pool their resources together, thus creating a very rich learning environment for a large number of students from all over the world.

The structure of the Macro University is illustrated by Figure 1. As mentioned above, a micro-university is a teaching or learning environment for an individual teacher/student, designed to serve the needs of that teacher/student. In particular, a micro-university may be a Growing Book as shown in Figure 1, where two of the micro-universities are Growing Books. A virtual university consists of one or more micro-universities. In the limiting case a virtual university is the same as a single micro-university. But usually a virtual university consists of many micro-universities and in addition can perform many complex administrative functions supported by a virtual administration office. The administrative tools include software tools for managing users, curriculum, facilities, resources, plans, etc. Each of the above tools can be used by the authorized users according to their roles and responsibilities in a virtual university. Virtual universities can be small, medium or large. It can be a single software module, a few software modules, or a complex configuration of software modules. For example, the Virtual universities of the Macro University may include: the Growing Book, Virtual Course-room, Virtual Collaboration Room [4], Virtual Laboratory, Virtual Library and Virtual Private Office, each of which can operate on a dynamically changing collection of tele-action objects [1, 3].

```
                ----Virtual University 1----Micro-University 1 (the Growing Book)
                |
Macro University
                |
                |           ----Micro-University 2 (the Growing Book)
                |           |
                ----Virtual University 2
                     ^       |
                     |      ----Micro-University 3
                     |
                  Virtual Administration Office
```

Figure 1. The structure of the Macro University.

In what follows, we describe a conceptual framework on how to design and manage the Growing Book. The basic MAWC (Match, Abstract, Weave and Customize) operations on the Growing Book are then presented.

2 A Multi-level, Multi-lingual, and Multi-modal Growing Book

As described above, the Macro University is a worldwide consortium of Virtual Universities. As such there will be a wide variety of curricula and educational programs for peoples with different linguistic skills, different cultures, and different perceptual preferences. The Growing Book should support the multi-level, multi-lingual and multi-modal usage of the shared content co-developed by many teachers. (a) **Multi-Level Usage**: The same course materials can be organized in different ways to be used in a regular semester course, a short course, an introductory exposition, an advanced seminar, etc. (b) **Multi-lingual Usage**: The same course materials can be transformed into different languages. (c) **Multi-Model Usage**: The same course materials can be used by people with different perceptual preferences and various handicaps.

The Macro University Consortium was established in the Spring of 1999 and now has more than seventeen international members. The participants of the Macro University are currently working together to develop a prototype Growing Book. The prototype Growing Book has the following characteristics: course materials accessible with a browser; common look-and-feel and common buttons; common assessment tool with adjustable granularity [5]; individual tools downloadable as plug-ins; examples in C and Java; adaptive learning with embedded audio/video clips; collaboration in content and tools evaluation, and availability in hard copy and CD. The prototype Growing Book is intended as a textbook for an undergraduate course on *data structures and algorithms*. The initial version of the Growing Book is already available for experimental purposes, and hard copies will be published by World Scientific Publishers.

In the Growing Book project, *adaptability*, *scalability* and *universal accessibility* are emphasized, which are driven by both teacher and student, so that the student feels to be actively driving his/her course like a helmsman in a motor boat, requesting explanations, special documents, homework corrections, etc. In this sense *interactivity* is a basic issue in the Growing Book model. We emphasize interactivity in managing all the different type of documents such as images, text, video clips, audio, etc., reflecting a teaching/learning communication model. The teacher may send multimedia documents and, without cumbersome delays, students may request explanations, ad-hoc documents that may enrich the lecture/exercise on a real-time basis. We also emphasize common assessment software tools, plug-ins for common platforms, multi-lingual capability through a button, truly effective distributed teaching, and lively animation and/or visualization of algorithms. The Growing Book thus poses many challenging research issues.

3 Operations for the Growing Book

As discussed in Section 2, students, teachers and authors all need an interactive language built upon some basic operations (triggered as events on specific and specified parts of the multimedia documents) that simplify their response with respect to novel concepts in a given course, retrieving extra documents from virtual libraries, or simply communicating with other students and/or other teachers. In this way there may be an enrichment with respect to a standard series of documents as when a new view is obtained with respect to the processing of a query in a given database management system.

The Growing Book is characterized by a *book profile* consisting of *chapter profiles*, each of which is a list of (attribute-name, attribute-value) pairs. As an example Chapter 1 of the Growing Book has the following chapter profile:

Chapter_No: 1
Chapter_Title: Stacks
Author_Affiliation: Knowledge Systems Institute
Author: fthulin@ksi.edu,1234
Chapter_URL: http://www.cs.pitt.edu/~chang/bookds/01htm/chap1.htm
Book_Password: 123
Chapter_Password: sem010
Teacher: chang@cs.pitt.edu,B122L judy@ksi.edu,044hw
Student: jung@cs.pitt.edu,7777x changsk@ksi.edu,xi43w
Who_is_Who: guru@cs.pitt.edu
Center_of_Excellence: www.ksi.edu
Reference: www.branden.edu
Tool: www.abs.com
Awareness: jung@cs.pitt.edu,10111 changsk@ksi.edu,10000

The *awareness attributes* are shown in bold face. For each chapter, the interested students, teachers and authors can each have their individual awareness vectors. Taken together, these awareness vectors determine the *student profile*, *teacher profile* and *author profile*. In other words, a user's profile is shaped by what he/she is aware of or what he/she wants to be aware of.

In what follows, the basic operations are divided into several groups. The operations of multi-level, multimedia matching, abstraction, weaving and presentation, and the concept of awareness, will be explained.

3.1 Operations for Multi-level, Multi-media Customization

The first group of operations support the matching, abstraction, weaving and customization of multimedia documents. These are called MAWC operations.

MATCH Chapter_No Paragraph: Select a paragraph of the chapter with Chapter_No, and find all documents that match the selected paragraph by keyword matching.

ABSTRACT Chapter_No Level_No: Create an abstraction of the chapter with Chapter_No at Level_No. For instance, Level 1 is title and a few keywords, Level 2 is title and immediate sub-sections, Level 3 includes all sub-sections, and Level 4 is the document itself.

WEAVE Chapter_No Tag Tool: Weave the pieces in Chapter_No that are surrounded by < Tag > and < /Tag > into a presentation stream, where Tag is defined for a specific media type.

CUSTOMIZE Chapter_No Tool: Apply Tool to materialize and customize the presentation from a presentation stream created by the WEAVE operation.

3.2 Operations for Increasing and/or Updating Awareness

The user can specify an *awareness vector* so that he/she can be informed about certain events. The awareness vector is a binary vector where each entry indicates the absence/presence of an awareness attribute. For example the awareness vector can be (1,0,1,1,0), indicating the user wants to be aware of any changes in fellow students (1st entry), domain experts (2nd entry), centers of excellence (3rd entry), references (4th entry) and tools (5th entry). A user can also set privacy, so that he/she is not included in any awareness information.

AWARE Chapter_No Name Password: In the chapter with Chapter_No, if Name and Password is in Author, Student or Teacher list, display info Name should be aware of.

CHECK_AWARENESS Chapter_No Name Password: In the chapterwith Chapter_No, search Author, Teacher and Student lists for matched Name and Password, and if found, display the Awareness Profile for Name.

SET_AWARENESS Chapter_No Name Password Profile: In the chapter with Chapter_No, search Author, Teacher and Student lists for matched Name and Password, and if found, add or reset the Awareness of Name to Name,Profile.

SET_PRIVACY Chapter_No Name Password: In the chapter with Chapter_No, search Author, Teacher and Student lists for matched Name and Password, and if found, add Name to Privacy list.

CLEAR_PRIVACY Chapter_No Name Password: In the chapter with Chapter_No, search Author, Teacher and Student lists for matched Name and Password, and if found, remove Name from Privacy list.

3.3 Operations for Communication

Communication operations are for sending messages to authors, teachers and fellow students. A user may not know their exact names and/or e-mail addresses, but he/she still can send messages to the group of people he/she wants to communicate with.

SEND_AUTHOR Chapter_No Message: Send Message to the Author(s) of Chapter_No.

SEND_STUDENT Chapter_No Message: Send Message to the Student(s) of Chapter_No.

SEND_TEACHER Chapter_No Message: Send Message to the Teacher(s) of Chapter_No.

3.4 Operations for Managing the Growing Book

There are many operations for gathering statistics and managing the Growing Book. Some of them are listed here. In addition to these, there are operations for version control and version management.

SEARCH_STUDENT Student_Name Book_Password: Find all chapters that Student_Name is studying.

ENROLLED Chapter_no Teacher_name Teacher_password: List students studying a chapter.

ADD_STUDENT Chapter_No Chapter_Password Student Password: If Chapter_Password
is correct, add Student,Password to the student(s) of Chapter_No.

DROP_STUDENT Chapter_No Chapter_Password Student: If Chapter_Password is correct, drop Student,Password drop the student(s) of Chapter_No.

DROP_STUDENT_ALL Chapter_No Chapter_Password Student: If Chapter_Password is correct, drop Student,Password drop the student(s) of Chapter_No.

CH_TEA_PWD Name Old_Pwd New_Pwd: Change password

ADD_CHAPTER Chapter_No Chapter_Password Book_password: Add a new chapter.

DELETE_CHAPTER Chapter_No Chapter_password Book_password: Drop an old chapter.

The Growing Book operations are implemented as commands for the customized IC Manager [1] of the Growing Book. When the user submits a command to the Growing Book, the customized IC Manager processes this command. The command consists of a name and its parameters. The command name is treated as a message type by the IC Manager to be passed on, together with the parameters, to the appropriate IC for processing. The Growing Book operations are implemented as actions (C programs) of the ICs managed by the IC Manager.

4 Applications in Distance Learning

In this section we first describe how a user applies the operations on the Growing Book to produce customized books. Figure 2 shows the initial screen for the Growing Book. The user can list the currently available books, create a new book, delete a book, update the book profile and login a book. Once the user has selected a book to login, the Growing Book retrieves the book profile and dynamically creates the table-of-contents, as illustrated by Figure 3.

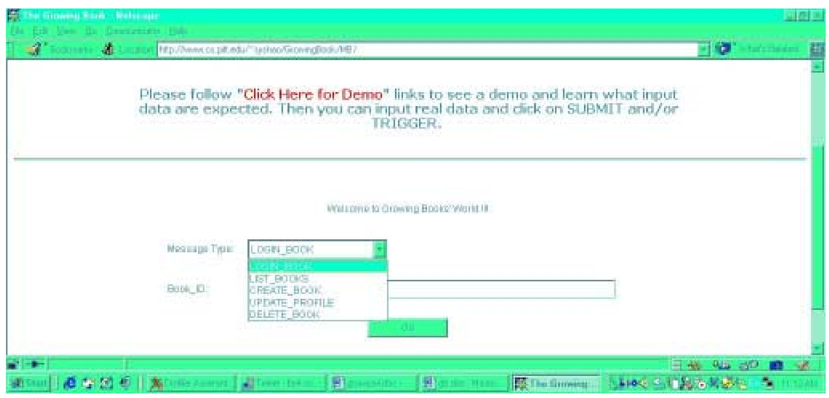

Fig. 2. The initial screen for the Growing Book

The user can now apply the Growing Book commands to search for the learning materials and present the learning materials at a level of abstraction of his/her choice. To experiment with the Growing Book, the reader can visit its website: http://www.cs.pitt.edu/~jung/GrowingBook/

Fig. 3. The table of contents is generated dynamically from the book profile

An experimental version of the Growing Book has been integrated into the distance learning environment at Knowledge Systems Institute, which is a private, not-for-profit graduate school of computer and information sciences founded by the author. The school offers accredited MS degree programs with concentrations in management information systems, software engineering, computer based education, bio-informatics e-commerce, etc. Knowledge Systems Institute's website is:

http://www.ksi.edu

and its distance learning website is:

DistanceLearning.ksi.edu

Fig. 4. The Distance Learning environment at Knowledge Systems Institute

Figure 4 illustrates the DL demo lectures top page of the distance learning environment at Knowledge Systems Institute. A potential student is first introduced into the welcome page of the environment. To find out how the distance learning environment works, the student can take a look at sample lectures and class listings. After a student has registered, an orientation is provided. Online help desk is available to provide support to the student.

Figure 5 shows a sample lecture. A book consists of many lectures, and each lecture consists of one or more slide presentations. At the end of each lecture there are lecture summary, review questions and sample quizzes.

Each online course is also a Growing Book. The user may choose not to use the Growing Book operations, in which case the lectures are static. If the user chooses to use the Growing Book operations, more information at different levels of detail can be obtained from the distance learning environment. This optional feature imposes no pressure on the students but offers additional support to the student when he/she becomes more proficient with the distance learning environment.

Fig. 5. A sample lecture

5 A Formal Model for the Growing Book Operations

To facilitate MATCH, ABSTRACT, WEAVE and CUSTOMIZE, we extend the HTML language by introducing a number of new tags. We will call these tags the MAWC tags. These new tags can also be considered as XML tags if XML is chosen as the base language.

In the following example we have two objects, o_1 and o_2. o_1 has two objects within it, o_{11} and o_{12}, and o_{12} has one object o_{121}. o_2 has one object which is o_{21}. The structure is kept by the order in which the strings appear in the file, in a top-down manner. so the structure and sequence of the presentation is preserved. The same pattern will be used for the multimedia strings as well.

```
<ts>
  <ts1>.............</ts1>
    <ts11>............</ts11>
    <ts12>............</ts12>
      <ts121>...........</ts121>
  <ts2>.............</ts2>
    <ts21>............</ts21>
</ts>
```

As a natural extension, let us consider the MAWC tags as: <ts1 parameters>. The parameters provide more detailed information on the objects. For example:

```
<ts1 name="chap1" keywords="tree, graph" url="URL_address" type=”mixed”>
```

We now present a formal model for MAWC operations. First of all, it is clear that the definition of objects is recursive, i.e., if $O_1, O_2, \ldots, O_n$ are objects, so is $\{O_1, O_2, \ldots, O_n\}$, where '{' corresponds to the <ts> tag, and '}' the </ts> tag. In general an object **O** is a well-formed expression ϕ involving other objects O_i, the opening bracket '{' and the closing bracket '}'. We write

$$\mathbf{O} = \phi\{O_1, O_2, \ldots, O_n\}.$$

Each object O_i has an *object profile* $P_i = (p^1_i, p^2_i, \ldots, p^m_i)$ where each attribute p^j_i denotes some known characteristics of O_i.

Given an expression $\phi\{O_1, O_2, \ldots, O_n\}$, the *level number* λ_i of an object O_i is the number of '{' that precedes O_i, minus the number of '}' that precedes O_i in the expression $\phi\{O_1, O_2, \ldots, O_n\}$. For a well-formed expression, the level number λ is always a positive integer.

a) The MATCH operation, $\mu_\sigma(\phi_1\{O_1, O_2, \ldots, O_n\}, \phi_2\{O'_1, O'_2, \ldots, O'_m\})$ extracts from $\phi_2\{O'_1, O'_2, \ldots, O'_m\}$ all the objects O'_i that are similar to $\phi_1\{O_1, O_2, \ldots, O_n\}$ with respect to the similarity function σ.

$$\mu_\sigma(\phi_1\{O_1, O_2, \ldots, O_n\}, \phi_2\{O'_1, O'_2, \ldots, O'_m\}) = \phi_2\{O'_1, O'_2, \ldots, O'_m\}$$

where O'_i in $\{O'_1, O'_2, \ldots, O'_m\}$ is similar to $\phi_1\{O_1, O_2, \ldots, O_n\}$ with respect to σ.

b) The ABSTRACT operation $\alpha_\lambda(\phi\{O_1, O_2, \ldots, O_n\})$ extracts all objects of level λ.

$$\alpha_\lambda(\phi\{O_1, O_2, \ldots, O_n\}) = \phi\{O'_1, O'_2, \ldots, O'_n\}$$

where λ'_i of O'_i in $\{O_1, O_2, \ldots, O_n\}$is equal to λ.

c) The WEAVE operation, $\omega_{type\text{-}k}(\phi\{O_1, O_2, \ldots, O_n\})$ weaves all type-k objects in $\phi\{O_1, O_2, \ldots, O_n\}$ into a new expression $\phi'\{O'_1, O'_2, \ldots, O'_n\}$. The predicate type-k is evaluated on the object profiles.

$$\omega_{type\text{-}k}(\phi\{O_1, O_2, \ldots, O_n\}) = \phi'\{O'_1, O'_2, \ldots, O'_n\}$$

where O'_i in$\{O_1, O_2, \ldots, O_n\}$is of type-k.

d) The CUSTOMIZE operation, $\chi_\upsilon(\phi\{O_1, O_2, \ldots, O_n\})$ creates a new expression $\phi'\{O'_1, O'_2, \ldots, O'_n\}$ that satisfies certain constraint υ on the expression.

$$\chi_\upsilon(\phi\{O_1, O_2, \ldots, O_n\}) = \phi'\{O_1, O_2, \ldots, O_n\}$$

where ϕ' satisfies certain constraint υ.

A MAWC operation has one (or two) expressions as arguments, and also returns an expression. In other words, both the input and the output are MAWC tagged documents.

Given a document with MAWC tags, the corresponding multiple level content tree can be constructed. Learning materials can be considered as a multimedia presentation (e.g. a collection of text, video, audio, image…etc.) with some kind of sequencing. The multiple level content tree supports the abstraction operation, which may be used as an efficient summarizing method.

6 Evaluation of the Growing Book

After a Growing Book has been created and the algorithms to visualize and access the objects in the Growing Book determined, we will put the Growing Book to test in the real distance learning environment, such as the one at Knowledge Systems Institute, and evaluate its use with different distance learning models.

The three basic ingredients of learning are the *learning materials*, the *teacher* and the *fellow students*. For any learning system to be successful, one must have easy and continuous access to all these three basic ingredients of learning. In distance learning some or all of the three basic ingredients of learning can be accessed at a distance. Depending upon what technologies are available - snail mail, telephone, radio, television, Internet, etc. - the resulting learning systems can be very different. However there are two basic distance learning models: the broadcast model and the interactive model. In the *broadcast model*, learning materials are provided at a distance, and a student learns by himself/herself. In the *interactive model*, class begins and ends on a particular day, and the teacher interacts constantly with students. The two basic models can be combined into other *hybrid models*.

Since a Growing Book is essentially a distributed knowledge source, an instructor can use it to teach both local students as well as non-local students, by combining live teaching with other modalities in instructional delivery. The question is: how should one combine these different modalities in instructional delivery? In other words, the Growing Book enables the teacher to experiment with different hybrid models for distance learning.

Although live teaching intuitively is the most effective, it is also probably the most costly, where cost can be measured by the instructor's time devoted to interacting with the students. The other modalities, while costing less, may be less effective. It will be a logical approach, if an instructor uses live teaching in one class period, followed by a few lectures delivered using other modalities of instructional delivery in the subsequent class periods. The result is a hybrid distance learning model. We can formulate hybrid assessment model as well.

In the real situation the hybrid learning model and the hybrid assessment model are interleaved. Assessment will be given after a lecture, followed by another similar interleaved process. The content of current assessment (or test) can be designed based on the content of previous assessments (or tests), or based on the content of instructional materials.

The assumption behind this scenario is that the effectiveness of live teaching in a class period will last for a few subsequent class periods. We call it the *residual teaching effectiveness*. However, such residual teaching effectiveness tends to wane and therefore must be reinforced by another live lecture and so on. The teaching experience of many teachers in various distance learning environments tends to confirm this assumption, but it requires more study. Also, the assessment process will test the hypothesis of effectiveness, which reflects the degree of understanding.

We define the *immediate teaching effectiveness* (ITE) of a class period n as monotonically increasing functions of the *degree of interaction* (DOI) of that class/assessment period, or the *degrees of understanding* (DOU) of an assessment outcome. In other words ITE(n) is set to f_1(DOI(n)) if class period n is a lecture, or f_2(DOU(n)) if class period n is an assessment.

The DOI can be determined based on class situation (i.e., how intensive the students ask questions), or the amount of communication data transmitted (e.g., for video/audio conference). The DOU can be defined as the outcome of a test or an assignment (i.e., the percentage of correct answers). The monotonic functions f_1 and f_2 reflect the effectiveness. In general, it is possible that the assessment process will enforce students to learn better, as compared to a class instruction. Therefore, f_2 will return a higher value as compared to f_1. However, this hypothesis requires some field test to justify the degree of significance and the correctness.

The *cost* of a class period is a monotonically increasing function of the degree of interaction of that class period, i.e., cost(n) is set to either g_1(DOI(n)) or g_2(DOU(n)). The *total cost* of a class, COST, is the sum of the costs of all class periods. The *teaching effectiveness* (TE) of a class period is the sum of immediate teaching effectiveness of that class period and *residual teaching effectiveness* (RTE) defined as a fraction of the teaching effectiveness of the previous class period. If RTE(n) is a_n TE(n -1), where a_n is a constant between 0 and 1, then the teaching effectiveness for the class period n can be expressed as follows: TE(n) = ITE(n) + RTE(n) = ITE(n) + a_n TE(n -1) = ITE(n) + a_n ITE(n -1) + a_n a_{n-1} ITE(n -2) + ... a_n a_{n-1} .. a_1 ITE(1). The value of a_n also depends on the activity of class period n. If the class period is for a test, the value of a_n is generally higher. This fact can be argued based on the pressure the students received from a quiz, an assignment, or a final exam.

Finally, the *cumulative teaching effectiveness* (CTE) is the sum of the teaching effectiveness of all class periods: CTE = TE(n) + TE(n -1) + ... + TE(1). Stated as an optimization problem, the problem of *distance learning strategy design* is to select the degree of interaction of each class period DOI(i) (or DOU(i)) such that the cumulative teaching effectiveness CTE is maximized, subject to the constraints that 1) the teaching effectiveness TE(n) for every class period is above a threshold b, and 2) the total cost of a class is below a threshold c.

Our hypothesis can be stated as follows: *the distance learning strategy that achieves the maximum cumulative teaching effectiveness using the Growing Book with a given cost constraint is the hybrid distance learning strategy where the degree of interaction varies from class period to class period*. To test this hypothesis, we will conduct the following experiments.

The Growing Book will first be used at a single institution by a single teacher to experiment with the hybrid distance learning model.

Then the Growing Book will be used at two institutions by a single teacher to experiment with the hybrid distance learning model.

Finally the Growing Book is used at a single institution by multiple teachers. This is then followed by the experimental usage of the Growing Book at two institutions by multiple teachers.

The Macro University will serve as the test bed for the proposed series of experiments. At each institution, the teacher who developed the chapter of the prototype Growing Book will also participate in this experimental study. Since the computer science department or program at every institution always has a course on data structures and algorithms, the selection of matching courses will not be a problem. A social scientist with training in education theory will be invited to serve as a consultant to help evaluate the usage of the Growing Book with different distance learning models.

7 Discussion

The demand for learning information technology (IT) is increasing each year at the undergraduate level, the professional level and the graduate level. For IT professionals working in the international job market, those who know a second language other than the mother tongue have a natural competitive advantage. The Macro University consortium is an international consortium to develop a unique hybrid distance education system, so that a student can learn both IT and a second language in an integrated learning environment. This unique hybrid distance education system is built upon the Growing Book developed at the University of Pittsburgh, which provides multilingual, multi-level, multimedia learning materials in a distributed learning environment. The objectives of the consortium are: a) to develop and deploy the hybrid distance education system so that it supports integrated IT and second language learning, b) to develop both introductory and a number of cutting edge online IT courses, and c) to evaluate the learning outcomes of the integrated learning environment.

The strategy to achieve these objectives is outlined below. Initially the partner institutions will concentrate on system development, software deployment and content development. University of Pittsburgh and Cleveland State University are responsible for system development and deployment. Knowledge Systems Institute will develop the content of online course materials for a selected number of IT courses. University of Salerno, University of Bari and University of Sannio will develop the English/Italian versions of the course materials. The partner institutions will then concentrate on the evaluation of learning outcomes by selecting a number of undergraduate and/or graduate students to participate in the learning experiment. The partner institutions will also jointly evaluate the learning outcomes using the approach described in Section 6. Institutions interested in joining the consortium are welcome to participate in this project.

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An Open Framework for Smart and Personalized Distance Learning

Ruimin Shen[1] , Peng Han[1], Fan Yang[1], Qiang Yang[2], and Joshua Zhexue Huang[3]

[1] Department of Computer Science & Engineering
Shanghai Jiaotong University, Shanghai, China
{rmshen,phan,fyang}@mail.sjtu.edu.cn
[2] Department of Computer Science
Hong Kong University of Science and Technology, Hong Kong, China
qyang@cs.ust.hk
[3] E-Business Technology Institute
University of Hong Kong, Hong Kong, China
jhuang@eti.hku.hk

Abstract. Web based learning enables more students to have access to the distance-learning environment and provides students and teachers with unprecedented flexibility and convenience. However, the early experience of using this new learning means in China exposes a few problems. Among others, teachers accustomed to traditional teaching methods often find it difficult to put their courses online and some students, especially the adult students, find themselves overloaded with too much information. In this paper, we present an open framework to solve these two problems. This framework allows students to interact with an automated question answering system to get their answers. It enables teachers to analyze students learning patterns and organize the web-based contents efficiently. The framework is intelligent due to the data mining and case-based reasoning features, and user-friendly because of its personalized services to both teachers and students.

1 Introduction

As distance learning becomes one of the hotspots in network research and applications, many web-based education systems have been established. Two good examples are Virtual-U [1] and Web-CT [2]. To cover the entire spectrum of the learning process, these systems have implemented a number of fundamental components such as synchronous and asynchronous teaching systems, course-content delivery tools, polling and quiz modules, virtual workspaces for sharing resources, whiteboards, grade reporting systems, and assignment submission components. These research and commercial e-learning systems enable large groups of dispersed individuals to interact, collaborate and study on the Web.

As distance learning becomes popular, new demands for more advanced features increase. For example, to satisfy the requirements of multimedia-based courses, teachers need to spend a lot of time to learn course-creation tools. This proves difficult for the senior teachers who are accustomed to the traditional ways of

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teaching. Another issue is that both the number of students using the Web based learning environment and the flow of e-learning materials grow very fast. This creates a problem of information overload for both students and teachers. Demands for personalized services increase. We note that the existing web-based systems often do not provide sufficient support on such aspects as giving personalized services to each individual student and helping them find their desired courses for study and answers to their questions. This problem has a great impact on the quality of network-based education and has contributed largely to the students drop rate.

In this paper, we present an intelligent distance-learning environment, which is developed and used at the Network Education College of Shanghai Jiao Tong University. The motivation of our work is to build a new distance learning system that enables students to conduct online studies easily according to their own educational backgrounds, study habits and paces. We are particularly interested in providing solutions to the information overload problem and personalized service. In short, our efforts are dedicated to make teachers feel that "everything is easy" and make students feel that "everything is available" and "everyone is different". Our system is being used by thousands of adult students regularly in Shanghai, China. In the following, we present the framework with an emphasis on the issues of providing answers to students' questions, and making personalized recommendations to students. We discuss data mining and case based reasoning techniques to solve these problems.

2 Overview of the System Architecture

The system is composed of a real-time classroom, an EOD (Education on Demand) course centre, a CBIR (Content Based Indexing and Retrieval) search interface, a learning assistance center and a data analysis center. During a class session, all the data the lecturer and students need, including video, audio, handwriting materials and screen operations, are transmitted simultaneously to each student's desktop. In the meantime, all interactions are recorded and public materials are published on the web. After the class session, students who were unable to take the class can view the same content on the web as that shown at the class. The CBIR search interface enables the students to find their desired materials conveniently and quickly. The learning assistance center consists of an assignment subsystem, an examination subsystem and an answer-machine subsystem that help students to complete assignments and exams on the Web, and answer their questions automatically. All the didactical and user access data are collected in log files and analyzed by the data analysis center. The system can provide personalized service to the students according to the analysis results. The details of these components are discussed in the following sections.

2.1 The "Everything Is Easy" Teaching Environment

Although multimedia tools have been built to help teachers create online courseware, some teachers still prefer to use blackboards. Especially, teachers teaching mathematics and chemistry feel it difficult to write complex symbols and formulas on computer screens. To make "everything easy" for these teachers, we have developed an intelligent board transfer system. The teachers can write anything on a computerized whiteboard and the content is transferred simultaneously to the students' desktops and integrated with the teachers' video and audio teaching materials. The students can write notes on the teachers' handwriting window. The combined information is stored on the network so the students can review it anytime later. We called such content as personalized notes. The teachers can also load their pre-prepared PowerPoint and Word documents into the transfer system, and then both the teachers and students can navigate these documents synchronously. Using this subsystem, the teacher can focus on the teaching content instead of formats.

All the useful data from a class session are stored and published on the Web. The students missing the class session can learn themselves anytime after the class. We also convert these contents to CDs for the students who are unable to view the active online lessons due to the limited bandwidths.

Under such an environment the teachers and students can always find a time to communicate that suits for their work and preference. This conforms to our philosophy of "everything is easy".

2.2 The "Everything Is Available" Assistance Tool

A distance-learning environment often contains too many materials for students to choose. It is important to provide a tool for students to find the right materials they need. A lot of work has been done in the past on this aspect. However, many efforts have been put on standardizing the courseware with a unified data specification such as XML so that they can be indexed on the Web. We believe that it is even more important to design an interface for the students to decide whether the knowledge he is searching for is inside the courseware and locate it. For example, if a student wants to review "The First Law of Thermodynamics", he can input the phrase through a textbox or microphone, and then the computer can locate the relevant materials in the courseware automatically through an answer machine system and a speech recognition system.

In our system, we use a Content based Information Retrieval technology to implement this function. As we described above, the courseware includes such information as the teacher's video, audio and tutorials. We consider the audio and tutorial information to be the most important materials and index them. The students can see both the teacher's video and the didactical materials such as the PowerPoint slides, as shown in Figure 1. They can also hear the teacher's voice. In addition, the system can support the courseware on-demand with the index keyword input.

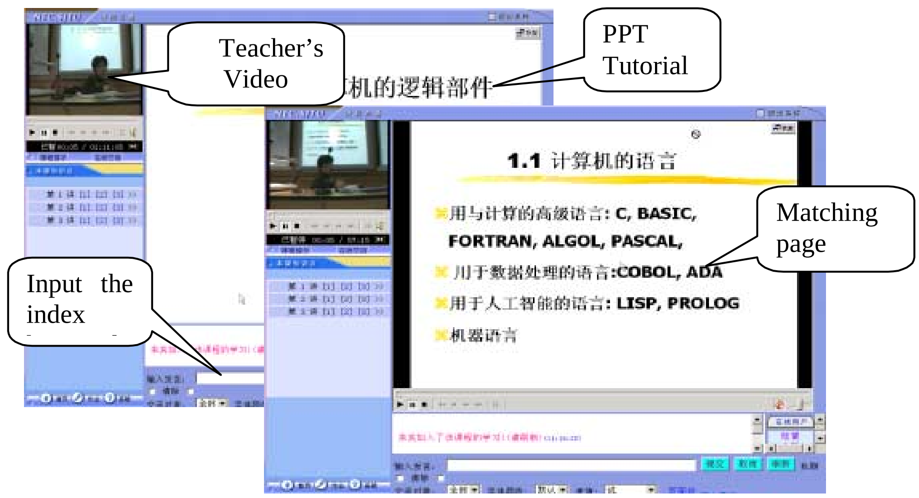


Fig. 1. Courseware on-demand based on CBIR (Content Based Information Retrieval)

Because the number of students is large, usually ten times or more than a conventional teaching class, a lot of teaching tasks have to be supported by the computer. Let's take Q&A(Question and Answer) System as an example. If there are 200 students online and each student asks only one question, then it will take a teacher several hours to answer all these questions. From our experience, many questions although expressed differently usually have the same or similar meanings. The solution to this problem is to share the answers among the students and let a computer recognize similar questions and answer them automatically. If the computer cannot find an answer, it transfers the question to a teacher. After the teacher answers the question, the answer is added to the Q&A database and shared among students. Therefore, as the Q&A database accumulates questions and answers, the hit rate grows over time.

There are already some existing question-answering systems in use. In comparison, our system emphasizes on efficiency rather than comprehension of the language. We have observed that only a limited number of questions are asked in each course and the questions are usually very simple. Thus, we adopt an improved key words matching algorithm to find the answer. After a period of accumulation, the hit rate of our Q&A system has risen to 90% and the corresponding time to answer each question is reduced to two seconds.

We first discuss the structure of our answer machine system in detail. The questions and answers are obtained through a standard web interface. The students using the system will leave behind many questions and potential answers. Over time, these questions and answers will accumulate in a log file. The log file can then be used for training an indexing structure for the question to answer association. This process continues whenever the system is in use, making the answer machine system a closed-loop system. We will adopt the lifetime learning paradigm of Yang and Zhang in [12] for acquiring indexical knowledge about cases in a case-based reasoning paradigm. In this paradigm, the answers are cases to be stored in a case base. The questions provide keywords that trigger the cases and rank them according to how well they can provide an answer for the questions. An important issue then is how to provide ranking for the keyword to answer association. We call this the index-learning problem.

The structure of a case base can be conceptualized as a two-layer structure, where the feature-values form one layer and the cases another. The feature-value layer is connected to the case layer through a set of weights to be maintained. We now extend the original two-layer structure of a case base into a three-layer structure, taking the two-layer architecture as a special case. In the case layer, we extract the answers from each case, and put them onto a third layer. This makes it possible for different questions to share a solution, and for a question to have access to alternative answers. An important motivation for this separation of a structure of a case is to reduce the redundancy in the case base. Given N questions and M solutions, a case base of size $N * M$ is now reduced to one with size $N + M$. This approach eases the scale-up question and helps make the case base maintenance problem easier, since when the need arises, each question and answer need be revised only once. In order to make this change possible, we introduce a second set of weights, which will be attached to the connections between cases and their possible solutions. This second set of weights represents how important an answer is to a particular question if this answer is a potential candidate.

The weights correspond to a mapping function between the input questions and the final answers. Different questions may in fact correspond to the same answer. When many students ask questions, over time this mapping can be learned by a relevance feedback algorithm. We adopt the relevance-feedback learning algorithm proposed by Zhang and Yang [12] for case-based reasoning system, where the weights are incrementally updated based on whether a particular case provides a right answer or not for an input question.

In order to validate the system, we have to gather more data from the students. The data should not only reflect what questions the students asked, as in the search engine query logs, but also how they rank the returned results. Given these question-answer log files, we can apply the above learning algorithm and keep the question to answer mapping always current [12, 15].

2.2 The "Everyone Is Different" Personalized Service

In a traditional education system, the course content is static and the teacher's assignments given to different students are the same. In reality, students have different backgrounds and the knowledge structure is dynamic. Given such diversity, how do we analyze students learning behaviors, characteristics and knowledge structures? Furthermore, how do we send the feedbacks of learning states to teachers? In addition, how do we visualize the analysis results to teachers and students intelligibly? In order to answer these questions, we propose a subsystem ---the Data Analysis Centre, which includes an analysis tool to support the student study behavior analysis. Figure 2 gives the framework of the subsystem.

In this subsystem, the resource database is composed of two kinds of data: the log files with specification of W3C and the attribute tables in the sub-function database.

The data-preprocessing module will deal with the original data to clean them up. The first task is to transfer the log files into database files with DTS (Data Transformation Services) tools. The second task is to create the corresponding tables of User_ID and IP. The transformation also solves the problem of the one-to-many relation between student's User_ID and IP attributes. The third task is to calculate the click-time and browse-span of one URL, which is very important to mine the data structure of students. The last task is to create new tables and views for further analyses.

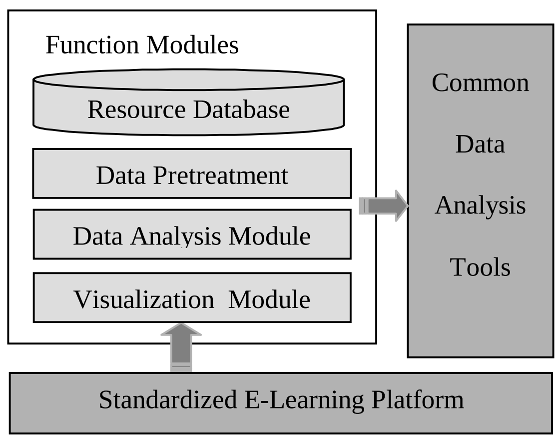


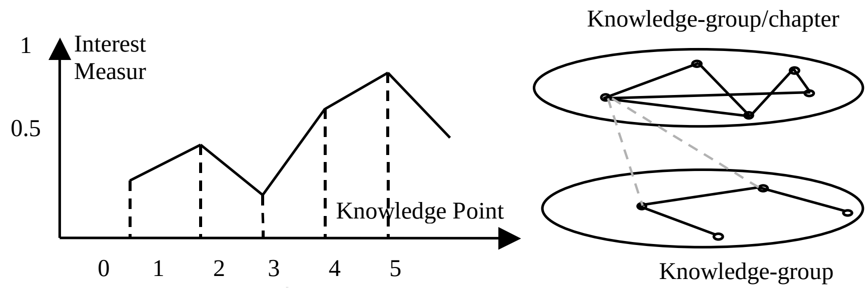
Fig. 2. Framework of the Data Analysis Centre

The preprocessing creates clean data. Since we organize data sources according to knowledge points and build relation tables of sources and knowledge points, we can assess the knowledge points from two aspects, the general information: to calculate the Interest Measure and the Mastery Measure of each chapter-point and knowledge-point based on the statistical data, and the personalized information: to assign the Interest Measure and the Mastery Measure to each student.

We use three techniques to discover knowledge and rules. The first technique is to use a classification algorithm to classify students into different classes based on their learning actions. Based on the classification, the teacher can organize different course contents and assign homework in different difficulty levels to each class. The second is to find association rules of different knowledge-points, the support and confidence values. The third is to organize and map the knowledge points using a concept map algorithm.

Using a visualization module, we can visualize all the analysis results in different forms. Figure 3-a shows the interestingness measure of knowledge points, based on the visit frequency of a certain chapter in a course, or the number of questions posted on the answer machine. It also shows the students' mastery measure of a given subject, determined by the students' feedbacks on whether they find the material satisfactory or not. The teacher can provide more scientific explanations online about a particular knowledge point with a high interestingness measure. He can also choose the low mastery measure knowledge point to teach in details and supply more reference materials to the students.

Figure 3-b shows the multidimensional association of knowledge points. The ellipses represent knowledge point groups, such as chapters. The circle represents a knowledge point. We can see not only the relationship between the knowledge points in the groups but also the relationship between the knowledge points in different groups. Such information can direct the teacher to re-organize the knowledge points more effectively.



(a) (b)

Fig. 3. Visualization of the Analysis Results

Furthermore, we can also represent a knowledge-point map which can show the relationship between the knowledge points and provide hints for the student as to what the prerequisite knowledge points are before the current knowledge point.

In our tests, the data Analysis Center can find some interesting rules and create useful graphs of the knowledge point structure. These results enable teacher to adjust the didactical progress and enable students to learn more personally.

Once we obtain the knowledge points, we now consider how to utilize the web log data accumulated by the web servers to derive interesting and useful association rules on the interesting knowledge points. Given a web log, the first step is to clean the raw data. We filter out documents that are not requested directly by users. These are image requests in the log that are retrieved automatically after accessing requests to a document containing links to these files. Their existence will not help us to do the comparison among all the different methods. We consider web log data as a sequence of distinct web pages, where subsequences, such as user sessions can be observed by unusually long gaps between consecutive requests. For example, assume that the web log consists of the following user visit sequence: (A (by user 1), B (by user 2), C (by user 2), D (by user 3), E (by user 1)) (we use "(…)" to denote a sequence of web accesses in this paper). This sequence can be divided into user sessions according to IP address: Session 1 (by user 1): (A, E); Session 2 (by user 2): (B, C); Session 3 (by user 3): (D), where each user session corresponds to a user IP address. In deciding on the boundary of the sessions, we studied the time interval distribution of successive accesses by all users, and used a constant large gap in time interval as indicators of a new session.

To capture the sequential and time-limited nature of prediction, we define two windows. The first one is called antecedent window, which holds all visited pages within a given number of user requests and up to a current instant in time. A second window, called the consequent window, holds all future visited pages within a number of user requests from the current time instant. In subsequent discussions, we will refer to the antecedent window as W1, and the consequent window as W2. Intuitively, a certain pattern of web pages already occurring in an antecedent window could be used to determine which documents are going to occur in the consequent window.

The moving windows define a table in which data mining can occur. Each row of the table corresponds to the URL's captured by each pair of moving windows. The number of columns in the table corresponds to the sizes of the moving windows. This table will be referred to as the Log Table, which represents all sessions in the web log. Figure 4 shows an example of such a table corresponding to the sequence (A, B, C, A, C, D, G), where the size of W1 is three and the size of W2 is two. In this table, under W1, A1, A2 and A3 denote the locations of the last three objects requested in the antecedent window, and P1 and P2 are the two objects in the consequent window.

W1			**W2**	
A1	**A2**	**A3**	**P1**	**P2**
A	B	C	A	C
B	C	A	C	D
C	A	C	D	G

Fig. 4. A portion of the Log Table extracted by a moving window pair of size [2, 2]

We now discuss how to extract sequential association rules of the form LHS →RHS from the session table. Here LHS refers to the left-hand-side of a rule, whereas RHS the right-hand-side of a rule. The association rules have been a main subject of study in data mining [3, 4, 5, 6, 8 9]. Our different methods below will extract rules based on different criteria for selecting the LHS. In this work, we restrict the RHS in the following way. Let {U1, U2, …Un} be the candidate URL's for the RHS that can be predicted based on the same LHS. We build a rule LHS→ Uk where the pair {LHS, Uk} occurs most frequently in the rows of the table among all Ui's in the set {U1, U2, …Un}. Ties are broken arbitrarily. This is the rule with the highest support among all LHS→Ui rules.

The first rule representation we consider is called the subset rules. These rules are the same as the traditional association rules which simply ignore the order and adjacency between accesses. Thus, when the association rule mining methods, such as the Aprioi method [4,5,6], are applied to the log table, we obtain the subset rules. As an example, table 1 shows the subset rules that can be extracted from a transaction.

Table 1. Subset rules

W1	W2	Subset Rules
A, B, C	D	{A, B, C} → D, {A, B} → D, {B, C} → D {A, C} → D, {A} → D, {B} → D, {C} → D

The second rule representation is called the subsequence rules, which takes into account the order information in the sessions. A subsequence within the antecedent window is formed by a series of URLs that appear in the same sequential order as they were accessed in the web log data set. However, they do not have to occur right next to each other, nor are they required to end with the antecedent window. When this type of rules is extracted from the log tables, the left hand side of the rules will include the order information. Table 2 shows an example of subsequence rules.

Table 2. Subsequence rules

W1	W2	Subsequence Rules
A, B, C	D	(A, B, C) → D, (A, B) → D, (B, C) → D (A, C) → D, (A) → D, (B) → D, (C) → D

For each rule of the form LHS→ RHS, we define the support and confidence as follows:

$$\sup = \frac{count(LHS, RHS)}{count(Table)} \quad (1)$$

$$conf = \frac{\sup(LHS, RHS)}{\sup(LHS)} \quad (2)$$

In the equations above, the function count(Table) returns the number of rows in the log table, and

$$\sup(LHS) = \frac{count(LHS)}{count(Table)} \quad (3)$$

From these rules, we can obtain interesting association relations between courses. For example, our rules can inform the teachers "Students who find Chapter 3 useful also find Chapter 5 useful". Knowledge like this will allow the teachers to organize the two chapters together on the web structure. It will also allow teachers to recommend students new chapters to read based on their current reading. Similarly, the same associations can be used to help organize the material better or form better student study groups. For example, a rule such as "Students who attends classes in the Wednesday classes often have difficulty with Calculus I" enables the teacher to improve the Calculus I material better online, or organize the students in that class to work together with students from other classes. We also plan to use different users information and log data to perform collaborative filtering analysis and provide recommendations [7] using Pearson Correlation.

The above-discussed framework assumes that the knowledge points are given beforehand. However, these knowledge points can be discovered from the web logs as well. Pitkow J. and Pirolli P. in [10] provide a longest subsequence mining method for extracting user profiles. Su, Yang, Zhang, Xu, Hu and Ma [14] provide an interesting method for clustering based on the web logs alone. In our study, we plan to combine both the content information and the user behavior information from the web logs to derive the clusters. The method that we propose to use is called clustering. Due to space limitations, we will not go into details on this subject.

3 A Distance-Learning Case Study

When a student connects to our NEC (Network Education College) home page (http://www.nec.sjtu.edu.cn), he can select which chapter or section to study. Our system provides multimedia study materials for students, including video, audio, images and text documents. The learning resources are well organized for study convenience. During a student's learning session, he may have a question to ask. Our system provides a functional button in every study page to help the student link to the Answer Machine at any time. When the student clicks the "Answer Center" button, he can see the Ask Question page. In this window, he can input the question in natural language and submit it as shown in Figure 5.

After receiving this initial query, the system shows a list of similar questions to the student. The student can choose the most similar one to see the answer. If all listed questions are not relevant, the student can submit the question to a teacher (see Figure 6). Beyond these functions, the Answer Center also provides other services, such as the Hot Spot of Lesson, the Hot Spot of Chapter, Search Answer and so on. For example, the Hot Spot of Chapter can provide the hotspots discussions of every chapter. The hotspots discussion can help students to find out what questions other students have asked and what the correct answers are.

The user can see the distribution of questions of a chapter or section in the selected time-span. The results can be shown in graphs, pie charts, histograms and so on. The user can choose different forms he likes and looks into details by clicking each part of the diagram (see Figure 7).

In addition, the relation of knowledge points can be shown in 2D or 3D graphs. According to the precedence and subsequence of a knowledge point, the system can recommend the imperative knowledge to learn or to prepare.

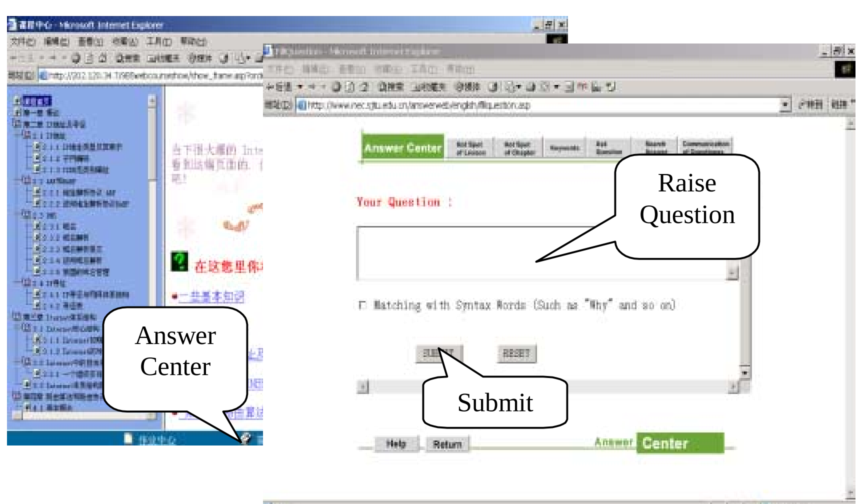


Fig. 5. Learning and Submitting Questions

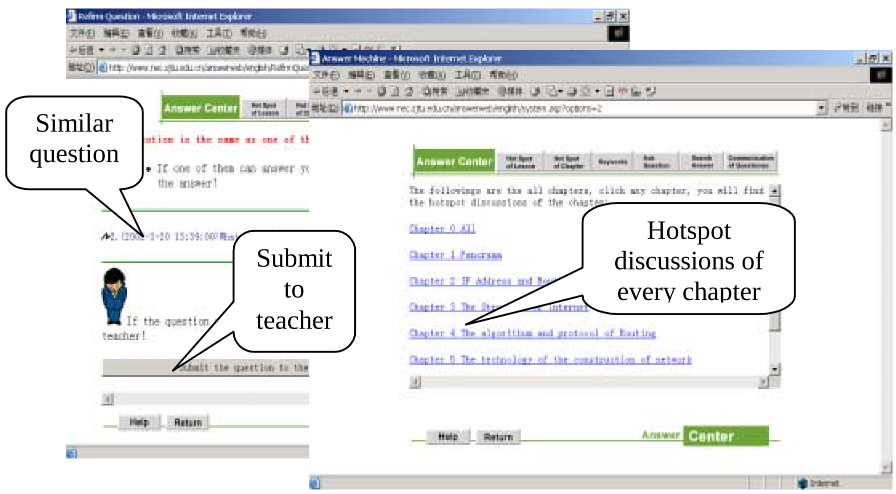


Fig. 6. Answering the questions in Answer Centre

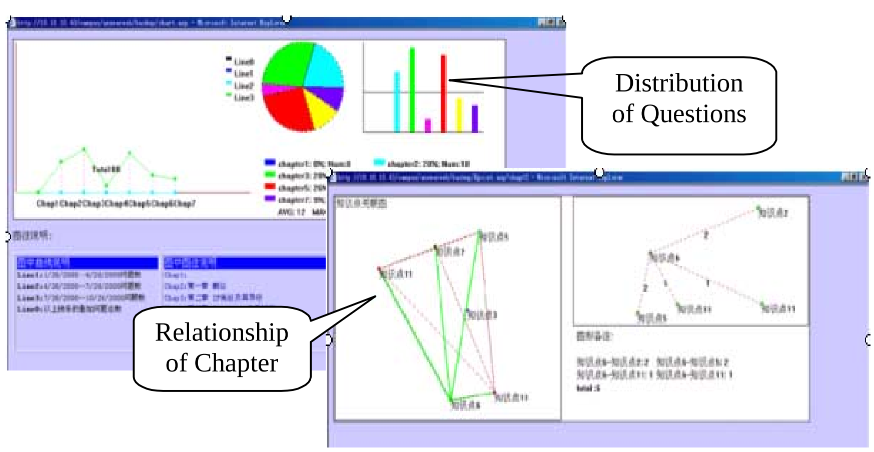


Fig. 7. Visualization results of the data analysis center

4 Conclusions and Future Work

In this paper, we have presented an open, adaptive framework to organize the course material. The heart of the intelligent system lies in a smart front end system we call Answer Machine, and an Intelligent back end system using web log association analysis and clustering analysis. In the future, we plan to offer more tests on the systems performance using the data we accumulate through real teaching sessions. Such validation will allow us to select the best intelligent teaching methods for an open virtual teaching environment.

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A Metadata Framework for Description of Learning Objects

William W. Song

Framkom, Box 1243, Isafjordsgatan 26, 164 28 Kista, Sweden
wsong@framkom.se

Abstract. The growing use of the Internet and the Web has been transforming the styles of learning. The large amount of learning resources available on the Web enables people to access learning materials of various subjects. Large enterprises can make use education materials from the Web and their internal network to maintain education and training for their employees and customers. Small and medium enterprises rely more on the Web for distribution of their product instructions and training books. Furthermore, learning styles are changing. Thanks to the applications of the Web, enterprises can allow their employees to attend training courses at home through connecting to the Internet and Employees can select training materials according to their preferences. Due to the huge amount of information supplied and the bad-defined structures for the learning information, it is difficult for the learners to find exact learning resources and to find the information easily. Based on the metadata model, we have to define a search model, which takes the users' search goals and users' preferences into consideration. Only by integrating the metadata model for learning resources and the search model for the users' search goals, can the users obtain a collection of learning materials best meeting their searching goals.

1 Introduction

The growth of the Internet and the World Wide Web is transforming teaching and learning at all levels of education in the workplace and at home. The Web is a huge repository containing all kind of resources for various purposes including learning and education. Many training and education resources are available on the web and the users can easily educate themselves by fetching the education materials from the web. The Internet enables people to find every kinds of learning information on various subjects and to access to the information at anytime and from anywhere. It is also quite convenient for the learning information suppliers to provide the educational resources and maintain them. These information pieces or resources for purposes of learning and education construct a type of web resources. This kind of web resources with quite distinct features is evolving on the Internet, called Learning Domain. An important characteristic of these resources (asynchronous systems) is that the Web can be used as a teaching medium as well as a source of knowledge about subjects.

However, in spite of the Web being so resourceful, its bad structures for any information supplied have become a big obstacle so that people cannot make use of

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the Web resources efficiently. Firstly, insofar there is no well-defined data model available for structuring the Web information. The importance of such data models is multifold, but obviously a collection of structured information will be far more than easy for people to search. The information suppliers are also benefited from such models since when they provide information to the Web they can easily make references to related information sources. As the learning domain is concerned, the relationship between the learning materials suppliers and consumers will be more critical for how knowledge is distributed and learned. Of course, how to find required learning information is also an essential problem. In the rest of the section, we will discuss these problems.

1.1 Metadata Modeling

To define a formal description framework for learning materials on the Web is very important. When viewing the Web as a huge resourceful information bank, to some extent, we would like to assume that the information there is somewhat structured. In other words, the information bank contains a set of cells, connecting to each other. The cells themselves may contain more interrelated components. In the reality, situations are quite different. The information suppliers only put their materials to the Web without really suggesting e.g. some subjects to categorize the materials. The learning material users have a big difficulty in find the learning information they require.

This situation occurs because there is no metadata used to describe these learning materials and no metadata schemas used to group the materials. Actually, the importance of applying metadata to description of the Web information has been gradually recognized and a number of metadata models have been proposed for the web information management. However, to our knowledge, a metadata model designed to well meet the need of learning domain is still lacking. It is difficult to say what kind of metadata model is more suitable to learning domain, but some basic requirements can be discussed. Firstly, we need to distinguish the content of learning materials from the carrier holding the content, since the carrier plays almost as similarly important role in learning domain as the content. Secondly, we need to consider various characteristics of knowledge contained in the Web information for learning because different users may require different styles of knowledge representation. Thirdly, we also need to discuss the involved parties in learning domain – the information suppliers and the information consumers.

1.2 Involved Parties

Two major parts, closely related to each other in learning domain, are learning resource supplier and consumers. The relationships between the learning information providers and the information consumers can be described as follows.

The Web can be considered as a resource and communication space, to which the information suppliers supply learning materials and from which the information consumers1 use the learning materials supplied. Usually, learning materials, such as courses, are stored and managed in an information system or a local web site (Intranet).

First we take the view form learning resource suppliers. The suppliers may give a sort of description of the structure of the information. The information suppliers usually make such description from their own view of the learning domain of interest. The description of learning information by one supplier may be in conflict with that by another supplier. The description may not be a well-defined one so that it is difficult for the users to understand and hence to effectively search for it. It is necessary to maintain a common metadata model for the learning object descriptions.

From the point of view of the learning material consumers, they expect to easily find the exact learning knowledge they need. They can provide a set of requirements or goals for searching for learning resources. The requirements and goals express what sort of learning materials they are seeking. The consumers may also provide their profiles as support. Indeed, profiles are sometime quite helpful. On the other hand, these requirements and goals can be vague, ambiguous, and even in conflicts. The profiles provided by the end users are very likely incomplete and bias-prone.

1.3 Search

As we can see from the above discussion, if we can use some metadata model to represent learning information from a supplier on the Web, learning material consumer will be able to find the learning information. This is based on an assumption that the consumer already knows exactly what he or she wants and what path (like keywords or URLs) to search. Actually, even if there is a well-defined metadata model, the suppliers may provide incomplete metadata to the learning materials, and more often than not, the consumers may not know what they really want.

Therefore, these requirements raise another question. The metadata model for description of learning domain requires a particular structure or structures, which are able to connect the learning resources in such a way that the users can obtain a collection of learning materials best meeting their searching goals. For example, a user's search requirements are "programming" and "electronic-commerce". We may find following results. If the metadata model describes a hierarchical structure of learning domain, the search may lead to either "programming" or "electronic-commerce". Perhaps one search engine may ask the user to provide weights to two search words. If a set of keywords is used, the search result will be meaningful only when two words are included in the description of the searched resource.

A cross-referenced structure, together with a hierarchical structure, in a metadata model can provide a satisfactory search result. Since in a learning domain, various learning resources are intertwined, a metadata model should reflect such feature. In

[1] In the following text, we may interchangeably use the information user(s), the resource consumer(s), and the user(s) to mean the same concept, the user(s) who ask for learning resources from the Web or elsewhere.

learning domain, referencing learning resources includes not only these hyper-linked, but those implied as well, e.g., under the same domain name.

1.4 Overview of the Paper

In this paper, we attempt to define a metadata model as a description framework to represent the learning materials distributed over the Internet. We expect the metadata model give a deep analysis and representation of learning characteristics. We propose the concept - learning object, to indicate all the objects in a learning domain. Based on the concept, we develop a metadata model for learning domain. Search is another important problem in learning domain. In the paper we propose a goal-driven method, which is expected to better lead the learning information users along with related information to right learning resources.

In the next section, we discuss some related work and give some assumptions for learning objects. In section 3, we propose the metadata model for learning objects, LOMD, through defining various objects within a learning domain. Then in section 4, we discuss a search method, called goal match (or goal driven) method. In section 5, we discuss the architecture of a learning system based on the learning object metadata model LOMD and the search goal driven method, and finally we discuss our future work in section 6.

2 Related Work and Assumptions

2.1 Related Work

Many research and application work has been proposed on the metadata topics as well as on the learning subjects. Among others, XML, Resource Description Framework (RDF), and Dublin Core (DC) are quite widely used in various areas as metadata languages.

XML (extensible markup language) is well-established metadata model, focusing on syntactic construction of the Web document modeling [11]. The XML specification defines a limited array of facilities for applying data types to document content in that documents may contain or refer to document type definitions (DTDs) that assign types to elements and attributes. However, document authors, including authors of traditional documents and those transporting data in XML, often require a high degree of type checking to ensure robustness in document understanding and data interchange.

RDF (Resource Description Framework), developed by the W3C working groups RDF Model and Syntax as well as RDF Schema, can be considered to be a general metadata model for describing the web resources, including electronic documents, images, sounds, movies, and other objects supplied to the web [6]. In our implementation for learning systems, we consider an RDF based language for representing learning objects and their relationships [2,9].

DC (Dublin Core), developed within the society of library and information science, focuses on how to describe electronic publications and how to manage them [1]. The Dublin Core is a metadata element set intended to facilitate discovery of electronic resources. Originally conceived for author-generated description of Web resources, it has attracted the attention of formal resource description communities such as museums, libraries, government agencies, and commercial organizations. The DC model provides a quite complete set of attributes for purposes of describing various characteristics of publications, in particular, in the library society.

Other than the development activities of metadata models, there are also applications where metadata models are used for learning domain [3]. The Instructional Management Systems (IMS) project is a well-known project on learning domain. The IMS Project aims to create recommendations for building Internet architectures for learning. The work is divided into five groups and one of them is called Metadata. IMS propose a set of metadata to be used with RDF/XML for describing web resources.

At the level of practical research and application, a metadata prototype for training course management, developed at Ericsson, is called KNACK [4]. A number of levels of description for from curriculum to media carrier element are presented to reveal a deep infrastructure of primary components and their relationships for learning domain. This is significant for reconstruction and reuse of learning objects. The SITI project LOUIS (learning objects for usable infrastructure) [5, 7] is attempted to further develop its basic metadata model based on the KNACK prototype, by integrating the features of RDF metadata model and pedagogical knowledge in the system. In the LOUIS project a metadata model particular for learning objects has been built up with description of various learning resources into several layers.

2.2 Assumptions

The Web is a huge resourceful bank repository for various learning purposes, whereas those resources constructing a learning domain is believed to possess its peculiar features. On one hand, there is no apparent border for knowledge on certain subject or topic, but the resources on the subject of interest are limited on the other. The knowledge in a learning domain follows a conceptual taxonomy structure. Due to the versatility of requirements on acquiring learning information, it should be necessary for learning objects to be decomposable. Furthermore, the learning users, according to their pre-acquired knowledge, may require different combinations of learning resources into “courses” that better serve their purposes. In this sense, granularity of learning information needs to be defined for such combinations.

In order to cope with such diversity of learning domain, we assume a **hierarchical structure** to represent a set of web resources and their interrelations (in the example of the education product, a learning object). Here we can further assume that an education product is **decomposable**. That is, an education product can be further decomposed into a collection of components, for instance, textbook, lecture, exercise, etc. Furthermore, these components (we will term them as objects, or web objects, resource objects, or learning objects in different circumstances) can themselves be decomposed. These components will be re-united to form a new education product based on the users' needs.

What **granularity** (i.e., how deep we shall decompose an object or a component) we should achieve relies on the users' requirements [9]. Let us take an example. Two students need some materials for a course. In general, the course consists of ten lectures, a number of homework, and one textbook. Assume that one student took five lectures once and did one homework, whereas another student happened to read some chapters of the textbook. Thus, the first student hopes to take the rest lectures and homework as well as reads the book while the second expects to take all the lectures and homework but the rest chapters of the textbook. Therefore, the "course" (virtual one) for the first student can be different from the “course” for the second student. In other words, textbook can be a component of a course in one case while in the other case, chapter will be a component of a course. Different granularities employ to meet different requirements.

If we construct a system by defining its three components consisting of a metadata model, a search model and a learning object repository, and name it to be learning system, then it would be indispensable to define a fourth component to perform all necessary operations. Here we just shortly discuss some assumed operations for the learning system. **Refinement** (decomposing) can be seen to be a basic operation. It breaks a learning object into a number learning objects, either conceptually (subset relationship) or structurally (partition relationship). **Versioning** is an important operation but difficult to manage since the modifications and updating (including versioning) made by the learning information suppliers can be done to any part of a learning resource. **Neighboring** is more a relationship than an operation. It means that a learning object is a neighbor of another object. **Integration** has two meanings. One is to combine learning components out of a number of learning resources and form a new learning object. The other is to aggregate a collection of requirements from a learning information consumer together with his preferences, etc. and to build up a semantic-rich and contextual-sensitive query.

3 Metadata Model for Learning Objects

3.1 Important Concepts

Here we introduce three important concepts: learning domain and objects, information carrier, and knowledge intensity. A **learning domain** can be considered to be a collection of knowledge with specific characteristics for purposes of learning and education. The collection of learning knowledge is organized based on semantic relations. Such semantic relations describe an intrinsic (collocation) structure of learning content. For instance, knowledge about computer programming is a basis and subsequence of knowledge about computer algorithm. The precedence of the knowledge about computer programming and algorithm depends on how we describe the two subjects, i.e., what attributes (or characteristics) we select for the subjects (or **learning objects**) and what values we assign to the attributes.

Information carrier is a medium that provides a display of knowledge content. A same content can be carried in different media. In a learning domain, the carriers maintaining learning resources play an extremely important role in providing versatile styles of learning and education information and therefore improving understandability and entertainment for the users. A carrier for a learning knowledge needs to be described in terms of a set of modeling attributes to distinguish it from other carriers.

Knowledge intensity indicates a spectrum of learning domain, where at one end the knowledge collection is common sense and on the other the knowledge collection from the experts. In other words, if we assume a scale to represent the learning intensity of how easy a course to be learned, we can say five degrees of very easy, easy, medium, difficult, and very difficult. For example, we may say the knowledge intensity increases in mathematics from primary school to high school. The importance of identifying the knowledge intensity (degree of ease-difficulty) for learning objects lies in the fact in which people need select learning objects according to their requirements, experiences and the already acquired knowledge.

In the following, we will produce an overall view of a metadata model for learning objects, in which the concepts described above will play a major role.

3.2 LOMD: Description Framework for Learning Objects

A learning domain has its own characteristics. Roughly, we call the components in a learning domain to be learning objects. A learning object can represent everything in a learning domain, for example, a course, a book, or a seminar. A learning object can be decomposed to be some smaller objects, called learning components. Each learning object has two components: learning content and learning carrier. A learning object component has some attributes. Learning object may have relationship with other learning object. In the following figure, we can see these basic conceptual components and their relationships for the metadata model – LOMD.

Note that according to the RDF syntax, we would add as a prefix to all the components "*Learning*" like in "*Learning object*". When no ambiguity occurs, we just use the names directly like "*Content*", but capitalizing the first letter of the names. Generally LOMD contains three types of components called Learning objects. The first is the resource type, including Learning Component, Learning Content, and Learning Carrier. The second is the reference type, including Learning Reference, Learning Neighbor, and Learning Link. The third is the attribute type, which has Learning Intensity as its instance.

The metadata model LOMD is hierarchical (or tree like) about its resource type, where each object in the hierarchical structure may contain more objects. It might be argued that Content and Carrier should appear as a pair, but if we observe their attributes we will find there is no need to distinguish them. On the reference type, the model is a networking one. Any semantic links can be associated with a learning object to provide semantic rich search. The attribute type includes the necessary metadata for the description of learning objects. A good example is the Dublin Core metadata model.

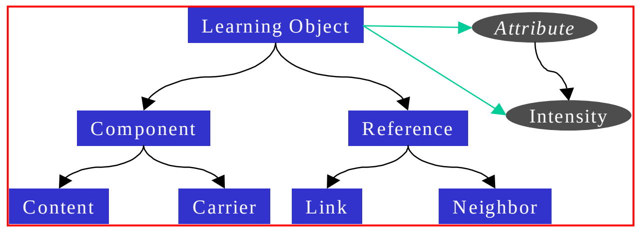

Fig.1. An overall view of the metadata model for learning objects

3.3 Learning Components and References

As we described previously, a Learning Object is either a Learning Component or a Learning Reference. Here we try to illustrate how the reference type is applied to couple the component type and how the attribute type is used to describe the component type. In order to give a better explanation of these relationships, we assume a set of rough definitions as follows:

Definition1. Ref(Comp1, Comp2) means that there is a reference, called Ref, from the component Comp1 to the component Comp2. Or simply Comp1 is referring (Ref) to Comp2.

Definition2. Attr(Comp, Value) means that the component Comp has the attribute Attr with the value of Value.

In the following we try to illustrate the main meanings of using references and attributes to describe components.

- Refer_to(Cont1, Cont2) indicates that Cont1 refers to Cont2.
- Holds(Cont, Carr) means that the content Cont holds a carrier Carr.
- Neib(Cont1, Cont2) means that the content Cont1 has a neighbor content Cont2.
- Intensity(Cont, “for_child”) means that the content Cont has a knowledge intensity, suitable for children.
- Subject(Cont, “RDF”) means that the subject of the content Cont is on RDF.
- Font(Carr, “Times”) means that the font of the carrier Carr is Times.

These informal stipulations are just to display how the metadata model LOMD manages a description framework for learning objects. When modeling a concrete learning domain, we can see the model is quite suitable.

3.4 Physical Learning Objects

In the SITI project LOUIS, we also defined a set of concrete learning objects. Some examples are illustrated below.

Course. A course in a learning domain is an object. It has as its attributes course number, course name, course length in numbers of lessons, course subject, course price, etc. It is related to a number of other objects: It is advised by a teacher. It is located at a (maybe virtual) classroom. It is paid through a department. The course is uniquely identified by its attribute - course number.

Lesson. A lesson is an object. A lesson is a component of a course. A lesson may inherit a number of attributes from the course as whole or part of its attributes, like course number. A lesson may inherit a number of relationships from the course as whole or part of its relationships, like being guided by a teacher.

Book. A book is a carrier. A book has its book number, size, numbers of pages, etc.

Document_template. A document template is a carrier. It has size, fonts, faces, etc.

4 Goal-Driven Search

Search for required learning resources is equivalently important in a learning system compared to the metadata model for description of learning objects. Although many search methods have been proposed, little attention is paid to a synthetic representation of information from learning information consumers, such as preferences. Furthermore, if we view the users' requirements as a set of goals, the process of search is that of goal matching. One may argue why goal driven search is possible for learning systems.

Firstly, learning object search is not a blind search as when we surf on the Web. Usually when going into a learning system, the users have already expectations in mind. Some of the expectations are quite clear but the others may be vague. No matter how unclear, incomplete, and ambiguous these expectations may appear to be, we consider them to be search goals. In addition, it would not be difficult to collect the users' preferences and profiles. In particular, when a learning system is used for a large enterprise, the employees and the customers' information has already been documented in advance. Therefore, the conditions for goal driven search are satisfied.

In the following we discuss what are the forms of goals driven search, how preferences and profiles may be represented, and what search paths mean in here.

4.1 Search Goal Structure

As discussed previously, the first important element in a search goal is what a user wants to find. This element should be expressed explicitly by the user. The element can just be a statement or one word for the subject to search. Since we allow search goals to be unclear, so a goal statement can be in the form of one word or a set of words, stating subjects or topics. The second element is assigned to be carrier of the learning objects being searched. Of course, we allow "null" as default value for the element.

Other than the goal statement and the carrier for searching a learning object, the users' preferences and profiles are also taken into consideration. The preferences and profiles from the learning information consumers are mainly used for tuning the goal matching process.

Therefore, a search goal has the following structure:

{[Goal-statement], [Carrier], [Preference], [Profile]} where

1. Goal-statement is a list of subjects or topics or a statement of search goal;
2. Carrier is the expected carrier of the learning object to be searched;
3. Preference is a list of statements that the user specifies;
4. Profile is a set of related information on the user.

Now we give some examples to illustrate how a search goal can be matched. Suppose that a university student wants to find some learning materials on Java. He or she may prefer a book on Java for beginners. Then the goal he or she may write is:

{[Programming, Java], [book], [beginner], [university student]}.

Another example is a search goal from a manager of a marketing department. He hopes to know *what is going on with electronic commerce on the market*. This goal needs some analysis first before fitting in the search goal structure. The goal needs to be decomposed into a number of sub-goals, e.g. electronic commerce, products, market, economic situation, trends, etc. Since the general goal is vague, the sub-goals are merely made to be better searchable. Therefore, two goals can be defined as follows:

{[electronic commerce, trend, products], [any], [any], [marketing department, manager]},

{[marketing, electronic commerce], [paper], [positive], [--]}.

More important here is how a formal construction can be made for goal description than goals themselves because goals will find their places when a set of exact descriptions for various goals are well specified. Regarding goal description and decomposition, readers can refer to [10] for details.

4.2 Search Goal Matching

The search goal match deals with the users' goal structure, e.g., what she or he would like to describe a learning object. In general, a user will provide a number of requirements, including search goals and carriers, along with the user's profiles and preferences. The goal match process will compare the user's requirements with the description items (metadata) of the learning objects stored and maintained in the repository (remember that the Web is a huge repository for learning objects). Once a goal match is found, either the matched learning object will be presented to the user, or further matches continue if there are a number of decomposed goals. Under this circumstance, we call search goal match contains search paths.

Search paths mean that a collection of goal driven requirements, preferences and profiles, is associated to different aspects in the LOMD schemas for a learning domain, seeing Fig.2. In the figure, the cubic, multi-layered box in the middle is a LOMD description of learning objects on a learning domain. Each layer is a LOMD schema with a hierarchical description of learning objects on e.g. a subject or a user preference. Here we show three layers, called respectively LOMD Schema-1, LOMD Schema-2, and LOMD Schema-3. The objects in different layer schemas are connected as e.g. neighbor relationship, displayed by red arrow lines. To the left of the figure, a flat box represents a search goal structure, where search goal statements, carriers, the user preferences, and profiles are included in the numbered smaller boxes. Search paths are these dotted arrow lines from the search goal box to the LOMD Schemas. This accomplishes the whole process of search goal matching.

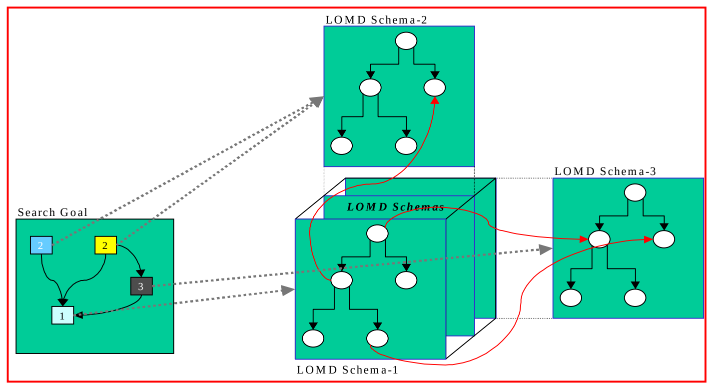

Fig.2. Goal match: Search paths

The search process is an integrated one since different search elements in the search goal structure are directed toward different LOMD schemas first and after goal matches, these search paths are synthesized together to form a meaningful search result. For example, consider this goal structure, {[marketing, electronic commerce], [paper], [general], [manager]}. The goal statement contains two sub-goals, marketing and electronic commerce. These sub-goals are analyzed in terms of the LOMD Schema-2 and then the analyzed results will be further checked together with the other results out from the LOMD schemas, Schema-1 and Schema-3.

5 Architecture for Learning Object Management

So far we have discussed two major concepts on learning objects. The first one is the metadata model (description framework) for learning objects, by using which we could sort out learning resources from the Web or elsewhere and organize the learning resources in a rational manner. The second concept is the search model, to which we introduced a goal match method. The advantages of the goal match method include processing vague and ambiguous search queries and using supporting information from the users. In this section, we consider a brief description of a possible learning system.

A learning system should first of all be associated with a group of information providers and a group of information consumers for acquiring the learning materials and resources from the suppliers and the information about the learning material consumers. A learning system contains four main components: A learning object analyzer for sorting out the learning resources from the Web, a search goal match mechanism for the users' search queries, a data repository for maintaining learning objects, and an intelligent interface to interact with the learning information providers and consumers. These components of a learning system are discussed as follows.

The learning object analyzer uses LOMD, the metadata model for learning objects, as a basic description framework, to analyze the learning materials and resources from the Web or provided by any information suppliers. Then the inputting learning objects are connected to each other in hierarchical and networking structures and maintained in the learning object repository.

The learning object repository maintains a set of metadata schemas in LOMD, where learning objects are organized in the hierarchical and networking structures. Each object is described by its relationships to other objects. The granularity for a learning object in the repository is also defined when an information provider put his information to the repository. So the objects in the repository are assumed to place in certain layers and they can be further decomposed when required.

The search goal match mechanism deals with the users' search goals. In general, a user will provide a number of goals, along with the user's profile and preferences. The goal match mechanism will compare the user's goals with the description items (metadata content) of the learning objects stored and maintained in the repository. Once a match is found, the matched learning object will be presented to the user. If there is more than one goal to match, then the mechanism will make an integration of all the goal matches with tuning support from the users' preferences and profiles.

The intelligent interface accomplishes three tasks. Firstly, it allows the information providers to easily put their learning objects to a right place in the repository, along with a set of suitable metadata descriptions of the objects. Secondly, it allows the consumers to suggest their requirements and find out what learning objects they need. Thirdly, it should be able to manage the changes, modifications, and maintenance of the metadata models, schemas, and contents.

6 Conclusion

In this paper, we propose a particular metadata model for learning domain, called LOMD, and a search goal match method. Our next step for the project, other than further development and refinement of the metadata model and prototype, we will tackle the following three problems.

1. Establishment of a network structure for representing learning objects, its coupling with the hierarchical structure, and mapping both structures to a repository.
2. Design of a graphical user interface for authoring learning objects and their relationships, as well as operations on the objects.
3. Design of a goal-matching mechanism. For example, if we see the users' requirements on a particular course, which need to be built out of the other course components, how to compose such course from a set of other existing course components can be considered to be a process of goal matching. This issue is extremely important when hundreds of courses are managed in the repository and about ten requirements proposed from a user for a particular course. The issue leads to what strategies can be adopted to match the user's goals and automatically or semi-automatically find the right course.

Further description of the idea of goal matching still needs more investigation not only from metadata domain but also from enterprise modeling area.

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A Web-Based Motivation-Supporting Model for Effective Teaching-Learning

Woochun Jun[1], Le Gruenwald[2], Jungmoon Park[3], and Suk-ki Hong[4]

[1] Dept. of Computer Education, Seoul National University of Education, Seoul, Korea
wocjun@ns.snue.ac.kr
[2] School of Computer Science, The University of Oklahoma, Norman, OK 73069, USA
ggruenwald@ou.edu
[3] Dept. of Computer Education, Seoul National University of Education, Seoul, Korea
gatepak@orgio.net
[4] Dept. of Business Administration, Konkuk University, Chungju, Korea
skhong01@kku.ac.kr

Abstract. Web-based Instruction (WBI) has been adopted in many educational systems. However, due to WBI's lack of face-to-face communication existing in a traditional classroom, their effectiveness is minimal. One way to lessen this problem is for these systems to implement a model that provides motivation to students. In this paper, we present a model to support motivation based on constructivism, which is known to be very suitable for WBI. The model is developed according to the four types of interactions: students-teachers, students-students, students-contents, and students-experts. We then describe the implementation of our model and its application to a third-grade science course for demonstration purposes.
Keywords: Web-based Instruction, Motivation, Instruction model.

1 Introduction

Rapid development of the Web technology has changed not only the initial role of the Web as the medium of information communication but also the ways of life in various ways. Especially, the Web has affected the traditional teaching-learning method. Web-Based Instruction (WBI) has rapidly become an important method for effective teaching-learning. It has the following unique characteristics that are different from those of traditional off-line teaching-learning, and thus requires the changes in its application to teaching-learning [2]. WBI overcomes the limitations of time and space, and enables rich information to be utilized as study materials through multimedia such as text, graphics, sounds, and animation. It makes interactions feasible [2,4,12,13]. That is, it enables dynamic interactions between teachers and students as well as among students themselves. In addition to efficient communication, problem solving and learning abilities can be improved through the dynamic interactions.

Although WBI has the above advantages, it has some drawbacks. It may weaken students' motivation due to lack of face-to-face communication. It is reported that 30 to 50% of all students who start a distance education course drop out before finishing

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[15]. Supporting constant motivation to students is a crucial factor to achieve success in WBI. In this paper, we present a model to provide motivation to students. There has been some research in the literature on this topic [3,10,17]. Most of the research includes psychological effects that are subjective and are not easily measurable. Our model is based on the principles of constructivism [6,16]. Our model provides students' motivation according to the four types of interactions: students-teachers, students-students, students-contents, and students-experts.

One of the main characteristics of our model is that teaching-learning is directed by students themselves. That is, students gather materials for themselves, determine the study subjects, and share information with each other. Further, diverse real and non-real time interactions can yield better teaching-learning processes. Teachers can respond to the requirements of students, and insufficient responses can be supplemented by cooperative work through the interactions between teachers and students. Also, for students to share information with each other and supplement their insufficient ideas, bulletin board systems (BBS), resources centers, chatting, and e-mails are utilized. Finally, study processes and relevant information are stored, and feedbacks are given to both teachers and students.

We implement our model and, for demonstration purposes, show how it can be used in a third grade science course.

This paper is composed of five sections. In Section 2, we present theoretical background, and in Section 3, we explain our motivation-supporting system design. Section 4 describes the system implementation and its application to a subject in elementary school. Finally, we conclude our work and discuss future study in Section 5.

2 Theoretical Background

2.1 Motivation

Motivation is an essential factor to students' actual study process. Specifically, motivation is crucial because education is planned to change students' values and to modify their pattern of behavior [5]. The factors that affect motivation can be classified as internal (individual) or external (environmental). Examples of internal factors are students' interests, curiosity, and desire to study. On the other hand, external factors include extrinsic rewards, such as privileges or tokens.

2.2 Web-Based Instruction

Recently, diverse teaching methods that use new media or knowledge have been applied in the field of education. The application of multimedia and the Internet to education is a representative example. WBI is to link abundant potential of the Internet to education. Also, WBI is to apply the positive characteristics of the Internet for effective and efficient education [9,11]. According to planned ways of study, intended interactions are conducted through the Web for developing students' knowledge and learning abilities. Specifically, WBI can provide educational environments that accommodate rapid social changes, beyond traditional repetitive studies for predefined contents and curricula.

2.3 Constructivism

In this Section, we introduce constructivism and argue why constructivism is easily adapted for WBI.

The basic principles of constructivism include three principles: learner construction of meaning, social interaction to help students learn, and student problem-solving in "real-world" contexts [1,6]. The first principle implies that learners construct their own meaning based on their experiences. That is, each person has a unique mental structure that allows him or her to derive meaning based on his or her experiences. According to constructivism, the course objectives and ways to reach them are not provided in advance. In this case, the Web can provide enough information easily. The second principle means that social interaction provides mediated interpretations of experiences among individuals. Constructivism encourages both self-directed work and cooperative work. The Web can provide both synchronous and asynchronous communication tools to support cooperative work. The third principle implies that students can increase problem-solving ability when they are faced with real-world problems. Students can get various experiences via WBI. WBI helps students participate in "real-world" problem solving.

2.4 Related Works

In the literature, there exist the following works on providing motivation.

In [3], they argue that the following may cause a lack of student motivation: family illness, students' unwillingness to deal with the content being delivered, funding problems at home or school, lack of interpersonal communication skills, no connection between what is being taught via the Web and his or her goals, etc. For possible solutions, they suggest the following: first, get to know the students. In order to do this, let students provide their photos and e-mail addresses at the beginning of semester. Also, if a student is experiencing a motivation problem, communicate with students immediately.

In [10], their motivational-design model has seven categories as follows: variation and curiosity, relevance, challenge level, positive outcomes, positive impression, readable style, and early interest. "Variation and curiosity" refer to maintaining curiosity and providing different learning styles to students. "Relevance" refers to linking the learning process to the goal or desire of the student. "Challenge level" refers to providing challenging problems to students in various manners. "Positive outcomes" refers to extrinsic rewards to hold students' motivation. "Positive impression" refers to organizing course materials in various ways to hold students' attention. "Readable style" means that providing readable expression in writing or speech. Finally, "early interest" means that interests must be supported in the instruction as early as possible.

In [17], their model for supporting motivation includes the following elements: attention, relevance, confidence and satisfaction. "Attention" is to provide interests or curiosities to students. Also, "relevance" refers to the applicability of the content to real life or other subjects. “Confidence” is to describe student’s understanding ability through the course or instruction. Finally, “satisfaction” is to provide any kinds of satisfaction to students after the course. The typical example includes fair grade and any positive rewards.

In [8], a motivational-design model is presented. The model includes 4 stages for a given course module: Define, Design, Develop, and Evaluate. In the “Define” stage, study objectives are developed. Also, students are analyzed for their background. In the “Design” stage, strategies to provide motivation are to be selected. In the “Develop” stage, course contents are actually developed. Finally, the “Evaluate” stage is to test students’ achievement and efficiency of the entire course module.

3 Design of a Web-Based Motivation-Supporting System

3.1 Basic Principles

Constructivism in teaching-learning assumes that students are active and positive in the learning process [6]. In addition, since constructivism emphasizes the students’ close interaction with their study environment, web-based teaching-learning is fit to constructivism [12]. Therefore, constructivism can be the theoretical foundation of teaching-learning model design. Since education activities are dependent on how teachers and students behave, communicate, and interact, interaction is considered a key concept in education activities [14]. As in education activities, interaction is also an essential factor in Web-based teaching-learning. Interactions in constructivism can be classified into four types as follows [7].

① Students and Contents

Interactions between students and contents are similar to interactions of hypermedia under constructivism. The principles that can be applicable to hypermedia forms belong here. Some examples are learning objectives, exercises, feedbacks, and interface environments.

② Students and Teachers

Interaction channels are more diverse and effective in Web-based teaching-learning than in any traditional teaching-learning. These types of interactions include interactions through e-mails, BBSs, resource centers, and discussion rooms. These types of interactions play an important role in facilitating study subjects and learning processes.

③ Students and Students

Web-based teaching-learning should provide communication channels among students that can promote cooperation in solving homework and assignment problems. Examples include synchronous channels (chatting, e-mail etc.) as well as asynchronous channels (bulletin board, resources center etc.). These channels will promote Web-based teaching-learning.

④ Students and Experts

The interactions with external experts can promote the effectiveness of completing homework. That is, when students confront difficulties in solving problems or need advices, they can contact with external experts through e-mail and BBS. Interactions with external experts can facilitate problem solving, and develop ways of thinking.

3.2 Web-Based Motivation-Supporting Model

The model has three phases: “before-class activity”, “in-class activity”, and “after class activity”. Each phase is explained as follows.

Table 1. Before-class activity model

Interaction / Activity	Student-contents	Student-teacher	Student-student	Student-experts
Recognize subject	Provide subject	Exchange ideas on subject	Exchange ideas on subject	Exchange ideas on subject
Search information	Read contents	Ask references	Exchange information	Ask for information
Share information	-	Exchange information	Share information	-
Decide subjects	Read contents	Ask if the subject is proper or not	Exchange ideas if the subject is proper or not	Exchange ideas if the subject is proper or not
Ask questions	-	Ask questions	Ask questions	Ask questions

Table 2. In-class activity model

Interaction / Activity	Student-contents	Student-teacher	Student-student	Student-experts
Check if the necessary information is ready	Read materials provided	Ask teacher if necessary information is ready	Ask each other if necessary information is ready	-
Identify study objectives	Read contents	Identify study objects	Identify study objects	-
Read materials	Read materials	Ask questions	Exchange opinions	-
Discuss	-	Exchange ideas	Exchange ideas	Exchange ideas
Present	-	Present opinion	Present opinions	Present opinions
Save results	Put results in BBS	Put results in BBS	Put results in BBS	Put results in BBS

Table 3. After-class activity model

Activity \ Interaction	Student-contents	Student-teacher	Student-student	Student-experts
Decide the best presenting group	-	Promote students' votes	Decide best presenter	-
Evaluate	Solve the problem in the study materials	Evaluate student performance	Evaluate colleagues' performance	Evaluate student performance
Further study	Read further study subjects	Provide directions for further study	Share information for further study	Ask questions for further study
Reflect	Read summary and review questions	Examine processes and outcomes	Examine processes and outcomes	Examine processes and outcomes

3.3 System Design

The system consists of two modules, one for students and the other for teachers. After a participant logs in the student module or teacher module, the system is operated in different manners according to participant rooms. Participant rooms consist of three stages (before-class activity, in-class activity and after-class activity), and contents provided in each room are different. The systems structure is shown in Figure 1.

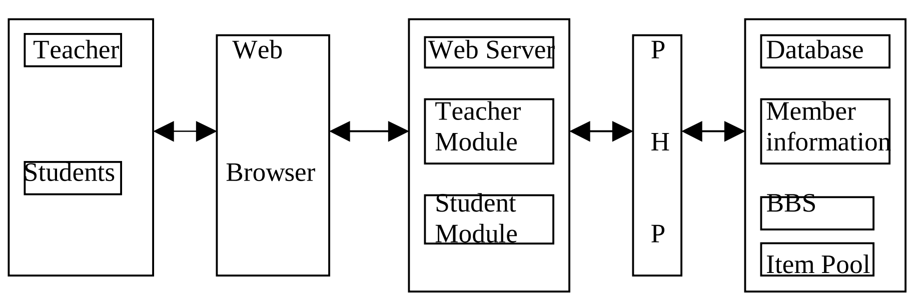

Fig. 1. System structure

1) Teacher Module

Teachers log in the system and can access the teacher module through authentication. In the *before-class* stage (preparation stage), teachers present study subjects and their relevant contents, and take an initial role as assistants. In addition, teachers, as guiders or supporters, motivate students to keep interests and curiosity through interactions. In the *in-class* stage (participation stage), learning objectives and study materials necessary to teaching-learning are provided through linking with the database. Teachers take a role of managers for the harmonious teaching-learning process. In the last stage, *after-class* stage (reviewing stage), the teachers review the teaching-learning process, and examine the possible problems or insufficiency in the process. Teachers, as encouragers or supporters, encourage students to share information, and to interact in synchronous or asynchronous manners.

2) Student Module

Students log in the system and can access the student module after attaining the authentication. Similar to the teacher module, the student module has three stages, *before- class*, *in-*class, and *after-class*. In the *before-class* stage, students search and examine the subjects presented by teachers. Students can share gathered information, and ask each other questions. In the *in-class* stage, students participate in the class, and study the subjects and discuss those subjects among themselves. Materials presented by teachers are used as a supplementary means. In the last stage, *after-class* stage, students review what they have studied, and examine their drawbacks and future study subjects.

4 Implementation of the Web-Based Motive-Supporting System

The system is developed to support effective teaching-learning. Our system has the following characteristics.

First, students' participation tools are reflected for the self-directed study. Further, in the stage of participation, the system induces students to recognize problems for themselves in addition to the subjects provided by teachers.

Second, overcoming the limits of time and space, the system provides participants' access anywhere and anytime. Beside the participation stage that is in class, log-in provides system access to help solve problems.

Third, the system enables students to supplement insufficient materials. For example, the system provides relevant reference sites in a navigation menu, in which students can find necessary materials with minimizing navigation errors.

4.1 System Development Environment

The system is developed using PHP and My-SQL. When students access the Web, the necessary processes are linked with the server through the system designed with PHP. In addition, databases are designed using My-SQL. The system development environment is shown in Table 4. The system is implemented in http://comedu.snue.ac.kr/~gatepark in Korean. Its English version will be available soon.

Table 4. Development Environment and tools

Items		Specification
Server	Operating System	Linux
	Web server	Apache
Client	Operating System	Windows 98
Database linkage software		PHP 4.0
Database server		MY-SQL
Web Browser		Internet Explorer 5.0
Web site construction Tool		Dreamweaver 4.0 Flash 5.0 PhotoShop 6.0

4.2 Interface Screen and Other Major Screens

1) Introduction Screen

The initial introduction screen is designed to let students select various menus as shown in Figure 2.

2) Interface Screen

Clicking the menu for "Let's participate" from the introduction screen, users can access the interface screen as shown in Figure 3. In this menu, Students can log in to the system.

Fig. 2. Introduction Screen

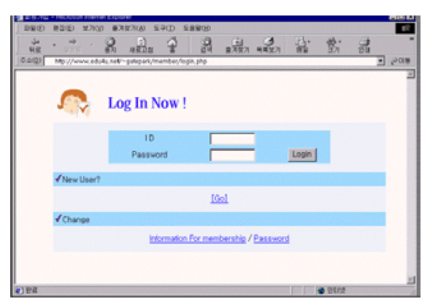

Fig. 3. Interface screen

3) Main Screen of before-class activity

After completing log-in, the main screen of preparation can be accessed. *Preparation* is the stage before the class. In this stage, study subjects are selected and necessary materials are searched through navigation. Also, gathered information is shared. The screen is shown in Figure 4.

4) Main Screen of in-class activity

This is the stage of in-class. During the class, teachers provide learning objectives and study materials, and students discuss and make a presentation for the completion of the assignment. The screen is shown in Figure 5.

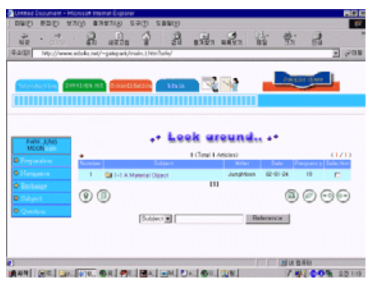

Fig. 4. Main screen of before-class activity

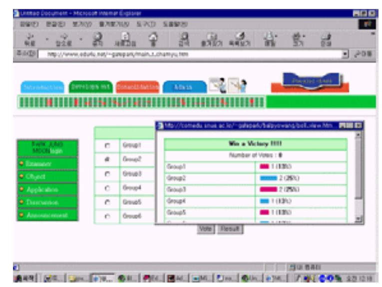

Fig. 5. Main screen of in-class activity

5) Main Screen of after-class activity

After class, discussion and review about the process of solving the assignment are performed. Teachers can find insufficient parts, and encourage students to express the desirable subjects and contents for the next class. The screen is shown in Figure 6.

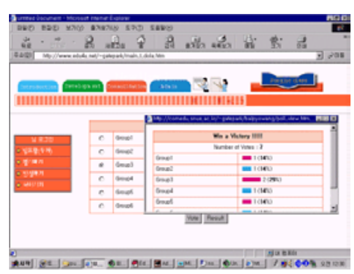

Fig. 6. Main screen of after-class activity

4.3 Trial Implementation

In this section, we show that our system can be applied to a third grade science course of an elementary school, although the system can be applied to any course. Each activity is explained as follows.

1) Before-Class (Preparation)

The guidance for teaching-learning before class is related to preparation of the class as shown in Table 5.

Table 5. Examples of before-class activity

Title of study unit: Substances in our surroundings		
Activities	Recognize subjects	What are common characteristics of substances?
	Search information	-Students are supposed to search relevant information through the Internet and put some reference sites in BBS. -Students also look for sites recommended by other students
	Share information	Based on information searched, exchange ideas on the common characteristics of substances for in-class participation
	Decide subjects	-Let students decide what kinds of topics to be investigated and put those topics in BBS - Teachers are supposed to provide their opinions on possible topics
	Exchange ideas	-Let students contact each other or ask experts for any questions on common characteristics of substances - Teachers need to assist students when they need help

2) In-Class (Participation)

The guidance for teaching-learning in class is related to participation as shown in Table 6.

Table 6. Examples of in-class activity

Title of study unit: Substances in our surroundings		
Study theme: Common characteristics of substances made of the same materials		
Study objectives: - find substances made of solid - find substances made of glass - find substances made of other materials		
Activities	Check if the necessary information is ready	Let students decide who gathered the most useful information
	Identify study objectives	Identify the common characteristics of substances made of the same materials
	Read materials	Compare the information searched by both students and teachers
	Discuss	-Make groups -Read references and exchange ideas by group -Put summaries of each group in BBS
	Present	Present the results by each group
	Save results	Save the final results after presentation and put those results in BBS

3) After-Class (Review)

The guidance for teaching-learning after class is related to review as shown in Table 7.

Table 7. Examples of after-class activity

Study theme: Substances in our surroundings		
Activities	Decide the best presenting group	-Decide the best presenter based on students' votes -Provide rewards to groups
	Evaluate	Evaluate processes and outcomes
	Further study	Let students decide further themes to be studied or their requests on BBS
	Reflect	Students and teachers are supposed to look back the study progress and discuss matters to be improved

5 Conclusions and Further Work

Even though motivation is critical to teaching-learning success, it has been neglected for quite some time. The main reasons of the motivation deficiency in the ordinary classes are limitations of space and time, that is, classroom as a closed space, and fixed class time for, say, 40 minutes. Further, since learning motivation is not a simple but rather complex process, it is difficult to develop motivation strategies with detailed tactics and tools.

This research suggested the following for dealing with the above issues.

For the first issue, with diverse study materials through the Web, students can overcome the limitation of physical space. In addition, classes do not have to be restricted to a fixed class time of, say, 40 minutes, because *before-class, in-class, and after-class* are available through the Web. For the second issue, we resolve this issue by utilizing various types of interactions, based on contructivism, and students' self-directed study during the problem solving process.

This research is focused on the interactions between teachers and students. However, the interactions with parents and external experts will be more reinforced. For the expanding interactions, diverse motivation techniques and tools should be also developed. After the effectiveness of this system is verified, supplementary research on the interactions and motivation should be continued.

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The Design and Implementation of a Web-Based Teaching-Learning Model for Information Communication Technology Application Education

Hyosook Jung[1], Woochun Jun[2], Le Gruenwald[3], and Suk-ki Hong[4]

[1] Yang-dong Elementary School, Seoul, Korea
est0718@chollian.net
[2] Dept. of Computer Education, Seoul National University of Education, Seoul, Korea
wocjun@ns.snue.ac.kr
[3] School of Computer Science, University of Oklahoma, Norman, OK 73069, USA
ggruenwald@ou.edu
[4] Dept. of Business Administration, Konkuk University, Chungju, Korea
skhong01@kku.ac.kr

Abstract Advances in information communication technology (ICT) require new paradigms in every aspect of our society. In this sense, schools are responsible for educating students to solve real-world problems with ICT. However, schools have not provided quality education to students for learning ICT and applying it. It is thus necessary to develop an ICT instruction model for students. One of the popular instruction models for Web-based instruction is the project-based model (NetPBL). It is a student-centered model in which students take initiative in all study processes. The model includes inquiry activities of areas, such as subjects, problems, and issues, and presentation activities of study results. The model also encourages interactions among students for achieving common goals. In this paper, we present an instruction model called Web-based instruction model for ICT (WICT) which provides four major enhancements to the existing project-based model. First, our model emphasizes learners' autonomy and helps them perform diverse learning activities. Second, learners can decide the learning objectives and strategies for themselves, and participate in the evaluation process of their study results. Third, by experiencing active information sharing and interactions, learners can acquire information communication ethics such as the utilization of sound information, network communication etiquette, and copyright protection. Fourth, learners can develop their creativity and problem solving abilities in the process of finding proper information, analyzing it, and eventually creating new information for their objectives. We then present the implementation of our proposed model in an example application of elementary school's social study courses.

Keywords: Web-based Instruction, Information communication technology.

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1 Introduction

In a knowledge-based society, ICT can support synthetic management of tremendous data that can be utilized by human. ICT is essential to the process of collecting, processing and analyzing data. In the field of education, ICT can provide many benefits. It can overcome the problem of time and space limits existing in traditional classrooms, provide new information to both students and teachers, support students' individual study, and provide authentic circumstances [2,4,6,11]. New paradigms in education, such as the one that calls for practical use of Internet, require improvements in computer literacy, computer ethics, and teaching-learning methods using ICT.

The objective of ICT education is to increase students' information literacy capability necessary for the knowledge and information based society and encourage them to apply their capability to study activities as well as daily life [6]. Therefore, both information literacy and applicability are important in ICT education. However, only improving information literacy capability has been emphasized in schools. Currently, to our best knowledge, there is only one formal instruction model for ICT application education [9]. The model is good for only courses whose problem-solving process and solutions are well defined. However, it may not work well for other types of courses that require complex thinking process and creativity. Thus, before the trial of ICT application education, it is very important to develop an ICT instruction model for students.

In general, any instruction model can be used to ICT application education. Among various instruction models, the project-based model is the most suitable due the following reasons [5]. First of all, the model allows students to take initiative through the study process. Second, the model includes inquiry activities of areas, such as subjects, problems and issues, and presentation activities of students' products. Finally, students are supposed to correct their misunderstandings through various interactions among students.

In this paper, we present an instruction model for ICT application education. Our model is based on the existing project-based model but includes the following additional features. First, it emphasizes learners' autonomy and distinctive characters, and helps them perform diverse learning activities. Second, learners can decide the learning objectives and strategies for themselves, and participate in the evaluation process of their study results. Third, by experiencing active information sharing and interactions, learners can acquire information communication ethics, such as the utilization of sound information, network communication etiquette, and copyright protection. Fourth, learners can develop their creativity and problem solving abilities in the process of finding proper information, analyzing it, and eventually creating new information for their objectives. And fifth, learners can obtain the opportunity for widening their ways of thinking by taking advantage of ICT, which overcomes the limitations of time and space in the traditional classroom. We then present the implementation of our proposed model in an example application of elementary school's social study courses.

This paper is organized as follows. In Section 2, we present the concept and necessity of ICT education, and supporting tools for ICT application education. In

Section 3, we discuss NetPBL. In Section 4, we present our model for ICT application education. In Section 4, we describe the implementation of our model in an elementary social study course. Finally, In Section 5, we give conclusions and further research issues.

2 ICT Education

2.1 Concept and Necessity of ICT Education

ICT education implies education based on computer and communication tools for current knowledge and information society [12]. ICT education can be classified into two categories: ICT literacy education and ICT application education. ICT literacy education (also called computer education) means education about computer and information communication. On the other hand, ICT application education is education about applying ICT to courses in various subjects such as math, science, and foreign languages.

The objective of ICT education is to provide capability for collecting and analyzing information necessary to each person, and let everyone use this capability to enjoy active and creative life [12]. In order to achieve this objective, ICT should be used to teach every class in school. Currently ICT education is more concerned with teaching how to apply ICT to each class rather than simply teaching how to use computers [7].

2.2 Teaching-Learning Activity Types for ICT Application Education

Activity types for ICT application education can be classified into 8 categories as shown in Table 1 [7].

Table 1. Teaching-learning activity types for ICT application education

Activity Type	Concept
Search information	Search information through visiting the Web site, reading CD-ROM title and printed materials, and exchanging ideas with others
Analyze information	Analyze information using various methods, such as survey or experiment, and forecast conclusions based on the analyzed information
Guide Students	In this type, teachers lead most study activities based predefined plans. Teachers are supposed to provide CD-ROM titles, presentation materials or Web page for students.
Discuss on the Web	Discuss on the specific topic with approved participants or anybody else using Chat, BBS (Bulletin Board System) and e-mail
Collaborate on the Web	Exchange ideas on common concerns with students from different regions and share the results
Communicate with Experts	Communicate with experts, parents as well as other teachers on the Web to obtain knowledge for problem-solving
Support E-pals	Exchange ideas with students from different regions using e-mail
Produce results	Produce results and publish them for others. The published forms include reports, presentation files or Web pages

2.3 Supporting Tools for ICT Application Education

The supporting tools for ICT application education and their characteristics are explained in Table 2 [7].

Table 2. Supporting tools for ICT application education and their characteristics

Supporting Tools	Characteristics
Word processor, Desktop publishing package, and presentation software	-Improve students' understanding and help students present their results
Graphic and animation	-Materialize abstract concept and provide clues for study -Provide intuitive recognition and motive to students
Internet Search Engine	-Provide necessary information for achieving study objectives
E-mail, BBS, on-line chat	-Help students exchange ideas with many people and understand various cultures
Simulation	-If experiencing real situation is dangerous, expensive and time-consuming, simulation let students experience virtual reality
Database and Spreadsheet	- Help students analyze results and verify their original hypothesis

Table 3. A teaching-learning model for ICT application education [9]

Stage	Substage
Introduction	- Introduce course - Create good atmosphere for students - Convey basic concepts
Presenting problems and information	- Present problems - Introduce assignments - Provide information and let student observe - Group activity
Problem solving	- Inquiry activity - Exchange ideas and converge those ideas - Provide supplementary information - Search information - Contact experts - Induce solutions - Induce conclusions
Presenting results	- Produce results - Present results
Conclusions	- Organize results - Contact experts - Apply results - Self-examine - Notify next topics

2.4 Related Work

In the literature, a teaching-learning model for ICT application education has been published in [9]. The model is based on the problem-based model. The teaching-learning model has the following five stages as shown in Table 3.
In this model, teachers have control over students' activities. In other words, students are supposed to follow their teacher's instructions and induce conclusions based information provided by the teacher. Thus, the above model is focused on solving problems whose solutions are predefined. That is, the model is good for only courses whose problem-solving process and solutions are well defined. However, it may not work well for other types of courses that require complex thinking process and creativity.

3 NetPBL

3.1 Concepts and Characteristics of NetPBL

NetPBL is a teaching-learning method that helps students collect various information by communicating with others on the Internet, and finish specific projects [8,10].

The characteristics of NetPBL are as follows [3,8].

- It deals with project with undefined solutions or many solutions.
- It accepts gracefully mistakes made by students in the course of the project.
- It lets student utilize various knowledge from diverse areas in order to finish the project.
- Students are responsible for their project and are supposed to solve problems encountered during the project.
- Students are evaluated regularly and supposed to reflect their study activities regularly.

3.2 Significances of NetPBL

The significances of NetPBL in education are summarized as follows [13,14,15].

First, it improves learning strategies and thinking skills. Instead of covering many superficial topics, it encourages students to work on a problem in depth. For achieving a goal, students are also given some freedom to follow what they like instead of a predefined sequence. NetPBL also supports life-long learning. Thus, students are supposed to think about a topic and exchange ideas continuously after the project is over. In addition, NetPBL encourages students to be active all the time. They are supposed to collect, organize and analyze information for themselves. They are also required to contact anybody if necessary. The NetPBL also encourages cooperative learning. A meditated conclusion can be reached by cooperative work through various interactions.

Second, it supports contextual learning. In NetPBL, students are encouraged to experience real-world problems. This makes learning less abstract and more connected to real life. In [1], it is argued "when students deal with authentic problems, it helps them to construct highly developed schema that contributes to an increased ability to solve problems".

Third, it emphasizes individualization. That is, it recognizes that different people learn best in different ways. NetPBL helps to support individualization with various options for representing feedback and discourse, etc.

Fourth, NetPBL emphasizes active participation.

4 The Proposed Model

4.1 Background

As we discussed in Section 3, NetPBL is a very useful instruction model in that it emphasizes students' active participation, various interactions, and evaluation for processes as well as products. On the other hand, the objectives of ICT educations

Table 4. Stages of NetPBL

NetPBL	
Stage	**Substage**
Start project	- Decide starting point - Plan study topics - Make question lists
Develop project activities	- Get ready for field study - Make observation - Ask experts for any question
Finish project	- Finish project - Individualize new knowledge

Table 5. Stages of the proposed model

The proposed model	
Stage	**Substage**
Plan	- Introduce project topics - Decide audience - Suggest evaluation standards - Organize topic Web - Make question lists
Perform	- Organize team members - Plan project - Advertise project - Select collaborators - Survey and discuss - Produce results
Evaluate	- Present and share results - Evaluate and reflect

are to increase students' applicability of ICT, students' problem-solving ability, and acquiring ethics on information communication [12]. In this sense, we believe that NetPBL provides the theoretical background for ICT application education.

In this work, we propose an instruction model for ICT application education. Tables 4 and 5 show the stages of NetPBL and our model, respectively.

Table 6. Stages and their subsequent activities of the proposed model

Stage	**Substage**	**Activity type**	**Tools and media necessary**	**Number of persons**	**Place for activity**
Plan	•Introduce project topics •Decide audience •Present evaluation standards •Organize topic Web •Make question lists	•Provide necessary information •Search information •Discuss on the Web	•Web search engines •Presentation software •Graphic and animation •BBS •On-line chat	Large group /individual study	Classroom /computer room
Perform	•Organize team members •Plan project •Advertise project •Select collaborators •Survey and discuss •Produce results	•Search information •Analyze information •Discuss on the Web •Perform collaborative work •Exchange ideas with experts •Exchange ideas using e-mail •Make conclusions	•Web search engines •Desktop publishing software •Word processor •Presentation software •Graphic and animation •E-mail •BBS •On-line chat •Database and spreadsheet	Small group/ individual study	Classroom /computer room
Evaluate	•Present and share results •Evaluate and reflect	•Discuss on the Web •Exchange ideas using e-mail	•Presentation software •On-line chat •BBS •E-mail	Large group/ small group/ individual study	Classroom /Computer room

4.2 Description of the Proposed Model

In this Subsection, we describe our model in detail. That is, we provide activity types, tools and media necessary for each stage, number of persons, and place for each activity. Table 6 shows each activity and its subsequent activities in the proposed model.

(1) “Plan” Stage

a) Introduce project topics

Teachers need to select project topics and describe project outlines, and present study objectives to students. Also, teachers have to present details for the project. When project topics are to be determined, the following should be considered: the topics are to improve curriculum and reinforce attainment of Internet technology. It is noted that students as well as teachers need to participate in deciding project topics.

b) Decide audience

In the traditional class, study activities and results are open to only students and teachers in classroom. But, with aid of Internet technology, students’ activities can be open to various people. In addition, those people can even participate in students’ projects. That is, they can cooperate with students and provide help to students.

c) Present evaluation standards

Before starting a project, it is necessary to present evaluation standards for the accurate assessment of students’ performance. Evaluation methods include paperwork, observation, and mutual evaluation. Especially, rublic has long been used to evaluate project activities and results [16]. A rublic means a set of criteria that define important parts of a project to be evaluated. Each criterion in turn defines several different grades of completion or competence. A rublic is used to provide clear guidelines to a reviewer how to evaluate a project. Since each criterion is clear and objective, different reviewers can make almost the same conclusions.

d) Organize topic web

The topic web is used to arrange words related to project topics made by teachers in the form of web pages. The topic web helps students guess range and size of activities in a project [17].

e) Make question lists

After the topic web is built, question lists are constructed by students. These lists are to help students collect questions they want to investigate in the course of the project. Teachers are supposed to put those lists on BBS.

(2) “Perform” stage

a) Organize team members

Depending on the project size, a group can have various members. In order to maximize interactions among members, each group is recommended to have 2-6 members. If more members are participated, some members may be inactive or isolated from others. Also, it is important to assign accurate duties to each member.

b) Plan project

Students are supposed to select subsequent project topics and complete project plans. Since success in a project depends on this step, teachers need to guide students carefully for completing the project plans. Before starting the project, students themselves need to examine and criticize the plan. This phase consists of the following two steps:

i. Decide project objectives, assignment, and results

Each group decides subsequent topics and decides project objectives, assignment, and results. Each group also determines how to recruit collaborators and how to compensate for their participation.

ii. Decide schedule

Decide the starting day and ending day for the project. Also, determine participants' application deadline and announce the deadline.

c) Advertise project

In order to find collaborators for a project, it is important to advertise the project broadly. In order to do this, the project title, and the project information, such as study objectives, project description, project schedule, participants' qualification, roles of participants, rewards for participants, contact information, and project manager, need to be advertised on the Web.

d) Select collaborators

Select qualified persons among participated collaborators for the project and share their contact information such as mailing address and e-mail address. Also, let students and selected collaborators know each other and find out issues that may occur during the course of the project.

e) Survey and discuss

In the survey activity, students are supposed to collect and organize information necessary for the project. Students find the relevant information on the Web or through exchanging e-mails with experts. Also, in the discussion activity, students can exchange and share opinions on the project. In addition, in this step, students are supposed to have off-line meetings regularly and report main events occurred in their team. Also, let team leaders report the project progress to all classmates.

f) Produce results

In this step, students should submit their results which are in the form of books or Web publications.

(3) "Evaluate" stage

In principle, students themselves need to reflect and evaluate their results and activities. In this case, teachers should give advice or encouragement instead of criticism. Mutual evaluation among students is also recommended.

a) Present and share results

Teachers and students present the project results and decide date to be published on the Web, roles of each participant, and presentation format, etc. This presentation provides very useful information to collaborators and audience. By doing so, results and ideas can be shared.

b) Evaluate and reflect

Based on evaluation standards, all processes and results need to be evaluated. The evaluation includes two factors. The first factor is to evaluate whether the main objectives and subsequent objectives under each of the main objectives are achieved or not. The second factor is to evaluate the project results through analyzing the results. After evaluation, students are supposed to reflect what they have done.

5 Implementation and Application of the Proposed Model

We implemented our model in site (http://use.chollian.net/~est718/pbl). Figure 1 shows the teaching-learning site map for our model.

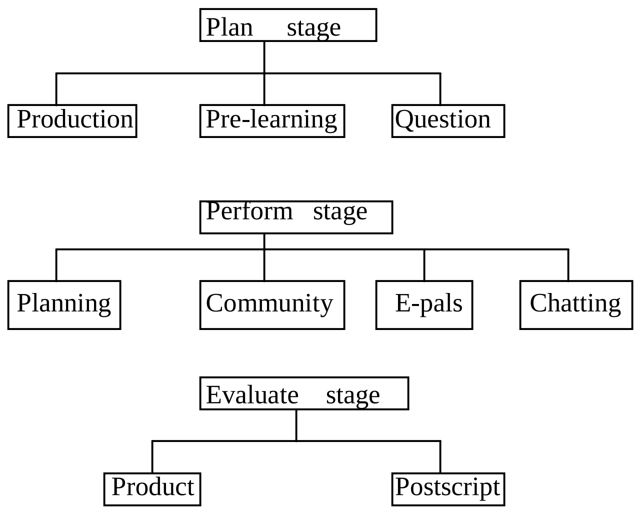

Fig. 1. Site map of our model

5.1 Plan Stage

Production guides subjects or topics, learning activity schedules, and evaluation criteria that teachers selected through the analysis of the education program and students' interests. *Pre-learning* induces students' experience and knowledge related to study subjects, and introduces useful study sites. In addition, the study of ICT literacy necessary to performing projects is explained.

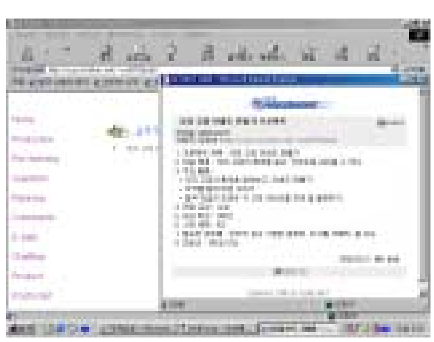

Fig. 2. Production screen

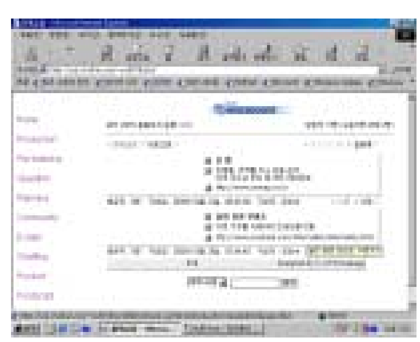

Fig. 3. Pre-learning screen

Question is used for students to post questions that happen during the course of the projects. The contents of a question can be added continuously, and posted questions are reviewed and discussed together at the end of *Question*. Figure 2 and 3 show *Production* screen and *Question* screen, respectively, in our Web site.

5.2 Perform Stage

Planning is used for students to turn in a detailed planning report, which explains detail subject selected by individual or a small group. The teachers prepare the planning report forms in advance, and guide the elements that must be included in the final report.

Community is the place where students can share diverse data and information gathered during the course of the projects. Students can also share ideas and discuss in depth with one another. Further, it is used for the regular meetings organized by individual teams in which teams report the major events happened in each team.

E-pals stores e-mails for the communication of external experts, parents, and the higher or lower grade students. Students can be supported to utilize special knowledge when they perform inquiry or research activities.

Chatting is used as a communication channel for the decision-making, and supports discussion activities for assigning roles and problem solving. Figure 4 and 5 show *Planning* screen and *E-pals* screen, respectively, in our Web site.

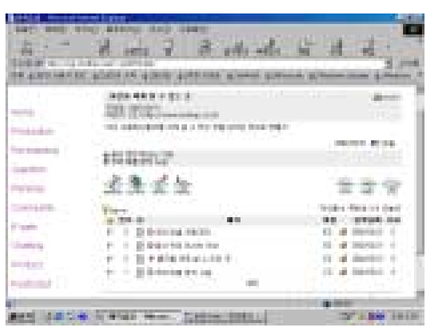

Fig. 4. Planning screen

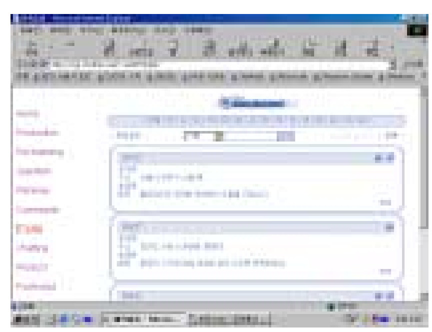

Fig. 5. E-pals screen

5.3 Evaluate Stage

Product shown in Figure 6 is the place where final results are published on the Web. The posted Web pages are shared with collaborators.

Postscript shown in Figure 7 is used when students want to discuss further on the previous subjects after the project completion. It provides opportunities to develop creative next projects.

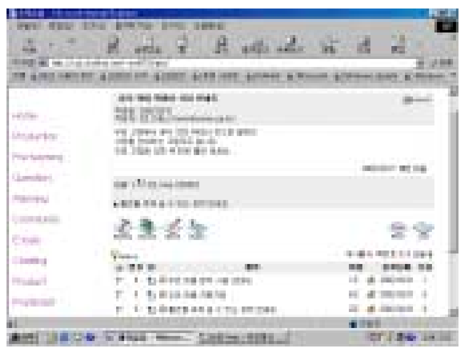

Fig. 6. Product screen

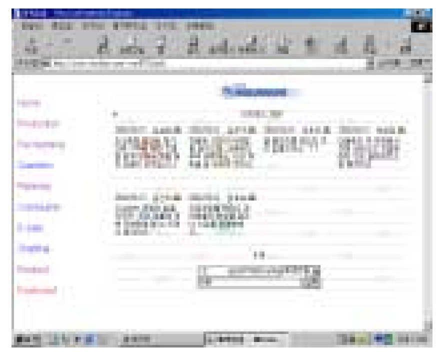

Fig. 7. Postscript screen

6 Conclusions and Further Work

ICT application education has been a sound social trend. The aim of this paper is to develop a teaching-learning model for ICT application education and illustrate the model's implementation in an example application of elementary school's social study classes. The paper suggests what kind of ICT can be selected at a specific time of learning, and how it can be utilized. In addition, the teaching-learning stages of the learning model are classified, and various ICT utilizing methods for each stage are introduced. As a result, time and effort for the preparation of ICT application education can be reduced.

The effectiveness of this model can be as follows. First, it emphasizes the learner's autonomy and distinctive characters, and helps them perform diverse learning activities, which is different from traditional memory-oriented education in a classroom. Second, learners can decide the learning objectives and strategies for themselves, and participate in the evaluation process of their study results. Therefore, they can enhance self-directed learning abilities. Third, by experiencing active information sharing and interactions, learners can acquire information communication ethics such as the utilization of sound information, network communication etiquette, and copyright protection. Fourth, learners can develop their creativity and problem solving abilities in the process of finding proper information, analyzing it, and eventually creating new information for their objectives. And fifth, learners can obtain the opportunity for widening their ways of thinking by taking advantage of ICT, which overcomes the limitations of time and space in traditional classrooms.

Even though this paper suggests a standardized learning model, teachers can develop their flexible study plan according to the their experience and study topics. In addition, it is necessary to develop instruction models reflecting gaps of ICT utilizing abilities among learners.

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On Analysis and Modeling of Student Browsing Behavior in Web-Based Asynchronous Learning Environments

Feng-Hsu Wang

Department of Computer and Communication Engineering, Ming Chuan University
5 Teh-Ming Rd., Gwei Shan District, Taoyuan County 333, Taiwan
fhwang@mcu.edu.tw

Abstract. Recently, the rapid progress of Internet technology stirs the widespread development of web-based learning environments in the educational world. As compared with conventional CAI systems, web-based learning environments are able to accumulate a huge amount of learning data. As a result, there is an urgent need for analyzing methods of discovering useful information from the huge log database for improving instructional effectiveness. In this paper, we focus on analyzing the historical browsing data to reconstruct a browsing model that enables teachers to identify some interesting or unexpected browsing patterns in student's learning process, and therefore might provide knowledge for teachers to reorganize their web structure for effectiveness. For this purpose, we had developed an analysis tool based on data mining technique. The constructed browsing model includes a set of document clusters and sequence rules among those clusters. Finally, an application of the analysis is conducted on a real database collected from three web-based courses in Ming Chuan University, Taiwan. Through this case study, we investigate the effectiveness of the analysis tool, and some revelations are presented and discussed.

1 Introduction

Web-based learning environments have been the main trend for technology-enhanced education in the last few years. In this new era of educational technology, Internet and WWW have been exploited as a vast repository of information, playing the role of rich educational resources. In web-based asynchronous learning environments, teachers could conduct many kinds of educational activities such as material posting, homework assignment, group discussion, online testing and so on. However, the most prevailing issue in such a learning environment is that it is not easy for teachers to monitor students' learning behaviors instantly. Nevertheless, as compared with conventional CAI systems, web-based learning environments are able to record most learning behaviors of the students, and hence are able to provide a huge amount of learning profile. As a result, there is an urgent need of analyzing methods to discover useful information for improved instruction performance from the huge log database. Previous investigations [1, 9] have discussed the methodology of using log database to

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improve system performance. At the same time, the historical learning records provide teachers with valuable resources to observe and analyze students' learning processes and performance.

Usually, web materials are divided into units of topics that are structured by some semantic relations among them [3]. This study assumes that analyzing students' browsing behaviors in an asynchronous web-based learning environment might reveal some insights into the true structure required of the material for being truly helpful for students' learning. Such knowledge about the dynamic browsing structure would be an important reference base for teachers interested in designing effective educational web documents. It may also be beneficial to the design of navigation guiders in adaptive learning environments. Therefore, this study proposes a novel browsing model to describe some useful browsing patterns, and develops an analysis tool based on data mining technique [5] to discover those patterns from the historical browsing database.

The browsing model actually consists of a set of document clusters and sequence rules among the document clusters. A document cluster indicates a set of documents that students often study together without specific order (the co-referenced knowledge units), while the sequence rules among those document clusters might reveal students' knowledge construction ordering in a specific target domain. In this study, we adopt the support rate in associative mining [2] as the main criterion for document clustering and sequencing. As a consequence, the analysis result provides a hierarchical view of document clustering and sequencing in different range of support values so that teachers can investigate them in different grain sizes (i.e., support values).

Finally, application of the analysis methodology is conducted on a real database collected from three web-based courses in Ming Chuan University, Taiwan. Three classes of Expert System course had been conducted for a semester in Ming Chuan University of Taiwan, and two of them were opened for daytime students and the other for on-job students. Students were grouped and they were required of a term project of building an expert system. During the semester, students had to work collaboratively in a web-based virtual classroom, in which students' interactions and activities such as document browsing were recorded in the back-end database for both evaluation and investigation purposes. The analysis result illustrates the potential capability of the method to reveal useful browsing knowledge as a basis for investigation and comparison of student's learning behavior.

2 The Knowledge-Supported Virtual Classroom (KSVC)

KSVC is built around the notion of managed knowledge space that facilitates the creation, sharing and exchanging of knowledge, where knowledge contributors can be teachers and students. The web material includes those coming from teachers as well as those knowledge documents created and organized by students through a collaborative learning process. As a result, KSVC provides an opportunity for teachers and students to work together to enrich the knowledge space with both the target knowledge from a diversity of perspectives and those knowledge hidden in traces of teaching/learning sessions. Fig. 1 depicts the knowledge-processing framework of KSVC.

The material base stores the knowledge documents for the target course, which are prepared and organized by teachers. The material may be classified as chapters, examples, figures, exercises, explanations, animations, videos, audios, and so forth, with prefixed linear or partially ordered sequences. Students can organize and present their knowledge documents as bookmarks, annotations, self-explanations, study reports, new findings, and so on.

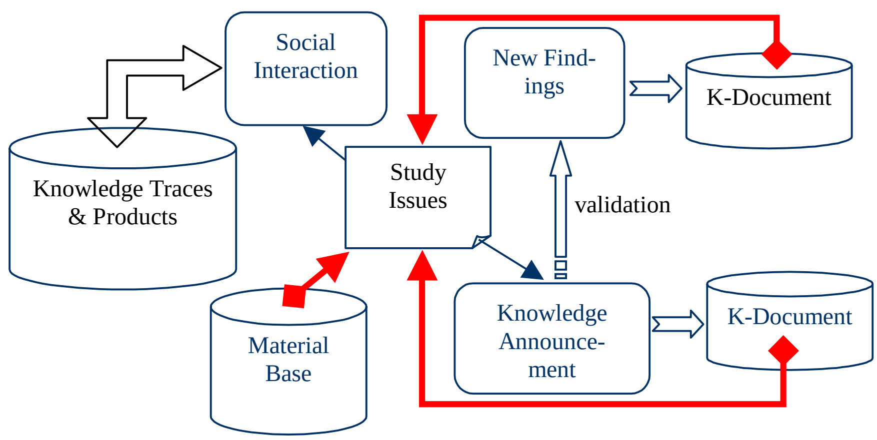


Fig. 1. Knowledge-processing framework of KSVC

When assigned a study issue for group working, students can access knowledge resources from the Material Base, Knowledge Announcement Storage and New Finding Storage. Students are strongly encouraged to post their findings on the Knowledge Announcement Storage so that they can earn more points at the final grading. Instructors can often visit the Knowledge Announcement Storage, validate the knowledge documents there and transport the qualified ones to the New Finding Storage. Students also need to work collaboratively to resolve the study issues through a social discussion stage, where group members generate, explain, share and exchange their positions and knowledge. The knowledge products of the discussion process are stored in the Knowledge Products, and instructors can set aside some time to investigate the products and group discussion processes, and may have a discussion with all students in the class.

3 The Document Browsing Model

First, we define a learning session as the duration when a student login into the system until he/she leaves the system. Also a session record containing only browsing activities is called a browsing-session record, which is the main focus of this study. In this study, we adopt the support rate in associative mining [2] as the main criterion for document clustering. In the following, we present preliminary definitions that are relative to the depiction of the browsing model.

Proposition 1: (Associative Relation) For any documents P_1 and P_2, we say P_1 is associated with P_2 if and only if P_1 and P_2 are "frequently" browsed in a learning session without "observable" ordering between P_1 and P_2.

Proposition 2: (Sequence Relation) For any documents P_1 and P_2, we say P_1 precedes P_2 if and only if P_1 and P_2 are "frequently" browsed together and there is "observable" ordering between P_1 and P_2.

The association relation given in Proposition 1 is aimed to describe those documents that students often studied together without observable sequences between them. This might happen frequently in a distance-learning environment when students are studying cross-reference documents in order to learn some concepts or practice problem-solving tasks. The sequence relation given in Proposition 2 is intended to describe those documents that students often studied together before studying another set of documents. The sequence relation shows possible prerequisite relations between the documents that indicate possible logical dependency in the knowledge construction process. Below we present the operational definitions of the associative document clusters and the sequence strength between document clusters.

Definition 3: Given a pair of documents (P_1, P_2), define the "page distance" between documents P_1 and P_2 as $\|P_1 - P_2\| = \frac{|\mathrm{SEQ}(P_1, P_2) - \mathrm{SEQ}(P_2, P_1)|}{\mathrm{N}(P_1, P_2)}$, where SEQ($P_i$, P_j) denotes the number of session records in which P_i precedes P_j, and N(P_1, P_2) is the number of session records containing both P_1 and P_2. Meanwhile, if SEQ(P_1, P_2) > SEQ(P_2, P_1), then call the "sequence strength" of $P_1 \bullet P_2$ is $\|P_1 - P_2\|$; otherwise the strength is 0.

Definition 4: Given a document cluster C of size n, the intra-cluster distance of C is $\underset{i=1..n,\, j=i+1..n}{Max} \| P_i - P_j \|$, where $P_i, P_j \in C$.

In this study, the intra-cluster distance of each document cluster is ensured to be no more than a user-specified intra-cluster distance threshold. Besides, we need another criteria for clustering documents. Hence, this study proposes another measure, *page similarity*, as follows.

Definition 5: Given a set of cluster C of n documents {P_1, P_2, …, P_n}, the intra-cluster similarity of C is defined as the support value, sup(C)=$\frac{N(P_1, P_2, \cdots, P_n)}{T}$, where N($P_1$, P_2, …, P_n) is the count of session records containing P_1, P_2, …and P_n, and T is the total number of session records.

Definition 6: A document cluster C is a valid associative cluster if and only if sup(C) $\geq$ *Support_Rate_Threshold* and $\|C\| \leq$ *IntraCluster_Distance_Threshold*.

Definition 7: Given two document clusters C_1 and C_2, define the *support* of the sequence rule $C_1 \bullet C_2$ as $\sup(C_1 \rightarrow C_2) = \frac{N(C_1 \rightarrow C_2)}{T}$ where $N(C_1 \rightarrow C_2)$ is the number of session records containing the pattern of $C_1 \rightarrow C_2$, and T is the total number of session records.

Definition 8: Given two document clusters C_1 and C_2, define the *confidence* of the sequence rule $C_1 \bullet C_2$ as $\frac{|\sup(C_1 \rightarrow C_2)|}{|\sup(C_1)|}$.

For illustration of the model construction process, consider the example shown in Table 1, and the minimum support rate and maximum intra-cluster distance are set to 0.5 and 0.1, respectively. Initially, we compute all clusters of size one (i.e., the large 1-itemsets) with sufficiently large supports, and we have the result of four clusters {A}, {B}, {C}, and {D}. Next, we proceed to discover clusters of size 2. We first generate all candidates of 2-clusters by combining pair-wisely the 1-clusters. Then check the validity of each candidate by computing its support and intra-cluster distance. The result is listed in Table 2. Since only {AB} and {CD} satisfy both the minimum support and maximum distance constraints, the two clusters {AB} and {CD} are found in the current iteration. Continuing this process, the new candidate cluster is {ABCD} with support 2/3 and intra-distance 1. However, since its intra-cluster distance is larger than the maximum distance, {ABCD} cannot be a valid document cluster. Hence, the final associative document clusters found are {AB} and {CD}, and Fig. 2 shows the constructed hierarchical clusters. The hierarchical clusters say that documents {A, B} and {C, D} are often browsed together with no specific orderings.

After the associative clusters {AB} and {CD} have been found, the model construction task next generates the hierarchical rule structure by computing the cluster sequencing support and confidence for each pair of clusters ({AB} and {CD} in this example). Viewing each document cluster as a lattice structure (as shown in Fig. 2), we devise an efficient lattice-product algorithm that outputs all feasible sequence rules in a lattice hierarchical structure for each pair of document cluster. By ’feasible’ rules we mean those with sufficient support and confidence (with a minimum support and confidence constraint, say 0.5 and 0.8, respectively). For instance, the hierarchical sequence rules computed for the cluster pair {AB} and {CD} are shown in Fig. 3. A link from a lower node X to its upper parent node Y indicates that the rule corresponding to node X is a generalizer of the one corresponding to node Y. For example, the rule {A}→{CD} is a generalized rule of the rule {AB}→{CD}. The (support, confidence) pair of the sequence rule {A}→{CD} is (0.66, 0.8), which says that if a student browses document A, then it is predicted with a confidence of 80% that he/she will next browse documents C and D (in any ordering). On the other hand, the sequence rule {AB}→{CD} with (0.66, 1) says that if a student browses documents A and B (in any ordering), then it is predicted with a confidence level 100% that he/she will next browse documents C and D (in any order). Such kind of information could be useful for providing personalized navigation guidance in web-based learning systems [6].

Table 1. An example database of browsing session records

Session #	Browsing path
1	ABCD
2	ABCD
3	BADC
4	BADC
5	CA
6	DB

Table 2. Support rates and cluster distances of 2-clusters for the database of Table 1

Cluster	Support rate	Cluster distance
AB	2/3	0
AC	5/6	1/5
AD	2/3	1
BC	2/3	1
BD	5/6	3/5
CD	2/3	0

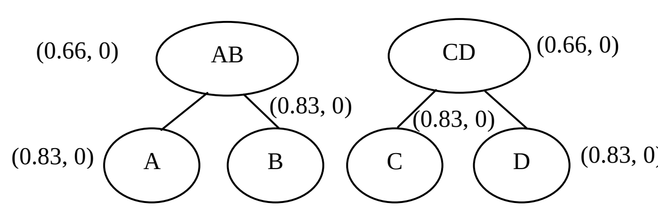


Fig. 2. Hierarchical clustering of documents with (support rate, intra-cluster distance) as node labels

4 Analysis and Modeling Process

This section presents the data analysis process which consists of the following five stages: 1) data filtering, 2) data transformation, 3) frequency analysis, 4) mining associative document clusters and 5) mining sequence patterns, as shown in Fig. 4. Since this study focuses on the browsing related activities, all other unrelated data are filtered out, including those activities of teachers in the classroom, and those browsing records with short stay-time, e.g., reference pass-by pages. To partially validate long-stay-time records, a client program could be deployed to monitor users' interactions with the computer. The program could accumulate the pre-specified time intervals (say 10 minutes) in which users had performed some actions such as clicking, mouse moving and keyboard pressing. Besides, the raw data has to be reconfigured for each student's browsing session. First, all the browsing records are sorted with the student id as a major key and start time as a minor key in an ascendant manner. Then, browsing records picked up between two successive "Login" records are grouped into a browsing-session record.

As it often happens that students navigate documents back and forth, we need a way to handle such a tree-structured browsing behavior [4]. This study adopts the preorder scan approach [7] for converting student's tree-structured navigation paths into a maximal ordered browsing sequence. In this approach, most sequencing information could be retained in the browsing session records. For example, consider a student′s navigation path as shown in Fig. 5. Using the method in [4], three forward reference paths, A•B•C, A•B•D and A•E will be generated. In contrast, our method will generate the A•B•C•D•E browsing sequence through a preorder traversal of the tree. As can be seen, the maximal ordered browsing sequence contains all the subsequence generated by [4] and many other potential sequences (like C•D in this example) as well. Hence, our approach preserves more potential sequences than Chan et al. and therefore allows more possibility for the algorithm to find sequential browsing patterns.

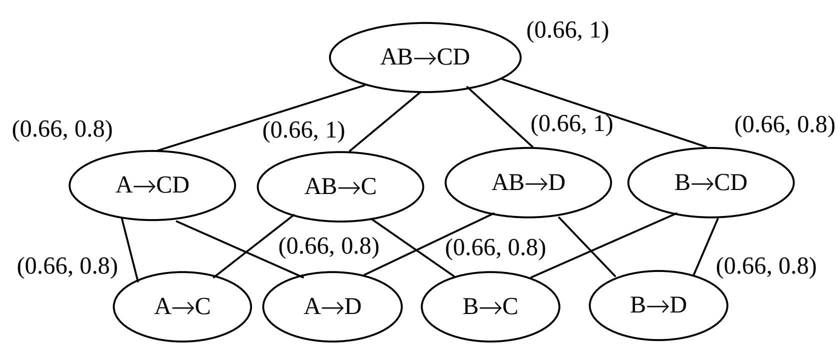


Fig. 3. Hierarchical sequence rules generated from the document cluster pair ({AB}, {CD}) with (support rate, confidence) as node labels

At first, frequency analysis is helpful for instructors to take an overlook of the usage of various categories of materials. Presently, the system provides two kinds of frequency analysis: (1) the hit rate diagram of the material, and (2) the summary hit rate diagram of the material categories (see Fig. 6). Finally, Fig. 7(a) and (b) show the screenshots of the clustering and sequence mining results, respectively.

This study applies the aforementioned analysis process in three web-based classes of the “Expert System” Course in Ming Chuan University, Taiwan. There are totally 172711 browsing records in the log database. Setting the minimum threshold of browsing time as 7 seconds, and the minimum support as 0.03, a total of 22846 general session records are left after the cleaning process, and a total of 960 browsing session records are attained after the transforming process. The total number of material documents is 96, and the number of sessions and average session length of each class are listed in Table 3. The material are divided into three categories: “Theory”, “Demo Systems” and “Design”, in which the Design category is further divided into “Languages”, “Operations”, and “Samples”, as shown in Fig. 8. Table 4 shows the coverage rate of each material category in the material database.

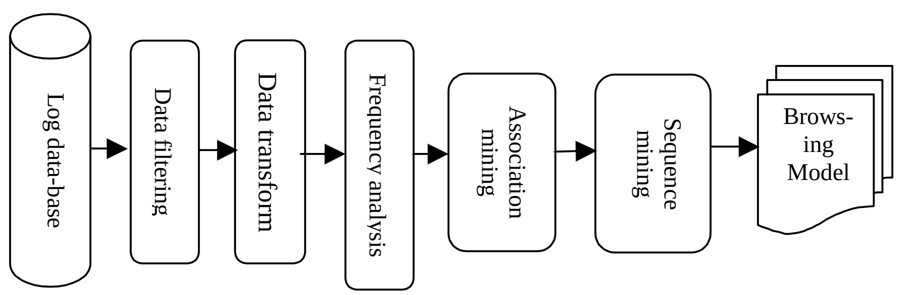


Fig. 4. The data analysis process of browsing model

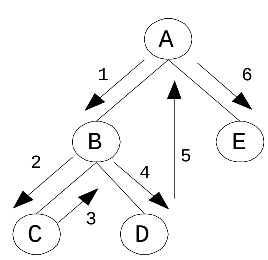


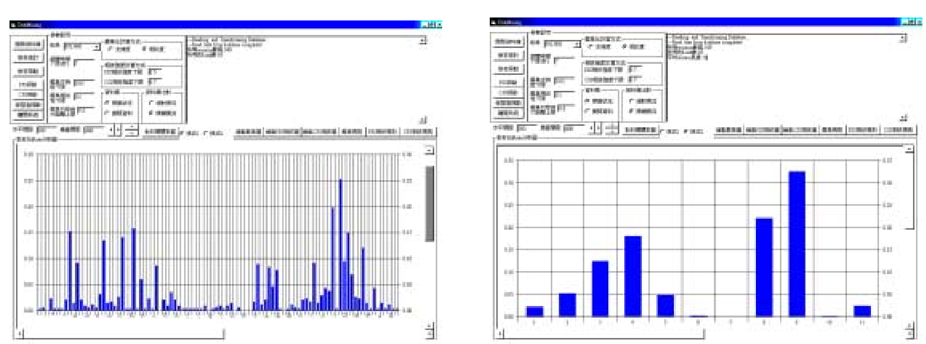
Fig. 5. An example of a browsing navigation tree

4.1 Discussion on Material Hit Rate Analysis

As shown in Table 5, students in all three classes spent more efforts in browsing material of the Design category, which might have something to do with the term projects that are required in all classes. As to the Theory and Demo Systems categories, both daytime classes prefer studying the Demo System category than the Theory one. On the contrary, the on-job class prefers studying the Theory category than the Demo System. Finally, Table 6 shows that all three classes reveal similar browsing patterns of material in the Design category; that is, the most on “Language”, then the “Operations”, and the least on “Samples”. This implies that the original intention of providing samples to help students lean the design task more efficiently is not effectively fulfilled, and it deserves more investigation to explore the reason why.

4.2 Associative Material Clustering and Sequence Mining

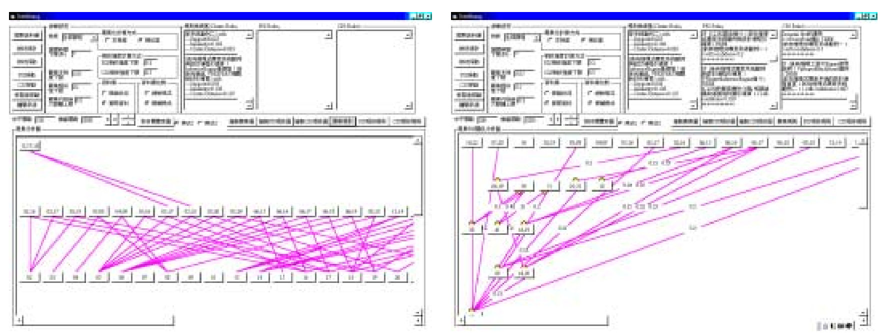
To increase the reliability of the mining results, this study combines the session records of the three classes for the associative and sequence rule mining tasks. The thresholds of the support rate, intra-cluster distance and cluster similarity are set to 0.03, 0.2 and 0.1, respectively. The sequence strength is set to 0.2. The result shows that 23 clusters are found with the largest cluster of size 3. Among these clusters, it is found that the “Theory” and “Demo Systems” categories are often browsed together, and “Demo System” and “Language” categories are also often browsed together. These imply that the cross-reference usage of the materials is effectively achieved.



(a) (b)

Fig. 6. (a) Hit rate diagram of documents; (b) Hit rate diagram of document categories

Most of the browsing sequences found meet the instructor’s expectations. Nevertheless, some interesting sequence patterns are also found. For example, the sequence rule ([Backward-chaining ES], [Inference Engines]) $\rightarrow$ ([CLIPS Language]) with confidence 0.3 reveals that some of the students mistook the "CLIPS language" (a tool for designing forward-chaining expert systems) as a candidate design language for backward-chaining expert systems.



(a) **(b)**

Fig. 7. (a) A screenshot of material clustering; (b) A screenshot of sequence mining

Table 3. The number of sessions and average session length of each class

Class	Number of Sessions	Documents	Average Session Length
A (Day Time)	349	85	2.9
B (Day Time)	334	85	3.1
C (On-Job)	277	80	3.4
Total	960	96	3.1

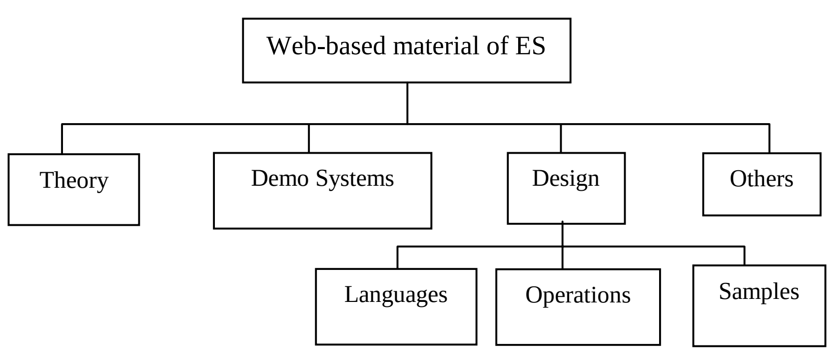


Fig. 8. The material structure of the Expert System course

Table 4. Coverage rate of each material category

Cate-gory	Descriptions	Amount	Rate
Theory	Concepts and Theories of Expert System.	21	22%
Systems	Demonstrations of Expert Systems.	10	10%
Design	Languages (CLIPS, VPExpert)	44	47%
Others	Syllabus, learning sheet, work sheet, catalog, score list, etc.	21	21%

Table 5. Hit rates of material category in each class

Class	Theory	Demo Systems	Design	Others
A (Day Time)	0.22	0.33	0.4	0.03
B (Day Time)	0.24	0.3	0.4	0.06
C (On-Job)	0.32	0.27	0.36	0.05

Table 6. Hit rates of the “Design” material category in each class

Class	Language	Operation	Samples	Others
A (Day Time)	0.45	0.3	0.13	0.12
B (Day Time)	0.45	0.25	0.15	0.15
C (On-Job)	0.44	0.22	0.12	0.22

5 Conclusive Remarks

This study develops a modeling process and tool for analyzing the historical browsing data in web-based asynchronous learning environments. In this study it is also found that the amount of browsing records is still not large enough for more accurate mining results. This might be attributed by the fact that most students are prone to download all materials first for off-line browsing at home. There are more pieces of work worth further pursuit. For example, more effective mining tools are still in lack for analyzing other kinds of learning information, such as the behavior of “thinking order” in web-based on-line discussion context, and also those tools for helping teachers to explore the relations among the various learning patterns and the learning outcomes [8]. The teachers can hence analyze the stored student learning data to answer the questions such as “what are the behavioral characteristics of students tending to good learning outcomes?”

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Conceptual Network Based Courseware Navigation and Web Presentation Mechanisms

Sanding Luo[1], Sha Sha[1], Deyao Shen[1], and Weijia Jia[2]

[1] College of Information Science and Engineering
Central South University, 410083 Changsha, Hunan, China
sdluo@mail.csu.edu.cn
[2] Department of Computer Engineering and Information Technology
City University of Hong Kong, 83 Ta Chee Avenue, Kowloon, Hong Kong
itjia@cityu.edu.hk

Abstract. We present a conceptual network model for the organization of courseware and the related information. Using the hierarchy and association rules of the concepts, we can organize components and courseware episodes as a multi-layer knowledge network, which has a reasonable classification and discloses the complicated interdependent relations among the knowledge. With retrieval based on concept and association among concepts, people can manage and develop courseware, and lead the course for self-organizing and study.

1 Introduction

Currently, the thriving web-based education has received more and more extensive attention. After the hardware condition of Internet has met the demands on how to develop multimedia CAI (computer-aid instruction), courseware using on the web becomes the focal point of all the concerns. Multimedia CAI courseware has gained a rapid development. However, in comparison with the rapid expansion and development of knowledge, there are still highly demands on courseware that are adaptive to the schemes and contents according to the teaching requirements. The courseware even if developed by an expert may not fulfill the educational requirements of knowledge evolution and the needs of personal learning. Design and implement the courseware and make them available on campus network are desired and designated for subject teachers and learners. Many people are doing the same work as to produce one similar courseware. But, to our best knowledge, many educational information concepts on the web cannot be fully utilized and no adaptive courseware for the individual study need is available on the Internet.

Recently the technology of building a network component database has been introduced [1, 2]. Each component consists of teaching materials and modes of statement. According to this idea, courseware is not treated as fixed and close modal, which is purely integrated software; instead, it is combined with a network components editor platform that is adaptive. No doubt that this idea has great value for fully making use

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of WWW educational resource as the multifold of the information. But the organization of teaching materials and the choice of model of statement are challenge tasks and still rely on an expert's personal style of instruction and the specific syllabus. On one hand, there is no sufficient suggestion about the how to organize the teaching materials for an educator to design a course. On the other hand, a guide on system and structure of knowledge is needed to satisfy with the varied demands of students when they learn knowledge on from web [3]. We believe that the structure of knowledge system is very complex in the Internet. It is not only the hierarchy and classification structure but also full of many kinds of associations and combinations of concepts and multimedia. It is difficult to model real useful knowledge with several relations [4]. A flexible knowledge association structure system, which is considered from point of view of the general framework, should be introduced.

In this paper, we present a new architecture to organize courseware based on the knowledge conceptual network [6]. The framework of system is made up of knowledge described by conceptual network, teaching material associated with knowledge, rule, and pattern of information. Conceptual network shows the interdependent relationships among the concepts. Each node in conceptual network describes the basic idea and general meaning of knowledge. Each edge in conceptual network displays the relationships among knowledge. The teaching information consists of episodic courseware that uses concept as it basic unit and related material. Each piece of information links a certain concept in conceptual network. Thus the information is formed into knowledge network for further use.

The paper is organized as follows. Section 2 briefly introduces the conceptual network. Section 3 discusses the conceptual association rules. CAI Courseware Architecture and Building Blocks are provided in Section 4 and conclude the paper in Section 5.

2 Conceptual Network

Conceptual network is used to model and expresses the inherent relationship among objective objects (concepts). It describes human natural understanding of the laws of the world through concepts and conceptual relations. With this framework, knowledge presentation depends on both the expert's understandings of domain knowledge and the ways of thinking for the knowledge organization. Generally speaking, it is required that presentation and structure of knowledge should have great degree of freedom in order to modify them easily once the basic requirements have been satisfied. To do this the network should be interconnected; no contradiction among knowledge and all the data should be consistent. The form of knowledge presentation should also be close to the commonsense. In our system, conceptual network can be modeled as a graph and a concept is treated as the basic knowledge node and its relations with other concepts are denoted as edges.

When organizing the teaching information and selecting the way of statement, one should make use of the existing knowledge system. For instance, when a student concerns about the techniques of image recognize, one can load the teaching information and its relevancy from teaching information database. At the same time one can find the preliminary and correlative knowledge about the subject. The system then prepares the correlative knowledge according to the learning record of this student for him to choose. Taking "digital image processing" as an example, Figure 1 shows the knowledge system described by conceptual network.

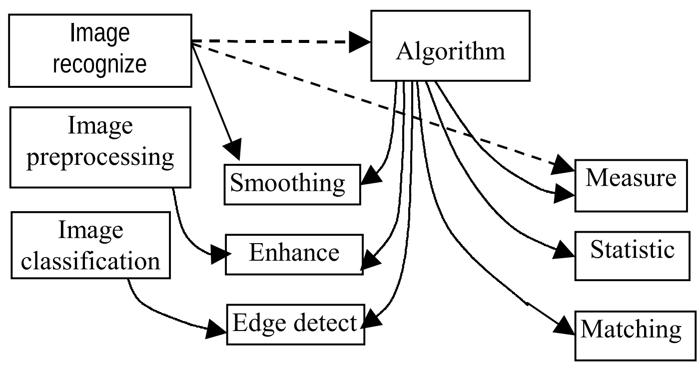

Fig. 1. A simple conceptual-network (local) on image processing

Conceptual network (CN) can be defined as a 5-tuple: *N* {*C, A, B, D, Kr*}, where *C* -- the concept words set; *A* -- the attributes sets; *B* -- the behavior set, *D* -- the document set which describes the concept in a multimedia form. *Kr* -- the knowledge relations among conceptual units. Fig. 2 shows a node's component structure.

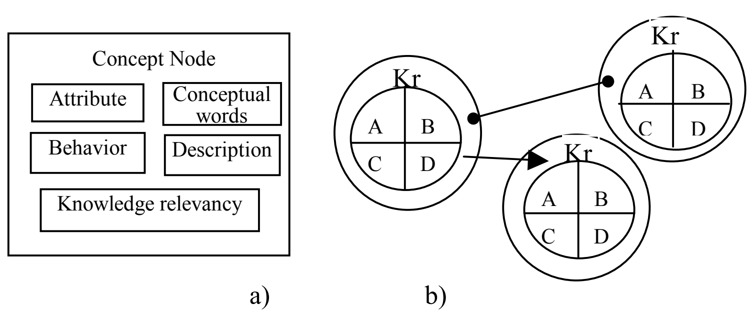

Fig. 2. The node model of concept a) 5-tuple of node; b) association between node and node. The unilateral association is indicated by arrow line, and bidirectional relation is shown by line with dots

In the following, we discuss the techniques of a concept node and its relationship.

2.1 Concept Node Design and ID

Each concept (word) should be given an ID, and each concept is associated with name and synonymy set of the concept. But different people may interpret a concept with different ways. Thus the concept should to be decided by the expert with domain knowledge. Each concept may have generalization, intension and extension as well as the regulations. One needs to understand a concept from all aspects of viewpoints. If these mechanisms are enforced for a concept, we may have different ways of deduction and we various degree of understanding to the concept. ID is denoted as a number, which uniquely represents a concept. A concept may have several (synonymy) terms, which is recorded in the synonymy set, but they all map to the identical ID. Concept is a node of knowledge, when defines the intention of concept we should centralize them. Using the visible hierarchical relation we can make a compact structure and deal the knowledge with categorizing. Due to the fact that the part of a concept often can be another whole concept or can be the part of another concept, we use link to describe the complex relations among concepts.

2.2 Attribute and Behavior of Concept

Attributes characterize the inherent feature of a concept. Behaviors show the outside features. The general features can then be abstracted and formed a higher level of concept that may posses more extension or general meanings. Both attributes and behaviors of a concept serve as the foundation of classification for the concept.

2.3 Presentation of a Concept and Concept Relevancy

A concept may be presented with variable types of media forms such as text, image, video, hyperlink and URL etc. All these presentations can be used as the original material in the information service.

A concept representation could be very complex as one concept may involve many concepts. All the concepts may refer to each other. They have different function in a conceptual graph, and they play different roles in the knowledge sentence. All the relevance forms a network links, thus the conceptual network expresses some kind of knowledge with complex associations among the concepts.

2.4 Structure of the Conceptual Network

For the preciseness representation and flexible management of a conceptual network, the hierarchy and classification of concept is applied with a tree structure. We first build a backbone tree and then form the conceptual network based on the backbone to structure the knowledge into the concept nodes and associations (links) among the nodes in the tree. In this way, complex conceptual combination boils down to clear structure without losing precise meanings and representations. Thus it is crucial to build such a tree for further as a backbone.

Every node in conceptual network is point which is described a part of knowledge. The backbone tree is expanded according to hierarchy of knowledge system. There are several kinds of affiliation in classification method may be used to expand a node in higher layer.

- Common - special. The child node is “a-kind-of” its parent. This relation shows difference on attribute, behave, goal, mode, effect etc.
- Entire-part. The parent is composed of some parts, such as components, elements, and steps of scheme or process. The child node has “a-part-of ” relation between higher layer and lower layer.
- Class-instance. Using the “is-an-instance” relation, we can derive an embodiment conceptual node from a generic abstract node in application.
- Recombination. The child nodes derived from parent by “a-kind-of” mode can recombined and become new child node. It consists of some attributes or other in branches but only one in same character.

An example of such a conceptual tree is given in Fig. 3.

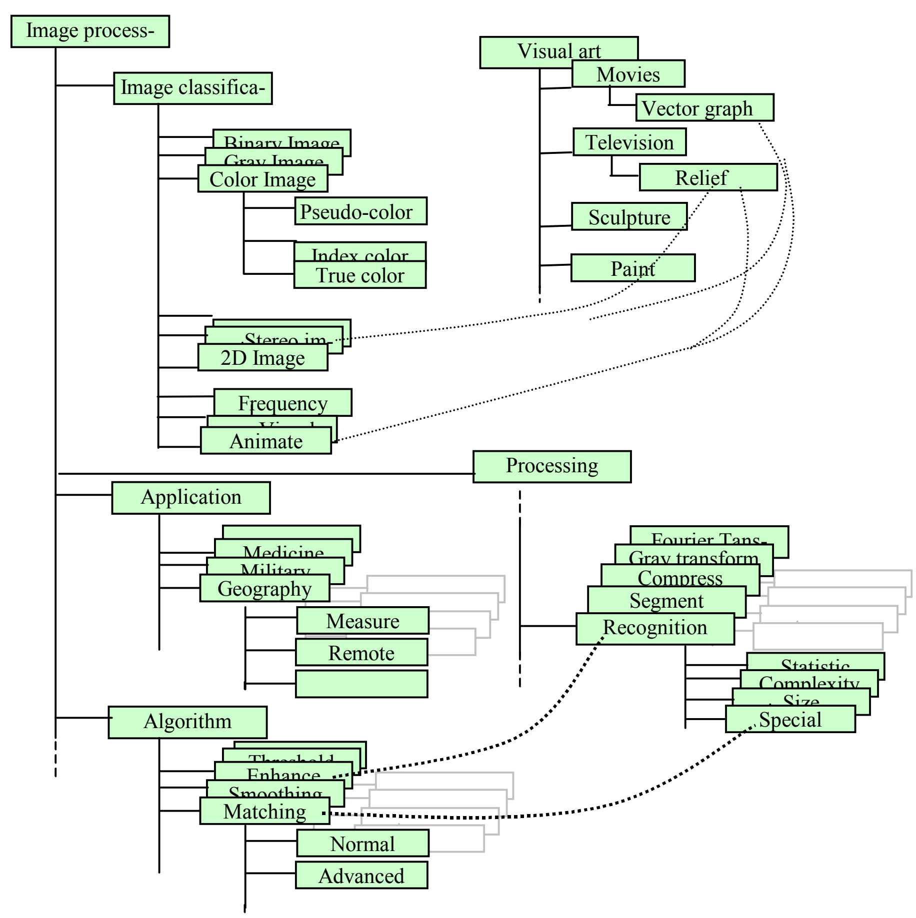

Fig. 3. Conceptual network based on backbone (hierarchical tree). Example of conceptual network (local) on image processing. The association between the nodes is shown by dashed

3 Conceptual Association Strategy

Conceptual network built by educators represents the skeleton of domain-knowledge. It reflects the relationship among the concepts and domain-knowledge. The CN also incorporate the knowledge-learning rules into account. The policy of conceptual associations is the foundation of courseware combination and the learning rules. And the concept associates are used to link to the related concepts. For easy discussion, we introduce several notations we will use in the subsequent sections.

Let P be a parent node and its child nodes set $C=\{C_i\}$, v_i be a value that shows the dependency between C_i and P. We can define the following functions in the tree.

$P = parent(C_i|v_i)$; $C_i = child(P)$; and $C_i = sibling(C_j)$, $i \neq j$

In a node, there are some knowledge phrases describing relations and the role of each node plays in a phrase. Let N be a set of concept nodes and R the role set. The phrases can be defined as ∈

$Kr = \{(n_i, r_k) \mid n_i \in N \text{ and } r_k \in R\}$

where 2-tuple (n_i, r_k) means n_i plays the role of r_k. In the following, we give an example by listing four types of concept association rules for the illustration of building up the tree and CN.

3.1 Conceptual Association from the Children Nodes

The concepts at the middle or bottom level are the child concepts of higher level in CN. The child concept is the subdivision of parent concept. There are three styles in classifying the concept in the organization of the CN:

- Classification according to the attributes of the parent;
- Classification according to the parent behaviors;
- Classified by the role of associations

Thus the children concepts further detailed parent concept in terms of extension knowledge. We may define the inference mechanisms between generalization and extension among the concepts as

Mode A (Specialization Extend): $N_{ex} = parent(\{C_i \mid i = 1,2 \ldots, k\})$,

N_{ex} is extend concept node set on node A.

Mode B (Induction Extend): $N_{ex} = parent(\{C_i \mid i = 1,2 \ldots, k\})$.

3.2 Association among Sibling Nodes

Cording to the relations among sibling nodes' associations can show as follow:

- Association among independent sibling concepts. It is associated from one part to another part through the parent concepts.
- Association among intersecting sibling concepts. This represents the extension of a concept.

- Association among ordered sibling concept. It denotes the relation on time, quantity, grade and so on. The presentation of this kind of association is procedure and fashion.

Similarly,Mode C (Sib Extend) : $N_{ex} = \text{sibling}(\{n_i \mid i = 1,2 \ldots, k; \})$.

Elements in N_{ex} are shorted by sibling relation case1 or case2 before using mode C.
Case1: If N_i is a part of entity it sorted by position for spatial extent.
Case2: If N_i is a part of process it sorted by steps for time extent.

3.3 Associations among Node Links

There are two kinds of relevant nodes: general link and special link. General link describes the common relation between two concepts. Special link can be subdivided into attributes, behaviors, aims, methods, and locations, and so on according to the existing of the rules that concepts obey.

- The general links describe the background and the related knowledge of a concept.
- Attribute links describe the relation of attributes. For example, the original attribute and ultimate attributes may be needed in one research.
- The behavior is the root cause of the change of attributes and associations.
- Behaviors aim at a certain purpose and obey a certain law. There must be some conditions and locations when the behaviors take place.

Thus the related mode is defined as

Mode D (Relative extend): $N_{ex} = \{N_i \mid i = 1,2 \ldots, k;\ N_i \text{ is linked } A\}$.

3.4 Multi-roles Combined Association

The multi-roles of a concept describe all the aspects of knowledge, which include causes and effects, agents and accepters, location conditions and restrictions etc. All these rule concepts are the nodes that have special relations with a concept. Define related mode as

Mode E (Role extend): $N_{ex} = \{N_i \mid i = 1,2 \ldots, k;\ N_i \text{ in } Kr\}$.

Where Kr-- knowledge sentence N_{ex} can be sort by fundamentality of roles in Kr.

The conditional association is the key to enhance the intelligence of the conceptual network, the corresponding association occurs when the conditions meet. According to the states of the course of learning, there will be conditional associations and a navigating study system is practiced in the Web-based learning.

4 Courseware Architecture and Web Presentations

Figure 4 shows the architecture of a courseware generating system architecture based on conceptual network. It has the following functions:

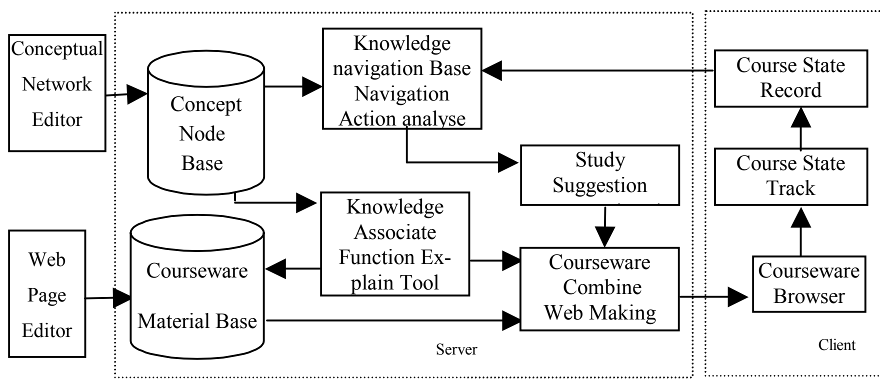

Fig. 4. The model of courseware building system based on conceptual network

4.1 The Assemble of Episodes Courseware

In lines of CN and the conceptual tree, the courseware architecture system is able to generate courseware episodes, which interprets knowledge from CN with association rules and provide instances of knowledge with multimedia presentations such as text, picture, video-audio and other information. Those information units may serve as the basic elements to form the web page and present in the web for learning. Generating web-presentation can be done through mark-up languages such as HTML/XML based on knowledge and database for convenience of information retrieval. Thus the modification on the file of knowledge is shifted to the modification of web page. Giving the file name and index number of all the episodes of courseware are assembled by the knowledge system. Hyperlinks of reference knowledge about certain pieces of knowledge are also included in courseware episodes.

4.2 Knowledge Associations and Links

The links and associations of knowledge are realized by interpreting the association functions of the concepts. For a give concept, in the CN, there exist related nodes, which related to this concept, can be linked by association rules and knowledge functions. Given a list of nodes according to the rules that a concept plays critical roles in the functions, the association rules can be applied. A learner then can be leaded to know more about the related contents and got more knowledge. Relation function of a concept $[C_x]$ can be described as:

$$function\ ([C_1],[C_2],\ldots,[C_n])$$

where $[C_x] \rightarrow [C_i]$ i =1, 2,…, n is the related rules for the concepts and knowledge associated with function $fun[C_x]$. Attributes A_{ik} and behaviors B_{ik} of $[C_i]$ are further treated as special descriptions of associations.

4.3 Navigation with Conceptual Network

The working procedure consists of formulation of the knowledge on several databases in Fig. 4. With starting concept, i.e., the concept to be learnt, we apply the association and analysis rules in the corresponding databases. The learner system thus can be implemented through navigation functions and linked with courseware episodes. At the same time, routing through the dynamic concepts visited and the paths are recorded for conceptual diffusion, and dynamic conceptual navigation. The routes for the visiting the concepts are also recorded. As a result, the concepts, episodes and visiting routes in the CN are presented by home-page generating rules. Thus, the system as integration can help a learner to study the related (association) contents. In this way, multi-concept information auto-adaptive retrieval is realized. More specifically, let Cr be the nodes that have been learnt (visited) and a set of association functions applied on Cr be Rr, then the association nodes to Cs can be defined as follows: (1) Child nodes (mode A: specialization), the parent nodes (mode B: induction), the sibling nodes (mode C: extension) and the nodes that link to Cr through Rr (mode D, E).

Using child node for example, a learner may derive learning knowledge by using deep first or width-fist search in the CN. Thus vertical or horizontal knowledge associations are established. It can be seen that the parent-son nodes form the vertical learning process and the sibling nodes forms the horizontal study process. However, the real learning process must be a hybrid of vertical, horizontal and other learning rules in the CN rather than only in the tree.

With vertical learning process, concepts and knowledge may be studied form level by level. Once the knowledge has been learnt in one level, that is, all the sibling nodes have been learnt, to generalize the concept and recommend a set of parent nodes that are suitable to the learns would be possible. We also setup the learning priority by

$$k = N_{rb}/N_b$$

where N_b is the number of sibling nodes, N_{rb} is the number of learnt sibling. The priority of related nodes is determined by

$$k = N_{rp}/N_p$$

where N_p is the number of node that link to $R_{ri} \in R_r$, N_{rp} is the number of learnt nodes.

For implement control of conditional navigation, The state of learning is set “0” (should not be learned for now), “1” (new knowledge), “2” (known a little by learner) , “3” (grasped completely by learner) and “4” (will not be shown for learner). In practice, the state of the node recommended is set “1”, and will be set “2” , “3” or “4” depend on the degree the learner knows the node. With the going on of course, the nodes whose states are “0” (should not be learned for now) will be set “1”(new knowledge is available) gradually. For example, node “N_{i+1}” shall be learned after the node “N_i”, then, the presentation of the knowledge in the navigating knowledge base as follows:

The initial state is set N_{s0}=1; N_{si}=0, i=1,2,3…, only N_0 can be shown.

As for the action of close the node N_k"(or the showing time arrive), a operation can be add: if N_{sk}>1 then N_{sk+1}=1, the show of N_{k+1} is allowed. So a linked navigating control is implemented, which will push the course of learning step by step.

4.4 The Synthesis of Web Presentation

Web page synthesis combines one or several conceptual courseware episodes to a multi-frame web page. Both the combination of page and the link of knowledge are processed according to the concept's association rules. The pattern of page design is also decided by courseware episodes. What kinds of episodes are placed is decided by concept's association rules. The layout of a web page is guided by the pattern of web constitutes. The use of concept's association rules refers to the conceptual baseline that is recorded dynamically by the hit number.

4.5 Dynamic Creation of Conceptual Baseline

1) Keywords and conceptual baseline

When learners enter a keyword, just like using in search engine, the system will consider this word as an object that the user may be interested in. Through the term-concept mapping of conceptual network and finding the concept's corresponding node in CN, documents of conceptual description and association function of related knowledge will be brought forth to the learner. If there is more than one concepts mapping to a keyword, the system can provide all of them or give a prompt for the user to decide to learn which path. Thus we called the path as the conceptual baseline.

Learners may enter several keywords at the same time, which indicates that the users may have interest in learning a series of objects, so some key words may be interrelated. Using the keyword-concept mapping approach (through association rules), a learner may navigate many concepts through these given concepts. Consequently, the corresponding web page generation should take into consideration of the "shortest" relation paths among the multiple keywords (concepts).

2) Multi-keywords and conceptual baseline

It should be noted that there is some differences between the navigation in a courseware and that in the Internet. Navigation in a courseware requests learners to concentrate on one piece of knowledge and does not need much correlated information. Therefore the compacted conceptual baseline may be suitable than conceptual network in courseware design as CN may introduce complexity. For a node with multi-level of paternity, it is better to treat the higher nodes as a domain restriction or context and the main descriptions of knowledge will be focused on child node and provide knowledge presentation accordingly. For example, "computer", "keyboard" can be comprehended as "the keyboard of computer". While "musical instrument", "keyboard" is thought as "the keyboard of musical instrument", such as keyboard of piano.

With the guide of conceptual network, according to the style of learners, system will respond to the mechanism of reasoning and association adaptively. With the keywords that users have interest in and the interaction of hitting hyperlink, the system will act like the search engine, provide the judgment, and form web presentation by loading the corresponding materials. Those form the basic mechanism of intelligent CAI courseware system. We have built a model of teaching conceptual network with example of "digital image procession". This model was used by upperclassman for its self-study and self-review. According to the experimental results, the system has following advantages:

- Student can browse the main contents of a course. No important concept will be lost.
- Student can control the learning schedule. The system can also recommend the knowledge that to be learnt for students.
- Have a higher reuse rate.

5 Conclusion

Organizing CAI courseware with conceptual network has the advantage of traceable conceptual paths and association rules. With our system, it is possible to organize the pedagogical knowledge and conceptual association adaptively by guessing learner's intentions, indicate a reasonable direction for further study so as to implement so called "intelligent instruction system". The further work of the system is to build a reasonably evaluations associated to individual history (trace) information and data so as to know whether the learners have understood or grasped the knowledge parts showed. The more further work, if possible, is to investigate the relationship knowledge is forgot with time, so that learners can be reminded of their forgot knowledge parts. The solution of above problems depend on the further study of the regulation about time-state in every learning mode, which will surely enhance the intelligence of the system.

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Web-Based Knowledge-Based System on Liquid Retaining Structure Design as Instructional Tool

Faris Albermani[1] and Kwok-wing Chau[2]

[1]Department of Civil Engineering, University of Queensland, Australia
e2kitip@brolga.cc.uq.edu.au
[2]Department of Civil & Structural Engineering, Hong Kong Polytechnic University
Hunghom, Kowloon, Hong Kong
cekwchau@polyu.edu.hk

Abstract. A novice engineer often faces many difficulties during the design of liquid retaining structures, which involve making many decisions on the basis of judgment, heuristics, code of practice, rules of thumb, and previous experience. There is a need to develop programming environments that can incorporate engineering judgment along with algorithmic tools. In this paper, the development of a web-based knowledge-based system in design of liquid retaining structures, using blackboard architecture with hybrid knowledge representation techniques including production rule system and object-oriented approach, is presented. It is based on British Standards Codes of Practice BS8007 and BS8110. Tailor-made explanations are furnished to direct and assist inexperienced designers or civil engineering students to learn and capture how to design liquid retaining structures effectively and sustainably in their design practices. The use of this intelligent tutoring system in disseminating heuristic knowledge as well as experience to practitioners and civil engineering students is demonstrated.

1 Introduction

A novice engineer may face many difficulties during the design process of liquid retaining structures involving making many decisions on the basis of judgment, heuristics, code of practice, rules of thumb, and previous experience. One has to select various design parameters including configuration, material, loading, etc. Although computer technology has been developing in a fast pace, their use in engineering field was mainly confined to the number crunching of large volumes of numerical data. In the realm of structural design, this use has been limited almost exclusively to algorithmic solutions [1]. Yet structural design problems are often ill structured and as such, needs arise for programming environments that can incorporate engineering judgment along with algorithmic tools [2]. The advances in artificial intelligence (AI) techniques have demonstrated the capability to furnish assistance in this domain during the past decades. A knowledge-based system (KBS), which is considered suitable for solving problems that demand considerable expertise, judgment or rules of thumb, has emerged promisingly covering a wide range of applications [3-11]. It has developed into practical problem solving tools that can reach a level of

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performance comparable to that of a human expert in some specific problem domains. All these applications can be broadly classified into the following categories: diagnosis; design; data interpretation; planning; and education. Areas of early applications of KBS technology include medical diagnosis, mineral exploration and chemical spectroscopy. Many researchers are developing programs that borrow AI concepts to automate common engineering analyses.

In this paper, a web-based KBS in design of liquid retaining structures, using blackboard architecture with hybrid knowledge representation techniques including production rule system and object-oriented approach, is presented. An expert system shell, Visual Rule Studio, is employed to facilitate the development of this prototype system, which is a coupled system integrating symbolic processing and numerical processing. The KBS developed is based on British Standards Codes of Practice BS8007: 1987: Design of concrete structures for retaining aqueous liquids [12] and BS8110: 1985: Structural use of concrete [13]. Tailor-made explanations are furnished to direct and assist inexperienced designers or civil engineering students to learn and capture how to design liquid retaining structures effectively and sustainably in their design practices. The use of this intelligent tutoring system in disseminating heuristic knowledge as well as experience to practitioners and civil engineering students is demonstrated.

2 Liquid Retaining Structure Design

In Hong Kong, most liquid retaining structures are constructed by reinforced concrete with design life of 50 years. Crack width checking is performed to ensure impermeability of concrete and prevention from corrosion of reinforcement. Two kinds of classification are usually used, namely, on the basis of the shape or the location. According to the shape, it is classified as rectangular, circular or polygon. If its location is used as the criterion, it is classified as underground or above the ground. Compared with a circular tank structure with the same width, a rectangular liquid retaining structure has larger volume. However, because of stress concentration at corners, rectangular structures will be more vulnerable to failure. It also has a weaker deflection control. With a circular tank design, not all the spaces are utilized. Since a circular structure can be constructed monolithically without any construction joints, it has better strength quality. With precise structural analysis, a circular structure has a better control in deflection, crack width, bending moment resistance, axial compression resistance, and shear resistance than rectangular structure. A polygon liquid retaining structure is usually used for aesthetic purposes, such as a fountain in a garden and the retaining height is usually not very high.

In some cases, the tank is connected to underground pipe network system, in order to reduce maintenance cost, it will be constructed underground to suit the invert level of the pipe network system. The underground structure is mainly subjected to lateral earth pressure or lateral water pressure, which is due to the underground water table. Besides structural failure mode, bearing capacity of soil and settlement of structure also need to be checked. If the soil bearing capacity does not satisfy the requirement, pile foundation or raft foundation will be required. A liquid retaining structure above the ground is only subject to liquid pressure due to its own retaining liquid. The structure can either rest on ground concrete slab immediately or rest on other types of supports.

In selecting design criteria and design method, considerations should be made to a myriad of factors including dimensions, location, ground condition, support condition, groundwater conditions, aesthetic properties, design life, exposure condition, usage, roofing, availability of construction materials. According to Code of Practice BS8007, two main classes of limit state are considered. Ultimate limit state is design against structural failure, including bending moment check and shear force check. Serviceability limit state is design against deflection and crack width. Normal crack width control is 0.2mm while, for severe cases, allowable crack width is 0.1mm. For underground liquid retaining structures, serviceability limit state design is also used in checking of bearing capacity of soil. In the design, factors of safety are involved to increase the structural reliability.

3 Features of KBS

KBS can be defined as an interactive computer system that incorporates expertise and provides advice on a wide range of tasks. It solves a specific complex problem mimicking the decision making and reasoning processes that resemble those of human experts. Intelligent tutoring system is a KBS with the purpose of instruction and teaching. The system has to engage the user in a dialogue systematically and actively. Solely explanations are not sufficient and the problem should be dealt with through interactive communication between the user and the system.

These systems typically consist of the following three basic components, namely, knowledge base, context, and inference mechanism. The heart and core of any KBS is the knowledge base, which is usually a collection of rules, typically in the form of IF….THEN….. The knowledge base is a collection of general facts, rules of thumb and knowledge specific to the problem domain. Other forms of representations commonly used are logic, frame-based schemes, nets, and the object-oriented approach. The context is a workspace for the problem constructed by the inference mechanism from the information provided by the user and the knowledge base. It contains facts that reflect the current state of the problem. The organization of the context depends on the nature of the problem domain. The context builds up dynamically as the problem domain is being considered. The context is used by the inference mechanism to guide the decision making process. The inference mechanism monitors the execution of the program by using the knowledge base to modify the context. Moreover, it manipulates the context using the knowledge base.

Apart from the three main modules described above, the system should also be provided with three other components that are not necessarily part of every KBS but are desirable in an integral final product, namely, a friendly user interface, an explanation facility, and a knowledge acquisition module. The function of the user interface module is to accept a problem description from the user and to interact with the rest of the system in order to analyze the problem or augment the capability of the system. It provides an interface between the user and the KBS, usually as a command language for directing execution. The interface is responsible for translating the input as specified by the user to the form used by the KBS and for handling the interaction during the decision making process. The explanation module provides explanations of the inferences used by the KBS. This explanation can be *a priori* – why a certain fact is requested, or *a posteriori* – how a conclusion was reached. The knowledge acquisition module, which provides a means for entering domain specific knowledge into the knowledge base and revising this knowledge when necessary, serves as an interface between the experts and the KBS.

When compared to KBS, conventional programs are very inflexible since they consist of a set of statements with predetermined order of execution. Their updates need considerable effort, because the programmer has to locate the appropriate place to update in the predefined sequence. The programmer must ensure completeness, namely, that the program performs correctly for all possible combination of conditions, and uniqueness of the solution, namely, that the output is unique for every possible input. The user perceives the program as a blackbox, where the program generates results for the input provided; one does not have any idea as to why the program has produced certain results. KBS eliminates some impediments posed by conventional programs by making a clear distinction between the knowledge base and the control strategy. This partitioning allows for incremental addition of knowledge, without manipulating the overall program structure; the programmer needs not guarantee completeness. Further, by ranking several alternatives either by an evaluation scheme or by the use of inexact inference methods, several solutions can be provided for a particular set of input conditions, thus relaxing the uniqueness constraint. The user can also question the results produced by the program through the explanation module.

4 Architecture of Prototype KBS

In this prototype system, the blackboard architecture, which is capable of supporting the development of systems in domains characterized by the interaction between diverse sources of knowledge, is adopted. The blackboard architecture has been successfully used in solving a wide range of tasks, such as speech recognition, signal processing, and planning. It provides a framework for integrating knowledge from several sources. The blackboard serves as a global data structure, which facilitates this interaction. A common analogy may be made to problem-solving in domains where a number of experts in different areas of specialties co-operate over the solution which any one of them could never achieve alone. In order to facilitate this process, they agree to use a blackboard to post any partial result they can contribute separately. Each expert takes turns to write on the blackboard and, in case more experts wish to write simultaneously, the conflict is resolved by some pre-defined strategy. Because of the modularity of knowledge sources, the blackboard architecture enables easy incremental development of a software system and developers can integrate different methods of knowledge representation in a single system. In a typical blackboard system, a number of knowledge sources communicate through a blackboard and are controlled by an inference mechanism.

A number of knowledge sources containing the domain knowledge constitute the knowledge base. These knowledge sources are independent chunks of knowledge and do not directly communicate with each other. Instead, they participate in the problem solving process by creating entries in a global database – the blackboard. Knowledge modules look at the blackboard to see if suitable data is present to trigger their execution. If they are selected, the execution results in new or altered data on the blackboard, which will then trigger other knowledge modules. The key to the solution by using the blackboard architecture is the cooperation of the knowledge modules present. Each knowledge source consists of a condition-action pair. Whenever a condition is satisfied in the blackboard, the action in the corresponding pair is executed accordingly.

The context comprises the information or entries generated by the knowledge sources during the problem solving process. Entries are the immediate results produced by the system. In a typical system, each entry has a certainty factor as well as a specification. The principal units in the blackboard are hypotheses, which are either primary guesses about particular aspects of the problem or partial solutions. Hypotheses at various levels are related through structural relationships. The blackboard is organized into a number of levels each representing different aspects or stages of the solution process. These levels depict an *a priori* plan for the solution of a problem that can be naturally decomposed into a set of levels. Each level contains objects and attributes that are important to the representation of the problem. Normally, knowledge sources are specific to certain levels in the blackboard, namely, the activation of a certain knowledge sources depends on the entries generated at certain levels in the blackboard, while the actions of the knowledge source modify entries at some other level.

Two main components, namely, the agenda and the monitor constitute the inference mechanism. The agenda keeps track of all the events in the blackboard and calculates the priority of execution for knowledge sources that were generated as a result of the activation of other knowledge sources. It is a list of knowledge sources or rules to be executed in the next cycle. Based on the success or failure of a particular rule, new rules may get added on to it or some may be deleted from it. The basis of giving priorities to the rules on the agenda may vary from system to system. Several problem-solving strategies can be implemented using the monitor. The monitor takes the element with the highest priority and executes it.

5 Knowledge Representation for Structural Design

Structural analysis can be delineated as a three-stage process involving modeling, solution, and evaluation. Before knowledge can be represented in structural analysis, the type of knowledge involved must be identified and classified. Static knowledge comprises definitions, axioms, and laws. These may be *a priori* or the result of scientific investigation. Static knowledge is ‘deep’ in that it is deduced from fundamentals. Dynamic knowledge is not deducible from any axiom, rather it is generally gained from experience. It refers to heuristics, which is related to the process of search or to knowledge based on experience. Dynamic knowledge can also be described as ‘shallow’, meaning that it cannot provide us with explanations of why certain decisions should be made.

The major approaches for declarative representation of knowledge in the AI literature are rule-based production system, frames and object-oriented programming. A production system is a collection of rules and is believed to be good at describing heuristic knowledge. For KBS developers, rule-based system tends to be more easily understood and thus accepted. A frame system, on the other hand, is suitable for a complex and rich representation of knowledge, such as static knowledge. Object-oriented programming concept is used, in which a computer program consists of a number of independent objects that process jobs by exchanging information they need via messages. Because of its modularity, data abstraction and inheritance characteristics, object-oriented programming will likely subsume other approaches in the very near future. To apply object-oriented program development, data representations for the model must be specified. There are three steps in the development of an object-oriented program, namely, selection of classes, specification of classes, and implementation of classes. Here, the word ‘class’ refers to a description of a set of similar objects whilst one member object in a class is called an ‘instance’. It is appropriate to utilize both representations together to solve structural design problems since it may take the advantages of both approaches.

6 Prototype Web-Based KBS

Expert system programming environments or shells are often employed in order to facilitate the development of KBS. These system shells contain specific representation methods and inference mechanisms. The knowledge base and explanation facility of this prototype system have been developed using a commercially available expert system shell called Visual Rule Studio which is a hybrid application development tool that integrates object-oriented techniques and expert system technology with traditional, procedural programming. Visual Rule Studio installs as an integral part of Microsoft Visual Basic 6.0 and appears within Visual Basic as an ActiveX Designer. As a part of the Visual Basic Integrated Development Environment, using a RuleSet in the application is similar to using a form or other Visual basic Designer. Besides, Visual Rule Studio is compatible with Microsoft Internet Information Server and Active Server Pages. As such, in order to allow it to reach any user with a web browser and Intranet or Internet access, the Ruleset components can be deployed as part of a web server based application.

The prototype system combines expert systems technologies, object-oriented programming, relational database models and hypertext/graphics in a windowing environment. It runs under and follows the conventions of Microsoft Windows. In a windowing system, any types of display windows can be represented as objects, each with its own private data or information. By defining various types of windows as different classes, such as checkbox group, hyperregion, promptbox, pushbutton, textbook, etc., they can inherit common characteristics and/or possess their own special properties. By isolating rules as component objects, separated from objects and application logic, Visual Rule Studio allows developers to leverage the proven productivity of today's component oriented development tools, such as Visual Basic. With Visual Rule Studio, rule development becomes a natural part of the component architecture development process. The complex and time-consuming problems of integrating multiple development tools and managing incompatible object models no longer exist. Visual Rule Studio becomes an integrated part of the Visual Basic development and produces objects that can interact with virtually any modern development software.

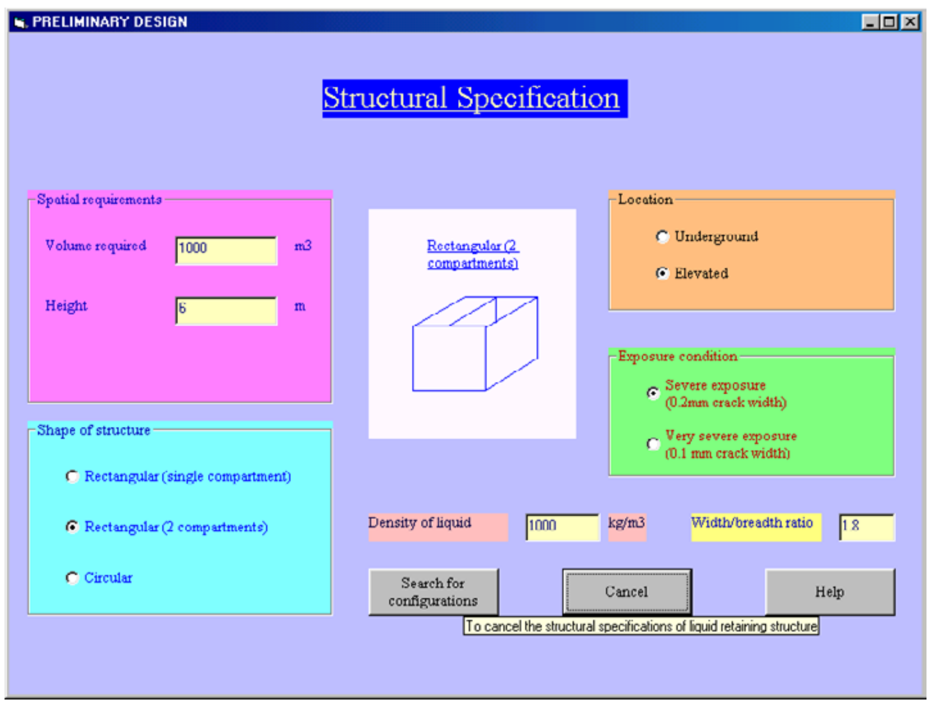

Fig. 1. Screen displaying structural specification of liquid retaining structure

In the system, Visual Rule Studio objects are employed to encapsulate knowledge structure, procedures, and values. An object's structure is defined by its class and attribute declarations within a RuleSet. Object behavior is tightly bound to attributes in the form of facets, methods, rules, and demons. Each attribute of a class has a specific attribute type. The Visual Rule Studio attribute types are compound, multicompound, instance reference, numeric, simple, string, interval, and time. Each attribute can have many facets and methods associated with it. Facets provide control over how the inference engines process and use attributes. Methods establish developer-defined procedures associated with each attribute.

Knowledge acquisition of the domain knowledge is basically from written documents such as codes of practice, textbooks and design manuals and complemented by experienced engineers involved with the design of liquid retaining structures. The domain knowledge is translated into procedures and methods using object-oriented representation. The system is compiled and encrypted to create a run-only system on a web server. The user can always overrule any design options and recommendations furnished by the system, thus playing solely the role of a knowledgeable assistant. The design is still under full control of the user.

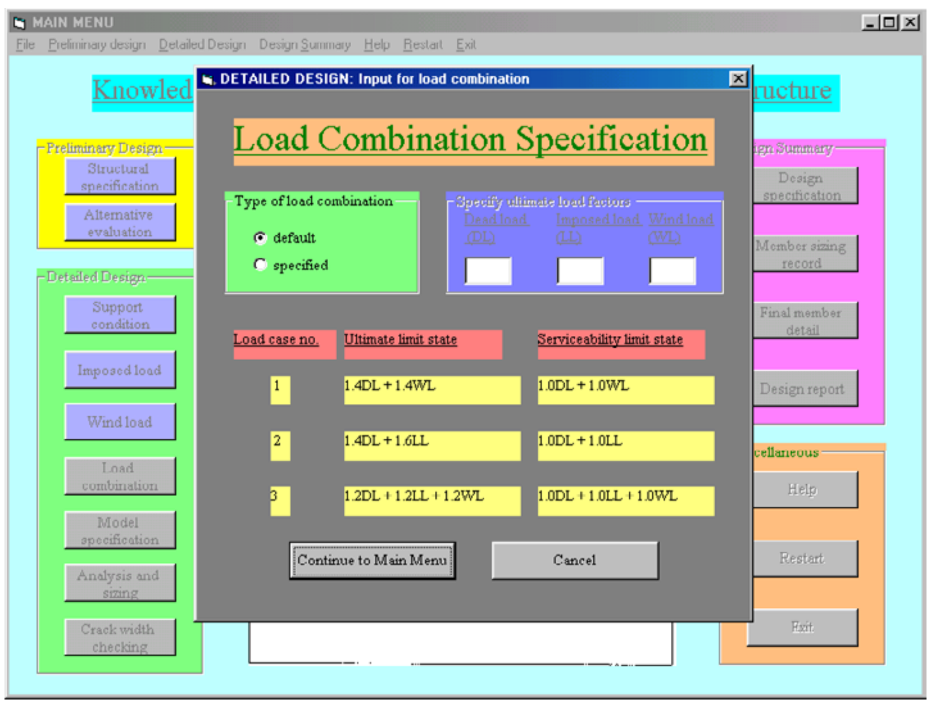

Fig. 2 Screen displaying specification on load combination

The inference strategies model the reasoning processes an expert uses when solving a problem. The Visual Rule Studio inference engines control the strategies that determine how, from where, and in what order a knowledge base draws its conclusions. It supports three types of inferencing strategies, namely, backward chaining, forward chaining, and hybrid chaining. Each of these inferencing strategies acts on specific knowledge base components. A mixed problem-solving strategy combining both forward chaining and backward chaining inference mechanism is employed in this knowledge module level. The user is required merely to supply the relevant data during each design stage and the system will determine the order in which different design knowledge modules are executed.

Besides, the system offers a state-of-the-art user interface. The use of a mouse or other pointing device makes the data entry a simple task even for novice computer users. As such, users simply point and click their way through the process to appreciate the dynamic behavior of the system. Input data entry is kept at minimum. Input data are provided by the user mostly through selection of appropriate values of parameters from the menus and providing answers to the queries made by the system.

It provides information about any individual member in multi-window graphics text display where graphic images are combined with valuable textual information. This kind of intelligent graphics is extremely valuable to structural designers because it enhances their confidence in the design provided by the KBS. Figure 1 shows the screen displaying structural specification of liquid retaining structure. The input data provided by the user is rejected if it is not within the range specified. It can explain its line of reasoning for obtaining an answer. Figure 2 shows the screen displaying specification on load combination. Figure 3 shows the screen displaying finite element analysis of liquid retaining structure.

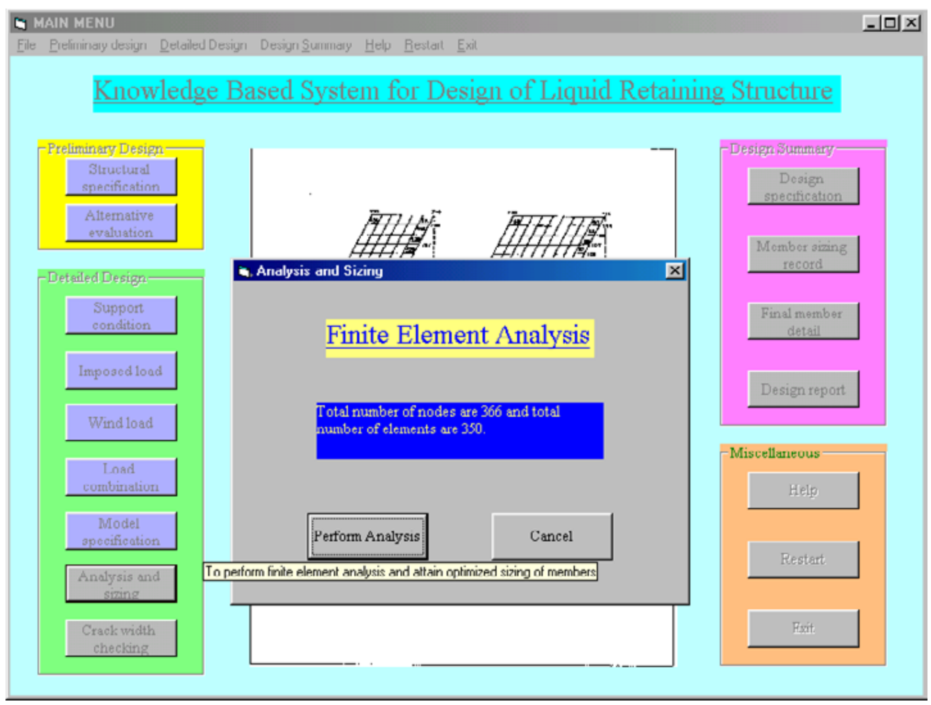

Fig. 3. Screen displaying finite element analysis of liquid retaining structure

7 KBS as Instructional Tool

It is generally acknowledged that one-to-one tutoring is the most effective teaching and training method, yet requires vast amount of resources such as instructors. Nowadays, personal computer is very popular in Hong Kong. Those who have a computer and a telephone line can have a tutor at home or in office by accessing the web-based intelligent tutoring system through the Internet. Intelligent tutoring system, being one type of KBS with particular purpose of teaching, can assist novice engineers or civil engineering students to acquire deeper understanding of the topic through the use of this system. Explanations are made to assist them to learn and capture how to design liquid retaining structures effectively and sustainably in their design practices. One of the key advantages in the implementation of the prototype system is to reduce the dependence on experienced designers for routine design works. In this way, they will have more precious time left and can concentrate their effort on other innovative and creative civil engineering designs.

It has been shown in this application that the flexibility and open infrastructure of Internet are capable to perform its major role as a medium in teaching and learning processes. Students or novice engineers can easily get hold of domain knowledge on both theory and design of liquid retaining structure through interactive communication with this system. Furthermore, structural optimization and best practical design on liquid retaining structure may be accomplished or at least improved substantially by the exploration of the interactive "What-if" scenario analysis. Engineering professional institutions and their senior fellows should acknowledge that the world is changing in a fast pace and that both engineering companies and novice engineers have practical needs that cannot be fulfilled for all aspects under the current educational and training format. The extant prevalent situation with tight financial constraints, as well as both global and private competition amongst construction profession as a whole, may not just happen as a short-term effect. Under the current situation, even if all the members adhere to the principle of value-added resources, the adversity may not be easily overcome. Hence, in order to cope with these challenges, new methods with the aim of delivering quality training to novice engineers may be entailed. Amongst a variety of feasible solutions that can lead to solution of some of these problems, web-based learning is one that is worthy of extensive investment, application as well as implementation. In the near future, the integration of information technology together with other methods will alter significantly the nature of the teaching and learning process. It is foreseeable that web-based learning, which has the potential to effect fundamental changes in the design of learning processes and the pedagogical system, has been gaining momentum with an irreversible trend.

8 Conclusions

In this paper, it is shown that a web-based KBS employing the hybrid knowledge representation approach, which combines production rule system and object-oriented programming technique to the design of liquid retaining structures is feasible with the implementation of blackboard system architecture. It is appropriate to integrate algorithmic and symbolic programming on structural design into a single computer-aided instructional tool running under a Windows platform. With the widespread popularity of Internet nowadays, the use of web-based KBS in training novice engineers or in transferring knowledge can have great potential.

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A Web-Based Language Learning System

Johann Gamper[1] and Judith Knapp[2]

[1] Free University of Bozen
Mustergasse 4, 39100 Bozen, Italy
jgamper@unibz.it
[2] European Academy Bolzano
Drususallee 1, 39100 Bozen, Italy
jknapp@eurac.edu

Abstract. We present an ongoing research project which aims at developing an electronic vocabulary learning system for the German and the Italian language. The system consists of an extensive dictionary, a collection of exercises, text units, a tandem-feature and an electronic tutor which guides the learner through a systematic vocabulary acquisition process. To ensure maximum effectiveness of the learning process, modern psycholinguistic methods are applied along with new media and technologies including adaptive hypermedia.
Keywords: Computer-assisted language learning, adaptive systems, intelligent tutoring systems.

1 Introduction

Research in the field of computer-assisted learning shows that multimedia and hypermedia teachware seems to be effective and motivating for the learner [5,6,7,14]. Over the last decade, more and more Artificial Intelligence techniques have been adopted in CALL systems in order to provide more stimulating and effective learning environments [9].

At the European Academy of Bozen/Bolzano we are currently developing a Web-based vocabulary acquisition system for the German and the Italian language, called ELDIT. The system consists of an extensive dictionary which will be enlarged with simple exercises, text units, and a tandem module. It contains a user model and adapts its content to the individual needs and preferences of each user. A tutor guides the learner through a systematic and individually shaped vocabulary acquisition process. The dictionary has already been implemented and is under evaluation. The other modules have been designed and are currently being implemented.

The paper is organized as follows: Section 2 gives an overview of the system architecture. Section 3 briefly describes the ELDIT dictionary. Section 4 outlines adaptable and adaptive features of the dictionary. In section 5 we present extensions towards a systematic vocabulary acquisition system. Section 6 describes a tutor for contextualized vocabulary acquisition. In section 7 we discuss related work.

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2 System Architecture

Figure 1 shows the overall system architecture of the vocabulary acquisition system. The query interface analyzes and dispatches the user requests. Depending on information obtained from the user model, the retrieved information is adapted to the specific user. The dictionary is the core module and has been implemented first. It is aimed to provide an extensive reference tool for a language learner. Currently, we are extending the basic dictionary towards a full vocabulary acquisition system. The extensions include small exercises, a text corpus, a tandem, and a tutor. While the exercises are rather simple focusing on the basic usage of the vocabulary, the text corpus contains larger text units including questions, which force the learner to produce complete sentences in the target language. The tandem module aims at supporting learner partnerships between Italian and German native speakers with the main objective to correct each others answers to the questions. The tutor glues all modules together and guides the learner through a systematic and individually shaped vocabulary acquisition process.

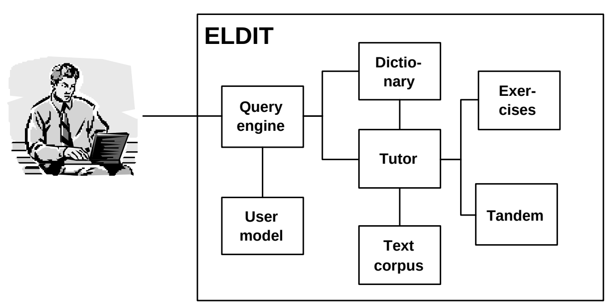

Fig. 1. Architecture of the ELDIT vocabulary acquisition system

ELDIT adopts a client-server model exploiting the standard Internet and WWW protocols. The ELDIT server is implemented using Java Servlet technology and runs on any Web-Server supporting the Java Servlet API. On the client side, the dictionary can be accessed by any Web-Browser. As uniform data representation language we use XML which in an easy way supports the separation between content, structure, and presentation. The query engine generates HTML-pages which contain JavaScript arrays with the data itself as well as links to an external JavaScript file and CSS file. When the browser interprets the page, HTML elements like tables, lists, paragraphs, and layers are generated dynamically by JavaScript functions. The presentation of the information is realized by CSS.

3 The ELDIT Dictionary

Vocabulary acquisition is an important part of foreign language learning. Back in 1950 lexicographers started to develop so-called learners' dictionaries: The vocabulary coverage is limited, word definitions are simpler and often supported by a picture, carefully selected lexicographic patterns and examples show the typical use of a word, etc.

The electronic learners' dictionary ELDIT (Elektronisches Lern(er)wörterbuch Deutsch ITalienisch) for German and Italian covers general language and consists of approximately 3,000 words for each language. For both the Italian and the German languages an intersection of different basic vocabularies has been built. In this way approximately 95% of the words in a normal text shall be covered [15].

Following the tradition of learners' dictionaries, ELDIT stores a large set of information for each word entry and the information pieces are highly interlinked. This complex set of information requires a well structured information presentation which has been designed according to psycholinguistic and didactic theories [2]. Figure 2 shows a screenshot of the dictionary entry for the German word "Haus" (English "house"). The left-hand frame shows the lemma "Haus" and the definition of different word meanings. The right-hand frame shows additional information, which depends on the selected word meaning and is organized in a number of different tabs. For example, the collocation tab lists the most frequent collocations along with their translation and an illustrative example. Adopting a comparative approach [4], ELDIT stresses specific differences between the Italian and the German language. Such differences are indicated by a kind of footnote numbers and are shown in an small window. A more comprehensive description of the linguistic and didactic features of the system is given in [1].

Each single dictionary entry contains a huge amount of information, which is carefully collected, analyzed, and selected by a couple of linguists. Each word entry contains the most important and representative collocations and usage patterns. Moreover, the dictionary is self-containing, which means that all words used in the examples, collocations, definitions, etc. are themselves dictionary entries (except function words and articles). As this data acquisition process is very time-consuming, we adopt an incremental approach. We started to create simple temporary entries which are now extended incrementally by our language experts with additional information.

Since a few weeks the first version of the dictionary is online and can be accessed at http://www.eurac.edu/Eldit. A first informal evaluation has been carried out a few months ago. Questionnaires about dictionary use in general and the use of ELDIT in particular have been answered by more than 40 persons. The evaluation revealed useful indications on how to improve the user interface and how to support the learner to use the dictionary in the right way. It is interesting to note that some of these user requirements can be met by adaptation techniques, e.g. providing the interface in the native language of the learner.

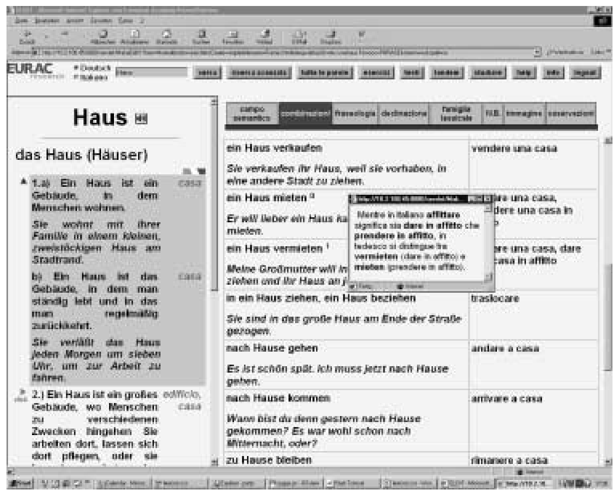

Fig. 2. ELDIT screenshot for the German word "Haus"

4 Customization and Adaptation

The ELDIT dictionary contains a huge amount of information for each word. But it is questionable whether all users will be happy with the presentation of the information and whether the provided information really meets just basic requirements? Different users have different interests and background, need different kinds of help, etc. These problems can be tackled by adapting the content and the presentation of the system to the individual user. We distinguish adaptable and adaptive features. Adaptable features allow for the manual, a-priori customization of the system and are described in section 4.1. Adaptive features cover the aspect that the system adapts automatically to the user, based on assumptions about the user as well as on observations about the user's interaction with the system. These features are described in section 4.2.

4.1 Customization

When a learner registers the first time for ELDIT, he/she is asked to provide some indications: native language, proficiency in the target language and in the use of the Internet, professional background and personal interests, etc. These pieces of information are used to customize the system to the user's preferences and needs. Table 1 summarizes the customization features.

ELDIT is a semi-bilingual dictionary. Word meanings are described by a definition, which is a typical element of a monolingual dictionary, and by a translation equivalent, which is a typical element of a bilingual dictionary. The user can choose between a semi-bilingual and a monolingual version of ELDIT. In the semi-bilingual version the user interface (menu entries, labels on buttons,

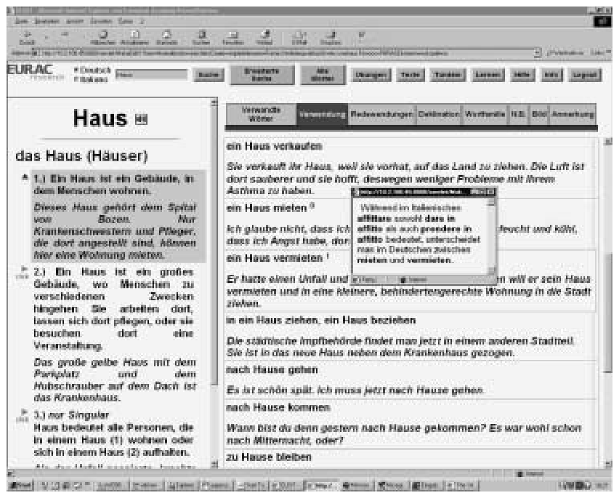

Fig. 3. Customized screenshot for the German word "Haus"

etc.) and explanations such as linguistic differences between the two languages appear in the native language of the learner. In the monolingual version the user interface as well as explanations appear in the language of the word entry itself, and there are no translation equivalents in the other language.

ELDIT makes extensive use of so-called lexicographic examples to show various aspects of the language. These examples can be adapted to the user's professional background. Currently, just a few exemplary words are elaborated, which contain different lexicographic examples for users with a general, medical, or technical background.

Depending on the language skills of the user, more or less detailed information on the words will be given. For example, detailed differences between the word meanings or complicated idiomatic expressions are hidden for beginners in order to avoid information overload.

Table 1. Customizable features in ELDIT

Feature	**Choice of user**	**Affected elements**
model	monolingual, semi-bilingual	translations, labels, explanations
domain	general, medical, technical	lexicographic examples
proficiency	beginner, advanced	meanings, idiomatic expressions
goal	language, exam	meanings, collocations, idiomatic expressions, synonyms, derivations, compound words
help	novice, familiar	content of and links to help file
annotation	—	annotation content

ELDIT is based on the vocabulary and the text units which are used for the examination of Bilingualism in South Tyrol. These resources are completed by a large number of collocations, definitions, idiomatic expressions, etc. Depending on the learning goal, a student might be interested in this additional information or not. If a student wants to prepare as fast as possible for the examination of Bilingualism, he/she gets only the core information which is relevant for this exam.

Another feature is the customization of the help files. Depending on the familiarity with the use of computers, “novice” or “familiar”, the online help is more or less detailed. Moreover, for a novice the dictionary entries contain a number of direct links to the corresponding help sections.

Finally, the learner has the possibility to save personal annotations for each word entry.

An example of customization is given in figure 3, which shows the screenshot for the German word “Haus” for a typical beginner. Note, that the screenshot is different from the one in figure 2 for the same word. The description of the word meanings on the left hand site is less detailed, and only the most important meanings are presented. Since the user prefers a monolingual dictionary, no translations are shown, and the menu and the footnotes are in the same language as the dictionary entry. The learner’s professional background is medicine, hence the lexicographic examples contain an increased number of words from the medical domain.

4.2 Adaptation

We will now concentrate on the system’s capability to observe the user, to store this information in the user model, and to adapt the system accordingly. Table 2 summarizes the adaptive features and the elements which are affected.

Table 2. Adaptable features in ELDIT

Observation	**Affected elements**
first or subsequent login	introduction page
experience with system	labels, links to help
preferences	info activated automatically

When a user enters the ELDIT dictionary for the first time, a general introduction will be provided which explains in detail how the system can be used. This introductory page will be replaced in the following sessions by a link to the page.

The evaluation carried out revealed that additional hints are required in order to improve the user interface, e.g. direct links to the specific help sections or labels which indicate how to interact with the system. These labels and links will be left out when the user has read the corresponding help sections and/or has more experience with the system.

After selecting the meaning of a word on the left-hand side, the user can select different tabs on the right-hand side which show specific information about the word. If a user's preference for a specific information can be detected, the system can immediately show the corresponding tab when the user selects a specific meaning. For example, if a user always listens to the pronunciation of a word, the system will automatically play the sound file when a new word is accessed. Similarly, if the user always looks at the pictures, they might be shown automatically when the user selects a specific word meaning.

5 Towards a Vocabulary Acquisition System

Despite its huge amount of information, the basic dictionary remains mainly a reference tool which is specifically designed for language learners. The learner shall consult the dictionary if he/she encounters an unknown word or wants to know more about a word's usage. Further modules are required in order to provide a system for systematic vocabulary acquisition in foreign language learning. Hence, we are currently working on several extensions of the dictionary: simple exercises, a text corpus, an email tandem, and a tutor.

5.1 Simple Exercises

Extensive word exposure is necessary in order to ensure a deep and solid embedding of new words in the mental lexicon [2]. Furthermore, the linguistic characteristics of target language input need to be made salient [4]. We consider these recommendations and divide the word acquisition process into three consecutive steps (similar to [10]), in which the user intentionally learns a new word:

- *Perception:* The learner explores the various properties of a word and gets an idea about the different word meanings. This goal shall be achieved by reading the definitions and translations, by looking at the pictures which represent prototypical objects, and by examining related words.
- *Usage:* The next step is to learn how to use a word in a specific context. The learner has to study typical patterns of word usage such as collocations and idiomatic expressions as well as the conjugation and declination of a word.
- *Characteristics:* Finally, the learner enlarges and completes his/her knowledge about a word. For that purpose, the learner is invited to study differences between the two languages concerning the specific word and its usage.

All three steps will be supported by simple drill and practice exercises, which allow the learner to practice immediately what he/she learned. The exercises can be generated automatically from the information of the dictionary stored in XML, with the additional advantage that the system can provide a simple "wrong/correct" feedback.

5.2 Text Corpus

In order to retain the acquired vocabulary, the learner has to produce target language output [4]. ELDIT provides text units which allow the student to apply the new vocabulary. The text corpus includes approximately 300 texts for each language. The texts are short articles selected from various magazines and books. Every word will be linked to the corresponding dictionary entry such that the learner can easily check unknown words. The educational value of this approach is widely accepted [14,16].

Each text contains a couple of questions which the learner has to answer with complete sentences in the target language. Note, that these exercises train the production of language and are different from the simple fill-in examples described previously.

5.3 E-Mail Tandem

As the current version of ELDIT is not able to correct the student's answers and to provide feedback, we are implementing an email tandem which brings Italian and German native speakers together to form learning partnerships. The system maintains a list of interested people. A new learner can search this list for a partner who is native in the learner's target language. If there is no suitable partner on the list, the learner can himself/herself submit an advertisement to the list.

Once a partnership is established, the partners shall exchange the exercises, correct the answers of the partner, and provide additional feedback and explanations. Tandem partners can assess the work of each other and give a score. This information will enter into the user model and can be used to adapt the system to individual needs.

Tandem learning is known as a very powerful method in language learning, where traditionally the learning partners meet each other. Our email tandem takes full advantage of the Internet and allows the communication between students independent of location and time. While oral communication is important and can only be trained in the traditional way, our tandem modul is meant as an additional possibility to train written communication especially for those people who don't have the possibility to meet a learning partner. Future plans include ideas about supervising tandem learners by an experienced teacher.

5.4 Language Tutor

The tutor supports a systematic vocabulary acquisition process which combines the basic dictionary, the simple exercises, the text corpus, and the email tandem. The tutor supports different learning approaches and helps the learner to select appropriate words and texts. In the most sophisticated form, the tutor generates an individual trail for the learner, which in a progressive way combines the study of single words with practicing these words on text samples. The tutor is described in more detail below.

6 Tutoring Vocabulary Acquisition

6.1 Methodology

Two different approaches for vocabulary acquisition can be distinguished. *Intentional* learning refers to an approach where the student explicitly learns a list of words. This form is faster, but can be superficial. *Incidental* learning refers to an approach where the student learns new words by extensive reading, which generally results in a deeper embedding of the information in the mental lexicon, but is slower.

In the ELDIT system we explore a combination of intentional and incidental vocabulary learning and exploit adaptation technologies, which leads to an individualized and contextualized vocabulary acquisition process. We distinguish two different approaches: vocabulary learning by word groups and vocabulary learning by text units. Ideally, these two steps should alternate such that vocabulary acquisition occurs continuously in a systematic and contextualized way. Words which have been studied should be applied immediately on a suitable text. Similar, if words have been checked during reading a text, they should be studied in more detail afterwards. However, the user has always the possibility to ignore the word groups and texts suggested by the system and do his/her own selection. The state diagram in figure 4 shows the interaction between the different steps.

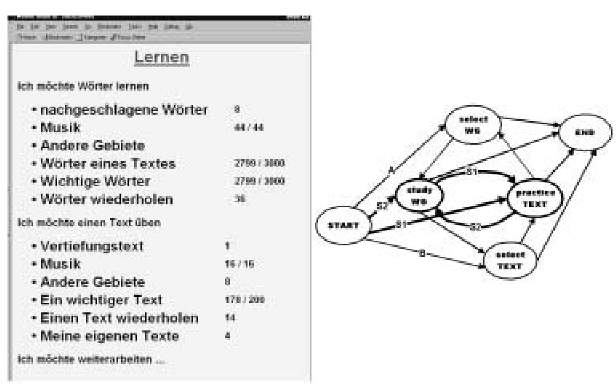

Fig. 4. The learning scenario

6.2 Vocabulary Acquisition by Word Groups

The basic idea of this approach is that the learner first studies a couple of new words and then reads a text which shows the use of these words in a larger context. To support this approach, the ELDIT vocabulary is arranged in different, possibly overlapping word groups. The most comprehensive group contains all words of the dictionary. Other groups contain the words of a specific domain, e.g. sport vocabulary, music vocabulary, or traveling vocabulary. At the lowest level of granularity, we have a word group for each text unit, which contains all words in the corresponding text. The words in a group are ordered according to their overall frequency in our text corpus. Thus, we order the words in each group from "more important" to "less important".

The system shows the different word groups (state "select WG" in figure 4) with an indication about the number of words which are unknown to the learner. The words inside a group are listed with an indication on how well the user already knows the word. Such annotations have been used in different systems and have been shown to be useful for students who are willing to collaborate with the system [7]. This meta information helps the learner to select new words.

Once a group of new words has been learned, the system selects a text to be practiced (transition S1 to state "practice TEXT"). In this way the new vocabulary will be repeated immediately on a small text example. If the user has studied a group of words which belongs to a single text, the system selects the corresponding text. Otherwise, a "best matching text" is selected. This text contains as many as possible of the just studied words and many other well known words.

6.3 Vocabulary Acquisition by Texts

The basic idea of this approach is that the learner first reads a new text and then studies the unknown words in this text. The texts are grouped in a similar way as the words. For example, we have groups which contain all texts which belong to a specific domain. The texts in each group are ordered according to a frequency value. The frequency value of a text is calculated on the basis of the frequency values of the words in the text. Texts with a high value contain many frequent words and are therefore considered to be "more important" than other texts (e.g. more specialized texts).

In this approach the learner starts by selecting a text example (state "select TEXT" in figure 4). The text groups are listed with an indication about the number of unknown words. For each text, we can calculate a score which indicates how well the learner knows this text, or more precisely, how well the learner knows the words in this text. Once the user has selected and worked through a text unit, the system summarizes all words for which the user accessed the dictionary and proposes these words for a more detailed study.

6.4 A Typical Learning Scenario

We will now describe a typical learning scenario in order to clarify our vocabulary acquisition approach (see also the screenshot and the state transition diagram in figure 4). The learner will first encounter the interface shown in figure 4, which lists different word groups, different text groups, and a next link ("Ich mchte weiterarbeiten..."). The learner can now decide to study either words from a selected word group (possibility A in the state transition graph) or a text from a selected text group (possibility B), or let the system decide the best next step (possibilities S1 and S2, depending on what the user has done the last time).

Suppose the learner decides to study new words from a specific word group. After selecting a word group (state "select WG"), the system proposes a couple of words from this group for study. The learner studies these words (state "study WG") by consulting the corresponding dictionary entries and the simple exercises. He/She reads the word definitions, compares different word meanings and their synonyms, examines collocations and idiomatic expressions, notices linguistic differences between the two languages, and carries out the corresponding exercises. During this task the user model will be updated with information about how well the user has done the exercises.

Once these new words are sufficiently known, the learner returns to the main interface. Following the next link "Ich mchte weiterarbeiten...", the system now selects a suitable text to be practiced. The text contains as much as possible of the just studied vocabulary. The user works through this text, reads the text, checks unknown vocabulary, answers the questions, and sends the answers to the e-mail partner (state "practice TEXT"). The user model is updated to reflect that this text has been practiced. The user model will be refined, when the learning partner gives a score for the corresponding exercises.

When the exercises with the text are completed, the user returns to the main interface. Following again the next link "Ich mchte weiterarbeiten...", the system will now propose the next group of words. In general, the new group will contain those words from the last practiced text unit, for which the learner looked up in the dictionary, but there might be exceptions. Again the user should study these words and carry out the corresponding exercises, then practice a suitable text, send it to the partner, etc. In this way vocabulary acquisition and application occurs alternately in a cyclic way. This cycle can always be interrupted and restarted. The learner can select his or her own next word group or text – maybe to change the topic – and afterwards again take advantage of the system's capabilities to select the next items.

7 Related Work

Adaptive educational systems have mainly been developed for teaching natural science and computer science [3,8,12,20]. Only a few adaptive systems exist for computer-assisted language learning: The FollowYou! system [17] is quite similar to our approach. The student can choose an arbitrary text file, and the system produces a lesson based on this text. As another example we mention the RECALL system [13] in which the student is guided through communicative role-play scenarios.

Several systems try to combine incidental and intentional vocabulary acquisition. In CAVOCA [10], vocabulary is taught by guiding the learner through three stages of the mental acquisition process. In PET2000 [5] a learner corpus was designed, and students use concordance tools to create their own dictionary. Similar to these two systems, ELDIT combines incidental and intentional vocabulary acquisition, but includes an additional step, where words are applied by practicing a text.

Recent advances in the Internet and WWW had a tremendous influence on teachware systems: the Web is becoming *the* medium for teachware systems. While some years ago computer-assisted language learning was dominated by systems on CD-ROM, nowadays Web-based systems with new possibilities are available for different languages [11,18,19,21].

8 Conclusion

In this paper we described ELDIT, an adaptive Web-based vocabulary acquisition system for the German and Italian language. The system contains a learner's dictionary with a large amount of information for each word entry including grammatical information, collocations, etc. A user model and adaptation features are included in order to improve learning efficiency. Currently, the dictionary is being extended with exercises, text units, and an e-mail tandem. All these modules are glued together in a systematic vocabulary acquisition process, which supports a combination of incidental and intentional learning. A tutor guides the learner through this process. Taking into consideration the user's interests and word frequency, the vocabulary acquisition process suggests to alternately learn new words and practice these words on a suitable text.

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WebMath: A Web-Based ITS System*

Chunnian Liu, Lei Zheng, Junzhong Ji,
Dong Jia, Chuan Jiang, and Wensheng Yang

School of Computer Science, Beijing Polytechnic University (BPU)
Beijing Municipal Key Laboratory of Multimedia and Intelligent Software Technology
Beijing 100022, China
ai@bjpu.edu.cn

Abstract. We have been developing a Web-based Intelligent Tutoring System (ITS) WebMath. In this paper, after describing the conceptual model of the system and its novel features, we present its network architecture and supporting techniques, reasoning about our choices. We also give an application session of the system that shows the present status of the system.
Keywords: Intelligent Tutoring Systems (ITS), Web-based ITS.

1 Introduction

So far, Computer Aided Instruction (CAI) systems fall into 4 general groups:

1. Standalone and unintelligent;
2. Standalone and intelligent;
3. Web-based and unintelligent;
4. Web-based and intelligent.

The WebMath system that we have been developing belongs to group 4. Intelligent CAI (ICAI) is also called Intelligent Tutoring System (ITS) [Mu99]. Thus WabMath is a web-based ITS system.

An ITS system can be characterized by its functionality and subject domain. In terms of functionality, WebMath is a one-to-one coached problem solving ITS helping students to do homework after attending their classroom sessions (other kind of ITS include those for teaching material synthesis and understanding, learning by examples, etc.). The subject domain of WebMath is high-school mathematics. The WebMath technique achieving its functionality has two novel features: (1). Using constraint programming for automatic problem solving. (2). A method for probability propagation in Bayesian networks to achieve two adversary requirements: exact probability computation and real-time response.

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Another important aspect of WebMath is that it is deployed on WWW. To do so, we have made various design decisions, such as the network architecture and supporting techniques for various parts in the architecture. Our system adopts the advanced multi-layer architecture based on J2EE[ACM01]. In this paper, we present this architecture and supporting techniques, reasoning about our choices.

Finally, we give an application session of the system that shows the present status of the system.

2 Conceptual Model of WabMath

The following Fig. 1 shows the conceptual model, without considering physical network architecture:

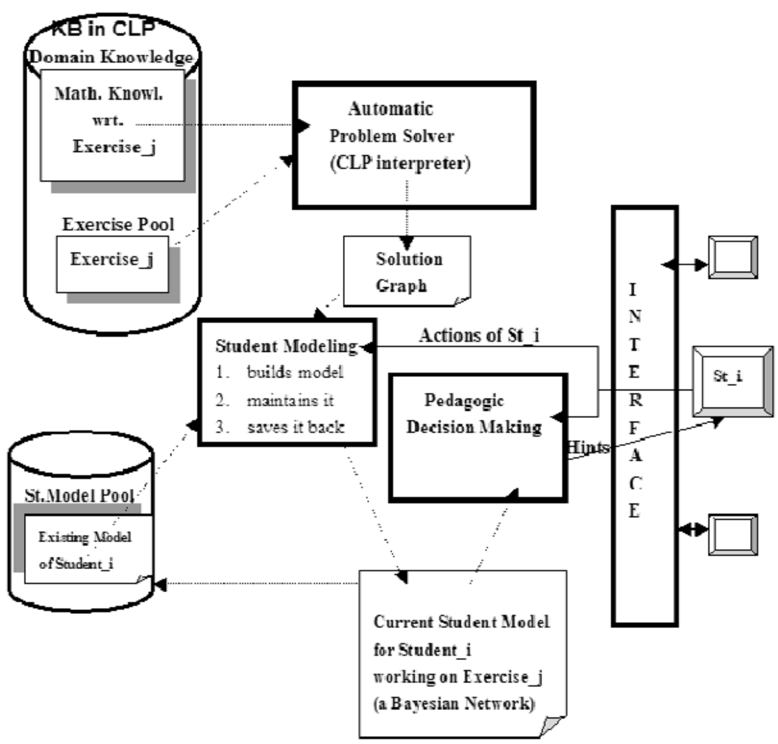

Fig. 1. Conceptual Model of WebMath

In Fig.1, solid lines indicate system-student interactions, while dotted lines represent internal data flow within the system. We describe in brief the major function modules as follows:

2.1 The Knowledge Base (KB) and the Automatic Problem Solver (CLP)

KB consists of domain knowledge (in our case, it is the collection of facts, rules, formulas taught in high-school mathematics) and a pool of student exercises. WebMath uses CLP (Constraint Logic Programming [Hen96]) programs to represent domain knowledge, and each exercise E is represented as a query to CLP "?- E". In this representation, a CLP interpreter can serve the role of the automatic problem solver well. The results of the CLP query "?- E". is a solution graph, representing all solutions and all solution paths for the exercise E. The nodes in the graph are goals, subgoals, facts and rules involved in correct solving of the exercise E.

Some other ITS systems (such as ANDES system [ANDES00]) represent domain knowledge in Horn clauses, using the logic programming language Prolog as the automatic reasoning mechanism. As far as we know, there are no any other ITS systems using CLP framework. Our choice of CLP instead of Prolog has the following advantages:

– Because Logic Programming is a special case of CLP, the expressive power in our system will surely increase. CLP can represent some high-school mathematics that is hard for pure Prolog.
– The domain knowledge might have been stored in more advanced constraint database [KLP00] instead of traditional relational, deductive, or object-oriented databases by making feasible the use of constraints to represent possibly infinite but representable complex data. We will explore these potentials in future.

2.2 The Student Model Pool and the Student Modeling Module

In the student model pool, WebMath maintains a formal model for each student (in order to achieve one-to-one coaching). Each student has his/her existing model concisely expressing his/her previous performance in exercises using Webmath. Essentially, the model shows his/her understanding level of the teaching materials relevant to the exercises he/she has done.
The student modeling module takes charge of several tasks:

– To combine the existing student model and the solution graph to build the current student mode – a Bayesian network. The combination means to set probabilities for rule nodes and conditional probabilities for other nodes in the solution graph, indicating the level of the student's understanding of various knowledge element.
– To update the probabilities of nodes when a student action (such as writing an equation) is observed. As the exact probability propagation is NP-hard [Mi97], we have to try several approximate algorithms, such as Gibb's

sampling [Hr90], logic sampling and likelihood sampling [Co93]. Especially, [DP97] proposes a method for probability propagation in Bayesian networks that suits our situation very well, satisfying two adversary requirements: exact probability propagation and real-time response.
- To save back to the student model pool a concise version of the current student model when the student quits the current session. It will be the existing model for the student when he/she enters WebMath next time.

2.3 The Pedagogic Decision Making Module

While a student working on an exercise using WebMath, he/she performs various actions (defining variables, entering equations, drawing diagrams, etc.). The actions are matched with the nodes in the student model (mismatching means poor understanding of a piece of mathematics knowledge from the student side, and the need of help from the system). Both the student modeling module and the pedagogic decision making module keep track of these actions. The former evaluates student's performance (updating the current student model, as said before); the latter tries to coach the student. Whenever the student makes an error (say, entering a wrong equation), or asks the system for help, this module makes various pedagogic decisions based on the student model: the most probable place in the solution graph where the student is working, what knowledge elements the student does not understand well, what kind of hints should be generated and presented to the student, and so on.

2.4 The Interface Module

This module displays a multi-window screen where the student chooses the exercise to do, enters various actions in solving the problem, asks for help, and receives the help and evaluation from the system.

A student session with WebMath can be summarized (functionally) as follows:

1. $Student_i$ enters the system.
2. The system loads the existing model for $student_i$, and suggests a set of exercises to do.
3. $Student_i$ chooses $execise_j$ to try.
4. The system loads $exercise_j$ together with the relevant domain knowledge, and generates the solution graph for $exercise_j$.
5. The system combines the existing model for $student_i$ and the solution graph for $exercise_j$, building the current student model.
6. $Student_i$ starts to solve the problem by entering various actions through the interface.
7. The system monitors $student_i$, evaluating his/her performance, as well as coaching him/her in the one-to-one style, until $student_i$ succeeds for $exercise_j$.

8. Based on the performance of $student_i$ in solving $exercise_j$, the system suggests the next exercise for $student_i$. Then step 4-7 will repeat.
9. When $student_i$ quits this session, the system saves a concise version of the current student model as the new existing model for $student_i$.

3 Network Architecture and Supporting Techniques of WebMath

Fig.2 shows the multi-layer architecture of WebMath, based on J2EE:

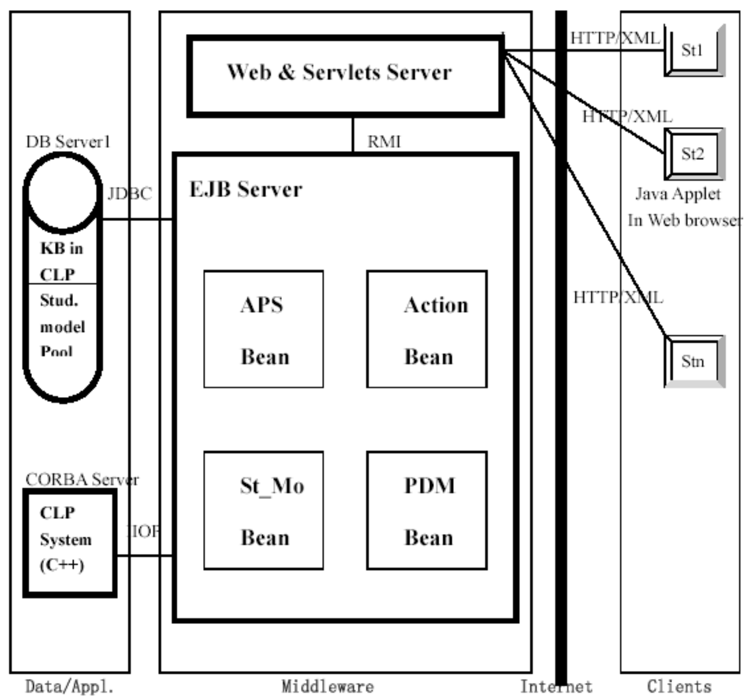

Fig. 2. WebMath's Multi-Layer Architecture Based on J2EE

There have been several efforts to deploy ITS on the WWW [BRS97, ASF98, OWK97]. WebMath adopts a more advanced multi-layer architecture based on J2EE[ACM01]. J2EE stands for "Java2 platform, Enterprise Edition". It proposes a Java2-based architecture for various complex tasks on enterprise level. The advantages of this architecture include:

- Portability inherited from Java2.
- Obtaining broad supports from many big IT companies (SUN, IBM, ORACLE, NETSCAPE, BEA, etc.), and becoming the mainstream in the area of network technology.
- Providing strong technical support to network application development. Besides the core EJB (Enterprise JavaBeans [RAJ01], see more later), it supports JDBC API for databases, CORBA for applications written in languages other than Java (such as C++), Java Servlets for user interaction, etc. As results, the developer can concentrate on the business logic of the task, without worrying about low-level implementation.

In the following, we will describe the three layers in turn:

3.1 Clients

On the client side, the student interface is implemented in a Java applet executable in a standard Web browser, and the XML page of WebMath incorporates the Java client applet, to be retrieved by students using the browser. The reason for this design is that in many cases, we need code running on the client, interacting with the student independently from the WebMath Server. These cases include:

- Frequent, complex interactions (concerning intelligent selection of terms from equations and immediate feedback from the system) is too much for a markup language. Code running on the client is needed. If we consider natural language interface (this feature will be added to WebMath in future), more computation has to be carried out "locally".
- Supplemental tools for student to solve problems are needed. For example, simple drawing tools should be provided in the menu of the interface window; An equation solver is welcome when the student is studying some higher-level subject in which the problem can be reduced to solving linear equations; etc. In these cases, we also need code running on the client, interacting with the student independently from the WebMath Server.
- For a Web-based ITS system, as far as the response time problem is concerned, one of the most important design targets is to speed up the communication as far as possible. In this aspect, Java applet can help a lot. Using Java applet we can establish a persistent socket connection with a persistently-executing application server program. In other words, the communication becomes more direct, rather than restarting the server program each time a client request arrives. As results, we could achieve quicker communication and server responsiveness.
- More flexible and enjoyable interactivity is needed to attract high-school students. The success of the system depends on whether the youngsters are eager to use and enjoy it. The interface should be visually interesting, incorporating animation, sound and other "funs". These features are not as serious as the core algorithms, but vital for the success of the system in real

world distribution. Most work of this kind has nothing to do with the core computation on the server side, hence can be carried out on the client side. Here we see another reason for code running on the client.
– If we think about Integrating different ITSs over WWW by model sharing, communication and cooperation, there are many deep issues to consider, but code running on the client is certainly more important than in the single WebMath system.

3.2 Middleware

On the middle layer, we have the WWW/Servlets server taking care of all communication between client side and server side. We also have the EJB server that is the core part of the J2EE platform, achieving the major functionalities of our WebMath system.
As we mentioned before, EJB[RAJ01] stands for "Enterprise JavaBeans". It is component oriented, and provides services common to all business applications, such as RMI (Remote Method Invocation), transaction manager, security, persistency, threads and states administration. So we only need to concentrate on our own business logic for WebMath, that was described in Section 2.
As Fig.2 shows, there are 4 main components in our EJB server:

1. APS Bean (Automatic Problem Solving Bean): generating the solution graph for an exercise by calling the CLP interpreter.
2. St_ Mo Bean (Student Modeling Bean): building the current student model, updating it based on the student actions, and saving its concise version back to the student model pool.
3. PDM Bean (Pedagogic Decision Making Bean): giving student help when he/she gets difficulties.
4. Action Bean: monitoring student's actions.

These components are developed based on functionalities, not for a particular application such as WebMath. So they can be reused by other ITS systems demanding similar functionalities.

We should point out that EJB server can support large number of students working with WebMath simultaneously. Even many students enter WebMath simultaneously, EJB server can still maintain necessary efficiency using techniques of resource-sharing and concurrent objects management. In fact, we (the developers of WebMath) need not to work on the implementation details. Instead, the EJB container is able to automatically manage the instantiation and reclaiming of its Beans to serve large number of users requests simultaneously.

3.3 Data/Existing Applications

WebMath has a database storing large number of exercises and related mathematics knowledge, as well as a pool of existing student models. The interaction

between the middleware and the database is realized by JDBC API that is an integrated part of J2EE.
The CLP interpreter that is used as the automatic problem solver in WebMath is an exiting application. It is big and written in C++. As it is impractical to rewrite in Java, we use CORBA technology to integrate it into our system.

4 A Session of WebMath Application

Supposing that a student has entered WebMath and chosen one exercise from a list suggested by the system based on his previous performance. The exercise is:
Given that function $y = \frac{24}{x+3} - \sqrt{x+4}$ *is defined in (0,5), Find the range of the function*
Before the student starts to solve the problem, his browser looks as Fig.3:

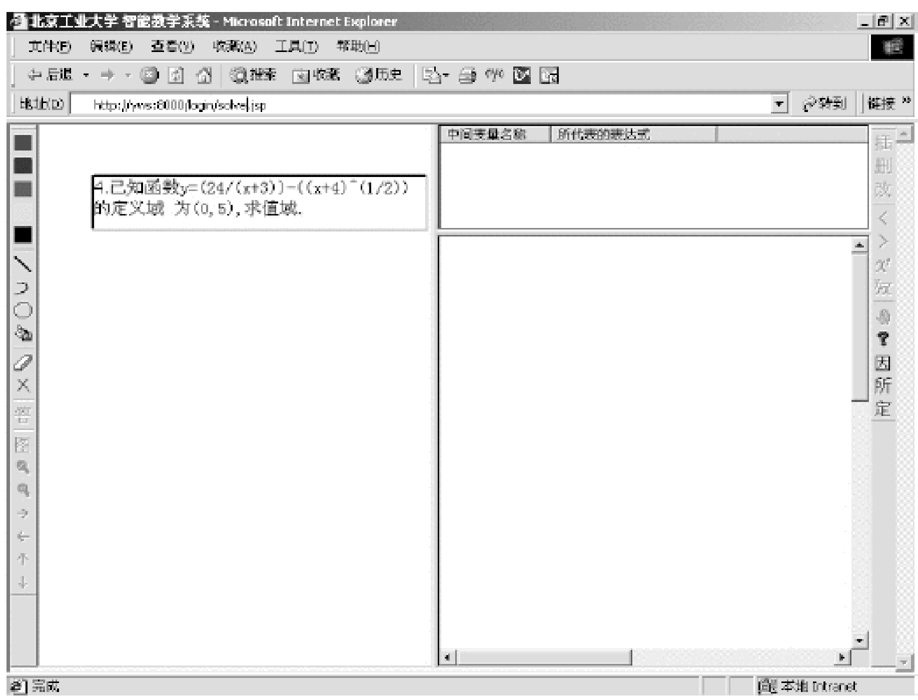

Fig. 3. Snapshot 1: Before the student starts to solve the problem

Now supposing that the student has made 2 correct steps in solving the problem:

1. *function* $y = x + 3$ *increases monotonously in (0,5)*
2. *range of* $y = x + 3$ *is (3,8)*
   then made a mistake in the next step:

3. *function* $y = \frac{24}{t}$ *increases monotonously in (3,8)*
   %% t is the student defined variable for x+3

The system found this mistake by (mis)matching this student action with the corresponding node in the current student model (a Bayesian network expressing the correct solution steps), and gave a hint to the correct step:
3.*function* $y = \frac{24}{t}$ *increases monotonously in (3,8)*
%% t is the student defined variable for x+3 At this point, the student browser looks as Fig.4:

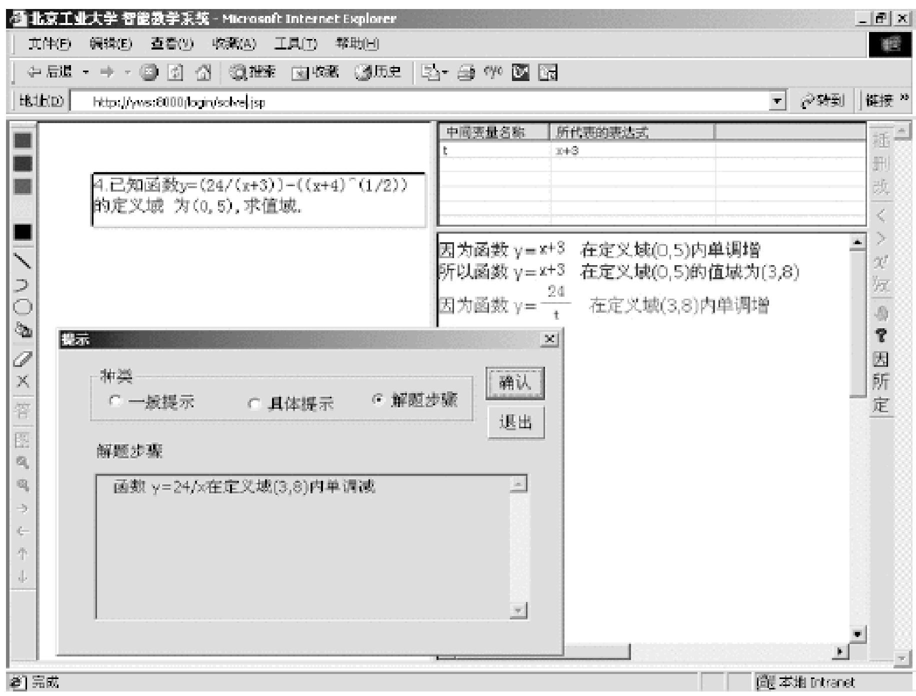

Fig. 4. Snapshot 2: When the student made a mistake and WebMath gave a hint

After reading the hint and correcting this mistake, the student continues to solve the remaining problem, entering further actions. Supposing that the student is not to make more mistakes, he/she will eventually get the correct answer to the exercise:

$$\textit{Range of function } y = \frac{24}{x+3} - \sqrt{x+4} \textit{ is (0,6) if it is defined in (0,5).}$$

And the student browser at this final point looks as Fig. 5 (note that a drawing of the function is presented in the browser, helping the student to understand the problem and solution better).

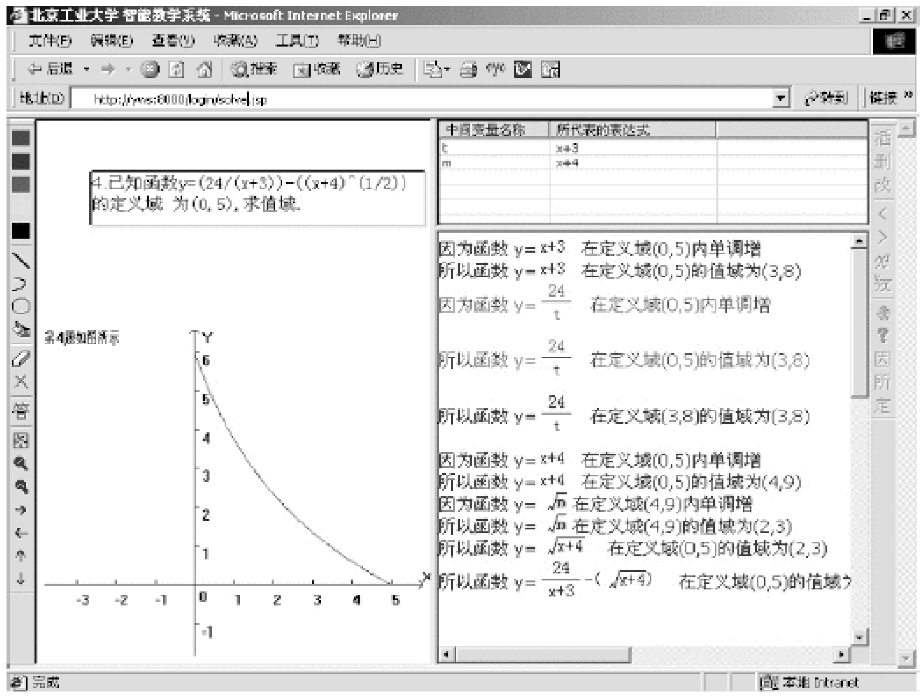

Fig. 5. Snapshot 3: When the student has solved the problem

Note that although the student finally solved the problem, his mistake made in step 3 was recorded silently in the system: the student modeling facility (St_Mo Bean) will decrease the probability associated with the node (representing the mathematic knowledge about the inverse proportion function $y = \frac{1}{t}$) in the student model, indicating that the student's understanding of that piece of knowledge is not very sound.

5 Conclusions

WebMath is a kind of Intelligent Tutoring System (ITS) supporting one-to-one coached problem solving in high-school mathematics. It is also a Web-based system. In order to support large number of students and speed up the development, we have chosen the advanced J2EE platform to design and implement our system. The design of WebMath and a preliminary implementation have been completed. The initial experiments with WebMath have been encouraging, indicated by the sample session of WebMath application reported in this paper.

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Smart Remote Classroom: Creating a Revolutionary Real-Time Interactive Distance Learning System*

Yuanchun Shi, Weikai Xie, and Guangyou Xu

Dept. of CS, Tsinghua University, Beijing 100084, China
{shiyc@,xwk@media.cs,xgy-dcs@}tsinghua.edu.cn

Abstract Real-time interactive virtual classroom is an important type of distance learning. However currently available systems are insufficient in the support of large-scale user access, and neither can they accommodate accessing with heterogeneous devices and networks. Furthermore, these systems are usually desktop-based, which results that the teachers' experience is completely different from teaching in a real classroom. The Smart Remote Classroom project tackles these difficulties through the development of the following technologies: 1) A hybrid application-layer Multicast protocol called TORM and an Adaptive Content Delivery scheme called AMTM. Together they enable large-scale users to access a virtual classroom with different devices and networks at the same time. 2) A dedicated software called SameView, which take use of the proposed TORM and AMTM technology and provide a rich set of functions for teachers and students to efficiently carry out the real-time interactive distance learning. Moreover, SameView can record the whole process of a class into a compound multimedia document for later retrieval and review of the class. 3) An augmented classroom called Smart Classroom, where the user interface of the SameView for the teacher are distributed in and fused with the room space. Thus the teacher can instruct the remote students just like teaching face-to-face in a conventional classroom. All these technologies has been successfully integrated and demonstrated in the prototype system.

1 Introduction

1.1 Motivation

We are seeing the need for wider access to education, support for life long learning, and more part-time and distance learning. The Web/Internet provides relatively easy ways to publish hyper-linked multimedia content, and reach a wide audience. Yet, we find that most of the courseware are simply the shift from textbook to HTML files - audience read from the book in the past and now read from the screen. However, in most cases the teacher's live instructing is very important for catching the attention and interest of the students. That's why Real-time Interactive Virtual Classroom (RTIVC) plays an indispensable role in Distance Learning, where teachers and stu-

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dents located in different places take part in the class synchronously through certain multimedia communication system and can have real-time and media-rich interactions. However, to provide this type of Distance Learning in large scale still remains some barriers:

1) *Lack of adequate technologies to cope with large-scale access.* Most Tele-education schools simply adopted commercial videoconference products as the operating platform for RTIVC, where all clients should connect to a centered MCU (Multi-Point Controlling Unit) and data initiated from one client is replicated (sometime maybe mixed) and forwarded to all other clients by MCU. However these systems are not scalable, for the maximum user number (usually ten more) is rigidly limited by the capacity of the MCU. So, today, most tele-education schools can only operate RTIVC classes on a small student number base.

   A possible approach to address the scalability issue is leveraging the IP Multicast technology, where no central data-replicating node like MCU is required. But the current state of the art of IP Multicast is still not fully matured. First, the IP Multicast service provided by network layer is a best-effort service. This is not tolerable for applications like RTIVC that are sensitive to the loss of messages. For example, the dropping of a single packet at one client will make the state of the whiteboard in a RTIVC system at this client lose consistency with other clients. Second, IP Multicast is not fully supported by many currently deployed routers in Internet. Today's Internet can be viewed as many Multicast islands that fully support IP Multicast being separated by the Unicast zones that are not capable of IP Multicast. Therefore, applications directly rely on the network layer IP Multicast cannot be successfully deployed on current Internet infrastructure.

2) *Lack of adequate technologies to accommodate students with different network and device conditions in one session.* Most current RTIVC systems have rigid requirements on the network and device conditions of the clients. Clients with inferior conditions either could not join the session or could not get smooth service quality. On the other hand, clients with superior conditions could not fully take advantage of their extra capabilities. Since handheld devices such as Pocket PC and Smart Phone, and wireless network such as GPRS and WIFI are becoming more and more popular, it is a natural demand to allow people to accept life-long education through these devices, while they will inevitable posses diversified capabilities and network connections.

3) *Desktop-based teaching metaphors are not natural enough for most teachers.* Most current RTIVC systems are desktop-based, i.e. the users should remain stationary in front of a desktop computer and use the keyboard or mouse to operate the class or to interact with others. This metaphor is particularly unacceptable for the teachers, because their experience here is of much difference from that in a real classroom. In a real classroom, they can move freely, talk to the students with hand-gesture and eye contact and illustrate their ideas conveniently by scribbling on the blackboard. Many teachers involving in Tele-education, when talking with us, complained that this divergence of the experience makes them uncomfortable and reduced the efficiency of the teaching and learning activity.

1.2 Smart Remote Classroom Project

The Smart Remote Classroom project [1] at our institute is a long-term project aiming at providing adequate technologies to overcome the above-mentioned difficulties in current practice of RTIVC and building an integrated system as an exemplar for the next generation real-time interactive distance learning in China. Currently we have made progresses in the following aspects:

1) A supporting platform for large-scale real-time interactive distance learning is developed. The work can be divided into two parts: First is a Totally Ordered Reliable Multicast (TORM) protocol [2][3], which implements an application-layer multicast protocol based on the combination of network-layer IP-Multicast and Unicast, and can accommodate large-scale users to access a RTIVC through current Internet infrastructure. Second is an Adaptive Multimedia Transport Model (AMTM) [4], which can trans-code or trans-author the transferred contents according to the device and network capabilities of each individual client of a RTIVC session, while remains the consistency of the content on the semantic level.
2) A dedicated software for RTIVC called SameView [5] (The name comes from the notion that no matter you are a local student or a remote student with which kind of connection, you can get the same view of the content of class) is developed, which runs on the developed TORM/AMTM platform and provides a rich set of interaction channels, e.g. the HTML-capable whiteboard, video/audio communication and chatting, for the teacher and students, when taking part in a RTIVC class. SameView also features in its class-experience recording capability. More specifically, all the activities and events occurred in a class, e.g. the slides teacher presented on the whiteboard, the annotations teachers made as well as the live video and audio, will be captured and recorded in a structured multimedia document. After some simple post-editing, this recorded document can be used as a piece of courseware that can be retrieved and played back later.
3) An enhanced classroom called Smart Classroom [6] is built, where the user interface of the SameView for the teacher are embedded within the 3D-space of the room and teachers can move freely and use the conventional teaching metaphors that they are familiar with to give classes to remote students, instead of the cumbersome desktop-based metaphors used in most of current RTIVC systems. Moreover, since it is a real classroom, it can accommodate locally attending students at the same time. This way we eliminate the difference of On-campus Learning and Distance Learning activities, because teachers can give classes to local students and remote students simultaneously, which can also reduce the required workforce of teachers.

The rest of the paper will be organized as following: First, we will discuss the supporting platform, the SameView and the Smart Classroom in detail one by one. Then, we will show how these technologies fit into the overall picture of a revolutionary real-time interactive distance learning system. Finally we give a conclusion.

2 The Supporting Platform for Large-Scale RTIVC

RTIVC is a typical large-scale interactive application, where there may be hundreds or thousands of remote students taking part in a virtual class. Reliable multicast is a useful network service but is also a research issue of challenge for the heterogeneity and the lack of full support of IP multicast in today's Internet infrastructure. Instead of following the traditional end-to-end model for reliable multicast, we developed a Totally Ordered Reliable Multicast (TORM) protocol taking a hybrid approach that exploits both IP Unicast and IP Multicast for data delivery. And during data forwarding, the Adaptive Multimedia Transport Model (AMTM) we proposed is applied to dynamically trans-code the multimedia data for users with different device and network capabilities.

2.1 Totally Ordered Reliable Multicast (TORM)

Large-scale interactive applications have demanding requirements on underlying transport protocols for efficient dissemination of real-time multimedia data over heterogeneous networks [7]. Existing reliable multicast protocols failed to meet these requirements due to following reasons: 1) most protocols presume the existence of multicast fully-enabled network infrastructure, which is usually not the case for current Internet; 2) protocols that are able to support multiple concurrent data sources only have limited scalability; 3) few of them have implemented an end-to-end TCP-friendly congestion control policy.

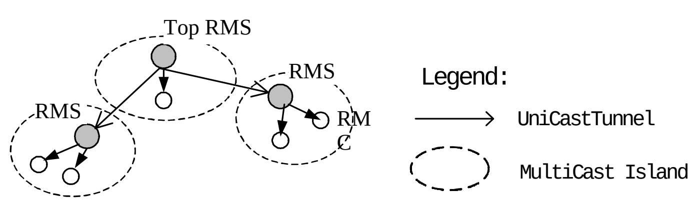


Fig.1. Architecture of TORM

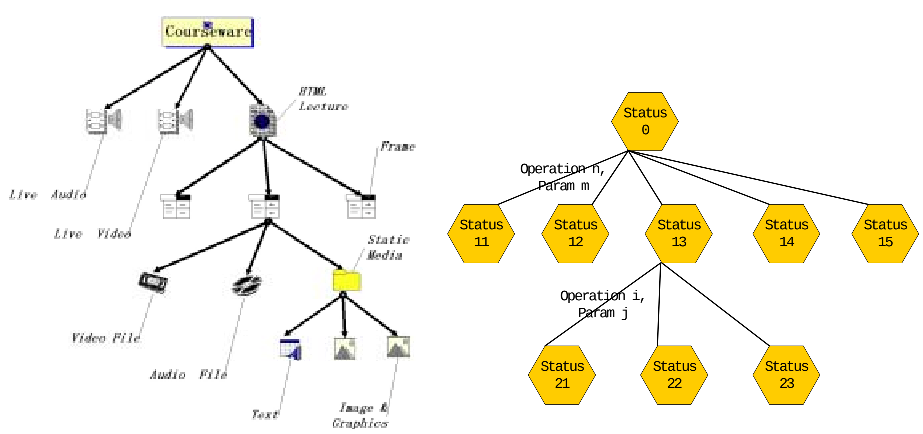
In TORM protocol [2], Multicast is used wherever applicable, and Unicast tunnels are created dynamically to connect session members located in separated multicast "islands" (refer to Fig. 1, where Reliable Multicast Server is called RMS for short and Reliable Multicast Client is called RMC for short). High scalability is achieved by organizing members of a session into a hierarchical structure, but in contrast to most of existing tree-based protocols, any number of concurrent sources are allowed to exist in a session. In order to support interactive applications that involve multiple users cooperatively operating based on a shared state, TORM also incorporates two serialization algorithms, i.e., distributed one and centralized one, to ensure totally ordered message delivery through all members. Another eminent feature of TORM is a novel congestion control scheme that is able to response to congestions in a timely fashion and can fairly share bandwidth with other competing network flows. Here real-time measurements of reception rate of all receivers, packet losses, and variations of

Round-Trip-Time are used as feedbacks for sender rate adjustments. Finally, network heterogeneity is fully addressed in TORM by partitioning receivers with different bandwidth capacities into homogeneous “domains”, so that receivers behind bottle-neck links are not likely to slow down the entire session. Trans-coding (AMTM) can also be applied on the border of domains to provide receivers with data in different qualities that best match their capabilities.

To testify the efficiency of TORM, we compared the loss recovery performance of TORM with SRM/Adaptive [8] through software simulation (more specifically, with NS2 [9]). The recovery latency and duplicate-request number of these two protocols were tested with star, 2-clusters and random topology. The result [10] shows that TORM has better performance than SRM as a reliable multicast protocol for large scale, real-time and interactive applications.

2.2 Adaptive Multimedia Transport Model (AMTM)

Adaptive Content Delivery (ACD) [11] bears the best efficiency among all possible types of Adaptive Multimedia Delivery schemes [12], in which application-layer semantics of the delivered data is coupled with underlying transport mechanisms. In Smart Remote Classroom project, the live instructing content and recorded courseware are in a compound multimedia document format. We developed AMTM to provide differentiated services for the delivery of this format of data to dynamically trans-code the multimedia data according to the variation of capabilities of each user as mentioned above without data redundancy.



(a) The Media Object Tree of a compound multimedia document

(b) A example transforming status tree of a Media Object

Fig. 2. Basic notions in AMTM

The Multimedia Compound Document Semantic Model in AMTM can describe the data organization, PQoS (Perceived QoS) and transforming of compound documents with the notions of Media Object, Content Info Value and Status Space of Transforming respectively. A compound multimedia document is parsed as a structural description of embedded Media Objects as is shown in Fig. 2 (a). Fig. 2 (b) illustrates a typical transforming status tree, where the original media is labeled with Status0, and converted into the new node Status11 through operation1 with parameter1, while subnode Status13 is transformed to newer nodes, namely Status21, Status 22, Status 23 and so on. The AMTM itself is used to abstract the process of adaptive delivery as finding the optimal resource allocation scheme and associated transformation plan for the embedded Media Objects by searching in the Status Space of Transforming. This policy is implemented in the RMS of TORM.

3 SameView – Software for RTIVC

SameView is an application developed for real-time interactive distance learning based on the proposed TORM and AMTM platform. Fig. 3 shows a snapshot of a SameView client.

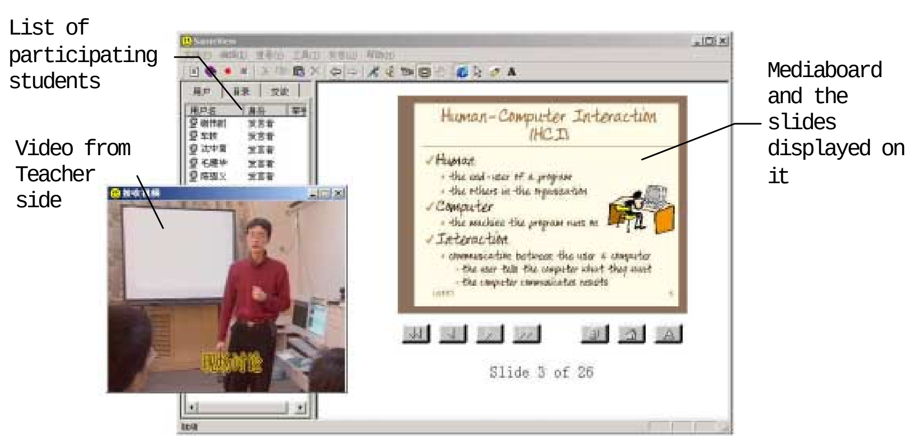


Fig. 3. A Snapshot of The SameView Client

3.1 Interaction Channels

SameView provides a set of interaction channels for the teacher and students to efficiently achieve the goal of teaching and learning.

1) **Mediaboard**, which is a shared whiteboard capable of displaying multimedia contents in HTML format. The teacher can show slides for the class on the board. Moreover, he can add annotations or scribble on the slides on the fly. All actions the teacher makes on the board, such as jumping between slides, scrolling the slides and writing on the slides, will be reflected on each student's client program. When permitted by the teacher, a student can also take control of the Mediaboard, for example, write down his solution to a problem issued by the teacher.

2) **Audio/Video**. The students can hear and see the audio and video of the teacher side. In addition, Student can also broadcast his audio and video to the others, when permitted by the teacher, for example, when the teacher asks him to give comments on a topic.
3) **Chat**. In addition, teachers and students can communicate with text messages.

3.2 Session Management

The users participating a class through SameView will play different roles in the class. The possible roles are Chair, Presenter, Audience and Anonymous. The following chart shows their respective privileges.

Role	Change other users' role	Action on Mediaboard	Broadcast Audio/Video to others	User Number with this Role	Listed on Participant List
Chair	Allowed	Allowed	Allowed	1	Yes
Presenter	NA	Allowed	Allowed	>=0	Yes
Audience	NA	NA	NA	>=0	Yes
Anonymous	NA	NA	NA	>=0	No

The teacher usually plays the role of Chair, while students are always initially assigned to the role of Audience. As a class going, the teacher can dynamically change the role of a student as necessary, for example, to invite the student to give comments on a topic. If there is more than one participant broadcasting Audio/Video at the same time, only the one who speaks loudest will exceed.

3.3 Class Recording

Fig. 4. Post-editing tool for the Same View recorded class

SameView can capture the exact process of a class by recording everything happened on all interaction channels, such as the slides the teacher showed, the annotations made on the slides as well as the live video and audio, into a structured compound document. The recorded information in the document keeps synchronized in the timeline and a SameView Player program is provided to play back the document. This way, students can review the class any time they want. Actually, this recorded document is also a good type of courseware for E-Learning. In addition, we also provide a post-edit toolkit for the teacher to edit the recorded document as necessary, such as to correct some mistakes made on the class, or to add some tags and indices to the document which can help the student to use the document more efficiently. Fig. 4 shows the interface of the post-editing tool.

4 The Smart Classroom

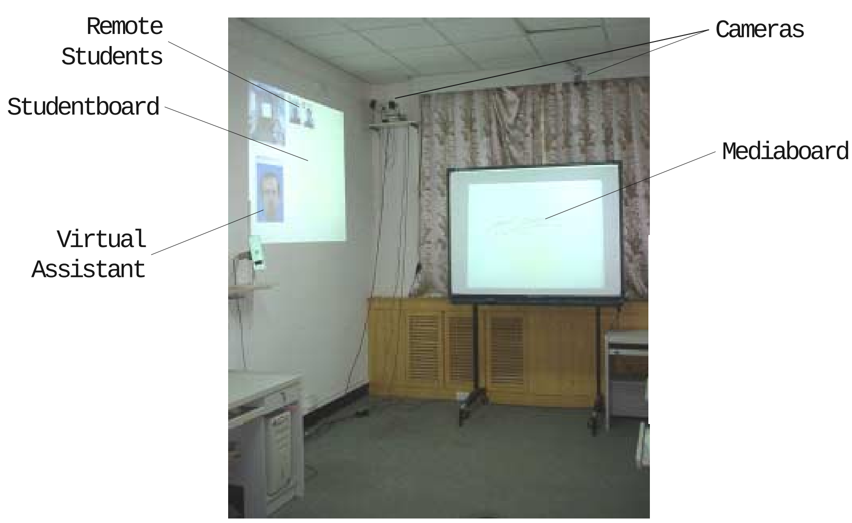


Fig. 5. Teaching area of the Smart Classroom

Smart Classroom is inspired by the research of Smart Space. Smart Spaces are work environments with embedded computers, information appliances, and multi-modal sensors allowing people to perform tasks efficiently by offering unprecedented levels of access to information and assistance from computers [13]. Smart Classroom is just such a Smart Space deployed in a classroom [6]. We augment an ordinary classroom with wall-sized displays, sensors, cameras and the associated computation and perception modules so as to allow the teacher in it to access the SameView system transparently, rather than appeal to a desktop computer. Through Smart Classroom, we actually extend the user interface of the SameView for the teachers from a desktop computer into the 3-D space of the classroom.

4.1 Room Setting

The room setting is illustrated in Fig. 5. The teaching area of the classroom are augmented with two facilities: Mediaboard and Studentboard. The Mediaboard here is a physical embodiment of the shared mediaboard of the SameView software for the teacher side, which is essentially a large touch-sensitive screen. Teachers can display prepared slides on this board and make or wipe scribbles on the slides with provided pens and erasers. Studentboard is a window to remote students, on which the image of remote students with Presenter roles will be displayed and the video and audio of the remote student who has the floor will be played here too. In the classroom, there are about a half-dozen cameras, each with different usage, installed at different places. For example, some are used to recognize the action of the teacher and some are used to capture the live video of the classroom for broadcasting to the remote students. In addition, the teacher wears a wireless microphone to capture his speech. The student area of the classroom is just the same as any ordinary classroom, which can be occupied by local students.

4.2 Natural Teaching Experience

In Smart Classroom, the teacher no longer needs to remain stationary in front of a desktop computer and, for most of common tasks involved in a class, the teacher no longer needs to use keyboard and mouse either. To this end, the following technologies are developed and integrated in the Smart Classroom.

(a) Teacher Scribbling on The Mediaboard (b) Teacher Driving The Cursor on Mediaboard With A Laser Pointer (c) Teacher Login to Smart Classroom

Fig. 6. Natural Teaching Experience in Smart Classroom

1. Pen-Based UI. The Mediaboard is displayed on a touch-sensitive screen (which is actually a commercial product called SmartBoard [14]). Teachers can control the display of the slides through manipulating directly on the board. Moreover, using the provided pens and erasers, teacher can write comments and scribbles on the slides or wipe the strokes, as illustrated in Fig. 6 (a).

2. Laser Pointer Tracking. We also implemented a computer vision module which can track the spot of the laser pointer on either Mediaboard or Studentboard. This way the teacher can drive the cursor or select an object on either board with a laser pointer, as illustrated in Fig. 6 (b).

3. Virtual Assistant. Interact with a dummy room seems awkward in some sense, so we introduced a Virtual Assistant figure into the Smart Classroom to impersonate the classroom against the teacher, which are displayed on the StudentBoard as illustrated in Fig. 6 (c) and Fig. 5. The Virtual Assistant combines Text-to-Speech, Face-Animation and Speech-Recognition technologies so that it can speak to the teacher when necessary and understand some voice commands of the teacher, e.g. "Give the floor to Tom" or "Jump to the previous page".

4. Login to The Classroom Based on Biometric Characteristic. In desktop-based RTIVC systems, a teacher should enter his ID and Password to login to the system. In Smart Classroom, we use a combination of face-recognition and speaker-verification technology to automatically identify the teacher. As the teacher enters the Smart Classroom, he first should show up in front of a mirror (behind which a camera for capturing the teacher's face is installed) and speak out his name, if both the face-recognition and speaker-verification processes are passed, the Virtual Assistant will greet him, indicating the Smart Classroom is now ready to serve him.

4.3 Smart Cameraman

When take a class in a real classroom, the students will change the focus of their sights as the context of the class changes. For example, when the teacher are writing a formula on the blackboard, the students will focus their sight on the formula, while when the teacher is showing a model in his hand, the students will focus their sight on the model. However, in most of current RTIVC systems, the students can only get the teacher-side video with a fixed scene no mater how the context of the class changes, which significantly decreases the efficiency of learning.

(a) The teacher was writing on the Mediaboard (b) The teacher was showing a model (c) The teacher was discussing with local students

Fig. 7. Different Scenes Remote Students Get According to Context of The Class

To cope with this problem, a facility called Smart Cameraman is introduced into Smart Classroom, which can distinguish among several different kinds of context of a class through observing some clues in the classroom and then select a camera with proper scene according the context from an array of available ones as the source of the video broadcasted to remote students. Currently, this module can successfully distinguish the following three kinds of context:

1) **Teacher Writing on Mediaboard**, where the teacher is writing comments or scribbling on the Mediaboard. In this case, the camera which focus on the Mediaboard will be selected as Fig. 7 (a) shows.
2) **Teacher Showing A Model**, where the teacher is holding a model in his hand. In this case, the camera which follows the teacher's hand will be selected as Fig. 7 (b) shows.
3) **Others,** for all other situations. In this case, the camera looks over the whole classroom will be selected as Fig. 7 (c) shows.

The cues used by the Smart Cameraman to estimate the current context includes the output of a Person-Tracking module which track the position of the teacher, a Gesture-Recognition module which can decide whether the teacher is holding something in his hand and the software state of the Mediaboard module.

5 The Overall Scenario

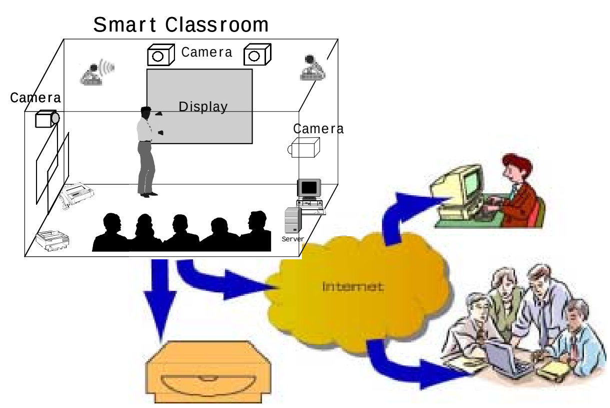


Fig. 8. Smart Remote Classroom System

Fig. 8 depicts how the above-described parts of the Smart Remote Classroom project are integrated into an overall scenario to enable a revolutionary real-time interactive distance learning practice. In this scenario, a teacher gives a class with natural ways in a Smart Classroom, where there might be local students, while the remote students connected by Internet access the class with SameView clients. The remote students can see the presented class materials, the annotations made during the lecture, the live audio/video of the Smart Classroom and also can take the initiative to interact with the teacher, just like attending the classroom locally. Furthermore, the process of the lecture will be recorded as a multimedia courseware for playback after class.

6 Conclusions

We developed a set of key technologies for real-time interactive distance learning and make a new paradigm of real-time interactive distance learning with following characteristics possible: 1) Unifying the face-to-face education and tele-education with the Smart Classroom, which in one hand give a consistent teaching experience to teachers and in other hand reduce teachers' workforce needed, for the teacher do not need to give the same class for the on-campus students and remote students separately. 2) Able to accept large-scale users to access the virtual classroom simultaneously with different network and device conditions. 3) The class can be recorded and turned into a piece of courseware for E-learning.

Currently we have made concrete achievements on each part of the project and the integrated system has been successfully demonstrated with controlled experiment conditions. Large-scope field evaluation is scheduled in next year.

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Critical Success Factors for Web-Based Organizational IT Training Systems

Hao Wang, Heng Xu, Hock Chuan Chan, and Ling Chen

School of Computing, National University of Singapore
3 Science Drive 2, Singapore 117543, Republic of Singapore
{wanghao,xuheng,chanhc,chenling}@comp.nus.edu.sg

Abstract. Over the years, organizational training plays an important role in human resource management in firms and organizations. With the rapidly changing technology and the increasing business demands, organizations especially IT departments have been investing greatly in web-based training. However, a successful web-based training system depends not only on the willingness from management, but also on IT infrastructure and employee acceptance, which is determined by many factors such as the degree of courseware customization and the level of collaboration.

In this study, propositions on the critical success factors of a web-based training system were raised and verified in a case-study involving two web-based courses in a large corporate IT department. The case study method is used to contrast between two modules, and demonstrate the critical success factors for the web-based IT training in a corporate environment. Four factors were identified including management involvement and support, courseware customization, level of collaboration and effective and consistent IT infrastructure. The insights gained and lessons learnt from this case study may hold valuable implications for both research and practice.

1 Introduction

Organizations are investing greatly in training to enhance the working effectiveness and efficiency of employees. With changing technology and fierce competition, the demand for organizations to employ effective and yet practical training systems is increasing. Wed-based training has emerged as an innovative approach to deliver organizational training to mass audiences. It provides self-directed, self-paced instructions and offers need-based information. It reduces the cost and time for training and avoids information overload [7,16]. Recent technology advances give web-based training much enhanced multimedia capability, allowing video clips and other types of media to be embedded to facilitate learning [1].

The advent of web-based technologies is dramatically increasing the usage of web-based training especially in organizational IT departments. Successful implementations of web-based IT training have been reported in the literature

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[8,20]. For example, It was reported that Cisco successfully developed a web-based curriculum to help learners develop a sustainable way to design and maintain their networks [8].

Despite the fact that IT training plays an important role in organizational training, the research on critical success factors (CSF) that impact implementations is still limited. Existing research only focuses on how to make a successful training course at a particular stage (e.g course development) or from a particular respective (e.g. from the learners' point of view).

For example, Swieringa identified the importance of understanding the individual trainee's needs and motivating factors [19]. One CSF was identified as employing traditional and integrative learning methods in organizational training [3]. Tao et al. discussed the lessons learned by a few Taiwan manufacturing companies on the CSF concept for a web executive learning system implementation [20].

The concept of CSF in the IS literature is well established for numerous contexts, for example, requirement analysis [14], IS planning [4], and project management [17]. However, organizational web-based IT training differs from traditional systems in scope and nature. A recent work identified five CSFs for web-based courses in tertiary institutions [18] . The results cannot be directly applied to the organizational web-based IT training as the training purpose and environment are different. Thus the development of CSF in organizational web-based IT training remains as an open research problem.

The purpose of this paper is to identify CSF for organizational web-based IT training, and discuss their implications for organizations. In the next section we propose the CSF. In section 3 we describe the case study based research methodology and approach. We introduce the cases in section 4 and present the data and case analysis in section 5 and 6. In section 7 we discuss the findings and implications, and conclude the paper.

2 CSF Proposition Based on Past Research

2.1 Literature Review

The focus of this study is to identify CSF for web-based training in IT departments. Following the Kirkpatrick's Four Level of Evaluation model that measures the success of IT training [10], we define organizational web-based IT training to be ***successful*** when it demonstrates the properties depicted in Figure 1.

The implementation of on-line courses is costly in both monetary and time/effort terms. As such, the benefits that such resources bring must outweigh these hefty investments. There have been numerous and varied studies describing factors that may affect organizational web-based IT training. We list the major factors below and hence the literature review is based on these: 1) management involvement and support. 2) courseware customization. 3) level of collaboration. 4) a blend of traditional and web-based training. 5) effective and consistent IT infrastructure.

Management Involvement and Support. In IT implementations, management plays important roles such as developing an understanding of the capabilities and limitations of IT, establishing reasonable goals for IT systems, exhibiting strong commitment to the successful introduction of IT, and communicating the corporate IT strategy to all employees [11]. It was reported that management involvement and support is important in the successful implementation of web-based training in organizations [5].

The involvement and support of the management might include: 1) linking the effectiveness of the use of web-based training resources to the measurement of employee performance. 2) using assessment from the web-based training as the pre-requisite for taking the expensive classroom-based training; 3) giving employees the flexibility to schedule their work and training.

The Customization of Courseware to Fit Specific Training Topics and Individuals. Different courses need to be conducted differently to achieve their objectives. Consequently, web-based courseware must be functionality rich to support different requirements. For example, course materials for software developers should contain adequate hands-on trial sessions, whereas course materials for network administrators should contain enough video clips and images to illustrate dynamic network changes [8].

The literature also emphasizes on the learning individuals. Training should be customized to individual student and made interesting. Olfman and Bostrom examined the use of personalized training to enhance training and motivation [13]. In addition, training should anticipate the individual's learning pace. It was noted that most trainees prefer self-direction in their learning cycles [7].

Level of Collaboration. Collaborative learning emphasizes cooperative learning, student-directed learning, and student interactions. Internet technologies facilitate teamwork and collaboration, allowing sharing, using, adapting, and locating information and communication. Therefore web-based courses can have built-in online collaboration support to facilitate class participation and discussions [15]. However there is a lack of study on the effect of offline collaboration (such as personal communication) for web-based training.

A Blend of Classroom and Web-Based Training. There have been debates on whether IT training should be purely web-based, purely classroom-based, or a blend of both. It is mentioned in a survey report [21] that 74% of all computer-skills training are delivered in a classroom by instructors, and 14% are delivered via computers. However, the authors of [12] conducted an empirical test to show that web-based training can be as effective as traditional classroom methods.

Effective and Consistent IT Infrastructure. There may be multiple initiatives in an organization involving multiple web-based systems for various training and learning needs. However, all these efforts must be based on a single effective IT infrastructure to deliver consistent performance across systems and across the entire organization network. Technical expertise, support, and infrastructure are discussed in [22].

2.2 Study Propositions

Since previous researchers have identified many factors that may affect the success of organizational web-based IT training, the objective of this study is to answer the following questions:

What are the critical success factors for an organizational web-based training system in IT departments?

To answer it, we make the propositions as depicted in Figure 1.

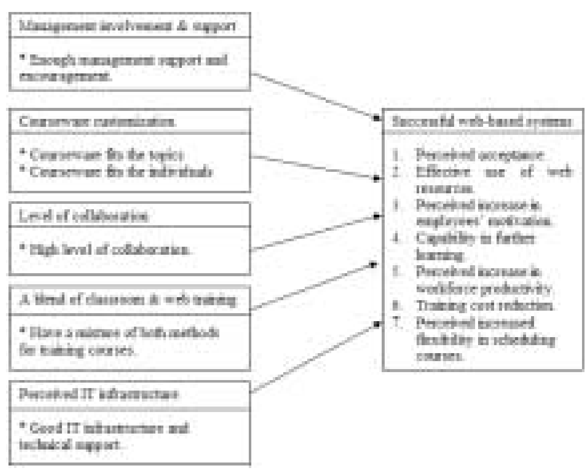

Fig. 1. Proposed CSFs for organizational web-based IT training

3 Research Methodology

Appropriateness of Case Study Research. We use the case study methodology to examine our research proposition stated in the last section. As noted in [23], a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-time context, especially when the boundaries between phenomenon and context are not clearly evident. The investigators should have little control over the phenomenon. This is inline with our research. The research involves not only technical issues but also more importantly, management and human factors, attributes that are social in nature and for which case study research is best suited. Plus, we, as observer investigating these issues, have no control over the events.

Case design The design chosen is a multiple case analysis, as shown in Table 1.

Table 1. Unit of analysis

Unit of Analysis	Embedded Unit	Constructs
Module	IT Staff	* Perceived management support. * Perceived customization of courseware to fit specific training topics and individuals. * Level of collaboration. * Receiving a blend of classroom-based and web-based training. * Perceived effectiveness of IT infrastructure.
	IT Management	* Management support * Assign a blend of classroom-based and web-based training. * Encourage and facilitate collaboration. * Commitment to build good infrastructure support
	Courseware	* Rich features that support customization for specific topic and individuals. * Support various forms of collaboration.

The research setting is an IT division in a well-established organization in Singapore. The division consists of 300 IT professionals in a few departments. It has recently implemented a web-based self-training and learning system. This system provides IT professionals a rich set of modules covering topics such as software project management, programming, and network administration. When designing this case, our premise is that trainees are familiar with the use of computers and IT facilities since they are IT professionals.

This research environment had certain distinct advantages for our study as it provides: 1) consistent network and web server (IT Infrastructure) across all courses; 2) consistent technical support across all courses; 3) similar trainee pool, all of them are from the same IT division.

Given this, we can reduce the amount of uncertainty and ambiguity caused by using different environments.

Information for this study was collected through interview and survey. We separately interviewed two different groups of sixteen employees for each module. Each group consisted of the trainees who had used or were using the investigated modules and some IT managers who were involved in staff training, knowledge management, online resource development and maintenance. This study was conducted over four months in 2001.

4 The Cases

Before choosing modules for study, we talked to a number of staff who had been through some web-based modules. The result of these informal personal discussions suggested that module A was seen as successful while module B was seen as unsuccessful. We believe that the comparison between a successful case and an unsuccessful case is more convincing.

Module A was about managing the company's local area networks with a particular tool. Course trainees were all from the Infrastructure Department. In the past, this course had been conducted in classrooms led by instructors, and it took three dedicated days to complete. Recently, this course was re-implemented on a web-based self-learning system. It was equipped with rich functionalities that included multimedia demonstration in video and audio. It also offered a web-based interactive network simulation program for trainees to practice the tool. The system allowed trainees to learn from anywhere at their own convenient schedules. Module A only had a trainee base of fifteen.

Module B was an introduction to two programming methodologies. This introductory course had been made mandatory for all the developers from a few departments in the IT Division and was the pre-requisite for the advanced programming methodology courses. Thus module B had a large trainee base of around 200. This course was initially designed and implemented on a classroom basis led by instructors and took two dedicated days. But it proved to be unsuccessful because the large trainee base caused scheduling difficulty. Very soon this course was re-implemented over the Web. The web version presented concepts and offered many programs for trainees to download and practice. The course materials were mainly in text and graph presentations. It provided a web-based threaded discussion forum.

5 Findings

In this section, we discuss the effects of the five factors on the success of a web-based training system.

5.1 Management Involvement and Support. For those trainees of Module A, their progress and the final test results were put on the monthly progress reports and were used as part of the metrics for annual staff evaluation. They were also given flexible choices in time schedules and places for doing the course. The managers said that the use of web-based module A was very effective as it reduced training budgets and received positive feedbacks from trainees. After a few rounds of successful trial, the management decided to stop the classroom version. Our above findings indicated that there was a fair amount of management support for module A.

For module B, the managers told us that the main reason for offering the web-based version was to ease scheduling difficulties. The trainees felt pressure from the managers, who reminded them frequently to spend time on the course and to participate in the discussion. However, the managers did not put enough attention to the trainees' learning results. Trainees' progress and learning results were not recorded for any evaluation. Thus the trainees, who often had to fight with tight project schedules and overtime work, always tended to delay or slow down the learning process.

Our findings therefore indicate strong support for the proposition that management involvement and support is a CSF for a web-based training system.

5.2 Courseware Customization. The contents of both modules were both well organized, leading trainees step-by-step along a logical learning path. Links to more related information on the Internet were provided. Links to the explanations of key concepts were also provided allowing easy revision whenever they appeared.

Module A used animated multimedia to explain key concepts that were difficult to explain in text. Multimedia was also used for the step-by-step guide on setup and configuration tasks of the network management tool. The majority of the surveyed trainees agreed that the animated multimedia demonstrations were interesting and greatly enhanced their understanding.

In comparison, module B did not have multimedia demonstrations or simulations. This might be because the topics of module B were mostly abstract programming methodology theories and thus it was mainly explained in text with some graphs. Trainees complained that the lack of multimedia content made dry topics more difficult to understand and reduced their learning interest.

Both modules offered the tracked learning status and progress of each individual. The web-based courses also provided a series of customized quizzes based on each trainee's progress. According to our survey, it showed that the trainees of both modules welcomed this web-based personalization of the course content.

Our above findings therefore provide strong support for the proposition that courseware customization is a CSF for a web-based training system.

5.3 Level of Collaboration. Module A did not have any built-in collaboration features. However, trainees of module A, all of whom were from one department, indicated that they 'collaborated' by directly discussing with their colleagues for clarifying their doubts over the course content. In addition, many trainees indicated that their peer relationships were even improved due to the discussion. Thus the Infrastructure Department itself served as a good community for discussion about the course content. This may not be true for other general courses as to be seen in module B.

Module B focused on software development processes and practices, which were not always clear-cut but rather prone to debates and discussions. Thus module B provided a discussion forum, which allowed participants to join some form of collaboration with experts and other participants. However, to our surprise, the usage of the forum was not high; only a few trainees frequently joined the discussions. The survey indicated that while all trainees agreed that collaboration was necessary for training, only some of them who were active in the forum believed online collaborations were useful. The rest of them preferred the offline face-to-face discussion. They said it took much time to post questions and to often revisit for answers in the forum. Some of them also felt awkward making comments in a forum, as they feared making mistakes publicly.

Although module A did not have any built-in collaboration facilities and module B saw the limited usage of such facilities, collaboration did occur offline for the web-based training. The preference for choosing offline collaboration could be: 1) immediate response 2) private communication 3) helped to improve peer-working relationship.

We do not mean that online collaboration is not important. In our discussion with trainees who were active in the threaded forum of module B, we learned that when they went for the external classroom training conducted by third-parties, they were shy to discuss with the classmates, who were strangers to them. This told us that online collaboration such as forums could help some trainees overcome the barrier of being passive in self-expression in public.

No matter whether online or offline collaboration was used to help trainees to learn, collaboration was necessary and important which was shown by both cases. ***Our above findings therefore provide strong support for the proposition that collaboration is a CSF for a web-based training system.***

5.4 A Blend of Classroom-Based Training and Web-Based Training. We noticed that for module A, the management decided to stop the classroom version after a few rounds of successful trial in the web-based training. However, most of the trainees did not agree that web-based training could generally replace the classroom version and they all would like to have a blend of classroom and web-based courses. The interviewed managers also said that they had no intention to convert all training courses to the Web.

Trainees of module A mentioned that some other networking courses like network troubleshooting, teaching by classroom version would be more appropriate. In classroom training, trainees could watch their instructor solve a real-time network problem and interrupt him at any time for asking questions. This type of course was not easily implemented over the Web due to the lack of face-to-face and real-time support. However, the same group of trainees also mentioned that they did want this classroom course to be videoed and put on the Web. Then they could review it for several times. Our above findings therefore indicate: 1) for some courses, web-based training is adequate; 2) the blend of web-based and traditional training is preferred for some type of courses.

Module B was the first and only web-based course among those programming methodology courses. The interviewed managers agreed that given the complexity of the topic, web-based training was not appropriate to give trainees good understanding on the topics and therefore they only put this introductory course on the Web. Most of the trainees agreed that web-based training was adequate for introductory courses while classroom training was more proper for advanced programming methodology courses. For such classroom training, they believed the Web should be used as a supplementary tool for storing references and reviewing purposes. This confirms the above two findings for module A.

Our above findings therefore provide weak support for the proposition that the blend of classroom-based training and web-based training is a CSF for a web-based training system.

5.5 Effective and Consistent IT Infrastructure. Module A and B were offered over the same physical network. The basic system requirements for trainees were a web browser and network access to the company Web. For module B, the mainly text-based contents were stored in the company's web server. The survey showed that trainees of module B did not perceive any delay or disruption caused by the network or web server, and also had no problems in the discussion forum.

For module A, the condition seemed more complex. The video shots of module A were stored on a video server and multicast to users using the video-on-demand technology. The employed interactive network simulation software was a client-server program written in Java, and its server part was stored in and executed from a separate Java-enabled application server. These complexities were hidden from trainees. However, strong technical support was needed to maintain the software.

Some trainees of module A pointed that the busy network traffic would slow down the performance of the training system some time. However, they added that the technical support teams quickly resolved the problems and thus their learning process was not delayed much. Trainees of both modules were satisfied with the response time. They all pointed that the unstable and slow-speed network would reduce the effectiveness of their training process.

Our above findings therefore provide strong support for the proposition that effective and consistent IT infrastructure is a CSF for a web-based training system.

6 Analysis of Findings on Module A and B

Module A was considered a success by both managers and trainees. A number of factors contributed to its success. 1) The management provided trainees flexible learning schedules and stimulated them for faster progress and better results. 2) The rich multimedia presentation made the course more interesting and attractive for trainees. 3) When they had questions, they freely talked to their colleagues in the same department. This offline informal collaboration improved the learning effectiveness. 4) With an effective network and the strong technical support, the trainees encountered few problems in using the web course materials. Therefore the trainees had no network or system barriers to learn over the Web.

In comparison, module B was perceived to be unsuccessful by the trainees. Despite the fact that the course was built on a good IT infrastructure, and the courseware was personalized to individuals, there were two adverse factors. 1) The lack of management support was one reason. Although managers had given verbal pressures to the trainees for fast progress and better results, there were no tangible actions taken. As a result, trainees who were developers facing tight project deadlines, often delayed or slowed down the learning process. 2) Module B was about abstract programming methodologies but the courseware did not attempt to employ multimedia tools to visualize concepts and to make them easy to be understood.

Table 2. Summary of factors

Constructs	**Module A**	**Module B**
Management support	High	Low
Courseware Customization	High	Average
Level of Collaboration	Offline collaboration: High Online collaboration: None	Offline collaboration: High Online collaboration: Low
Blend of Traditional and web-based Training	Explanatory course: Low Experience sharing course: High	Introductory course: Low Advanced course: High
IT Infrastructure	Good	Good
Success	**High**	**Low**

Table 2 summarizes the contrasting factors for the two cases.

Putting all these findings and evidence together, we can conclusively state that the critical success factors of a web-based training system are: (1) management support and involvement, (2) degree of courseware customization, (3) level of collaboration, and (4) effective and consistent IT infrastructure.

7 Discussion and Conclusion

From the data and analysis, we have found four important CSFs for organizational web-based IT training, namely management support and involvement, customization of courseware, level of collaboration and effective and consistent IT infrastructure. The cases also suggest that the following factor might be a CSF for web-based training but more evidence is required: having a blend of classroom and web-based training for trainees.

One common framework for organizational IT training outcome is the Bostrom, Olfman, and Sein's framework [2]. Its essence is that the principal outcomes are based on both understanding of the software to be learned and the motivation to use it.

Our findings tie in well with this framework. Management support and involvement is clearly a motivation factor for trainees. Customization of courseware helps trainees to have a better understanding. And the interesting course contents attract trainees to learn. A high level of collaboration enables trainees to discuss problems and exchange ideas, thus improving their understanding. The perceived effective and consistent IT infrastructure removes any possible system barriers for the use of the system.

From the cases, we have found that offline collaboration is important and necessary. Although online collaboration is shown important in the literature, offline collaboration, which is neglected in the web-based training literature, has unique advantages such as getting immediate response (as in both cases), improving peer working relationships (as in the case for module A), and keeping communications private (as in the case of module B.)

We have also found that the blend of classroom-based training and web-based training is not necessary for every course. Although module A and B were purely web-based, trainees agreed that the mixture of two training methods could be useful for experience sharing courses and advanced courses on programming methodology. This finding fits some criteria for the integration of traditional and web-based learning [19].

Based on these findings, there are several important practical implications for organizations to consider before investing and developing such web-based training resources/software. They are:

- Organizations should allocate enough management support and involvement, given its importance in web-based organizational IT training.
- Courses should be customized to the specific training topic, and designed to incorporate functions that personalize the course contents according to the individuals.
- Organization should encourage offline collaboration among trainees.
- Organizations may consider employing either classroom or the Web, or both for different IT training course to achieve the best result.

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Application of Quality Assurance in Web-Based Laboratories

Reggie Kwan and Jimmy S.F. Chan

School of Science and Technology
The Open University of Hong Kong, Hong Kong
rkwan@ouhk.edu.hk
sfchan@ouhk.edu.hk

Abstract. Asynchronous communication in traditional courses has proven to be inadequate in both the turn-around time and the lack of physical and psychological connection between the learners and the facilitators. A Web-based course provides new challenges regarding communications. Some students are already isolated geographically and have a difficult time making a connection with the facilitator and other students. This paper describes the "closed lab" conducted on the Internet in a programming course and how the conditions be monitored through the application of quality assurance (QA). Components of this course such as animated learning materials, notes, assignments, laboratories, and exams are all provided entirely through the Web. In this course, a virtual lab is run once a week to synchronize learning materials, to answer programming questions instantaneously, and to promote a learning community. This paper summarizes the experience in adopting the 5S in condition monitoring in the "virtual laboratory", adoption of QA in condition monitoring and how this methodology can be extended to wider education sector.

1 Introduction

The society has focussed upon three major concerns in recent years. These concerns include information technology (IT), quality assurance (QA) and green environment. These three areas of concerns have brought us fundamental changes in the way we work and live. IT on its own has created a significant impact world-wide, bridges the communication distance for associates and partners, let it be in business or research. It is an enabling technology providing a platform for which other disciplines should build upon for efficient operations, better communication and more business opportunities. Quality assurance (QA) has been and continuing to one of the focuses of attention in industry, servicing sectors as well as education. It is very important to have a quality mechanism from the design of course content right through to the lecture (in case of conventional university) or to the course materials (in distance education). With advances in computing technologies, many courses provide on-line learning environment to enhance student learning. Educators have an important role to play in improving learning effectiveness, spark student interests and at the same time provide assured quality. In this paper the authors discuss experience gained in providing students with closed-labs under close condition monitoring at the Montana State University. The experience gained can further be developed to suit the Hong Kong environment. This paper also describes an extended model in on-line closed

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labs in computing and engineering courses including two of the three major concerns, IT and QA.

The two computer science departments at Montana State University—Bozeman and Montana Tech of The University of Montana have been developing and running a Web-based course for non-traditional Master's students by using, among other things, streaming lectures, virtual labs, and a virtual learning community. Four professors and two teaching assistants are involved in the development and coordination of the course. The project is funded by the Office of the Commissioner of Higher Education of Montana.

The course is a 10-credit sequence titled "CS301 Web-based Introduction to Computer Science I & II," which covers essential concepts of 28 semester credits of regular course work. It is designed to help students with previous degrees in other disciplines and want to pursue Master's degree in Computer Science. The course is the revised version of an existing innovative course sequence that has been taught both through traditional techniques and through two-way video at Montana State University—Bozeman [1].

2 Course Structure

The course is structured around the following components;
1. Course notes in html, postscript, and text format;
2. Executable examples;
3. Content-driven multimedia lectures created in Macromedia Authorware®;
4. Books and CD's;
5. Assignments;
6. Examinations;
7. A virtual learning community; and
8. A virtual laboratory.

The overview of the course can be viewed at http://webclass.cs.montana.edu/~cs301.

2.1 Virtual Laboratory

Both computer science departments believe in the closed lab concept as described by [2]. Since this course is a Web-based course using the Web as an instructional medium [3], a conventional physical lab with face-to-face interaction is not possible. It is only natural for computer science educators to extend the use of the computer and the Internet from learning tools to teaching tools [4]. One of the major objectives was to "connect students in distant locations in a meaningful way" [5]. The team decided to run the lab with synchronous communication by using Microsoft's NetMeeting®. The following table shows the five time slots from which each student can choose one:

Date	Time	Mode of delivery
Tuesdays	2pm to 5pm	live
Wednesdays	12pm to 3pm	on the Web
Wednesdays	3pm to 6pm	on the Web
Wednesdays	6pm to 9pm	on the Web
Thursdays	6pm to 9pm	on the Web

The contents of the lab each week are used to synchronize concepts with the lecture of the week. The lab contains in-lab (closed lab) activities as well as programming project outside of the scheduled lab (open lab).

2.2 Lab Structure

The contents of the lab vary very little with the conventional lab in a conventional programming course. The difference is mainly communication among participants. The virtual lab makes use of all the features in NetMeeting to enhance teaching and learning: chat, whiteboard, audio and video conferencing, and application sharing. Before any collaboration tool is used, students need to download NetMeeting from www.microsoft.com and connect to the directory server (cs.mtech.edu) that is set up for the virtual lab. The NetMeeting server, cs.mtech.edu, is maintained by the Computer Science Department at Montana Tech of The University of Montana. Students can get through a lab without logging on to NetMeeting if he/she has no need for discussion or assistance from one of the facilitators or teaching assistants.

Chat

Though the feature chat in NetMeeting handles one-to-one communication extremely well, it is most commonly used when there is a many-to-many communication. It provides the teaching assistant the chance to clarify simple concepts, syntax and semantics problems of a program segment. It gives students a chance to communicate with several other students simultaneously. Some students also like to save all the discussions in a log file for later reference. The chat feature is used more often than the other features in the course.

Whiteboard

When the same question is asked over and over, either the teaching assistant or the facilitator can clear up a concept by putting the detailed explanation on the whiteboard because all participants of the NetMeeting session can view the whiteboard while the explaining is in progress. The whiteboard is most efficient when used with audio.

Audio and Video Conferencing

According to the specification of NetMeeting, modems communicate at 28.8kps should have no problem with video conferencing. However, we found video conferencing inadequate for two reasons. First, it can only handle one-to-one communication. NetMeeting does not support "broadcast" video. Secondly, owing to the quality, it is not worth the effort. The maximum resolution is 480 by 320 and the refresh rate is no more than several frames per second at best. Students do not feel it is necessary to see the facilitator or the teaching assistant. Furthermore, since most students do not possess a video camera on their PC, the video communication is reduced to one way only.

Audio conferencing has been heavily used as the collaboration tool of choice [6] in the virtual lab as expected by students who are most likely audio-learners [7]. The quality, however, is almost as good as the telephone. While the student is browsing the course Web page or conducting NetMeeting, it makes sense to communicate with audio. In order to make a phone call, a student would have to stop using his/her modem and thus NetMeeting. One word of caution, with the delay on the net and the absence of body language, students either talk all at once or offer long awkward delays. This problem can easily be solved by the use of commercial products such as HearMe in which one-to-many mode is supported. Before someone speaks, he/she would have to pick up the token and thus no more than one person can talk at any given time. On the other hand, the one-to-one audio support in NetMeeting 3.0 is adequate for the purpose of our virtual lab. Any need to broadcast information is done through text chat or whiteboard.

3 Application Sharing

It is difficult to provide any assistance if the teaching assistant and the facilitator rely solely on the description from the student regarding the problems of his/her program. Application sharing/collaborating provides the facilitator a chance to look at the whole program with which the student has trouble. The owner of an application such as the compiler can simply share the application with another participant. Then, both participants of NetMeeting can share the ownership of the application during the session. Thus, in theory both participants can see, edit, or compile one single program. It is as close to having both participants in one room as possible under the circumstances. Though the delay is bothersome and requires a great deal of patience on both parties, it is better than emailing a file back and forth for some students. The participants of a shared application can have different combinations other than just teaching assistant and students. There were numerous occasions when multiple students shared and collaborated on one single program. Thus, a synchronous virtual learning community is formed during the lab [8].

4 Quality Assurance

There were 30 lab sessions in the course of a full year. As most of the universities in the states, each semester has 15 to 16 weeks of instructions. The team decided to divide all programming concepts into 30 lab sessions, and thus each semester has 15. The team of four professors and two teaching assistants (TA) met in the summer before the fall semester to decide the rough topics and concepts in each laboratory

(Figure 1 shows the concept of QA applied in the design of virtual labs) and to brainstorm different expected problems/difficulties and possible remedial actions. This incorporated quality assurance at the design stage. In the implementation stage, stringent QA with three tiers of quality check mechanism was applied. Each lab was then designed by the TA at Montana State University, it is then check by the team members at the MT of the University of Montana. The TA went through each lab as a student to check if the amount of work is appropriate with respect to time and its technical correctness, then the professor at MT validated the pedagogical values of the lab (as shown in Figure 2). Quite a number of labs were modified after the checking process. The lab is then given to a live audience on Tuesday before giving to the students who attended the virtual labs on the subsequent days on Wednesday and Thursday. Thus, fining tuning was possible before the first virtual lab each week.

Since running the virtual labs was a brand new venture for both Computer Science Departments at the two universities, monitoring the positive and negative aspects of this project was a top priority. The professor at MT eavesdrops on all virtual lab by simply subscribing to the NetMeeting server during the lab hours. Since the text chat session can be saved in a text file, there is no need for real time monitoring. However, the monitoring of the application sharing part had to be done at the time when it happened. All sessions were monitored while it was going on. As it turned out that the C++ compiler was the only thing that was shared through the Web. As a matter of fact, the debugger was used 80% of the time when sharing was going on. Monitoring through NetMeeting was proven to be adequate and non-invasive.

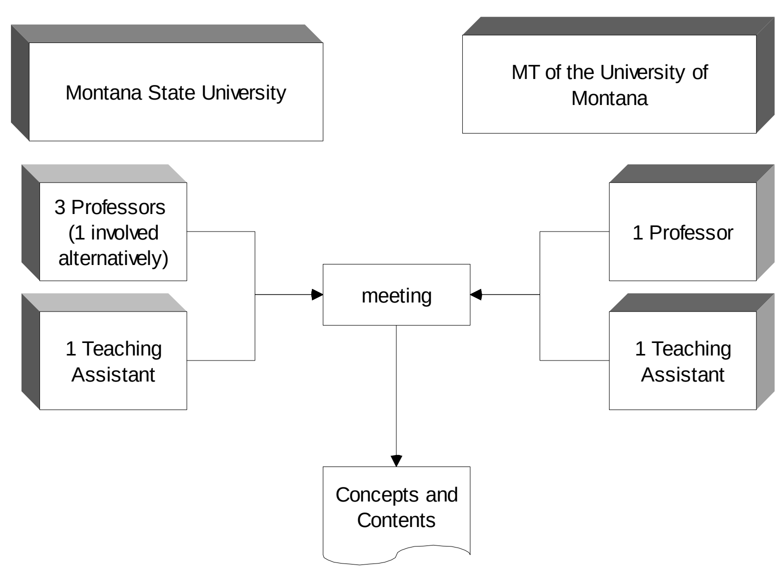

Fig. 1. Meeting between the two Universities for Generating Concepts and Contents of Virtual Labs

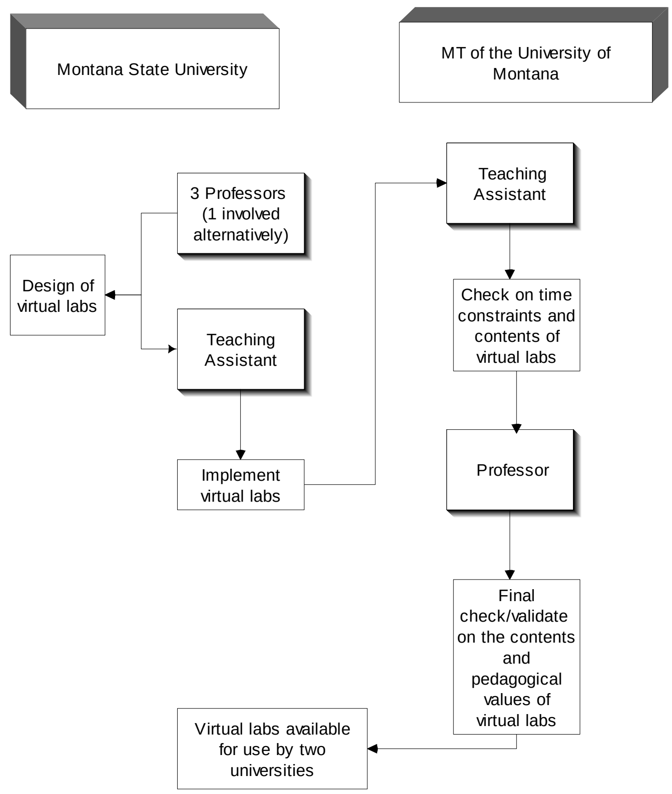

Fig. 2. Quality Assurance in the Design and Implementation of Virtual Labs

5 The Virtual Lab Experience

The virtual laboratory has been an essential part of the Web-based course developed by the two computer science departments. It not only synchronizes learning materials; it also provides students a virtual human contact. It has proven to be a mixed blessing so far.

5.1 A Facilitator's Perspective

A conventional course in programming gives the instructor ample chances to sense whether students are getting the materials through body language in lectures and observations in a closed lab without resorting to examinations. A Web-based course lacks the standard interaction between the learner and the facilitator [9]. However, the weekly virtual lab in this course provides instantaneous feedback to the facilitator as well as a chance to get to know the students through the Web synchronously. The opportunity to observe students non-intrusively has a lot of potentials. It also allows a facilitator the flexibility of being somewhere other than the computer lab. In more than one occasion during lab hours on Wednesday, some of us actually stayed at home baby-sitting and running the virtual lab concurrently.

The speed of NetMeeting through modems has been very disappointing. The slowness reduces the virtual lab to mostly chat in text. Audio conferencing is far from traditional face-to-face group discussion. As mentioned earlier, it gets confusing when there are more than four participants especially when the audio quality is sub-telephone. Application sharing is so slow that most students stop using it after a couple of tries and resort back to emailing files back and forth.

Another unfortunate aspect of the virtual lab is turf. Students, for no apparent reason, tend to limit their communications to the school in which they signed up this course. We rarely get any comments or questions from students who signed up this course through Montana State University--Bozeman. The opposite is true for Montana Tech students who seldom communicate with MSU--Bozeman facilitators or teaching assistants. Students failed to make use of all the resources in both campuses.

5.2 Students' Perspective

Students were interviewed during and at the end of the first semester to obtain feedback that lets the team improve the course while it is in progress. We were especially interested in students' assessment of the virtual lab component of the course. The results have been overwhelming mixed. Some local students insist to attend the live lab every week while out of town students have no choice but to attend the lab conducted on the Web. However, a large group of local students do appreciate both set-ups. Thus this group of students do have first hand experience both with the virtual lab concept and practice. On one hand, they favor the virtual lab idea. On the other hand, most of them are displeased with the speed imposed by their modem. Interviews are conducted in the middle and again at the end of each semester. Their comments include:

> I really like the different time slot of the labs especially the one at night. I usually work on the lab the weekend before. I get on to NetMeeting Wednesday night only when I have a problem. Well, I do get on a lot. I mostly use chat and audio. I try to avoid collaboration because it is too slow. Sometimes I prefer emailing the program to the TA.

> I make use of it [virtual lab] a lot especially during the lab on Wednesday night. And I sometimes use it on the weekends with Nat [another student]. I only limit myself to chat and audio conferencing. I like the idea of the sharing feature except it is painfully slow and it's hard to tell who has the control. It's not

> worth the waiting time. I would rather drive up to Tech during "live" labs or to your office.
>
> I can see the great potential of sharing the compiler with the TA and other students if I had broadband. On the other hand, I do like saving an hour each way especially when the pass is snow-packed and icy.

Almost every student interviewed commented on the slowness of this set-up particularly the application sharing and collaborating feature. Nevertheless, a learning community is formed on the Web by using emails and NetMeeting.

6 Where Do We Go from Here?

The success in the rural state of Montana has profound influence in moving courses online using tools such as NetMeeting as one of the researchers has recently moved from Montana to Hong Kong. Though Hong Kong is a city that is always proud of the efficiency of its public transportation, NetMeeting is being tried to conduct online tutorials in Hong Kong so as to save the travelling time of tutors and students. Synchronous communication can be done cost-effectively especially when broadband is catching on quite rapidly in Hong Kong. However, the effectiveness of using the Web to replace face-to-face contact between tutors and students remains to be seen in Hong Kong.

The 5-S philosophy had long been established as a good practice in Japan for more than two centuries. The original 5-S philosophy [10] includes Seiri (Structurise), Seiton (Systematise), Seiso (Sanitise), Seiketsu (Standardise) and Shitsuke (Sustain), which have different translations by different practitioners. Further, quality is more than an issue and it should be put into practice. The authors propose to implement the 5-S philosophy in virtual lab, together with the current QA procedure adopted. This requires the course coordinator (CC), tutors and students to participate not only in the virtual lab but also in the good practice of QA and 5-S. This includes the following:

(a) Structurise – To sort all files, directories and programmes in hierarchical order. CC, tutors and students are required to discard any unnecessary files or programmes and to improve the version control. This good housekeeping ensures less confusion.

(b) Systematise - This focuses on efficient and effective storage methods. Good filing system is a must to allow easy access to files and documents. All participants must maintain backup storage of files and programmes.

(c) Sanitise – All participants should eliminate any junk files and maintain a clean and virus free environment. This implies that each participant must maintain a good habit in scanning viruses and disinfect any contaminated files on regular basis each time his/her PC is booted up and while it is idle. Particular attention is paid to emails and attached files.

(d) Standardise – Participants must improve the transparency of his filing system where files and directories should be labelled with proper and meaningful names. Tutors and students must be given sufficient information on, for examples, the virtual lab, timeslots for logging in and standard operation procedures.

(e) Sustain – This requires self-discipline from each participant to maintain a good practice of the above (a) to (d).

7 Conclusions

The idea of using modern technology to enhance teaching and learning is as old as teaching itself. It is only natural for this Web-based course to get on this bandwagon. In the case of virtual laboratory, the concept is well received by facilitators and students of the course. The communication speed imposed by modems does post a big hurdle. It is too slow to live up to its potentials unless all participants subscribe to broadband connections. Having said that, we still would recommend the virtual lab model discussed above for a Web-based course when students and facilitators are scattered geographically. Migrating to the Web has proven to be a success for this course. A large part of this success can be attributed to the QA procedure we imposed in the virtual lab.

Quality has been a focus of attention in many sectors, and education is one. The implementation of QA and 5-S in education have significant improvement and achievement in the teaching and learning process. Apart from maintaining high quality, it helps instructors conduct good housekeeping and provides ways of improving efficiency and security especially when it comes to distance education.

Notes on the Authors

Reggie Kwan was professor and head of the Department of Computer Science at Montana Tech of the University of Montana before taking a leave of absence to join the Open University of Hong Kong (OUHK). Jimmy Chan had been a senior lecture at University of Wolverhampton before joining OUHK.

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Towards Open Standards: The Evolution of an XML/JSP/WebDAV Based Collaborative Courseware Generating System

Changtao Qu and Wolfgang Nejdl

Learning Lab Lower Saxony, University of Hannover
Deutscher Pavillon, Expo Plaza 1
D-30539, Hannover, Germany
{qu,nejdl}@learninglab.de

Abstract. In this paper we present the evolution of a collaborative courseware generating system that is featured by XML-based course structure representation, JSP-based dynamic courseware presentation, and WebDAV-based collaborative courseware authoring. While the first system implementation employs a proprietary design that uses a self-defined XML DTD to represent course structure, the second and the third system implementation take an open standard based approach, which are respectively SCORM 1.1 and SCORM 1.2 conformant. In the latter two implementations, all learning resources contained in an existing Java course are re-designed according to the SCORM 1.1 and SCORM 1.2 Content Model and further annotated with corresponding SCORM metadata. In addition, the course structure is re-constructed utilizing SCORM 1.1 Content Structure Format and SCORM 1.2 Content Packaging Specification. The evolution of the collaborative courseware generating system is motivated by our efforts to improve the reusability and interoperability of learning resources.

1 Introduction

Since the summer semester 1999, the joint CS1 course "Introduction to Java Programming" (Info1 for short) has been shared between three German universities and the Free University of Bozen in Italy. During the past two years, we have been successively working on three system implementations of Info1 with the purpose of exploring efficient approaches to improving the reusability and interoperability of learning resources. While the first system implementation employs a proprietary design that uses a self-defined XML (eXtensible Markup Language) DTD (Document Type Definition) to represent course structure, the second and the third system implementation take an open standard based approach, which are respectively SCORM (Sharable Content Object Reference Model) 1.1 [1] and SCORM 1.2 [2] conformant. In the latter two implementations, all learning resources contained in Info1 are re-designed according to the SCORM 1.1 and SCORM 1.2 Content Model and further annotated with corresponding SCORM metadata. Also the course structure is re-constructed

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utilizing SCORM 1.1 CSF (Content Structure Format) and SCORM 1.2 CP (Content Packaging) Specification. In this paper we will present these three system implementations of Info1, showing its evolution towards open standards.

2 General Design

In figure 1 we illustrate the general infrastructure of the collaborative courseware generating system.

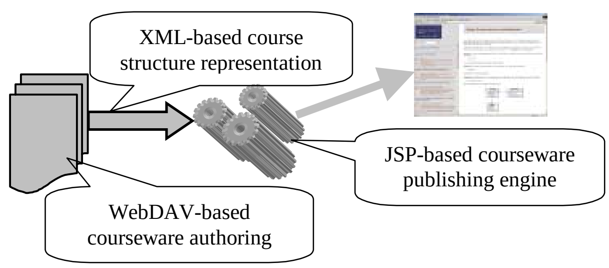

Fig. 1. General infrastructure of the collaborative courseware generating system

The system is constructed from a WebDAV (Web-based Distributed Authoring and Versioning)-based courseware authoring module and a JSP (Java Server Pages)-based courseware publishing engine. The standard data interface between both is XML.

Although the general infrastructure is commonly shared by all three system implementations of Info1, there are some essential differences between them. First of all, the three system implementations are different in how they represent the course structure using XML. This essential difference clearly marks the system's evolution towards open standards. Moreover, the different representations of the course structure also determine the reusability of our JSP-based courseware publishing engine that is responsible for dynamically presenting XML-based course structures on the Web. In figure 2 we firstly illustrate a common module of all three system implementations of Info1: the WebDAV-based courseware authoring module. It is used to support collaborative courseware authoring in three system implementations.

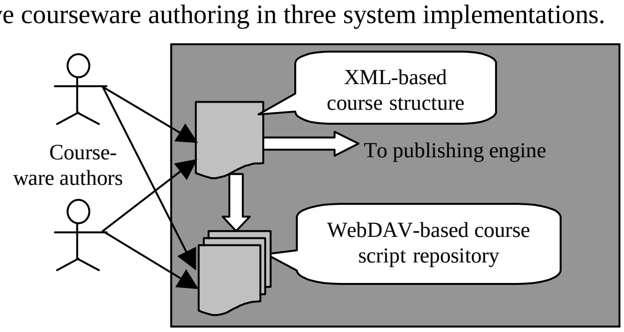

Fig. 2. WebDAV-based courseware authoring module

The courseware authoring module comprises a WebDAV-based courseware repository that is used to store course script files, and an XML file that is used to represent the course structure. The latter also serves as the standard data interface between the courseware authoring module and courseware publishing engine in order to cleanly separate course content from courseware presentation. The WebDAV-based courseware authoring module is shared by all three system implementations of Info1, which can enable geographically-dispersed authors to collaboratively accomplish the courseware authoring process.

WebDAV [3] is an IETF specification that is originally designed to add interoperability and collaborative capabilities to the Internet. It provides sets of extensions to the HTTP protocol that allows geographically-dispersed users to collaboratively edit and manage documents directly on the remote server. The current functionalities of WebDAV include: (1) locking mechanism, used to prevent the “overwriting” of changes in a distributed, multi-user authoring environment; (2) namespace manipulation, used to manage document repository on the remote server; (3) properties manipulation, used to handle XML-based metadata of document; and (4) collections, used to create sets of related documents and to retrieve listing of their members. Utilizing WebDAV, the courseware authors can “in-place” (directly on the remote server) implement most of activities needed for collaborative courseware authoring, e.g., editing course script files stored in the courseware repository, manipulating the repository’s namespace, utilizing locking mechanism to prevent “overwriting”, or manipulating properties of a specific course script file in order to exchange ideas and opinions among lecturers. At present there are many popular WebDAV-enabled authoring tools, e.g., Microsoft Windows 2000, Windows XP, Office 2000, Office XP, FrontPage 2000, Internet Explorer 5.0, Adobe Photoshop 6.0, Acrobat 5.0, Macromedia Dreamweaver 4.0, etc., which can be directly used by the authors to complete courseware authoring process. Since all these WebDAV-enabled tools are aware of WebDAV’s methods (propfind, lock, unlock, etc.), they can “in-place” handle all course script files without the need of an explicit download and upload process. Additionally, the document locking and unlocking are also automatically managed by these WebDAV-enabled authoring tools. In fact, according to our practical experience, the WebDAV-based courseware authoring module has greatly improved the efficiency of the courseware authoring process [4].

3 The First System Implementation: Proprietary Design

The first system implementation of Info1 adopted a self-defined XML DTD to represent the course structure. In figure 3 we illustrate this XML DTD.

In the DTD definition, several self-defined XML elements, e.g., “CourseUnit”, “CourseElement” are adopted to describe the course structure. Also the metadata of the course scripts (e.g., URIs or URLs) are described in these elements in the form of “attributes”. Although principally this is a proprietary approach to representing the course structure, we can still achieve a certain reusability of courseware publishing engine based on this DTD. In fact, all courseware that are represented using above

XML DTD can be directly rendered by our JSP-based courseware publishing engine without the need of any re-configuration process [4].

```
<!ELEMENT Courseware (Title, Author+,Description?, CourseUnit+)>
<!ATTLIST Courseware
 xmlns:courseware CDATA #FIXED "http://www.kbs.uni-hannover.de/Courseware" >
<!ELEMENT Title (#PCDATA)>
<!ATTLIST Title
  pic CDATA #IMPLIED >
```

```
<!ELEMENT Author (#PCDATA)>
<!ELEMENT Description (#PCDATA)>
<!ELEMENT CourseUnit (Overall,Location?, CourseElement*)+>
<!ATTLIST CourseUnit
 name CDATA #REQUIRED
 url CDATA #REQUIRED>
<!ELEMENT Overall (#PCDATA)>
<!ELEMENT Location EMPTY>
<!ATTLIST Location
 uni (all|Hannover|Dresden|Hildesheim|Bozen) #IMPLIED>
<!ELEMENT CourseElement (#PCDATA)>
<!ATTLIST CourseElement
 name CDATA #REQUIRED
 url CDATA #REQUIRED >
```

Fig. 3. Self-defined XML DTD

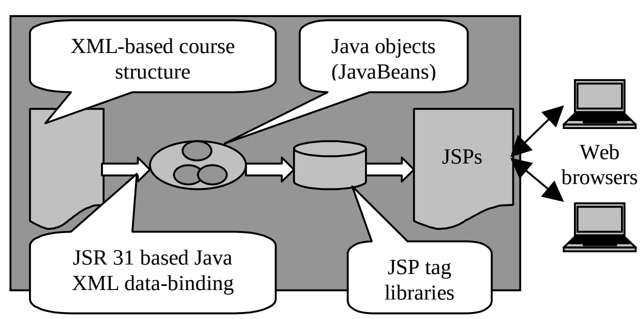

Fig. 4. Infrastructure of courseware publishing engine

Figure 4 shows the infrastructure of the courseware publishing engine implemented in the first system implementation. Besides JSP, we also employ several “reusable” technologies, e.g., JavaBeans, JSR (Java Specification Requests) 31-based Java XML data-binding [5], and JSP tag libraries in order to achieve the reusability of the courseware publishing engine. For a more detailed description of this courseware publishing engine please refer to our previous publication [4].

4 The Second System Implementation: SCORM 1.1 Conformant Design

Although we have achieved certain reusability of the courseware publishing engine thanks to the inherent flexibility of XML, the first system implementation has two notable drawbacks. First, it is proprietary. On the one hand, the course structure represented using our self-defined XML DTD cannot be directly rendered by other courseware publishing engines. On the other hand, the courseware publishing engine bound to the self-defined XML DTD cannot be re-used to generate other courseware represented using other XML formats.

Second, the metadata of learning resources contained in Info1 are not annotated and managed in the first system implementation. This makes it very difficult to reuse and exchange learning resources between our partner universities.

Therefore, in order to achieve more interoperability, especially in order to find an efficient way to reusing and exchanging learning resources, we decided to shift to the open standard: SCORM 1.1 in the second system implementation.

The SCORM 1.1 was released by ADL (Advanced Distributed Learning) in January 2001. One of the most important features of SCORM is its good compatibility with other learning resource specifications. The SCORM 1.1 smartly references IMS Learning Resource Metadata Specification [6] (in SCORM 1.2, also IMS Content Packaging Specification [7]) and IEEE LOM (Learning Object Metadata) [8] as well as other specifications and further integrates these specifications with one another to form a more complete and easier to implement model. With regard to metadata sets, SCORM 1.1 is downwards compatible with IEEE LOM 3.5 and IMS Metadata Specification 1.1. Regarding Content Structure representation, it defines SCORM 1.1 CSF, which itself is derived from AICC CMI CSF [9]. The SCORM 1.1 also defines a Content Model that consists of three components: Raw Materials, SCO (Block), and Course. Together with its metadata specification and CSF, the Content Model can enable the reuse and exchange of learning resources at different aggregation levels. More importantly, the SCORM 1.1 also provides a RTE (Run-Time Environment) that offers a standardized way for SCO (Sharable Content Object)-based learning resources to communicate with LMS (Learning Management System) through the use of common API. During the development process, the RTE can provide us with the beneficial guidance to the system implementation.

The SCORM 1.1 conformant design of the second system implementation consists of four tasks: (1) adapting existing learning resources into SCORM 1.1 Content Model; (2) representing course structure using SCORM 1.1 CSF; (3) annotating and managing learning resource metadata; and (4) constructing SCORM 1.1 RTE.

4.1 Adapting Learning Resources into SCORM 1.1 Content Model

The learning resources contained in Info1 include not only some self-made “internal” materials, but also lots of “external” learning resources that directly exist on the Web. According to the SCORM 1.1 Content Model, these “internal” and “external” learning resources are reasonably designed as Raw Materials, SCO (Block), and Course in the second system implementation, as depicted in figure 5.

During the design process, we've given a special consideration to the differentiation between Raw Materials and SCOs. While each course unit of Info1 can be naturally designed as a SCO and all its underlying raw materials (e.g., figures, tables, etc.) can be naturally designed as Raw Materials, the "external" resources have to receive more attention while being adapted into the SCORM 1.1 Content Model. Because the SCO represents the lowest level of granularity of learning resources that can be tracked by a LMS using the SCORM RTE, and also SCO itself must be independent of learning context, we intentionally designed all "external" learning resources as Raw Materials in order to retain some reasonable learning context between "external" resources and SCOs (course units)[10]. Additionally, we have also organized several SCOs into higher aggregations (Blocks), which can further facilitate the reuse and exchange of learning resources at different aggregation levels.

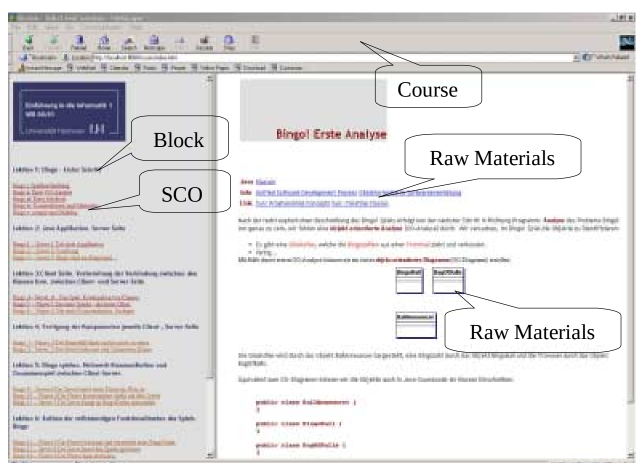

Fig. 5. SCORM 1.1 conformant Info1

4.2 Representing Course Structure Using SCORM 1.1 CSF

The SCORM 1.1 employs CSF to aggregate learning resources into a cohesive unit of instruction, e.g., course, lesson, and module, etc. In comparison to the use of self-defined XML DTD in the first system implementation, representing course structure using SCORM 1.1 CSF constitutes the key to our shift from proprietary design to open standard based development. On the one hand, the CSF-based course structure can be now directly rendered by any other SCORM 1.1 (also AICC CMI CSF) conformant courseware publishing engine, on the other hand, our courseware publishing engine (SCORM 1.1 RTE) implemented in the second system implementation can be now re-used to generate other SCORM 1.1 conformant courseware. In figure 6 we illustrate the SCORM 1.1 CSF-based course structure representation of Info1. It could be directly rendered by any SCORM 1.1 conformant courseware publishing engine.

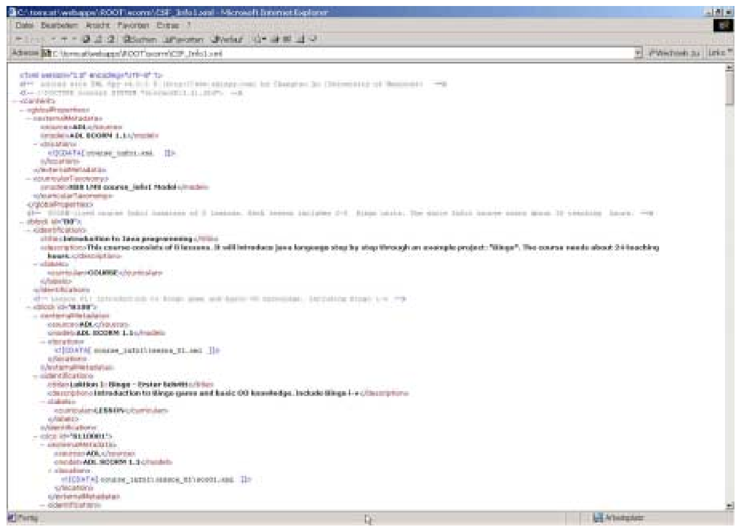

Fig. 6. SCORM 1.1 CSF-based course structure representation of Info1

4.3 Annotating and Managing Learning Resource Metadata

In order to facilitate the reuse of learning resources at different aggregation levels, all learning resources in Info1 are annotated with SCORM 1.1 metadata on the basis of four aggregation levels (Raw Materials, SCO, Block, and Course). During the metadata annotation process, we've paid special attention to the metadata's compatibility with other popular specifications while still remaining 100% compatibility with the SCORM. The SCORM 1.1 Metadata Information Model is broken up into nine categories: General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation, and Classification. Besides complying with all guidelines provided by the SCORM "best practice" for each category, we applied the ACM Computing Classification System [11] in the "Classification" category, which fits very well to describe learning resources contained in Info1 at the "ontology" or "terminology" level. Also in the "Relation" category, the relationships between four aggregation levels are described using "HasPart", "IsPartOf", etc., which nicely reflects the course structure at "metadata" level. In figure 7 we illustrate the SCORM 1.1 conformant metadata of a typical Block in Info1.

In order to effectively manage the metadata of learning resources, we choose a native XML database: dbXML [12] to store SCORM metadata Application Profiles. Figure 8 shows the architecture of dbXML-based, SCORM 1.1 conformant metadata repository.

Fig. 7. SCORM 1.1 conformant metadata of a block

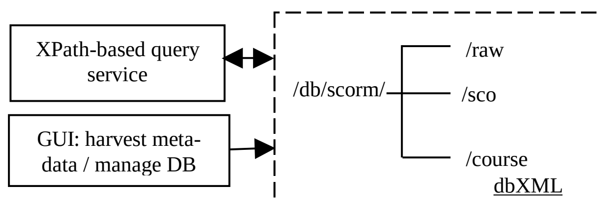

Fig. 8. Architecture of dbXML-based, SCORM 1.1 conformant metadata repository

As a so-called native XML database, dbXML provides a natural way to store, retrieve, update, search, and discover SCORM metadata. In dbXML, all metadata Application Profiles are stored in their original XML format according to three aggregation levels defined in the SCORM 1.1 Content Model. The search and update of metadata can be easily accomplished taking advantage of W3C XPath language [13] and XUpdate language from XML:DB Initiative.

4.4 Constructing SCORM 1.1 RTE

The SCORM 1.1 RTE serves actually as our new courseware publishing engine in the second system implementation. It takes SCORM 1.1 CSF as the input and then dynamically generate courseware presentation on the Web. In figure 9 we illustrate the infrastructure of SCORM 1.1 RTE.

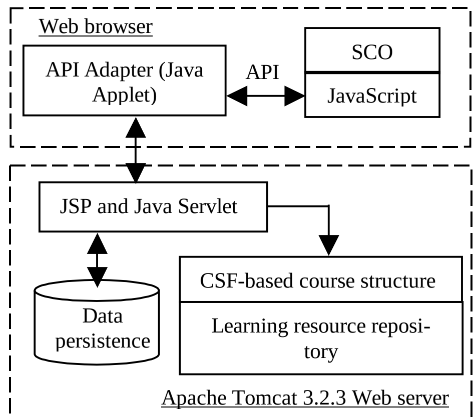

Fig. 9. Infrastructure of SCORM 1. 1 RTE

The SCORM 1.1 RTE is constructed on a JSP&Servlet-enabled Web server: Apache Tomcat 3.2.3. On the server side, a JSP component is used to dynamically render SCORM CSF-based course structure into the navigation menu which is depicted in the left frame of figure 5. This menu appears as a series of hyperlinks whose targets contain the corresponding launch locations of SCOs. Additionally, there are also several Java Servlet components that are responsible for controlling actual sequencing of SCOs, handling communication between RTE and SCOs (e.g., getting and setting Data Model), and managing persistence of Data Model [10]. Our current SCORM 1.1 RTE implementation directly employs the CMI Data Model Java binding API provided by AICC. On the server side, the persistence management of Data Model uses Java serialized objects.

On the client side, a non-face Java Applet is implemented as the SCORM RTE API Adapter and embedded in the left frame of figure 5. This API Adapter Applet provides the communication to the RTE server-side Servlet components for Data Model persistence management. Note that on the client side, the SCOs cannot make direct communication with the RTE server to call API functions. All calls from SCOs must take the API Adapter as a broker and use client-side JavaScript. Moreover, all learning context existing within a SCO must also be managed by SCO itself using embedded client-side JavaScript.

5 The Third System Implementation: SCORM 1.2 Conformant Design

At the beginning of October 2001, we began to develop the third system implementation inspired by our desire of pursuing more openness and interoperability of the collaborative courseware generating system. The third system implementation is based on SCORM 1.2, which was released by ADL in October 2001. In comparison to SCORM 1.1, SCORM 1.2 has several important improvements. Regarding metadata specification, the SCORM 1.2 sits on a higher level than SCORM 1.1, offering downwards compatibility with IMS Metadata Specification 1.2.1 (instead of IMS 1.1 in SCORM 1.1) and IEEE LOM 6.1 (instead of LOM 3.5 in SCORM 1.1). With regard to the Content Structure representation, SCORM 1.2 deprecates SCORM 1.1 CSF and provides a CP specification which is derived from the IMS CP specification 1.1.2 [7]. As a matter of fact, the use of SCORM 1.2 CP enables a new functionality of our courseware generating system. That is, on the basis of SCORM 1.2 CP, the learning resources in Info1 can be physically packaged and unpackaged. This will greatly facilitate the exchange of learning resources between different LMSs.

In general, in order to shift the second system implementation to the third one, we have to fulfill four tasks: (1) transferring learning resources from SCORM 1.1 Content Model to SCORM 1.2 Content Model; (2) representing course structure using SCORM 1.2 CP; (3) annotating and managing learning resource metadata; and (4) constructing SCORM 1.2 RTE.

5.1 Transferring Learning Resources from SCORM 1.1 Content Model to SCORM 1.2

Although there are some nomenclature changes from SCORM 1.1 Content Model to SCORM 1.2 Content Model, the structure of the Content Model remains untouched. We can simply transfer the learning resources from SCORM 1.1 Content Model to SCORM 1.2 using the rules defined in table 1.

Table 1. Content Model transfer from SCORM 1.1 to SCORM 1.2

SCORM 1.1 Content Model		SCORM 1.2 Content Model
Raw Materials	⇨	Assets
SCO	⇨	SCO
Block	⇨	Content Aggregation
Course	⇨	Content Aggregation

5.2 Representing Course Structure Using SCORM 1.2 CP

The SCORM 1.2 CP extends the latest IMS CP specification with several additional SCORM-specific elements particularly in the "organization" section where SCORM 1.2 Content Structure is located. By means of such sort of extension, the SCORM 1.2 CP can effectively define the structure and the intended behavior of a collection of learning resources along with the 100% downwards compatibility with the IMS CP. In comparison to our second system implementation in which the course structure is represented using SCROM 1.1 CSF, representing course structure using SCORM 1.2 CP in the third system implementation can achieve more interoperability thanks to the higher popularity of IMS CP. More importantly, because the course structure is now self-contained described in a SCORM 1.2 CP Application Profile, including all descriptions of dependency and relationships existing between learning resources, not only those “internal” resources existing physically in a package and described by URI, but also those “external” resources existing on the Web and described by URL, all learning resources in Info1 can be now exchanged between different LMSs based on SCORM 1.2 CP, either partially or as a whole. Such sort of exchange, namely, importing, exporting, aggregating, or disaggregating packages of learning resources, makes it feasible to reuse the learning content at various aggregation levels.

As an example, we illustrate the SCORM 1.2 CP Application Profile of Info1 in figure 10. Based on this CP Application Profile, Info1 can be not only physically packaged and unpackaged, but can also be dynamically presented on the Web by any SCORM 1.2 CP (also IMS CP) conformant courseware publishing engine.

5.3 Annotating and Managing Learning Resource Metadata

Because IEEE LOM, the cornerstone of SCORM 1.2 metadata specification, has experienced considerable change from version 3.5 to version 6.1, all SCORM 1.1 conformant metadata we’ve generated in the second system implementation have to be modified according to the SCORM 1.2 metadata specification in the third system implementation. Fortunately, since the SCORM Content Model remains almost unchanged from SCORM 1.1 to SCORM 1.2, we only need to concentrate on the syntax change while transferring SCORM 1.1 metadata Application Profiles from the second system implementation to the third one. However, due to the nomenclature change, and especially the change of metadata schema from SCORM 1.1 to SCORM 1.2, the architecture of dbXML-based metadata repository has to be modified according to the SCORM 1.2 Content Model (Assets, SCO, Content Aggregation).

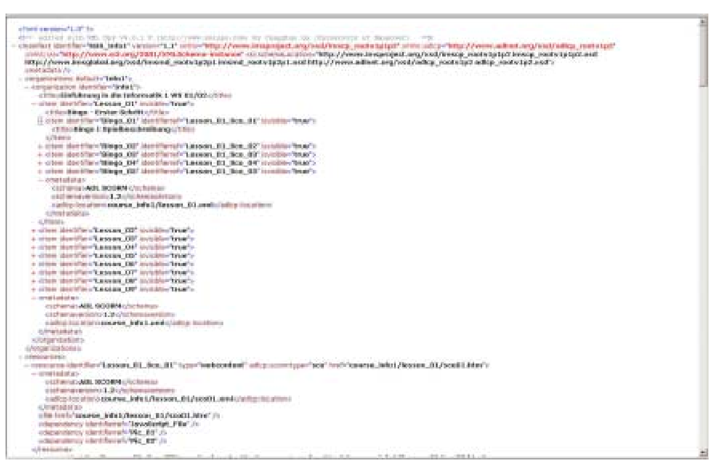

Fig. 10. SCORM 1.2 CP Application Profile of Info1

5.4 Constructing SCORM 1.2 RTE

Since the RTE definition remains unchanged from SCORM 1.1 to SCORM 1.2, all implemented functionalities in SCORM 1.1 RTE can be directly transferred to SCORM 1.2 RTE implementation. However, because the course structure is now represented using SCORM 1.2 CP, we need to modify the “parser” JSP in order to handle SCORM CP Application Profile. Also the new functionality of SCORM 1.2, namely, physically packaging and unpackaging learning resources based on the SCORM 1.2 CP Application Profile, needs to be developed.

6 Conclusions

In table 2 we list a brief comparison between our three system implementations.

Table 2. A comparison between three system implementations

	1st Version	2nd Version	3rd Version
WebDAV-based collaborative courseware authoring	Yes	Yes	Yes
Course structure representation & courseware publishing engine	Non-interoperable	Interoperable with SCORM 1.1 CSF and AICC CMI CSF	Interoperable with SCORM 1.2 CP and IMS CP 1.1.2
Metadata annotation and management	N/A	Conformant with SCORM 1.1, IMS 1.1, and LOM 3.5	Conformant with SCORM 1.2, IMS 1.2.1, and LOM 6.1
Exchange learning resources	N/A	Yes, based on SCORM 1.1 Content Model	Yes, based on SCORM 1.2 Content Model
Physically package & unpackage learning resources	N/A	N/A	Yes, based on SCORM 1.2 CP or IMS 1.1.2 CP
Courseware interactivity	N/A	Yes, based on SCORM 1.1 RTE Data Model (AICC CMI Data Model)	Yes, based on SCORM 1.2 RTE Data Model (AICC CMI Data Model)

The evolution of our XML/JSP/WebDAV based collaborative courseware generating system is actually motivated by our efforts to improve the reusability and interoperability of learning resources. From the proprietary design in the first system implementation to the SCORM based development in the second and the third system implementation, our system always evolves towards open standards and has become increasingly open and interoperable. Currently the exchange of learning resources based on our second and third system implementation is already underway between several German universities and institutions. Also the SCORM 1.1 and SCORM 1.2 conformant metadata repositories are now being integrated into a Peer-to-Peer distributed searching network: Edutella (http://edutella.jxta.org) with the purpose of further improving the reusability and interoperability of learning resources.

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An Educational Community Using Collaborative Virtual Environments

Christos Bouras[1,2], Dimitrios Psaltoulis[1], Christos Psaroudis[1],
and Thrasyvoulos Tsiatsos[1,2]

[1] Computer Engineering and Informatics Dept., Univ. of Patras, Greece
{bouras,psaltoul,psaroudi,tsiatsos}@ceid.upatras.gr
[2] Computer Technology Institute, Greece
{bouras,tsiatsos} @cti.gr

Abstract. The use of Collaborative Virtual Environments in e-learning is one of the most promising uses of the virtual reality technology. While a lot of research has been done in the area of collaborative virtual environments corresponding to the sharing of events, very little research has been done on specific services and functionality. However both the requirements and the kind of the offered services affect significantly the design of a system. In this paper we present an Educational Community to support e-learning services using Collaborative Virtual Environments from both the technical and functional point of view.

1 Introduction

On the past few years a number of interactive virtual reality (VR) systems have been developed. An Educational Virtual Environment (EVE) [1] is a special case of a VR system where the emphasis is more on the "education and collaboration" rather than on simulation. EVEs actually are Collaborative Virtual Environments (CVEs) [2] that can be used for educational applications such as collaborative e-learning. Collaborative e-learning is any kind of learning process performed by more than one person that takes place mainly in a virtual environment. According to this definition we should implement collaborative learning if and when there is a need for several people in a certain organization/ institute/university to learn together [3]. Moreover we should implement collaborative e-learning systems in order to satisfy the need of several people, in several places, in a certain organization/institute/university to learn together. The realistic visualization of the classrooms can only be accomplished by a 3D model of a virtual learning environment [4]. Furthermore to encourage more learners' participation, their better representation, more learner-to-learner interaction throughout community features, more contribution by the learners, less hierarchy and more empowerment, it is efficient to use collaborative virtual environments. Most of the commercial web-based training solutions lack sufficient realization of real-time communication features, meaning a shared sense of space and presence. In general, third party applications refer to features such as application sharing and video conferencing. Thus, there is a definite need for integrated solutions that can offer a

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much higher degree of usability and that do not demand additional technical requirements as in the case of most commercial systems. Therefore, we have to achieve the right balance among user requirements, learning methods and applied technologies and standards [5], with a view to implementing a system that is user centered and effective. Neither investigating new learning methods, nor inventing new technologies can accomplish the above requirement. We believe that a flexible and open system will satisfy the need of different user groups exploiting a bundle of technologies in a uniform and effective way. The application of virtual reality and the use of multi-user real-time communication platforms satisfy the need of efficient delivery of synchronous learning services. Collaborative virtual environments have drawn attention because they can provide learners and tutors with advanced interfacing capabilities and real-time communication support [6]. Motivated by these advantages, we have designed and implemented a prototype for collaborative e-learning using collaborative virtual environments. In this paper we focus on the implementation and design issues of the platform that support this prototype, as well as on the effectiveness of the prototype with respect to the collaborative e-learning application. We initially describe a virtual community for e-learning, its basic functionality and usage scenarios, which is based on collaborative virtual environments. We then describe the architecture and the main components of the platform that we have designed and implemented in order to support this virtual community. Afterwards, we discuss the effectiveness of our prototype in both the functional and technical point of view. Finally we present some concluding remarks and our vision for the next steps.

2 A Virtual Community for e-Learning

In order to implement a functional and effective e-learning virtual community, our first step is to investigate its main functional features. These functional features should differentiate an e-learning environment from other virtual environments (3D or not), which are designed and implemented for general use. According to [3] every virtual environment that has the following features can be characterized as an e-learning community:

- The environment should be explicitly designed. It can be visited by users, who have different roles and rights. It should be represented by various representation forms, which can range form simple text to 3D worlds. It should support various e-learning scenarios and have common features with a physical space
- The educational interactions in the environment should change the simple virtual space to communication space
- The learners in the environment should not be passive, but they should be able to interact
- The system that supports the e-learning environment should be able to integrate various technologies

According to the previous stated features of an e-learning virtual community the main requirements that should be met are the following:

- The e-learning environments should be based on templates that ensure a well-established community, able to handle users, e-learning material, user interaction, and different learning scenarios.
- The environment should offer various synchronous and asynchronous communication channels: chat, audio, e-mail, forums, shared objects, application sharing, gestures
- The environment should be populated by users who are represented by 3D avatars
- The environment should be aesthetic and easy to use

Actually the virtual community for e-learning is an integrated environment, which is based on a set of different virtual worlds that aim to offer to the participating entities the ability to navigate and interact in 3D shared space.

2.1 Usage Scenarios - Functional Specifications

The proposed system aims at offering innovative opportunities for the educational use of shared spaces for collaborative e-learning. The initialization of certain events when a user enters specific areas, the integration of sounds, the interaction through certain objects, the animation of objects in the virtual worlds and the interaction of the worlds with other applications enhances the user's sense of realism. The EVE provides the users with a shared sense of space, as all participants can be presented with the illusion of being located in the same place, such as in the same room, building, or terrain. It also supports a shared sense of time, meaning that participants are able to see each other's behavior as it occurs.

Based on the above, it is obvious that the EVE comprises a media over which educational procedures and interpersonal communication could be performed in a manner closer to the end users' need and perception. By simulating well-known everyday life procedures and actions, the EVE aims at presenting sophisticated services to the inexperienced user. Moreover, the environments could serve as a meeting point among the members of a learning community (e.g. university teachers and students). They provide the means for exchanging ideas, accessing amounts of information and collaborate on learning activities. Our EVE is designed in order to support two user scenarios. The first one is the collaborative e-learning scenario, which is more collaborative, open, unstructured and symmetric. The second one is the on-line lecture scenario, which is less collaborative, mainly tutor centered, more structured, more hierarchical

The main entities in the above scenarios are the learners, the tutor, the moderator, the shared objects and the educational material. According to the scenario the students and tutors have different access rights and authorities. Both the educational material and the shared objects can be manipulated by the previous three active entities (learners, tutor, moderator). The moderator participates only on the collaborative e-learning scenario. In the on-line lecture scenario the participating entities are the learners, the tutor, the shared objects and the educational material. The tutors' entities have the greatest access and amount of authorities and the students' entities have full access but limited authorities. The tutor would interact with the whole system through the appropriate user interface, which consists of a typical web browser, a VRML browser and a set of Java applets. This interface could give the tutor the ability to upload learning material to the available WWW server and to initiate and control learning sessions within the appropriate virtual worlds. On the other hand, learners will participate in the learning sessions through a different user interface with fewer capabilities. Both user interfaces are easy to use and need no specific knowledge from the point of the user.

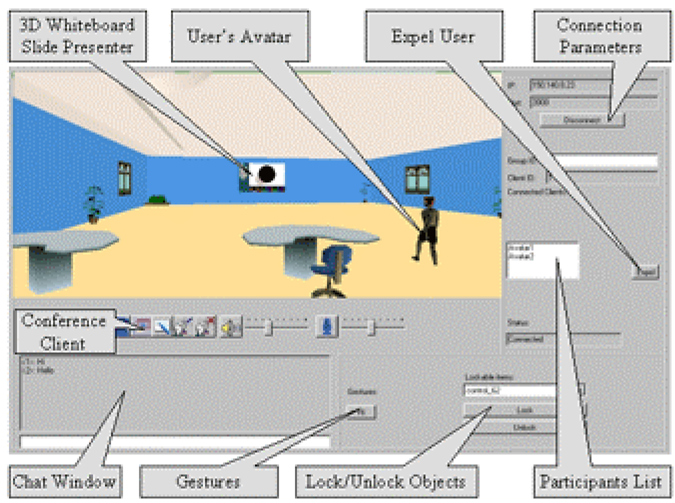

Fig. 1. User Interface

The functionality that the prototype offers to the learners/tutors is the following:

- 3D representation by articulated, human-like avatars
- Audio and chat communication as well as gestures to express feelings and actionsg
- Application/document sharing and collaboration on them
- 3D library with educational content and manipulation of 3D shared objects (if they are not locked by the tutor)
- Predefined animation, viewpoints
- 3D Slide presenter/whiteboard and 2D whiteboard

In addition, the tutors are able to

- Upload 3D/2D learning material in the 3D shared space
- Moderate the learning session by locking shared objects, and allowing/preventing the collaboration on the shared documents
- Expel an annoying student from the virtual world
- Lock/unlock shared objects to prevent/enable their manipulation by the learners

In the Fig. 1 the tutor's user interface is depicted.

In the collaborative e-learning scenario the participating entities are the learners, the moderator, the shared objects and the educational material. All the learners have the same access rights and authorities as in the on-line lecture scenario and in addition they can upload 3D/2D learning material in the 3D shared space, and locking shared objects. Aside from the learners capabilities the moderator can expel an annoying student form the virtual world.

3 Architecture and Components

In order to achieve the above goals our design is based on the following concepts: Scalability, consistency, extensibility and openness Also the proposed system should support several forms of data should be supported and embedded in the EVE. Furthermore, the users in an EVE should be able to communicate based on widely accepted conference standards (such as H.323 and T.120). An EVE should be a web-based application implemented with international accepted standards and technologies (HTTP, VRML[1], and JAVA). Finally the users should be represented by H-anim[2] compatible avatars, which support animation and gestures, for user representation.

The main step in the design phase was to specify the architecture of the system (Fig. 2), which should meet all the above-described functional and technical requirements in order to support the e-learning community in an effective way. The main concept of the proposed architecture was to divide the processing load of the necessary services of the e-learning community to a set of responsible servers. There are two types of divisions: (a) the division of the hosting of multi-user 3D worlds to set of communication servers (a set of these servers is called Message server), and (b) the division of the provision of specific functionality, into dedicated application servers.

The basic idea of our architecture is to divide the processing load of necessary services of an EVE (such as application sharing, chat and audio communication, educational content, etc.) to a set of servers [7] aside from communication of users or management of the virtual worlds as described in other models [8]. Furthermore, the structure of an educational community implies a the virtual environment can be separated into smaller parts, which are virtual rooms dedicated to a specific e-learning course. Therefore the lessons in the e-learning community are conducted in course 3D rooms. This provides a "segmentation" of the virtual community that enables us to design a communication model that consists of a number of message servers.

These types of servers are described in the following paragraphs.

3.1 Servers

As mentioned above the architecture is based on a set of servers, each designed to carry out a specific operation. These servers can be categorized in two main categories: Communication servers and application servers.

The communication servers (a set of these servers is called Message server) are responsible for the connection of the users and the consistency of the 3D shared space. Communication servers are:

- ConnectionServer, which handles the connection requests of the participants.
- InitServer, which holds the current state of the virtual community. When a new participant (client) arrives in the virtual world, it transmits the entire list of shared nodes that maintains, to the newly added client.

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- VrmlServer, which is responsible for sending update messages to the participants.

The application servers are responsible to offer specific functionality to the participants:

- ChatServer, which is responsible for the chat communication
- Conference Server, which is responsible for the application and data sharing, the whiteboard capability as well as the audio communication

Also the prototype uses an HTTP server, which contains all the necessary, HTML pages, VRML files, 3D object and other e-learning material.

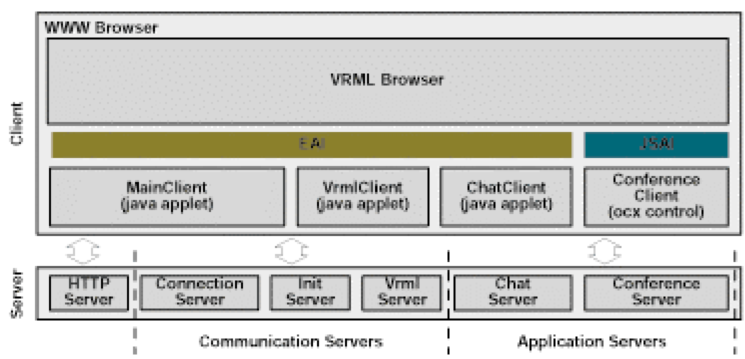

Fig. 2. Architecture and Components

3.2 Clients

The client, in order to communicate with the above-described set of servers, consists of six components: the web browser, the VRML browser, the MainClient, the VRMLClient, the ChatClient, and the ConferenceClient. The Vrml Browser is a plug-in, used to navigate user in the VRML world. Any VRML97, EAI[3] compliant browser could be used for this cause. Parallel Graphics' Cortona is a tested and recommended solution. The MainClient is a java applet that establishes and terminates the initial connection to Message Server. It presents the current connection status and a list of the participants populating the same 3D world. The VrmlClient is a java applet responsible for the interaction between the user and the 3D scene. It works in two phases. In the first phase, it receives all shared nodes from InitServer and initializes the VRML world. In the second phase, the VrmlClient sends and receives events to and from VrmlServer and updates the VRML scene according to the received events. In addition, this module gives the participants the capability to make predefined gestures and to lock/unlock shared objects. The ChatClient is a java applet that implements the exchange of chat messages among users in the same VRML world and it offers text conference functionality to the prototype. The ConferenceClient has a twofold role: it acts as an application sharing client and audio client. It allows

[3] Web 3D Consortium. External Authoring Interface (EAI), Final Draft International Standard, **http://www.web3d.org/technicalinfo/specifications/eai_fdis/index.html** .

participants to enter in an application sharing (T.120) and audio (H.323) conference that is established in the Conference Server. This module is an ActiveX control and is based on the Microsoft NetMeeting SDK[4]. It offers the participants the functionality of document/application sharing, 2D shared whiteboard, and collaboration on documents as well as audio communication.

3.3 Layer Model

According to [9] where a layer model for distributed virtual worlds is defined, the architecture of our prototype is based on layers shown in the following Fig. 3.

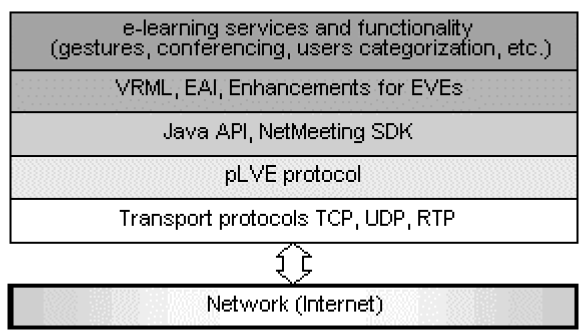

Fig. 3. Layer model

The underlying network is the Internet (without multicast capabilities) and UDP and TCP communication is used for the transmission of packets, according to the desired functionality. For example we use TCP communication for the initial connection to the ConnectionServer and UDP communication with the ChatServer. In addition we use the RTP protocol for the audio communication. On top of the network layer we have implemented a suitable application-specific protocol, which is called pLVE [10]. For sharing virtual worlds we use a java network interface and an enhanced VRML - EAI [7], suitable for maintaining a consistent 3D scene (distributing the necessary events) among all the participants over the network.

Finally, making the worlds shared we have implemented the rules for the interaction between users in order to provide the previous desired functionality such as gestures, users' roles and rights, lock/unlock objects etc.

4 Effectiveness of the Prototype with Respect to e-Learning

In the previous paragraphs we presented the features that an e-learning community must have, and we proposed an architecture that can support the needed learning scenarios. In the following paragraphs, we are going to perform a functional

[4] Microsoft Windows NetMeeting 3 Resource Kit, ©1996-2001 Microsoft Corporation.

evaluation of our Educational Community, which is based on the previously described architecture and we will discuss some technical issues with respect to the implementation of our prototype.

4.1 Functional Evaluation

The main aim during the design of our Educational Community was to achieve the required functionality in a simple and effective manner. We believe that we successfully tackled some important issues of an EVE, which we present in this paragraph.

Space Sharing, User Interaction and Avatar Representation. An EVE should be a place where different users can communicate with each other and with the environment as if they where in a real classroom. We accomplish the need to create the illusion that all users share the same space by transmitting all the events that occur, in the order they occur, to all of them. Furthermore, the existence of objects in the world that can be altered by the users, the shared objects, coupled with the feature of importing a new object into the world, give to our Educational Community a dynamic character, fulfilling the not-static nature of an EVE. Users can communicate with each other by sending either text messages or audio streams. Moreover, avatars' gestures provide a more realistic interaction among users, expressing when needed the emotion of each one to the others [11]. Regarding the avatars' representation in the educational community we focus on functions for representing oneself to others and for visualizing the others than for self re-presentation. Available functions in our prototype are:

- Perception: the ability of a participant to see if anyone is around
- Localization: the ability of a participant to see where the other person is
- Gestures: Representation and visualization of others' actions
- Identification: Each avatar has a unique number which is placed in his/her body in order for the other avatars to recognize him/her
- Social representation: Except the unique number in the avatar's body has placed a letter according to his/her status/task in the community. For this reason we use the letters T, L, and M for the tutors, learners, and moderators respectively.

User Categorization. In an EVE we need to have users with different roles and rights. For example a tutor must have more rights than a student and he must be able to perform a different role in the Educational Community. We accomplish this by providing each user with an access level that is set by the administrator during the creation of a new user's account. Furthermore, each shared object contains a variable that controls the access rights of that object. Thus, if a shared object has its access level equal to "STUDENT", then only users that have their access level equal or greater than "STUDENT" can access this object. That is not enough though. A user that is a tutor in a certain world might be a student in one or more other worlds. Since a different Message Server (that maintains its own list of users) serves each world, the achievement of this feature is not difficult by assigning a different access level to this user in each Message Server.

Learning Tools. Though both space sharing and user categorization is surely necessary in an EVE, they are not enough to characterize a Virtual Environment as a Learning Environment. As stated by its name, the most important feature an EVE should have is to contain tools suitable for teaching. In the prototype of our Educational Community we provide the following tools:

- A 3D Whiteboard: This whiteboard supports slide projection, line, circle and ellipsis drawing in a wide range of colors and text input in many sizes and colors. It also offers an UNDO last action and and CLEAR ALL previous action capabilities. The 3D Whiteboard is a part of the VRML scene and it can be seen through navigating in the world.
- A 2D Whiteboard: the 2D whiteboard is based on the Microsoft's NetMeeting whiteboard.
- A 3D Library: This library contains links to web pages that have educational material. A book on a shelf of the library represents each link. When a user clicks on a book, a web page is loaded in a separate window. The 3D Library supports dynamic addition and removal of books.

Locking/Unlocking Objects. There are cases where we need a certain object to be accessed only be one user at a time. For example when a user writes on the whiteboard nobody else must be able to write or delete something on it. We accomplish this by adding a variable named LOCK in each shared object. This variable controls the status of the object. The variable can take as values: -1 (the option of locking the shared node is disabled), 0 (the shared node is available for a user to lock it), >0 (The user with ID = LOCK has locked the shared node).

When a user, who locked one or more objects in a world, leaves the scene without releasing the lock, the objects are automatically unlocked. Moreover, a user with higher access level than the one that possesses the lock of an object can obtain the lock of that object from the other user.

Expelling Learner/Participant. Sometimes, a learner/participant can become annoying, preventing the smooth completion of a lecture. In these cases, the tutor (in the on-line lecture scenario) and the moderator of the class (in the collaborative e-learning scenario) has the ability to expel this user. The only action he/she has to take is to select the user from a list of all users participating in the class and to press the Expel button of the user interface. Clicking this button the user is disconnected of the system.

4.2 Technical Issues

In the process of developing our prototype, we encounter important problems such as the sharing of update messages, the initialization of the 3D worlds, the integration of the avatars, the audio communication and the scalability of the system. In this paragraph we will present some technical issues that came up during our effort to solve these problems.

Shared Events. As mentioned earlier, in order to achieve the illusion that all users share the same space, we have to transmit all the events that occur to all clients. At this point we had to deal with the following problem: What happens if an event-packet is lost during its transmission from the user’s client to the server and what happens if it is lost during its transmission from the server to a client. The first case is not dangerous, as the packet never reaches the server. Therefore, we have chosen to ignore this case and consider that the packet had never been sent. The user has the chance to re-send it if he wants to. The second case is the one that puzzled us the most. Since the event-packet reaches the server, it is transmitted back to all clients. Thus, if a client does not receive it, or receive it out of order, a problem of consistency among clients is immediately created, which puts in danger the stability of the system. We solved this problem in two parts. Firstly, every packet that reaches the server is numbered and then it is propagated to all clients. Every client that receives a new packet checks if its number is the expected one. If it is not, then the client requests the retransmission of the lost packet or packets. The second part of the solution covers the case where the server does not have any activity for a long time and as a result a client might have lost a packet and have not yet discovered it. In order to attain this matter, an empty numbered message, a NOP message, is sent every few seconds when there is no activity at the server.

Initialization of the Current State of the 3D World. Though transmitting Shared Events to all clients of the users populating a certain world is enough to maintain the consistency among them, the problem of initialization of a new client still remains. More specifically, the problem is the transformation of the 3D (VRML) scene of the newly added client in order to become identical with the scenes of all the others. One solution is to store all shared events in a file and then transmitting them to the new client would accomplish what we want. Unfortunately, this solution becomes less effective and inapplicable while the number of shared events increases as the time passes. In order to solve this problem we had to adapt a new concept; The SharedNode. A SharedNode is an abstract representation of a VRML node that contains only fields that we want to be able to be altered. These fields, which we call SharedEventIns or SharedEventOuts, are the representation of VRML EventIns or EventOuts respectively. Each SharedNode, SharedEventIn or SharedEventOut must have the same name as the VRML node, EventIn or EventOut that represents. This implies that only VRML nodes that were named using the DEF statement can become shared. Using SharedNodes, the procedure of initializing a new user becomes easy. We create a SharedNode for each VRML node we want to become shared. Then, we add the routes that have a SharedNode at least one of their ends and at the same time, we remove the corresponding route from the wrl file. In each instant, this set of SharedNodes, which we call SharedList, fully describes the present situation of the VRML scene because only fields of these nodes can be changed. Thus, the SharedList is the only information that a new user needs in order to update its VRML scene.

Avatars. The insertion of Avatars into the world created many problems for which the solution was not always so obvious. The fact that we wanted to have many duplicates of the same avatar, each having a different name in the same world, was the first problem we had to deal with. There was no way to assign a unique name to each Avatar, because the CreateVrmlFromUrl function did not support this feature. A different approach had to be followed. We created an empty node named with the DEF statement using the CreateVrmlFromString function. Then, we created the avatar using the CreateVrmlFromUrl function and we set it as a child to the named node. Thus, the requested feature was accomplished, as each avatar was wrapped in a node with a different name. A new problem appeared though. The access of a specific node of an avatar with the getNode() function was not possible because each duplication of an avatar had a node with the same name. This situation led us to create one more class; The SharedAvatar. A SharedAvatar inherits a SharedNode, thus, it has all the features of a SharedNode. Furthermore, it includes some special characteristics that help solve the previously described problem. Apart from the default SharedEventIns “Translation” and “Rotation” that determine the Avatars position in the world, it contains a pointer to a VRML node. This pointer is set during the initialization of a new SharedAvatar with the address of the Avatar’s node that has been created using the CreateVrmlFromUrl function. This pointer provides immediate access to the Avatar’s node, thus, we can use the “children” field of that node to access every node we need, avoiding the use of the getNode() function.

Audio Communication. The audio communication is based on client-server architecture. As described earlier the client is an ActiveX control, which is based on Microsoft NetMeeting. The server is a H.323 compatible conference server (actually we use MeetingPoint Conference Server). This server is a software Multipoint Control Unit (MCU) and allows three or more H.323 terminals to connect and participate in a multipoint conference. The MCU includes both multipoint controllers, which manage the H.323 terminal functions and capabilities in a multipoint conference, and multipoint processors, which process the audio, video, and data streams between H.323 terminals. For each room of the community we have established is a corresponding session in the conference server where the participants the specific room can automatically connect entering in the room.

Scalability. One of the main problems that we have encounter was the support large number of simultaneous users and/or provided services. This problem is very crucial for our prototype, which is designed for educational use, and it should be suitable for widespread use. For this reason the basic concept that affected the architecture of our prototype was the distribution of the workload. In order to divide the processing load of specific services we use different application servers such as the Conference Server, and Chat Server. In addition a separate Message Server (which consists of a ConnectionServer, an InitServer, and a VrmlServer) is used to serve each 3D world of the community. The separate sub-servers is used to carry out each of the specific operations of a Message Server. Following this approach, we achieve our initial goal of shattering into pieces the processing work and increasing the scalability of our system.

5 Conclusion - Future Work

In this paper we have presented a prototype, which targets the offering of e-learning services using collaborative virtual environments. This prototype is based on a research platform whose both design and implementation are based on the requirements of e-learning services. Implementing this prototype we have encounter not only technical problems, but also educational issues that help us use in a more efficient way the new ways of communication and interaction that distributed virtual reality technologies offer. These problems and their solutions have also been presented. Our next steps have to do not only with the integration of additional features and functionality to the system but also with improvement of scalability and networking characteristics. In more detail we would like to improve the scalability of the system supporting multicast communication between the MessageServers and offering multicast groups for each world of the community. Furthermore we would like to improve the stability of the system making each message server back-up server of the rest of message servers. From the functional point of view we would like to improve the avatars' representation including functions such as visualization of the interest focus, and communication with facial expressions as well as to develop a 3D brainstorming board in order to support collaborative learning techniques.

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KGCL: A Knowledge-Grid-Based Cooperative Learning Environment[1]

Hai Zhuge[1], Yanyan Li[1], Jia Bi[1], and To-yat Cheung[2]

[1]Knowledge Grid Research Group, Key Lab of Intelligent Information Processing
Institute of Computing Technology
Chinese Academy of Sciences, 100080 Beijing, China
{zhuge,liyy}@ict.ac.cn

[2]Department of Computer Science, City University of Hong Kong, Hong Kong, China

Abstract. Knowledge Grid is a platform that enables uniform and effective knowledge sharing and management across the Internet. Based on this platform, this paper proposes a cooperative learning environment KGCL. It supports the knowledge-level cooperation between human and computer, and enables the enrichment of not only the resources in the Knowledge Grid but also the knowledge of users by means of knowledge refinement, knowledge reuse and drawing together online participants. Currently, the prototype of the KGCL has been implemented and is available for use online. Experiments show that the environment can promote the effectiveness of teamwork.

1 Introduction

With the fast development of Web technologies, information retrieval becomes an important part of Web-based learning approaches. However, the huge amount of information on the Web hinders people from accurately finding useful information with the traditional search engines. Unlike the traditional search engines that only use keywords to match documents, a number of new question answering systems have been developed (e.g. [1,2]), which try to "understand" the users' questions in natural language, and return concise answers from a knowledge base. Nevertheless, the correctness of the generated answers depends on human assistance in most cases, and the knowledge base is relatively small and static. On the other hand, these systems only serve single user without cooperative function.

A Knowledge Grid is an Internet-based application platform for sharing and managing the distributed heterogeneous knowledge resources in a uniform way. It organizes knowledge resources in a Knowledge Space that specifies knowledge at *concep-*

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tual level, *axiom level*, *rule level*, and *method level*. An implementation model of the Knowledge Grid was early proposed in [7]. A Semantic Grid model including the Resource Space Model and the Knowledge Browser was introduced for the fist time in [12].

By making use of the merits of the Knowledge Grid, search engine and QA technology, this paper proposes a cooperative learning environment KGCL. It could evolve from the initial to the advanced state through incorporating the automatic knowledge collection function and the reuse of participants' experience. In this way, the resources in the Knowledge Grid and the knowledge of participants are both enriched.

2 Architecture

The architecture of the environment consists of three parts: the KCB (Knowledge Collection Board) interface, the knowledge collection mechanism, and the Web-based answer extraction mechanism as shown in Fig.1. The KCB interface serves as an open area for users to freely post their questions or answers. In the knowledge collection mechanism, the Raw Knowledge Base stores all the unprocessed questions and corresponding answers provided by users or the Web-based answer extraction mechanism. The Knowledge Engineer is responsible for assisting the K-Refinement module to refine knowledge.

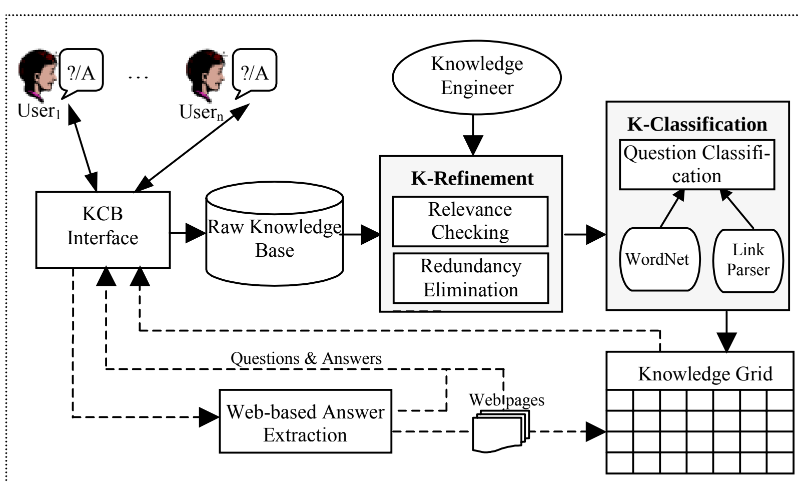

Fig. 1. Architecture of the KGCL

The K-Refinement composed of the Relevance Checking module and the Redundancy Elimination module fulfills the task of refining the knowledge in the Raw Knowledge Base. The K-Classification only contains the question classification module that classifies the questions under the assistance of the WordNet [5] and Link Parser [3]. The Web-based answer extraction model adopts the method proposed in [4]. It firstly parses the questions and then sends the transformed queries in parallel to several search engines, extracts relevant summaries from the retrieved web pages, ranks the candidate answers, and finally returns the questions and the most relevant answers to the KCB with links to related materials.

3 Knowledge-Grid-Based Collaborative Mechanism

Different from traditional blackboard mechanisms, the KCB allows users to exchange knowledge while collecting knowledge. It has three functions: *View*, *Sort* and *Search*; and three components: automatic e-mail component, chat component and Bulletin Board component. In addition, the KGCL can roughly determine the interests of users by counting the number of clicking and visiting time on some topics, and then automatically form the interest groups. Hence, each user can belong to one or more interest groups. If a user posts a question on the KCB, the KGCL will automatically inform other users belonging to the same interest group. If users of the same interest group know the answer to this question, they can post it on the KCB, then the KGCL will automatically process the answers and recommend answer.

Fig.2 shows the cooperative learning process of the proposed environment. A group has two members $user_1$ and $user_2$. They respectively fulfills sub-$task_1$ and sub-$task_2$ of a common task. The teamwork process involves three workflow processes: one for common task and two for individual users [8]. During working, each user can post their questions on the KCB as well as help another by posting answers on the KCB. For each question, the KGCL will search answer in the Knowledge Grid that provides knowledge supporting service. Meanwhile, the KGCL will assist the users by extracting answers from the Web.

Assume a group has more than two members, performing the tasks of the same type denoted as T_1, T_2, …, and T_n, K_0 is the initial sum of knowledge owned by the members of the group, and K is the knowledge they need to complete all the tasks. We use K_{i-1} to denote the knowledge owned by the group before performing the ith task, then $K - K_{i-1}$ is the unknown knowledge for the group to complete the ith task and the following ones.

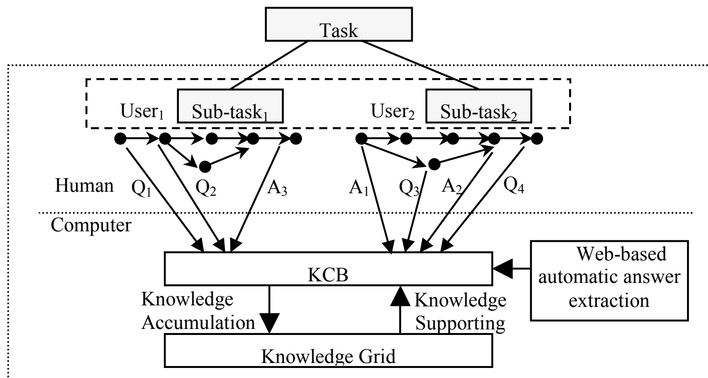

Fig. 2. The cooperative learning process

The questions asked for acquiring the needed knowledge are denoted as Q_{i-1}, i.e. $K - K_{i-1} \cong Q_{i-1}$. P_i is the set of problems encountered when dealing with the ith task, it corresponds to a set of questions denoted as $P_i \cong q_{u1} \cup q_{u2} \cup \ldots \cup q_{un}$, where q_{ui} is the questions proposed by the ith user. The learnable knowledge takes the form as the <problem, solution> pair where the problem and solution respectively is the set of questions and answers, e.g., $<P_i, S_i>$ denotes the knowledg learned by users after completing the ith task. The change process of knowledge increase and question decrease is described as follows:

T_1: $K_0 = K_0$ $\quad K\text{-}K_0 \cong Q_0,\quad P_1 \cong \{ q_{11}, q_{12}, \ldots , q_{1n} \}$;

T_2: $K_1 =< P_1, S_1> + K_0$, $\quad K\text{-}K_1 \cong Q_1,\quad P_2 \cong \{ q_{21}, q_{22}, \ldots , q_{2n} \}$;

……

T_n: $K_{n-1} =< P_{n-1}, S_{n-1}> + K_{n-2},\quad K\text{-} K_{n-1} \cong Q_{n-1},\quad P_n \cong \{ q_{n1}, q_{n2}, \ldots , q_{nn} \}$.

The process shows that the users' questions are gradually decreased by dealing with a series of tasks of the same type, i.e., the knowledge of each user is enriched after they cooperate to accomplish a task. Hence we have the following formulas hold:

- $Q_0 > Q_1 > \ldots > Q_n$;
- $K_0 < K_1 < \ldots < K_n = K$; and,
- If all the questions encoutered in performing each task are answered, we have $P_1 \cap P_2 \cap \ldots \cap P_n = \emptyset$ hold.

4 Knowledge Collection Mechanism

4.1 Knowledge Refinement

Knowledge refinement is implemented by relevance checking module and redundancy elimination module. The relevance checking module determines whether the questions belong to the appropriate categories. Our approach adopts the SVM [6] to classify the texts into appropriate classes. Simultaneously, the Knowledge Engineer checks the relevance of knowledge so as to guarantee the correct classification of questions.

There are two types of knowledge redundancy: explicit repetition, and implicit redundancy, i.e., knowledge can be derived from other existing knowledge. As some implicit redundant knowledge may enhance the efficiency of a system, we currently only deal with the explicit case.

By analyzing a large quantitive of questions, we design many question templates and group into clusters according to their meaning. We also design an ontology that consists of noun-abbreviation, composite word, and verb-synonym, etc. For example, *define*, *describe* and *introduce* concern the explanation or definition of concepts. Currently, the Redundancy Elimination module considers the following two factors in determining whether there have redundant questions or not. If redundant questions exist then mark the appearance times whilst deleting the duplicates.

– *Keyword focus*. The keyword focus is a phrase in the question that disambiguates it and emphasizes the type of answer being expected. As for various questions, we'll firstly extract the keyword focus and then identify its meaning by referring to the ontology. If the keyword foci are synonymous, then the Redundancy Elimination module will take into account the structure of a sentence.
– *Structure*. The Redundancy Elimination module will find the matching templates according to the questions. If their corresponding question templates belong to the same question cluster, then we can infer the questions are redundant. For example, the sentences "*What's knowledge grid*?", "*What's the definition of knowledge grid*?" and "*Introduce knowledge grid*" actually have the same meaning.

Different from one-sentence question, an answer may contain several sentences. As for the inconsistency and redundancy of multiple answers to the same question, the Knowledge Engineer will check the consistency and integrate the answers with the help of GUI. The Knowledge Engineer is also responsible for maintaining the question templates and ontology.

4.2 Knowledge Classification

The Knowledge Grid uniformly specifies the following four types of questions. The concept-level questions are the simplest ones, which mainly concerns the explanation or definition of a concept as well as some attributes of a concept. The axiom-level questions are relevant to some common sense and the relationship between concepts. The rules-level questions ask the reason for some axioms, and the method-level questions take into account finding a solution to a given problem.

With the help of the Link Parser and the WordNet, the knowledge classification module classifies the questions into the above four types based on their interrogative words and sentence structures. The Link Parser is used to analyze the sentence structure so as to output the sentence parse in form of relationships between words (called *links*) instead of a tree structure. We also consult WordNet to determine the type of the keyword and the relationship between keywords. The WordNet is a lexical database for English language, containing words grouped into sets called synsets. Synsets are linked to each other by different relations, such as synonyms, hypernyms and meronyms. Most natural questions contain a *wh-phrase* or *how-phrase*, which consists of the interrogative word and the subsequent words associated with it. According to the type of words following the interrogative word, the concept-level questions consist of three types including *wh-adverb*, *wh-noun*, *how-adjective* sentences. The *wh-adverb* phrases begin with single question words such as “what”, “who”, “when” and “where”, which inquire about the explanation of something, people, the time and place. The *wh-noun* phrases usually begin with “what” and a following noun, for example, “what year”, “what height” and etc. The *how-adjective* phrases, such as “how long” and “how many”, contain an adjective in addition to the question words. Both of the *wh-noun* and *how-adjective* phrases are related to the attributes of concepts. The axiom-level questions begin with “is”, “does”, “which”, etc., which expects the answers to explain the relations or to confirm or deny users’ existing hypotheses. The questions began with “why” interrogative or other formats such as “what’s the reason for…” obviously belong to the rule-level. The method-level questions mainly begin with “how to” and other semantics similar phrases such as “The approach of …”.

5 Implementation

A friendly interface of the KCB has been implemented and incorporated into the operation interface of the Knowledge Grid (available at http://kg.ict.ac.cn) to perform knowledge collection, sharing and learning based on human-computer cooperation. As Fig.3 illustrates, the scalable knowledge category hierarchy is arranged on the left portion of the interface, the function items are arranged on the up portion of the interface, and the questions and corresponding answers are intuitively arranged on the central portion of the interface.

After entering author name or keywords, users can click the button “start” to search relevant items. Users can select the display manner by clicking the button “GView” or “QAview”. Users can click the “Title” to sort the items in the time order, or click the “Hit” to sort the items in the order of clicking rate. If a user has some questions, he can click the corresponding category and then click the “New” button to post new questions on the KCB. If a user knows the answer to a question, he can click this question and then post his answer on the KCB. In addition, the build-in e-mail, chat and bulletin board components enable users to share their knowledge flexibly. The collected knowledge are refined and put into the Knowledge Grid. These functions support users to cooperatively fulfill tasks through effectively sharing knowledge.

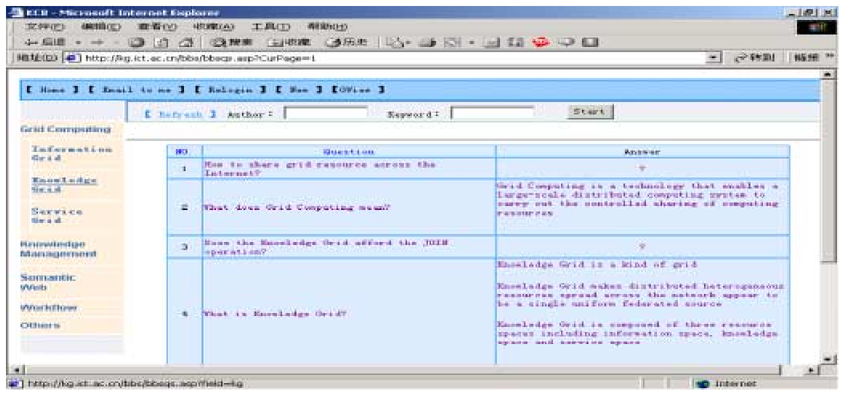

Fig. 3. The KCB interface of the Q-A display

6 Evaluation and Comparisons

We have used the KGCL to realize knowledge sharing and learning in research groups and software development groups. The applications show that group members have different abilities to contribute knowledge and the experienced members obviously contribute much more than the novices. The applications also show the group members are interested in knowledge of different levels. The questions about the method-level knowledge are asked at high frequency by all members, and the newly joined group members show more interests in learning concepts and axioms. The main impetus comes from the sharing of the problem-solving methods. In most cases, a group member's problems can be immediately solved by reusing the existing knowledge or solved by cooperating with the other group members.

Table 1. Experiment result

User type / Sub-Tasks	Novice (D_1)	Sophomore (D_2)	Experienced (D_3)
Sub-T_1	M_{11}: crawling	M_{12}: hyperlink analysis	M_{13}: text parse
	Q_{11}: $\{q_{111},q_{112},q_{113},q_{114}\}$	Q_{12}: $\{q_{121},q_{122}\}$	Q_{13}: $\{q_{131},q_{132}\}$
	A_{11}:$\{<a_{111},D_2>,<a_{112},C>, <a_{113}, D_3>, <a_{114}, C>\}$	A_{12}: $\{<a_{121},D_3>,<a_{122},C>\}$	A_{13}: $\{<a_{131}, D_2>, <a_{132}, D_1 >\}$
Sub-T_2	M_{21}: word cut	M_{22}: feature extraction	M_{23}: classification
	Q_{21}: $\{q_{211},q_{212}\}$	Q_{22}: $\{q_{221},q_{222}\}$	Q_{23}: $\{q_{231}\}$
	A_{21}:$\{<a_{211},D_3>,<a_{212},D_2>, <a_{212}, C>\}$	A_{22}: $\{<a_{221},D_1>,<a_{222},D_3>\}$	A_{23}: $\{<a_{231}, D_2>\}$
Sub-T_3	M_{31}:question processing	M_{32}: information searching	M_{33}:information filtering
	Q_{31}: $\{q_{311},q_{312}\}$	Q_{32}: $\{q_{321}\}$	Q_{33}: $\{q_{331}\}$
	A_{31}:$\{<a_{311},D_2>,<a_{311},D_3>, <a_{312}, D_3>\}$	A_{32}: $\{<a_{321},D_3>\}$	A_{33}: $\{<a_{331},D_2>\}$

We have conducted two experiments to test the effectiveness of the KGCL in assisting two small groups (members are all research students) to share and learn knowledge. Each group includes a novice, a sophomore and an experienced developer. In the first experiment, group members cooperatively developed a Chinese web pages search engine system with Java under the assistance of KGCL. Each developer is assigned a sub-task. Table1 tabulates the questions and answers posted by the developers during their cooperation process. The task comprises three sub-tasks: the *clawer design*, *text classification* and *information retrieval*, denoted as Sub-T_1, Sub-T_2 and Sub-T_3 respectively. M_{ij} denotes module included in the *i*th sub-task developed by the *j*th developer. Q_{ij} is a set of questions presented by the *j*th developer during performing M_{ij}, and A_{ij} is composed of pairs <answer, provider> that indicate developer or computer provides the answer to a certain question. The detailed questions and corresponding answers are showed in table 2.

Table 2. Question answer examples

Modules	*Questions*	*Answers*
M_{11}	q_{111}: Where can I find Java programming instance?	<a_{111}, D_2>: see http://java.sun.com/
	q_{112}: How to update a record in the database?	<a_{112}, C>: UPDATE mytable SET fields='***' WHERE …
	q_{113}: What's multithreading technology?	<a_{113}, D_3>: The concurrent operation of more than one path of execution within a computer.
	q_{114}: How to access Oracle database with Java?	<a_{114}, C>: ODBC or JDBC
M_{12}	q_{121}: How to analyze hyperlink?	<a_{121}, D_3>: Refer to paper "PicASHOW: Pictorial Authority Search by Hyperlinks on the Web"
	q_{122}: How to divide a string with Java?	<a_{122}, C>: Use the class StreamTokenizer
M_{13}	q_{131}: How to delete the tag of html files?	<a_{131}, D_2>: html tag match
	q_{132}: How to extract the text from html files?	<a_{132}, D_1>: Use templates
M_{21}	q_{211}: How to cut words?	<a_{211}, D_3>: Keywords matching based on the thesaurus
	q_{212}: Is there any existing NLP tool?	<a_{212}, D_2>: Link Parser <a_{212}, C>: MEI-parser
M_{22}	q_{221}: How to represent the features of text?	<a_{221}, D_1>: A vector of keywords and its weight
	q_{222}: How to create a class model?	<a_{222}, D_3>: Synthesize all the feature vector of the class
M_{23}	q_{231}: How to classify the text?	<a_{231}, D_2>: Calculate the similarity between the model and the text
M_{31}	q_{311}: How to process a question in natural language?	<a_{311}, D_2>: Template design and matching <a_{311}, D_3>: Use the existing NLP tool to parse the question
	q_{312}: What's the next step after parsing the question?	<a_{312}, D_3>: determining the question types
M_{32}	q_{321}: What's key technology of searching?	<a_{321}, D_3>: Keywords matching based on the classification
M_{33}	q_{331}: How to extract the answers from the retrieved web pages?	<a_{331}, D_2>: Use the technology of word cut and feature extraction whilst referring to paper "Scaling Question Answering to the Web"

As table 1 shows, each user learned knowledge at each stage of developing the system. For example, novice learned the basic operations on the "class" in Java after completing the first module. Knowledge learned in the earlier developing stage has been reused in the later developing stages. For example, the key technology of cutting word learned in developing M_{21} can be reused in developing $M_{31}$and M_{33}. As the questions and answers are finally added to the Knowledge Grid, the knowledge resources in the Knowledge Grid are also enriched.

We carried out the second experiment in case of without using the KGCL by assigning another group the same task. In this case, the novice respectively encountered four, two and three problems (questions) during performing the modules M_{11}, M_{21} and M_{31}. The sophomore respectively encountered two, three and two problems during performing the modules M_{12}, M_{22} and M_{32}. The experienced developer respectively encountered two, one and one problems during performing the modules M_{13}, M_{23} and M_{33}. Among these problems, there are two problems that repeated twice. The developers had to spend time in solving those repeatedly appeared common problems. Hence, the development duration was prolonged. On the other hand, any newcomer of the group is hindered from learning knowledge from other group members. Therefore, the cooperative learning without using the KGCL is not as effective as the case of using the KGCL.

Fig.4, Fig.5, Fig.6, and Fig.7 intuitively show the experiments results according to the small-scale experiment data. Fig.4 shows that the number of questions posted by the developers is decreased more quickly with using the KGCL than the case of without using the KGCL during the same period. Fig.5 shows that the development duration is shortened more quickly with using the KGCL than the case of without using the KGCL when performing the same set of tasks. Although the shape of the curves may vary with performing different types of tasks, we find that the difference of development duration is increased as shown in Fig.6, and it is irrelevant to the types of tasks. Fig.7 shows the knowledge in Knowledge Grid is increased with the increment of the times of cooperative work. The knowledge increment is measured by counting <question, answer> pairs.

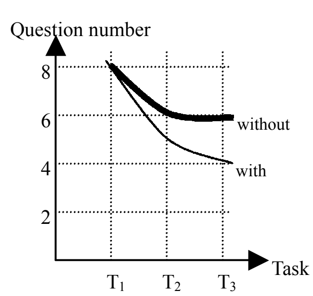

Fig. 4. Question number change

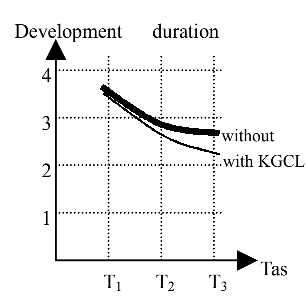

Fig. 5. Development duration change

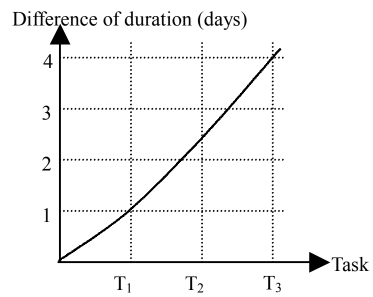

Fig. 6. Development duration difference

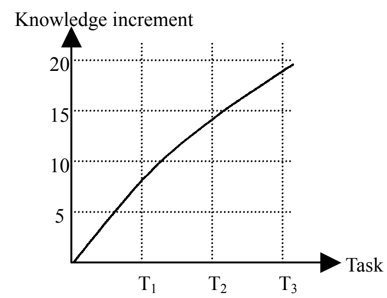

Fig. 7. Knowledge increment

7 Conclusion

The proposed learning environment effectively supports collaborative learning by incorporating the KCB-based knowledge sharing, the Knowledge-Grid-based knowledge reuse and the Web-based answer extraction mechanism. The environment realizes a knowledge processing loop during teamwork processes. The loop consists of knowledge generation, knowledge collection, knowledge storage, knowledge sharing and knowledge reuse. The knowledge sharing and reuse in turn inspire knowledge generation.

Based on the proposed architecture of the environment, we have implemented the prototype of the KGCL and embedded in the Knowledge Grid VEGA-KG. Applications in small-scale research groups and software development groups show that the learning environment can promote the effectiveness of teamwork to some extent.

The proposed environment is still in its early stage and needs to be improved in the following aspects. (1) Incorporate reasoning into knowledge refinement mechanism. (2) Apply the environment in large-scale groups. (3) Incorporate process models like the workflow model [8] and the Knowledge Flow model [9-11] into the environment.

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A Component-Based Architecture for Adaptive, Collaborative Web-Based Learning

Yugyung Lee[1] and James Geller[2]

[1] School of Interdisciplinary Computing and Engineering
University of Missouri-Kansas City
leeyu@umkc.edu

[2] Computer Science Department New Jersey Institute of Technology
geller@oak.njit.edu

Abstract. The limitations of current Internet-based learning systems (e.g., their inability to deal with diverse learners and requirements and the high cost of developing a new learning system) have lead to educational middleware that can handle diverse requirements and various learning components distributed over the Internet. Following the paradigm of component-oriented development we have designed a learning middleware suite, called the Collaborative and Sharable Learning (CoSL) system. CoSL is both a platform for building e-learning systems and a tool set for making it easier to develop course materials for e-learning. The CoSL system is context-independent so that its adaptation to a specific topic can be achieved with limited effort and time. To meet the challenging requirements of learning systems, the CoSL system has adopted three advanced techniques: (1) XML-based data exchange and integration, (2) agent-based communication and (3) data mining-based intelligent decision making. CoSL allows us to build and manage global learning systems in a distributed and heterogeneous environment.

1 Introduction

The Internet has influenced every aspect of our daily lives, including education. In particular, online courses over the Internet allow learning irrespective of student location. Furthermore, the Internet can be used to improve the quality of traditional instruction by providing advanced digital means of conveying class materials. For instance, web-based lectures allow instructors and students to share information and ideas with the entire class, supplemented by multimedia resources and electronic mailing lists. New technologies such as digital video links, will allow further refinements of distance education [13].

Many efforts have been made to build learning architectures based on the Learnerware paradigm. In this paradigm, Learning Management Systems (LMS) act as the core of online learning. Learning through the Internet requires distribution of large-scale systems over networks across the world. There are some limitations in current Internet-based learning. A centralized online learning system is not appropriate for dealing with diverse learners across the world. This leads to the emergence of distributed learning environments where various learning

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components communicate with each other. Another problem is that the development of an LMS is expensive and complex. We envision a sharable learning environment, where each academic department operates an LMS tailored to its needs that also communicates with other LMSs.

The major challenge for such an LMS is to provide integrated and cooperative means of access, because such a global learning system is based on heterogeneous, distributed and autonomous data sources. Our solution to this problem is to provide educational middleware that can handle various learning objects and teaching operations over different systems. Such a middleware system allows the sharing and redistribution of learning objects, (i.e. a sequence of course contents packaged as a module), the personalization of delivery across a network and the collaboration with other institutions. The Sharable Courseware Object Reference Model [26] provides a common reference model for courseware sharing between multiple LMSs. Such an LMS allows to plug-in executable contents ("Assignment Units") on the learner's interface and exchange data with that content, further enabling the dynamic presentation of course contents and the collection of student behavior data.

A typical LMS performs the tasks of managing online learning, keeping track of student progress, and recording course completion [31]. Adaptive Hypermedia systems build a model of the goals, preferences, knowledge and traversal behavior of the users [5]. Adaptive learning environments usually support adaptive navigation. This includes adaptive annotation and adaptive hiding, as well as adaptive presentation of course contents, and generating study problems of the appropriate difficulty [1]. The key element of an adaptive system for instruction is a student model that contains information on the changing student behavior (interactive history), student progress and the student's feedback, goals, and preferences. An adaptive educational system should incorporate pedagogical strategies, and apply them based on a student's psychological profile, [28]. A system that adapts its use of strategies can truly be a useful learning material provider to the student and a technological aid to human instructors.

In our model, an optimal learning environment is defined as one that supports high learning performance with maximum satisfaction and utilization (with minimum effort and time). Adaptive learning is a way of discovering similarities between learners based on their personal profiles. We have developed a learning model incorporating the learner and instructor as well as the sharability and reusability of patterns of knowledge between learning components. Through data mining and collaboration within a distributed learning community, the reusability and sharability of these knowledge resources can be achieved. In this paper, we describe an architecture called the CoSL (Collaborative and Sharable Learning) system, which provides a way to build and manage global learning systems in a distributed and heterogeneous environment. XML is used to integrate heterogeneous data. A meta-learning model is used to determine an optimal learning environment for a learner. Distributed multiple agent technology [14] has been employed to support the communication within and between distributed learning systems.

The rest of this paper is organized as follows. In Section 2, we introduce our CoSL system. In Section 3 we describe a prototype implementation. In Section

4, the interface and interactions of our CoSL system are described. In Section 5, we review related work, and in Section 6, we conclude with a summary.

2 Our Approach: Collaborative and Shareable Learning Systems

Our solution to the problems in distributed learning is to provide an educational middleware system. The CoSL system acts as the core of an infrastructure composed of local Learning Component Systems (LCS). All components and all object types are constructed as modules with interfaces, which are specified in XML. Agents support the communication between the components of this architecture.

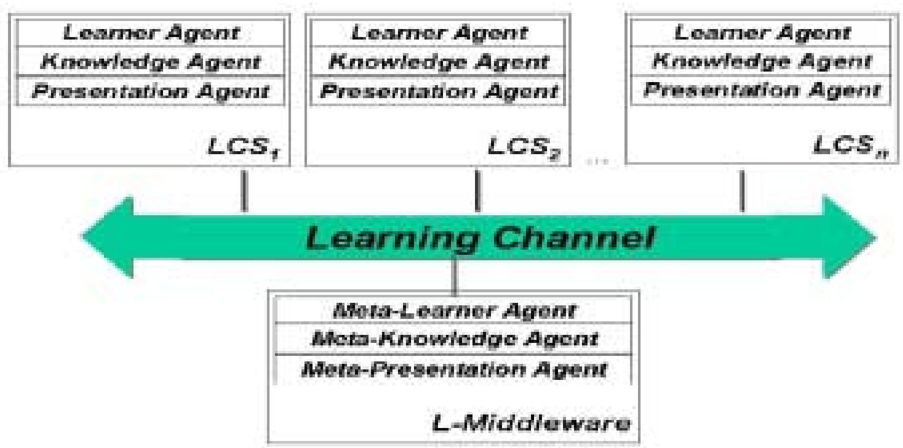

Fig. 1. Collaborative and Shareable Learning System

For our purposes, middleware is a layer of software, which exists between the Internet and multiple software applications, to provide the connectivity between applications running on different systems [8]. Today's large-scale distributed systems use various types of middleware. The most popular examples include the Common Object Request Broker Architecture (CORBA), Microsoft's Component Object (COM) and JAVA Remote Method Invocation (RMI). Services provided by middleware include identification, concurrency, fault tolerance, and security. Our educational middleware (Figure 1) supports unified interactions and communication through the Learning Channel, which connects components through well-defined interfaces. Each component is plugged into the framework for distributed learning.

2.1 Components of the CoSL System

Our CoSL system has been designed following the paradigm of component-oriented development [27]. The learning component has contents, activities,

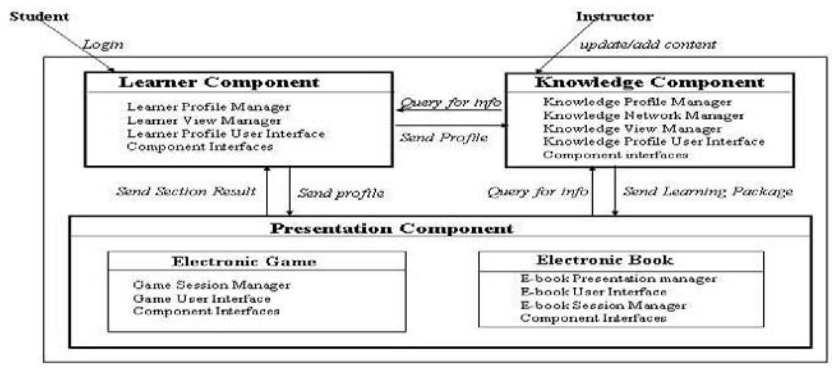

Fig. 2. Learning Component System (LCS)

rules, constraints and operations to deal with extension or modification of generic learning patterns (using composition and substitution). A component can be constructed by composing multiple smaller components according to their similarities in terms of their abstractions, properties, and constraints. For instance, a topic package contains sub-topic packages. Through substitution, parameters associated with the original component can be adapted to a new application.

Figure 2 shows an example of our Learning Component System. The component-based development allows a complex system to be considered as an arbitrary number of smaller components. These components are autonomous with no need for a master component. A system composed of components with well-defined interfaces can be extended with new components. For instance, a new multi-media component can be easily incorporated in a component-based learning system.

The objects within a component can be defined using a type model [27], which describes the state of the objects or the component(s). Each learning object is described with a type, attributes and associations, which represent relationships to other objects. The main purpose of a type model is to provide a vocabulary in which to describe actions, which include interactions e.g. between objects or components inside the software.

Learning components are considered to be self-contained and loosely coupled. Components have limits imposed on them by the framework in which they are deployed. External communication with other components can only be done through framework services. Learning systems should be context-independent just like the ubiquitous screw. Context independence means that a component is easily transferable from its development context to a variety of application contexts. A component should be easily replaceable by other components with similar functionality but better or different characteristics. This framework is the glue that binds the different learning components together.

2.2 Learning Channel

All the communication between components is done through the Learning Channel. The Learning Channel has been inspired by the event channel of Enterprise Java Beans. Through an advanced communication mechanism in the Learning Channel such as registration and broadcasting, collaborative interactions between components can be established. An agent may participate in more than one Learning Channel and communication with multiple agents is carried out using multicasting.

To support interactions through the Learning Channel, each component has an interface, called a "port." This interface includes typical facility services that can be used to access the knowledge element, learner element and presentation element within any LCS. These ports function as sockets and a local LCS can be plugged into the Learning Channel to become a part of the global learning system.

In order to build and reuse ports, we use templates and we categorize ports. With a template, the properties of a port are specified. These include the port name, the local learning system name, the LCS name and release number, the host machine name and network address, and the learning topic and its presentation modes. For the purpose of reuse, all existing ports are categorized by their properties. Thus, a port can be reused as the basis for building a new port that belongs to the same category. For example, we build the Discrete Mathematics (DM) port first. Then we discover that there is a need for a Data Structures and Problem Solving (DSPS) port. As these two learning systems possess quite similar properties, the DM port is applicable for DSPS without essential changes.

3 The Development of the Learning Component System

A prototype of the Learning Component System (LCS) is currently being implemented using IBM Aglets [14], JAVA and XML (Figure 2).

3.1 The Learner Component of an LCS

The key to the ability to customize a course presentation is a model of the learner. The Learner Component provides a Learner Profile representing the learner's generalized objective, behavior, learning performance and cognitive style. Learners differ in their learning objectives. For example, a learner may be a busy executive with little time, interested in a short course, or he/she may be a student who has a whole semester for taking a course. Also, the learner has an associated Cognitive Style preference. For example, some learners prefer first getting a subject overview, whereas others prefer to focus on a specific topic and to ignore the big picture. These two styles roughly correspond to the global and local Cognitive Styles and can be applied to customizing lessons.

3.2 The Knowledge Component of an LCS

The domain knowledge to be covered needs to be efficiently organized for quick retrieval and update. One popular representation of domain knowledge is as a concept hierarchy. In this research, a concept hierarchy, called the Knowledge Network (KNet), is constructed to represent content to be covered in Web-based learning. Our KNet has been a directed acyclic graph (DAG) of nodes and links. A node represents a content element and a link represents a relationship between content elements. The KNet represents concepts at different abstraction levels and contains multiple relationships including Is-a, Part-of, Contained-in, Assoc-with, Related-to, Example-of, Applicable-to, Easier-than, etc. in a single hierarchy [16][15].

The KNet is used to determine the level of abstraction for a given topic, to interpret relationships between topics, to keep track of the learning process and to evaluate the progress of learners. Pointers to lecture notes, tests and homework problems, are attached to topic nodes. The knowledge agents help the learners to find appropriate topics and to adjust their learning levels according to their learning styles and abilities. For a beginner, more demonstrations might be useful, while for advanced learners more comprehensive content would be presented. The Knowledge Component manages level of difficulty, type of knowledge and problem solving behavior. Knowledge is declarative, procedural, or structural. There are three levels of difficulty (hard, medium and easy). The problem-solving behavior is defined as top-down or bottom-up.

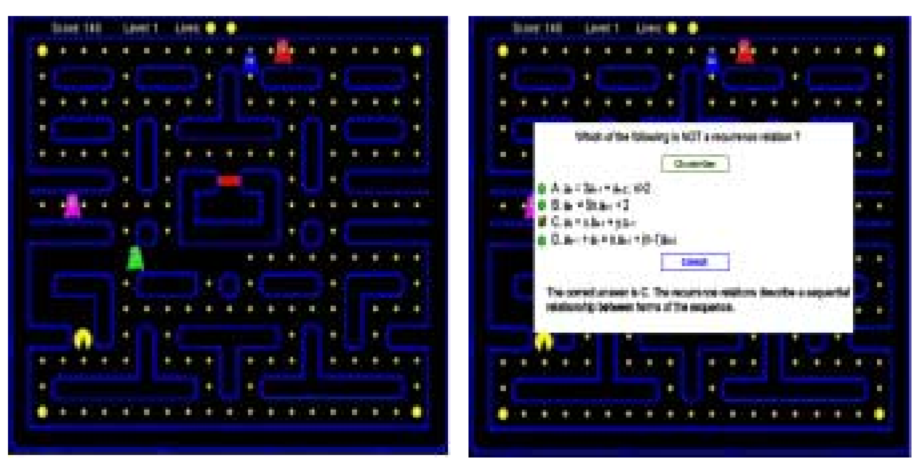

Fig. 3. The Interface of the Presentation Component: (a) Game Interface (b) Quiz Interface

3.3 The Presentation Component of an LCS

The Presentation Component responds to the learning proclivities of the learner as shown by the learner's profile. We implemented two Presentation Views: E-book View (Guided View or Discovery View) and E-Game View. A typical learning episode may require a combination of different Presentation Views. The Presentation Views take into account the instruction mode (guided, self-learning and game-oriented), presentation mode (audio, video, text) and presentation strategy (top-down, bottom-up, local, global, hierarchical, and flat).

The E-Game View (Figure 3) has a dual purpose: to quiz a student about class material, and to let him play a game he will hopefully enjoy. Essentially, the game is the well-known arcade game PacMan with integrated quiz questions. The game is interrupted whenever the user needs to answer a multiple-choice question. A text box will display "Wrong!!" or "Correct!!" and then the user can return to the game. When the game is over, the quiz score will be returned to the Learner Component.

4 Interactions and Interfaces in a CoSL System

4.1 XML-Based Data Exchange and Integration

XML (Extensible Markup Language) is a specification for a standard information exchange language on the Internet. XML specifications available for sharing educational information include the Universal Learning Format (ULF), the Learning Material Markup Language (LMML), and the IMS Metadata specification. We have adopted XML for specifying interactions between components in our CoSL system. For instance, an undergraduate student's Learner Profile, written in XML, can be used on different LCSs across academic departments where each LCS handles department-specific courses. XML also allows metadata to be stored to select and adapt the course material presentation. Furthermore, through XML's ability to specify user-defined link tags (XLink), we can model the learner with one or more XML documents. We can also define entities to refer to data in non-XML storage formats such as academic transcripts. XML-based interactions between components simplify heavy-duty data transformations required in a typical middleware system, through the support of formalized data representation mechanisms such as DTDs or XML Schemas. Figure 1 shows parts of a Learner Profile. Learner Profiles are determined by one or more cognitive features. The Learner Profile contains: (1) the order orientation, (2) the problem solving orientation, (3) the direction orientation, (4) the view orientation, (5) the interaction orientation, (6) the focus orientation and (7) the flexibility orientation. The System Profile is specified in a similar way. It contains the Learner_Views, Knowledge_Views, Presentation_View, and System Evaluation. At this stage in our research, Learner Profiles are defined without differentiating between different courses that the same person might be taking at the same time or at different times. The problem of keeping track of such differentiations and developments is difficult and will be addressed in future research.

Table 1. Learner Profile in XML

```
<?xml version=”1.0” encoding=”utf-8”?>
<!DOCTYPE DOCUMENT [
<!ELEMENT DOCUMENT (LEARNER_PROFILE)>
<!ELEMENT LEARNER_PROFILE (COGNITIVE_STYLE)>
<!ATTLIST LEARNER_PROFILE LEARNER_ID ID #REQUIRED>
<!ELEMENT COGNITIVE_STYLE (ORDER_ORIENTATION,
PROBOLEM_SOLVING_ORIENTATION, DIRECTION_ORIENTATION, VIEW_ORIENTATION,
INTERACTION_ORIENTATION, FOCUS_ORIENTATION, FLEXIBILITY_ORIENTATION)>
<!ELEMENT ORDER_ORIENTATION (In-Order—No-Order)>
<!ELEMENT PROBLEM_SOLVING_ORIENTATION (Top-Down—Bottom-Up)>
<!ELEMENT DIRECTION_ORIENTATION (Global—Local)>
<!ELEMENT VIEW_ORIENTATION (Internal—External)>
<!ELEMENT INTERACTION_ORIENTATION (Collaborative—Individual)>
<!ELEMENT FOCUS_ORIENTATION (Parallel—Sequential)>
<!ELEMENT FLEXIBILITY_ORIENTATION (Liberal—Conservative)>
<!ELEMENT In-Order (#PCDATA)>
<!ELEMENT No-Order (#PCDATA)>
<!ELEMENT Top-Down (#PCDATA)>
<!ELEMENT Bottom-Up (#PCDATA)>
<!ELEMENT Global (#PCDATA)>
<!ELEMENT Local (#PCDATA)>
<!ELEMENT Internal (#PCDATA)>
<!ELEMENT External (#PCDATA)>
<!ELEMENT Collaborative (#PCDATA)>
<!ELEMENT Individual (#PCDATA)>
<!ELEMENT Parallel (#PCDATA)>
<!ELEMENT Sequential (#PCDATA)>
<!ELEMENT Liberal (#PCDATA)>
<!ELEMENT Conservative (#PCDATA)>
]>
```

4.2 Collaboration between Multiple Agents

Learning systems in the Internet need to rely on cooperative agents for supporting an adaptive learning environment. Software agent frameworks have gained much attention as alternatives to distributed static object frameworks, because of their social abilities, intelligent decision-making, concurrent execution and mobility [35]. However, designing an efficient model for collaborations between agents is a challenge.

In CoSL, multiple agents collaborate to achieve the single goal of adaptive learning. A Learner Profile is constructed from a learner's observed behavior. This profile can be used to present appropriate information to the learner. By studying the learner's cognitive behavior the agents can dynamically alter the learning contents and presentation over time. Specifically, the agents participate in a number of important tasks such as analysis of the learning, retrieval of resources, delivery of services to learners and adaptation to new patterns and services.

The control structure of the CoSL system is hierarchical in terms of its distribution to different agents. Figure 4 shows the two-layer architecture of the CoSL system: the middleware (Learning Middleware) layer and the Learning Component System (LCS) layer. The functions of the different components are as follows:

– The Learning Component System Manager (LCSM) makes the final decision on the dynamic learning view to be presented based on the information from

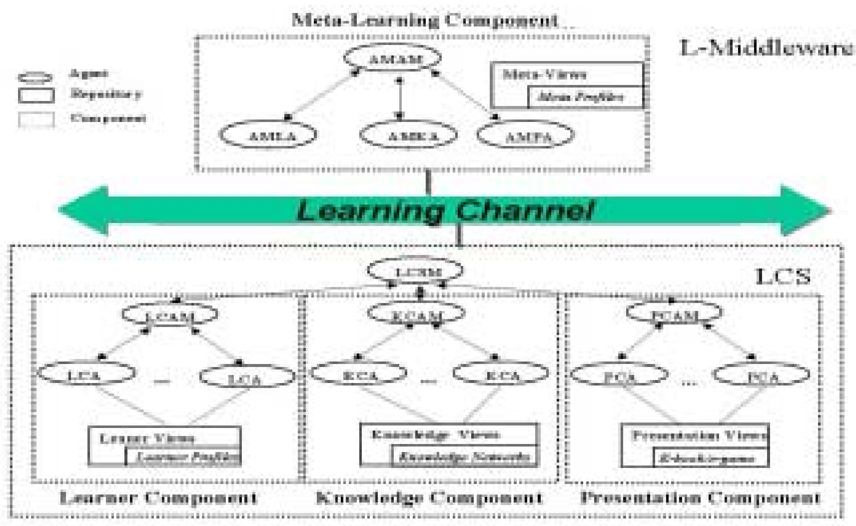

Fig. 4. Agent Hierarchy of our CoSL System

the learner component (LCAM), the knowledge component (KCAM) and the presentation component (PCAM), all described below.

- The Learner Component Agent Manager (LCAM) is the manager of the Learner Component Agents (LCAs) and is in charge of the Learner View generation. Each LCA is an expert on a specific learner variable (such as thinking style, learning behavior, etc.) and maintains the Learner's Profile for that variable.
- The Knowledge Component Agent Manager (KCAM) of Knowledge Component Agents (KCAs) is in charge of Knowledge View generation. Each KCA is an expert on a specific KNet topic (such as mathematical logic). The KCA determines the topic and type of knowledge (declarative, procedural or structural) to be presented to the learner.
- The Presentation Component Agent Manager (PCAM) is in charge of selecting an appropriate Presentation View according to input from Presentation Component Agents (PCAs). The PCAs manage several variables and such as presentation mode and learning strategy. The PCAM selects presentation modes such as game-based or hypermedia-guided learning and selects an instruction mode, such as model-based, problem-solving-based or theory-based learning.

Agents are activated by a request for a learning episode and the consequent Knowledge Component and Learner Component retrievals. Guided by the current learning situation they dynamically form an adaptive sharable learning environment that fits the current learning process. This learning environment will change over time to optimize the learner's adaptive learning session. In order to avoid a communication bottleneck, we allow communication at the intermediate level (LCAM, KCAM, and PCAM.) The Learning Middleware has three meta-components and each component has interfaces to the local LCSs: Meta-

Learner, Meta-Knowledge and Meta-Presentation. Due to space limitations we cannot describe these in detail.

To summarize, the overall control is partitioned into two layers: the Learning Middleware and the Learning Component System (LCS). There are three types of agents in the Learning Middleware and three more in the LCS. Each agent concentrates on its own specialized tasks and resources (Metadata Repository, Learner Profile, Knowledge Network, and Presentation Repository) and generates its specialized dynamic views: Learner, Knowledge, and Presentation.

4.3 Adaptive Learning Using Data Mining

Accurate model building is critical to providing an adaptive learning environment. Adaptive personal learning can be achieved through information filtering and classification using data mining techniques. In our system, learners are classified according to their attributes, learning processes and environment, using the popular classification algorithm C4.5 [21].

Learner information stored on online systems can be mined for good learning behavior patterns, which can then be applied by adaptive teaching systems to refine the instruction provided to an individual online learner. In the LCS level, we use data mining techniques to implement the decision process by which the Knowledge Views and Presentation Views are constructed using Learner Views.

At the Learning Middleware level, learner information is also used across distributed learning systems to match students with similar learner type profiles and facilitate collaborative exchanges (”peer-group supported learning”) between students. This is also used to measure and evaluate the system’s services by analyzing the performance of its learners in solving problems, the average rate of topic knowledge acquisition, and the fitness of its pedagogical strategies.

4.4 The Use of CoSL in a Real Learning Setting

We have initiated a set of experiments using our CoSL framework with groups of UMKC students. The student group is composed of about 60 students in a Discrete Mathematics course that is taught as a Computer Science introductory course. As the first outcome of these experiments, we were able to collect data for learner teaching profiles. These will enable the CoSL system to customize course materials to fit the learning preferences of individual students and also to optimize its own teaching strategy. Further experiments are planned to confirm whether our CoSL system can be used to reinforce the concepts covered in a traditional class and serve as a bridge between the practical and the theoretical aspects of the course material.

5 Related Work

Weber [32] focuses on interactive and adaptive Web-based learning to support learners with different background knowledge and skills. Individual or tailored instruction based on learners’ needs and background has not been achieved yet

[18]. In order to facilitate online learning based on learners' backgrounds and individual differences, researchers have investigated psychological variables affecting the quality of online learning. They have identified demographic variables (e.g., age, gender, occupation, etc.) [2], field dependence/independence variables [3], a locus of control variable [29], and learning styles [6]. The importance of user modeling has been emphasized in the learning community. Milne et al. [20] focused on the development of composite learner models, incorporating both domain-related data and information about personal attributes such as capabilities and preferences. Schwab et al. [25] used machine learning methods to acquire a user-interest profile from observed user behavior and implemented a methodology for learning explicit user profiles which were described in Web pages.

Wesley et al. [33] used distributed rational agents to manage the acquisition and presentation of multimedia information in a distance learning environment. [7] developed intelligent computer aided instruction (ICAI) software using agent technology for sharing teaching experiences and tutoring dialogs. Rickel et al. [23] introduced two types of agents, students and pedagogical agents, communicating using virtual reality. Some researchers focused on the interactions of multiple agents including a conceptual framework for multiple agents [19] and user models and their maintenance [4].

The interactions among agents distributed in different environments are feasible through research on agent communication languages such as KQML [9]. Our multi-agent approach is different from current agent research in that we consider agents to be equal partners with the learner rather than using a single agent as a secondary support. The use of XML has rapidly increased, due to its flexible and powerful features for knowledge representation, acquisition and presentation. XML is used in the communication protocol of the MathWeb system [11]. Liu et al. [17] also focus on developing a prototype system for XML-based collaborative knowledge sharing over the web.

Stonick et al. [30] designed on-line, multimedia topical learning modules to evaluate student levels of expertise in choosing course activities for distributed, collaborative and guided learning. A study on designing externally controlled training procedures for adaptive learning demonstrated the ineffectiveness of totally self-guided learning and suggested efficient ('intelligent') combinations between externally guided and self-guided learning [24]. Gustafson et al. [12] built instructional models to provide conceptual and communication tools that were used to visualize, direct, and manage processes for generating episodes of guided learning. Veermans et al. developed a learner modeling system to provide discovery learning support based on evidence in situations where the learner needs support and based on the nature of that support. As an example of game-based learning, "dialogue game" [22] models features of the tutorial process such as the learner playing the role of an "explainer" while the system plays a facilitating role. Another study showed that game-oriented learning is more effective than straight tutorial animation [10].

6 Conclusion

To resolve the limitations of learning through the Internet, we have introduced a distributed learning environment architecture that provides effective teaching services for diverse learners using various learning components. We have developed the Collaborative and Sharable Learning (CoSL) system, which is context-independent, so that adaptation to a new topic can be achieved with limited effort and time. A prototype of the CoSL system has successfully employed XML-based data exchange and integration, agent-based interaction and communication, and intelligent decision making based on data mining.

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Virtual Programming Lab for Online Distance Learning

Jiannong Cao[1], Alvin Chan[1], Weidong Cao[2], and Cassidy Yeung[1]

[1]Internet and E-Commerce Lab, Dept. of Computing
Hong Kong Polytechnic University
Hung Hom, Kowloon, Hong Kong
csjcao@comp.polyu.edu.hk
cstschan@ comp.polyu.edu.hk
[2]Department of Mathematics, Jiangsu Institute of Education
Nanjing, Jiangsu, China
wdcao@jlonline.com

Abstract. In this paper, we describe the design of the WebVPL system, a Web-based Virtual Programming Lab for on-line distance learning. The underlying setting is a collection of Lab server computers hosting education and programming software. Students use personal computers at home to access over the Internet one of the Lab servers, which performs functions to accommodate various requests from the student such as software usage. The lab servers can be located in different buildings and even at different campuses. WebVPL facilitates resource sharing among different schools and overcomes the limit of geographical distances. The design of the WebVPL system includes the user interface, agent-based client side functions, the structuring of Lab servers, the mechanisms to locate user requested software packages / services and to present various forms of data and information, and the interfaces to various education and programming software packages. We discuss various implementation issues and describe a prototype of the WebVPL.

1 Introduction

During the last several years, e-learning has emerged as one of the fastest-moving trends in education and is booming. Thanks to the widespread access to the Internet, on-line education is enabling students and professionals to learn from afar, keeping pace with technological and managerial changes. Thousands of technical and management courses are now being offered by universities, for-profit professional development centers, and industry training facilities worldwide [24].

Underpinning the teaching and learning over the Web, the global connectivity of the Internet and a new generation of hardware and software applications have equipped distance learning with new methods of delivery. The convenience of Web education made distance learning effective and flexible, even in the absence of face-to-face interactions in the classroom. Nowadays, students who take courses on-line can access the courses whenever and wherever convenient. They can download the

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lecture note from the Web, communicate with each other and their instructor through e-mail, and took exams by responding to questions on computer screens.

Although several e-learning software supporting on-line lecturing and tutoring have been found popular [13,22,23] and many works have been done in providing Web-based learning and teaching [8,19,20,24], there has been not many reports on providing students convenient on-line access to programming facilities available in computer labs. Only a few works can be found which develop either ad hoc or special purpose Web programming facilities [14,17,18]. In this paper, we describe the design of the WebVPL system, a generic Web-based Virtual Programming Lab for on-line distance learning. The powerful features of the WWW, especially the integration of the widespread Internet protocols, allow us to design software to facilitate the access to existing resources available on the Internet in an integrated fashion [9]. In addition to navigation through hypermedia documents, using the remote access capability of the Internet technology, various software programs can be executed remotely through WWW. In WebVPL, the underlying setting is a collection of Lab server computers hosting education and programming software. Students use personal computers at home to access over the Internet one of the Lab servers, which performs functions to accommodate various requests from the student, ranging from downloading software from the school lab servers, working through interactive demonstration and tutorial sessions, and submitting a program for execution on a Lab computer using specified software package.

The collection of Lab server computers forms a *virtual* programming laboratory because the machines can be located in different buildings and even at different campuses. It facilitates resource sharing among different schools and overcomes the limit of geographical distances. The WebVPL system design includes the user interface, agent-based client side functions, the structuring of Lab servers, the mechanisms to locate user requested software packages / services and to present various forms of data and information, and the interfaces to various education and programming software packages. Technologies such as virtual reality, Java Applets and Servlets, mobile agent, XML, and Web/HTTP servers can be used to implement the underlying mechanisms and facilities of the virtual Lab, such as software resource locating and interfacing, real-time interaction, and information presentation. Using these technologies allows the system to achieve high-performance, scalability, and disconnected operation through reduction in network bandwidth and delay, load balancing, and code mobility.

The rest of this paper is organized as follows. Section 2 describes the requirements of the WebVPL system design. Section 3 presents the overall system architecture and describes the functional components of the system. Section 4 discusses implementation issues. Section 5 describes a prototype of WebVPL and consolidates the implementation issues. Finally, Section 6 concludes the paper and describes our future work.

2 System Requirements

The main objective of WebVPL is to provide a general framework for Web-based access to programming lab facilities. We have carefully studied the requirements of student programming exercises in developing the on-line virtual laboratory services. The virtual laboratory system to be developed should support students located in different geographical areas, who need on-line and real-time access to programming facilities from a number of different sources. Students have choices of launching an interactive application, or submitting a program for compilation and execution, obtaining the results, conducting (possibly interactive) testing/debugging runs of programs, reading help files and software manuals, etc.

Reflecting these requirements, our design of the WebVPL system aims at architecture with the following features:

- *Accessibility*: The service of provided by the system must be widely accessible. We decided that the service should be provided on the Internet, using WWW to reach a wide range of students. Students can access WebVPL on campus in the physical laboratory, and from their home through dial-up connection using PPP or SLIP, using various platforms. Web browsers also create a user friendly environment.
- *Easy to use and Effectiveness*: The system should provide a user-friendly interface to facilitate ease use of the virtual lab services and should confirm to real-world programming practice. The user interface allows the user to select the desirable services in an integrated manner. It should provide an introduction to the virtual lab system, a comprehensive window-based menu of services, and other relevant information about the virtual lab.
- *Interactivity*: Interactivity is important when students doing programming exercises using a software. The system should allow the user to conduct sessions with interaction-enabled software.
- *Multimedia*: The system should provide multimedia information to the user to enhance their comprehension of the information provided. In addition to text description, the system should provide video and audio clips for viewing properties information.
- *Support for collaboration*: Students doing group programming projects need to collaborate. The system should provide facilities for them to communicate with each other and perform collaborative work.
- *Efficiency*: The system should efficiently locate the software requested by the student, providing resource sharing with location transparency and workload balancing.
- *Modularity and extendibility*: The system should be designed with modules that interact with each other only through their interfaces so that they can be replaced without affecting other parts of the system. New components and modules can be added and/or new requirements can be satisfied. This also increases the flexibility of the system and its capability of keeping pace with the new features rapidly occurring in the e-learning world.

To achieve the above goals, the structure of the system must be well designed. In the next section, we present the design of the system architecture.

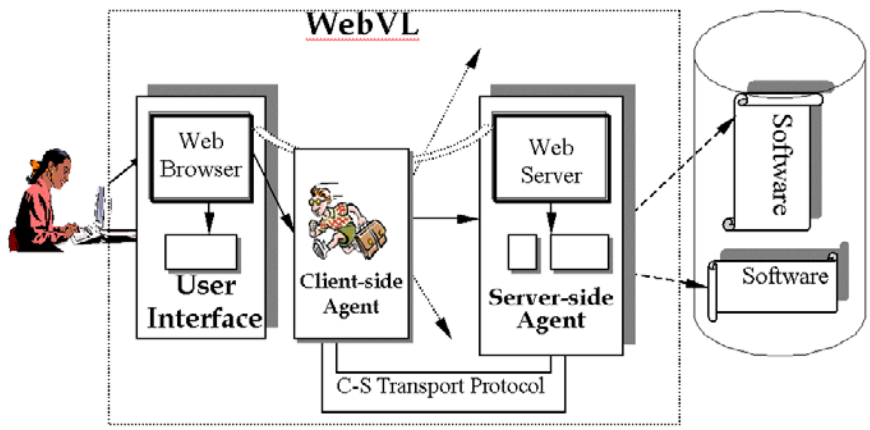

Fig. 1. System architecture of WebVPL

3 System Architecture

The WebVPL system has a Web-based client-server architecture and consists of three major functional modules: *User Interface*, *Client-side Agent,* and *Server-side Agent*. The primary purpose of the User Interface component is to provide the means for the user to configure the programming exercises and to obtain feedback on the activities and results of the programming. Client-side Agent is responsible of dispatching the user's requests to a suitable site for execution in the virtual lab environment. Server-side Agent receives the requests from distinct students and interface to the requested software for carrying out the programming exercises. Overall, the system provides an environment through which Lab software may be accessed and controlled interactively. Figure 1 shows the high-level system structure and illustrates the major components and their interactions in the generic virtual lab environment.

The loosely coupled architecture separates out different aspects of interfaces with the user and the software, underlying programming environment, and dispatching of user requests into separate functional modules. Each module is self-contained and can be replaced and extended. This supports incremental development. In the rest of this section, we briefly describe the roles and functions of the modules illustrated in Figure 1.

3.1 Graphical User Interface (GUI)

The student connects with the WebVPL system through a graphical user interface. WebVPL can be regarded as a collection of software tools. The GUI allows the user to select these tools. The user-driven nature of the WebVPL system should be reflected in the design of the GUI. The GUI is aimed at providing students convenient access to the virtual lab services and information and enable students to interact with the remote software in terms of configuring the programming experiments, sending parameters and data, and obtaining results. Among the others, the services to be provided by the user interface module should include:

- Provide information about the virtual lab and enables the student to find required lab software;
- Provide access points to the remote software. Once the student has selected the lab software to experiment, the GUI should allow the student to interact with the software.
- Represent and display information about and from the remote software. Ideally, the GUI should mimic the interface of the software.

To achieve these goals, the user interface has been decomposed into several sections including Introduction, Display & Configuration, Control and Information and communication.

3.2 Client-Side Agent (CSA)

The CSA is responsible for taking the student's request for accessing specified software and dispatching the request to a suitable machine in the virtual lab environment. Its task also include communicate with the server-side agent for the representation and transmission of data and commands passed between the client computer and the remote platform on which the requested software runs. It formats the student's input data for transmission to the remote server and converts the message data received from the server into the format suitable for display at the student's terminal. Client-side Agent can also include more advanced features such as personalization, client-based load sharing … etc.

3.3 Server-Side Agent (SSA)

The SSA is mainly responsible for carrying out the requests from the distant students for programming using specified software at the server site. It interfaces the software for executing commands, invoking functions, and passing data. It also needs to interact with the CSA.

Software used in a lab can be classified according to the platform on which they are executed and their interfaces: interactive vs. batch processing, GUI-based vs. command line interpreter based, etc. One important task of SSA is to provide a mapping of the interface of the software to that to be displayed at the student's computer. The simplest case is when the software has a command line interface with possibly some parameters. In this case, a "direct mapping" can be easily performed. Things can get much more complicated if the software has its own graphical user interface and its execution requires interaction with the user. In this case, conversion and wrapping up are necessary. Providing a standard interface to software permits flexible linkage of the software into the particular programming course design adopted by individual teacher.

The WebVPL system is designed to consist of multiple lab servers to satisfy the requests from multiple students. The load balancing and process migration are supported by the proxy server controlled by SSA. The proxy server maintains the seamless connection to the client and handles the backend process migration between different lab servers. It makes the load balancing and process migration transparent to the student and maintains the consistent interface during transferring the software process from one lab server to another.

3.4 C-S Transport Protocol (CSTP)

Once the CSA finds the target server site for carrying out the student's programming exercise, it will set up a connection to the SSA at that site. The CSA and SSA communicate using the C-S transport protocol (CSTP) which provides a message passing facility that permits data and commands to be encoded and transmitted within Web browsers and accessed by CSA and SSA. In principle, the interaction between the student and the software is in the form of input from the student and the response from the software. Since the interaction can be of various forms, the CSTP is needed to provide a communication environment necessary to facilitate the interactions. The CSTP should have the property that all data saved as the CSTP specific format should be able to be accessed by CSA and SSA who know how to recreate the data from this. This will facilitate the mapping of the lab software's interface objects at the student's computer.

4 Implementation Considerations

In this section, we discuss the issues and considerations in the implementation of the proposed WebVPL system using current technologies, which provide cross-platform and worldwide accessibility, support for "interactive" documents, ease of integration of multimedia/hypertext materials, and sophisticated network and database connection protocols [6].

The students as clients connect to the WebVPL system structured as a group of Lab servers. Each Lab server maintains a collection of lab software. Some of the lab software can be partially or fully replicated at the Lab servers. There are several solutions to the problem of providing transparent access to scalable services provided by a group of servers and sharing the load between the different servers. Examples are DNS Aliasing, HTTP redirect, Magic Routers, fail-safe TCP and Active Networks [1], [4], [27].

In the implementation of the GUI, major functions of the Web Pages can be implemented using various tools, including Web authoring tools, Java Applets, scripting (e.g., JavaScript), screen-capture software, and VRML. The *rooms metaphor*, a concept introduced by XeroxParc [3,20], can be used to mimic the real-world laboratory environment in terms of interacting with the computer and organizing the lab documents. For example, with the use of Internet-oriented virtual reality technology [7,25], the GUI can be designed to provide a illusion that the students enter a lab room to sit in front of a computer to run a program and, at the same time, gain access to different information resources located in the room. Dynamic web pages with increased interaction with the user and sophisticated visual effects can be achieved through the use of JavaScript, DHTML and Applets. Other aspects of the GUI implementation such as two-way dialog with the server (interactivity between the student and the lab software) through the GUI will be discussed in the following sections.

The CSA can be designed as a proxy object to a normal Web browser. To configure the Web browser to enable the WebVPL, the user simply configures his/her browser to use locally executed CSA daemon by setting the proxy server as 127.0.0.1 or localhost. The CSA acts as a mediator between the Web browser's normal Http request/reply and WebVPL services on the network. This approach requires no re-invent of a new Web browser. Various task-scheduling techniques with load sharing can be used by the CSA to dispatch the student's request to a suitable proxy server in SSA.

The proxy server in SSA is responsible for handling server-side load sharing and process migration among the lab servers. It dispatches the student's request to a suitable lab server in the WebVPL environment and maintain the connection and consistency of the interface during migration of a task from one lab server to another. The client side only keeps track of the location of proxy server in SSA and is not aware of any migration and changes among the backend lab servers. SSA also coordinates to perform periodic checkpointing on software process in the proxy server to facilitate fault tolerance. The backup status of the software process is automatically resumed in other lab server when one lab server is halted.

The interaction between the student and the software is largely supported by Web server and client extensions. Information and feedback can be facilitated by HTML push/pull mechanisms and techniques for local processing of small, embedded applications such as Java Applet. On the other hand, techniques based on the use of forms within HTML documents to let clients initiate and interact with server-side applications enable us to create appropriate tools that can interface Web browsers to software applications. For example, using the forms facility and CGI scripts (Common Gateway Interface) or Java Servlets, we can build CSA on the Lab servers which provide runtime services to WebVPL related requests/replies. The web server runs the CGI script or servlet, which outputs an HTML page that the server returns to the client [2]. Depending on the lab software to be accessed, the functions of the CGI/Java servlet programs can be as simple as invoking a local command line or shell script program, or as complex as interfacing a sophisticated, interactive software.

A given lab software can be accessed from a command embedded in an HTML document. From the student's point of view, he / she simply follows a link that can cause a WWW server to execute a program or a shell script, which, in turn, can spawn a process/thread that will handle the interactions with the distinct student. The server-side agent, implemented as a cgi-bin or Java servlet program, runs during the whole session and is responsible of interfacing the student with the local software program. It obtains the student provided information, such as program commands, code, parameters, etc, from the fill-out forms, processes it if necessary, and then passes it to the software in the required format. For example, the student can submit Java code for execution in a text area within an HTML form; the server side agent would save the code to disk, attempt to compile the code and, if compilation was successful, run the executable file on some test data. When the output is produced by the software, the server-side agent sends the output to the student, most probably as HTML documents that are dynamically generated. These HTML documents may be just simple text files, or contains fields that have to be filled by the student and then transmitted back to the software program, or links to actual sites of the software vendors. It can also contain embedded links that lead to other executable programs. Figure 2 illustrates the above interaction scheme in WebVPL.

By utilizing the information expression that Web browsers and the CSTP support, various forms of multimedia data as output from the software can be saved and communicated about over the Web [15]. For accessing lab help facilities such as programming manuals and help files, due to the ease of interfacing with external viewers in WWW browsers, different types of documents can be viewed by using the viewing programs associated to the various types. This has the advantage of extensibility: new types can be defined with appropriate viewers if necessary. Thus, when the student requests to read help files or programming manuals in the software packages, the WWW browsers will retrieve the documents and launch the corresponding viewer for the display.

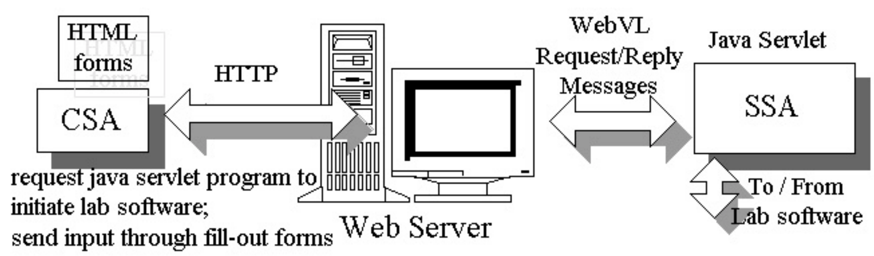

Fig. 2. Interaction of components in WebVPL

For implementing the CSTP, we propose to use HTTP as the baseline protocol by extending relevant HTTP headers and the support for the transfer of WebVPL specific headers, control information, and data formats. Potentially we can develop a new specification of XML-based [10,12] CSTP transfer syntax. This approach has the advantage of being conforming to standards and portable to various platforms.

We are also considering the use of mobile agents in the development of WebVPL. A mobile agent is a computer program that can autonomously migrate between network sites, i.e., it can execute at a host for a while, halts execution, dispatches itself (together with its data and execution state) to another host, and resumes execution there - all *under its own control* [11]. It has been found that mobile agent is especially suitable for structuring and coordinating distributed applications running in a wide-area environment like the Internet [16]. In our case, for example, mobile agents can be employed to locate the requested software for programming exercises, to collect load information at individual Web servers, and/or to automatically and transparently determine for the client the “best” server to execute a specified task [5]. Mobile agents can also be sent by either the client or the server to perform local interactions or display information at the peer site.

5 A Prototype of WebVPL

We have implemented a prototype of WebVPL whose architecture is shown in Figure 3. The prototype currently has only one Lab server built in Linux environment. The lab software in the prototype supports X window protocol. The client can access the system through web browser. The graphical user interface is implemented by signed Java applet and can be regarded as the CSA with simple functions for collecting the user to the Lab server for accessing X window based software. It consists of virtual desktop, File Explorer, application service, lab talk and displaying adapter. The virtual desktop captures the user request on accessing the software and organizes other functions in the system. The file explorer allows the users to access the file system in both the local machine and remote lab account. Application service provides Lab Talk facilitates communication between lab users. The displaying adapter allows client receive the software interface information from server.

The WebVPL runtime consists of administration, connection, access control, communication and remote control. The remote control can be regarded as the SSA without agent function. It modifies and redirects the software displaying information to the client side using the CSTP that is understandable by the displaying adapter at client side. In the prototype, we have used X.11 protocol to transfer the software interface information between client and server. The displaying adapter in client side is implemented with wiredx [26] that is used to interpret the X.11 protocol.

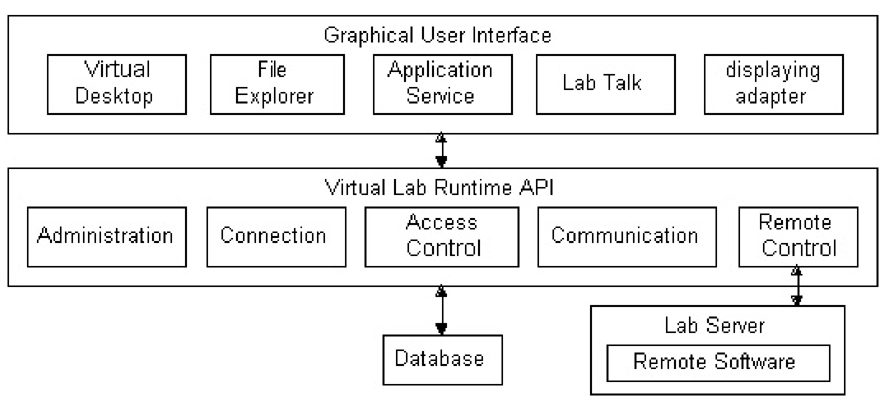

Fig. 3. The architecture of implementation prototype

The load balancing scheme used is shown in Figure 4. When the client request is dispatched to proxy server. The proxy server determines the least loaded lab server and establishes the connection to that lab server. The application resource consumption and user usage mode can be record to help the system to accurately determine further incoming request. Assumptions have been made to make the prediction valid. The previous user usage behavior can be used to predict the future usage behavior of the same user. The application resource consumption processes some pattern. Additional assumptions are under investigation. The resource monitor is to monitor the resource usage in different machine. This helps to determine the least loaded server and prevent overloaded a particular server. Whenever overloading is detected, process migration takes place. During process migration, the status are saved and then resumed in the other server. The proxy server records the checkpoint by saving the current status of running software periodically. The status is resumed on other server when server failure occurs.

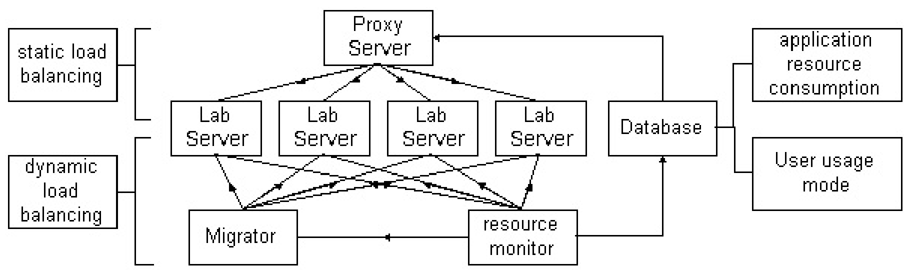

Fig. 4. The architecture of load balancing among lab machine

The demonstration of the prototype is illustrated in Figure 5. The application running on the remote lab server is launched on the local client side. The client can interact with the application through this interface. The interface is the same as the interface of the software running at the local machine. It processes the running power of the remote lab server and independent of local client running power.

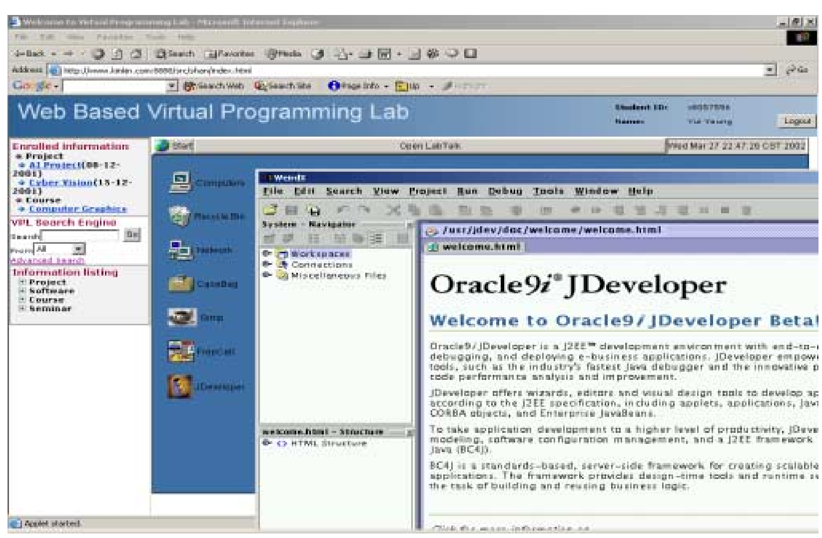

Fig. 5. Launching the JDeveloper running in the remote lab server at the client web browser

6 Conclusions

In this paper, we have described the design of a Web-based virtual lab software system, which allows distant students to gain access to various programming lab software by using a standard Web browser such as Netscape and Internet Explorer. The research described in this paper improves the existing work on distance teaching and learning which lack some of the important features that are associated with traditional education activities such as laboratory exercises. By doing so, we are developing special software and laboratory materials designed to facilitate students access to a wider range of information and educational services. Using WebVPL, students can use programming lab facilities which they otherwise might not be able to access due to the incapability to be present in the lab or shortage of laboratory time. Furthermore, our design of the virtual programming lab takes into consideration of integrating facilities from several labs, which enables more resource sharing and offsets the high cost in developing programming lab materials by wider usage of the lab materials across different campuses.

Currently, the implementation of the WebVPL is undergoing. The various advanced Internet and WWW based technologies discussed in this paper are employed to develop the underlying mechanisms of the on-line virtual laboratory environment. There are challenges and difficulties in building WebVPL. For example, we have not come up with the accurate formulae on dispatching the client request to the lab server to make sure that the processes in the lab server are running in the most effective way. This parameter depends on the application behavior and application types. The memory deficiency tolerance degree of the application affects the behavior of software process running under a memory deficient environment. In fact, we have found that the memory usage of application does not increase linearly since some of the applications are designed to share some memory among several instances. Therefore, the combination of applications affects the memory usage and the performance of software processes. We are actively investigating these issues, starting with more detailed experiments on different applications behavior.

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The Vega Grid and Grid-Based Education

Zhiwei Xu[1], Wei Li[1], Hongguang Fu[2], and Zhenbing Zeng[2]

[1] Institute of Computing Technology, Chinese Academy of Sciences,
Beijing China, 100080
{zxu,liwei}@ict.ac.cn
[2] Automated Reasoning Laboratory, Chinese Academy of Sciences
Beijing China, 100080

Abstract. This paper presents research work conducted at Chinese Academy of Sciences, on the Vega Grid technology and dynamic geometry technology, and how the two can integrate to provide a dynamic geometry education system based on grid technology.

1 Introduction

This paper presents research work conducted at Chinese Academy of Sciences, on the Vega Grid technology and dynamic geometry technology, and how these two technologies can integrate to provide a Vega Education Grid, a grid-based education system for mathematics.

Vega Grid is a research project at Institute of Computing Technology, Chinese Academy of Sciences. *MXP* (Math Experience) is a dynamic geometric education system developed at Automated Reasoning Laboratory, Chinese Academy of Sciences. Currently, these two teams are collaborating to develop a high-performance intelligent education software deployable on a wide-area grid platform. The initial focus is mathematics education, with strong emphasis on dynamic geometry.

In Section 2, we discuss the Vega Grid research project. Section 3 describes the MXP system. Section 4 identify challenges of the MXP system, and presents the architecture of the Vega Education Grid, a grid-based mathematics education system under development.

2 The Vega Grid Project

The Vega Grid project aims to learning fundamental properties of grid computing, and developing key techniques that are essential for building grid systems and applications. Current research work includes terascale grid enabling clusters, the Vega Grid Software Platform, Vega Information Grid, and Vega Knowledge Grid.

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The Vega Grid research is both a basic research and an applied research project. As such, it is driven by technology trends and application trends. We have closely followed development in computing grid (e.g., Globus) [4, 6], data grid [1], information grid and knowledge grid [15], and business grid (e.g., OGSA [5] and web services [8, 11]). More importantly, the research results of the Vega Grid project are currently being used in several application fields, such as Digital Olympics, bioinformatics grid, education grid, and integrated information sharing systems in the railway industry.

2.1 The VEGA Service Grid Principle

After carefully analyzing applications requirements, we identified the *VEGA Service Grid* Principle to guide our development. The service grid concept abstracts three aspects of applications requirements: (1) The Vega grid should enable user visible services, not just an infrastructure. (2) Service is the main mechanism for users to interact with grid. (3) The criteria used to evaluate grid functionality and performance should evolve from traditional criteria to service-oriented criteria, such as Service Level Agreement (SLA). To realize the service grid concept, the Vega Grid project follows the following VEGA principle:

- ***V***ersatile Services and Resources. The grid should have the ability to support various services and resource, not just scientific computation. The Vega Grid project aims to providing for the minimal common requirements of various grid applications.
- ***E***nabling Intelligence. The grid should support intelligent computing, such as automatic production of information, knowledge and services. However, the grid itself is not the intelligence provider, but it provides enabling technology to assist developers and users to achieve intelligent grid applications.
- ***G***lobal Uniformity. From the user's viewpoint, the grid can be viewed as a single virtual computer, supporting Single System Image, Single Sign-On and other related technologies. Heterogeneous resources among geographically distributed grid nodes should form a uniform, connected, inter-operable resource pool, instead of many isolated small islands.
- ***A***utonomous Control. The grid should not be ruled by a central administration. All components can freely join or leave the grid at their own will. A resource provider has full control its resource exported, and a resource user can use resources as he like within the purview of his right.

2.2 A Grid Computing Model with Active Memory

Turing machines and random access machines (RAM) [3] are basic computer models, especially for sequential computing at a single site. The PRAM and the BSP models [7, 14] extend RAM to cover parallel computing. The Vega Grid team proposed a new model of *Computer with Active Memory* (CAM), where the memory cells are equipped with traditional read/write operations as well as new execution operations. This CAM model can be used to study architectural mechanisms and algorithms design of grid computing.

The CAM model differs from the RAM model in several aspects, as illustrated in Figure 1. In traditional RAM (or PRAM) model, a processor can only read from or write to a memory cell. In the CAM model, a processor can also *execute* a memory cell. This is accomplished by new instructions specific to CAM.

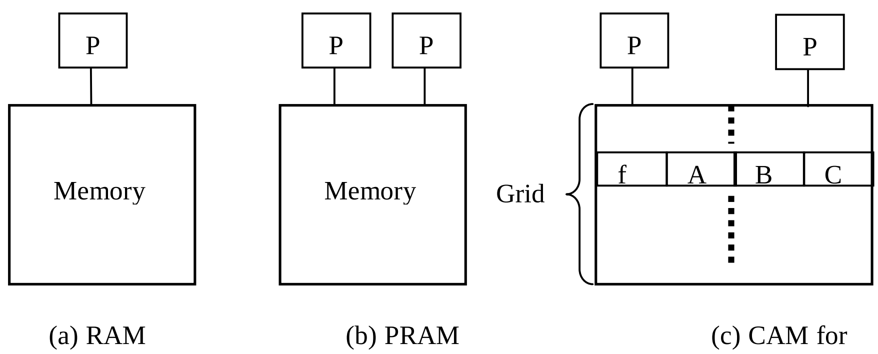

Fig. 1. Comparison among three computing models: RAM, PRAM, and CAM

This CAM model is better suited than RAM and PRAM for modeling grid computing. Each memory cell in CAM can be viewed as a grid node. The entire memory can be viewed as the grid. A processor of CAM represents a client device or a user of the grid. Instructions of CAM can be viewed as users requests to the grid for desired services. For instance, suppose a memory cell *X* in a CAM is divided into four fields, labeled as (*X*, 0), (*X*, 1), (*X*, 2), (*X*, 3). A CAM instruction "store (*X*, 0), *f* " deploys service *f* on grid node *X*. An instruction "move (*X*, 3), *Y*" transfers data from node *Y* into node *X*. A CAM instruction "**execute** *X*" then can be interpreted as execute service *f*, with parameter *B* and *C*, and writes the service results into *A*.

2.3 The Vega Grid Architecture

The CAM model has been used in designing our Vega Grid system. Its three-layer architecture is illustrated in Figure 2. At the grid hardware layer, we are developing Dawning 4000 and Dawning 5000 superservers, which are clusters with enabling technology to support grid platforms and applications. Other components at the grid hardware layer include a client device and a router. The Vega Grid Client is a thin client device for grid users. The Vega Grid Router, which enables application-level connectivity and allows resources to be efficiently deployed and discovered.

The platform layer includes grid system software and middleware, such as Globus, OGSA, web services, and other commercial grid software.

The application layer includes various application software servers, such as database servers, web servers, and business application servers. The Vega Grid adds two new components at this layer, one at the client side and one at the server side. The Vega Grid "Browser" extends a traditional web browser, by allowing users to write to and to operate the grid. The Vega Grid Server is a portal to the grid, which provides a logically single entry point for users to interact with the grid, and to handle processing tasks that are common to all grid services.

The Vega Grid "Browser" and the Vega Grid Server interact through a new protocol, called the Grid Service Request Protocol (GSRP). Another new feature is the Grid Service Markup Language (GSML), which allows users (not necessarily programmers) to specify grid services and user interface in an easy to use fashion.

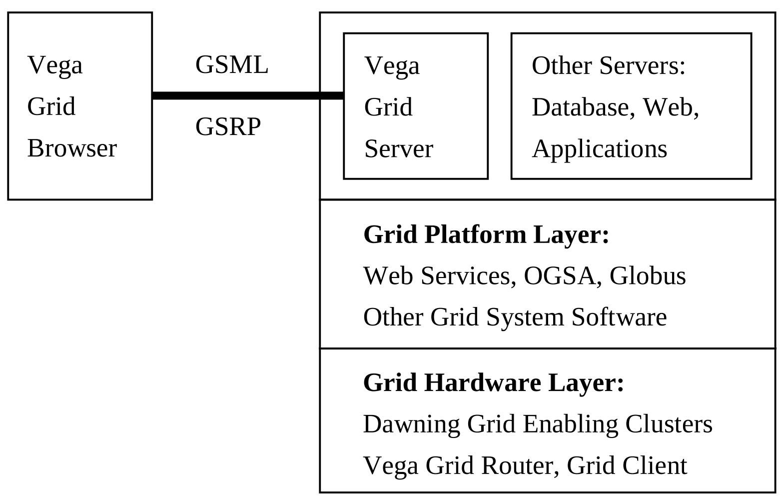

Fig. 2. The Vega Grid Three-Layer Architecture

3 The Math Experience (MXP) Project

Ever since their introduce in the 1990's, dynamic geometry software (DGS) packages have become a standard tool for students, teachers, and mathematicians to build dynamic visual models to assist teaching and learning of various mathematical concepts and theorems [2, 9, 10,13]. They allowed students to become geometric experimenters, and to make their own discoveries. But a common drawback of these software is that they can not answer why. If you want a readable and logical proof process produced by computer automatically for a problem, the previous DGS can not do it, because they did not include a automated reasoning engine (prover) and a symbolic computation platform (solver). Symbolic computation software like Mathematica and Maple provide powerful tools of solving mathematical problems, but solving geometric problems is still a weak point.

In recent years, we are researching and developing a dynamic geometric system named MXP (Math Experience) with a geometry information search system (prover) and a symbolic computation platform (solver) [12]. The DGS part of the software is used to generate a problem, the prover and solver are used to solve the problem automatically. In the following, we use an example to illustrate how MXP can be used to generate a geometric problem and to provide a readable proof.

3.1 Problem Generation in MXP

A geometric problem includes the known and conclusion parts. If a problem is input by keyboard directly, we have to face the understanding of nature language, but it is very difficult. It is fortunate that the dynamic geometry is a constructive process and the semantic of every step is definite. So we can let the computer automatically generate problems by the constructive process. The approach to generate a geometric problems can be divided two steps: (1) Generating the statements (Known and Conclusion) of the problem by the drawing process; (2) Constructing the database of the known an conclusion.

With the MXP software, a user selects the drawing tools to construct the geometric sketch in the worksheet and generate the conclusion by selecting the pattern of conclusions. The statements of constructions are shown in the window labeled "Problem". The database of the known and conclusion is a black-box for users, which has a specific data structure. Figure 3 shows an example of the problem generating process. Table 1 illustrates the relationship among drawing sketch, statements and inner data structure.

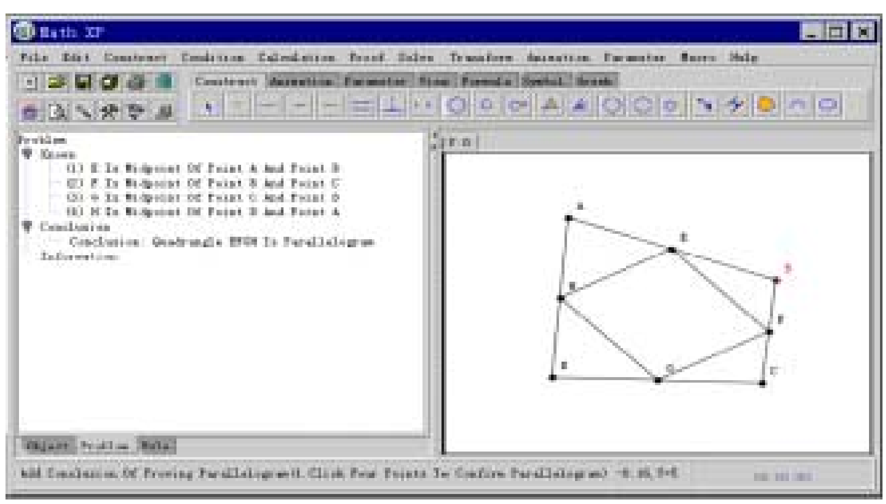

Fig. 3. Problem Generating in MXP

Table 1. Relationship among Drawing Sketch, Statements, and Inner Data Structure

Step	Drawing Process	Expressing Sentences	Data structure
1	Free Point A		(point A)
2	Free Point B		(point B)
3	Free Point C		(point C)
	Free Point D		(point D)
4	Middle Point E of Point A and Point B	E Is The Midpoint OF Point A and Point B.	(:mp E (:segment A B))
5	Middle Point F of Point B and Point C	F Is The Midpoint OF Point B and Point C.	(:mp F (:segment B C))
6	Middle Point G of Point C and Point D	G Is The Midpoint OF Point C and Point D.	(:mp G (:segment C D))
7	Middle Point H of Point A and Point D	H Is The Midpoint OF Point A and Point D.	(:mp H (:segment A D))
8	Adding Conclusion	Quadrilateral EFGH IS Parallelogram.	(px4 (:4gon E F G H))

3.2 Theorem Proving in MXP

In order to let computer produce a traditional proof automatically, a geometry information search system (Prover) and symbolic computation platform (Solver) are introduced into the MXP. The prover is a geometry information search system based the rules including axioms, concepts and theorems. The solver is a computer algebra system based symbolic computation including polynomial computations, factorization and equations solving. We will focus on the prover design.

Firstly, we should establish a rule database by collecting the axioms, definitions and theorems in textbooks. Then, we can formalize every rule as a function with inputs and outputs, so that some new facts can be outputted automatically when all input facts of a function are satisfied.

Secondly, we classify all facts and establish a fact database. Then we can get a expanding fact database by applying every rule in rule database to the fact database. It is obvious that the expanding fact database has a limited fact database owing to the limited number of rules. So the automated reasoning process is closed.

Thirdly, we should check whether the conclusion is in the fact database or not till the fact database reaches its limitation. If it is true, we can get a proof, otherwise the prover can not answer the problem. Maybe we should add new rules in the rule database. The whole process is summarized in Figure 4.

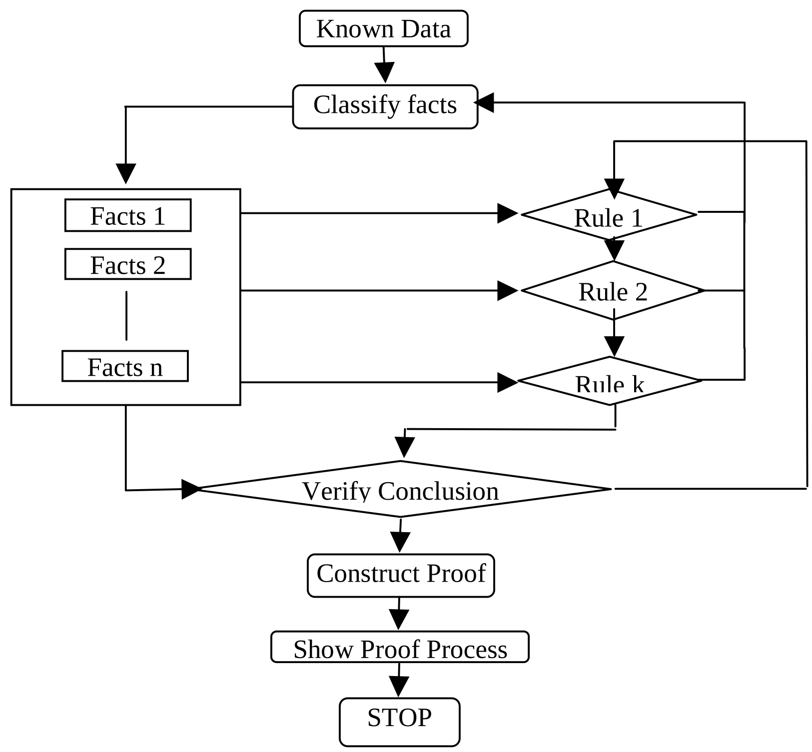

Fig. 4. Automated Reasoning Based on Rules

The above algorithm is straightforward. The real challenge is to deal with equivalence classes, data structures and search efficiency carefully. On a general personnel computer, we get a proof in several seconds for the example in Figure 3 by MXP. The proof is showed in Figure 5. The red lines are to help understand the proof process.

3.3 Summary of MXP

As a dynamic geometry software, MXP can be used to build dynamic visual models to assist teaching and learning of various mathematical concepts. As an automated reasoning software, MXP can be used to build dynamic logic models which can do reasoning themselves.

MXP is a powerful computer program for geometric reasoning. Within its domain, it invites comparison with the best of human geometry provers. It implements most of the effective methods for geometric reasoning introduced in the past twenty years, including the deductive base method, Wu's method, the area method, the Groebner basis method, the vector method, and the full-angle method. With these methods, users may automated prove geometry theorems, to discover new properties of theorems, and to generate readable proofs for many geometry theorems.

MXP supports the concept of dynamic visual models, that is, models built by computer software that can be changed dynamically. With MXP, we can build four classes of dynamic visual models: geometric transformations, loci generation, diagrams of functions, and loci generation.

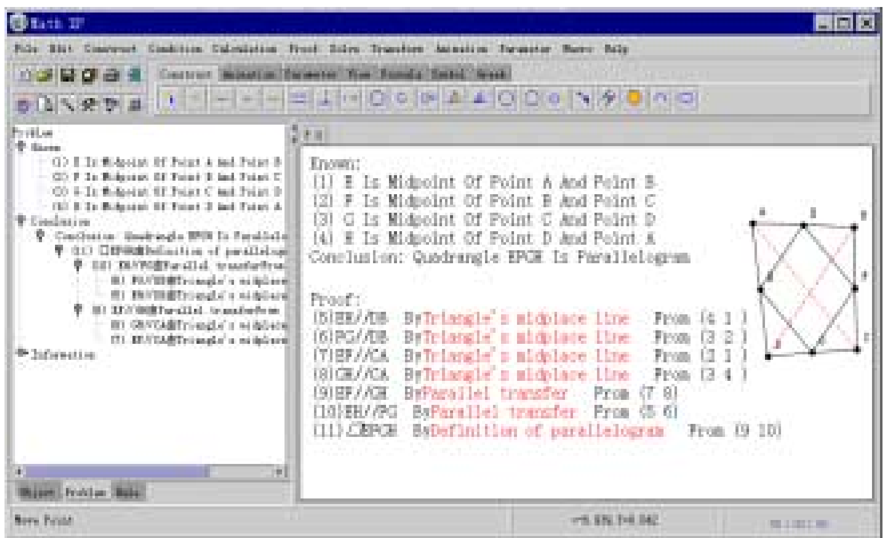

Fig. 5. The proof of the example in Figure 3

4 The VEGA Education Grid

The current MXP software is implemented with Java on the PC platform, as a stand-alone software system. As such, it encounters several challenges:

- **The Interconnect Problem**. The current MXP system considered network support (e.g., using Java to code the system). But, it is no trivial matter to enable application-level connectivity among people and machines to build a grid-based learning community.
- **The Performance Problem**. The performance and functionality of MXP is limited by a user's PC (e.g., a user cannot perform large-scale factorization). Although there may be much powerful resources on a grid, we lack the means to share them.
- **The Intellectual Property Problem**. As a standalone PC software, MXP is easy target for piracy. Any third-party add-on, either software or knowledge base, is also susceptible to this problem.

To solve these problems, we are developing a Vega Education Grid system (VEG). Its architecture is shown in Figure 6, based on the Vega Grid architecture in Figure 2.

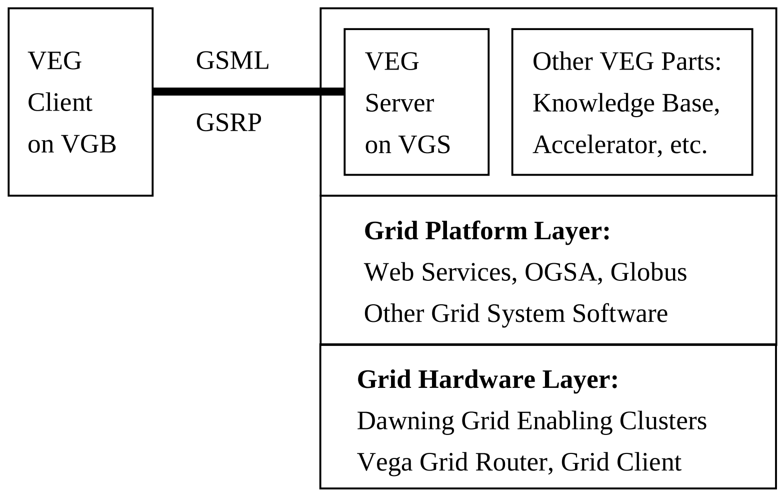

Fig. 6. The Vega Education Grid (VEG) Architecture

The interconnect problem is challenging, because it involves building communities (see Table 2) among students, teachers, machines. The latter include hardware, software and knowledge base on a grid platform. The parties involved have different knowledge structures and different ways of communication.

Table 2. Parties in a Web-Based Learning Community

Parties Involved	Student	Teacher	Machine (Grid)
Student	S2S	S2T	S2M
Teacher	T2S	T2T	T2M
Machine (Grid)	M2S	M2T	M2M

Two Vega Grid technologies, the Vega Grid Browser (VGB) and the GSML, play an important role in helping solve the interconnect problem. The VEG client is more powerful than a traditional Web browser, as it must provide graphic, interactive functions needed by the MXP, and it needs peer-to-peer functions to support S2S, S2T, T2S and T2T interactions. The GSML language provides a means for students and teachers to add knowledge and services to the Vega Education Grid, without programming.

The Vega Education Grid is equipped with a transparent, resource sharing interface, allowing "out-sourcing" computation tasks and knowledge base queries to powerful back-end servers as well as client-side machines. This helps solve the performance problem.

Another feature of Vega Grid, called *dynamic deployment*, helps alleviate the intellectual property problem. The VEG client, although contains most software of MXP, is not a standalone system anymore. It must be connected to the grid to function properly. At boot time and runtime, essential modules of MXP are transparently loaded via the VEG server into a client machine's memory through the Internet. These modules are not stored into the disk file system of the client machine, even when the VEG client exits. We have successfully implemented such dynamic deployment system for operating system kernel level mandatory access control. Initial experiments show that such dynamic deployment only takes a few seconds.

5 Conclusion

In this paper, we described research progress of the Vega Grid project and the Math Experience (MXP) project. We identified three challenges of standalone education software, and proposed a Vega Education Grid architecture to help solve the problems. The Vega Grid project has implemented a running prototype, and some Vega technology (e.g., the resource monitoring system) has been deployed in field applications. The MXP project has produced a stable software system in Chinese version, and a preliminary English version of the software is available for download at http://www.acailab.com/. The Vega Education Grid is under development.

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Experiences in Running a Flexible, Web-Based, and Self-Paced Course*

Francis Y.L. Chin, C.K.M. Wong** and V. Mak

Department of Computer Science and Information Systems
The University of Hong Kong
{chin,ckmwong,vmak}@csis.hku.hk

Abstract. With the advancement of computer and Internet technologies, web-based teaching and learning is an emerging mode of study. The *Pervasive and Interactive Learning System (PI-Learning)* is developed from the experience of running the broadening course, *Foundations to Information Technology (FIT)* at the University of Hong Kong. FIT is a self-paced course catered for thousands of students with different backgrounds, capabilities and expectations, under different time and venue. PI-learning supports to the running of the FIT course.
This paper describes how the FIT courses run, and how PI-Learning supports the most effective and most economical way of running the course. In particular, we describe how different features of the Internet facilitate different modes of learning and teaching to cater to the different needs of the students, how the course notes are linked with the assessments, how the assessment system is used for monitoring students' progress, our experiences and future development in running the course, and finally, the essential factors to run this type of courses successfully.
Keywords: Distance Learning, Web-based Learning.

1 Introduction

Traditional teaching and learning takes place in schools or universities, where students travel to attend classes and meet teachers for discussions. The interactions between teachers and students are *synchronous* [1], i.e., they can give immediate responses to the other parties. This mode has been used for thousands of years and is still the main education model used around the world. The major disadvantage of this mode is that classes are delivered in a pre-set order, venue and time; a student cannot re-attend a class if he/she misses it.

Computer and Internet technologies introduce another mode of study - distance learning. The distributed nature of the Internet allows students to have better access to up-to-date course materials [4,5,6]. The distance learning model is specially developed to cater for the needs of students who do not have time to attend regular classes (e.g., part-time students having a full-time job), or are

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** Corresponding author. Tel.: +852-2241-5137.

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geographically located far away from the institutes (e.g., attending courses offered by overseas universities). Teachers and students may not meet each other throughout the whole course. In addition to books, materials are delivered in the form of video-tapes, CD-ROMs, webpages, etc. and students and teachers interact through video-conferencing or emails. The drawback of this model is that the responses are *asynchronous* - students may need to wait for replies from teachers, which makes the direct interaction difficult and teaching and learning less effective.

The FIT course is a broadening course on Information Technology offered to all students at the University of Hong Kong. To take advantage of both approaches and to cater to the various needs of students effectively and economically, the course was designed to run in a hybrid mode - both physical meetings and distance learning are used. On one hand, the course is most *effectively* run because it offers a range of study choices to different types of students - from a mostly passive self-paced course to a mostly proactive course with one-to-one tutorials and guidance. On the other hand, this course is most *economically* run because students can flexibly get what they need, from mass education to individual tutoring, and none of the services will be wasted. To support the running of this course, a web-based system was developed.

There are many web-based teaching and learning systems in the market, which also have features and tools suitable for our course. However, none of them can provide easy customization to fit the total needs of the course. In view of this and the uncertainty of future needs, PI-Learning was developed even though most features in PI-Learning are also available in other web-based teaching and learning systems.

The organization of this paper is as follows. Section 2 briefly describes the objectives of the FIT course and different modes of study. Section 3 is about some specific features of the PI-Learning system. Section 4 contains experiences in running this course, and finally, Section 5 concludes.

2 The FIT Course

2.1 Required Features

The FIT course was first introduced to students in the academic year 1998-1999. It aimed to ascertain that students had acquired an acceptable level of proficiency in Information Technology to enable them to benefit from their university education, and be well-equipped for their career after graduation. There are more than two thousand students enrolled in the course in each academic year. The course attempts to bring these students with different computer backgrounds to the same minimum acceptable level of IT proficiency.

The main requirement of this course is *flexibility*. Students are expected to learn at their own pace, depending on their capabilities, backgrounds and expectations. Some may need a lot of help, encouragement and guidance while others may need minimal help. Students can choose their own study sequences which suit their course of study. For example, a student who has learnt document processing previously may spend less time on that section of the course. Students can also arrange the study sequences according to their own needs, for example, a student may choose to learn to write webpages first in order to do an assignment for another course, before learning a tool for presentation.

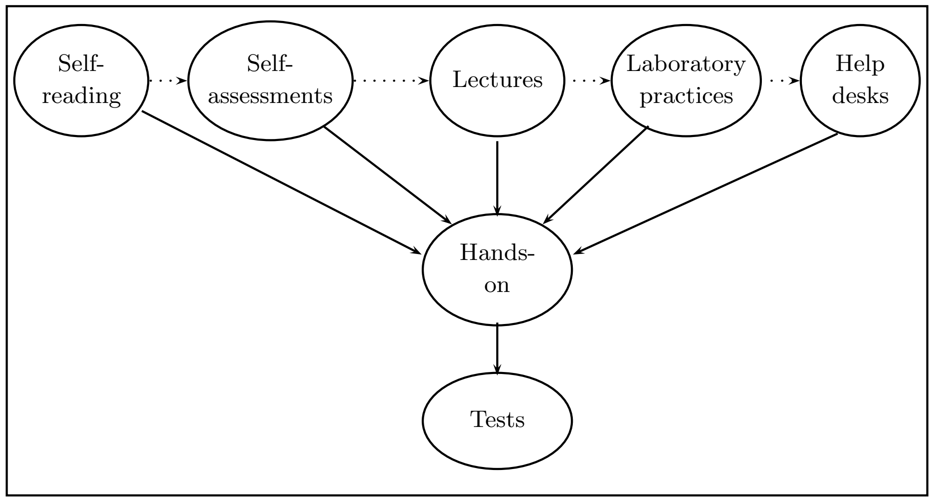
The assessment procedure also incorporates this flexibility characteristic. Each student needs to pass some tests, but the tests can be taken anytime throughout the semester. This assessment procedure also provides a monitoring mechanism for the tutors to identify those students who need special attention.

In addition, the course is intended to be a *self-learnt* course. By reading the course notes and following the steps in the handouts, students should be able to understand the materials without going to *all* lectures and laboratory practices - they can selectively attend classes or seek special help according to their strengths and weaknesses. Communication channels are provided such that students can easily seek help when they encounter problems. In this way, students are not only learning the materials covered in the course, they are *learning to learn*. This is a life-long skill and is applicable to other subjects and fields as well. The course should be able to effectively and economically provide these features.

2.2 Teaching and Learning Modes

Due to the unique course aim, the teaching mode of FIT is very different from other courses in the University. The course is divided into six modules, each focuses on different important aspects of Information Technology, such as networking, web publishing, word processing, spreadsheets, presentation tools and computer security. The modular approach of this course provides the flexibility for students to "pick and drop" difficult aspects of IT in any sequence of learning. The teaching and learning process consists of several components to suit students' needs:

Self-reading and self-assessments. The course materials of each module are presented with interactive multimedia animations and movies for students to learn through self-reading. The course materials contain a lot of examples and self-assessments for students' self-practice. The materials are easily accessible by students and are updated each semester.
In the FIT course, each module has self-assessment exercises for students to check whether they have fully understood the course materials of that particular module. The questions are designed to accurately assess the knowledge of students. The questions also contain some feedback mechanisms to direct students for further revision if the assessment results are not satisfactory.



Lectures. The course offers lectures. Lectures focus on the theory part of the course materials. The mode of holding lectures is different from traditional courses. Since students are expected to learn most of the materials by themselves, attending lectures is totally voluntary. To provide the greatest flexibility, the same class on a topic is held more than once, so that students with different class schedules should be able to attend one lecture without time conflict. Also, they can re-attend any lecture again at a different time if necessary.

Laboratory practices. Laboratory practices focus on teaching practical computer usage. During lab sessions, students attempt exercises under close supervision of teachers.

The mode of holding laboratory practices is similar to that of lectures. The main difference is that lab sessions are held throughout the semester, but lectures are conducted only in the first half of the semester. This means that students can decide their own study sequences according to their interests and needs. This approach completely fulfills the self-paced and self-learnt aim of the course.

Help desks. In a self-learnt course, it is vital that students can easily seek help when they encounter problems. Tutoring is in the form of help desks. Students can contact teachers through the course telephone hotline, email and discussion group. They can also come in person to meet tutors directly. While hotline, email and consultation hours serve individual student needs, the discussion group is a public channel which benefits the whole class and saves resources. The reason is that many students may want to ask the same question and, instead of explaining the answer to each of them separately, all students can read the posted answer in the discussion group.

Tests. There is no predefined order in attempting the module tests. Students can freely choose their own test sequences themselves. In addition, many test sessions are provided at various time of the day throughout the semester.

Each student is allowed 3 attempts for each test - if he/she failed previously, the test can be taken again but marks will be deducted. Questions in the tests are randomly drawn from a large pool, so that students will be answering different questions in their second or third attempt.

Monitoring. In order to monitor each student's progress in the course, individual student profiles are kept. Teachers can check whether a particular student has studied the notes, taken the self-assessments or passed any tests. For students who have not actively practiced self-learning, teachers will remind them through emails and/or telephone calls for the extreme cases.

To accomplish all the above, the course needs the support of a web-based system. The reasons are as follows:

Hosting of course materials. Since the notes should be easily accessible by students, the best approach is to deliver the materials through the Internet. By using the Web, students can read the notes anywhere - at home, in the campus or even in cyber-cafes. In addition, the notes are updated periodically to reflect the advancement of technology. By using an online system, the updated notes are automatically available to the students.

Management of self-assessments and tests. Due to the course's large enrollment figure, it would take much time and effort for teachers to mark all the self-assessments and tests manually. The system should be able to automark the questions and give instant feedback to students, so that they do not have to wait for the teachers to finish marking. An interactive system is needed for immediate responses.

Monitor students' progress in the course. To monitor the progress of each student, teachers need to keep record of notes they have studied and their assessment history. These records will change whenever students read course materials and work on assessment questions. Using a web-based system, students' actions can be easily captured and teachers can retrieve the list anytime they want.

Online reservation of laboratory practices and tests. Since students are allowed to choose the time slots for laboratory practices and tests, reservation functions are needed in order to control the number of students in each session, as the number of seats in the laboratory is limited. An online system can let students make reservation whenever they are connected to the Internet and can immediately update the sessions' reservation quota.

3 The PI-Learning System

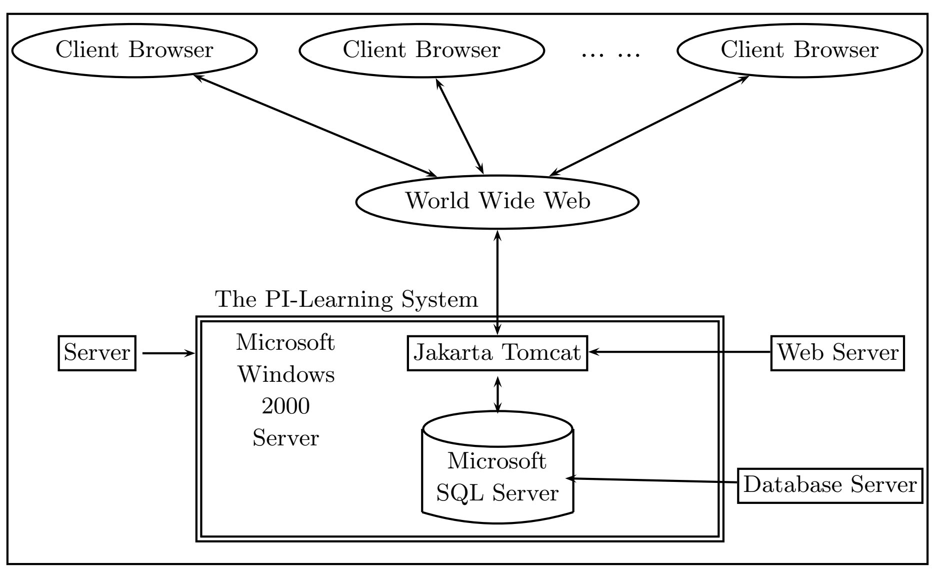
The PI-Learning System was developed to support the FIT course. The main purpose of it is *not to replace but to supplement classroom teaching*. It contains some common functions other similar systems have, and some specially designed for the course. How it facilitates the running of the course is described below.

3.1 System Architecture

The PI-Learning System was developed using the Java technologies. Due to the platform-independent characteristic of Java, the system can be used on different platforms without rewriting all the code. Currently, the system is hosted in a Microsoft Windows 2000 Server with dual CPUs, using the Jakarta Tomcat web server and Microsoft SQL database server.

At the client side, teachers and students need only a browser (either Internet Explorer or Netscape Navigator) to access the system. To them, the system is simply a collection of dynamic web pages which response to their requests. The major advantage of this model is that users do not need to install additional software packages in order to access the system. Any modifications on system functions is done at the server side only, users do not need to do anything in order to use an upgraded version of the system.

An overview of the interactions between users and the system is as follows:



3.2 System Functions

Course materials' organization. Course materials are in the form of web pages. They can contain anything that can viewed by browsers - text, graphics, animations, sound, movies and interactive exercises. Teachers upload course materials to the system and organize them into different modules, sections and levels. Students can access the course materials as long as they have access to the Internet.

Discussion group. Teachers and students participate in discussions through the online discussion group. By using this function, students voice their opinions about the course and ask questions about the materials they find unclear. Teachers make announcements in the discussion group.

Progress monitoring. At any time, teachers can request the system to produce a list of students who have not been actively accessing the course materials, doing self-assessments and reserving seats for laboratory practices and tests. Teachers then send emails to prompt the students, reminding them to keep up and prepare for tests. Students are kept informed of their tests' performances, so that they can schedule their time to prepare for tests and/or re-takes accordingly.

Self-assessments. Teachers create questions - in the form of multiple-choice, true or false, and fill-in-the-blanks questions - and arrange them as self-assessments. The system automatically marks the questions once the students finish the tests. This feature saves teachers' time in marking, and provides instant feedback to students about their performances.

Online tests. Similar to self-assessments, teachers create tests through the system. Whenever a test is loaded, the questions are randomly drawn from some question pools pre-set by teachers. In addition to the three question types as in self-assessments, there is one more type for tests - instruction type. Students will be asked to do some tasks using the computer (e.g. send an email or format a Microsoft Word document), but teachers need to mark these questions manually.

Online reservation. The tool is especially designed for the course to provide flexibility to students. They can reserve laboratory practice and test sessions, and teachers can check the booking status of labs and tests. By checking the booking status of labs and tests, teachers will open more sessions for labs that have higher demand and vice versa, and more test sessions when many students have not yet passed the tests.

3.3 Future Development

Besides these functions, the following are under development to enhance PI-Learning. They are developed from the experience of running the course and can be used in other courses/universities.

Linkage between course materials and assessments. Teachers can link up course materials with tests easily. Whenever students fail to answer a particular question, the system will give them guidance on the portion of notes to revise again. This prevents students from wasting time looking for the materials to which the question relates.

Adaptive assessments. Intelligence was built into the system to cater for individual students' standards and needs. Each time a student takes a test, the system analyzes his/her past performance and draws questions accordingly. If the student is less familiar with the content, or has not taken the test before, easier questions are drawn, otherwise, he/she will need to answer more difficult questions. This mechanism keeps track of the standard each individual student has achieved, and, based on this information, adjusts the level of difficulty accordingly. The time spent on the assessments depends on the capabilities of the student. Hopefully, all of them can eventually attain the same level of proficiency.

Mobile learning. The main drawback of web-based learning is that students need to have access to a computer and the Internet in order to read notes or take assessments. To cope with this, PI-Learning supports downloading notes and assessments onto PDAs. In this way, the learning process can take place anywhere. As PDAs become more and more popular, mobile learning is definitely the future trend.

These functions are expected to be finished by summer 2002 and will be put to use in the coming academic year.

4 Experience of Running FIT

The FIT course has been running for four years. At the end of each semester, students are asked to fill in a survey about the course and the results are mostly positive. This section discusses some of the feedback from students and the problems we have encountered. We will also discuss what we find essential for web-based teaching and learning.

Online delivery of course materials. Although the Internet is a popular and easily accessible medium, students still prefer to read hard copies of notes. The reason is that they find that reading through the monitor is tiring. In addition, connecting to the Internet costs money and takes a long time before they can read every single page. Also, it is found that animations makes the notes more interesting, but text version containing the information inside these data files should be provided for revision purpose. ***Thus, for web-based learning to be attractive, we must provide online materials that are interesting, like interactive animation, accompanied with materials for students' revision.*** Students can thus experience something more than just plain reading online.

In the current academic year, CD-ROMs with the whole set of notes and a printable version is delivered to students. However, the sales figure of the CD-ROMs is only about 25% of the total number of students. This shows that CD-ROMs may not be the best way to deliver the materials. The ideal delivery method of course materials still needs further investigation.

Furthermore, frequent update and maintenance of the course materials are needed, so that students can have access to the most up-to-date version. This aligns with previous findings of other researchers [2].

Application of course materials. The usefulness or relevance of the course materials in the students' daily lives is also an important factor. Some students may find some topics of not much use in their daily lives and hence are not so eager to read such topics by themselves. For example, some students reflect that learning image editing software is not useful for them. Thus, learning must be motivated by the students' interest in the topics.

Moreover, students must be given opportunity to apply what they have learnt. The course materials taught must integrate with their normal learning environment. For example, students show more interest in learning presentation software when they are given chances to use such software to give presentations in their own major subjects. ***Cooperation with Faculties to understand student needs is a key to success.***

Self-learning mode of the course. The attendances of lectures and laboratory practices are around 30% of the total enrollment figure, whereas the failure rate of the course is about 10%. The main reason why students fail is because they cannot keep up with the progress, but some may even never attempt any tests. Therefore, the 10% failure rate should not be used to measure the success of the system. The attendance and failure rates show that most students are able to learn the course materials by themselves without coming to lectures and labs.

However, in each semester, there are always a small portion of students (about 1%) who require a lot of attention and encouragement in order to pass the course. This figure is very low when compared to those who do not need help at all. Thus, the resources required to run this course is much less than that needed for traditional courses. ***Nonetheless it shows that assistance is essential as a supplement for a web-based course to be successful.***

Flexibility of study and test sequences. Students appreciated the flexibility the course provides very much, since they can attend labs and tests according to their abilities and time-tables. They also find it convenient to reserve a seat through the system. Moreover, the multiple attempts for tests lessen students' study pressure, as they are given more chances to fulfill the requirements of the course.

Occasionally, problems arise when some lab and test time slots prove more popular than others (e.g. weekday lunch time's sessions are more popular than those on Saturday mornings), where other sessions are far from full. As a consequence, the average attendance rate of labs and test sessions are around 50%. ***This reflects that more resources are required in order to provided flexibility to students.***

Various communication channels. The web-based learning system must be supported by some communication channels. For the FIT course, students can contact the teachers easily when they need help. We find that for urgent matters, they prefer to use the telephone hotline, and they use emails and discussion group for the rest. ***This shows that traditional direct communication channels are still needed.*** We also find that the usage of the chatroom is very low. The chatroom was designed to provide interactions with teachers. However, students are online usually after office hours when teachers are not online. This may explain the low usage and why students choose other channels for communication. This agrees with other studies on the same topic [3].

In general, students participate quite actively in the discussion group and nearly all of the discussions are initiated by students. However, discussions among themselves are very rare. Students are mainly using the communication channel to ask teachers questions. Only a few students will really respond to other people's questions even if they know the answers. ***This shows that more encouragement are needed for students to participate in discussion groups.***

Computerized tests. The FIT tests contain two part - a theory section consisting of multiple-choices, true or false and fill-in-the-blanks questions, and a practical section with instruction type questions. Students can view the theory section results once they have finished the tests, but need to wait for teachers to mark and release the practical section's results.
The only complaint from students about taking tests through computers is that they found reading on screen tiring. ***However, most of the students find this mode of assessment acceptable.***

5 Conclusion and Future Investigations

The running of the FIT course is based on an innovative education model. Both distance learning and traditional teaching modes are used. Students are expected to learn by themselves at their own pace. They are the initiators in the teaching and learning process, whereas the main role of teachers is to provide guidance and to monitor their progress. To facilitate the successful execution of this model, a web-based teaching and learning platform is needed.

This lead to the development of the PI-Learning System. For students, it is a place for them to read notes, discuss and reserve lab sessions; for teachers, it is a course management tool with monitoring and test functions. The use of the system saves manpower and time. Each semester, thousands of students are enrolled in the course but the teaching and technical team consists of a total of 10 persons only. Without the system, it would be infeasible to run the course with such a small number of staff and at the same time provide such a flexible and proactive approach. As a general rule, about 20% students consume 80% of our teaching resources.

Although students respond positively to the self-paced and self-learnt mode of the course, there are some areas which need more investigations - the method to deliver course materials, the way to encourage students to actively participate in online discussions, and how to increase the utilization of laboratory and test sessions. Indeed, only by improving in these aspects can we fully exploit the advantages of the hybrid teaching and learning mode FIT is using.

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Virtual Teaching and Learning Based on Multimedia Techniques: Experiences from a Master Program Delivered over the Internet

Karl Kurbel

VGU - Virtual Global University, School of Business Informatics
and European University Viadrina Frankfurt (Oder), Germany
kurbel@euv-frankfurt-o.de

Abstract: Providing multimedia-based courses over the Internet is a challenging task. Technological requirements are far more exacting than for simple HTML based courses as in traditional web-based teaching. Low-cost multimedia technologies, in particular technologies for video production and delivery over the Internet, have just become available. Established rules and recommendations how to use those technologies effectively are still missing. In this paper, different approaches to the production and delivery of multimedia-based courses are outlined and illustrated by examples. A specific focus is set on videos as the main instructional medium. The examples are taken from real courses that have been produced for an Internet-based study program leading to a master's degree in Business Informatics. This program is provided by a virtual organization. Experiences reported are based on course material for that program. All facets of producing lecture videos require a significantly long phase of learning and getting acquainted with the technology. A learning curve could clearly be observed.

1 Introduction: Is Education Virtual?

The focus of this paper is virtual education and technologies used for that purpose. It is based on experiences from building a virtual study program which is briefly outlined in section 2 below.

The key attributes in the title of this paper, "virtual" and "multimedia", call for some initial remarks. Virtual learning and teaching, virtual classroom [Porter 1997], and virtual university have become common buzzwords in the field of higher education. But what is virtual about it? Teachers preparing and giving courses over the Internet will hardly consider their work as "virtual", but rather as "real" and time-consuming, and students taking these courses will have to do real work and not virtual work to get their degrees.

The original use of the term virtual as it has developed in information systems research and practice referred to organizations as being virtual [Davidow, Malone 1992]: Organizations, or different organizational units from various organizations, network to form a new organization which is not a real one in the legal sense, yet it behaves like a real one.

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Virtual universities seem to match this description to a certain extent. Some of them exist only as virtual organizations, without a legal framework that would establish them as a legal organizational body of its own. Typical examples are combines of universities, institutes or departments that loosely tie up to provide together a number of courses over the Internet [Granow 2001]. In Germany, there are combines like VIROR[1], VHB[2], VIKAR[3], and others.

Another type of virtual universities are real organizations, yet considered "virtual" because their appearance to the outside world is based on the Internet. An example is the Jones International University (JIU)[4], a fully accredited university in the US. JIU is a real university but courses are taught online only.

The third type of virtual universities are organizations which have features of both real and virtual organizations. An example is the Virtual Global University (VGU)[5]. VGU provides distance education over the Internet, carried by a network of partners, but on the other hand it exists as a private limited company in a legal framework as well.

Considering the above arguments it is certainly problematic to speak of "virtual" education. However, we will continue to use that attribute since it has become very common regardless of its appropriateness. Under the term "virtual education" (likewise, virtual learning, virtual teaching) we will summarize all types of education which use the Internet as the main carrier for content and as the main basis for communication. This includes communication between and among all parties involved in higher education processes -- students, teachers, and administration.

Somewhat easier is the definition of multimedia technologies for Internet-based education. Multimedia nowadays refers to electronic media, of course. Multimedia technologies in the following are technologies for creating, storing and providing text-based information (like HTML pages), still pictures (graphics), sound (audio tracks), moving pictures (video tracks), and combinations of those.

The subsequent sections of this paper are organized as follows: Section 2 describes the background of the work reported here, an Internet-based master program provided by virtual organization. In section 3, the multimedia technologies used in that program are discussed and illustrated by means of real examples. Section 4 covers production and delivery of video-based courses as the technologically most advanced form of instruction. Section 5 summarizes our experiences with multimedia technologies in virtual education.

2 Background of the Work

The work reported in this paper is based on experiences from planning and conducting a virtual master program in Business Informatics. This program was developed

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[1] VIROR = Virtuelle Hochschule Oberrhein; http://www.aifb.uni-karlsruhe.de/viror .

[2] VHB = Virtuelle Hochschule Bayern; http://www.vhb.org .

[3] VIKAR = Virtueller Hochschulverbund Karlsruhe; http://vikar.ira.uka.de .

[4] JIU: http://www.jonesinternational.edu .

[5] VGU: http://www.vg-u.org .

by the Virtual Global University (VGU), an organization founded by 17 professors of Business Informatics from Germany, Austria and Switzerland [Kurbel 2000]. It is offered worldwide, leading to the degree of an "International Master of Business Informatics" (MBI).

VGU is a private virtual organization. VGU would not have been able to award an officially recognized master's degree by itself. Instead a cooperation agreement with a "real" state university was established. This partner university is the European University Viadrina (EUV) in Frankfurt (Oder), Germany.

While VGU provides expertise and teaching for the program, EUV is responsible for ensuring that the academic and educational standards of the program are maintained at an appropriate level. Ordinances, rules, and regulations for virtual MBI students are equivalent to those for students of EUV's regular face-to-face programs. This cooperation ensures that the master's degree awarded is an official degree fully recognized by German state law.

3 Multimedia Techniques Employed in the MBI Program

Many courses and programs in today's virtual education are still text and paper based. We will refer to those as "traditional" virtual courses and programs. In the United States, for example, a large number of virtual educational offers is available but the vast majority of those offers is traditional in this respect. In Europe, more advanced multimedia technologies for higher education have been investigated in research projects and prototypical courses over the past 10 years [e.g. Bodendorf, Grebner 1998]. Advanced tools for cooperative work are also being investigated [Kloeckner 2001].

For the master program underlying this paper, multimedia technologies above the text-based level were intended to play a major role in the instructional design. The technologies for the MBI courses were chosen depending on the type and on the content of a course. The following instruction modes are used.

3.1 Video Courses

Our first trials to approximate the look and feel of a real lecture in a real classroom were videos taken in a lecture hall and provided for viewing. With powerful video processing and encoding tools (like Media Studio Pro[6], Windows Media Encoder[7]) and easy-to-download video players (e.g. Windows Media Player[8], RealPlayer[9]) available today, video recordings were the primary choice as media type for MBI courses. Watching a lecture recorded in a real or simulated classroom comes close to

6 http://www.ulead.com/msp .
7 http://www.microsoft.com/windows/windowsmedia .
8 http://www.microsoft.com/windows/windowsmedia .
9 http://www.real.com .

listening to a real lecture. Slides, blackboard writings and other types of illustrations are recorded along with the speaker.

Video files are not downloaded completely before playing but transmitted in a streaming format. This is clearly an advantage since video files tend to be very large. However, even with a streaming format severe restrictions regarding the data transmission rate are in effect (see section 4). Therefore the size of a video window is normally kept small so that the file to be shown will need less space and the audio and video quality finally reaching the viewer is still acceptable.

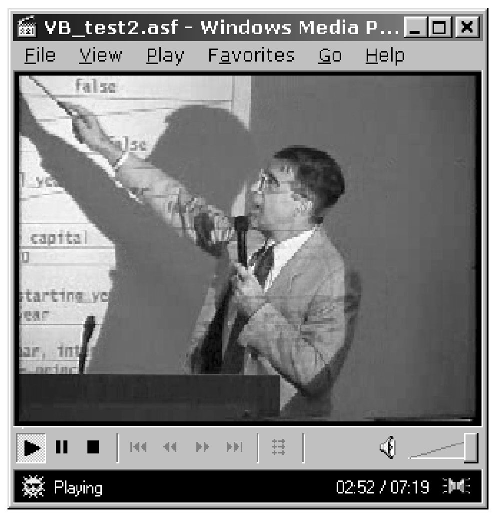

Fig. 1. Demo of a recorded lecture video[10]

The limited size of the window on the monitor's screen is a problem when both the person giving the lecture and the material used for illustration are recorded in one video. While a small window of, say, 9 x 6 cm, is sufficient to see (and hear) the speaker explaining things, it may be to small to allow the user to recognize what is written on the transparencies. For transparencies with large fonts like in figure 1, the one-window approach may still be all right. However, when online computer screens are recorded in this way, nothing will be readable for the viewer any more.

3.2 Multimedia Courses Based on Video plus Presentation Material

The aforementioned problem can be avoided if the person giving the lecture and the material used for illustration are presented separately. Production of this type of video is more complicated since now the two components need to be synchronized. The video showing the speaker is recorded by a digital camera. If the camera is not a

[10] The figure shows Prof. Dr. Karl Kurbel, European University Viadrina Frankfurt (Oder), Germany.

digital one, the analogous recording has to be digitalized afterwards for further processing.

When computerized presentations are used, for example Powerpoint slides, a different technique for recording the presentation material can be employed. Since slides do not move like a person speaking does nor change continuously, they can be converted to GIF files. Tools to do so automatically are available today. Since GIF files are smaller than videos, less bandwidth is needed. In return the window size on the screen can be increased significantly.

If a realtime program presentation, for example a demo of a CASE tool or an ERP system, is shown and discussed by the lecturer, a video containing the presentation material can be recorded by means of a screen recorder (e.g. ScreenCorder[11]).

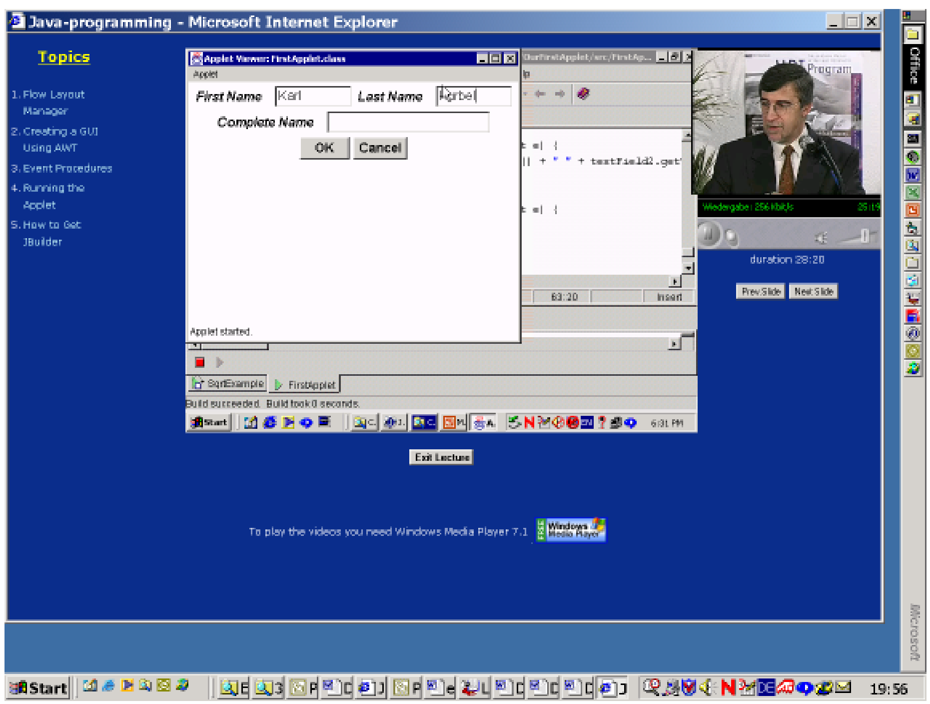

Fig. 2. Video with online screen recording[12]

Figure 2 shows a screendump of a video-based course from the MBI program where both the lecturer and the presentation material are recorded and played in separate windows.

[11] http://www.matchware.net/screencorder2/default.htm .
[12] Showing Prof. Dr. Karl Kurbel in the MBI course "Java Programming".

3.3 Audio-Based Courses with Presentation Material

Video production is a non-trivial task requiring experience and plenty of time. Low transmission rates are hampering delivery of videos over the Internet. One way to bypass part of these problems is to use only an audio track instead of an audio-visual presentation of the speaker on the screen. Sound can be used nicely in combination with Powerpoint slides or other presentations to form something like a "narrated slide show". Like in a real classroom, the speaker explains the things illustrated on transparency or slide; however, he or she is not visible.

This is clearly less "lively" than a video accompanying the presentation material but a lot easier to produce. Figure 3 illustrates this approach by a screendump from another MBI course (for obvious reasons without sound in the proceedings version). The lecturer is shown in a picture.

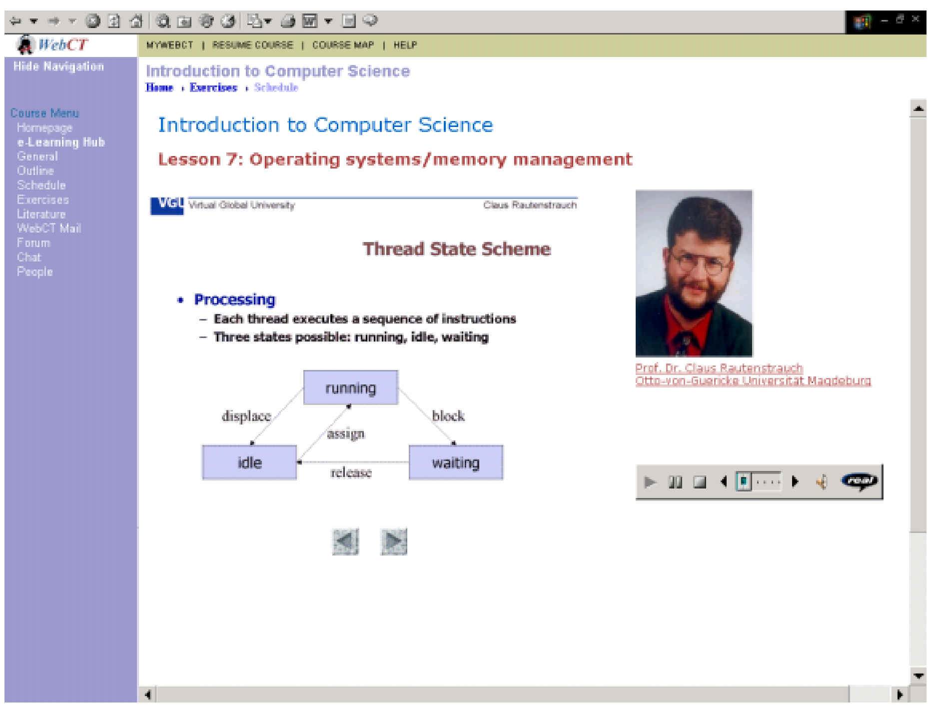

Fig. 3. Audio track and Powerpoint slides[13]

[13] Showing Prof. Dr. Claus Rautenstrauch, University of Magdeburg, Germany, in the MBI course "Introduction to Computer Science".

3.4 Audio-Based Courses with Presentation Material and Text

Just listening to an audio track may be tiring for the viewer. More than in a video-based course, there is some risk that the viewer may miss important points which are discussed by the lecturer but perhaps not stressed sufficiently.

For this reason, audio-based courses can be enhanced by supplementing the lecturer's monologue with text passages transcribing his or her verbal explanations fully or partially. In figure 4, an example from an MBI course employing this technique is given.

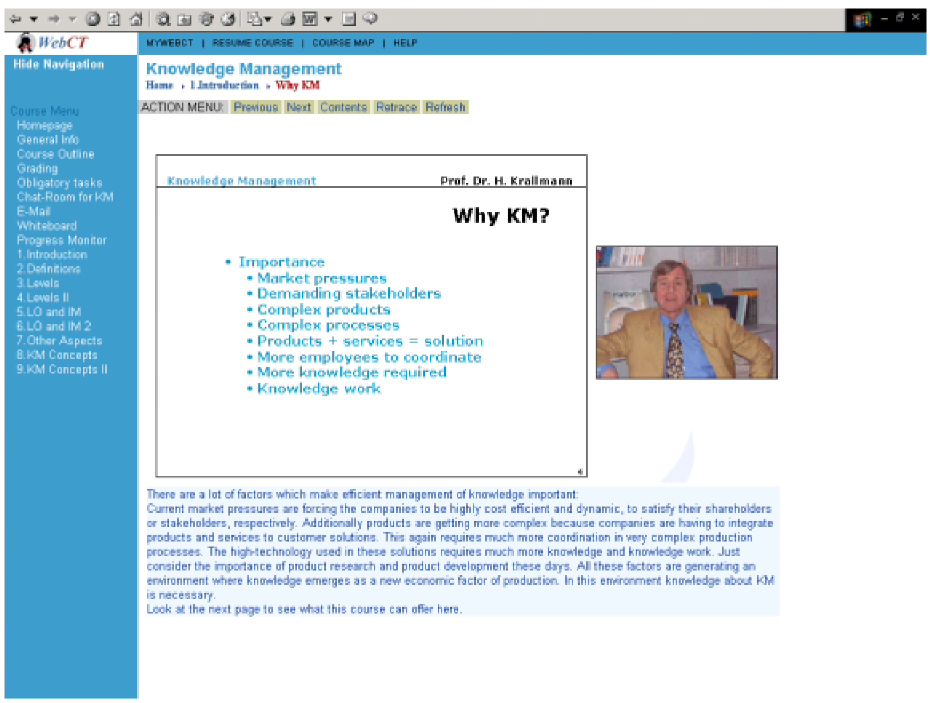

Fig. 4. Audio track, slides, and text annotation[14]

3.5 Hypertext-Based Courses

This type of course follows the traditional text-based approach. Structured course material is used as in a conventional distance education program. However, all material is provided electronically and can be viewed with a browser. Hyperlinks connect text, graphics, and exercises in a meaningful way. Video clips and voice annotations may be included as well. Figure 5 shows a screendump of a hypertext-based course from the MBI program.

[14] Showing Prof. Dr. Hermann Krallmann, Technical University of Berlin, Germany, in the MBI course "Knowledge Management".

3.6 Textbook-Based Courses with Multimedia Techniques Incorporated

An increasing number of textbooks comprises not only written and printed text but also supportive features provided on the website of the author and/or the publisher [for example, Griffin, Ebert 2002; Laudon, Laudon 2002). Nowadays the support goes far beyond additional exercises or examples not given in the book. Some books have a complete learning environment in the Web, providing videos, audio clips, and interactive exercises.

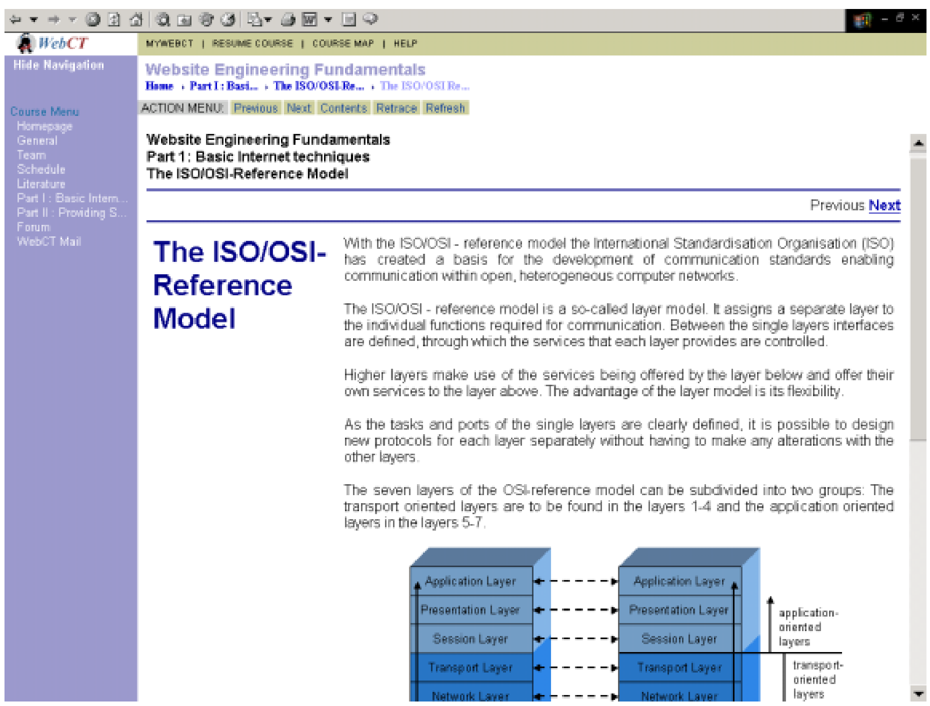

Fig. 5. Text document (HTML)[15]

Selected courses of the MBI program are based on web-supported textbooks, thus enriching the traditional text-based approach to virtual education with built-in multimedia features.

4 Producing Video-Based Courses for Delivery over the Internet

Since video-based courses are the technologically most advanced ones in VGU's multimedia mix for the MBI program, we will take a closer look at how to make

[15] Material by Prof. Dr. Stefan Eicker, University of Essen, Germany, from MBI course "Website Engineering Fundamentals".

lectures available on video for a global audience. The fact that students can be distributed worldwide implies not only different time zones but also a variety of different qualities of Internet access. Some people have very fast access but others have to cope with slow dial-up connections.

As a consequence, unless everybody is served with the smallest common denominator (i.e. the least audio and video quality), different versions of the lecture videos have to be designed for different target groups. For VGU's video-based courses the following categories of users are considered.

4.1 Fast Internet Access

The best video and audio quality is obtained by viewers who have an Internet connection of at least 300 kbps (kilobit per second). This is the case with ADSL (asymmetric digital subscriber line) or with computers directly connected to a network by dedicated lines and a LAN (local area network); e.g. in large companies, universities, and the public administration sector.

Normally videos operate with 25 fps. However, through trial and error and during a long learning phase, we found that a frame rate of 12 fps (frames per second) is the best compromise between quality and bandwidth requirements, maintaining both clear focus and smoothness of the lecturer's movements. The screenshot of figure 2 above was taken from a video with these settings.

4.2 Fairly Fast Internet Access

Users with an Internet connection of above 100 kbps are served with a video version that provides still fairly good video quality; however, some mistakes from automatic compression may show. For example, when the lecturer moves fast, the quality of the video decreases. In the worst case (very fast movements), the video may even exhibit small gaps.

The quality of presentation material accompanying the video is not effected. Since mostly GIF files are used, the resolution can be kept at 240 x 180 pixels as in the previous version for 300 kbps.

4.3 Moderate Internet Access

This video version is for students who have an ISDN (integrated services digital network) connection to the Internet, i.e. a transmission rate of 64 kbps. The video quality is a little below the 100 kbps version but still on an acceptable level. Sensitivity against fast changes of the pictures (e.g. moves of the lecturer) is the same as in the 100 kbps version.

Some reduction in size had to be put into effect regarding the window for presentation material. Powerpoint slides and other material is now displayed at a resolution of 176 x 132 pixels only.

4.4 Slow Internet Access

In order to serve persons with a modem dial-up connection, low-end videos with fewer frames per second, 8 fps, are produced. Although this is only one third of the frame rate of normal Internet videos, the visual appearance is still reasonable if no rapid changes of the pictures occur. Since a lecturer normally stands or sits at a desk but does not jump around when he or she is being recorded, the effect of reducing the frame rate is merely that movements appear slowed down or with delay. The modem speed expected for this version is 56 kbps.

4.5 Very Slow Internet Access

It may be questioned if multimedia-based courses make sense for students who can access the Internet only through a 34 kbps modem -- and how long such connections will survive. However, there are major parts of the world where this type of Internet connection will continue to exist (or yet come into existence).

In our experiments we found the solution to be similar to the variant described in section 3.3 (audio-based courses with presentation material). By giving up the video component in favor of an audio track we achieved a version with very good quality of sound and presentation material. Although the user is expected to have at least 28 kbps available, this type of course runs even with a transmission rate of 16 kbps.

5 Experiences and Conclusions

Since multimedia technologies at low cost or even for free have just recently become available, reliable experiences and recommendations how to use them are still lacking. Therefore the settings chosen for the above video versions had to be largely gained from trial and error. The same is true for specific tools employed. For example, our video versions are being compressed with the Microsoft Media Video V8 codec. As an alternative, the MPEG-4 V3 codec might be considered. The quality achieved with either codec appeared to be the same at first sight. However, after some trials we found specific parameter settings that gave the Microsoft Media Video V8 codec a clear advantage over MPEG-4.

All facets of producing lecture videos require a significantly long phase of learning and getting acquainted with the technology. A learning curve could clearly be observed. In the beginning of our efforts, the time to produce a sequence of video and audio material for a 90-minute lecture took about one week elapsed time after the video had been recorded, keeping two persons completely engaged. After one year of production and hands-on experience with videos, this time has decreased to two days (still keeping two people occupied).

The multimedia versions outlined above were tested and tried from locations all over the world. The ADSL version basically ran without problems in Germany. It was possible to view the ISDN version in locations in the Middle East (Dubai) and in India, for example. Slow access versions were available all over the world. The author saw the slow-access version (56 kbps) in a normal home in a mid-size town of Central

India and was able to listen to the low-end version (28 kpbs), in good audio quality, in a small village of the same area. Nevertheless, coping with small bandwidths and keeping quality at an acceptable level at the same time is a matter of trade-offs.

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Experiences in Developing a Large-Scale School IT Project: Processes, Outcomes, and Issues

John Barrett, Nadia Hing-Wah Ng, and Kathy Edwards

City University of Hong Kong

Abstract. This paper proceeds from the products, processes, and experiences associated with developing customised courseware, learning tools, and Web sites for a large-scale educational multimedia project to discuss issues of likely concern to others engaged in achieving educational innovation and support through IT development. The two and a half year project - a cooperative venture between two Hong Kong secondary schools to promote the use of IT for teaching and learning by providing the necessary technology, educational materials, and support environment - was supported with expertise from the City University of Hong Kong and conducted under the Hong Kong Government's Quality Education Fund scheme. What were the outcomes of such extensive activity? How were the development processes conducted? Are there any significant general issues that need consideration by future developers, educational administrators and teachers, funding bodies, and governments?

1 Introduction – The QEF Project

This paper reports on a cooperative venture between two schools, The Hong Kong School for the Deaf (HKSD) and St. Stephen's Girls' College (SSGC), that combined with City University of Hong Kong (CityU) to promote the appropriate use of IT for teaching and learning by providing the necessary technology and educational materials and support environment. The project group recently implemented a package of on-line materials designed to enhance student learning and Information Technology-related skills. This is the fulfillment of a joint two and a half year project conducted under the Hong Kong Government's Quality Education Fund scheme.[1]

The scope of this extensive project ranged from equipping classrooms with the latest technologies, establishing Web sites and providing online communication technologies to designing and producing customized courseware and tools for learning.

As well as the general advantages claimed for Web-based teaching, the unique features of this co-operative development project include:

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[1] QEF Project EMB/QEF/P/1998/2247: "A Joint Project to Enhance the Use of IT in Teaching and Learning in Secondary Schools through the Development of Intranets, Computerized Courseware, and Student Forums on Internet Web Sites".

J. Fong et al. (Eds.): ICWL 2002, LNCS 2436, pp. 263-274, 2002.

1. A "Joint Project" site that demonstrates the courseware and learning activities, documents the development processes, and provides easy navigation to the separate school sites.
2. Links between the schools, which each administer their own secure Intranet site of courseware and tools (protected by entry requirements).
3. Custom-developed in-house tools designed to address specific learning needs.

In the remainder of this paper, we will detail the building of the sites, courseware, and tools; explain the production arrangements; and raise some important questions that all developers of IT educational projects will face.

2 Web Sites

In the initial stage of production there was one consolidated Production Web Site (http://www.itschools.cityu.edu.hk) having three sub-menus: The QEF Project; Hong Kong School for the Deaf, and St. Stephen's Girls' College. The Project Site (http://www.itschools.cityu.edu.hk/index_qef.html) contains representative material of all produced courseware and all unrestricted documentation, and describes the production processes. It showcases the courseware, tools, and production/ management processes for teachers, evaluators, and the community at large. It also lists the credits for all involved in content preparation, educational/technical production, and implementation.

As proposed, each school has developed an Internet site:

Hong Kong School for the Deaf http://www.hksfd.edu.hk/courseware/index.html

St. Stephen's Girls' College http://www.ssgc.edu.hk/qef

Establishment of the two school project sites on their separate Intranets was an enhancement allowing for better communication and use of these resources within and between schools. All teaching/ learning materials as explained in the next section of this paper are contained on these sites.

3 Courseware – Custom-Built Materials for Interactive Learning

The resulting interactive courseware cover Chinese Language, English Language, and Mathematics in both schools as well as Sciences (Biology, Physics, Chemistry, Integrated Science) and Art in SSGC.

The site includes highly developed courseware using authoring tools to make dynamic presentations and interactions while incorporating sophisticated multimedia illustrations, animations, audio, video clips and digital photos.

All public documentation including process details and displays of outcomes pertaining to courseware can be found on the Web sites. The project web site http://www.itschools.cityu.edu.hk/courseware.html displays courseware samples for St. Stephen's Girls' College (Chinese, English, Mathematics, Physics, Biology, Chemistry, Integrated Science, and Art Gallery) and Hong Kong School for the Deaf

(Chinese, English, Mathematics) and associated tools for Forum, Quiz, Science Challenge, Lab Skills, and the Physics Game.

The objective of providing courseware for the target subjects in both schools was fully met. The extensive process of focusing the purpose of the courseware in line with the curriculum and student needs and balancing this with innovation, creative ideas and the reality of the development processes, of course meant there would be minor adjustments and operational implementations that were variations on some of the initial ideas, mentioned as examples, in the original proposal. In fact, the goals achieved were more ambitious and innovative than those initially proposed. This was due to ambitious goals and efforts by the teachers, the designers, the production team and the management group in producing quality-learning materials. Adjustments to any initial proposal must be expected and accommodated if innovation is to be encouraged, especially in the application of new technologies to learning environments. One benefit of an approach that fosters creative solutions is the increased knowledge, confidence, and interest of teachers involved in the development process.

4 Learning Tools

A significant outcome of the project was the development of customised learning tools:

- An interactive “Art Gallery” that simulates a walk-through Gallery displaying SSGC student artworks. It includes a search function allowing visitors to "sort" the collection by art medium, by artist, or by form and year.
- A virtual Science Workbench to enhance Lab Skills. This tool was designed to promote scientific thinking and reasoning as students conduct virtual experiments or review laboratory techniques. To more nearly replicate "real" conditions, unexpected results are included in the array of possible outcomes. Photos provide visual prompts to assist recall. Students are encouraged to repeat an experiment to consolidate their understanding of procedures, in contrast to just trying to remember lists of apparatus and “the right” conclusion.
- The Science Challenge is a virtual symposium that currently addresses three important scientific issues facing the community – Alternative Forms of Energy, Genetically Modified Foods, and Laser Eye Treatment. The Challenge environment enables students to assess arguments and counter arguments, to weigh facts/evidence, and to evaluate the reasoning and data presented by various speakers. Students analyze each presentation and rate it against specified criteria. They then rank all the presentations in order of merit. Finally they submit their “consultant's report” to the Commissioner (the teacher). Follow-up discussion on the Web and in-class provides further opportunities to review alternatives and bolster reasoning skills.

4.1 Commercial Tools Adoption

A comprehensive review of commercial learning tools enabled the project team to identify suitable conferencing software that adds Forum type discussion groups to the Art Gallery and to the Physics, Integrated Science, and Biology courseware. These initial forums can be expanded by the schools as new content and new ideas arise.

Similarly, the commercial quiz package QuestionMark “Perception” was incorporated into the schools' intranets to provide a tool for on-line quizzes in any discipline area. A major component of the Physics courseware is a game-like interface specially created and programmed using Perception as its "engine". The Physics Game presents and scores over 1,500 randomized physics questions.

Built on the commercial package Tramline TourMaker, the Biology component provides Web-based tours of Biology topics for Form Four students and above. Topics presented for investigation, exploration, and consolidation include the brain and nerves, the cell, the blood, the gene, energy release, hormone regulation, and skeletal functions in support and movement. The tours of interconnected topics are constructed to link to a wide variety of professionally produced resource materials on the Web, and to encourage students to explore further on their own.

5 Project Development and Implementation

Courseware for both St. Stephen’s Girls’ College and The Hong Kong School for the Deaf progressed through the entire development cycle and is now fully implemented in each school. Although restricted to their respective Intranets, students and staff in each school have full access to this content that is now being widely used and evaluated in the schools.

This section presents a brief summary of the process of courseware development for the QEF project. It is written from the perspective of the producers (i.e., those involved in design, production and implementation) and documents the sequence of courseware development activities, following an established methodology [1] [2].

5.1 Production of Material

Production was concerned with the three major product categories: Web Sites, Courseware, and Tools for Learning.

Producing Web Sites. Design and production of the Project Web Site and the two school Intranet courseware sites was a major undertaking. It involved developing the architecture for navigation and functionality, extensive programming work to build the three sites and applied graphics design and production to deliver an attractive and workable interface.

Nearing completion of the project, the consolidated Production Site was reorganized as three separate sites sharing a common interface design. Each school has its own secure Intranet site and is in full control for management and security.

They also have full control over on-line and network-accessible materials; e.g., test results, e-mail messages, conferencing documents.

Courseware. Courseware for both schools was produced in a dedicated Courseware Development Laboratory (CDL). The CDL houses specialists in programming, database construction, Web construction, interface design and development, graphics and multimedia creation and technical integration. This provided an efficient means of utilizing resources between all required courseware. Production decisions were made about such aspects as the most suitable authoring approach, the 'look, feel and action' of interface elements, how interactivity would be handled, what information would be collected and how it would be stored. The CDL has employed similar conceptual, theoretical foundations and procedures in producing another large-scale project for a simulated environment in Building and Construction technology [3].

In practice, interpreting the design into a functional program, even with the script and storyboard, still proves to be a demanding task. Mixing media, moving data between different elements, and addressing issues of Web functionality (such as speed of presentation) require time and expertise to arrive at a suitable solution and resolution in the actual courseware or tool.

Producing Tools for Learning. As well as producing courseware the project aimed at providing "tools", or application software, to support teaching and learning. Two different development processes took place:

1. In-house production involved design and development of various engines for the learning activities,
2. Application of commercial tools that involved an analysis and selection process, adaptation to local needs, special preparation and input of content and interface customization.

Production Facility. Production of courseware, tools and sites for this QEF Project demanded optimal management of staff expertise, production resources and time - along with a carefully and continually orchestrated "division of labour".

The Courseware Development Laboratory (CDL), Division of Computer Studies, City University of Hong Kong, is a facility dedicated to producing computer-based education material [4]. This covers courseware encompassing programming/ authoring and graphics, educational Web sites and production/configuration of tools. As well as project production tasks, staff work on interpretation of design (i.e. operationally defining storyboards), editing of content or preparation of multimedia elements (e.g. recording and editing audio files) including visual and interface aspects and components such as graphical objects, animation, screen layout, colour arrangements, and interface 'look and feel' consistency.

The lab comprises a team with expertise in the various areas of production. Staff concentrated on two or three courseware areas or site components, especially in programming/authoring. Other areas like graphics and system configuration required expertise to be distributed widely over disciplinary areas, tools and Web sites.

All materials progressed through a managed development cycle of forming designs, building-in an educational focus, creating content and bringing that to Script form then generating the Storyboards. This process formalized content, programming, and interface requirements in their proper relationships and sequence. With materials at least 80% formed, production took place in the CDL.

5.2 The Development Cycle

Depending on the many influences, courseware, tools and the three Web sites generally progressed through the development cycle phases of pre-production, production, and post-production as summarized in Table 1.

Table 1. Development Process Cycle

PHASE	COVERAGE	OUTCOME
PRE-PRODUCTION		
1. DESIGN	Design Concept	Ideas, Metaphor
	Instructional Design	Learning Specifications
	Content Design	Concept Map
	Implementation Needs	Implement Requirements
2. CONTENT	Generate content materials	Edited Content
	Structured Sequences	Diagrams
	Scope (Breadth/ Depth)	Script
	Format/ Media	Media Resources
	Practice etc.	Learning Activities
3. INTERFACE	Flow and Control	Flowcharts
	Input/Navigation	e.g. Outlines
	Interaction	Storyboard
	Functionality	(e.g., “PowerPoint” models)
PRODUCTION		
	Prototype to Operational Model	Resource Editing
	Resource Objects	Style/layout
	Graphics	Graphical elements, Animation
	Media Mixing	Audio/ Video objects
	Authoring	Functional Programs
	Programming	Web and Data elements
	Integration	Functional program
POST-PRODUCTION		
	Review	Feedback for development
	Implementation	Fully operational package
	Follow-up	Minor corrections
	Distribution	Storage, packaging, Versions
	New Proposals	
	Documentation	Project Website reports

In reality, the combination of contextual factors, the variation in the desired nature of computer-based learning experiences and time required in each phase of the cycle for different courseware and the use of multi-skilled team-based development approach resulted in a complex of activity that demanded careful and constant management.

5.3 Teamwork for Development

The "team-based" network model has proved successful over the past 6 years in project development at CityU [5]. It is a co-operative arrangement that uses expertise "at the right time for the right job". In practice the project demanded the expertise in both schools and the CDL to continually add value during the development cycle.

The general educational needs and presentation ideas were jointly fleshed-out in "work-groups" consisting of teachers, instructional designers, and scriptwriters, with occasional but vital input from technical specialists.

Teachers from SSGC and HKSD were the "knowledge providers," drawing upon their unique insight into students' needs and learning requirements. They worked with technical and educational design specialists from the CDL to form the overall design, interface metaphors, interaction requirements and content scripts. The next phase was to produce the storyboard in order to specify programming of the "flow and control" sequences and where interactions where required. This content then needed visual elements to provide interest and perceptual cues and in order to promote visualization during the learning activities. Of course, much effort went into preparing, editing, reviewing and fine-tuning content materials. This whole process applied to 11 disciplinary areas, 4 in-house tools, and mounting the Forum and Quiz. Overall, more than 60 teachers were directly involved with up to 10 design and production staff in producing upwards of 23 sub-projects.

5.4 Management of Projects

This was a large-scale project covering five disciplinary areas distributed between two quite different schools. Also, sub-projects each had special requirements, along with wide variations in content scope and resource availability. Planning development, coordinating production activities, supervising staff, liaising with clients, documenting/ reporting progress, and handling technical, educational and socio-cultural communications were major managerial responsibilities over the course of this project—as is the case for most large-scale projects [6].

Management can be considered as two interrelated sets of activities. The first is Project Management, concerned with the organization of resources over time for sub-projects of disciplinary courseware and tools for each school. This required co-ordination and monitoring of the components involved and liaison between content providers and developers through all stages of the development cycle.

The second organizational function is concerned with Production Management. This was essentially Operations Management of the production facility - the Courseware Development Laboratory. A Designer/Manager provided planning, leadership and supervision by working closely with the key personnel in authoring, graphics, and Web production. The assistance of a support secretary was invaluable in a large-scale project involving many communication channels, many multimedia elements (files), as well as documentation and reporting requirements. The Lab Manager was responsible for the allocation of work resources as well as personnel management, with support from the University's Human Resources Office. The Principal Investigators conducted financial management of the courseware development within the University and ultimately reported to the QEF Project Management Committee.

Planning and operations management played a major role in co-ordination and quality review. Four mechanisms were employed:

1. *Design and Production Workgroups* - Conferred daily to clarify design issues and resolve interface/ functionality and technical problems.
2. *Weekly Operations Meetings* - Ensured workflow and work distribution, allocation and monitoring of activities.
3. *Bi-weekly Management Meetings* - Reviewed progress, resolved major design/ production issues, allocated action responsibilities and conducted formal planning and scheduling.
4. *Client Review Sessions* - For each courseware sub-project, critical "show and tell" sessions with the content providers/clients at each significant design and production phase.

Progress of courseware development was regularly up-dated on the graphical progress charts on the Development Web site. These charts showed the extent of materials to be produced and their corresponding array of development attributes. This information is now presented in the Scope Charts accessible on the site.

5.5 Importance of Management

There are many 'hidden costs' in the overall conduct of such large projects. For example, the Management Committee frequently met "after-hours" and this is not factored into the project's real cost. Similarly, production required accommodation, equipment and support provided by technical staff of the Division of Computer Studies and this was contributed "free" by City University under "Community Service" responsibilities as part of the original proposal. In addition, the co-ordination of such a large-scale project demanded managerial expertise and administrative support well beyond what is usually estimated in project proposals.

Like all large-scale construction projects, Web development demands mid-term and day-to-day monitoring of progress, supervision of skilled staff, and production co-ordination. Project management is a necessary, time-consuming and significant factor in successful projects, yet it is easily overlooked or underestimated.

5.6 Teachers' Experiences

One pleasing spin-off during the project was not only an improvement in communications networks but a noticeable improvement in the IT skills of participating teachers, as demonstrated in discussions, feedback, and the handling of project files.

An effect that should not be underestimated is the project's contribution to professional development in terms of experience gained by teaching staff, administrators, and each school's technical (IT) staff. Despite the QEF decision to not fund release-time for teachers in this particular joint project, all participants, in learning about IT and producing relevant materials for their pupils, expended tremendous effort and gained valuable insight into the nature of producing technology-based teaching resources. Experience was gained through a combination of the following:

- Initial concept and design workshops at CityU
- Preparation of "Open Day" prototype demonstrations
- In-house training and workshops
- Materials design, development, and evaluation activities
- Special training (e.g. Perception)
- Final handover "training" conducted in each school.

6 Issues Arising

6.1 Educational Design

Second only to the quality of content, the underlying instructional framework supporting an interactive design that promotes thinking (learning, problem solving, communication, etc) has greater impact on cognitive process than does "the medium" employed. Elaborate technical effects may be "nice-to-haves," but the primary goal is an interesting and attractive multimedia program that makes optimal use of the Web as a medium of delivery. Educational purpose and technical implementation must enhance and support one another if the result is to be an effective and efficient site that promotes cognition (learning and thinking).

6.2 Producing Web-Based Learning Materials

Towards that end, educators and developers need to ask themselves some hard questions before undertaking Web-based educational projects. The following questions are a starting point for sorting out the most suitable way to go about creating a Web learning environment:

- What resources do we have and what needs developing? (A strength of the Web is that many relevant resources could be linked from one "home-site," minimizing the need to reproduce basic resources.)

- Where and how will resources be acquired or produced and how much time and money do we have?
- How is the project to be coordinated/managed, and by whom?
- From where will “content” come?
- What media resources (if any) are required and where will they come from? (This question has to be asked with due consideration not only of the Law of Copyright but also of the often drawn-out process involved in seeking permission from “authors.”)
- What kind of resources will be required to provide access to the finished product?
- Most importantly, what is the educational purpose and learning outcome that could reasonably be expected from any produced materials?

All such questions provide an “acid test” for any chosen development model. To address these, the approach adopted for Web materials development at City University in this joint Schools project was a cooperative team model.

6.3 Considerations for Justifying Project Funding in Joint Proposals

When schools combine their planning and resource ambitions with those of like-minded educational institutions in joint proposals, important cultural and organizational issues get added to the mix of consideration defining the sorts of projects worth proposing and - particularly - worth funding. Clearly, once multiple institutions are involved, responsive, high-standard project management becomes a critical need and should thus be provided for in the project proposal. Additional factors that project administrators, product developers, and especially funding review committees should assess are:

- Do participating institutions have needs, goals, and educational "cultures" in common?
- Do participants have a full understanding of and commitment to the educational multimedia development process?
- Are there clear support policies and programmes of practice in the applicants’ institutions?
- Will instructional/educational and technical design be forthcoming?
- How and by whom will quality content be provided, and is provision for this requirement included in the funds allocation? (copyright license fees, teachers' release time, etc.)
- Do the applicants have the resources to complete and implement the project (time, tools, expertise, infrastructure)?
- Do the applicants have the development experience to conduct and complete the project (noting that this is relative to the nature and scale of the proposal)?
- Are there significant on-going cost implications that should be recognized for forward planning purposes?
- Finally, will the courseware products represent value for money, both in the immediate project context and in their wider applicability? Is the courseware to be disseminated beyond the participating schools or restricted in its application?

An overarching question concerns the ability of both the management and the development teams to accommodate or assimilate not only differences in languages but the diversity in cultures within and among institutions as well. Our experiences in this joint project highlighted very different goals and expectations between the schools and between these schools and the university. Such differences are to be expected when any new and demanding technology-based project is attempted. But the idea of co-operative production ventures between schools and universities raises many “belief, value, and desire” issues as well as fundamental questions about “business models” and general modes of operating.

6.4 Content Issues

To borrow from a cliché about real estate, the three most important factors determining the value of educational multimedia are "content, content, and content."

Earlier, we mentioned the extent to which the enhanced IT proficiency of teachers and technical staff in the schools constituted a positive but secondary outcome of the project. In fact, the original proposal asked for the funding of release time for teachers, to free them from regular teaching duties so that they might focus on participating in the project and developing the best possible content for the proposed courseware. In accepting the project, the QEF slashed these "professional development" funds from the budget.

Acceptance and continuation of the project after deleting the funds that would enable teachers to prepare content placed a tremendous strain on all project participants. Without release time, preparing courseware content and participating in courseware design and review constituted additional, uncompensated responsibilities ‘over and above’ already heavy teaching loads and extensive (required) involvement in school activities. Often, teachers were caught between their duties to the school, to their students, to the project, and to themselves as professionals. Repercussions upon the project included compromised production schedules, unavoidable cutbacks in courseware scope, additional and unplanned commitment of resources to develop alternative content, and occasionally strained relations among project participants

We cannot emphasize enough that the provision for quality content is paramount in any courseware project. It is “unfair” to all responsible for developing quality-teaching resources to underestimate the amount of work and commitment required to produce quality content, without which production becomes a meaningless exercise and an unjustifiable expense.

6.5 Value for Money?

In recent years, the large sums of money expended to promote "IT in Hong Kong schools" raises another important question that QEF administrators, teachers, developers, parents, students, and the community as a whole must consider (especially in the current economic climate): What is the (likely) return on all this investment in IT for Education? In other words, are the QEF and Hong Kong taxpayers getting real educational value for their dollar?

The answer to that question should be apparent in the demonstrable quality of the final products of all this investment. Furthermore, these “investment products” should be amenable to update and extension by teachers and technical staff in each school, and should be flexible enough for other schools to use readily and effectively. Of course each school Intranet node is potentially available for all Hong Kong Schools if the resources are made accessible via an Internet site. What's required is, at base, the organizational structure to promote and support the sharing of resources. But the schools and the QEF have to be clear about copyright, ownership, intellectual property and distribution arrangements, and must recognize the need for (and cost of) maintenance, updating and extension.

Communicating and overcoming development problems provides valuable experience for all participants in projects such as this, but there is a need for public discussion about the nature of cooperative IT development (production) between universities and schools before it is regarded as the most efficient and effective way of producing technology-enhanced learning materials and environments. The same applies to centralized models as well as school-based development arrangements. Possibly a network of school-based facilities, universities, and commercial providers (especially publishers) built around a supply hub (for instance, in the new Cyberport) could be a better solution for Hong Kong and for international markets.

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Enabling Communities by Constructed Media: The Case of a Web-Based Study Environment for a Talmudic Tractate

Ralf Klamma[1,2], Matthias Jarke[1,2,3], Elisabeth Hollender[2], and Dagmar Börner-Klein[2]

[1]Lehrstuhl für Informatik V, RWTH Aachen
Ahornstr. 55, D-52056 Aachen, Germany
Phone: +49 +241 8021501, Fax: +49 +241 8022321
klamma@cs.rwth-aachen.de
[2]Collaborative Research Center FK 427 'Media and Cultural Communication'
Bernhard-Feilchenfeld-Str. 11, D-50969 Cologne, Germany
[3]Fraunhofer Institut FIT
Schloss Birlinghoven, D-53754 Sankt Augustin, Germany

Abstract. The Babylonian Talmud is still an authoritative source for many orthodox Jews, an dialogic encyclopaedia of knowledge and one of the most impressive pieces of world literature. However, the distribution of this knowledge is limited by the burdensome task of studying this complex work. The paper presents a comprehensive study environment for a Talmudic tractate which transcribes an original printed edition into a structured electronic version, thus enabling much easier ways of studying the text with hypertextual annotations and dynamic knowledge level-dependent features. This radically changes the addressable knowledge communities.

1 Introduction

Many approaches to hypermedia environments for computer-supported learning have been proposed in the last years (cf. e.g. [8, 9, 22]). But still, the task of addressing the student with the right level of support is an open question, especially in constructing knowledge libraries serving both teaching and research needs.

Large knowledge repositories or digital libraries are used in online learning settings such as virtual universities [2, 12]. These libraries recognize learning and teaching as a knowledge management task on digital archives stored in database systems. A well known example is the Open CourseWare project at the Massachusetts Institute of Technology[1]. These projects try to strengthen the abilities of the students to synthesize und be creative with intellectual capital and knowledge objects.

Web based cooperation platforms for learning environments are available, from text-based multi-user dungeons [6] to avatar-based 3D environments as in the Euroland project [21]. An example supporting both learners and researchers in

[1] http://web.mit.edu/ocw/ .

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organizing materials and working together is a widely used cooperation platform on the internet, the BSCW System [3] (Basic Support for Cooperative Work). The BSCW system is used for organizing course contents or research data and coordination of learning or project efforts. For advanced cooperation support among researchers, teachers and learners we need to personalize digital libraries [25] to build local instances of digital libraries and handsets of needed literature. A possible solution to this problem is the use of XML (Extensible Markup Language) based knowledge repositories capable of handling semantically enriched multimedia documents. XML based data management issues were discussed in depth in [4, 11, 20] but few project are known using XML databases to build study environments, e.g. [14].

The 'Semantic Web' [15, 29] tries to create a global digital medium based on meta content descriptors and XML databases [26]. To build knowledge repositories on XML databases ontologies [10] will play an important role. However, existing learning environments based on XML [27][2] tend to just virtualize in-class learning situations with strong, often negative impact on the social behaviour of the students. The danger is to lose social capital in the learning community [1].

In the interdisciplinary Collaborative Research Center 'Media and Cultural Communication', a conceptual framework has been developed to structure the set of questions sketched above. Applied to the domain of media support for learning, the framework suggests to study three perspectives [18]:

- the *inter-medial transcription* provided by the approach, i.e. the manner in which collections of learning materials are re-structured by the new media
- the *change in address spaces* to which the transcribed learning materials can be directed, both at the physical level of data transport and at the conceptual level of understandability.
- the *re-organization of localities* stimulated by the new media, i.e. the changes in existing communities of learning or the creation of new ones.

In an interdisciplinary cooperation between a Jewish Studies project and a Computer Science project within this Collaborative Research Center, we have developed a web-based study environment for a Talmudic tractate [13] called CESE (Comprehensive Electronic Study Environment) that can be considered as a rather extreme case of this *transcribe-address-localize framework*.

The CESE *transcribes* the traditional folio page structure of the Talmud into a multi-lingual hypertext system which is structured by, and overlaid with annotations representing a theoretical framework of understanding developed by the Jewish Studies. This structure is offered via the Internet, thus changing the physical address space for readers from a few libraries and synagogues to anywhere in the world. Moreover, the theory-based restructuring and annotation of the texts provides a direct visual understanding to lay persons who would otherwise have required years of study, whereas the multilingualism opens the text structures to readers with non-existing or limited knowledge of Hebrew. Last not least, the existence of this constructed medium has created a *new community structure* of teachers and learners as students are enabled not just to read complex texts passively much earlier in their curriculum than with previous technologies, but also to participate actively in

[2] E.g. the digital library metadata initiative, http://www.dlmeta.de/jdlmeta/dlmi/index.jsp .

discussions with specialists, even including critiques of the knowledge organization offered by the constructed medium (i.e. the transcription) itself.

The Talmudic CESE has been the first attempt to apply the transcribe-address-localize framework not just descriptively but use it as a design guideline for a constructed medium. In the remaining sections of this paper, we describe the application domain, the underlying theoretical Jewish Studies framework, and the technical solution approach followed in CESE. In the final section, we report on preliminary experiences with external reactions to, and initial practical usage of, the system and indicate conclusions and further research needs.

2 Background on the Babylonian Talmud

The Babylonian Talmud edited from the 3rd to the 9th century C.E. is one of most impressive pieces of world literature. Even in our modern times the impact of the Talmud on Jewish life can not be overestimated. For orthodox Jews the Talmud is still an authoritative source of Jewish religious laws. In addition, the many volumes of the Talmud written in Hebrew and Aramaic are an encyclopedia for the transfer of many knowledge facets. In most cases this knowledge is organized as dialogs, partly logical, partly associative. Therefore, readers can access the Talmud with different concepts of studying on different levels of reading and furthermore, in a non-linear manner. This organization of knowledge depends on a guidance for studying the texts and the contents. For that reason, the accompanying commentaries from the Middle Ages and early modern times are grouped around the Talmud text on the printed page ever since the first complete edition was printed in Venice in 1520-23. Traditionally, the Talmud is studied cooperatively in Talmud schools (Jeshiwot). Thus, the organization of knowledge in printed Talmudim is influencing the transfer of knowledge.

The Babylonian Talmud is the largest collection of texts from rabbinic literature, covering some 5000 folio pages in the standard edition printed by Romm in Vilna (1880-1886). It is also one of the favorite examples of existing hypertexts before hypertext theory. Its traditional layout with the Mishna and the Gemara as the main block on the page and several commentaries grouped around them, first developed by the Christian printer Daniel Bomberg in Venice (1520-23), has invited many interpretations both from scholars of Jewish Studies and from hypertext-specialists and scholars of literary hypertexts. D. Porush notes [23]:

> *The Talmud is just as likely to "send" the reader to a page elsewhere in the Talmud as to the next page. You can open the Talmud almost anywhere to begin, although standard Talmudic learning progresses, at least at first, in a highly-arbitrary sequence of books. We also see that the Talmud promotes marginalia, scribbling or commentary, and a non-linear non-directed form of knowledge. ... Notes and marks refer the reader to arguments elsewhere in the Talmud. In short, modern computer users will quickly recognize that the Talmud is a hypertext system: a means of gathering clusters of information that is non-linear, promotes interpretation, is multi-vocal (or collaborative in the extreme), tends towards anonymity, is non-directed, packages information*

in multi-referential but discrete pages, and de-constructs the authority of a single author.

It might be worthwhile to analyze this equation before discussing the possible creating of a "hypermedia-Talmud". The hypertext metaphor can be doubly applied to the Talmud: Both the external structure of the Talmud and its internal structure can be described as hypertext.

The external structure is the combination of texts on the traditional page of Talmud. The main texts on the page are the Mishna, edited in the 2nd century C.E., and the Gemara, that was probably closed in the 8th to 9th century C.E. They are carefully edited compilations that show the traces of several editing processes, each of them with its own agenda for the logical, rhetorical and thematic outline of the texts. The medieval and early modern commentaries included in the printed editions were composed by single authors (with the exception of the Tosafot, whose publishing-history differs from that of all other commentaries) either as commentaries on the completed and closed texts of the Babylonian Talmud or on single tractates, or as supercommentaries on preexisting commentaries. All commentaries take up *lemmata* from the Talmudic text and create links into the text, attaching their own explanations. While we read and study the Talmudic page by looking for links from the inside to the outside, the commentators actually created links from the "outside" to the "inside". Most of the older commentaries were not originally written on the margins of copies of the Talmud. They required the use of two manuscripts simultaneously. The page of Talmud therefore fits the description of hypertext: it brings together and links documents in a way that enables the reader to use several connected documents at the same time.

As to the internal structure of the Talmudic text, it can be also described as a hypertext because, like all rabbinic texts, it is a unique combination of new and old material. In each text we find a great number of passages that occur in parallel transmissions of textual units copied from their sources and inserted at suitable positions in the target texts. This created an internal hypertext-structure that connected Midrashim and Talmudim via nodes of shared text. Associations and structures were created that connected the different parts of the Talmud and enabled different ways of reading. The Gemara itself is – beyond the linear text – a web of units connected by associations that offer a multitude of possible readings. The Talmud itself is a hypertext-structure. In spite of this it should be noted that the Talmudic text is not fragmented in the way modern hypertexts are usually structured.

The idea of the Talmud as a hypertext has invited attempts to render the Talmud as electronic hypertext. The available products focus on the traditional mode of Jewish Talmud study and connect the Talmud passages with their respective commentaries and with passages from halakhic works that deal with the same topic.

3 Previous Digital Libraries for Jewish Studies

Jewish Studies was one of the fields where electronic texts became available for scholars rather early in the development of digital libraries. Given the technical developments we can now look back on a history of very different questions and solutions, most of which have undergone several changes within the history of one "product".

Electronic texts of rabbinic literature with more or less sophisticated search-engines were sold from the 1980's onwards. In UNIX and DOS they needed to overcome the barrier created by ASCII and the national code-pages, usually by forcing the user to use the Israeli national code-page and thus not being able to access any regional national characters. The fact that Hebrew had no universal ASCII standard but existed both in lower ASCII and in higher ASCII added to the representation problem. The main function of these early electronic texts was the concordance: search-engines would find all occurrences of a given string in the selected database [7]. Programming energy accordingly went into the search-engines that are by now able to combine different strings, to include all or select prefixes and suffixes with the string, or even to perform grammatical searches that will find all occurrences of a *lemma* or root. Hyperlinks that will call a connected passage to the screen were a comparatively late feature. Generally it can be said that these databases are retrieval systems for authoritative texts. Some of them have export-filters but due to the problems of Hebrew representation cut-and-paste is usually not supported. While marketing strategies often connect these tools to the study of rabbinic texts, their actual ability to teach the knowledge and techniques necessary for a thorough understanding of rabbinic texts is minimal to non existent.

With SGML [16] (Standard Generalized Markup Language) and the Text Encoding Initiative's (TEI) attempt to provide a standard document type description (DTD), the description of electronic texts in a meta-markup-language became possible and spread widely in European literatures.[3] It did not however catch on in Hebrew literature, possibly because of the previously existing concordance-based works in this field, possibly because SGML does not support any of the Hebrew standards and no SGML-editor or -browser supports right-to-left (RTL) text. L. Barth attempted to adopt the TEI DTD for his electronic edition of *Pirqe deRabbi Eliezer*, a visionary project that includes transcription and tagging of all available sources of this Midrash. He defines many new standards and overcomes the TEI DTD standard of describing mainly the physical structure of a published book as opposed to its contents-structure. His ingenious reworkings in order to use Hebrew in SGML evince the need of a complex mark-up-language that masters multilingual and bi-directional texts.

Text tagged with the TEI DTD can be used for complicated retrieval processes and comparisons. Several other projects have shown how these SGML texts can be further enriched with additional information and made the core of complicated information systems that include text, commentary, illustrations, etc.[4] A special case of SGML tagging and application is "The Wife of Bath's Prologue on CD-ROM", published in 1996 by P. Robinson.[5] This application enables extensive research into the presented sources. An optimal depth of tagging and commenting has been reached combined with collation, hyperlinks and digital images. This depth is possible only if the amount of text studied and prepared is limited: in this case the corpus contains 861

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3 For a description of TEI and the widespread use of their DTD cp. http://www.uic.edu/orgs/tei .

4 Cp. e.g. the Perseus-Project, at http://www.perseus.tufts.edu.

5 P. Robinson, *The Wife of Bath's Prologue on CD-ROM*, Cambridge 1996.

lines – albeit in 53 manuscripts. Since all possible research activities had to be preprogrammed into the electronic text, the work is a fine example of state-of-art-scholarship as well, with hardly any questions on the text, its transmission and its linguistic features left open.

4 Design and Implementation of the CESE

Any attempt to produce a full electronic Talmud-text that is as exhaustive in its textual quality and commentary will have to fail, given both the size of the Talmudic corpus and its long history of commentaries that would have to be included. The open character of the Talmud and its ongoing commentating processes interdicts any attempt of completeness. Instead every electronic presentation of the Talmud will have to address a specific audience with its specific needs, in our case, German university students of rabbinic literature, who will use the tool both in class and for their preparation of talmudic texts for class discussion.

Rabbinic literature is, as mentioned earlier, a kind of hypertext before hypertext theory existed. None the less, it is usually printed in traditional book-form. Accordingly, our German translations were also published as books and therefore were originally prepared for camera-ready copy. The electronic edition however will use the facilities of computer-based hypermedia representation and presentation. As we rely on the printed edition [5], we have a document space containing Microsoft (MS) Word documents. All these documents are formatted according to guidelines that transform the structure of the text into a visualization scheme on paper. Hence, we need a hypermedia representation and presentation.

Fortunately, the set of presentation and representation languages grouped around the XML technology solve our problem. To transform the document space given by MS Word documents we chose XML for the following reasons. First, XML allows – like HTML [28] and SGML – hypertext linking features. However, HTML allows only presentation oriented tagging of documents, i.e. no semantics are supported directly. Furthermore, HTML lacks the possibility to define new tags. In short, HTML is a language for representation. On the other side, SGML is a very complex meta language for the electronic representation of text and the available SGML-editors are very costly and do not support Hebrew. Beyond this, browsers for SGML depend on a local installation of the software and the documents and are intended for use in CD-ROM based productions only. With XSL (Extensible Stylesheet Language) there is a convenient way to transform the XML documents into other XML documents, e.g. HTML pages for representational purposes. Second, XML provides extensive hypermedia linking facilities with extensions like XLink and Xpointer. Third, XML is specified for Unicode use, thus supporting also Hebrew. Fourth, there are available XML databases to construct a database. To summarize, XML technology is an ideal candidate for designing and implementing the study environment. It allows the division of representation and presentation, the support of hyperlinks, Hebrew language and advanced database functions.

To realize a XML-based study environment a DTD is not really mandatory. This is an advancement compared to SGML, where each used tag has to be provided by the

DTD. Nevertheless, we need a DTD for two main reasons. First, we want to realize a database containing hypermedia objects semantically tagged by XML. Hence, for describing schema information a DTD is a good choice. Second, we want to semi-automatically transform existing materials, such as German translations of Mishna, Tosefta and Babylonian Talmud Megilla into XML documents to fill our database.

We developed the conversion tool DocToXML to transform the existing MS Word documents into an XML representation. DocToXML is written in Visual Basic for Applications. In the current version DocToXML is able to transform the whole given document space into XML. Yet, not all information in the DTD can be extracted from the document space and conversion errors are possible.

To add tags to the transformed XML document and to correct errors we use the XML editor XMLSpy 3.5. XMLSpy is a general purpose XML editor for little projects and one of the few handling Unicode. For every given XML document we can check well-formedness according to the definition of XML, e.g. that every position of opening and closing tags is correct, and validate against a given DTD. After performing these two procedures we can ensure that the XML document can be represented on the screen with XSL.

XSL is a stylesheet language to specify the presentation of a class of XML documents by describing how an instance of the class is transformed into an XML document, e.g. an HTML page. We developed a stylesheet for representing the XML documents as HTML pages using JavaScript as script language. Since we rely on HTML any popular browser, e.g. Microsoft Explorer or Netscape Navigator, is capable of representing our study environment.

The main feature of the environment is the handling of the multidimensionality of the text. In the environment we can fix certain features we describe in detail below while we can change other features like the language. In Figure 1 the colored sections are enabled features in the Hebrew language representation of the Talmudic tractate. We can switch to German without loosing our study context. All colored sections remain the same. The loaded document carefully conserves the layout created for the German translation. Indentation is kept. The curly brackets in the printed text that marked passages that have parallels in other rabbinic texts were substituted with bright red arrows in the electronic text. Footnotes from the printed translation indicating the exact parallels had to be translated into a different visualization scheme. In this case we chose commentary-boxes that appear when the mouse is moved onto the arrow. The commentaries, many of which are not part of the printed translation, are indicated by blue bullets. Additionally, as in the printed edition, the mishnaic and biblical texts under discussion in the Talmudic text are marked on the left margin of the text. The same column contains indicators for the textual structure.

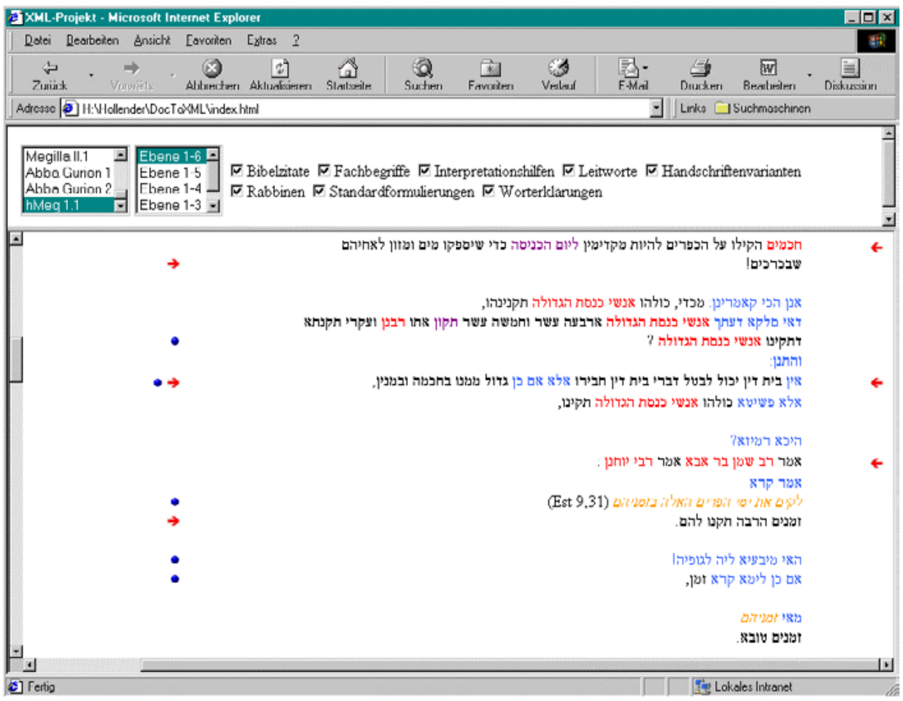

Fig. 1. Screenshot of the study environment in an internet browser (all readable information in Figure German and Hebrew)

Each document represented in the browser has different parameters that can be manipulated by the reader in the study environment to give further information on-demand. The parameters are visualized by checkboxes in a non scrolling frame. Thus the chosen parameters are visible all the time. Additionally, the given parameter setting is saved when the user changes the document, enabling her/him to follow a chosen path of study through longer units of text. The parameters are:

1. Ebenen (Levels): We have differentiated five levels of textual structure which are enumerated in a scrollable listbox. The reader can chose how many of the levels are to be displayed and the whole page layout adopts itself to the chosen level. Hidden paragraphs leave a small amount of white space as their trace, thereby indicating roughly the amount of hidden text.
2. Bibel (Bible): If marked, all hypertext nodes containing quotes from the Bible are highlighted in orange and italics, preserving the tradition from printed books in addition to the color-code.
3. Fachbegriffe (Technical Terminology): If marked, technical terminology from the Talmud and from Jewish Studies are highlighted in grey. If the pointer is moved over the highlighted text a small text-box with light yellow background and a red margin containing a short definition and explanation of the concept in question, pops up next to the highlightened word. The window closes again when the pointer is moved away.

4. Handschriftenvarianten (Manuscript Variants): If marked, a small green glyph is displayed before the text to which significant variants exist. If the mouse moves over the glyph, a text-box with the text of the variant and its source is displayed.
5. Interpretationshilfe (Interpretation hints): If marked, little blue squares are inserted before words or phrases in the screen representation. If the mouse is moved over such a square, a textbox pops up. The textbox is only visible while the mouse is over the square and an interpretative help is given.
6. *Leitworte*: If marked, *Leitworte* are highlighted in a bright blue. We plan to create links so that the reader can jump serially to the next *Leitwort* by clicking on the highlightened word once XLink and XPointer have been fully implemented.
7. Rabbinen (Rabbis): If marked, names of rabbis are highlighted in red, if the mouse is moved over them a little textbox with a short “biographical” note pops up. A separate window with longer “biographical” and bibliographical information can be opened with a mouse-click.
8. Standardformulierungen (stock phrases): If marked, phrase nodes are highlighted in dark blue and if the mouse is moved over them, a little textbox with the original text (in the German translation) or the German phrase (in the original text) and a short explanation of the function of the phrase in the Talmudic argument or the hermeneutical rule employed pops up.
9. Worterklärungen (language explanations): If marked, words are highlighted in purple and if the mouse moves over them, again a little textbox with a language explanation pops up.

With the exception of the stock phrases, where the original text shows the German translation on demand while the translation shows the original phrase on demand, the Hebrew text is enriched with the identical information as the German translation. Both groups of texts together create a unified document space.

5 Discussion

As already mentioned, the organization of knowledge in the Talmud is influencing the way, the Talmud is taught. Aim of the CESE is to represent and present the synchronous and historical multidimensionality of the text and the commentaries in an XML based study environment to make these texts – formerly readable by specialists only – accessible to beginning students and other interested parties with limited knowledge of both Hebrew and Jewish Studies concepts. By offering visualization of inherent structures of the talmudic text and connecting meaningful pieces of information to textual elements the CESE introduces new options into the study of texts while retaining traditional aspects like the use of commentary.

This re-addressing of ancient teaching and study methods has rapidly created a world-wide research, teaching, and learning community which is reflected by the broad discussion on conferences, workshops, and meetings on the concepts and the technical solutions. This discussion and evaluation of the CESE by German students of Jewish Studies have produced many ideas how the study environment could be improved, but they also confirmed that the right approach was taken. Teachers and students alike consider the realization of the hypertext-concept by hidden knowledge items that can be brought to the screen on demand a highly useful technique. Many users commented on the clear division of knowledge and structure on the screen which compares positively with the crowded image of the traditional Talmud page. Especially beginners felt more comfortable accessing hidden information on demand than checking the commentaries on the printed page. Both the simple visualization scheme and the clear cut division of knowledge items in categories, each again associated with a different color and thereby visible, helped beginning students to focus on the talmudic text and specific questions they had to tackle with the CESE.

Requests for changes by students most often focused on minor visual elements, like the color-coding for certain categories or the division of the screen, while teachers discussed possible changes in contents structures like the exact differences between categories we introduced and the possibilities to include further types of knowledge, like all medieval and early modern commentaries contained on the printed Talmud page.

The ability of the CESE to hide some levels of the talmudic discussions has provoked discussions of the textual structures represented in the CESE and thereby enhanced the scholarly discourse in Jewish Studies beyond the development and use of the CESE. The discussion of how a text is broken down into units has provoked the question, how it will be possible to allow for users to change the status of certain structural elements like levels. Any changes a user introduces should be retainable and exchangeable with other users without blocking access to the original version. Since studying Talmud has always been a communal activity, the CESE should support study groups. As an electronic study environment, it can break through the traditional boundaries of common place and common time and allow for variegated study groups to share the study experience.

Many proposals for the further development of the CESE both by users and by the designers focus on pedagogical tools and enhanced interactivity. Student users have requested the equivalent of a syllabus or study plan in order to acquire specific knowledge and skills. This could be realized by "study paths" or by prompts that direct the user. Teacher have asked for the integration of testing tools, best to be used also as self-testing tools, like the option to apply the color-coding manually and have it checked by the CESE.

6 Conclusions and Outlook

In this paper we presented and discussed a prototypical learning environment built on top of a XML based digital library, mature enough to draw first conclusions reflecting the development process. Complex, multidimensional representation of semi-structured data can be tackled by using developed or available DTD or schemes. By relying on metadata standards we are open for new learning modules, other environments and further developments, e.g. we plan the integration of user needs in the environment by using modeling techniques used in building large knowledge repositories, organizational memories, and adaptive hypermedia environments. The CESE environment was built as a cooperation project between the Jewish studies and computer science under the research umbrella of the interdisciplinary and

Collaborative Research Center ‘Media and Cultural Communication’. The key to this successful cooperation was to find a transdisciplinary research questions we can be answered by one discipline alone.

In our CESE environment we use DTD developed for our special needs since the metadata standards in the human studies are sufficient to rebuild the complex, multidimensional Talmud text and commentary electronically. We think that XML offers this capabilities and the successful development of the CESE strengthen this hypothesis. The next step is to combine the current environment with multimedia features. We plan to let the Talmud be read by a Rabbi and to tape it on video. If we describe both the video data and the Talmud with the MPEG-7 metadata standard [16], we can use the text as an transcript of the video and present both, video and text, synchronously in the extended study environment. A similar approach using the MPEG-7 metadata standard and video sequences for the construction of the digital library has already been successfully experimented with in building another CESE-like application, the prototype of a virtual entrepreneurship lab (VEL) intended to help technology students gain an understanding of how to start a company with their technologies [19].

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Innovative Teaching through the Cyber University

Ronnie C.T. Cheung

Department of Computing
Hong Kong Polytechnic University
csronnie@comp.polyu.edu.hk

Abstract. The development of Web-based learning leads to a revolution in traditional teaching methods. The rapidly growing demand for e-learning has lead to the development of the first Cyber University in Hong Kong (the Hong Kong CyberU). In this paper, we address the issue of how Web-based instructional development cope with this new style of learning. On the technical side, the cyber mode of learning impose different requirements for conducting tutorials and laboratory sessions. A new platform is required for students to work remotely through the Web. Using a courseware for the Web-based MSc program in e-Commerce, we demonstrate how cyber laboratory sessions can be conducted. Flexibility and mobility are the key features of our courseware developed. The innovative approach to teaching are designed to provide students with an on-line interactive learning courseware delivered through the Web. After the courses have been delivered, students are evaluated for the performance through written examinations. We formally evaluated the examination results of one of the Hong Kong CyberU course and concluded that the learning effectiveness of the students does not exhibit any noticeable difference from those courses offered in conventional mode. Thus, the Hong Kong CyberU model used in the MSc in e-Commerce program is a successful example of an e-learning program that is delivered solely through the Internet.

1 Introduction

As a new development in local tertiary education in Hong Kong, the Hong Kong CyberU was established for the delivery of post-graduate programs leading to academic awards from the Hong Kong Polytechnic University. The Hong Kong CyberU (HKCyberU™) is co-founded by The Hong Kong Polytechnic University (PolyU) and Pacific Century CyberWorks IMS. With PolyU's expertise in professional education, research and consultancy, and Pacific Century CyberWorks HKT's telecommunication and broadband capabilities, the first Hong Kong-based cyber university was founded in July 2000. A major development of the HKCyberU is the launching of the MSc in e-Commerce program. We started the development of an MSc program in e-Commerce in 1999 [2,5], which was successfully validated through the validation panel of the Hong Kong Polytechnic University in May 2000. Based on the course materials for the MSc in e-Commerce program, a HKCyberU version of the program was developed in parallel. The first eight courses (or subjects) for the HKCyberU version of the MSc program were developed and delivered in the year 2000. As these

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courses are delivered in a remote learning mode, the Internet is used as the medium for delivery of course materials, for communicating among lecturers and students, and to provide an interactive learning environment for the HKCyberU.

The first student intake starts in September 2000 and there are 70 new entrants to the cyber versions of the MSc in e-Commerce program each year. The students make use of the WebCT platform [6] to go through the on-line lectures and quizzes at their own pace. To assist their study, the HKCyberU provides regularly scheduled on-line tutorials that give instant response to their questions raised, the bulletin board to post their queries, the on-line chat rooms to discuss with the tutors and other classmates and a few face-to-face meetings with the lecturers.

It is obvious that there exist distinct differences in the mode of material delivery for HKCyberU and the conventional classroom teaching. We have also evaluated the two different modes of teaching to determine the impact on the students. In particular, we compared the examination results of two groups of students during the semester from September 2000 to February 2001. One group of students attended the course through conventional classroom teaching, the other group of students studied the same course through the on-line mode provided by the HKCyberU. Both groups of students were supervised by the same lecturers, and had to attend a formal written examination in person with identical examination papers at the end of the course.

This paper is organized as follows. First, we review the background of the HKCyberU. The we discuss the development of Web-based Learning software for cyber mode of delivery , and the structure of a learning unit for cyber courseware. In Section 3, we describe the application and development of multimedia contents using video and audio. In section 4 and 5, we discuss an innovative approach to conducting cyber laboratory sessions using a Web-based architecture. The learning effectiveness of the HKCyberU model is evaluated statistically in a trial pilot in Section 6. A discussion on the evaluation results then follows in Section 7. Finally, this paper concludes with a brief summary of what we have achieved so far.

2 Course Development

At present, we have developed eight courses using the WebCT platform [6,7]. Each course includes a series of on-line lectures delivered on the Internet. For each course the student must go through the on-line lectures, together with the on-line quiz, which follows the lecture. We also use the tracking facilities in WebCT to analyze the access record of each student. This helps us to reveal situations where students are not using our facilities on the Web. It also contributes to the assessment of student participation in the courses. Students are also expected to work on exercises and case studies. Each student is expected to discuss the exercises and case studies with their peer group and participate in the discuss forum through the bulletin board system provided by WebCT. They are also expected to communicate with the tutor and other students through email and on-line chat rooms. The basic structure of a Web-based lesson (or simply unit) consists of the followings:

- course materials in the form of Web pages that include wide usage of animation and graphics,
- cyber lectures in the form of short video recording presentations by lecturers on the important areas of that unit,
- exercises related to the topics of that unit in the form of quiz, self-test and discussion forum.

There are various facilities that directly promote interactions between staff and students. These include: bulletin board, chat room, quiz, cyber lectures and cyber laboratory sessions.

- Bulletin boards: There are forums in each learning unit. In this form of interaction, anyone, including students, tutors, and instructors can actively participate in the forum. The forums are organized logically for easy browsing, traversal and exploration.
- Chat rooms: A tutor will schedule on-line chat room tutorial sessions with each study group. The tutorial will assist students to address questions related to case studies and assignments. This is done on-line through the Web in an interactive manner.
- Quizzes and/or short questions: Each lesson is decomposed into a number of smaller units on different topics. For each topic, students will be required to attempt the quizzes or short questions that are directly related to the topic just covered. The purpose is to promote active learning and to reinforce the understanding by the students on the topic. Grading can be done automatically and progress monitoring can be achieved.
- Cyber Lectures: Students can select to play/replay any part of the cyber lecture by selecting the appropriate slide headings.
- Cyber laboratory sessions: Students can work on UML and JAVA-based courseware using a browser remotely at home.

3 The Use of Video/Audio on the Web

We have developed a number of video-based presentations on the Web using the Microsoft Windows Media Services Software Development Kit. Windows Media Services uses Advanced Streaming Format (ASF) for streaming of video over the Internet. It includes a number of tools, which include Windows Media Encoder, Windows Media Author, and Windows Media Indexer. The tools provide for plug-in to Microsoft PowerPoint for producing files on the Internet in ASF. The Windows Media Encoder is capable of encoding different media formats, including AVI files, into ASF files. The Windows Media Author is a tool to synchronize WAV files with image files to produce ASF files. The Windows Media Indexer can be used to synchronize ASF files with URL and other resources and can produce appropriate scripts. It can be used to define the association interactively, or used through command scripts. The disadvantage of using Microsoft tools is that these tools are not available and applicable in high end UNIX servers. However since these tools are fully integrated with Microsoft PowerPoint, they are very useful for creating prototypes of on-line versions of lectures on the Internet. We have produced all the lectures for four courses on the Internet. To produce an on-line lecture (with audio) on the Internet, we perform the following process:

- pre-record all lectures during normal running of the courses,
- pass all recordings together with PowerPoint slides to a technical writer for re-writing the lecture scripts,
- with the completed lecture scripts, the lecturer can do the recordings for each slide accurately,
- rehearse the timings for each slide,
- publish the lecture from PowerPoint to on-line lectures in ASF (using PowerPoint software with ASF plug-in).

Since all lecturers teaching in the HKCyberU have taught similar courses in the conventional mode, we record all the lectures so that the recordings can be used for writing of technical scripts for the cyber lectures. The cyber lectures are compressed versions of the lectures on the Internet. Normally the duration of a cyber lecture is only one third of that of a conventional lecture.

Since PowerPoint can generate on-line lectures in Advanced Streaming Format using plug-in, the use of PowerPoint and Windows Media tools is very effective. To make modifications to individual slides and lecture scripts on PowerPoint is easy because it can be done by the subject lecturer directly. Since the cyber versions of the courses are being produced for the first time, we also need lots of revisions to our lectures. Compared with other approaches [4], this approach helps us to produce quickly a prototype version of the cyber lectures that can be delivered on the Internet.

4 Web-Based Environment for Innovative Cyber Teaching

The use of WebCT provides environment for Web-based learning. However, in a Cyber University, there are various central computing facilities and various applications that are used for teaching computing subjects. Many of these tools are Java-based. These tools require the use of a Web server or in some cases, complicated software installation and set up are required. Since cyber university students are studying at a distance, they not be able to use the central computing facilities in our computing laboratories. The WebCT environment does not provide any facilities for such requirements. Since many of our subjects relates to the teaching of Java and Java-related tools, we have developed a Web-based environment for students to use Java-related facilities and object-oriented programming tools (implemented as Java-Swing applications). To access the central facilities and the related software, students only a browser at home to work remotely. No complicated software set up is required. Figure 1 shows the basic architecture of our remote working environment. To access our software, such as remote compilation/execution engine and interactive JSP tool, students login to our remote server and work on their Java source code. The compiled class files and feedback are send to the students PC/workstations at home.

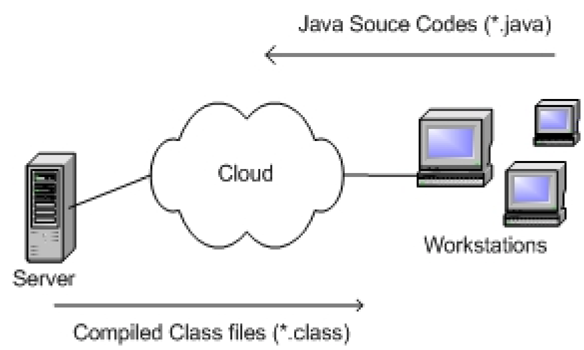


Fig. 1. Basic architecture of the remote working environment

When the user wants to use the swing applications (e.g. an UML drawing tool), he or she clicks on the link on our Web page, which points to a JNLP file. JNLP [8] is a specification that was defined as part of the Java Community Process to provide a generic mechanism for launching Java applications. The basic concept is that all the applications should be stored on a Web server and launched from either a Web browser or a launcher application such as the Application Manager. An application is defined by an application descriptor that is accessed via a URL.

This descriptor is an XML file that describes everything about an application, including its name, the JAR files that comprise it, the class containing the main() method required to start the program, which versions of Java are required to run it, and other information analogous to the contents of the header of a native executable file. The JNLP client interprets the application descriptor and loads the application in much the same way an operating system reads an executable file header to load and execute an application.

An application descriptor begins with the <jnlp> root element. Its attributes define the version of the JNLP specification it complies with, a base URL for the hrefs used in the file, an href for the JNLP file itself, and the version number of the file, which is the same as the version number of the application. Within the `<jnlp>` element, the following six subelements can be defined: `<information>`, `<security>`, `<jre>`, `<resources>`, `<application-desc>`, and `<extension-desc>`. Both an `<application-desc>` and `<extension-desc>` element cannot be defined together. A JNLP file either defines an application or it defines an application extension. An extension is a set of related resources, such as interdependent class libraries contained in multiple JAR files. Application descriptors can be dependent on extension descriptors, making it easier to factor out parts of an application that can be independently upgraded or installed.

The `<information>` element defines general information that the JNLP client can use to provide user feedback, such as the name of the application, a brief description, and an icon to use on the desktop or in Application Manager. The `<security>`

element defines the security restrictions to impose on the application. The `<jre>` element specifies the types of Java runtime environments required to run the application in addition to initialization parameters such as initial heap size. The <resources> element defines the resources the application requires, including JAR files containing the application, extensions used by the application, and system properties. Finally the `<application-desc>` element defines the class that starts the application and initial argument values.

The JNLP file loads the Swing Application to the students' local computer through web start, which automate the whole process of locating the required files for initial running and subsequent update of an application.

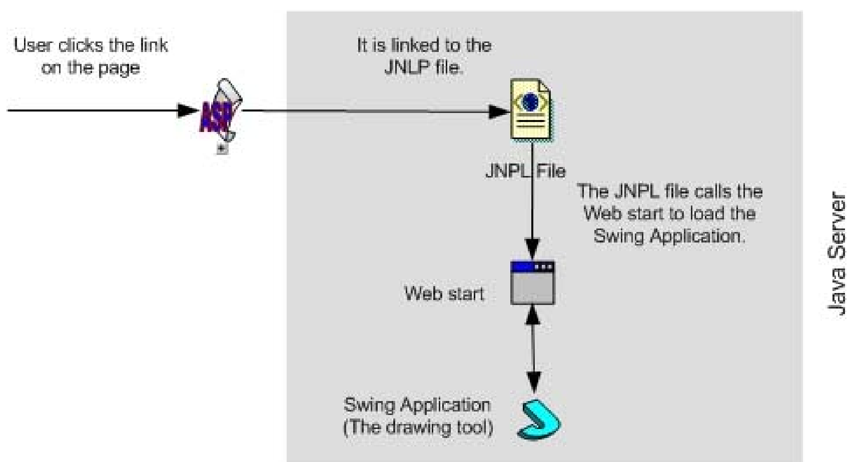


Fig. 2. Use of JNLP file for starting a Web-based application

Since not all servers support JNLP, we have to use a Java server. A famous server that supports JNLP is Apache Tomcat. Unlike original Apache HTTP server and Microsoft IIS, it supports JNLP file type. Figure 2 shows the how the JNLP file is used and Figure 3 shows the screen layout of the UML drawing tool page used for virtual laboratory sessions.

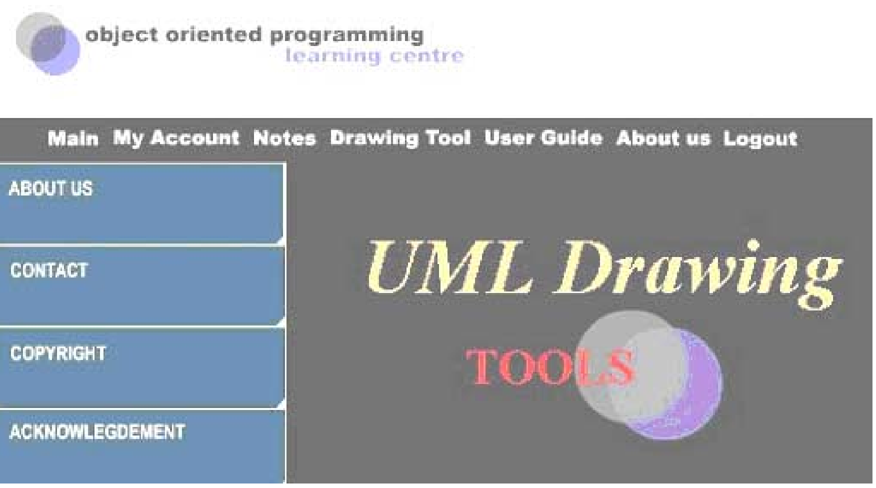


Fig. 3. Screen layout of a web-based UML drawing tool

5 Virtual Laboratory Sessions

One of the challenges in a cyber university is to provide an environment for students to attend virtual laboratory sessions through the Internet using a browser. This is important, especially for students working in the Internet and e-Commerce area. There are various software that needs to be configured and it is important to have a central facilities that can be accessed remotely using a browser. Through the Internet, students can use their login name and password to login into the Virtual Laboratory. The system needs to check the username and password with the backend database. After access has been granted, it will redirect to a menu on the screen our topic, such as online tutorial, user guide of the tool and other relevant materials for the virtual laboratory sessions.

We have developed a Web-based tool for Learning Object-Oriented Programming (WEBOOP). WEBLOOP provides a Web-based Interface for students to draw UML diagrams through the Web. One of the important features of the tool is convert the diagram into Java source codes. Students can also compile the source codes (either modified by the user using the Java code editor provided) into compiled class files on the server. By drawing the class diagrams as a kind of servlet, the system can also generate servelet code, which can be executed by a simple click on the icon using a browser. The source codes are automatically generated and displayed for editing. Figure 4 shows a screen dump of WEBLOOP for mapping UML patterns to Java code, and figure 5 shows screen dumps of WEBLOOP for on-line editing and compilation of programs :

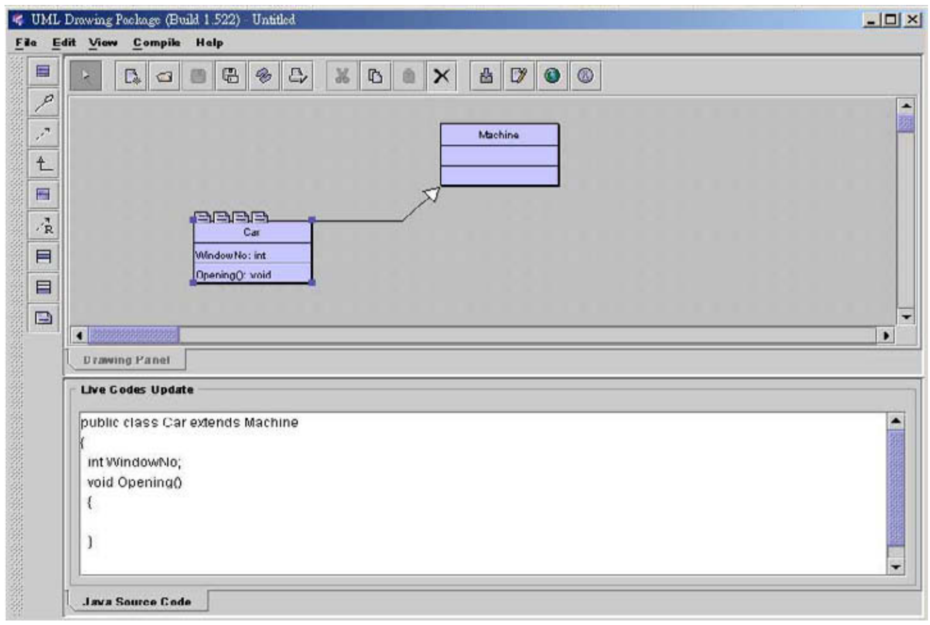
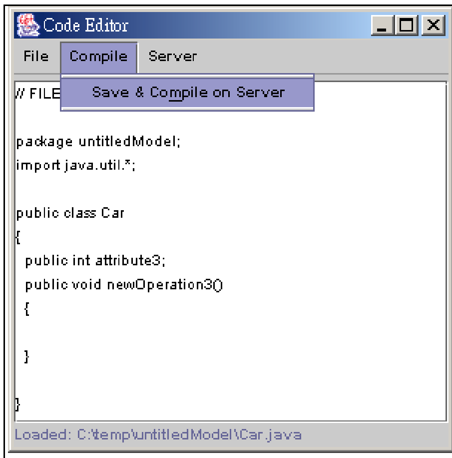
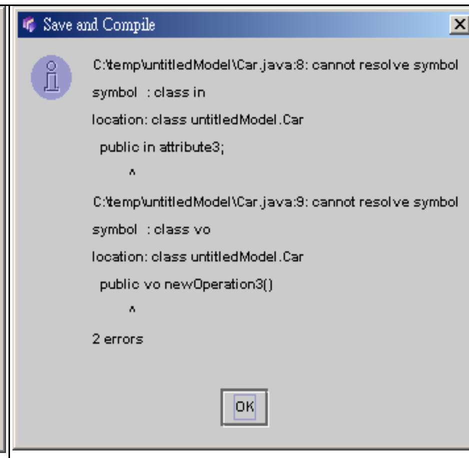


Fig. 4. UML drawing tools and mapping of UML patterns to Java

WEBLOOP was developed using Java Web Start technology. Java Web Start is a new application-deployment technology that allows the user to launch full-featured Web-based learning applications with a single click from the Web browser. It allows the user to launch and manage applications on the Web. Java Web Start provides easy, one-click activation of applications, and guarantees that students are always running the latest version, eliminating complicated installation or upgrade procedures. Traditionally, distributing software across the Web requires the user to find the installer on the Web, download the installer, locate the installer on the system, and then execute the installer. Once the installer is executed, it prompts for installation directories and installation options such as full, typical, or minimum. This is typically a time-consuming and complicated task that must be repeated for each new version of the software. The Web browser is used to automate the entire process. There is no complicated download, setup, and configuration steps, and the students are guaranteed to always be running the latest version. The systems architecture of the virtual laboratory system WEBLOOP for teaching OO-methods is shown in figure 6. It can be divided into the following components:

- The web server
- Backend database system.
- The Swing Application
- The Java Server
- The Compilation Server
- The Servlet Execution Engine





To compile the source code, users can click compile and then Save & Compile on server in the menu bar.	Once the students modified the codes and if there are errors, messages are displayed to the students machine at home.

Fig. 5. Sample screens of WEBLOOP for on-line editing and compilation of programs

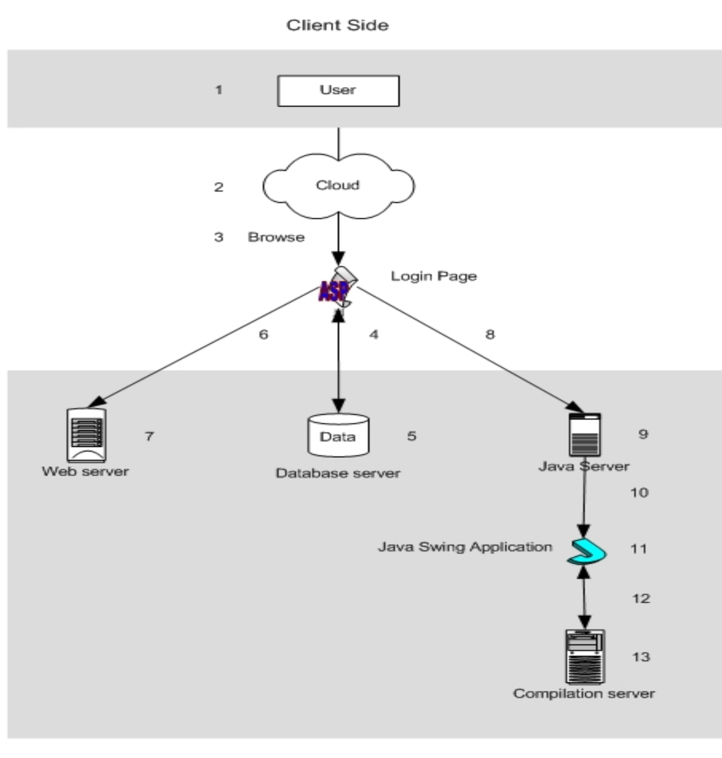


Fig. 6. Systems architecture of Web-based learning software WEBLOOP

The systems flow for WEBLOOP can be explained using table 1. It describes in details, the system flow for students to use Web-based learning software that was developed using JAVA (e.g. the UML drawing tool used in WEBLOOP).

An advantage of this approach is that it allows students to access remote facilities, without the need to install/set up/update new versions of software on that own PC. All steps requires to use the central facilities are automated using a browser. Furthermore, by making the UML classes as a sub-class of servlet using the UML drawing tools, the system is able to generate servlet code patterns. Students can execute the compiled servlet classes through the Web browser. The servlet classes are executed at the servlet execution engine located at the server. The results of the execution are displayed interactively by invoking the execution on the browser. By working at home or at their office, the students do not need to set up their own server, as all activities are maintained and activated through the central server.

Table 1. System flow for WEBLOOP (with reference to the numeric labels in Figure 6)

1.	The user is a student who is attending the virtual laboratory sessions through the Web
2.	The user access the system URL by opening a browser via the Internet.
3.	The login page allows the students to access their personal workspace, providing a feature for tracking individual student activities.
4.	Each login to the system requires validation against the student administration system. It provides access to schedules for virtual laboratory sessions.
5.	The database is integrated to the student record system in WebCT.
6.	If permission is granted, the user then can retrieve information from the web server. Normally, the web pages contain all the information related to our topic, such as online tutorial, user guide of the tool and other relevant materials for supporting the virtual laboratory sessions.
7.	The web server (Microsoft Internet Service Server IIS 5.0) hosts the virtual laboratory course materials.
8.	Student invokes the drawing tool (developed using Java Swing).
9.	The Java server is an Apache Tomcat server.
10.	The Java server is invoked and sends the Java Application to the user via Web Start.
11.	This Java Swing application (UML drawing tool) can be launched from the browser by using Web Start.
12.	The system compiles the source code generated (after editing the program) and invoke the compilation server by sending the Java source code files (*.java).

6 Evaluation of the Web-Based Learning Approach

To evaluate the teaching effectiveness of the HKCyberU program, the University conducts teaching evaluations regularly at the end of each semester, through student feedback questionnaires. In general students are satisfied with the HKCyberU mode of teaching. Since the way the courses are being delivered in the HKCyberU is different from the conventional mode of teaching, it is quite difficult to use surveys to conclude whether a HKCyberU course is fully compatible with a conventional one. Instead of drawing conclusions from survey and questionnaires, we compare the examination results of two groups of students during the semester from September 2000 to February 2001. One group of students attended the course Internet Computing through conventional lectures and classes and the other group of students studied the course Internet Computing on-line through the HKCyberU. The two different groups of students are supervised by the same lecturers. Both groups of students attended a formal written examination with the same examination paper. Table 2 shows the results of the examination scores of both groups of students.

Table.2 Mean GPA for two different groups of students

	HKCyberU Students	Conventional U Student
Sample Size	48	54
Mean GPA	2.59	2.87
Standard Deviation	1.06	0.94

We want to test whether there is a difference in the examination scores between the two groups of students. Let μ_x and μ_y represent the population mean score of HKCyberU students and conventional class students, respectively.

We want to test $H_0: \mu_x = \mu_y$
against $H_1: \mu_x \neq \mu_y$
at the significance level $\alpha = 0.05$

Since the population variance of the mean scores for both populations for the HKCyberU and conventional class students σ_x^2 and σ_y^2 are both unknown, we assume that $\sigma_x^2 = \sigma_y^2$. Using n to stand for the sample size for HKCyberU and m for the sample size for conventional class, we can then take

$$T = \frac{\bar{x} - \bar{y}}{S_p \sqrt{1/n + 1/m}} \quad (1)$$

to be the test statistic, with the pooled standard deviation

$$S_p = \sqrt{\frac{(n-1)S_x^2 + (m-1)S_y^2}{n+m-2}} \quad (2)$$

In this case, since with two-sided test, $t_{0.025}(48 + 54 - 2) = 1.980$, we have the reject region **R**

$$\mathbf{R} = \{ T : | T | > 1.980\} \quad (3)$$

Since $S_p = 0.9982$, we have $T = -1.414$, with degree of freedom 100. As $|T| = 1.414 < 1.980$, H_0 cannot be rejected at 0.05 level of significance and that implies the mean of the examination scores for HKCyberU students cannot be considered as different from that of the conventional class students. The result concludes that although the way HKCyberU courses are being delivered in a different manner, it is still possible to attain the same standard as conventional courses.

7 Discussion

Although the mean GPA for the two groups of students turns out to be insignificant, this should not be generalized so easily to other disciplines. This is because the courses that we offered in our HKCyberU programs in this study are primarily Internet and e-Commerce based ones. Students who are keen to pursue this area tend to study hard and are quite well-adapted to the use of the Web as the information delivery as well as information exploration media. The pool of students we attracted thus represent those who are suitable to study over the Web as the new distance learning model. This also helps to explain the relatively small difference in terms of performance. Furthermore, our enrollment statistics also indicates that the dropout rate for the HKCyberU course stands only at a mere number of 4 out of 54 (7.4%), which is also comparable to that of normal courses. Thus, the HKCyberU initiative turns out to be a reasonable success, in terms of student performance and dropout rate, compared with traditional learning programs.

8 Conclusion

In this paper, we have presented the development of the courseware for a cyber version of a MSc in e-Commerce program. As a new development in local tertiary education in Hong Kong, the program was offered through the Hong Kong CyberU. At present, eight HKCyberU courses have been developed, based on materials for the conventional MSc in e-Commerce program. Various facilities are used for on-line delivery of Web-based learning supported by the WebCT platform. We have address the issue of how Web-based instructional development cope with this new style of learning. On the technical side, the cyber mode of learning impose different requirements for conducting tutorials and laboratory sessions. A new platform is being developed for students to work on cyber laboratory sessions remotely through the Web.. We have formally evaluated the examination results of a HKCyberU course and concluded that the standard of this course is the same as that offered in the conventional mode, which is an encouraging result. Our experience has shown that the rapid development of Web-based learning, virtual laboratories and virtual universities provides a different approach to learning. It can be concluded the cyber university provides an innovative way of teaching through the Web. However, a new challenge for this new mode of teaching and learning is to migrate existing courses to cyber versions so that they are managed under one single umbrella. It is expected that the HKCyberU will offer courses that bear the full professional standard as our conventional courses and more courses can be delivered through Web-based learning programs [1, 3] in the future.

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Supporting Practices in Web-Based Learning*

Changjie Tang[1], Qing Li[2], Rynson W.H. Lau[2], and Xiaodong Huang[1]

[1] Computer Science Department, Sichuan University, P.R. China

[2] Department of Computer Science, City University Hong Kong, Hong Kong

Abstract. Student practices are an important aspect in schooling. This article explores a possible solution of this issue for Web students in the field of computer science. Taking a DBMS implementation course as an example, the practical experiences are introduced, including courseware organization, question answering, project assignments and checking for Web Learning. The courseware is featured with: (a) self-navigation by semantic links, (b) seeing before learning, (c) provision of source code and practice-slots, (d) learning with tasks, and (e) personalized interface facilities. The special techniques inside the implementation of a personalized interface, such as user information table, behavior table, topic level tree and the page producing mechanisms are also discussed. A strategy to get the feedback of Web students is proposed, namely, by setting up a shadow class on campus to reflect the feedback of all Web learning students.

Keywords: Web learning, practical classes, learning with task, shadow classes.

1 Introduction and Background

Recently, Web-based learning has been attracting more and more attention. A lot of research results, prototypes and products are published and widely applied in the education sector. Wang and Sun discussed an urgent problem facing distance language learning, the synchronous distance education [1]. Ochi et al. [2] proposed a Web customizing system for sharing educational resources. Ateyeh et al. [3] introduced a modular method to the development of multimedia courseware. Tang et al. proposed a technique to construct personalized courseware based on data mining [4]. It is worth particular noting that research on data mining over the distance learning has received some significant attention and interesting results [5-7]. However, only limited work has discussed the issue of student practices on Web-based learning.

Some education experts argue that Web-based learning falls short of student practices. It is true that there are some difficulties for web students to have experiments in the fields of Chemistry, Physics or Biology. This paper explores the issues for computer science students based on our experiments on a Web course called “Implementation of Small DBMS in C” [8]. The courseware is available from a book called “The Internal Structure of the Database System and its Implementation in C" published in 1995 [9]. The courseware was put up on a Web server of South-West Site of CERNET (China Education and Research Net) during 1996-1999, and is now

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accessible from the Web server of Sichuan University. The courseware has a total of 380 pages (or 6,020,000 Chinese characters). It is a compulsory course for master students in the database field and an elective course for undergraduates. The students will be learning it themselves on the Web.

The paper is organized as follows. Section 2 summarizes the contents and features of the course. Section 3 discusses a feature of the courseware, namely "learn how to learn", and proposes a strategy to obtain the feedback from Web students by *shadow class* on campus, which may dynamically reflect the status of the students. Section 4 describes the special techniques used in the implementation of personalized interface facilities, such as the user information table, behavior table, topic level tree, and the personalized page producing mechanisms. Finally, section 5 briefly concludes this paper.

Table 1. The contents of the courseware

Parts	**Contents** (text and source codes)
1	Simple history and key issues in the implementation of DBMS
2	The Control flow and Data flow ,the modules of typical DBMS
3	The interface, Menu Driver, Event Driven, Mouse driver etc.
4	Data Storage structure and transfer mechanisms of CerBase
5	Index and B-Tree of CerBase, B-Tree cache, full-debug code
6	Data Definition Language (Create, modify structure, index etc.)
7	Data Manipulation Language of CerBase (projection,selection,Join,)
8	User input and Output, (Accept, Input, Window, Printer modules)
9	Mathematics Module and statistical module of CerBase .
10	The command Interpreter (shell) of CerBase.
11	Using Language C as Host Language of CerBase
12	The tool-box (string tools, file-tools, output-tools, transfer-tools)
13	The text editor of CerBase (edit command, edit program in window)
15	The optimization and transplant of CerBase
16	The Security and Integrity of Cerbase (principle and techniques)
17	The setup and debug of CerBase
18	About the authors

2 Contents and Features of the Courseware

The courseware "Implementation small DBMS in C" was first named as CerBase [8]. It was a subproject of The Resource Construction Project of CERNET (China Education and Research Net). It was written in Chinese and this does not prevent us from describing the idea, features and the experiences of our practices in Web-based learning. The courseware is modified on a yearly basis according to the teaching experiences. The latest version consists of 143 HTML files and some GIF files, the contents of which are as shown in Table 1.

The structure of courseware is neither very complicated nor very colorful, but is a piece of complete work. The source code of CerBase is of 63,000 lines in total. Our practices in the last 3 years show that it is neither too difficult nor too easy for the students to learn on Web.

The courseware is characterized as a flexible resource for Web-based learning with the following features:

1. *Self-navigation by semantic links*: The total 143 HTML files are linked to each other according to their semantic associations. It is easy to navigate in the "ocean" of CerBase. Students can go to any part of the course conveniently.
2. *Seeing before Learning*: A fully debugged CerBase.EXE, source code and necessary obj files are provided to each registered Web learning student. They can run the EXE first to see what the system can do, and then read the courseware and the source code to understand the detailed implementations inside the DBMS. In order to understand difficult codes, students can use the debugging mechanism.
3. *Practical Style with source code*: The CerBase can be viewed as a simplified version of Hbase - a temporal Database with rich semantics [9,10]. For the simplicity and readability for undergraduates, we removed the temporal mechanisms from Hbase while keeping 90% of the fully debugged source code with detailed comments. Thus, students can learn the data organization, the index, DDL and DML operations by the source code. The well-organized illustration text gives the principle, algorithm and idea for each function.
4. *Practice-Slots*: The courseware was organized in practice-oriented style. We have omitted 10% source code of some modules from CerBase; they are replaced by the practice-slot functions such as the following:

   ```
   practice_slot(char *s_name)
   { printf("This function is home work assigned to s_name, \r\n"
             "and should be completed before June.20,2002.\r\n");
    }
   ```

   Students can run a pre-compiled EXE file to see where their tasks are and what roles the tasks will play. These practice-slot functions are relatively easy and can be finished by a student in two to four months. The list of typical practice-slot functions include DO-Update, DO-Memo, DO-SQL, Do-Semi-Join, etc..
5. *Learning with tasks*: Once students have registered this course, a task is assigned to them. This is often done in a face-to-face style in the first week of each semester. After this step, students can lean the course with a clear idea of the assigned task and a commitment pressure that makes students study harder.

6. *Personalized interface*: This feature is added to CerBase in the year 2000, the principles of which can be found in [4]. It aims at improving the performance of the module named "Question and Answer for Debugging" and to improve the friendliness of the browser for the courseware. The main idea is that when students just login the Web leaninig page by a conventional browser (such as IE or Netscape), they will see a simple page as shown in Figure 1. During the learning period, a personalized mechanism records individual students' behaviors in the User-Info-Base. By mining the association rules, the system "knows" the users' behaviors, guesses the users' favorite links, and presents them to the user. When a student makes his/her subsequent (eg, 20th) login, he/she will probably see the (improved) pages as shown in Figure 2.

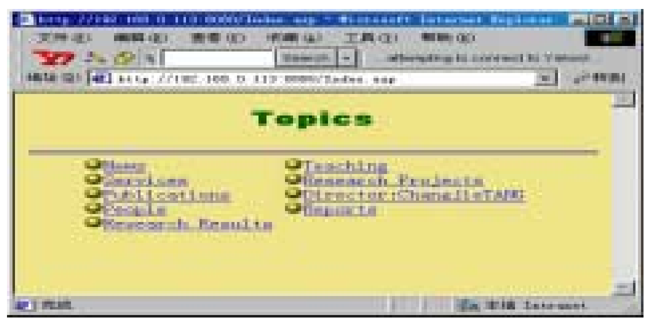

Fig. 1. The first login page

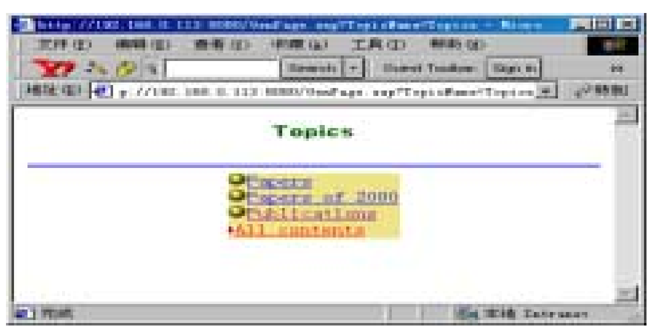

Fig. 2. The 20th login page (personalized)

3 Practical Attractions and Strategies

A courseware needs some attractive sections to survive in the competition. By our experience, the attractiveness in the contents (such as readability, logicality, reusability codes) is more important than the format (color, motion, flush, etc.).

3.1 Learning How to Learn

In our courseware, Part 5 (index and B-Tree), Part 9 (mathematics module), Part 10 (the command interpreter), and Part 11 (C as host language of CerBase) are most welcomed by the Web students. The attractiveness of Part 5 is mainly due to the following aspects:

1. *Clear idea on structure*: It gives a clear illustration in the viewpoint of mapping the concept of index and a clear idea of three levels (illustrated by source code) of in the B-Tree structure, besides the traditional books. We found that, to illustrate the structure, the source code is clearer than general descriptions.
2. *Small inventive "tricks"*: There are a few small "inventions" in the implementation of CerBase such as the re-use- stack for unused B-Tree node and the B-Tree cache. These ideas are new and the techniques are applicable to other areas other than DBMS. Students seem to like such flavor and materials a lot.
3. *Commonsense knowledge illustration*: For a difficult part of the course, the courseware tries to give some examples to illustrate the idea. For example, to explain the recursive procedure of split and-merge node, the courseware gives a common sense example, viz., an army organization example with growing or reducing scale. Speaking philosophically, such an example is very similar to a B-Tree's growth and shrinking, which people can understand more easily.
4. *Modify-able and re-useable source code*: A bug-free source code of B-Tree is not easy to be found in other books. It provides a learning base upon which modifications and re-use of the code by the students can be accommodated.

Once having a chance, the courseware always tells students to learn how to learn. The courseware emphasizes that a specific technique for DBMS may be useful, but the idea and the methodology hidden there are more important and more useful in the future for the students.

Part 9 contains a recursive-reducing algorithm for complex mathematical and Boolean expressions with at most 64 embedded levels. According to the feedback, some former students who had this Web-based learning experiences have modified this module and used in their real-life projects. Part 10 (the command interpreter) is a real challenge to student's intellectual capabilities, and part 11 (C as Host Language of CerBase) teaches students to use CerBase Library flexibly in their own projects.

Our experiences show that, a good Web learning courseware should be based on good research results and/or good textbooks. (An analogy is that the Web presentation is a good actor who cannot give out a good play without a good script.)

3.2 The "Shadow Class" Strategy

The experience shows that in order to get better result for Web-based learning, the feedback of the Wen students is more important than that of students on campus, especially when the courses are practical ones (like DBMS). The main difficulties for a practical computer science course faced by the Web students include the following:

1. As the software and hardware keep getting updated rapidly, the problems associated with platforms also need to be changed each semester. It is not easy for both the students and teachers to predict (and hence prepare in advance) the problems and the background on the platforms without face-to-face interactions.
2. The debug technique for programming is an art rather than a science. The user problems are not easy to predict even by the professional programmers and developers (eg, those in Microsoft) who developed the debugger. Indeed, requests

to explain various (sometimes strange) debugging messages are some frequent questions raised by the Web students.

3. Without feedback from students, a Web teacher is difficult to modify the courseware as well as the frequently asked questions and their answers.

In order to obtain the feedback from the web students, a *shadow class* is set up in the campus for them. All these students are registered Web students who live near to the campus. There is a specific schedule for question asking and answering. In order to reflect the real status of all the Web students, the students in the shadow class should be "typical" enough (just like a training set in the classification problem). Based on this assumption, data mining techniques can be applied on the Web students; currently some data-mining programs are under development.

4 Implementation of Personalized Interface Facilities

4.1 Architecture

To implement a personalized interface (abbreviated as PI), we adopt an architecture as shown in Figure 3. Simply speaking, PI = Association-Miner + Personalized Page producer, where Association-Miner is based on User-Infor-Base. It uses an efficient association rule mining method. The Association-Miner analyses the user information during web learning, such as user behaviors, favorite topics, clicking habits, etc. The personalized page producer records the user's behavior and produces the personalized pages. A detailed part of the Association-Miner description can be found in [3].

There are some special techniques used in producing the personalized pages. The key ones include the following: (1) user registration module, (2) user click record module, and (3) personalized page producing module (according to association rules), as elaborated in the following subsections.

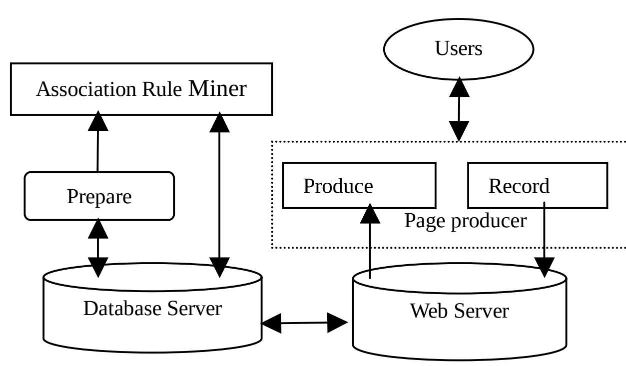

Fig. 3. The architecture of the personalized interface system

4.2 User Registration Module

When a Web student logs into the system for the first time, the system registers him/her in the User-Info table, and produces a *User Behavior* table and *Level-tree* table for the student (through an ASP program named Register.asp). The User Behavior table that keeps track of a user's clicks is shown in Table 2.

Table 2. User Behavior table

Serial Number of Logins	Serial Number of Clicks	Topic Name
1	1	News
1	2	Papers
1	3	Publications
2	1	Papers
2	2	Papers of 1999
……	……	……

The meanings of *Serial Number of Logins* and *Serial Number of Clicks* follow from the names naturally. *Topic Name* is the topic that has been clicked by the user. On the other hand, the *Level tree* table for a user is used to keep the topic level tree, i.e., to indicate which level the topic just clicked (by the user) belongs to. Its format is as shown in Table 3.

Table 3. Level tree table

Level name	Level ID	Topic name
Index	0	Topics
Department	1	News
……	……	……

4.3 User Click Record Module

When a user clicks a link with a topic, the system records this click into *User Behavior* table and then produces the personalized page according to this topic and the user's habit that the system has learned before. (The issue of producing the personalized page will be dealt with in the next subsection.). The process of behavior recording is transparent to users.

Note that, when recording users' behavior, different users will cause different tables to be inserted. Thus, the implementation for the insert statement (SQL) must be varied according to the users. As it is somewhat tricky, we provide some detail of implementing the insertion below:

```
sql="insert into " UserID +"_Behavior" +" values('"
sql=sql+SerialNum_of_Login+"', '"+SerialNum_of_Click+"', '"
sql=sql+TopicName+"'"+")"
```

The values of variables such as 'SerialNum_of_Login' and 'SerialNum_of_Click' are pre-calculated, thus the string 'sql' contains the insert statement for a certain user. In this way, we can apply different operations for different users.

4.4 Personalized Page Producing Module

The main idea of this module is as follows: the system searches from a User Association Rule (UAR) table the association links (i.e., who favors which links; cf. Table 4), and constructs a new page with these links. If there is no useable information in the UAR table, then the default page will be returned by the server.

As shown in Table 4, the concepts of rule, support and confidence are the same as those defined in [11]. When a topic is clicked, the page-producing module (a program) gets the Topic-Name and UserID, then according to the UAR table and topic level tree, determines the topics to be displayed. The specific tasks to be performed by this program are the following:

1. Decompose association rules.
2. Determine the topics to be displayed.
3. Organize the page layout.

Table 4. User association rules table

Rule	Support	Confidence
{People}==>{Faculty}	0.34	0.77
{Topics}==>{Publications}	0.55	0.55
{People, Topics}==>{Faculty}	0.31	0.4
{Papers, Topics}==>{News, Publications}	0.3	0.6
……	……	……

Tasks (2) and (3) are mainly implementation issues, whereas task (1) is solved by the following algorithm.

Algorithm (Decomposition of association rule)
Input: user association rules and user Level-Tree
Output: A table called Output-Level-Tree contains the topic tree for constructing new page
Steps:

```
Find the level of TopicName from user's LevelTree, denote it as level1;
Find all the rules with TopicName in the left set, insert it in  rule set 'rsrule'
while not rsrule.EOF       // process all rules in rsrule
```

```
          locate the right part of the rule
          goto the first topic in the right of the rule
          set parameter b=the character just after current topic
          while b<>"}"           // process all topics in the right of the rule
               take one relative topic
               Get the level of current topic, as level2, from LevelTree Table
               if level2>level1 then put Target in OutputLevelTree for user
          end while
          rsrule.movenext        // Locate to the next association rule
     end while
     output OutputLevelTree;
```

Based on the result of the above algorithm (i.e., OutputLevelTree), the topics to be displayed are acquired through the following SQL statement:

```
sql="select distinct TopicName from "+UserID+"_temp"
```

Let the result of the above query be denoted as reList. From the above code, since the parameter distinct is adopted, there is no duplicate object on reList. Thus it is easy to display the topics by HTML and every topic (as a link). If a link is clicked, a new process of click recording and personalized page producing will be (recursively) started.

By now we have generated the personalized page, but we should not bereave the rights of students to access the default page. Thus we have added another link, which is the option of 'All Contents' as shown in Figure 2. When it is clicked, it will lead the user into the default page rather than the personalized one.

5 Summary

In this paper, we have discussed the importance of practicing activities for Web students and studied a practical course for Web students, "Implementation DBMS in C". The main features of it include (1) self-navigation by semantic links, (2) seeing before learning, (3) practical style with source code, (4) practice-slots, (5) learning with tasks, (6) personalized interface, and (7) teaching students "learn how to learn".

We further described the key issues and special techniques inside the implementation of a personalized interface, including the system architecture, user information table, user behavior table, user topic level tree and the personalized page producer. We also proposed an important strategy in the administration level for Web students, i.e., to set up a "shadow class" on campus that can correctly reflect the feedback of all Web learning students. In this way, a Web teacher can improve his/her courseware and adjust teaching schedule promptly and effectively, so that the students learning on Web can acquire the same guidance as that in the face-to-face training on campus.

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A Web-Based Lecture Video Database System with Flexible Indexing Method Using Action Logs

Akira Okada and Yahiko Kambayashi

Department of Social Informatics, Graduate School of Informatics, Kyoto University
Yoshida-Honmachi, Sakyo, Kyoto 606-8501, Japan
{aokada,yahiko}@db.soc.i.kyoto-u.ac.jp

Abstract. To support video retrieval is the most important issue in Web-based learning environments using video on demand technologies. In conventional systems, to satisfy this requirement has led to the increase of labor or hardware cost. In this paper, we propose the new technique for indexing video records of lectures. The system records various operations on computer together with video data, which will be used for indices. Furthermore, the implementation requires no special hardware device or additional work of teachers. Thus, this method can realize both improvement of search-ability and cost reduction. The system has already been used actually in Kyoto Women's University and can be evaluated by results achieved there.

1 Introduction

Video records of lectures are so useful for many users that various studies to manage and utilize them are performed. Recent developments of video streaming technologies on Internet, which are called Video on Demand (VOD), improve the effect and efficiency of such methods dramatically. A teacher or an organization such as a university can distribute their lectures for students all over the world very easily. A student can access them from anywhere at anytime, only by using a Web browser. On-line universities are realized by various organizations, such as Open Course Ware at MIT [11].

Even if a system is used only within a university, VOD technologies are enough valuable for reviewing by students or lecture analysis by teachers. At Kyoto Women's University, some teachers started a project to construct a lecture video database for only internal use. About 70 lectures are recorded on video and provided on a Web page. Many students have accessed them for self-study and the system are generally popular among students.

However, existing VOD-based learning environments, which include the system in Kyoto Women's University, do not equip enough functions to satisfy requirements from students and teachers. The most serious problem is the insufficiency of search-ability. A user must perform two tasks to obtain information s/he requires from a video database system. The first is called "global search" to find some streams that may include information s/he seeks. The second is called "local search" to identify the

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portions s/he should play for his/her purpose. These functions are strongly required for efficient learning, but most of conventional systems cannot support both of them.

Though some advanced research projects have addressed to improve search-ability for lecture archives, they cannot be introduced into every actual organization due to costs or hardware resources. For example, the system developed in eClass project [1-3] gave an advanced solution to improve quality of VOD-based learning environments without increase of working burden on teachers. However, to use this system, every lecture must be provided in an electronic classroom that is equipped a projector or a touch panel screen. In Kyoto Women's University, we are planning that lectures of all courses will be recorded on video streams and opened on the Web in future. To use the system of eClass in Kyoto Women's University, we must introduce electronic equipments into all of classrooms, and it has no reality for costs. A new lecture video database system that follows the requirements of Kyoto Women's University should be developed.

In this paper, we will give a resolution to realize the reduction of working costs of teachers or requirements to hardware resources, and the improvement of search-ability for video data at the same time. We show the importance of "flexible data structure" and "Web-based interface" to construct VOD-based learning environments for practical use. The requirements presented by Kyoto Women's University seem to be common with many of universities all over the world. Therefore, the contributions in this paper will be valuable for the development of Web-based learning using VOD technologies.

This paper is constructed as follows. In section 2, analysis of requirements to functions is given. In section 3, we describe design of the system to satisfy requirements. In section 4, we show the implementation of the system that is used in Kyoto Women's University actually. In section 5, we give conclusion of this paper.

2 Requirement Analysis

As mentioned in section 1, we cannot introduce conventional systems into Kyoto Women's University directly and the new one that can improve both of search-ability and manageability. In this section, we analyze the requirements to user support functions in Kyoto Women's University and decide policies for system design.

2.1 Requirements

Requirements to System Functions. Video records of lectures can be used for various purposes. For example, purposes of teachers will be quite different from students. Therefore, to design useful functions, detailed analysis of user requirements should be performed.

Usages of VOD-based learning systems in actual educational organizations can be classified into some types. The following usages are assumed when a user views a video record of a lecture:

1. Used by a student who was present the lecture for reviewing. S/he has much knowledge about the lecture, such as contents or structure.
2. Used by a student, who takes the lecture but was absent from it, for self-study. S/he has some knowledge about it, but does not know the detail.
3. Used by a student who has no relation to the lecture. For example, s/he may receive it as a result of keyword search for a lecture video database. In this case, s/he will have little information about the contents of it.
4. Used by a teacher who gave the lecture for self-checking or analysis. Of course, s/he knows well about it.
5. Used by a teacher who wants to refer a lecture by others for some help. S/he has little knowledge about it.

In this project, the major purpose of introduction of a lecture video database system is to support self-study by students, rather than lecture analysis by teachers. Thus, the system must provide functions for mainly users belong to 1 or 2.

Requirements for functions can be discussed being based on the above assumptions. At first, simple search functions that can be developed easily, such as keyword search for streams using title or syllabus text of a lecture, seems to be not useful for user 1 or 2. They will have identified the stream that they should view for self-study. Functions to search for the inside of a video stream, such as "local search" functions are more important than "global search" functions. Some of user 1 may replay the whole of a stream to review the entirety of a lecture, and local search functions are not necessary for them. However, the other of 1 will replay some parts of a stream to review only contents they could not understand during the actual lecture. In this case, the provision of local search functions will influence on learning efficiency and be required strongly. Therefore, the enrichment of local search functions is the most important issue in the system of Kyoto Women's University.

Requirements to Management. In addition to functional requirements, there is some restriction about management of the system, which we have to consider. Kyoto Women's University consists of some faculties covering a wide area of sciences and most of students and teachers do not major in computer science. Furthermore, hardware resources are quite limited. Therefore, for example, to design complex user interfaces or functions that demand special hardware should be avoided. Concretely, the following consideration is required.

- **Classroom or lecture environment:** There are some rooms that have no electronic equipments such as projector, screen or network devices in Kyoto Women's University, so the system must be able to work in traditional classrooms that have only "chalk and blackboard". In Addition, wide differences of style to give a lecture among teachers should be taken more seriously. A teacher uses various presentation tools, such as PowerPoint slides or Video materials, during a lecture. On contrast, another one does not use any tools, even blackboard. S/he only speaks throughout a lecture. Techniques adopted in the system should be able to improve search-ability in both cases.
- **Computer environment on accessing to video records:** In viewing of video records, there are also some restrictions. It is assumed that students access lecture archives from a machine installed in the computer room of the university. Environments of machines (spec, OS or installed software) in the computer room

are not unified. For example, Windows PCs and Macintosh computers are intermingled in a room. With considering costs to administrate client machines, it is desirable that students can access records using only Web browser and a few standard software products.

- **Working costs of teachers and students:** Of course, both teachers and students have no time to waste. Thus, the amount of works that they must perform for system management should be as little as possible.
- **Ability of students:** As mentioned above, most of students do not major in computer science. Thus, user interfaces of the system must be quite simple.
- **Flexible management of records:** Many conventional systems focus only recording and reviewing a lecture, and it has been ignored how to maintenance or manage lecture records.

It can be emphasized that the requirements described in section 2.1 will be common with many organizations. These issues have not been addressed in most of conventional research projects, but should be resolved to spread VOD-based learning environments all over the world. In this paper, we aim to satisfy all the requirements at same time, without tradeoffs.

2.2 Studies of Conventional Methods to Improve Search Ability

We have shown requirements for system functions in section 2.1. At next, we investigate video retrieval techniques for local search to satisfy them in this section.

Information retrieval for multimedia data is one of the important research fields in computer science, so some methods to improve search-ability for video streams have already been established. We examine whether they are available or not in the system of Kyoto Women's University with referring requirements mentioned in section 2.1.

- **Hand indexing** [5]**:** This is a method to input meta-data, which are usually text data with a time stamp, on hand. Indices with high accuracy can be generated by this method, but it requires a large amount of works for indexing.
- **Automatic indexing by activity recording** [1,6,7]**:** This method, which is adopted in eClass or other advanced projects, can generate indices automatically by recording a video stream and some other operations on computers (such as slides or hand-written notes) synchronously. For example, in the case of recording operations of changing slides, a user can start playing from each points in the stream when a slide were changed for the next one. The advantage of this method is that indices with high quality can be compatible with low labor costs. However, it demands special hardware resources, software products and abilities to operate them.
- **Image processing:** This technique can detect the points when the image of a video stream changes greatly and generate indices using them automatically. In many systems, a user can access an index by choosing a thumbnail image. This may be useful for movies or TV news but not for lecture records, because they usually consists of only the image where the shape of a teacher is projected and no indexing point will be found.
- **Speech recognition** [8]**:** This method can convert voices included in a record into text data with time stamps and provide them as indices. The processing also can be

performed automatically, but there is a problem about precision or noise. Furthermore, SCAN project has reported that this method cannot support all kinds of tasks in viewing stream documents.

At present, one of the above techniques is necessary to support local search for video streams. However, there is no method that can satisfy the requirements completely. New methods are required to develop the system in Kyoto Women's University.

2.3 Policies and Methods to Satisfy Requirements

In this section, we show the basic ideas and define the policies in system design. We have focused automatic indexing based on activity recording techniques to improve search-ability, since it is valuable that useful indices can be generated without increasing of teachers' works. The conventional methods suppose all the devices are connected each other by network and synchronized recording of activities is available, but such equipments cannot be set up in all classrooms. It is also unable to demand all of teachers to use a complex system that has functions for synchronous recording in all lectures. To solve this problem, it is required to develop a mechanism that can perform indexing based on activity recording with no special devices and deal with various lecture styles of teachers. In this paper, we propose the following two policies as one solution to such a difficult but general problem.

- Record and accumulate any activities or operations that may be available for indices to video streams.
- Construct an activity recording environment that is independent from hardware resources or lecture styles.

We aim at, that is, realization of the video indexing method based on activity recording that is available in any lecture given in any organizations. To develop the system in accordance with them, the following techniques should be developed.

- **Flexible structure of lecture records:** Data structure of lecture records must be very flexible. For example, a teacher may use some documents or PowerPoint slides, which include useful keywords for indices. Another teacher may use no tools and give a lecture only by speaking. Lectures by both of them can be recorded with every operation and stored on database.
- **Utilization of notes taken by students during a lecture:** If a teacher does not use any tools on computer during a lecture, no operation for index can be recorded. Of course, it is desirable that some indices can be achieved in such a case. Operations by students, such as notes or questions are also valuable for indices and performed in any lectures. In that lectures that a teacher hope to use no tool, operations by students should be utilized. Especially, notes taken by students seem to be most useful since they usually reflect the content of a lecture directly.
- **Distributed recording of operations:** To make it enable to record user operations in any classroom, network connection among devices should not be assumed. It means that synchronized recording of operations on multiple devices is not available. It is required to record operations in stand alone environments and merge them after a lecture. This method cannot guarantee precise synchronization strictly,

but it is not required under the condition that operations are used only for indices and synchronized replaying is not considered.

If a system based on them can be developed, it will be very useful in not only Kyoto Women's University but also many other organizations. However, it is not so easy to design and implement the above methods on Web-based lecture video database system. In section 3, we show the design of the system used in Kyoto Women's University, which reflects the above ideas and policies.

3 System Design

In this section, we describe the design of the Web-based lecture video database system for Kyoto Women's University.

3.1 Concepts

Based on all the discussion in section 2, there are the following representative functions that must be developed:

– Management of video streams, teaching materials and all kinds of operations for indices on the central database.
– Web-based interface where a student can perform all kinds of learning activities, such as referring documents used in a lecture, viewing video streams or posting a question to the teacher.

The image of these concepts of the system is shown in Fig.1.

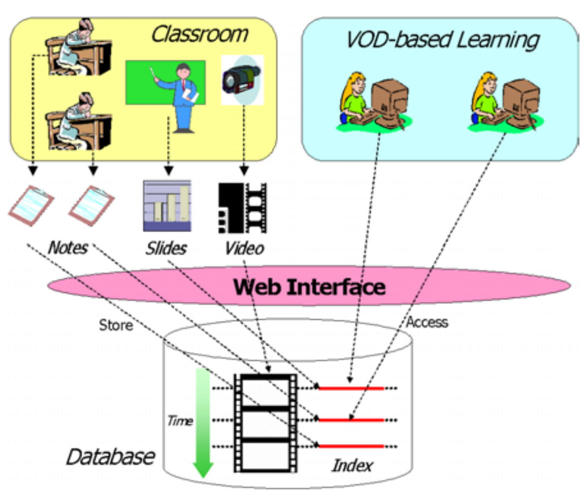

Fig. 1. Concepts of lecture video database system

Many of system components can be designed by combining existing technologies, but the following two elements to implement the methods described in section 2.3 are not common with conventional systems and should be designed originally. We show the technical details of them in section 3.2 and 3.3.

– Database schema to realize the flexibility of structure of lecture records.
– Method to access indices on the Web.

In addition to the main system, the text editor for student to take notes with time stamps during a lecture is required. It can be implemented easily.

3.2 Database Design

At first, we must design the schema of the database, which is placed in center of the system and necessary for accumulation of every kind of operation logs recorded in a lecture. Action History model, which is developed in our former research [9][10], is adopted for the database. In this paper, we show the characteristics and some examples of lecture records using Action History.

Action History model is a schema design on standard relational database to store activity records in form of operation logs. This model has two important characteristics. The first is that it can represent all of 4W1H, such as what, who, where, when and how. To record an operation, all of them are required. The meanings of 4W1H are shown in Table 1. Incidentally, "why" cannot be captured and recorded automatically. The second characteristic is to make logs possible to deal with multimedia data, such as video or sound, on relational database model.

Table 1. Meanings of 4W1H in an activity record

What	What kind of operation was performed?
Who	Who performed the operation?
Where	Where (what working environment) a user performed the operation under?
When	When the operation was performed?
How	How was input value of the operation?

To realize these two features, some technical ideas are incorporated in Action History model as follows.

– **Hierarchical structure:** A set of logs constructs tree structure to represent values of "where". To say conceptually, a log put on parent node represents a general operation and child nodes of it represent more detailed operations.
– **Link to multimedia file:** To deal with multimedia data on relational databases, links are introduced. This means multimedia data (perhaps will be binary files) are placed out of a database table.

Action History model has ability to represent records various kinds of user activities in systems that have complex function structure. The definition of Action History is shown in Table 2.

Table 2. Definition of Action History model

$H=\{H_1, H_2\ldots\}$	
$H_n=(HID_n, PH_n, M_n, I_n, TS_n, TE_n, N_n, L_n)$	
HID_n	An identifier of an operation log
PH_n	An identifier of a log which is the parent node
M_n	The kind of operation
I_n	User's input value
TS_n	Time when the operation is started
TE_n	Time when the operation is finished
N_n	Name of a user who performed the operation
L_n	Link to multimedia data (represented as path name where a file is put)

An example of lecture records is shown in Table 3. This is the record of the lecture whose title is "Mathematics 1", which started at 13:32 and finished at 14:34. This record includes the following operations during the lecture, in addition to a video stream.

– Use of three pages of a document by the teacher for his/her presentation.
– Note taking by a teaching assistant. S/he has written down two phrases in this lecture, such as "Introduction" and "Foundation of differential equation".

Table 3. An example of lecture records

HID_n	PH_n	M_n	I_n	TS_n	TE_n	N_n	L_n
0	--	LECTURE	"Mathematics 1"	13:32:18	14:34:25	teacher	--
1	0	DOCUMENT	"Page 1"	13:35:20	13:39:45	teacher	Page1.html
2	0	DOCUMENT	"Page 2"	13:39:45	13:52:26	teacher	Page2.html
3	0	DOCUMENT	"Page 3"	13:52:26	13:58:31	teacher	Page3.html
4	0	NOTE	"Introduction"	13:35:12	13:35:12	TA	A4.smil
5	0	NOTE	"Foundation of differential equation"	13:44:14	13:44:14	TA	A5.smil
6	0	VIDEO	"Video 1"	13:32:18	14:34:25	teacher	Video1.rm

The advantages of adopting Action History Model in the lecture video database system are as follows. They are meaningful to utilize recorded operations for video retrieval.

– Logs of every kind of operations, which are useful for indices to a video stream, can be integrated and stored on a database table.
– Search functions for lecture video records can be developed easily by only standard database search operations using time stamps and hierarchical relations.

3.3 Web-Based Interface

For a student in a VOD-based learning environment, it is insufficient that s/he can only refer the content and timestamp of an index. S/he will hope the function to play a video stream from the point where the index points out. SMIL technology developed by RealNetworks Corporation [12] provides an appropriate solution to this requirement. SMIL is a language based on XML and can represent synchronized presentation consists of multiple streams. An example of a SMIL document is shown in Fig.2. If a user accesses this file, it starts automatically to play file “video.rm” from the point when fifteen seconds have past from the top of the stream.

The advantages to use SMIL technologies in the system are as follows:

– SMIL documents can be generated by the system easily since they are written in plain text.
– Installation of RealPlayer into client computers is required to interpret and play SMIL presentations, but it is a very famous software product and available free.

To realize the required user interface to play video, only the following processes must be performed when an operation log is stored on database as an index.

1. Compute the value of duration written on “clip-begin” field from time stamps of a log.
2. Generate a SMIL document and put it on a Web Server. The URL of it is stored on field L_n of a log.
3. Generate a hyperlink to the SMIL document when students view the lecture record.

```
<smil>
  <body>
    <video src="rtsp://videoserver2/kyojo/video.rm" clip-begin="15.0s"/>
  </body>
  </smil>
```

Fig. 2. An example of a SMIL document

4 Implementation and Actual Use of the System in Kyoto Women’s University

By using the techniques described in section 3, the system to satisfy all the requirements of teachers and students can be realized. In this section, we show the outline of system implementation in Kyoto Women’s University.

The lecture video database system has been implemented using only PHP language and PostgreSQL is used for the central database. Only two server machines are necessary to provide services of the system. The main components and the database system are installed on one computer. On another one, Realserver is working for streaming of video data. On client computers, only Web browser and RealPlayer are used to access accumulated lecture records. In addition, a video camera and a notebook computer to take notes are used in recording of a lecture. Altogether, the required hardware and software resources are general and not expensive. Thus this system can be introduced easily into not only Kyoto Women's University, but also any universities or organizations.

An example of client-side user interface is shown in Fig.3. A student can search for lecture video by specifying keywords included in notes. If a phrase in notes is obtained as the result of searching, s/he can play video from the point when it was taken during the lecture by only clicking it. This user interface is similar to normal navigation on Web pages, so all students can use it easily.

In Kyoto Women's University, at present, 67 lectures in various fields are recorded on video with notes for indices. The system will be used in earnest from April 2002. Furthermore, to evaluate the usability of functions or educational effectiveness of our indexing method, collection of data for experiments, such as access logs by students, will also start at the same time.

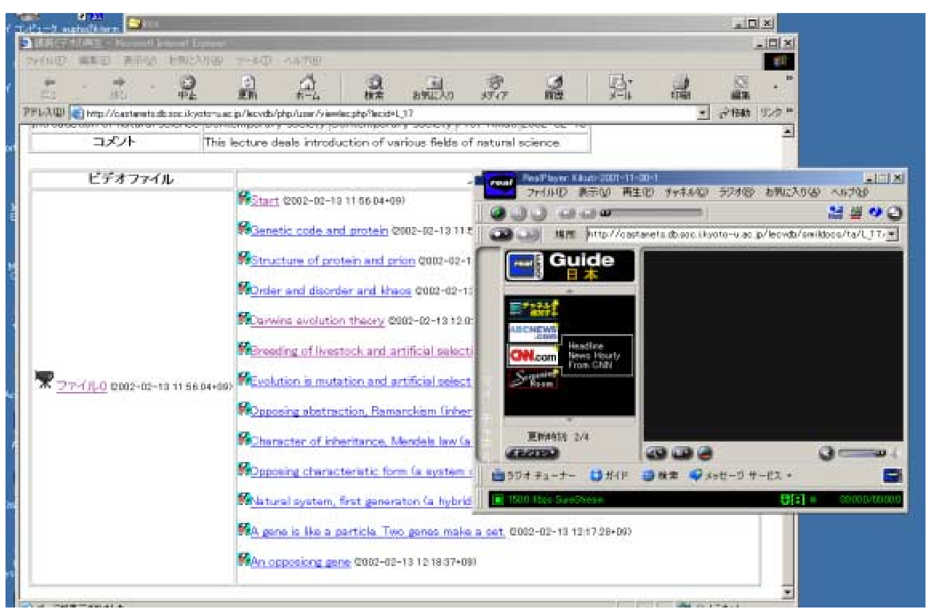

Fig. 3. An example of user interface

5 Conclusion

In this paper, we have introduced a new method for indexing video records of lectures. The system can utilize records of various kinds of operations for indices in our method. The major contribution of our system is as follows:

- Extensive use of various kinds of recorded operations for advanced search functions.
- Our system does not require special hardware to implement.
- The system can be used by teachers without much knowledge of computer usage. Reduction of teachers' work load is also realized.

Our system can be introduced into many organizations easily since it requires a few costs for them. Thus, the contribution of this paper will be able to improve the quality of VOD-based learning environments that are spreading all over the world.

For future work, it is most important to enrich user support functions such as visualization of video contents, and to evaluate them by results of practical use in Kyoto Women's University. There are few studies that perform experimental evaluation of a lecture video database system that is highly advanced on such a large scale. We are expecting that new and valuable knowledge in distance education can be achieved through this project.

Acknowledgement

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A Locking-Based Transaction Scheduling Algorithm for Supporting Web-Based Classes*

Chanjung Park[1] and Hwakyung Rim[2]

[1] Department of Computer Education, Cheju National University
Ara-dong 1, Jeju-si Jeju-do, 690-756, Korea
cjpark@cheju.ac.kr

[2] School of Electronic and Information Technology, Kyunghee University
Seochon-ri 1, Giheung-up Yongin-kun Kyonggi-do, 449-701, Korea
ackyung@khu.ac.kr

Abstract. With the advance of computer and communication technologies, a lot of virtual schools provide web-based classes that provide learning environments out of temporal and spatial constraints. Various techniques are required to build the virtual schools efficiently. One of them is the scheme for database management in web-based classes and among the functions provided by a database management system, a transaction scheduling algorithm is needed to process multiple user transactions concurrently. Recently, several research works on transaction scheduling algorithms suitable for web-based classes have been proposed. However, the existing transaction management schemes have inappropriate features for supporting web-based classes. In this paper, we first present the requirements for the transaction management for web-based classes and then we propose a new concurrency control algorithm with a new scheme, called mark, for supporting web-based classes. We also present examples to illustrate the behavior of our algorithm, along with performance comparisons with other algorithms. The simulation results show that the proposed algorithm can achieve significant performance improvement.

1 Introduction

Recently with the advance of the Internet technologies, many applications using the Internet are developed as means of both sharing information and communication with many people. In addition, world wide web(web) as one of the Internet applications promotes to change our lives. The development of web technology derives many applications such as e-commerce, virtual universities, remote medical treatment, and so on with the changes due to the globalization of information society. In educational fields, the needs for web-based classes increase because people want to learn on a demand basis. The web-based classes provided at virtual universities should be designed systematically and they require a lot of hardware, network, and instructional resources. Currently, virtual

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schools are opened in many web sites and more courses will be provided due to the increased demands on web-based classes [9,11].

Four layers are required for implementing web-based classes [11]. *Service Access Layer* provides physical environment that can be accessed by users to support educational contents. A transfer protocol and the network technologies related to the transfer protocol are included in this layer. *Service Creation Layer* supports various kinds of educational issues such as group/individual education and synchronous/asynchronous education. In addition, this layer also includes the interactions between instructor and students. *Contents Creation Layer* manages authoring tools and database servers for providing web-based classes. *Student Management Layer* serves enrollments, manages classes and student registrations, and so on. Among four layers, in order to substitute web-based classes for traditional classes, virtual schools offer more various kinds of helpful courses and contents to students. As a result, the virtual schools should manage a large volume of data efficiently. In other words, a database system for web-based classes is required for the virtual schools.

In a traditional database system, multiple users share a database and the database system processes the transactions requested by the users concurrently. Thus, the database system must guarantee the correct executions of transactions. Serializability is the definition of correctness for concurrency control in a database system [3]. There are many research works on the concurrency control algorithms that guarantee the serializable executions of transactions [5,7,8]. Besides serializability, there are many features such as on-line, real-time, interactivity, and remote accessibility to be considered for supporting transactions in web-based classes. In order for a database system to ensure serializability, when a transaction manager schedules transactions, it uses some mechanisms such as locks or timestamps. These mechanisms cause either the blockings or the abortions of some transactions. Some commercial algorithms maintain multiple versions for each data item in order to reduce the contentions when several transactions access the same data [4] . Hence, concurrency control algorithms based on multiversions provide a higher level of concurrency than those that are based on a single version.

Conventionally, transactions are categorized into two types: (i) queries (or read-only transactions) and (ii) update transactions. However, if there is no additional consideration, queries are blocked by update transactions, and vice versa due to data contentions between transactions. Thus, in a query-intensive environment such as a virtual school and a decision support system, if the additional consideration for eliminating the data conflicts between queries and update transaction is given, we can achieve a good performance of the system [10,15,16]. Many research works have provided the various efficient algorithms to reduce the data conflicts between queries and update transactions [4,5,8,14]. In [4] , weaker levels of consistencies have been proposed and thus, serializability cannot be guaranteed. [14] has satisfied serializability. However, in this algorithm, a parameter, namely a version period, is used. Therefore, if a wrong version period is used, transactions may read very old versions of data items.

And the algorithm does not provide a method to reduce the conflicts between update and update transactions.

In this paper, we propose a new concurrency control algorithm based on locking that eliminates blockings between queries and update transactions. In addition, the proposed algorithm reduces the conflicts between update and update transactions with a new method, *called mark*. In the existing algorithms, all the transactions have the same version selection point such as the current time or the start time of the transactions. However, in the proposed algorithm, each transaction has its own version selection point. Our algorithm ensures serializability and provides newer versions than [14]. The remainder of this paper is organized as follows. In Section 2, we present the requirements for the classes in web and the correctness criteria for multiversion concurrency control algorithms and the existing multiversion concurrency control algorithms based on locking. In Section 3, we define some terminologies that are used in the proposed algorithm. We then present a new locking algorithm with mark for web-based classes. We also show some examples to illustrate how our algorithm schedules transactions. After giving the correctness proof and the performance evaluations of the proposed algorithm, we conclude this paper in Section 6.

2 Background

In this section, we first present the requirements for the classes in web and the correctness criteria for multiversion concurrency control algorithms. We then summarize the rules of multiversion two-phase locking (MV2PL) algorithms and the method proposed in [14] as the related works of our algorithm.

2.1 Requirements for Transactions in Web-Based Classes

One of the requirements for implementing web-based classes is real-time education. Students request to access multimedia course materials in a real-time manner via the Internet and the students and instructors communicate with each other interactively. Especially, the interactions between the multimedia course materials and the students are very important because the interactions provide feedbacks to students besides the information delivery, which allow them to achieve their learning goals. On the other hand, since web-based classes are based on a distance-learning environment, they access databases remotely. In addition, the course materials provided by the web-based classes are multimedia contents and thus, the transaction processing time in the database for the web-based classes becomes long [11]. When a database is constructed for the web-based classes, students usually retrieve the database rather than update the database. Thus, if a transaction manager schedules transactions by separating queries from update transactions, then it achieves better performance.

2.2 Correctness Criteria

The objectives of concurrency control in a database system are the avoidance of inconsistent retrievals and the preservation of the correct state of a database. In this section, we introduce some definitions presented in [3]. They are the correctness criteria for multiversion concurrency control.

Definition 1. A multiversion (MV) history[1] H is *serial* if for any two transactions T_i and T_j that appear in H, either all of T_i's operations precede all of T_j's or vice versa[3].

Definition 2. A serial MV history H is *1-serial* (or *one-copy serial*) if for all i, j, and some data item x, if T_i reads the value of x created by T_j, then $i = j$, or T_j is the last transaction preceding T_i that writes into any version of x [3].

Definition 3. An MV history H is *one-copy serializable* (or *1SR*) if its committed projection, C(H), is equivalent to a 1-serial MV history, where C(H) is the history obtained from H by deleting all operations that do not belong to committed transactions in H [3].

According to Definition 2, in a 1-serial MV history, transactions always read the most recent versions. It is easy to see that the serial execution of transactions is correct. However, in order to maximize the performance of a database system, several transactions may be executed in an interleaved manner. Thus, correctness criteria for multiversion concurrency control should be defined.

2.3 Related Works

In the Two Phase Locking (2PL) algorithm [3], a write lock on a data item x prevents other transactions from obtaining read or write locks on x, to control the concurrent execution of transactions. The Two Version Two Phase Locking (2V2PL) algorithm [3] relaxes these rules so that conflicts between read and write locks are eliminated. However, conflicts among write locks remain. On the other hand, the MV2PL algorithm [2] removes all conflicts between read and write locks. Hence, each data item may have many versions that are written by active transactions, called uncertified versions. However, transactions can read only the most recently certified version in order to ensure serializability. Therefore, MV2PL has a certify lock which is used to delay the commitment of a transaction until there is no active reader of data items that are about to be overwritten. Certify locks conflict with read locks as well as with other certify locks.

Let us consider the following history in Table 1. In the history, $r_i[x_j]$ indicates that T_i reads x certified by T_j, while $w_i[x_i]$ indicates that T_i writes x. Also, c_i

[1] A *history* indicates the order in which the operations of transactions are executed relative to others.

is the certifying operation of T_i. According to the rules of MV2PL, when T_2 certifies its operation at 3, it is blocked by T_1 because T_1 holds a read lock on x. However, T_2 can certify at 3 without violating serializability.

Table 1. Motivated Example History

Time / Trans.	1	2	3	4	5	6
T_1	$r_1[x_0]$			$r_1[y_0]$	c_1	
T_2		$w_2[x_2]$	c_2 (blocked)	blocked	blocked	c_2

On the other hand, [14] has proposed a transient versioning algorithm for queries. In this algorithm, queries can access old versions of data items without being locked and this algorithm offers a parameter, called a version period. When a transaction starts its execution, a specific version period is assigned to the transaction. While queries select versions at its version period, update transactions select versions on the basis of the current time. Therefore, if the length of a version period is long, transactions read very old versions. Otherwise, the number of versions maintained by a data manager are increased. In the following section, we present a new algorithm that eliminates the conflicts between queries and update transactions.

3 A Proposed Algorithm

In this section, we define a new scheme, called *mark*, and a version selection point of each transaction T. And then, we present the rules and features of our algorithm. After a data structure for keeping information of a version is defined, an efficient version maintenance scheme is presented.

3.1 Terminology

We assume that each transaction T declares a read set, denoted by $R(T)$, which contains the data items read by T and a write set, denoted by $W(T)$, which contains the data items written by T. $R(T)$ and $W(T)$ are declared when T starts its execution.

Definition 4. While a transaction T holds a read lock on a data item x, if a certify lock on x requested by another transaction T' is permitted or while T' holds a certify lock on x, if a read lock on x requested by T is allowed, then we say T is *marked* by T'. And x is also marked.

According to the multiversion locking mechanisms, if a transaction holds a read lock on some data item x, other transactions cannot obtain certify locks on

x, and vice versa. However, in our algorithm, we eliminate the conflicts between read and certify operations. For each transaction T, $VSP(T)$ is defined as the version selection point of T. Initially, $VSP(T)$ is set to $+\infty$. When T is marked for the first time, $VSP(T)$ is changed to a positive integer. For each transaction T, $VSP(T)$ has the following characteristics.

VSP_1 When T requests a read lock on x, if T is marked for the first time by other active transaction T' (i.e., T' holds a certify lock on x), then $VSP(T)$ is set to the time when T requests the read lock.

VSP_2 When T requests a certify lock on x, if T's which hold read locks on x are marked by T for the first time, then $VSP(T')$s are set the the time when T requests the certify lock.

VSP_3 T can be marked several times. However, $VSP(T)$ is modified only when T is marked for the first time.

VSP_4 If T is not marked, then when T finishes its certify operations, $VSP(T)$ is set to its certification time.

For example, in Table 2, T_1 is marked by T_2. Therefore, at time 4, $VSP(T_1)$ = 4 and $VSP(T_2) = +\infty$. After T_2 finishes its certification operation, $VSP(T_2)$ is set to the certification time, 4 + ϵ. In other words, $VSP(T)$ is treated as a virtual certification time of T.

Table 2. An MV History for Illustrating the Mark

Time / Trans.	**1**	**2**	**3**	**4**	**5**	**6**
T_1	$r_1[x_0]$				$r_1[y_0]$	c_1
T_2		$r_2[y_0]$	$w_2[x_2]$	c_2		

3.2 Rules

We assume that a transaction T declares a read set $R(T)$ and a write set $W(T)$. Firstly, we examine all the possible conflicting modes of any two active transactions that are classified by their read and write sets.

(1) $R(T_i) \cap R(T_j) \neq \phi$: Since there exists no conflict between a read and a read operation, T_i and T_j do not mark with each other. Hence, they should read data items which are certified before their version selection points.

(2) $R(T_i) \cap W(T_j) \neq \phi$ (or $W(T_i) \cap R(T_j) \neq \phi$) : We consider the following MV history MV_1.

$$MV_1 = r_i[x_o]\ w_j[x_j]\ w_i[z_i]\ w_j[y_j]\ c_j\ c_i$$

In this case, since T_i has a read operation on x, T_i can be marked by T_j. However, if T_i certifies before T_j, then T_i is not marked. Therefore, there is no problem. However, if T_j certifies before T_i, then T_i is marked by T_j on a data item x. As a result, $VSP(T_i)$ is set to the certifying time of T_j. If T_i reads the data versions which are created before $VSP(T_i)$, then they can execute concurrently without violating serializability.

(3) $W(T_i) \cap W(T_j) \neq \phi$: In a algorithm which maintains multiple versions, there exist conflicts neither between write and write operations nor between write and certify operations. Therefore, T_i and T_j do not mark with each other.

(4) $R(T_i) \cap R(T_j) \neq \phi$ and $R(T_i) \cap W(T_j) \neq \phi$: $VSP(T)$ represents the virtual certification time of T. And the write operations after $VSP(T)$ cannot affect other transactions until its certification time.

$$MV_2 = r_i[x_o]\ w_k[x_k]\ c_k\ r_j[x_?]\ w_i[y_i]\ r_j[y_?]\ c_j\ c_i$$

In an MV history MV_2, if T_j reads x_k and y_o which is the earlier version of y_i, then serializability cannot be guaranteed. Thus, when a transaction T_j reads a data item x, a transaction manager checks if x is marked or not. If x is not marked, there is no problem. However, if x is marked, it checks whether there exist common data items which are both written by any transaction in MTL and read by T_j. If so, $VSP(T_j)$ is changed to $VSP(T')$, where T' is the transaction which is in MTL, is marked due to the data item, and has the smallest VSP. In MV_2, T' is T_i.

(5) $R(T_i) \cap R(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$: This case is similar to the previous one. In an MV history MV_3, if T_i and T_j read the same version of x, then there is no problem.

$$MV_3 = r_i[x_o]\ w_k[x_k]\ c_k\ r_j[x_?]\ w_j[y_j]\ w_i[y_i]\ c_i\ c_j$$

However, if not, there can exist a cycle caused by the third transaction T_k. In other words, if T_i is marked, then T_k's write operation on x should be hidden to T_j until T_i commits. Thus, the version T_j reads should be restricted by T_i. If T_i is not marked, $VSP(T_j)$ is not influenced by $VSP(T_i)$. Otherwise, $VSP(T_j)$ is set to $VSP(T_i)$, In general, $VSP(T_j)$ is set to $VSP(T')$, where T' is the transaction which is in MTL, is marked due to the data item, and has the smallest VSP.

(6) $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap R(T_j) \neq \phi$: In this case, T_i can mark T_j, and vice versa. If both T_i is not marked by T_j and T_j is not marked by T_i, then as shown in an MV history, MV_4a, there is no problem.
$MV_4a = w_i[y_i]\ r_j[y_0]\ w_j[x_j]\ c_j\ r_i[x_j]\ c_i$
$MV_4b = r_i[x_0]\ r_j[y_0]\ w_j[x_j]\ w_i[y_i]\ c_j\ abort(T_i)$
In MV_4a, T_i reads the version of x which is certified by T_j. However, if one of the transactions is marked, then due to their read sets and their write sets, one of them cannot continue executing its operations. In MV_4b, since T_i holds a read lock on x and T_j holds a read lock on y, neither T_j can certify on x nor T_i can certify on y. A deadlock occurs according to the rules of the MV2PL. Even though they are scheduled by our algorithm, serializability cannot be guaranteed because a cycle occurs. Thus, since T_j certifies its operations, T_i is aborted. The strategies for aborting one of the transactions are various.

(7) $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$: In this case, if T_i is not marked by T_j, there is no problem. However, as shown in an MV history MV_5, when T_j certifies, T_i is marked by T_j. In order to guarantee serializability, we should devise an algorithm for resolving the conflict.

$$MV_5 = r_i[x_0]\ w_j[x_j]\ w_j[y_j]\ c_j\ r_i[y_0] w_i[y_i](ignored) c_i$$

We suppose that a transaction T_i reads a data item x and then writes x later. According to the MV2PL rules, while a transaction T_i reads a data item x, if another transaction T_j tries to commit on the same data item x, then T_j is blocked by T_i. On the other hand, with mark method, T_j finishes the certification operations without delaying. Instead, because of the obsolete write operation of T_i on x, T_i should be aborted to ensure serializability. However, the abortion of T_i is unnecessary because there cannot exist a transaction which reads the version of x written by T_i until T_i certifies. It is very similar to the Thomas Write Rules [12]. Therefore, though the obsolete write operation of T_i on x may be ignored, we do not lose serializability. In MV_5, the write operations of the marked transaction T_i onto the data items written by both T_i and T_j may be ignored.

In the cases *(8)* ˜ *(11)*, two transactions T_i and T_j are update transactions because their write sets are not empty.

(8) $R(T_i) \cap R(T_j) \neq \phi$ and $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$: T_i can be marked by T_j because $R(T_i) \cap W(T_j) \neq \phi$. And $VSP(T_j)$ is affected by $VSP(T_i)$ because $R(T_i) \cap R(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$ (or $R(T_i) \cap R(T_j) \neq \phi$ and $R(T_i) \cap W(T_j) \neq \phi$). Like the previous case (7), T_i's write operations onto the data items which are written by both transactions are ignored to ensure serializability. As shown in an MV history MV_6, T_i's write operation on x is ignored so that T_i precedes T_j in serialization order.

$$MV_6 = r_i[x_0]\ r_i[y_k]\ r_j[y_k]\ w_j[x_j]\ w_j[y_j]\ c_j\ w_i[x_i](ignored)c_i$$

(9) $R(T_i) \cap R(T_j) \neq \phi$ and $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap R(T_j) \neq \phi$: Since $R(T_i) \cap R(T_j) \neq \phi$ and $R(T_i) \cap W(T_j) \neq \phi$ (or $W(T_i) \cap R(T_j) \neq \phi$), $VSP(T_j)$ is affected by $VSP(T_i)$ (or $VSP(T_i)$ is affected by $VSP(T_j)$). Like the above case (6), if T_i is marked by T_j, then one of the transactions should be aborted to resolve a deadlock. Otherwise, serializability cannot be guaranteed. Therefore, an earlier certified transaction continues its operation, while the other transaction should be aborted.

(10) $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap R(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$: In this case, since $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap R(T_j) \neq \phi$, a deadlock can occur. Therefore, the same operations which are described in case (6) and case (7) are performed.

(11) $R(T_i) \cap R(T_j) \neq \phi$ and $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap R(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$: Since $R(T_i) \cap R(T_j) \neq \phi$ and $W(T_i) \cap W(T_j) \neq \phi$, $VSP(T_j)$ are influenced by $VSP(T_i)$ according to T_i's marking condition. Since $R(T_i) \cap W(T_j) \neq \phi$ and $W(T_i) \cap R(T_j) \neq \phi$, a deadlock can occur. The same operations which are described in case (9) are performed.

In summary, the proposed algorithm is described as follows:

$Mark_1$. When T starts, T declares its $R(T)$ and $W(T)$.

$Mark_2$. $VSP(T)$ is initially set to $+\infty$.

$Mark_3$. A marked transaction list (MTL) is set to NULL and when a transaction T_i is marked, its identifier i is inserted into MTL.

$Mark_4$. There is no conflict between read and three operations, read, write, and certify. However, there exist conflicts between certify and certify operations.

$Mark_5$. When T starts, for a transaction T' in the MTL, the transaction manager checks if $R(T) \cap R(T') \neq \phi$ and $W(T) \cap W(T') \neq \phi$ or $R(T) \cap R(T') \neq \phi$ and $R(T) \cap W(T') \neq \phi$. If so, $VSP(T)$ is set to the $VSP(T_s)$, where T_s has the smallest version selection point among the transactions in the MTL.

$Mark_6$. When T reads a data item x, the transaction manager checks if x is marked or not. If so, we define a transaction T' as the one that is in the MTL and has the smallest VSP. And it checks if there exists common data items between $R(T)$ (or $W(T)$) and the write set of the transaction T'. If so, $VSP(T)$ is set to $VSP(T')$. Otherwise, T selects the version of x which is the most recently certified before $VSP(T)$. If $VSP(T)$ is $+\infty$, the $VSP(T)$ is interpreted as the current time.

$Mark_7$. The write operations of a transaction T are not deferred by other operations. A new version is written in the local space of T. After T certifies its write operations, the new versions written by T are opened to other transactions.

$Mark_8$. When T is marked by T', the followings are checked.

$Mark_{8.1.}$ $R(T) \cap W(T') \neq \phi$ and $W(T) \cap R(T') \neq \phi$.

If the above condition is true, by Definition 4, T' requests a certify lock while T holds a read lock (or while T' holds a certify lock, T requests a read lock) on the same data item. Therefore, after T' certifies its operation, T is aborted to resolve a deadlock in addition to ensuring the serializable executions of transactions.

$Mark_{8.2.}$ $R(T) \cap W(T') \neq \phi$ and $W(T) \cap W(T') \neq \phi$.

If the above condition is true, we ignore T's obsolete write operation on the data items which are also written by T' so that their execution result is the same as the one that T precedes T'.

$Mark_9$. When T executes its certify operations, if T is a marked transaction, then it is deleted from the MTL. If T is not marked, then $VSP(T)$ is set to its certification time.

Let us examine the history shown in Table 3. T_1 and T_3 are update transactions while T_2 and T_4 are queries. In MV2PL , T_3 is blocked until T_1 commits. However, in our algorithm, T_1 is marked by T_3 and T_3 can certify at time 7 without blocking. In other words, the conflict between update and update transactions is eliminated. The execution result of the above history is equivalent to the one that T_2, T_1, T_3, and T_4 are executed sequentially. One more important advantage is that the proposed algorithm provides newer active query T_1, T_4 has the same version period as T_1. Therefore, T4 reads x_0 instead of x_4. On the other hand, our algorithm provides a newer version to T_4 than [14].

Table 3. An MV History for a Comparison

Time / Trans.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
T_1	$r_1[z_0]$		$r_1[x_0]$					$w_1[y_1]$			c_1	
T_2		$r_2[y_0]$					$r_2[z_0]$					c_2
T_3				$w_3[x_3]$	$w_3[z_3]$	c_3						
T_4									$r_3[x_3]$	c_4		

4 Correctness Proof

Theorem 1. A multiversion schedule, H, is one-copy serializable(1SR) if and only if MVSG(H, $\ll$) is acyclic [3].

Theorem 2. Every history produced by our algorithm is 1SR.

Proof: Let $\{ T_1, T_2, \cdots, T_n \}$ be a set of transactions, and let H be a history produced by our algorithm over $\{ T_1, T_2, \cdots, T_n \}$. Let cr_i represent the certification of T_i. Define a version order as follows: $x_i \ll x_j$ implies $cr_i < cr_j$. First, we examine the versions that a transaction T_i selects. If T_i is not marked, then the rules for selecting versions are the same as those of MV2PL, and only the most recent versions are selected. Otherwise, the versions read by T_i are those whose certify times are less than $VSP(T_i)$. We prove that MVSG(H, $\ll$) is acyclic by showing that for every edge $T_i \rightarrow T_j$ in MVSG(H, $\ll$), $VSP(T_i) < VSP(T_j)$ and if $VSP(T_i) = VSP(T_j)$, then $cr_i < cr_j$.

Suppose $T_i \rightarrow T_j$ is an edge of the serialization graph, SG(H), of an MV history H which is a direct graph whose nodes are transactions and whose edges represent all conflicting relationships between two transactions. This edge corresponds to a reads-from relationship (i.e. for some x, T_j reads x from T_i). Then, since all transactions read certified versions of data items, $cr_i < cr_j$.

Next, we consider version-order edges. Let $w_i[x_i]$, $w_j[x_j]$, and $r_k[x_j]$ be operations in H, where i, j, k are distinct, and consider the version-order edge that they generate. There are two cases: *(i)* $x_i \ll x_j$ and *(ii)* $x_j \ll x_i$. The first case implies $T_i \rightarrow T_j$ is in MVSG(H, $\ll$). If T_i and T_j are not marked transactions, then $VSP(T_i) < VSP(T_j)$ by $Mark_9$. If $VSP(T_i) > VSP(T_j)$, then T_i violates the rule $Mark_9$. In addition, by the definition of $\ll$, $cr_i < cr_j$.

The second case implies $T_k \rightarrow T_i$ is in MVSG(H, $\ll$). Then, by the property of MV2PL [3], either $cr_i < cr_j$ or $cr_k < cr_i$. However, by the definition of $\ll$, if $x_j \ll x_i$, then $cr_j < cr_i$. And since certification operation follows either read or write operations, in case of $cr_i < r_k[x_j]$, $cr_j < cr_i < r_k[x_j]$. Therefore, we can notice that T_k is marked because it does not read the more recent version than x_j. As a result, $VSP(T_k) < VSP(T_i)$. If T_k is not marked transaction, T_k executes its certify operation before T_i does. Thus, $cr_k < cr_i$ and by $Mark_9$, $VSP(T_k)$ $< VSP(T_i)$. Since all edges in MVSG(H, $\ll$) are in VSP order, MVSG(H,$\leq$) is acyclic. Therefore, by Theorem 1, H is 1SR.

5 Performance Evaluations

In this section, we present simulation results to show the performance of the proposed algorithm, called MARK, compared with two other concurrency control algorithms. Since MARK is based on multiversion locking, we compare it with algorithms that are based on locking. The first algorithm is 2PL [3] and the second algorithm is MV2PL [2] . We compare the proposed algorithm with 2PL and MV2PL in terms of the transaction restarting ratios and the average service time per transaction. Formula F_1 represents the restarting ratio and the Formula F_2 means the average service time per transaction. In Formula F_2, $FinishTime(T_i)$ is the finish time of a transaction T_i and $StartTime(T_i)$ is the start time of the transaction T_i, respectively.

**F_1: ** *Restarting ratio = (the restarting number of transactions) / (the total number of transactions)*

**F_2: ** *Average Service Time* $= \frac{(\sum_{i=1}^{N} FinishTime(T_i) - StartTime(T_i))}{N}$*, where N is the total number of transactions.*

5.1 Simulation Model

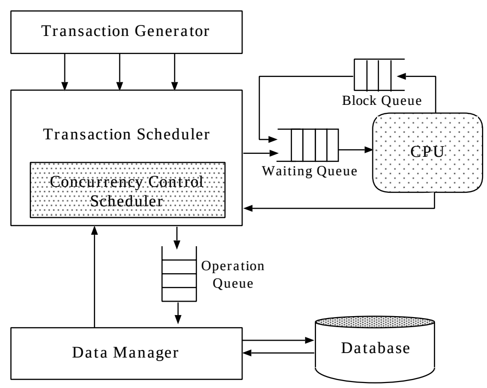


Fig. 1. Simulation Model

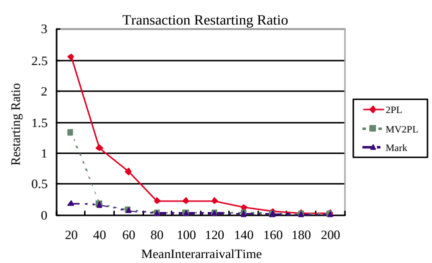
To evaluate the performance of the proposed algorithm, in this paper we employ SLAM II [1] as a simulation tool and adopt the simulation model of Figure 1. If transactions are generated in the transaction generator, they are submitted to the transaction scheduler. And then, the transaction scheduler assigns a deadline and priority to them by the following formula. As we suppose a soft deadline for each transaction in this paper, transactions are not aborted even if they miss the deadlines. The initial values of the parameters, in Table 4, used in the simulation are initialized on the basis of the values in [13].

Table 4. Parameters

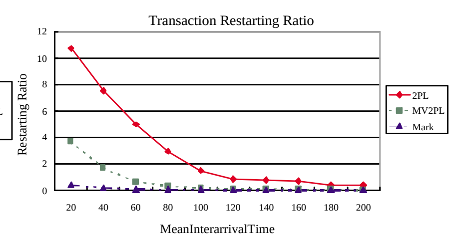
Parameter	*Value*
Database Size	100
Slack Time	10
Number of Security Levels	4
Page Hit Ratio	0.5
Number of Operations per Transaction	5 $\sim$ 30
Disk Access Time	25 msec
CPU Computation Time	10 msec
Restarting Overhead	10

5.2 Performance Analysis

Figure 2 shows the restarting ratio of transactions as the mean interarrival time (MeanInterarrivalTime) changes. The x and y axes represent MeanInterarrial-Time and restarting ratio, respectively. Since 2PL provides one copies per data item, it shows a worse performance than the algorithms based on multiversions. As the MeanInterarrivalTime becomes lower (i.e., more transactions are generated within a given time period), the restarting ratios of transactions become higher seriously for 2PL and MV2PL. However, the restarting ratio of transactions for the proposed algorithm is the lowest because it considers the types of transactions. In other words, queries are not aborted by other transactions in the MARK. Thus, the restarting ratio for MARK is the lowest among all algorithms. When a transaction size becomes bigger, the gap between 2PL and the algorithms based on multiversions are widened.



(a) Transaction size=10



(b) Transaction size=15

Fig. 2. Transaction Restarting Ratio

Figure 3 shows the average service time per transaction as the MeanInterarrivalTime changes. Compared with other algorithms, transactions finish their executions more shortly in the MARK because it never aborts queries. However, in the MARK, the service time per transaction shows a upward curve as the MeanInterarrivalTime becomes high because the operation time of transactions stay at the ready queue becomes longer when the MeanInterarrovalTime becomes lower. The MARK has a shorter service time per transaction than other algorithms. When MeanInterarrivalTime becomes bigger than 60, the service time per transaction decreases sharply. That means when MeanInterarrivalTime becomes bigger than 60, the algorithms have similar performances.

In summary, we have shown that the proposed algorithm has better performance than other algorithms with respect to the restarting ratio and the average service time. However, the proposed algorithm has an overhead that should store write sets for each transaction additionally due to mark. It should also check whether a transaction is a query in a conflicting mode. The mark should keep the information on transactions whether they are queries or not. In

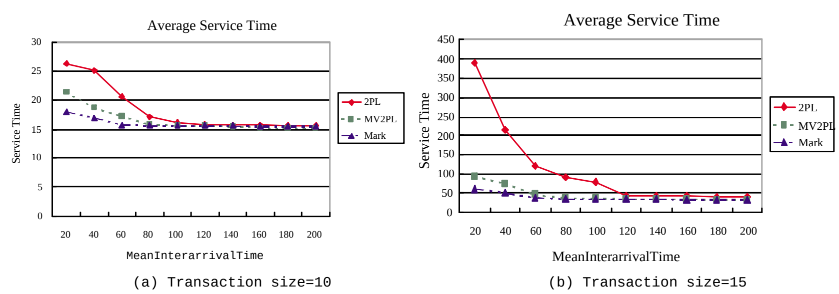


Fig. 3. Average Service Time

case that queries have a considerable portion of entire transactions, the proposed algorithm is the best among all algorithms.

6 Conclusions

Traditionally, in order to ensure serializability, concurrency control algorithms use locking scheme or timestamps. With these methods, queries are blocked due to the update transactions, and vice versa. However, if the blockings of queries are eliminated, we can achieve a better performance. This feature is especially adequate for query-intensive systems such as decision support systems, virtual schools, e-commerce, and so on. In this paper, we have examined the requirements for the transaction management for web-based classes and then proposed a new concurrency control algorithm for supporting web-based classes. The proposed algorithm eliminates the conflicts between queries and update transactions by maintaining multiple versions and by using a new scheme, called mark. The mark scheme allows that each transaction has its own version selection point to satisfy the requirements. We have also shown the simulation results and known that the proposed algorithm can achieve significant performance improvement. A concurrency control algorithm for supporting web-based classes should consider real-time requirements, interactivity, remote accessibility, and security features besides serializability. The proposed algorithm can be extended easily in order to support real-time feature and security requirements. In the near future, we extend the proposed algorithm so that it can ensure various requirements for web-based classes.

The contributions of our paper are as follows. First, we proposed a concurrency control algorithm that eliminates both the blockings of queries and the unnecessary delays of update transactions by using a new method, called mark. Compared with the existing algorithms, the proposed algorithm reduces the waiting time for finishing a transaction. In addition, it gives newer versions to transactions than the existing algorithms. Next, the proposed algorithm with mark may consume more storage for maintaining multiple versions. However, recently, the power of computer hardware is sharply increasing. Along with the increase in the power, the cost has fallen as dramatically. Thus, for the systems such as decision support systems or virtual schools that execute many queries, the proposed algorithm can provide faster response time than the existing algorithms. In the near future, we quantify the staleness of data versions and the number of versions maintained by a database system at a time.

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Database and Metadata Support of a Web-Based Multimedia Digital Library for Medical Education

Jianting Zhang[1], Le Gruenwald[1], Chris Candler[2],
Gary McNutt[1], and Wei Shung Chung[1]

[1] The University of Oklahoma, School of Computer Science, Norman, OK, 73019
[2] The University of Oklahoma, College of Medicine, Oklahoma City, OK, 73104
ggruenwald@ou.edu
Phone: 1-405-325-3498

Abstract. Digital Libraries play an important role in education; they are beneficial to both instructors and students. Many Web file-based course material systems have been built, but most of them do not have effective management mechanisms. Instead, they often have broken links and do not support metadata. To transfer these course materials from a file repository to an integrated and searchable educational digital library, database and metadata supports are needed. In this paper, we report our design and implementation of a Web-based multimedia digital library for medical education with database and metadata support. Our system is built on top of SQL Server, a relational database management system. It adopts the Instructional Management System (IMS) standard for metadata representation and the National Library of Medicine's Medical Subject Heading controlled vocabulary to remove ambiguity and inconsistency in metadata definitions. It includes a sophisticated search engine for both database content and metadata. It also supports the IMS Content Packaging Specification for learning materials export and exchange.

1 Introduction

Hippocrates [9], the online curriculum website of the College of Medicine at the University of Oklahoma hosts a diverse collection of curricular materials organized by courses. The acquisition of thousands of images, videos, animations, and the construction of numerous web pages has resulted in an immense repository of educational resources occupying 1.5 Gigabytes of space that has grown unwieldy and is difficult to manage. In its current file-based system implementation, it lacks general and domain specific metadata support, which makes it difficult to search for data, share it with other organizations, and add new functionality. It does not allow search on multimedia attributes, medical terminologies and other important information that are not explicitly stored in course material (e.g., intended end user, user hits, etc). Thus, it does not support queries like “Find all heart images for first year medical students that have horizontal and vertical size greater than 200 pixels”.

Supported by a grant from the University of Oklahoma Bioengineering Center (OUBC), we converted this static file repository into a database-based multimedia digital library. In this paper, we present our conversion design and implementation.

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The rest of this paper is arranged as follows. Section 2 gives a brief overview of related work. Section 3 presents the overall architecture of the system. Section 4 discusses the mapping of web contents and metadata attributes to database schemas. Section 5 discusses metadata based searching and content packaging. Finally Section 6 presents conclusions and future work directions.

2 Related Work

The differences between a web-based system and a digital library are well recognized in [10]. The authors argued that digital libraries can be considered islands of specialized collections on the Web which have their own management policies for publishing and access control. Link consistency and metadata support are the other two factors that distinguish a digital library from a Web-based system. Our solution to these problems is to use database technologies and build our system on top of a RDBMS to ensure data and link consistency, reduce redundancy and provide access and security. We also use RDBMS to store metadata and support metadata queries.

The National SMETE Library program [11] is among the largest efforts in developing digital libraries targeted for educational purposes. A panel session on the NSDL program was held at the first ACM/IEEE-CS Joint Conference on Digital Libraries [1]. Although developed independently, we share most of the design principles for the information architecture of a SMETE education digital library proposed in [2]. There are studies on developing domain specific education digital library systems, such as the Biology [3] and Earth System [4]. However, no detailed design and implementation information is available.

Metadata can be defined as data about data [5] or information about the information [6]. There exist several popular metadata standards, such as the general purposed and simplified Dublin Core metadata [12], MPEG-7 for multimedia [13], XML related metadata standard which includes Document Type Definition (DTD), XML schema and Resource Description Framework (RDF) [14]. In addition, IEEE Learning Object Metadata (LOM) specifications are specifically designed for learning material [15]. The specifications have been adopted by IMS (Instructional Management System) Global Learning Consortium [16], a leader in online distributed learning activities. We adopt IMS metadata content packaging specifications that support XML binding automatically. While our current system only supports limited multimedia attributes, we plan to support MPEG-7 multimedia content description standard with XML binding in the future.

Unified Medical Language System (UMLS) [17] is one of the most prevalent systems in representing medical knowledge; it includes Metathesaurus, Specialist Lexicon and Semantic Network. Many applications using UMLS, ranging from automatic metadata generation to medical knowledge inference, can be found at the UMLS research websites and American Medical Informatics Association (AIMA) annual meetings [18]. Different from other projects that use UMLS, in this system we primarily use only one of the UMLS Metathesaurus called MeSH (Medical Subject Heading, [19]) controlled vocabulary as the source of the taxopath specified in the

LOM metadata model [15] to remove ambiguity and inconsistency in defining metadata of medical educational materials. We plan to use other components in UMLS to develop a more semantic-rich system in the future.

We have two primary goals in this study, one is to convert an existing operational file-based repository into an integrated web-enabled educational digital library on top of a mainstream relational database, and the other is to provide metadata services from educational, multimedia and medical perspectives. We will explore these topics in the subsequent sections.

3 Multimedia Medical Educational Digital Library: Proposed Architecture

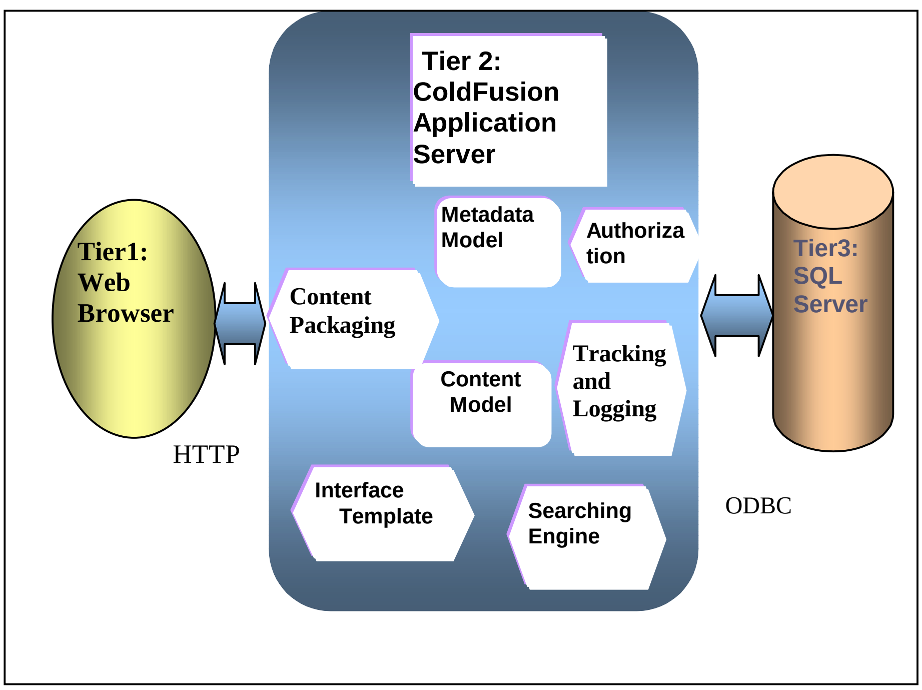

Fig. 1. System Architecture

The proposed architecture shown in Fig. 1 adopts a three-tier architecture based on web-database technologies. The first tier is Web Browser. Although any mainstream Web browser can be used, Microsoft Internet Explore 5.0+ is recommended to reduce compatibility problems. The second tier is the middleware tier or business logic tier and is implemented using ColdFusion Markup Language (CFML). Based on the content model and metadata model that we will explain in detail in Section 4, several modules are developed. The third tier is the database server. Although major DBMS systems can be used in the architecture, we use SQL Server 2000 Standard Edition for its high performance/price ratio.

There are totally five logic components in the proposed architecture based on content and metadata models, namely Authorization, Tracking and Logging, Interface Template, Searching Engine and Content Packaging. Three types of users, Learner, Instructor, and Administrator, are identified. The privileges of a Learner is a subset of the privileges of an Instructor. For example, a Learner is only allowed to view the course content while an Instructor is able to edit the course content and view usage statistics for which he/she is responsible. Similarly, the privileges of an Instructor is a subset of the privileges of an Administrator, An Administrator is responsible for all course material and system usage statistics. The tracking and logging module is designed for data mining purposes to discover learning patterns for future system improvement. The Interface Template module generates Web content dynamically according to the templates an authorized user chosen. All dynamically generated Web pages are context-aware, i.e., different GUI and content will be rendered for different users logging in under different roles. The search engine module divides metadata elements into different logic groups and allows users to combine them arbitrarily. Within each group and for each metadata element in the group, the search engine allows users to specify metadata element specific values or value ranges to query against the metadata database. Finally, the content packaging module extracts explicitly stored metadata elements as well as those that are implicit between tables, and generates a zipped package compatible to IMS Content Packaging Specifications for export and exchange. Since our goal in this paper is on database and metadata related topics, we will focus on the metadata generation, search engine and content packaging modules.

4 Metadata and Database Design

4.1 Conceptual Design of Metadata Management

We define the smallest reusable course material as the Minimum Reusable Learning Object (MRLO). The whole system contains MRLOs through different levels of aggregation. Although the architecture allows an arbitrary number of hierarchical levels, we currently have five levels of learning objects (LO) in our system: Course, Subheading, Resource, Section and Multimedia. Fig. 2 shows a typical example.

- -Course (Biochemistry)
  - -Subheading (Metabolic Pathway Animations)
    - -Resource (Interactive Slide Atlas)
      - -Section (Cytology)
        - -Multimedia File (Slide91.jpg)

Fig. 2. Hierarchy of Learning Objects

An upper-level LO can have multiple lower-level LOs while a lower-level LO can be used by multiple upper-level LOs. Therefore their relationship is many-to-many. In our application, the classification of Course, Subheading, Resource, and Section objects is more of semantic because the content of LO is refined from an upper level to a lower level. These LOs are all in the form of HTML documents and can be generated using any popular HTML authoring tools by instructors. On the other hand, the classification of multimedia files is more of syntactic, i.e., based on media types. Usually a multimedia file is a sub-LO of a Section LO, while in some cases, a large multimedia file itself could be a standalone Resource LO. All types of LOs have a set of common mandatory metadata attributes and each type of LO has its specific ones. For example, “size” (in kilobytes) is common to all LOs while “number of pages” and “number of words” are specifically designed for text LOs. Fig. 3 shows the LO hierarchy in our system and specific metadata attributes for each type of LOs. Fig. 4 shows a set of common metadata attributes and their relation with related entities, such as contributor, funding agency and most importantly, the MeSH based taxonomy system.

Most of the metadata attributes shown in Fig. 3 and Fig. 4 are self-explanatory. We put Microsoft Word/PowerPoint/Excel, PS/PDF along with HTML as text LO. Text LO has two basic specific metadata attributes, namely number of pages (slides) and number of words. For Image type LO, we have Horizontal Size (HSize) and Vertical Size (VSize) to denote width and height of an image. ColorDepth refers to the number of bits used for a single pixel. For video type LO, we add Number of Frames and Run Time besides HSize and VSize commonly shared with Image type LO. For audio type LO, currently we are only concerned with Sample Rate and Run Time.

Metadata attributes shown in Fig. 3 and Fig. 4 can be classified into two categories, those that can be automatically obtained when the LO is created and those that must be explicitly specified (the later category is bolded in the two figures). Metadata attributes specific to multimedia types of LOs can be retrieved when they are uploaded to the system, such as using Microsoft COM object to retrieve the number of pages/slides/words of Microsoft Word/Excel/PowerPoint [20], Java Advanced Imaging (JAI) package [21] to retrieve HSize/VSize/ColorDepth. Similarly metadata attributes for video/audio can be retrieved using commercial or open source packages. Some of the metadata attributes common to all types of LOs can also be automatically generated by recording system events, such as creation date, last edit date, last access date, number of user hits, format (in terms of MIME type) and physical file size. For the common metadata attributes that has to be explicitly input by users, such as Title, MeSH IDs, we have several GUIs, such as standard Web forms and Java Applets, to help users input metadata attribute values conveniently and efficiently.

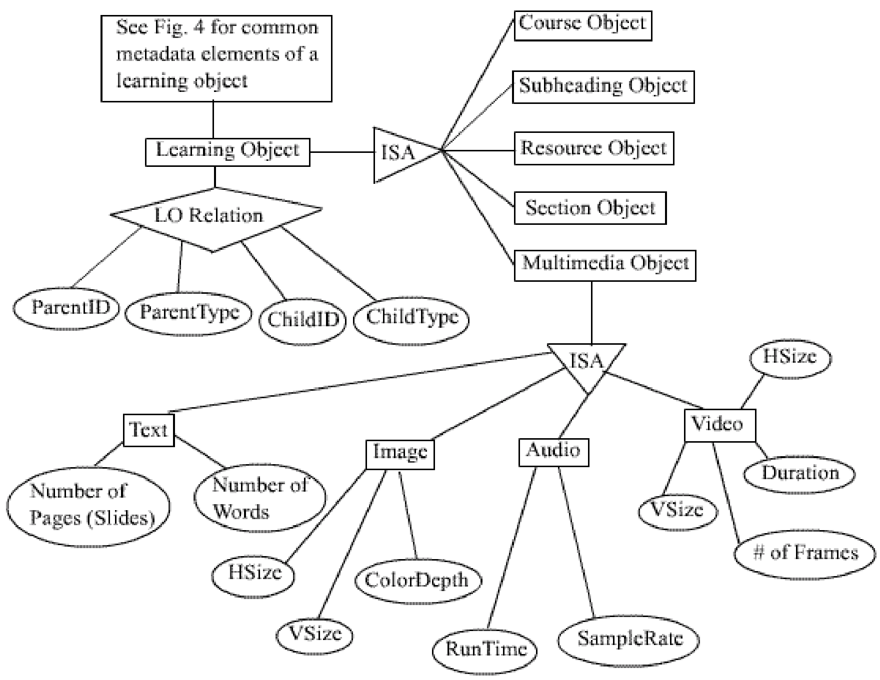

Fig. 3. LO Hierarchy and Special Metadata Attributes Associated with a LO

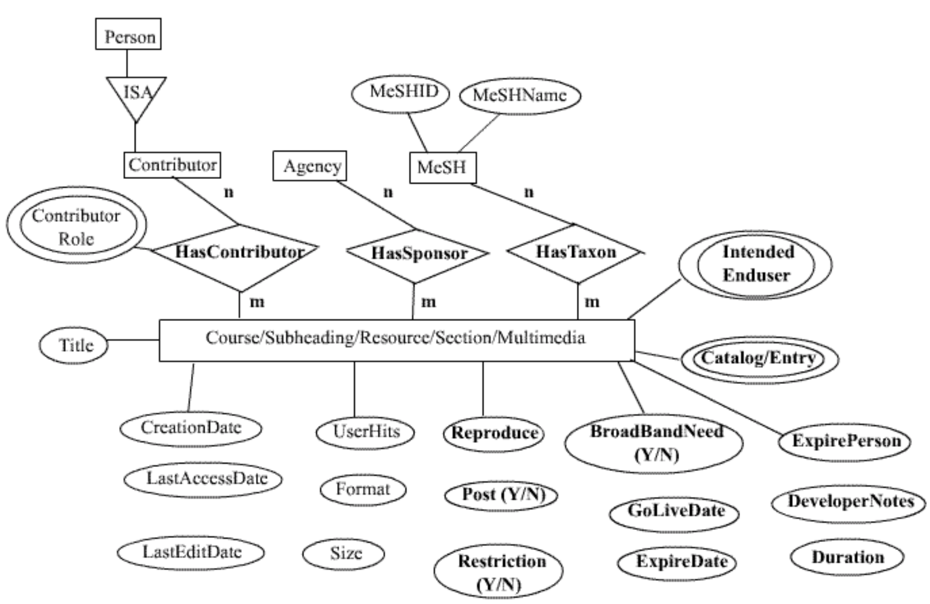

Fig. 4. Scheme for Common Metadata Attributes of a LO

4.2 Mapping Conceptual Design to RDBMS Implementation

There are two major advantages for using a relational database to manipulate metadata over flat-file based metadata (such as HTML page and XML document):
1) Technology maturity: RDBMS provides matured indexing methods and efficient query processing against metadata items while XML-Query is still under discussion [13], not to mention XML-query efficiency.
2) Storage: Metadata stored in RDBMS is in binary format and thus can save space. In addition, some of the relationships which are required to be listed explicitly in an XML document are naturally implicit in RDBMS tables and do not need extra storage.

Learning objects have recursive many-to-many relationships. This reflects the requirements that a higher-level LO has multiple lower-lever LOs while a lower- level LO might be reused in multiple higher-level LOs. We put the metadata elements common to all LOs into one table and metadata elements specific to a particular type of LO into a separate table. We call this paradigm “Vertical Segmentation” of metadata attributes. Tables may be joined together through a common unique ID in both tables. The relationship is recorded in a separate table that has four attributes (ParentID, ParentType, ChildID, ChildType). Given ID and Type we may refer to the corresponding tables to retrieve the metadata elements specific to a LO.

The Vertical Segmentation design has the following advantages:
1) Conceptual Simplicity: In many cases, queries are only on generic metadata elements. Thus we only need to work on the base table and no union operation is needed.
2) Coding Simplicity: we greatly reduce the length of query strings by only querying on the single base table in most cases instead of performing UNION operations on multiple tables.
3) Flexible Extensibility: It allows user to add additional LO types and redefine their relationships and the SQL query code on the base metadata table can be reused without any modification.

Although Video learning objects can be extended from Image type, our design uses the conventional “Horizontal Segmentation” of metadata attributes instead, i.e., all metadata attributes specific to Image type LO are put into one table and all those specific to Video type LO are put into another table. The primary concern is that most queries on Video need to retrieve all metadata elements of Video type LO, including elements shared with Image Type LOs. We would need costly JOIN operations if we use Vertical Segmentation design that put metadata attributes specific to Video Type LO into a separate table. Our decision on whether to have separate tables for base-type LOs and sub-type LOs is based on their degree of association in frequently used queries.

4.3 Mapping RDBMS Table Structure to IEEE/IMS Metadata Specifications

The mapping between IMS/IEEE metadata specifications and our metadata tables is shown in Table 1. It is clear that the mapping is an intersection between IMS metadata specifications and our internal database schema. The reason is twofold. Firstly, not all metadata fields are needed by the specifications. Some of them are for internal use only, such as the number of user hits, GoLiveDate and expiration related attributes. Secondly, not all metadata attributes in the specifications are needed and supported in our application. This mapping will be used for content packaging and export of course materials (Section 5.2).

Table 1. Mapping between IMS/IEEE Metadata Specifications to Database

IMS/IEEE Metadata (No/Name)	RDBMS Table/Data Fields
1.1 Identifier	LearningObject/LOID
1.2 Title	LearningObject/Title
1.5 Description	LearningObject/DeveloperNote
2.2 Status	LearningObject/Post
2.3 Contribute (Role/Entity/Date)	RLOCont/(LOID,userID,ConType,Date)
4.1 Format	LearningObject/sFormat
4.2 Size	LearningObject/nSize
4.4 Requirement	LearningObject/BoardBandNeeded
5.5 intendedenduserrole	LearningObject/IntendedEndUser
5.9 Typicallearningtime	LearnongObject/Duration
6.2 copyrightandotherrestrictions	LearnongObject/(Restriction)
7 Relation	LORelation(ParentID, ChildID)
8Annotation (Person/Date/Description)	Annotation/(LOID, UserID, Date, Description)
9.2.2 taxon	KeyWordMapping/(LOID,MeSHID)
9.4 Keyword	KeyWordMapping/(LOID, Keyword)

5 Metadata and Database Supported Applications

In this section, we show how to build a metadata searching engine and content packaging module for learning object export and exchange.

5.1 Building an Online Metadata Searching Engine

We first divide the searchable metadata attributes into several logical groups as shown in Table 2. The user will first select on the metadata attributes which he/she wants to search in each group. The system then renders the metadata attribute specific criteria for the user to specify. The MeSH keywords will be mapped to MeSH IDs. For the string based attributes, the user will be asked to specify the sub-string they want to be contained in the metadata attributes. For the number and date based attributes, the user will be asked to input a lower bound limit and an upper bound limit. Fig. 6 captures a screenshot illustrating the three steps of the metadata based searching process.

Table 2. Logical Group of Metadata Searchable Attributes

	Group	Attribute Name	Attribute Value Type
Basic	1	MeSH Keyword	Single String, need to map to MeSH IDs
	2	Title DeveloperNote Annotation	Single String
	3	Size UserHit	Range of numbers
	4	CreationDate LastEditDate LastAccessDate	Range of Date
Multi media	Text (Word/Excel/ PowerPoint)	Number of Pages (Slides)	Range of numbers
		Number of Words	Range of numbers
	Image (GIF/JPEG)	Hsize	Range of numbers
		Vsize	Range of numbers
		ColorDepth	Multiple Selections
	Audio (WAV/AU) (To be implemented)	SampleRate	Multiple Selections
		RunTime	Range of numbers
	Video (Real/ QuickTime/Flash) (To be implemented)	Hsize	Range of numbers
		Vsize	Range of numbers
		RunTime	Range of numbers
		Number of Frames	Range of numbers

5.2 Content Packaging

The IMS Content Packaging Specification provides the functionality to describe and package learning materials, such as an individual course or a collection of courses, into interoperable, distributable packages [22]. It is closely related to the IMS metadata information model [13,23]. In our implementation, when an Instructor/Administrator sends a content packaging request, the system will extract related explicit or implicit information from the database tables and generate a Manifest in the form of Extensible Markup Language (XML). The Manifest together with the related learning object content are added to a Zip file by calling a server-side Java class. The Java class is able to zip a whole directory by recursively calling itself. It can also zip the content of a memory variable by specifying a file name that is associated with the variable.

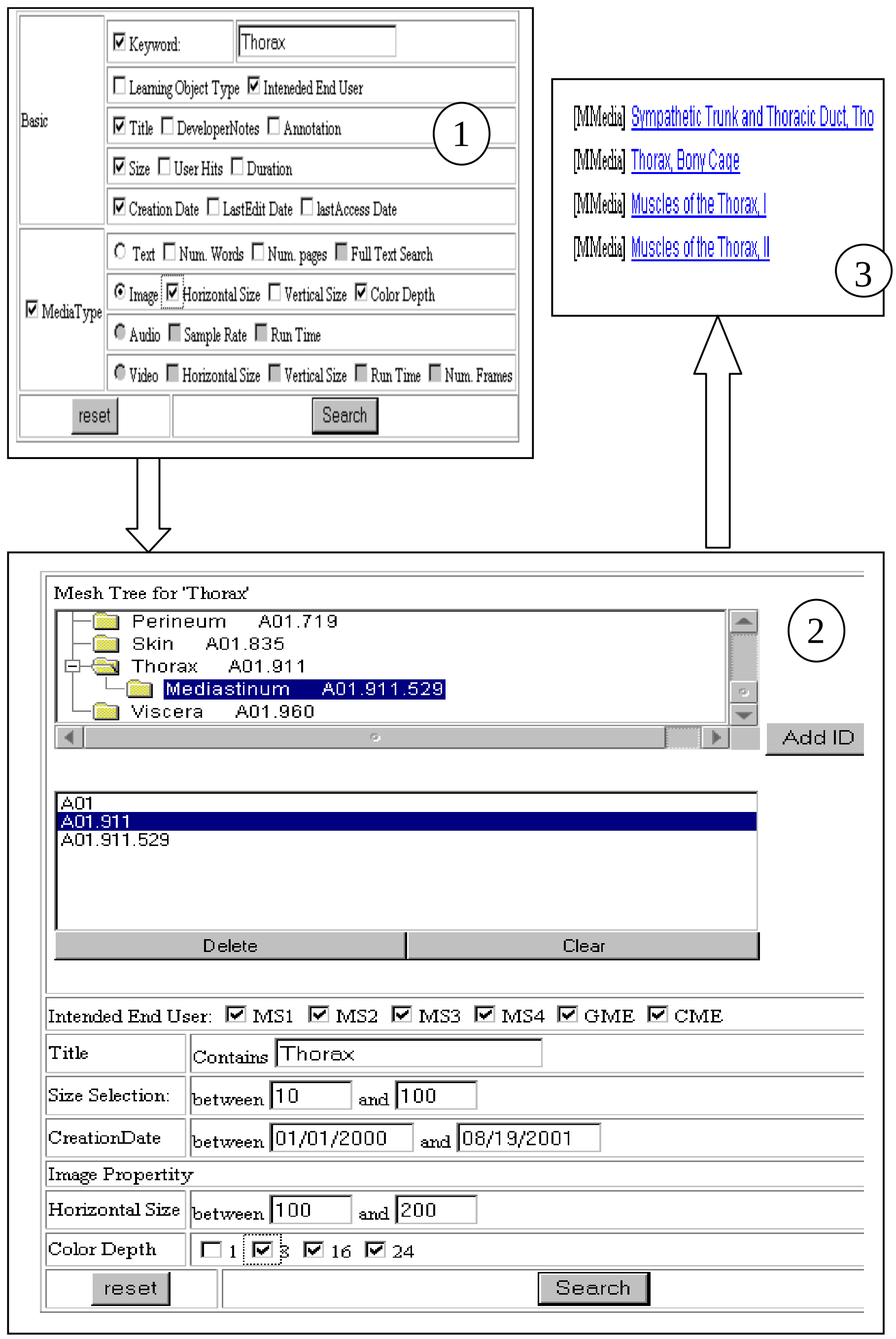

Fig. 6. Steps of the metadata based searching process

6 Conclusion and Future Work Directions

In this paper, we summarized our work in transferring a file repository into a multimedia digital library on top of a database system for medical education. We presented our design and implementation of database schemas, metadata management, metadata-based searching engine and IMS compliant content packaging. In our future work, we want to add more semantic-based metadata attributes, such as incorporating UMLS semantic networks, to LOs. We also want to use standardized multimedia description scheme, such as MPEG-7, as multimedia metadata. Finally, as an integrated system, we want to provide better GUI and web-content authoring tools in developing medical education resources to enrich our digital library.

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Design and Evaluation of Lecture Support Functions for Question Databases

Chisa Sumitomo, Akira Okada, and Yahiko Kambayashi

Graduate School of Informatics, Kyoto University
Yoshida-Honmachi, Sakyo-ku, Kyoto 606-8501 Japan
TEL +81 75-753-9140 FAX +81 75-753-4970
{sumitomo,aokada,yahiko}@db.soc.i.kyoto-u.ac.jp

Abstract. One of the serious problems in a large-scale class is how to give some level of satisfaction to students. A degree of satisfaction of students will be improved by realizing useful interaction between a teacher and students. Though there are various kinds of communication methods, “questions and answers” databases can be regard as very much important, since the efficiency of questions-answer process is improved and analysis of student behavior can be realized. It is expected to discover important information by analyzing a set of questions. In this paper, we have designed a question-answer database, which will store all questions and corresponding answers. As search functions such as keyword search can be used to analyze data, we have to develop the following two capabilities. (1) Question handling capability (2) Question analysis capability. We have performed experiments by collecting questions, in order to evaluate usefulness of search functions and analysis functions.

1 Introduction

Distance learning is one of the promising areas to be used widely in the coming society due to the progress of computers and networks. It is served by many universities, such as University of California Extension [13], University of Wisconsin Extension [14], Stanford Online [12], Harvard Extension [4] and MIT Center for Advance Education Services [6]. In Europe and Australia there are also many examples in order to cover wide areas, even several countries. Each of them has well-devised service such as real-time distribution of lectures on the Internet, publicity of lecture video records on the WWW and so on. Although it is a research project, Classroom 2000 [1, 5] in Georgia Institute of Technology should be also mentioned because of its advanced functions. Our project, VIEW Classroom [8] also realizes various advanced functions, where VIEW stands for “Virtual Interactive Environment for Workgroups.”

Distance learning is based on communication between a teacher and students who are distributed in different places and possibly different time. In distance learning, students do not have to get together in one classroom. Question databases to be discussed in this paper are useful tools to communicate among students and teachers. They will also help understanding of course materials by students and improving course materials by teachers.

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Communication among participants is focused in many research projects [2, 11]. In general activating communication is major research topic. Reuse of communication data to be discussed in this paper is not considered previously. A quality of a lecture will be improved by grasping participants' opinions or demands. Accumulating data of communication and utilizing them are promising to improve quality of distance learning.

In this paper, we focus on the usefulness of databases of "questions and answers" to improve lecture quality or to improve efficiency of self-study. Utilizing a set of questions supports self-study by a student and analysis of a lecture by a teacher. An experiment is taken with collecting questions and answers and these data are verified for grasping some useful functions and demands of a teacher or students. Some functions for question databases are designed on the basis of the experimental result.

2 Basic Design of Question Databases

2.1 Problems in a Large Classroom Setting

In this section, some important aspects of questions and answers are discussed in association with problems in a conventional classroom setting.

In a large-scale class that consists of one hundred or more students, there are various problems. Especially, it is an important issue for a teacher to manage a lecture that makes a student satisfied. Sometimes a student is not satisfied with a boring one-way lecture. It is difficult for students to obtain an accomplishment in such a lecture. Dissatisfaction of students will be able to be reduced by making interaction between a teacher and students.

There is a "questionnaire method" [3], which is one of the methods of communication in a conventional class without computers. In the lecture, all students must give at least one question about the contents to a teacher during the lecture. This method has used practically in some lectures and proved to produce good results. It can be also introduced in a distance learning.

In the research of this method, the researchers verify how selecting questions effects on students psychologically, and propose a method that utilizes the questionnaire with the lecture. They had not focused on extracting useful information effectively from a set of questions.

However, the following problems still exist for such a lecture.

- **Limitations on the number of questions to be answered**

In the lecture that introduced this method, it is usually impossible for a teacher to answer all questions given from students during the lecture. Thus, many good questions may be ignored.

- **Difficulty in selecting good questions**

A teacher should select good questions from many questions by hand. It is a big burden for him, since he should spend much time to investigate all questions.

- **Delays in answering questions**

Questions should be accepted at any time, and should be answered as soon as possible. When students come to a point that they cannot understand, the only help is to ask questions. They may feel difficulty in continuing their learning without receiving answers quickly.

- **Repeated questions**

Frequently a teacher repeats similar lectures every year, thus has to answer similar questions. To help him, similar questions/answers have to be reused to eliminate teacher's overload.

- **Lack of advantages for students**

There are advantages for a teacher to know questions of students and improve a teaching material by knowing general trend of questions. In the case that a teacher does not answer the question of Student A though a teacher answers other questions. There is little advantage for Student A. Although he can get several answers, he cannot have an answer to his important question.

In case of big classes, participants may feel difficulty to understand questions and answers in detail. Effective interaction support facilities are expected, especially in a distance learning system.

2.2 Facilities for Communication between a Teacher and Students

We have been developing distance learning system VIEW classroom [8, 9]. VIEW Classroom can support teaching and learning by using database facilities. The Question Support Facilities in VIEW Classroom include the following means to support communications between a teacher and students [7, 10, 15]. We assume that each student issues his question in a sentence form. Many questions are collected in every lecture that introduce a questionnaire method. Vast array of questions are accumulated on database easily by using these technology.

- **Automatic Answers Facility**

We had focused on replying to a question automatically in our research group [7, 10, 15]. During or after a lecture, VIEW Classroom system saves both questions and answers in a database. When a student asks a question that has been stored, the system answers the question automatically and immediately. This facility reduces the teacher's time in answering, and student's time in waiting for answers. It also partly solves the problems of limitations on the numbers of questions to be answered, delays in answering questions, and repeated questions.

- **Display facility for questions**

Questions are classified into two groups: questions that are answered automatically and questions that have to be answered by a teacher. The facility allows for a teacher to see the list of questions ordered by key phrases or grouped by similarity. It helps teachers to select quickly an essential question.

- **Search facility for questions**

It is necessary for a teacher and students to extract useful information from database. In such a case, generally a keyword search is used. A teacher uses slides in a lecture, so it is necessary for a teacher and students to classify many questions by slides related to the given question.

- **Display facility for tendency of questions**

Questions indicate information such as interest or comprehension of students. By analyzing them, a teacher can get some useful information for a lecture. It is useful that students' questions are accumulated on database and to offer analyzing support functions.

These functions are relatively easy to materialize technologically, but these functions have not been verified whether or not they are truly useful to support analyzing many data.

Therefore it is important to collect questions in practice, apply these functions to a set of questions and verify an effectivity of these functions. By analyzing real data, further important functions may be found. Then we can improve question databases.

3 Experiments

3.1 Objectives of Experiments

We expected the effects of using question databases are as follows.

1. The system will help to improve the degree of satisfaction of students.
2. The system will support efficient self-study.

As questions can be classified by keywords and slide-numbers, students had to specify keywords and a slide-number that related questions when they gave questions. Students retrieved questions they want by specifying them.

The system is also useful to form questions. Even if students cannot understand the contents and they cannot form questions, by showing questions that were retrieved by a slide-number or keywords, students may grasp what they did not understand. By reviewing other questions, a student may be able to generate his own question.

Moreover the following two points are also necessary to evaluate.

- Accuracy of the search results

  It is important to evaluate whether or not students can get questions they require, by a slide-number and a keyword search efficiently. The results can be used to improve search functions.

- Other kinds of classification of questions

  In order to realize various kinds of search functions, we may have to use other kinds of classifications.

3. Mining of questions to find out general tendency of questions

Such in formation is useful for teachers as well as students.

3.2 Experiment Overview

We experimented in the lecture of "graph theory" in Kyoto University. This course consists of ten sections and questions are collected for each section.

Environments of the Experiment.

- Lecture style

The teacher gives a lecture by using slides. As about one hundred twenty students attend every week, and about one hundred questions were collected per one class.

The lecture is given at a conventional classroom, that is we do not use networked computers during the class. Before starting a lecture, question forms are distributed among students. The forms are collected after a lecture. In the first about thirty minutes of a lecture, a teacher explains around thirty questions that are selected from questions in a previous class. A teacher omits a reply to questions that are regarded as not important nor obvious from the contents of a lecture.

- Teaching material

Lecture is given by slides. Answers of questions that are collected previous classes are also classified by slides. Students have to ask questions with a slide-number.

- Questionnaire format

As has been mentioned, a set of questions is categorized by a slide-number or keywords. A question that was not met this condition was not included in an experiment sample.

Students ask questions with the slide-number, keywords, and contents. Students also can describe opinions and requests to a lecture. Accumulated questions are used for system improvement as well as lecture improvements.

- Search function system and message board

Questions and answers are accumulated on database. A teacher and students can search them with search functions (Figure 1) and a message board is developed to write further questions and requests for the system or the lecture.

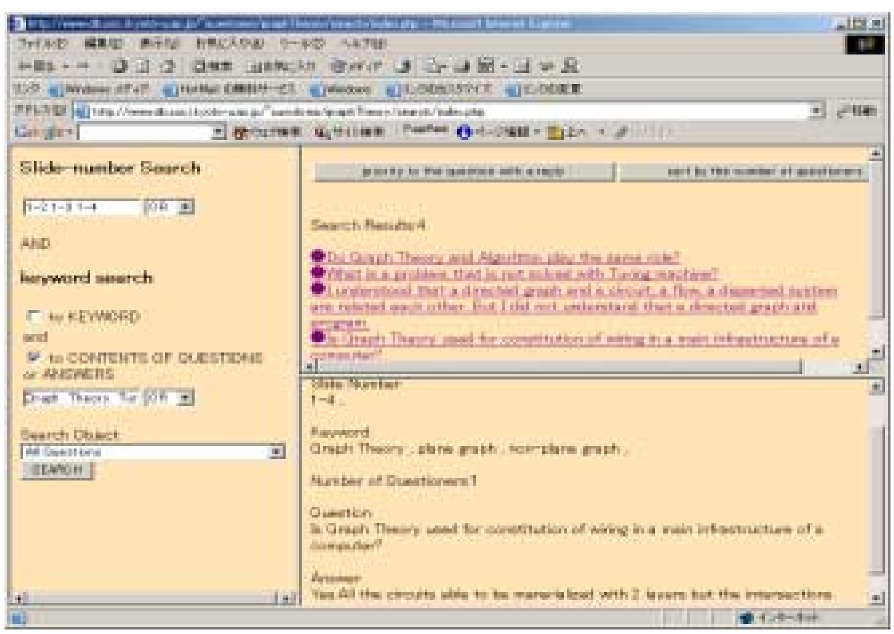

Fig. 1. Search function system

4 Analysis of the Experiments

The result of the experiment will be shown in this chapter. We analyzed contents of questions, a questionnaire data, access log of search function and others, together with opinions of students or a teacher.

4.1 Questionnaire Data (1)

This questionnaire was collected the end of 5th lecture. Here are results of analyzing it.

- About collection of questions

Many students approved collecting a question and replying to it. Some students oppose collecting a question by force but that form produced an effect in [3]. Reason of such dissatisfaction is that we were not able to support students well because this experiment was the first attempt to collect a question.

- Evaluation of classification methods

Many students feel that both classification methods were useful. Some students wanted to classify whether or not questions have replies, questioner number or a level of question quality.

The prototype system has two functions, slide-number search and keyword search. Questions are classified by the levels of quality and by the existence of the corresponding answers. Ordering functions are also implemented.

4.2 Questionnaire Data (2)

This questionnaire was collected the end of an examination. Students used the search function for study for an examination. Here are results of the analysis.

- Searching questions on the web

Many students feel that this attempt was good. Some students were dissatisfied that a teacher replayed only high-level questions and answered a part of questions. Most students seem to be satisfied with the search functions, but there are requests for some additional high-level functions.

- Search functions

Some students did not use system because period of using the system was limited and environment was not arranged well. Some students wanted functions that display statistics of number of questions, classifying by level of importance and displaying questions and a teaching material simultaneously. As a list of questions is not sufficient, ranking of a question, overall trend and other teaching material are requested.

4.3 Use of Access Log for Students' Behavior Analysis

The following facts were found by analyzing access logs.

1) Similarity between a question that students views and a question that a teacher replied

There were thirteen questions that had answers in top twenty questions students often checked. In seven questions that had not answers, three questions are solved by showing answers of similar questions, three questions are so easy, one question is no answer. If some similar questions are collected, most questions students checked had answers.

2) Interest of students

Because students could only use a system after all lectures, they often checked questions for an examination. Their interests were grasped from a searching condition and questions that were often checked in some degree. Accordingly it is expected that it is possible to grasp trend of their interests or their questions by analyzing the access log of the system in a usual lecture period.

3) Trend of access to a system

Figure 2 shows the trend of access to a system. A vertical axis shows how many times each function had been used. A horizontal axis shows functions of the system. Most students used a keyword search function. It is because that they may often use a keyword search function on the Web. We expect that the reason for not using a slide-number search function is that it is inconvenient to enter a slide-number without reading a teaching material at the same time.

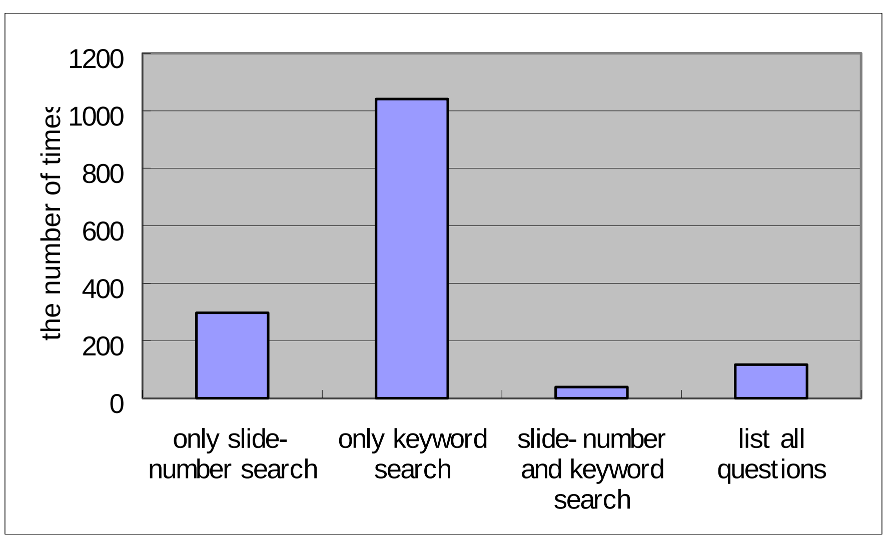

Fig. 2. Trend of access to the system

4) Problems of search functions

Students were satisfied with search functions, a slide-number search and a keyword search. As user interfaces for slide-number search, keyword search and chapter-based search are similar, students sometimes confuse and make mistakes.

4.4 Classification of Questions

Classification Method.

1. Uniqueness of a slide number

In the case that a teacher explains one algorithm with several sheets of teaching materials, one student asks a teacher about the algorithm and his question is registered on database as one in a "slide-number 1". Another student may give the same questions but thinks it is in a "slide-number 2". He cannot get a question he wants by using a present slide-number search. The following are conceivable as the solution method of this problem.

- A category is prepared by a teacher.
- Concurrence probability of a slide-number

Some students ask questions with "slide number 1"(number of questions is A). The other students ask them with "slide number 2"(number of questions is B). The other students ask them with "slide number 1 and 2"(number of questions is C). Concurrence probability D is C/(A+B). If D is over certain probability, slide 1 and slide 2 are the same category.

2. Non- Uniqueness nature of keyword

Some students set the title of a slide as a keyword and some students set different keywords to same questions. If students write keyword freely, it is impossible to classify questions on the basis of contents by using these keywords.

Contents of Question.

Contents of questions are distributed, such as about an explanation of a word, questions about a progressive content. Questions are classified by using intentions of questioners. It should allow students to question about contents of a lecture, such as a blackboard, an explanation of orally.

Also there was the following problem that was not hypothesizing.

- Some questions are generated due to the high-speed of the lecture. Information about situation of a lecture is necessary.
- Two questions have same answers but these questions are set different slide-numbers or keywords. Students can find related questions by the shared answers.
- Even if number of questioners is the same, this distribution is various. For example, if there are five questioners, five students ask different questions or they ask the identical questions. Information for a teacher to improve a teaching material or a lecture is very much important.

A teacher evaluated that checking questions were useful for improvement of a teaching material. It is necessary to select questions that should be replied in consideration of the knowledge students have, since students of two faculties are attending.

5 Future Research Problems

We propose that it allows students to question after a lecture. It is necessary for a teacher to support to extract a question he should reply.

It is conceivable that the following function is necessary from the result of an experiment.

- Classify by using context information

Contents of questions are distributed. It is realized that an intention of a questionnaire is extract by checking the end of sentence. If students select an item from the list that has various intentions, such as a question, a suggestion, a basic question or a progress question, it is possible to classify by using them.

- Record the contents of a lecture in addition to slides

Contents of a blackboard and an oral explanation are accumulated on database. User can search these information and get important one.

- Related questions

Students are able to learn the related question simultaneously. For example, it displays the results with layer structure based on contents.

- Distribution of questions

Questions are divided into some group by classifying on the basis of context information. Distribution of a set of questions is observed by checking the number of a group.

- Design of user interface

For a teacher：To know the trend of a set of questions is useful for improvement of a lecture. General tendency is found out by mining of questions. For example, screen shots are shown below (Figures 3, 4). In Figure 3, a vertical axis shows each slide. A horizontal axis shows the number of questions.

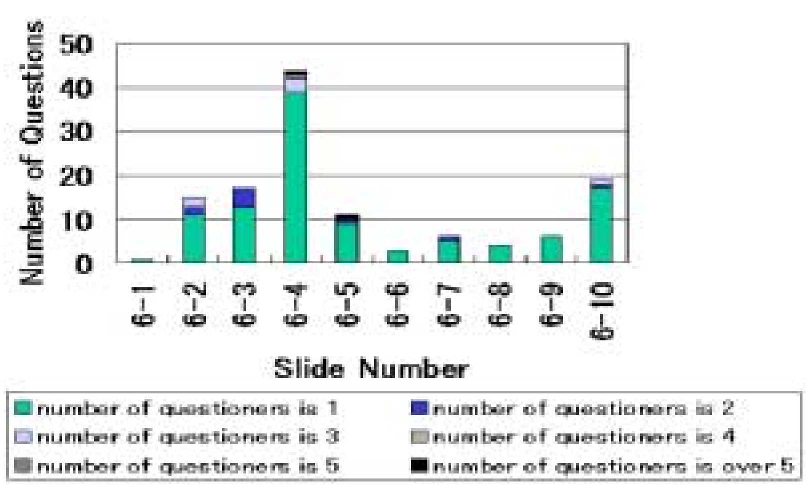

Fig. 3. Number of questions in each slide

In Figure 4, a vertical axis shows each keyword. A horizontal axis shows the number of keywords.

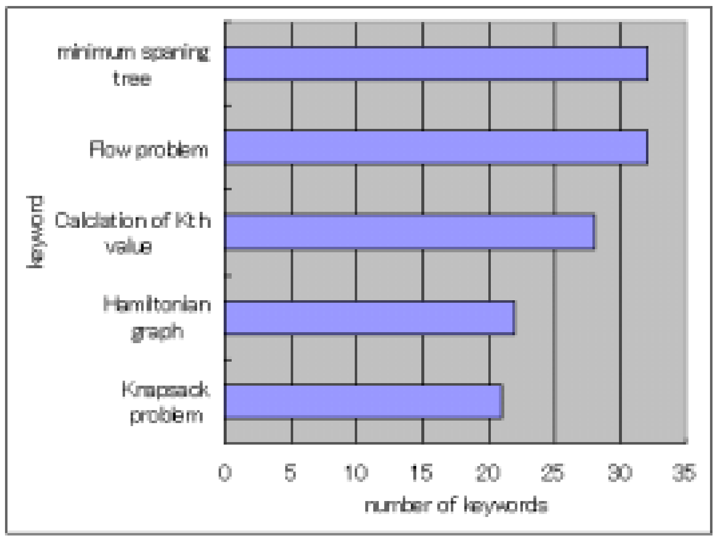

Fig. 4. Top five keywords that students used

For a student : It is necessary to pick out some keywords each chapter to support to input keywords in a keyword search function. These keywords are used as references, when students' own questions are not evident and they cannot ask. The system supports students to grasp contents of a lecture systematically by presenting questions on the basis of a relation. To display statistics information, such as number of questions or keywords that other students used is useful.

- Additional data

Students sometimes cannot get some questions they want because they can only search questions and answers. It is necessary to be stored a teaching material and to search it, so they can get better questions efficiently.

- Intention of a teacher

As a teacher cannot answer all questions, he should write comments instead of an answer, for example a basic question, a difficult question, a good question or a bad question. It is necessary to make a comment list for reducing the burden of a teacher. Only fundamental item is extracted easily or only important item is selected by using such information that are stored on database.

- A situation of a lecture

A circumstance of a lecture is often recorded on videotape. It is possible to extract some information from the picture technologically for example, by image processing.

We expect that this picture is useful to the following purpose.

- Extraction of the question that is related by a temporal connection
- If students can ask questions with a movie, they can question about contents besides slides.
- If contents that a teacher already explained are regarded as answers, the burden of a teacher will be reduced by attaching the question to an appropriate location of a movie.
- Students can search a necessary part of a movie easily by making a question as the index of a video.

6 Summary

We focus on "questions and answers" as one of the means of communication in a distance learning class. We have collected questions actually and analyzed them, and examined the method of classification by a slide-number and keywords on question databases. We constructed the search function system and many students used this system and took some questionnaires. As a result, we proposed advanced functions that utilize question databases. With use of the system, a teacher can get important information for making a lecture better. Students also can get situation of other students and it is useful for them to study by themselves.

There are many useful applications of questions databases. We can combine this function with other functions of VIEW classroom and aim at the realization of a system for better education environment.

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Using Page Classification and Association Rule Mining for Personalized Recommendation in Distance Learning*

Daling Wang, Yubin Bao, Ge Yu, and Guoren Wang

School of Information Science and Engineering
Northeastern University, Shenyang 110004, China
{dlwang,baoyb,yuge,wanggr}@mail.neu.edu.cn

Abstract: With the rapid development of Internet, distance learning applications over Internet become more and more popular. This paper introduces a personalized learning system for web-based distance learning and focus on the web usage mining techniques aimed at personalized recommendation service. First, this paper presents a web page classification method, which uses attribute-oriented induction method according to related domain knowledge shown by a concept hierarchy tree. Second, the paper presents an algorithm of mining association rules with one-support using Freq-Set-Tree. Third, based on their current access patterns, page classes at the home site, page integration from other sites, and the rules discovered in mining, recommendation pages are made and presented for the students.

1 Introduction

Recently, distance learning technique is developing rapidly with development of Internet techniques. Many different forms of distance learning system are developed. In China, many network colleges have been established by more than 20 universities. Now, there are two forms of distance learning: video meetings and VOD-style learning. With the former, a teacher gives the same lecture to students at different places. With the latter, each student can subscribe courses required by her/himself and watch scripts, images and other contents related to the courses, i.e. personalized learning[1]. However, there are two major problems in the current web-based distance learning system: (1) Students often get too much information returned by a query to browse in detail, some of which is not what s/he really wants. (2) Each student has different foundation, capability and interesting, so the requirements to the course information are not the same, but the information provided by network has same form and content so that they can not meet the requirements of individual students. The problems result in that personalized learning cannot be realized easily.

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The research on web mining for personalization has made some achievements in e-Commerce[2-5]. However, distance learning is different from e-Commerce in many aspects, mainly, purposes and methods as follows:

- The purpose of a commerce web sites for personalization is to attract customers to buy its commodities as possible through personalized recommendation pages, this is so-called “converting browsers into buyers”, thus the pages only recommend their commodities without other ones. The purpose of education network is making students obtain more knowledge, and many network colleges have published their courseware through Internet, so the recommendation pages of the distance learning should give students more information including both themselves and others.
- Recommendation for distance learning doesn’t only rely on the rules discovered by web mining but also rely on the domain knowledge and teaching plan about the course. The rules are just used as reference or advice for recommendation. For example, if the rule “$URL_1 URL_2 \Rightarrow URL_3$” is found, where, the content of URL_1 is about “intelligent information processing”, content of URL_2 is about “data mining”, and content of URL_3 is about “opencast coal mining”, then thus recommendation will not be given even though its support is very large. But in a supermarket, the discovered rule “milk beer⇒diaper” may be valuable although diapers are not coherent with milk and beer explicitly.

Due to characteristics of distance learning, web mining and recommendation for it should do more work in usage mining and recommending. First, collecting the web page information from the other web sites which are related with what students accessed, then classifying the pages according to their topics, and finally, send recommendation pages to the students according to the access pattern of students.

According to the requirements and characteristics of distance learning, we design a personalized learning system for distance learning (WebTutor), in which web usage mining technique is utilized to make personalized recommendation for an individual student on her/his access pattern. WebTutor is installed in the server side of a learning site (called *home site*), consisting of **web usage miner**, **web page integrator** and **personalized information recommendation maker**. Web usage miner finishes the work including preprocessing web log data, executing algorithms of web mining, generating rules, and establishing web page classification for the home site and other sites. Web page integrator gets web pages related to teaching from other web sites using search engine in order to recommend more information to students, and constructs a new page file including the URLs and topics of web pages from the home site and other sites. Personalized information recommendation maker will make recommendation pages with the web page of the home site and other sites for a student according to the mining results and his/her current access pattern. Many web usage mining methods can be used in WebTutor, but this paper focuses to the web page classification method and association rules mining algorithm.

The rest of the paper is organized as follows. Section 2 describes a web page classification method, Section 3 presents a preprocessing method for web usage mining, Section 4 introduces the association rule discovery of web usage mining. The pages integration and personalized recommendation is shown in Section 5. Finally, Section 6 gives conclusion and future work.

2 Web Page Classification in WebTutor

In WebTutor, web page classification is to classify all web pages on their topics including home site for preprocessing and other sites for integrating in order to mine association rule and recommending on topic. It will apply attribute-oriented induction method[6] according to related domain knowledge shown by a concept hierarchy tree. An example of concept hierarchy tree is shown in Fig.1. When classifying, the concept ascending will be performed along the related concept hierarchy tree and stop the ascending when reaching the restricted hierarchy.

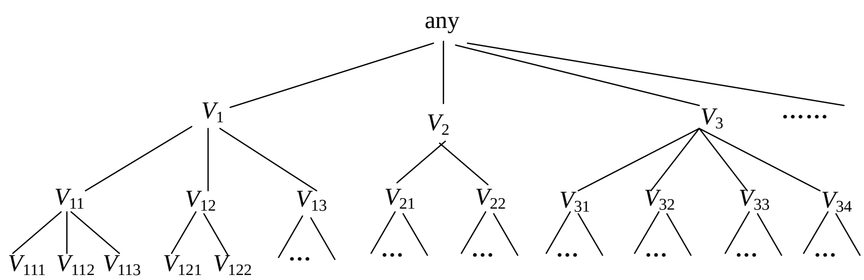


Fig.1. An Example of Concept Hierarchy Tree

Using the tree in Fig.1 to do concept ascending, the rules of ascending includes:

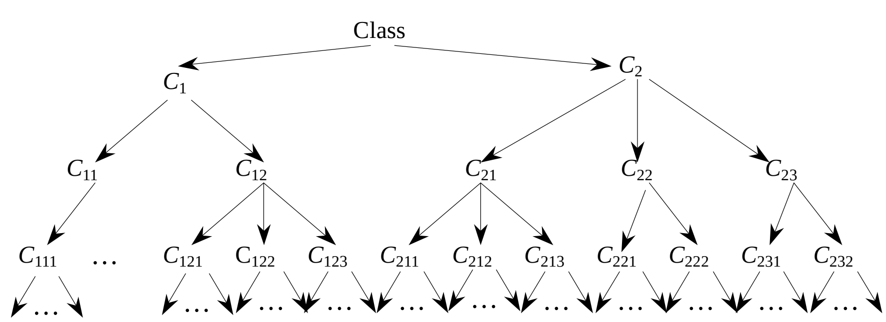
$V_{111}\ V_{112}\ V_{113} \rightarrow V_{11}$; $V_{121}\ V_{122} \rightarrow V_{12}$; ……

If not reaching restricted hierarchy, the ascending will be continued as follows:

$V_{11}\ V_{12}\ V_{13} \rightarrow V_1$; $V_{21}\ V_{22} \rightarrow V_2$; $V_{31}\ V_{32}\ V_{33}\ V_{34} \rightarrow V_3$; ……

In this case, V_{11}, V_{12} and V_{13} will be classified into V_1, V_{21} and V_{22} will be classified into V_2, and V_{31}, V_{32}, V_{33} and V_{34} will be classified into V_3.

Obviously, there should be many concept hierarchy trees about every course and their content in order to classify topics from home site and other sites. But sometimes, not all topics can be contained in related trees, the topic having not contained in the



Class: Computer C_1: Hardware C_2: Software C_{11}: Interface C_{12}: Architecture
C_{21}: Operational System C_{22}: Database C_{23}: Data Structure C_{111}: Introduction of Interface
C_{121}: CPU C_{122}: Memory C_{123}: I/O C_{211}: Overview of OS C_{212}: Thread C_{213}: Process
C_{221}: DBMS C_{222}: Application of DB C_{231}: Tree C_{232}: Binary Tree ……

Fig.2. An Example of Concept Hierarchy Tree about Computer Course

trees will can not be classified. In this case, we have to establish a new tree or insert the topics into a tree existed so that the topics can be ascended to higher hierarchy and classified.

For example, Fig.2 is a concept hierarchy tree about computer course. Now there are some topics as follows:

T_1: Binary T_2: CPU T_3: RISC T_4: DBMS T_5: Array

We use concept ascending method according to Fig.2 to class these topics. After first concept ascending, the result is:

T_1, T_5: Data Structure T_2, T_3: Architecture T_4: Data Base.

After second concept ascending, the result is:

T_1, T_4, T_5: Software T_2, T_3: Hardware.

Where, T_3 and T_5 don't appear at beginning, after concept ascending, they are inserted into the tree, and T_3 is as a subtree of Architecture and T_5 is as a subtree of Data Structure. The result hierarchy of concept ascending relies on the real application. Generally, lower hierarchy is used in integration and higher hierarchy is used in preprocessing of data mining in WebTutor.

3 Preprocessing of Web Usage Mining in WebTutor

As we know, local caches, proxy servers and firewalls make the web logs of servers not accurate. The inaccurate web logs will results in the improper results of web mining. In order to solve these problems, many researchers are exploring using some heuristics and supply some methods[7-9]. Based on these researches and the characteristics of recommendation for distance learning, the steps of preprocessing of web usage mining in WebTutor are designed as follows:

Step 1. *Data acquisition*. The HTML files are collected, whose name are kept in the log entries about the HTML file requesting. These HTML files are relevant in most cases. Such files as .txt, and .gif can be pointed by HTML files with links, so they are useless for recommendation and need not be considered in mining.

Step 2. *Topic acquisition*. It aims to obtain the topic of every URL for providing related pages. Sometimes the topic can be got from the name of the URL path, but sometimes it has to access the URL.

Step 3. *Class acquisition*. The step will use the web pages classification in Section 2. It will define the corresponding class for every URL. In distance learning, the recommendation not only relies on the mining results but also has to do further analysis, so the topic of every URL and its class need to be obtained.

Step 4. *Session acquisition*. The goal of this step is to make the unique students be identified and obtain session from the student identification. Here we have to use some heuristic rules to do so because of inaccurate web log data at server side. The heuristic rules are defined as below:

Heuristic 1. If the *Agents* of two log records in a log file are different, then the two records represent different students even if their IPs are the same.

Heuristic 2. According to topology of a web site, if a page requested is not directly reachable by a hyperlink from any of the pages visited by the student, then the visitorof the page is another student.

We can identify the unique students with above heuristic rules and identify every session using following criterions:

Criterion 1. For a given timeout, if the *Time* between two page requests exceeds the timeout, it is considered as that a new session starts.

Criterion 2. If the class of a topic in requested page is different from that of the previously requested page, then it is considered as that a new session starts.

The result of preprocessing will generate a session file, it will be used as the data source for web usage mining. The session file has the form as follows:

<*Session ID*, *Class*, {*URL*}$^{+}$>

Now we take an example to explain the process of preprocessing in WebTutor. Fig.3 shows the topology of a web site for "Computer" course. We can build a new log file shown in Tab. 1 through combining access log, referrer log, and agent log.

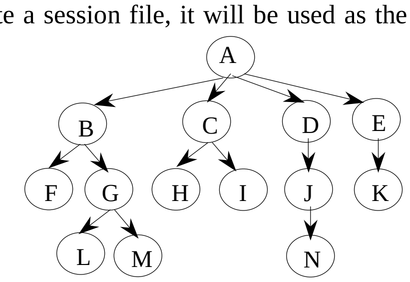


Fig.3. The Topology of A Computer Course

Table 1. A Log File through Combining Access Log, Referrer Log, and Agent Log

#	*IP Address*	*Data & Time*	*Request & Protocol*	*Referred*	*Agent*
1	202.118.27.52	02/Oct/2000:08:57:09 0800	"GET *A*.html HTTP/1.0"	-	Win98
2	202.118.27.52	02/Oct/2000:08:59:03 0800	"GET *B*.html HTTP/1.0"	A	Win98
3	202.118.24.40	02/Oct/2000:09:02:10 0800	"GET *A*.html HTTP/1.0"	-	Win98
4	202.118.24.40	02/Oct/2000:09:05:08 0800	"GET *B*.html HTTP/1.0"	A	Win98
5	202.118.27.52	02/Oct/2000:09:07:04 0800	"GET *F*.html HTTP/1.0"	*B*	Win98
6	202.118.27.52	02/Oct/2000:09:10:15 0800	"GET *G*.html HTTP/1.0"	*B*	Win98
7	202.118.24.40	02/Oct/2000:09:11:02 0800	"GET *G*.html HTTP/1.0"	*B*	Win98
8	202.118.27.52	02/Oct/2000:09:14:11 0800	"GET *A*.html HTTP/1.0"	-	WinNT
9	202.118.27.52	02/Oct/2000:09:15:09 0800	"GET *C*.html HTTP/1.0"	A	WinNT
10	202.118.27.52	02/Oct/2000:09:18:02 0800	"GET *H*.html HTTP/1.0"	*C*	WinNT
11	202.118.24.40	02/Oct/2000:09:19:17 0800	"GET *A*.html HTTP/1.0"	-	Win98
12	202.118.24.40	02/Oct/2000:10:57:04 0800	"GET *C*.html HTTP/1.0"	A	Win98
13	202.118.24.40	02/Oct/2000:10:59:11 0800	"GET *H*.html HTTP/1.0"	*C*	Win98
14	202.118.24.40	02/Oct/2000:11:02:11 0800	"GET *I*.html HTTP/1.0"	*C*	Win98
15	202.118.24.40	02/Oct/2000:13:00:08 0800	"GET *D*.html HTTP/1.0"	*A*	Win98
16	202.118.24.40	02/Oct/2000:13:07:00 0800	"GET *J*.html HTTP/1.0"	*J*	Win98
17	202.118.24.40	02/Oct/2000:13:10:34 0800	"GET *N*.html HTTP/1.0"	*N*	Win98
18	202.118.24.40	02/Oct/2000:13:12:36 0800	"GET *E*.html HTTP/1.0"	*A*	Win98
19	202.118.24.40	02/Oct/2000:13:18:30 0800	"GET *K*.html HTTP/1.0"	*E*	Win98

From Tab.1, we can get following URL sequence as data with Step 1.

A B A B F G G A C H A C H I D J N E K

After Step 2, we can get the page topic related with every URL. The every topic is shown in Tab. 2.

Table2. URLs and their Topics

URL	*Topic*	*URL*	*Topic*	*URL*	*Topic*
A	Computer	*B*	Operating System	*C*	Database
D	Data Structure	*E*	Interface	*F*	Overview of OS
G	Process Management	*H*	DBMS	*I*	Application of DB
J	Tree	*K*	Introduction of Interface	*L*	Processes
M	Threads	*N*	Binary Tree		

Next we can get the page class related every URL using Step 3 according to the concept hierarchy tree in Fig.2, and the result of the step is:

$\{A, B, C, D, F, G, H, I, J, L, M, N\} \in$ Software $\{E, K\} \in$ Hardware

Next step, we will partition the URL sequence generated in Step 1 into some unique sessions. At first, we can partition the sequence into two sequences because of different IP address. The first sequence consists of record {1, 2, 5, 6, 8, 9, 10}, and the second one consists of other records. Then, according to heuristic 1, we partition first sequence into {1,2,5,6} and {8,9,10}. Then we partition sequence {3,4,7,11,12,13,14,15,16,17,18,19} into {3,4,7} and {11,12,13,14,15,16,17,18,19} with heuristic 2. Finally, supposing 40 minutes as timeout, we can partition the latter into {11,12,13,14} and {15,16,17,18,19} with criterion 1, and partition {15,16,17,18,19} into {15,16,17} and {18,19} with criterion 2. We convert above sequences partitioned by heuristics and criterions into sessions consisted of URLs and show them as Tab. 3.

Table 3. Preprocessing Result

Session ID	*Class*	*URL Sequence*	*Session ID*	*Class*	*URL Sequence*
1	Software	*A, B, F, G*	4	Software	*A, C, H, I*
2	Software	*A, B, G*	5	Software	*D, J, N*
3	Software	*A, C, H*	6	Hardware	*E, K*

4 Association Rule Mining in WebTutor

4.1 Association Rule in WebTutor

In WebTutor, we require to discover such association rules as follows through mining for good recommendation performance and not excessive mining time.

- Every rule has an antecedent restricted size and its consequent with 1-size.
- The different combination with restricted size about URL in the session file should be contained in the set of frequent itemsets as many as possible.

The antecedent restricted size presents the number of active session window. If it is too small, the intention of users is not explicit, but if it is too large, it is difficult to get correspond rules. So we restrict the number of active session window in 1~*n* (*n* is a given threshold) in order to get enough rules and recommendation. Otherwise, the enactment of support threshold is a difficult problem whether multiple[10] or single[11] support. Meantime, different domain, different dataset and different recommendation all will result in different requirement to support. In order to give recommendation, we designate a one-support, which means that all combinations with restricted size 1~*n* in any session record are frequent itemsets.

Obviously, if the support count is one, too many frequent itemsets will be discovered, and it will result in "itemset blast" which will bring such two problems: (1) Too long time is spent for mining, and (2) Too many rules are got from the frequent itemsets so that recommendation is hardly done with the rules.

In this case, applying conventional algorithms of mining association rule hardly solve the problems because it concerns not only enactment of support but also mining speed and storing space. Meantime, the conventional algorithms can mine all rules with different size antecedent and consequent, which are not required for recommendation. So it is necessary to design a new mining algorithm and a new rule storing structure. Based on the idea, we propose the association rule mining with one-support and the storing structure of frequent itemsets.

4.2 Frequent Itemsets Storing Structure

Many frequent itemsets will be generated due to one-support, so an appropriate data structure has to be created to store the frequent itemsets. Here we give a definition as follows:

Definition 1: Freq-Set-Tree is such a tree structure used to store frequent itemsets with one-support and every node of which is a 4-tuple <iname, support, llink, rlink>.

Where, "iname" is the name of itemset stored, "support" stores the support of the itemset, "llink" is a point linking to another node which is a combination of current "itemset" and another letter, and "rlink" is also a point linking to another node which has same prefix and size with current node. To "right", 1-size is an exception and all 1-size itemsets are linked by "right" in this case.

Supposing "*ABEFH*" is a session record in web log and *n*=4. To one-support, there are these frequent itemsets.

Size=1: *A*, *B*, *E*, *F*, *H*

Size=2: *AB*, *AE*, *AF*, *AH*, *BE*, *BF*, *BH*, *EF*, *EH*, *FH*

Size=3: *ABE*, *ABF*, *ABH*, *AEF*, *AEH*, *AFH*, *BEF*, *BEH*, *BFH*, *EFH*

Size=4: *ABEF*, *ABEH*, *ABFH*, *AEFH*, *BEFH*

The storing structure using Freq-Set-Tree is shown in Fig.4.

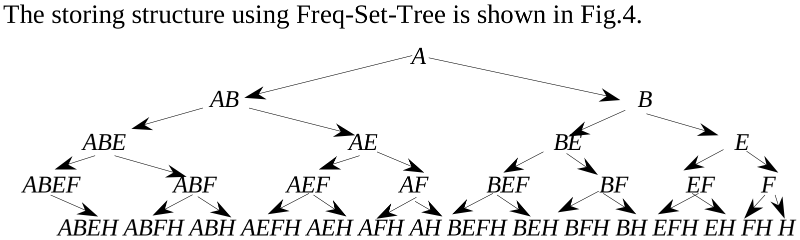


Fig.4. The Storing Structure of A Session Record in Log with Freq-Set-Tree

4.3 Process of Mining Association Rule in WebTutor

The algorithm includes getting frequent itemsets and generating association rule with an antecedent restricted size and 1-size consequent. The former is to create a Freq-Set-Tree from 1-size to (n+1)-size itemsets (n is antecedent restricted size) and the latter is to obtain rules from the Freq-Set-Tree.

The creation of Freq-Set-Tree is given in Fig.5. Where, "generate all k-size itemsets" uses apriori-gen algorithm[9]. Difference with apriori is that here L_k=C_k and means k-size itemset.

```
for all records in database D
    for (k=1, k≤n+1, k++) {
        generate all k-size itemsets into k-set;
        for all ksi∈k-set
            if ksi has existed in Fre-Set-Tree then support of ksi ++
            else insert ksi into Fre-Set-Tree and assign its support as 1;
    };
```

Fig.5. Algorithm of Building Freq-Set-Tree

In the process of getting frequent itemsets, the support count threshold is assigned one in order to obtain enough frequent itemsets, so too many rules will be obtained. But of all rules with same antecedent, only those with maximal support are useful.

In order to get its (i+1)-size itemsets with maximal support for a given i-size itemset, next idea is considered. Because all itemsets are ordered and each item of every itemset is ordered, for an i-size itemset *isi*, only the (i+1)-size itemsets are considered, of which the prefix is *isi* and its precedent. For example, in Fig.4, to *AB*, only *ABE*, *ABF* and *ABH* are considered, to *AE*, only *ABE*, *ABF*, *ABH*, *AEF* and *AEH* are considered. Here *AB* is the prefix of *ABE*, *ABF* and *ABH*, and *AE* is the prefix of *AEF* and *AEH*. Meantime, because *AB* is the precedent of *AE*, when finding 3-size itemsets with maximal support for *AE*, *ABE*, *ABF* and *ABH* are also considered besides *AEF* and *AEH*. In accordance with the same idea, *ABEF* and *ABEH* are processed for *ABE*, *ABEF*, *ABEH* and *ABFH* are processed for *ABF*, and *ABEF*, *ABEH*, *ABFH* and *AEFH* are processed for *AEF*, so are other itemsets.

The rules discovered will be stored in a rule set, which has such form as follows:

< *antecedent*, *consequent*, *support*, *confidence*, consequent-*topic*>

4.4 An Example of Mining

We take the example of mining using Tab. 2. Supposing the restricted size of antecedent is 3, we can get frequent itemsets as follows:

Size=1: *A*:4, *B*:3, *C*:2, *D*:1, *F*:1, *G*:2, *H*:2, *I*:1, *J*:1, *K*:1, *N*:1
Size=2: *AB*:2, *AC*:2, *AF*:1, *AG*:2, *AH*:2, *AI*:1, *BF*:1, *BG*:2, *BK*:1,*CH*:2, *CI*:1, *DJ*:1, *DN*:1, *FG*:1, *HI*:1
Size=3: *ABF*:1, *ABG*:2, *ACH*:2, *ACI*:1, *AFG*:1, *AHI*:1, *BFG*:1, *CHI*:1, *DJN*:1
Size=4: *ABFG*:1, *ACHI*:1

They can construct a Freq-Set-Tree and the rules can be generated as in Tab. 4.

Table 4. An Example of Rule set

antecedent	*consequent*	*support*	*confidence*	*consequent-topic*
A	*B*	2	1/2	Operating System
A	*C*	2	1/2	Database
……	……	……	……	……
AB	*G*	2	1	Process Management
AC	*H*	2	1	DBMS
AF	*B*	1	1	Operating System
……	……	……	……	……
ABF	*G*	1	1	Process Management
ABG	*F*	1	1	Overview of OS
ACH	*I*	1	1	Application of DB
……	……	……	……	……

5 Pages Integration and Recommendation in WebTutor

5.1 Page Integration

As mentioned above, we should give recommendation with guidance in order to make students learn more knowledge. So we recommend not only the pages at the home site but also at other sites. To do so, after getting association rules and when using the rules to recommend for students, we recommend the page related with the URLs in *consequent* of the rules set and meantime recommend the pages from other sites dealt with same topics.

In order to get related pages from other sites, integrator in WebTutor will search and collect the page URLs and their topics from other sites through search engine of Internet, and then classify them according to their topics using attribute-oriented induction method, and finally, integrate the page URLs and store them in a page file. The page file attributes consist of following set:

{*URL*0, <*URL*1, *Topic*1>, <*URL*2, *Topic*2> }

Where, *URL*0 is the URL of the home site, *URL*1 and *URL*2 are the two URLs from other sites, which have the related content with *URL*0, and *Topic*1 and *Topic*2 are the topics of *URL*1, *URL*2, respectively.

The purpose of the page file is to recommend *URL*1 and *URL*2 when recommending *URL*0. Where, *Topic*1 and *Topic*2 have been classified through concept ascending to a given hierarchy. Generally, hierarchy ascended for integration is lower than the one for preprocessing. In integration, the hierarchy of *URL*1 and *URL*2 is related with the one of *URL*0.

5.2 Recommendation

In order to give better recommendation for a user according to his/her access pattern, a method with weight of URL is used. Here we give a definition about recommendation weight as follows:

Definition 2: Supposing w is **recommendation weight** with which the PRI of every URL is determined in a rule when recommending. To any such rule as:

$$URL_{a1}URL_{a2}\ldots URL_{an}\Rightarrow URL_{c}$$

Its recommendation weight can be computed as follows.

$$w=support(URL_{a1}URL_{a2}\ldots URL_{an}URL_{c})+l\ (URL_{a1})+l\ (URL_{a2})+\ldots+l\ (URL_{an})$$

Where $support(URL_{a1}URL_{a2}\ldots URL_{an}URL_{c})$ is support of the rule, $l(URL_{ai})$ (i=1,2,…,n) is length from the URL_{ai} to URL_{c}. Obviously, w is related with not only support of the rule but also the path length from every itemset in rule antecedent to rule consequent. The longer the path length is, the larger w is and higher PRI of recommendation is, because the longer path length is, the less probability the URL_{c} is accessed directly from URL_{ai} by a student, in this case, the URL_{c} should be first recommended.

In accordance with the opinion, some rules with same antecedent perhaps have different recommendation weight even though they have same support, and those with large weight will be first recommended. For the purpose, rule set created by mining should be modified next form:

<*antecedent*, *consequent*, *support*, *confidence*, *recommendation weigh*, *consequent-topic*>

Meantime, after computing w according to Fig.3, the rule set shown in Tab. 4 becomes the form shown in Tab. 5.

Table 5. An Example of Rule Set with Recommendation Weight

antecedent	*consequent*	*support*	*confidence*	*recommendation weigh*	*consequent-topic*
……	……	……	……	……	……
A	*C*	2	1/2	3	Database
A	*G*	2	1/2	4	Process Management
……	……	……	……	……	……
AB	*G*	2	1	5	Process Management
AC	*H*	2	1	5	DBMS
AF	*B*	1	1	3	Operating System
……	……	……	……	……	……
ABF	*G*	1	1	6	Process Management
ABG	*F*	1	1	6	Overview of OS
ACH	*I*	1	1	6	Application of DB
……	……	……	……	……	……

In real application, there are perhaps next cases:

1. The URL sequence length (number of active session window) accessed by a student is less than n.
2. There is not any rule matched up to current access pattern.

In order to recommend as much information as possible to the student, in above cases, next measures will be taken:

- To case 1, real URL sequence length *l* (*l*<*n*) is used to search corresponding rules. Because the antecedent of rules mined includes 1~n size, the process can be realized easily.
- To case 2, supposing "*l*:=*n*", then the operations "*l*:=*l*-1"and "searching the rules with *l*-size antecedent in rule set" are executed repeatedly until corresponding rules are found.

An example of recommendation process is following, when a student accesses *A*, *A* composes the antecedent of an association rule in the rule set shown in Tab.5 and a rule $A \Rightarrow G$ is found, so *G* at the home site and related pages at other sites will be recommended. Then the student continues to access *C* (He/she may access other page), *AC* composes the antecedent of another association rule and $AC \Rightarrow H$ is found, so the *H* at the home site and related pages at other sites will be recommended. If the student continues to access *H* or related page, a rule $ACH \Rightarrow I$ will be found, *I* and related pages at other sites will be recommended. Here a record **<"*I*", "http://www.informatik.uni-trier.de/~ley/db","DBLP","http://www.ccf-db.org. cn/ndbc2001", "18th NDBC">** will be located in the page file. According to the results, in current windows, *H* page is displayed, "*I*", "DBLP" and "18th NDBC" are recommended. "DBLP" and "18th NDBC" are linked to "http://www.informatik.uni-trier.de/~ley/db" and "http://www.ccf-dbs.org.cn/ndbc2001", respectively. Fig.6 shows the interface of recommendation using rule "$ACH \Rightarrow I$". A recommendation window is partitioned into two sub-windows, one of them is displaying window and used to display current page of URL accessed by the student, another one is recommending window and used to show topics of URLs recommended. The topics are "hot keys" with hyperlink and are linked to their URLs. When a topic is clicked, its URL will be accessed and its page will be displayed in display-window.

Fig.6. An Example of Recommendation Page

6 Conclusion and Future Work

According to the characteristics and requirements of distance learning, we designed and implemented a personalized learning system WebTutor, and its key point is recommendation with guidance. To do so, we get the topic of every page in preprocessing and use the topics when identifying session, accord an algorithm of mining association rules with one-support using Freq-Set-Tree in association rule mining for getting good recommendation performance and not excessive mining time, apply the technique of integration and classification of pages for recommending related pages of not only the home site but also others. In the paper, we also take examples to explain above processes.

In order to give better recommendation for students and make more object and correct evaluation to mining algorithm and recommendation pages, our future work includes such work as follows:

- To combine association rules mining with other rules mining such as clustering, classification in web usage mining so as to get more accurate access patterns of students.
- To integrate web usage mining and web content mining for improving the content of recommendation pages.

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Web-Based Video Indexing and Retrieval for Teaching and Learning

Simon So

Department of Information and Applied Technology
Hong Kong Institute of Education
10 Lo Ping Road, Tai Po, N.T., Hong Kong SAR, China
swwso@ied.edu.hk simon@so-hk.com

Abstract. Constructivist approaches to learning focus on students' ability to construct knowledge themselves rather than directly receiving from the teachers. At this end, a highly visual environment to provide authentic learning experiences is essential to students. In this paper, we draw on the recent development in visual information retrieval and multimedia database concepts to develop the framework of a web-based interactive video indexing and retrieval environment. This rich learning environment allows the students to anchor into different aspects of the video contents for in-depth analysis and collaborative learning. An on-going project of a micro-teaching system using digital video cases is being developed. This system makes use of streaming technologies and SMIL to provide multimedia synchronization standard over the web. We demonstrate the conceptual framework of this learning environment and the initial results of this system in this paper.

1 Introduction

With the advent of consumer level multimedia computing facilities and Internet capabilities, research effort on visual information retrieval [2,3,6,8,9] and multimedia databases [10,12,13,18] to organize, store and retrieve multimedia data for both stand-alone and Web-based applications has significantly increased. Multimedia data indexing and retrieval are at the core research topics for multimedia databases. Generally, indexing information is in the form of domain-specific or domain-independent meta-data. These meta-data could be feature-based, object-based, syntactic and semantic abstraction of the multimedia data. They could be obtained manually, semi-automatically or fully automatically. Traditionally, low-level features such as color and texture are automatically generated, but may not be robust enough for applications required high-level semantic or pragmatic indexing information [4]. Therefore, it is fair to say that human intervened annotation is the only sensible option for many multimedia applications such as the research project described in this paper. We are interested to provide an interactive video indexing and retrieval environment for effective teaching and learning [7,11,15]. It is true that meta-data based on human annotation are subjective and draw criticism from computer vision or image/video

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processing specialists. However, this is the most direct and effective way for high-level indexing and, therefore, adopted by this research project.

This paper is organized as follows. In Section 2, a teaching and learning application for micro-teaching using video cases is introduced. It is an excellent example where video indexing and retrieval techniques and multimedia database concepts can be applied. The system architecture and design for the proposed web-based video system is outlined in Section 3. In Section 4, we demonstrate the prototype and initial results of the micro-teaching system. We conclude this paper in Section 5.

2 Micro-teaching Using Video Cases for Pre-service Teachers

In the practicum and methods classes, student teachers usually conduct trial or experimental lessons. Video tapes are often used to record their teaching practices to provide the bases for exploration and discussion of various teaching skills. Additional video tapes of in-service teachers may also be called upon to contrast the field experiences and made comparison to achieve better learning outcomes. By viewing video cases [14,17], student teachers are able to examine different aspects of classroom teaching and benefit from multiple perspectives when viewing is done collectively with fellow students or practising teachers.

Using analog video tapes for teaching analysis has a number of limitations. Beside the inconvenience of their linear accessing nature, the disadvantages include the following:

1. Physical video tapes are bulky in handling and viewing;
2. It is difficult to annotate important teaching characteristics onto the video tapes;
3. Searching similar characteristics from the repository of related video tapes are clumsy and not easy; and
4. Critical reflection by student teachers cannot be easily done visually and interactively.

If video tapes are digitally stored, video segments can be searched and viewed at ease in a classroom environment with computing facilities. Furthermore, video clips can be annotated with salient features for the purposes of indexing and retrieval. If the learning platform is available over the Internet, a greater flexibility could be realized. With the advance and maturity of streaming technologies, it is now possible to efficiently stream and synchronize multimedia data over the Internet [1,16,19]. It provides the technological niche to this project.

3 System Architecture and Design

The conceptual view of the micro-teaching system using video cases is illustrated in Figure 1. Two functional components are depicted to show the off-line processing of video clips and the on-line video streaming of multimedia data. The system generates and composes SMIL scripts dynamically from the server side according to the user's navigations. In addition to the video repository, a number of textual databases are needed to support the overall operations of the system. For examples, a database is needed to keep track of the indexing information of the video clips. A facility to foster students' discussion and reflection is desirable. This database could involve tracking students' learning activities.

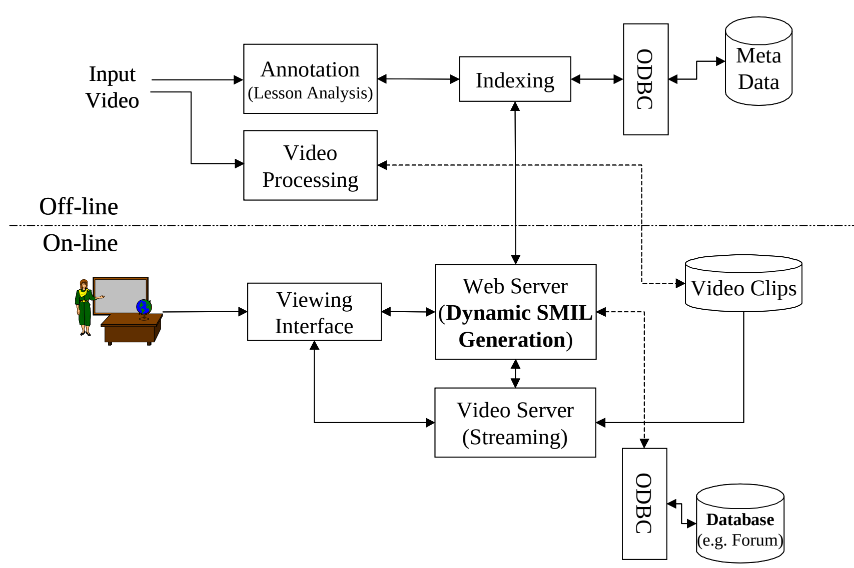

Fig. 1. The Conceptual Framework for Indexing and Retrieval of Video Cases

4 Initial Results

Figure 2 shows our prototype for the micro-teaching system. A student teacher conducts teaching in a practicum class. The four teaching sequences, namely *introduction*, *motivation*, *development* and *consolidation*, can be viewed serially or in any order by clicking the links. Key points are further explained and annotated. The corresponding SMIL scripts are dynamically generated as shown in Figure 3.

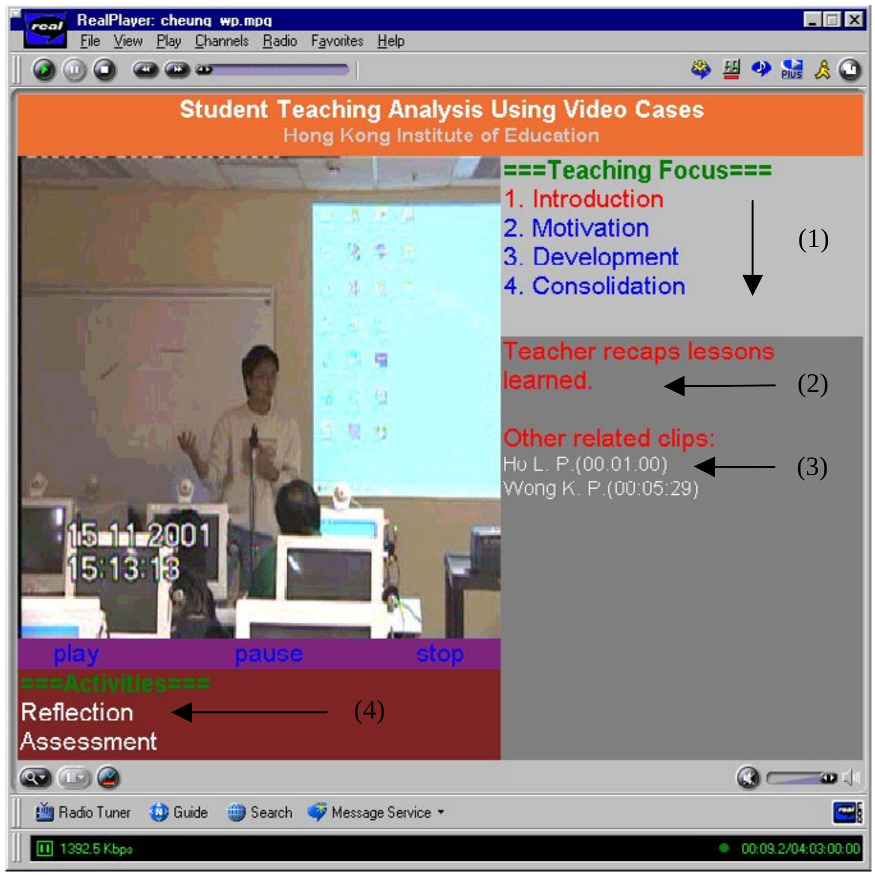

Fig. 2. A Sample Screen Shot for our Prototype is illustrated. (1) The four teaching sequences are evolved over time. (2) For each teaching sequence, annotation with key points may be provided. (3) If there are any video clips related to the topic, hyperlinks are given to provide instant access to the relevant part of the video clips. (4) Forum is provided for further discussion

```
<smil>
<head>
   <layout>
   <root-layout width="700" height="550" />
   <region  id="banner"  left="0"  top="0"  width="700"
height="50" z-index="1" />
   <region  id="video"  left="0"  top="50"  width="400"
height="400"   background-color="blue"   fit="fill"   z-
index="1" />
   <region    id="objective"    left="400"    top="50"
width="300" height="150" z-index="1" />
   <region    id="progress"    left="400"    top="200"
width="300" height="350" z-index="1" />
   <region  id="button"  left="0"  top="450"  width="400"
height="25" z-index="1" />
   <region     id="activity"     left="0"     top="475"
width="400" height="75" z-index="1" />
   </layout>
</head>
<body>
   <par>
      <text id="the_banner" src="banner.rt"
region="banner" />
      <video id="the_video" src="ChanTS.mpg"
region="video" clip-begin="00:01:00.0" clip-
end="00:11:59.0"/>
      <text id="the_button" src="button.rt"
region="button" />
      <text id="the_objective" src="obj1.rt"
region="objective" />
      <text id="the_progress" src="pro2.rt"
region="progress" />
      <text id="the_activity" src="act1.rt"
region="activity" />
   </par>
</body>
</smil>
```

Fig. 3. SMIL Scripts for Figure 2

In Figure 2, video links to other related clips are provided. This feature allows the learner to precisely anchor onto related video clips in the database more efficiently and effectively. Figure 4 shows the related video clip (starting at 00:01:00 of the video footage) with the student teacher, Ho LP, after clicking the corresponding link in Figure 2.

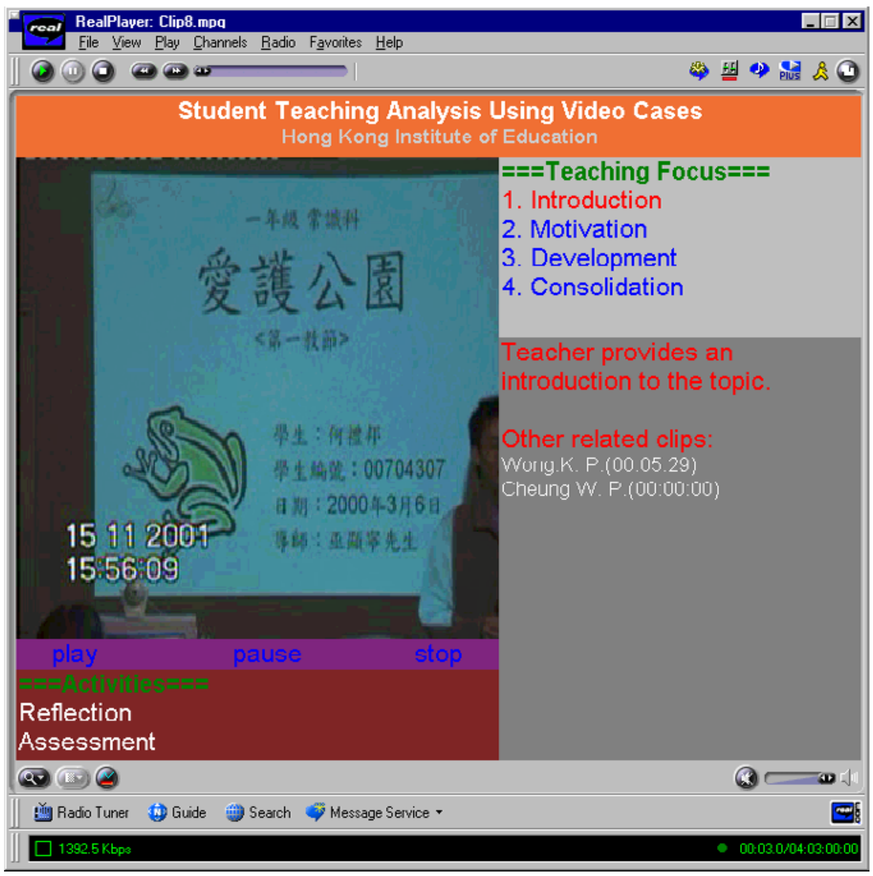

Fig. 4. A Sample Screen shot from Selecting the video clip of "Ho, LP" in Figure 2

Student teachers can also enter into the forum for critical reflection at any time by clicking the hyperlink as illustrated in Figure 5.

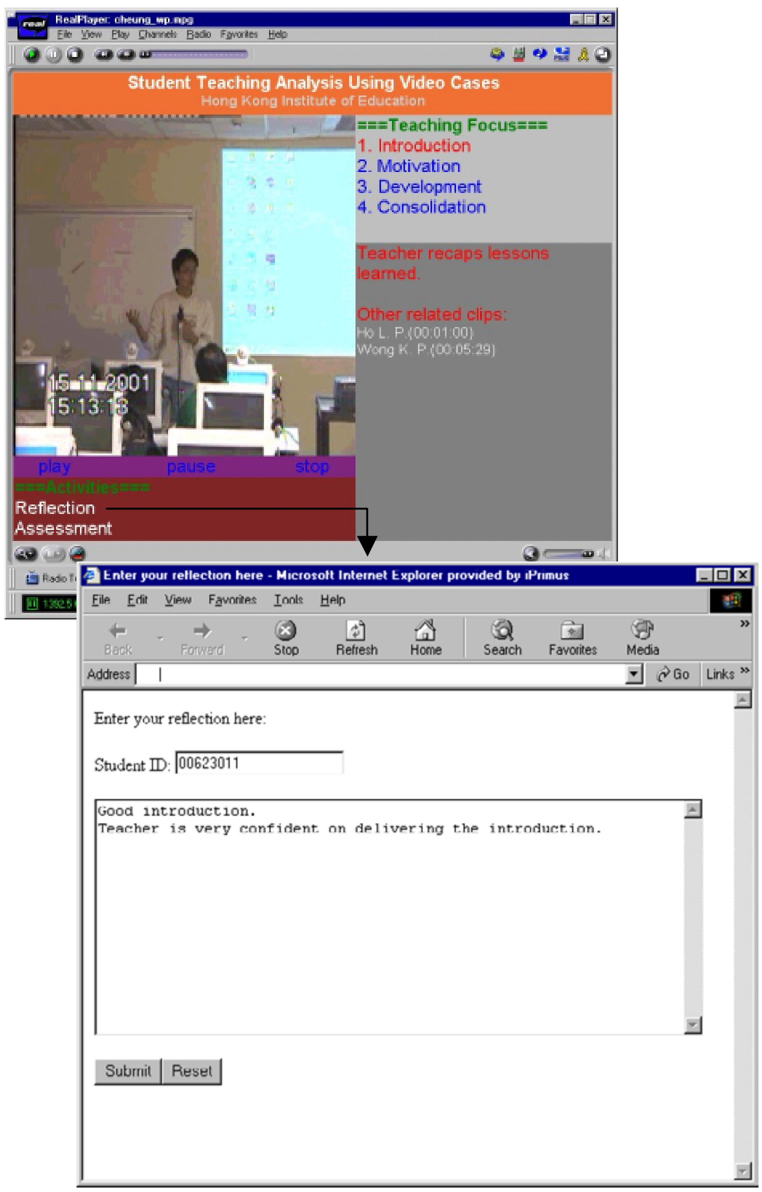

Fig. 5. A Sample Screen shot with Critical Reflection

The advantages of using streaming technology to build the video cases in our system are the following:

1. The video cases can be viewed online;
2. We can directly and effectively index into any portion of the video clips in our repository;
3. One can easily control the timeline and important points can be re-visited at ease;
4. We do not need to split and/or merge clips into a single clip for the teaching and learning purpose; and
5. Video stream can retrieve without long delay over the Internet.

Furthermore, by responding to the on-line reflective forum, the student teachers can thoughtfully examine effective teaching principles and practices of each video case. Viewing and critiquing the videos side by side on-line is the key learning strategy that provides opportunities to develop student teachers' reflective thinking skills and interactive reflections with their classmates. Unlike any class discussions, viewing videos in a detachment setting, student teachers can independently develop their own reflections about a specific teaching skill and then argue with their peers in a discussion forum.

5 Conclusive Remarks

The proposed video system using visual information retrieval and multimedia database concept is presented. It is a highly visual environment focused on teaching and learning for pre-service teachers over the Internet. The flexibility of this system is apparent in comparison to the conventional approach of analyzing video tapes for teaching practice. Furthermore, the system fosters an authentic and student-centered learning experience.

The idea presented in this paper can apply not only to the micro-teaching system, but also to a larger context of learning activities where situated learning is required. The proposed technique for generating SMIL scripts on-demand from the server side is a novel concept. It provides a powerful mechanism for diverse applications.

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Applying Multimedia Authoring Tool and XML Techniques to Standardized Knowledge Management for Web-Based Learning

Yueh-Min Huang[1], Chin-Chiang Chang[1], Pin-Ying Chiu[1], Shin-Chang Huang[1], and William Cheng-Chung Chu[2]

[1] Department of Engineering Science, National Cheng Kung University
Tainan, Taiwan, R. O.C.
raymond@mail.ncku.edu.tw
[2] Department of Computer Science and Information Engineering, Tunghai University
Taichung, Taiwan, R.O.C.
chu@csie.thu.edu.tw

Abstract. In this paper, we address the development of a standardized multimedia tool that can record desired audio and video as well as the instructor's actions imposed on the knowledge materials simultaneously. Furthermore, for effective management of courseware resources, this work also follows XML (eXtensible Markup Language) specifications, especially the tagging and semantics, to produce a sharable courseware under the scenario of SCORM (Sharable Courseware Object Reference Model) and ULF (Universal Learning Format) standards. Under the frameworks above, we can speed up the production and reorganization of courseware for web-based learning.

1 Introduction

It is an evitable trend for fast data and information exchange through the World Wide Web. The e-learning is one of the applications to make the academic organizations and enterprises switch the way of knowledge exchange. However, as many schools and enterprises have switched their conventional training mode to e-learning, two problems occur with the switch simultaneously. The first is that it's easy to get rich information through the Internet but hard to find an effective and systematic way to acquire useful knowledge. The other is that a vigorous multimedia tool is essential for those users who face learning new domain knowledge. A vigorous multimedia tool can facilitate users viewing knowledge object conveniently and producing information object to enrich the knowledge database at schools or enterprises easily.

This work aims to develop a multimedia tool which can compose a clip of course material together with synchronous A/V file as a knowledge object. And, the expertise will apply to integrate the scenario of national standards, which will make information objects shared and reused more efficiently. By XML-based scheme, the systematic materials and recorded A/V files will be organized systematically according to the user preference or the design of the system administrator. By the tool, the academic organizations and enterprises can speed up their development for web-based

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demic organizations and enterprises can speed up their development for web-based course and building a perfect e-Learning-on-Demand environment.

The rest of paper is organized as follows. In section 2, we briefly address some backgrounds that this work based on, mainly the multimedia streaming and international standards for e-learning. The architecture of the prototyping system is presented in Section3. In the section, we also show some implemented codes to make the paper more readable. Finally, the concluding remarks are made in Section 4. In the section, we also enlighten some future works.

2 Research Background and Approaches

The underlying framework of this study involves the issues of multimedia streaming and e-learning standards. We briefly describe them as follows.

2.1 Multimedia Streaming Architecture

Multimedia streaming is a technology that transmits audio and/or video media over computer networks in a real-time manner. It segments audio and/or video media then delivers each of segmentation separately, so that viewers can quickly enjoy a clip of the audio and/or video media file without waiting for the complete transmission.

The source of streaming transmission is either live source, like video recording, transmitting in network, audio source from a broadcasting station, or streaming media storing on server. No matter which manner applied, media files are never downloaded to the end computer. Once these data arrive at the computer of viewer, they are played out by streaming plug-in; these data will not be stored on hard disk of viewer's computer. To enhance effect of streaming, video or audio is compressed. The compression may reduce the quality of media with the payoff of the file size. It is a tradeoff between seamless streaming and the media quality.

There are several advantages for streaming broadcast and we briefly address them in the following.

1. *Playing immediately:* Viewers can watch streaming media instantaneously without waiting for a lengthy download of a complete file.
2. *Live program:* Streaming broadcast is the only way of live broadcast presently, like broadcasting news or programs in a network.
3. *No restriction on the size of media files:* Streaming broadcast does not limit the size of media files, so viewers can watch video or listen to audio media while the media data has being transmitted.
4. *Multicasting:* Allow many viewers enjoy the same streaming file at the same time.
5. *Broadcast Randomly:* As regarding pre-recorded programs, viewers can pause, seek, and play file by themselves.
6. *Media data will not be duplicated:* Streaming broadcast allow you to control the spread of your media and copyright. The real film's data will not be duplicated to the storage of viewer's computer.

2.2 National Standards

Currently, there are many e-learning tools to help users build up learning environment, but the plentiful and attractive courseware is the key role for the construction. The way to provide and establish a plentiful knowledge database is to do instructional innovation, and make teaching material shared and reused which can speed up the courseware development and exchange. Therefore, we study some international standards related to teaching materials. Based on them, we design and implement an authoring tool to do knowledge management and exchange, and develop a content standardized system platform. In the following, we briefly address those related issues.

ADL SCORM Specification. The Sharable Content Object Reference Model is developed by the White House Office of Science and Technology Policy (OSTP) and the Department of Defense's ADL (Advanced Distributed Learning) initiative [1]. This initiative was launched to "Provide access to the high-quality education and training, that can be tailored to individual learner needs and delivered cost effectively, whenever and wherever they are required."

SCORM emphasizes on Web-based Training (WBT). It follows some specifications as AICC [2], IMS [3], IEEE (LTSC) [4], and combines those via XML instead of creating a new specification again. SCORM states these main criteria: r*eusable, accessible, durable, interoperable, adaptable, and affordable*.

Web-based Learning conformed to SCORM specification consists of three main sections.

1. *Content Aggregation Mode:* an Extensible Markup Language (XML)-based specification to represent Course Structure Format (CSF), therefore we can exchange knowledge course object and make learning materials reusable.
2. *Run-time Environment:* defining a conforming Learning Management System (LMS) or authoring tool to read and interpret CSF files correctly.
3. *Meta-data:* describing about SCO, Asset and Content Packaging, so that we can search and combine those small-analyzed blocks to a new course.

Saba ULF Specification. Universal Learning Format is developed by Saba for handling data on web-based learning system [5]. It combines some other specifications and provides a complete set description to define learning format. The functions and characteristics of ULF formats are as follows,

1. *Catalog Format:* represents all information of learning resources used to locate and discover XML/RDF metadata.
2. *Learning Content Format:* defines table of content, references, course structure and objectives, and other assessments. Therefore, material provider can structure learning resources as reusable chunks, and then modify and recombine them to create new courses.
3. *Competency Format:* defines models of a skill, knowledge, and behavior that can be measured. Thus, organizations can manage and hold related information with competency model.
4. *Certification Format:* a learner could be qualified about particular fields. The format offers organization to keep learner records.

5. *Profile Format:* an XML-based representation for learner profile information. With that, we can track and analyze the learning history or progress of individual learners.

By standardized definition of teaching course resources and user profile data, we can achieve an objective that authors can rapidly migrate and transform existing learning objects.

3 System Architecture

3.1 Multimedia Courseware Authoring Tool

In order to increase learner interesting in learning, we can apply multimedia techniques to improve course presentation. It can help enterprises do web-based training or product demonstration effectively, and make academic organizations develop web-based courseware more vivid. We try to develop a multimedia courseware-authoring tool what apply streaming techniques to various course and build a knowledge content editor system. And they can upload courses to streaming server through client-server structure to save the time in preparing a course material.

We simulate a course scenario by synchronizing course video stream and HTML-based lecture presentation. The system includes two main components: course-authoring system and teaching demo system. The course authoring system records the temporal information of the CODE (Course On Demand) video data stream and HTML-based lecture note navigation process. The teaching demo system presents the synchronized CODE and HTML-based lecture note navigation. Students can use the teaching demo system for reviewing courses on demand. The following is the architecture of the multimedia courseware-authoring tool.

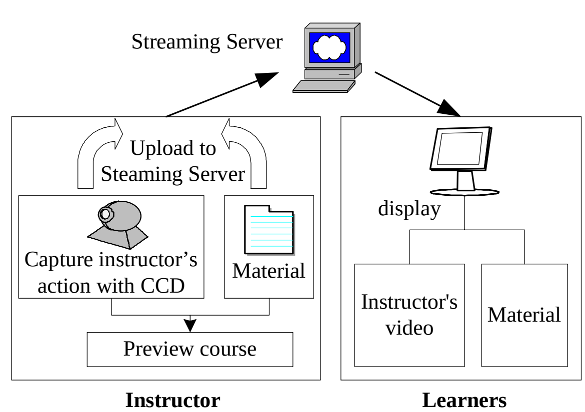

Fig. 1. Architecture of a Multimedia Courseware Authoring Tool

As for the implementation of course-authoring, main function is to impose some lines or marks on the html file of browser. We implement it by the method: Windows Hook + Windows Media Encoder, because that encoder can record the course authoring on browser completely. In the manner, students can browse teaching materials more flexibly and stably in any places.

Windows Hook is one of Windows API, Hook is defined in MSDN as follows:
A hook is a point in the system message-handling mechanism where an application can install a subroutine to monitor the message traffic in the system and process certain types of messages before they reach the target window procedure.[6]

Our authoring system is composed of Record Module, Streaming System Module, Painter Module, Video Capture Module and File Upload Module. We will describe some of main functions as follow:

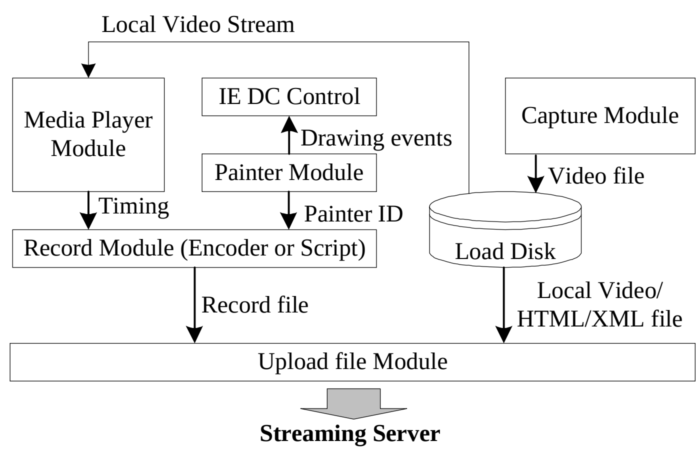

Fig. 2. Architecture of Teacher's Authoring Functions

Record Module. We employ WMEncoder Object of the Windows Media Encoder SDK Interface to record course authoring. The Windows Media Encoder SDK uses source plug-ins to capture streams, and transforms plug-ins to manipulate streams. The following table categorizes the availability of plug-ins by scheme type [6]:

Table 1. Available of Plug-ins by Scheme Type

Scheme Type	Plug-in Type	Description
Device	Source	Captures a stream from an attached device.
File	Source	Captures a stream from a file.
ScreenCap	Source	Captures a stream from the screen.
UserScript	Source	Sends a script stream to the encoder engine.
TCGroupTransformPlugin	Transform	Enables accelerated rendering of a stream without audio or video distortion.

In our authoring tool, we apply ScreenCap type to record course authoring and Device type to capture video streaming.

Painter Module. We provide the functions of freehand line, line, circle, rectangle, line bar, and etc in the module, and even more we facilitate a blackboard eraser function that can restore the improper authoring actions.

The principle of the drafting on browser's DC is straightforward. We use a Microsoft Web Browser control to establish a browser's view. Since making authoring action on browser's view is different from that on other's DC, we must deal with mouse's message particularly. With IE browser, all its DC has a function of repainting that will avoid changing window's content when our window is over-layered by other's window, or user minimizes, maximizes, changes, or moves in our window.

In addition to the functions mentioned above, the browser's DC can also repaint the content by changing of web page's content, like active GIF image, or dynamic content, and changing of font's color when our mouse pointer is over the characters of Hyperlink, which makes t our authoring graph clear. Two functions, VML and SVG, can be applied to make Vector Graphics.

Capture Module. We establish this module by using Microsoft Media Encoder SDK. We use CCD to capture the video stream of the given materials provided by teacher, and our course-authoring tools to complete a Synchronous Lecture.

The following figure is the layout of authoring tool presented to the instructor. The layout consists of three main areas:

Fig. 3. Layout of Authoring Tool (1) Preview the video image of CCD, (2) authoring tool bar, and (3) browser and the area of course authoring

As the framework of course-authoring system shown above, on the instructor site, instructors can edit materials by adding desired video, and record instructing actions imposed on the materials synchronously. Then, they can upload the edited video and modified materials to the streaming server and provide users to learn it.

On the other hand, for the learner site, with the streaming server providing VOD (Video-On-Demand) service, multimedia materials could be offered to raise quality of web-based learning. Learners can download the recorded teaching video and browse courseware with instructor's actions (such as the: drawing on the key sentences) at the same time. This manner is to simulate an on-live course by synchronizing course video stream and HTML-based lecture presentation, which will make knowledge course more vivid.

3.2 Standardized Courseware

The more standardized courseware of web-based learning and web-based training, the easier the knowledge object exchange can be made to benefit the construction of material resources database and improve e-learning system. To achieve standardized course purpose, there are two frameworks provided. One is adopting XML [7] data model to normalize course resources, and the other follows the RDF [7] (Resource Description Framework) regulars to structure the expression.

The reason for adapting XML is its structured characteristic. It is easy to generate data, read data, and ensure that the data structure is unambiguous via XML framework. For example, by using tags and attributes, we can keep the course resources reusable. By employing XML framework, we can integrate different course material sources as shown in Fig. 4.

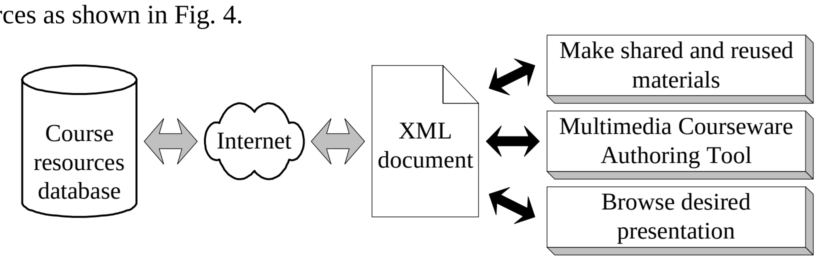

Fig. 4. A XML-based System

The XML-based course system has several significant advantages as follows:

1. Knowledge courses expressed by XML are highly readable. XML meaningful tags can be defined by us, and then course materials can organized module by module. Thus, we can exchange and reuse extendable materials easily.
2. Due to separating control of data content and data present way, course can be managed systematically according to the user preference or the design of the system administrator through XSL (eXtensible Stylesheet Language).
3. XML-based system can process separated resources of knowledge database anywhere, which is key feature the web-based learning system.
4. With support of UTF-8, the system can make several languages appeared in one page possible, which allow users can view multi-language courses.

Besides XML technique described above, the other technique is to take RDF (Resource Description Framework), which uses XML as an interchange syntax to implement. The main goal of RDF is to define a mechanism for describing resources suitable for any domain in a unique way.

Before building a new teaching course, instructors can search knowledge database with their desired searching conditions first. By those techniques, course resources can be easily reused and recombined. Then with multimedia courseware authoring tools, instructors can record the desired audio and video (A/V) as well as the instructor's actions imposed on the knowledge materials. The purpose is to avoid courseware of web-based learning system from being isolated and monotonous, and benefit standardized knowledge management for web-based learning and web-based training. The emphasized system model is shown in Fig. 5.

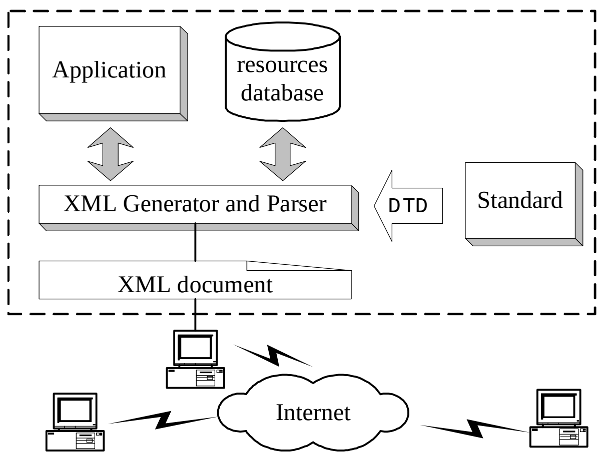

Fig. 5. Resource Shared and Reused Model

3.3 Web-Learning System

According to the above descriptions, we design a web-based learning system to provide multiple courses for users. And our proposed system consists of two components: a multimedia courseware authoring tool (what was explained on section 3.1), and an instructive service system.

In the learning system, we divide users into three groups. And based on each course, there are several functional parts. Besides, there are also some functions based on users. We address some main parts in the following.

Users

- *Administrators:* manage and maintain “System”, “Member”, “Department”, and “Course” information.
- *Teachers/Instructors:* manage and maintain functions of what course related, for instance, “Material”, “Assignment”, “Exercise/Exam”, “Discuss Board”, and “Vote Board”.
- *Students/Learners:* study desired course and use the functions of what course related.

Functions

- *Course-related*

1. *Material:* teachers can edit shared, reused knowledge resources and information to build a course.
2. *Exercise/Exam:* build a question and become a database for teachers easily make a new exercise/exam.
3. *Assignment:* assign and correct students' works.
4. *Discuss Board:* at each course, discussion between teacher and students each other.
5. *Vote Board:* teachers can hold a vote and learners can express their opinions for several fields. Then teachers can get statistic and analyze learner records.

- *User-related*

1. *Schedule:* a calendar represent dated matter, and will remind users daily things when they login.
2. *Notepad:* provide users to record some private events.

After the instructors using the courseware authoring tool to record the teaching activities into a multimedia knowledge object, they can build a complete, shared, and reused course on the system platform shown in the following.

Fig. 6. Maintain a Course

As shown in Fig. 6, it is the layout screen for the teacher to maintain a course. A new course is built in two separate parts: administrator set base information first (such as course name, teacher name, offered of which department, add and drop date, and etc.), and the teacher set advanced ones (such as difficult degree, in what language, course description, and notation). The functional model is shown as the Fig. 7.

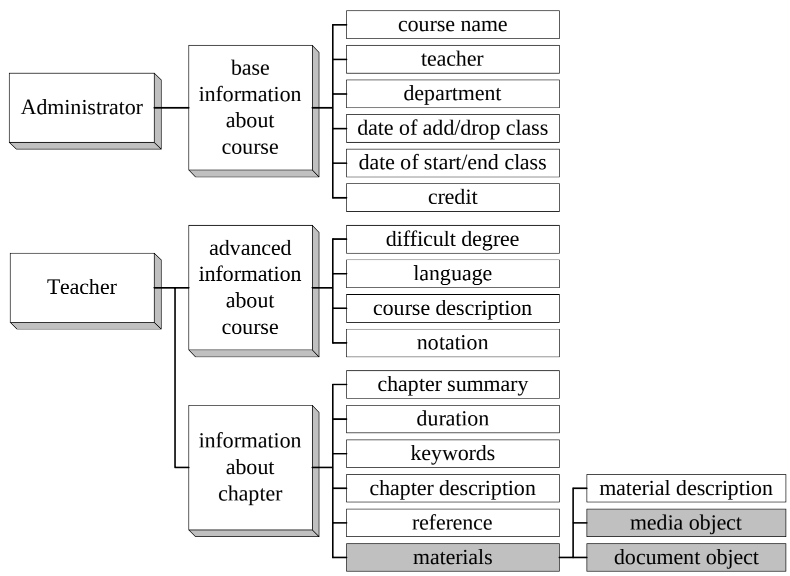

Fig. 7. Functional Model of Course Maintenance

Then teachers can build a chapter about this course with providing some information described as above figure. After teacher doing chapter information maintenance, those course and chapter information stored with standardized XML tags is looks like that:

```
<?xml version="1.0"?>
<course id="FC0001" name="Introduction to information and computer engineering" description="course description">
        <teacher>teacher</teacher>
        <department>FC</department>
        <choose datestart="20011001" dateend="20011230" />
        <class datestart="20020101" dateend="20020430" />
        <credit>3</credit>
        <prestudy />
        <difficulty>2</difficulty>
        <language>Traditional Chinese</language>
    <notation />
    <chapter id="CHP01" name="Internet Introduction" description="chapter description">
        <duration>60 minutes</duration>
        <status>open</status>
        <keywords>www,e-commerce</keywords>
        <reference />
        <section id="SECTION01" type="normal" description="section description">
                <link>related.doc</link>
        </section>
        <section id="SECTION02" type="media" description="section description">
                <link>intro.wmv</link>
        </section>
```

```
    </chapter>
  <chapter id="CHP02" name="Homepage Design" description="chapter description">
      <duration>90 minutes</duration>
      <status>close</status>
      <keywords>homepage</keywords>
      <reference />
      <section />
    </chapter>
</course>
```

And on the learner site, they can view and study the multimedia courseware through the web browser without setting any extra application. All the chapter related materials is arranged in a link list to provide learners learn desired ones on demand. Upon the learner's request, it possible to shows word document, picture, web page, text file and other materials with instructor actions on it.

In addition, standardized courseware has the advantage for a teacher to build a course material. By XML-based technique, they can search existing knowledge database first, and they can recommend the quotation immediately for their course if some desirable resource is found.

When finishing the creation of each courseware, we will divide total information into two parts: one will be stored in a table index file used for searching, and the other will be stored in a unique file for each course. In order to facilitate of the content searching effectively, the index file is required. The basic information it contains may look like that:

```
<?xml version= "1.0"?>
<toc>
   <material href="course001.xml">
         <author>teacher01</author>
         <topic>Introduction to information and computer engineering</topic>
         <domain>computer</domain>
   </material>
   <material href="course002.xml">
         <author>teacher02</author>
         <topic>Network Management</topic>
         <domain>computer</domain>
   </material>
</toc>
```

As the instance above, if an instructor searches material topic name with the index item "computer", system will search the information index file and find out the node: <topic>Introduction to information and computer engineering</topic>

Now we can use the found topic "computer" related node <material>, "href" attribute "course001.xml" to link and show the detail information. Consequently, searching results will present a serial list with functions of changing to courseware view mode, or adding it to own course.

By the manner, the most advantages of the courseware structure are systematic and hierarchical. We can search the index information instead of searching all courses one by one. With a multimedia authoring tool and courseware edit system with fine searching ability, it will create materials in a free and easy way for web-based learning system instructors.

4 Conclusions and Future Work

In the work, we have addressed a framework of providing standardized course resources and implemented a multimedia courseware-authoring tool based on it. The new style instructional development can enhance teaching performance, decrease courseware construction cost, and speed up the development of web-based learning or web-based training for academic organizations and enterprises.

With multimedia technique applied to courseware authoring tool, instructor can record desired audio and video (A/V) as well as the instructor's actions on the knowledge materials easily. For example, instructor can draw a line or a circle, paint an area, and use virtual bright stick to point out a sentence, and so on.. On the other hand, learners can enjoy *live-like* in studying courseware created by the multimedia courseware authoring tool. However, there are still many works to be done to make a complete e-learning environment, such as observing a learner learning status by data-mining technique. For instance, we can give different rated learning courses and directional steps according to different users graded in a test or the ability recorded about learning a new knowledge.

Besides applying multimedia authoring tool and standardized courseware to make campus or enterprises develop various and shared teaching courses, we can proceed with data mining to make e-learning more *intelligent.* For example, we can analyze users' profile data systemically, and look for proper sites to exchange or share information for facilitating users' study.

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Fifth Normal Form Made Easy with Novel Web-Based CAI HCI

Joseph Fong[1], Irene Kwan[2], Margaret Ng[1], and K.L. Lau[1]

[1] Department of Computer Science, City University of Hong Kong, Hong Kong,
csjfong@cityu.edu.hk
[2] Department of Information System, Lingnan University of Hong Kong

Abstract. As Internet computing becomes a norm in everyday life, web-based learning is acceptable to many people. However, it is a challenge to build a satisfactory Computer Aided Instruction (CAI) on Internet. Not only it is difficult to guide the users through the operations of a CAI, but also it is hard to measure the effectiveness of the CAI. This paper presents a methodology of using a set of Human Computer Interface (HCI) rules to develop a CAI for database normalization. It applies a constructivist theory for the users to automate his/her own database design on the CAI. The result is a user friendly CAI for the users to learn and apply database normalization skill effectively. A case study of normalizing an data entry form up to fifth normal form is used for illustration.

1 Introduction

Normalization is one of the elementary topics in database system design. The purpose of database design is to utilize an accepted methodology to match a good table structure. To get the desired results, the processing is known as normalization. The methods of normalizing the table schema in a relational database system can help make the program code easier to understand, easier to expand upon, and in some cases, actually speed up the application. *CAI in Database Design*, aims to facilitate online database design by asking students to use a manual that is provided to design their own database. Most people are already familiar with the traditional teaching method, for example teaching normalization, which has time and geographic location constraints. Classroom instruction is one way of providing instruction to students. The teacher may just need to pour out all that they know.

Constructivism is a teaching method that is different to the traditional teaching method. In the Constructivist theory the emphasis is placed on the learner or the student rather than the teacher or the instructor. It is the learner who interacts with objects and events and thereby gains an understanding of the features held by such objects or events. The learner, therefore, constructs his/her own conceptualizations and solutions to problems. Learner autonomy and initiative is accepted and encouraged [1]. *Database Design Case Study on Internet* and *CAI in Database Design* fall within the same basic assumption about learning.

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1.1 Related Work

Constructivism emphasizes real life experienced activities. It assumes that "Learning should occur in realistic setting"[2]. It is an emerging trend in education worldwide and is a movement of the focus from that of teaching to that of learning[3]. Effective university learning are those with high degree of interactivity and engagement and which provide a motivating environment based on well structured knowledge base [4] These activities and conditions incorporate such tasks as the solution of real world reported to increase student motivation, to develop their critical thinking and deepen their understanding of significant content[5]. "Classroom training is often characterized by the phrase "sage on the stage" because the instructor must somehow transfer his or her knowledge to the learners"[6].

1.2 CAI Architecture

Due to the fact that normalization has many data interactions between user and engine, a question-answer based approach is not suitable for all cases. The *CAI in Database Design* was designed to solve this problem. The approach is similar to concepts of ruled-based algorithm and forward chaining.

A function (program) is defined, the functions returns a value of success or failure (solved or not solved). If it returns with a success value, then the function also returns the sequence of selected steps that solved the problem. If the solution seems hopeless, the value is returned as failure. In other words, it's doing things over and over, a program for alphabetizing, compare until you get to and end - solve or fail[7].

A computer system that provides for solving problems in a given field or application area by drawing inferences from a knowledge base[8]. The term "knowledge-based system" is sometimes used synonymously with "expert system", though it is usually not restricted to expert knowledge. Some knowledge-based systems have self-learning capabilities.

Knowledge of normalization will be required to build a KBS. Based on the KBS, an inference engine will be formed by ruled-base system. The user interface will act as an agency to monitor the entire the interaction between the inference engine and the user. The inference engine and user interface forms the core of CAI.

The main function of the system is to provide step-by-step instruction and examples for users to recognize normalization algorithms and to provide guidance for users to generator normal form. Dynamic interaction, graphic user interface (GUI), stepwise guidance and multimedia are the system characteristics to attract the users in learning normalization of database designs. To physically store the database, two major areas are used. They are Normal Form Generator and Evaluation. User-defined attributes and dependencies are stored in the database of the Normal Form Generator, which contains project table, attribute table, function dependency table multi-valued dependency table, join dependency table, and normal form table. The Evaluation page provides the evaluation form for user to evaluate the usability of this. User can submit their question, comment and feedback electronically.

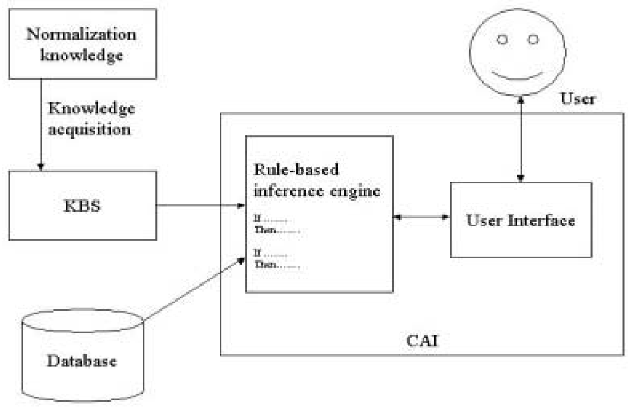


Fig. 1. Architecture of the CAI system

2 Data Base Design CAL Development Using WBL Approach

An important issue of CAI is a good user interface design. The most important part of the guidelines, however, wasn't the catalog of interface widgets and gizmos. It was the list of "design principles" which they believed lay at the heart of any good interface [9]. The following is a list of basic design principles for the user interface development guidelines.

- Consistency – Things that work one way in one part of the system should work the same way in other parts. This allows users to learn something once, then apply that knowledge again and again as they use the computer.
- Aesthetic integrity – A good deign is understand and lets the user concentrate on the information being presented.
- Perceived stability – Even if your program thinks it knows what's best for the user, keep in mind that they're the ones in control, and that no change in their environment should happen without their knowledge and permission.
- See-and-point, not remember-and-type – Instead of making users remember and type this sort of data, the computer should always give them a list of valid possibilities and let them choose from it.
- Direct manipulation – Good graphical interfaces allow their users to feel as if they are directly controlling a little world inside the computer. Instead of abstracting out their work to a set of command words, they can just grab the things they want to work on using the mouse and interact with them directly.
- What You See Is What You Get (WYSIWYG) – Documents on screen should match what they'll look like when they're printed.
- Feedback and dialog – Good programs never keep the user guessing. They react immediately when you perform an action, such as clicking a button.

- Forgiveness – Humans make mistakes. Good programs allow for this by letting them undo their last action, or even revert to a previous version of the document.
- User control – No matter what, the user must be the one in control at all times. Nothing destroys a user's peace of mind faster than having the computer appear to be taking over the action.

The following is a stepwise of applying a CAI for automating database normalization up to fifth normal form[10]:

Step 1. First Normal Form - A relation is in first normal form (1NF) if it does not contain repeating attributes (groups).

Candidate key is an attribute or set of attributes that uniquely identifies individual occurrences of an entity type. Primary key is an attribute that uniquely identifies any given entity or relationship. It is selected to be a candidate key. Composites key is a candidate key that consists of two or more attributes.

By the above example, "Faculty Code" and "Date of issue" are the (composites) keys of this form.

Due to this form will be issued periodically, "Faculty Code" is not sufficient to identify this form periodically. Thus "Date of issue" is necessary to be one of the keys.

Repeating group is an attribute or group of attributes within a table that contains multiple values for a single record.

Example -

City University of Hong Kong

Faculty Code: SE   Faculty Name: Science and Engineering   Date of issue: 2001 March 20

Student ID: 50123456   Student Name: CHAN, Tai Hang
Department Code: CS   Department Name: Computer Science
Programme Code: BSeCS   Programme Name: Bachor Science (Hons) in Computer Science

Course Code	Course Name	Lecturer	Textbook	Semester Taken
CS2113	Computer Organization	Dr. Y. K. KWOK	Computer system	1998 Sem A
CS3103	Operating System	Dr. T. M. CHAN	Operating system design	1998 Sem A
CS3334	Data Structures	Dr. H. C. HUNG	Computer system	1999 Sem B

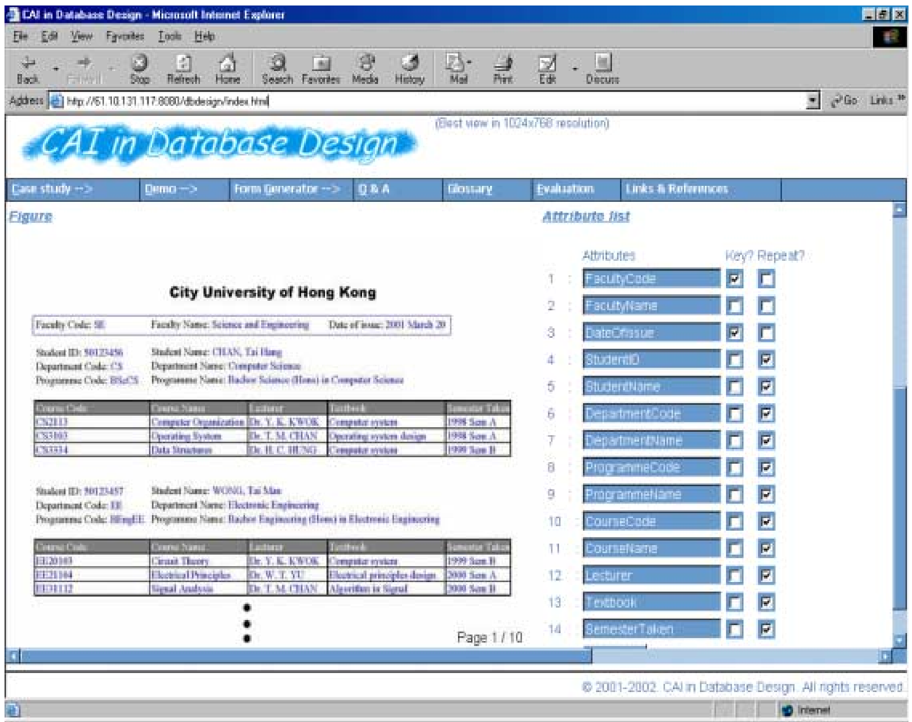
Student ID: 50123457   Student Name: WONG, Tai Man
Department Code: EE   Department Name: Electronic Engineering
Programme Code: BEngEE   Programme Name: Bachor Engineering (Hons) in Electronic Engineering

Course Code	Course Name	Lecturer	Textbook	Semester Taken
EE20103	Circuit Theory	Dr. Y. K. KWOK	Computer system	1999 Sem B
EE21104	Electrical Principles	Dr. W. T. YU	Electrical principles design	2000 Sem A
EE31112	Signal Analysis	Dr. T. M. CHAN	Algorithm in Signal	2000 Sem B

Page 1 / 10

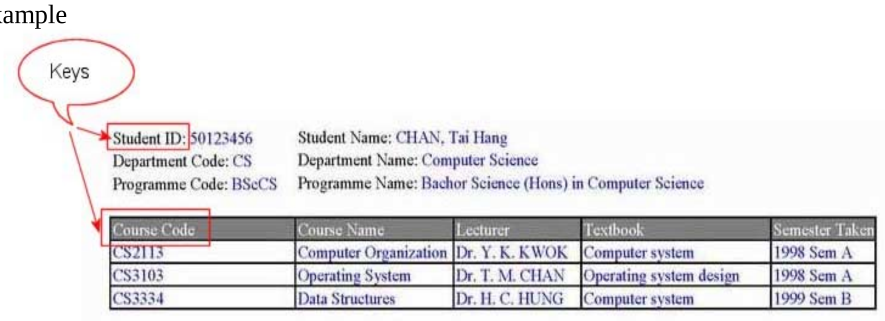
By the above example, attributes which marked inside rectangle are repeating attributes. You can see the Student ID, Student Name, Course Code, Lecturer, etc. are contains multiple values for this form.

CAI screen



Step 2. How to Define the "Key(s)" of Repeating Group?

Example

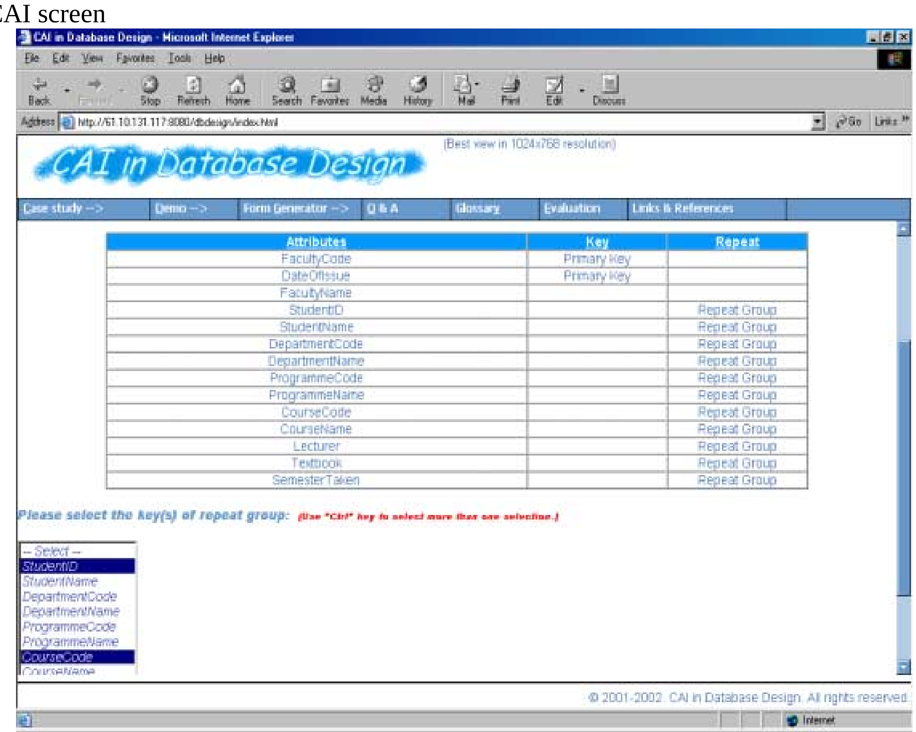


Student ID: 50123456 Student Name: CHAN, Tai Hang
Department Code: CS Department Name: Computer Science
Programme Code: BScCS Programme Name: Bachor Science (Hons) in Computer Science

Course Code	Course Name	Lecturer	Textbook	Semester Taken
CS2113	Computer Organization	Dr. Y. K. KWOK	Computer system	1998 Sem A
CS3103	Operating System	Dr. T. M. CHAN	Operating system design	1998 Sem A
CS3334	Data Structures	Dr. H. C. HUNG	Computer system	1999 Sem B

By the above example, "Student ID" and "Course Code" are the (composites) keys of repeating group. If we request to find out the lecturer of "CHAN, Tai Hang" who study the course of "Operation System, "Student ID" is not sufficient to find out the lecturer. Thus, "Course Code" is required and combines which "Student ID" to find out the lecturer "Dr. T. M. CHAN".

CAI screen

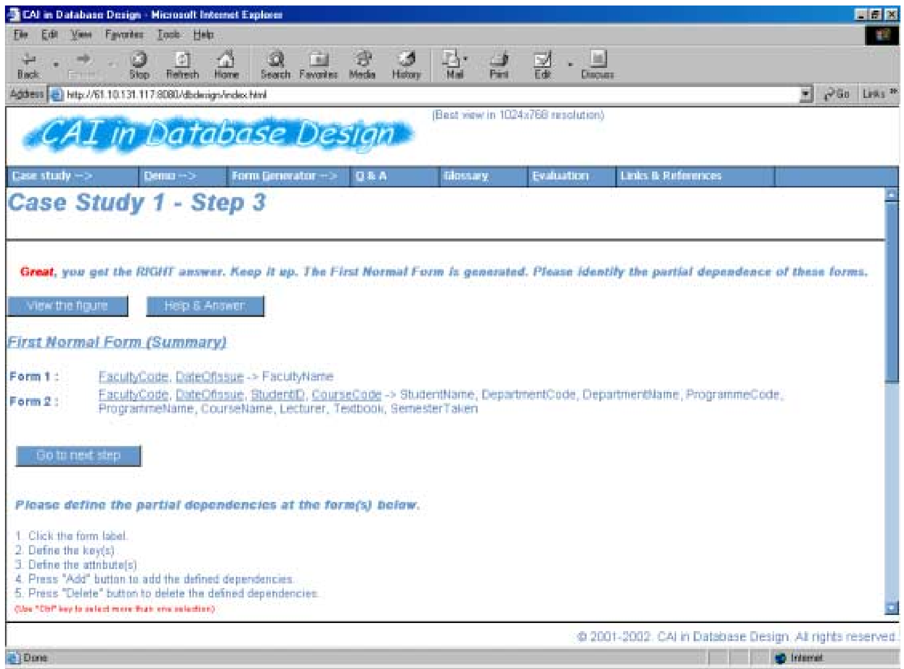


Step 3. Second Normal Form - A relation is in second normal form (2NF) if it is in first normal from and no non-key attribute is dependent on only a portion of the primary key.

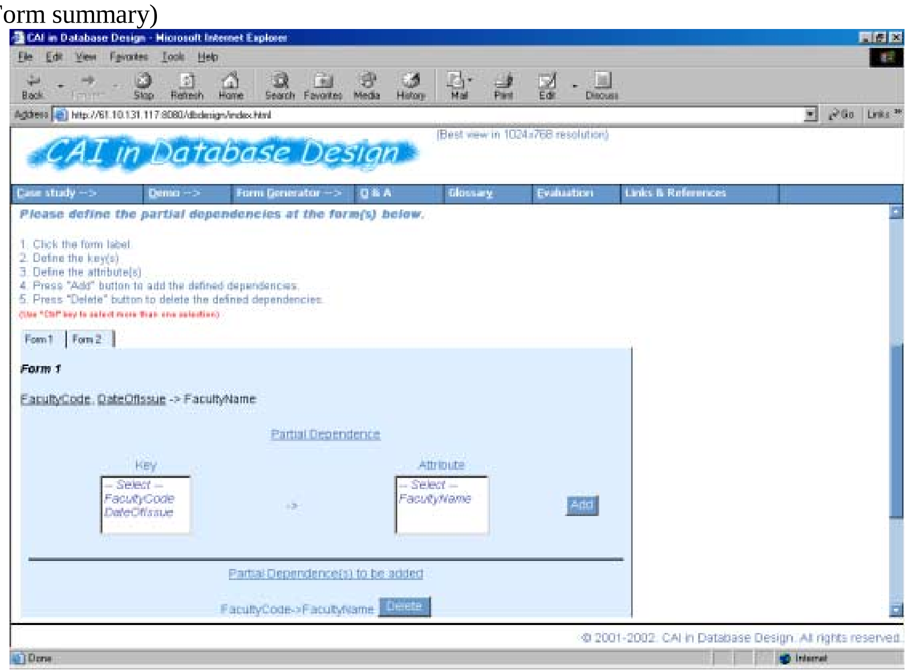
Functional dependency describes that attribute B is functionally dependent on the attribute A (denoted A -> B) if each value in attribute A determines one and only one value in attribute B. Dependencies based on only a part of the primary key are called partial dependencies.

By the above example, there is a partial dependences. Faculty Code, Date_of_issue → Faculty Name because of the existence of the functional dependency Faculty Code → Faculty Name.

CAI screen



(Form summary)

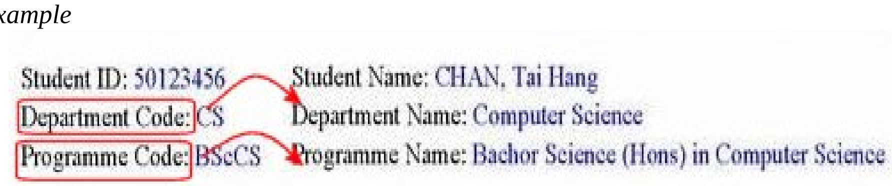


(Define the dependencies)

Step 4. Third Normal Form - A relation is in third normal form (3NF) if it is in second normal from and if the only determinants it contains are candidate key.

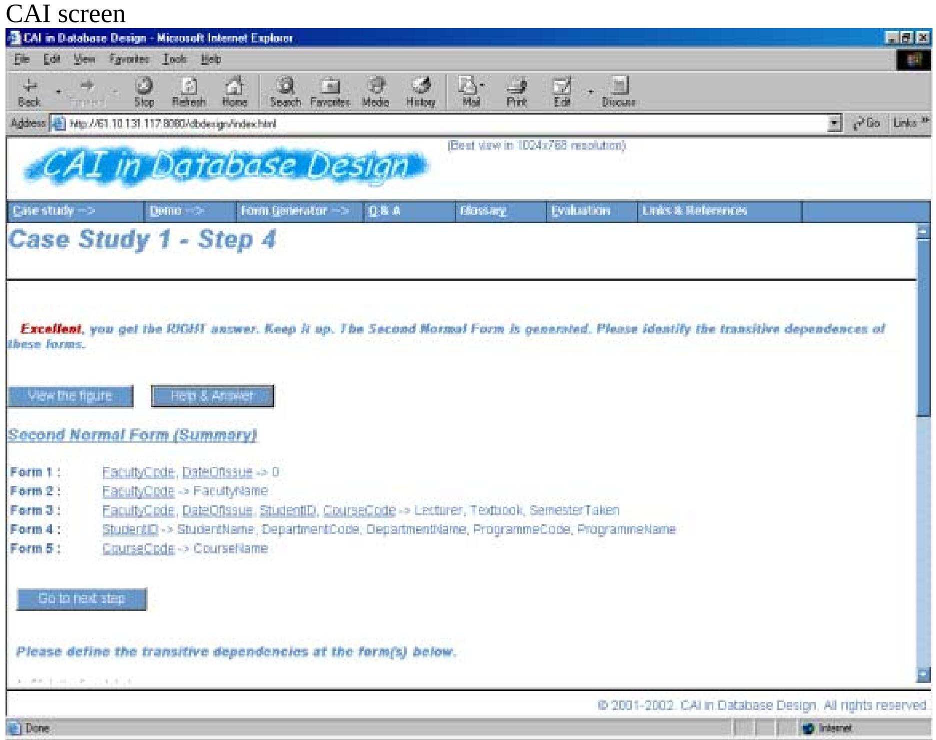
Functional dependent describes that attribute B is functionally dependent on the attribute A (denoted A -> B) if each value in attribute A determines one and only one value in attribute B. A non-key attribute is functionally dependent on one or more other non-key attributes.

Example



By the above example, there are two transitive dependences. "Department Code -> Department Name", "Programme Code -> Programme Name". "Department Code" and "Programme Code" are non key attributes.

CAI screen



Transitive Dependence(s) to be added

DepartmentCode->DepartmentName

ProgrammeCode->ProgrammeName

Step 5. Fourth Normal Form - A relation is in Boyce-Codd Normal Form and contains no multiple sets of multi-valued dependencies.

Multi-valued dependency (MVD) represents a dependency between attributes (A, B, and C) in a relation, such that for each value of A there is a set of values for B and a set of values for C. However, the set of values for B and C are independent of each other.

Example

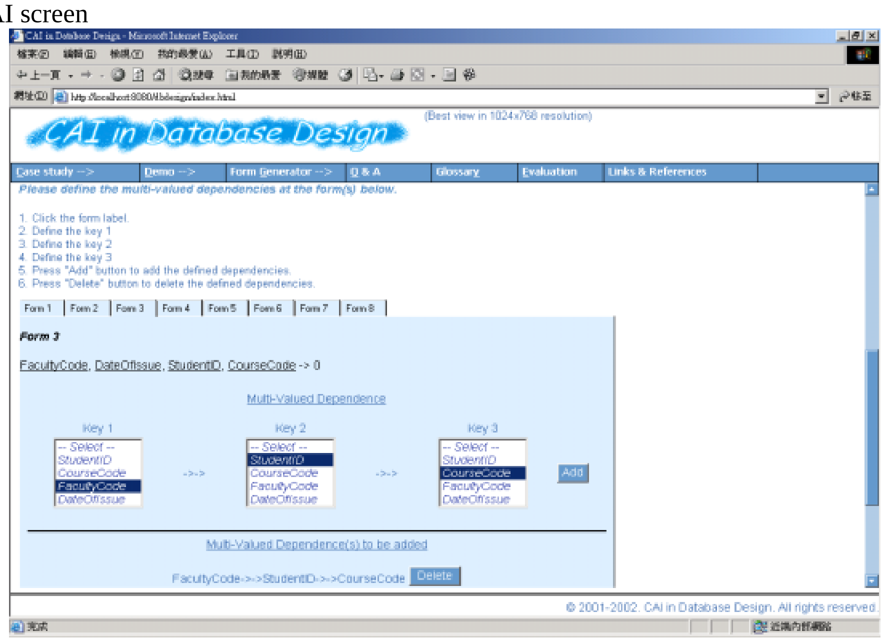
Faculty_Student_Course Relation

Faculty Code	Date of issue	Student ID	Course Code
SE	2001 March 30	50123455	CS2113
SE	2001 March 30	50123455	CS3103
SE	2001 March 30	50123455	CS3334
SE	2001 March 30	50123456	CS2113
SE	2001 March 30	50123456	CS3103
SE	2001 March 30	50123456	CS3334
SE	2001 March 30	50123457	EE20103
SE	2001 March 30	50123457	EE21104
SE	2001 March 30	50123457	EE31112
HSS	2001 March 30	50123458	SA2923
HSS	2001 March 30	50123458	SA3108
HSS	2001 March 30	50123458	SA3110

By the above example, we concentrate in Faculty Code, Student ID and Course Code. For each faculty, he has more than one student and more than one course. By this relation, we can define that faculty contains multi-valued dependency (MVD) to student () and contains MVD to course (). Thus there are two multi-valued dependency (MVD) for this form (relation).

MVD 1: Faculty Code ->-> Student ID
MVD 2: Faculty Code ->-> Course Code

CAI screen



(Define the multi-valued dependencies)

Step 6. Fifth Normal Form - A relation that contains no join dependency.

Lossless-join dependency is a property of decomposition, which ensures that no spurious rows are generated when relations are reunited through a natural join operation.

Example

Student_Course Relation

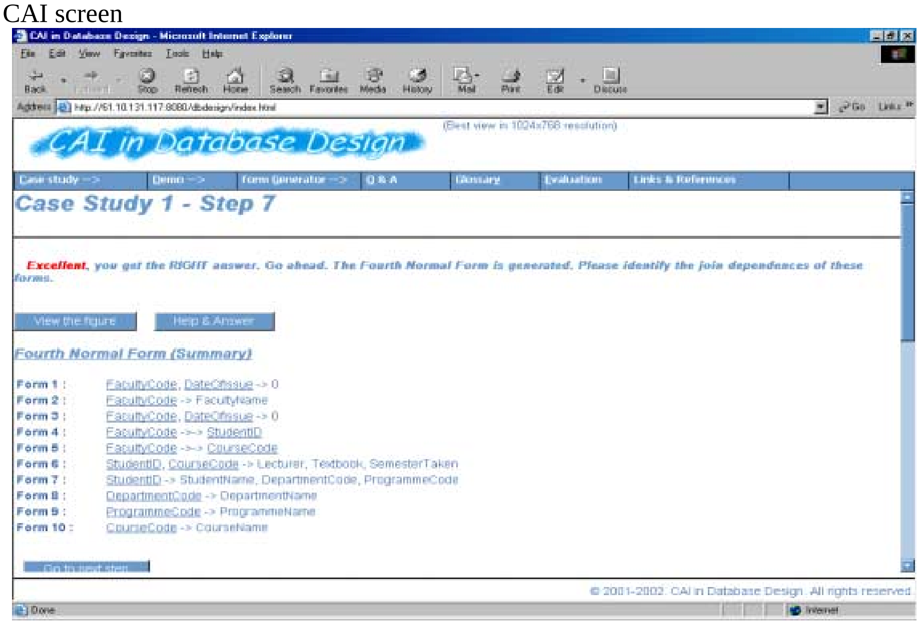
Row	Student ID	Course Code	Lecturer	Text Book	Semester
1	50123455	CS2113	Dr. KWOK	Computer system	1999 A
2	50123455	CS3103	Dr. CHAN	Operation system design	1999 A
3	50123455	CS3334	Dr. HUNG	Computer system	1999 A
4	50123456	CS2113	Dr. KWOK	Computer system	1999 A
5	50123456	CS3103	Dr.CHAN	Operation system design	1999 A
6	50123456	CS3334	Dr.HUNG	Computer system	1999 A
7	50123475	CS2113	Dr. FONG	Computer structure design	1999 A
8	50123475	CS3103	Dr. FONG	Operation system design	1999 A
9	50123475	CS3334	Dr.HUNG	Computer structure design	1999 A
10	50123476	CS2113	Dr.FONG	Computer structure design	1999 A
11	50123476	CS3103	Dr.FONG	Operation system design	1999 A
12	50123476	CS3334	Dr.LAM	Computer structure design	1999 A

By the above example, we are concentrate in Course Code, Lecturer and Textbook. For example, course "CS2113" is taught by lecturer "Dr. KWOK" with using textbook "Computer system" (Row 1) and lecturer "Dr.FONG" with using textbook "Computer structure design" (Row 7). If we specify and additional constraint that we are required to lookup lecturers which using specific textbook. This constraint specifics a join dependency on the Student_Course Relation. However, the structure of this relation does not support this constraint, as it does not restrict the addition of Row 1 and Row 2. As the Student_Course Relation contains a join dependency. To remove the join dependency, we decompose the Student_Course relation into three 5NF relations.

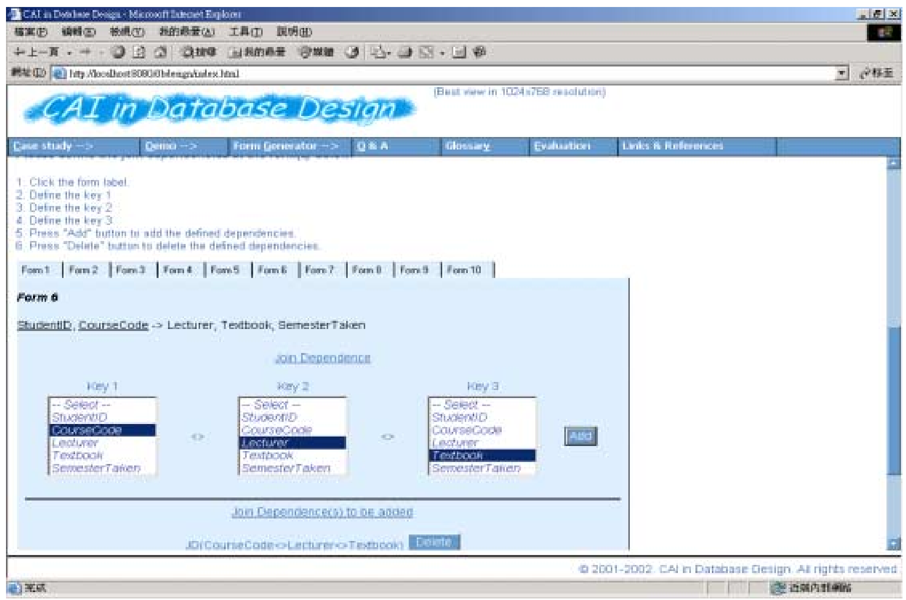
JD 1: Course Code NJN Lecturer
JD 2: Lecturer NJN Textbook
JD 3: Textbook NJN Course Code

Remark: NJN - Natural join symbol

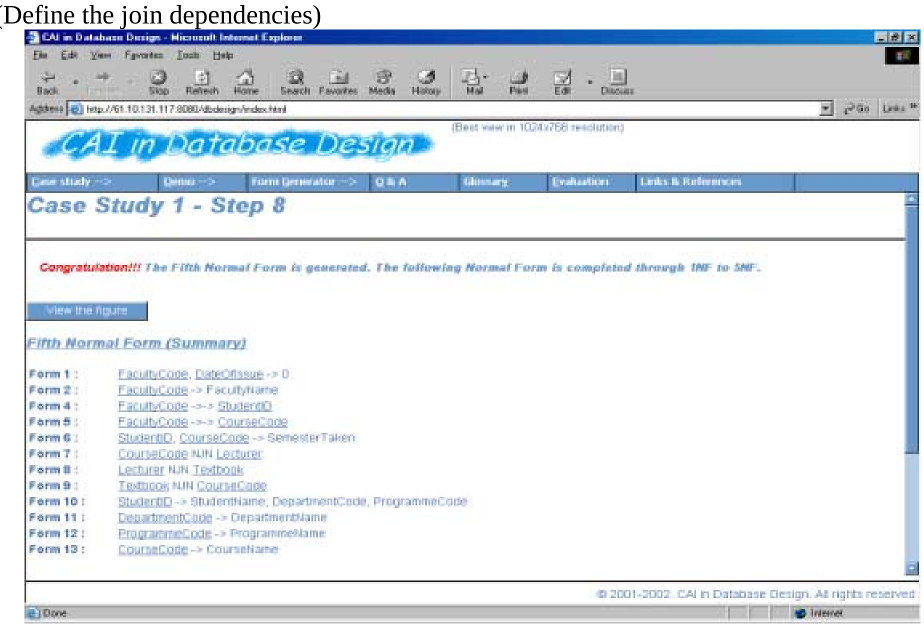
CAI screen



(Form summary – 4NF)



(Define the join dependencies)



(Completed)

3 Conclusion

Computer technology has made a substantial contribution in teaching and learning to Higher Education during the past few decades. Until recently, Internet technology promises to become even more pervasive in this arena, there is a paradigm shift from Computer based Teaching (CBT), and its related methods, such as CAI, to IBL, such as CAL using WBL approach and its corresponding variants. Traditional physical classrooms teaching and CBT often use different technologies, types of media, and forms of interaction. CBT provides basic interaction that contributes to the predefined interaction with the learners while WBL, with its network technologies, multi-media forms of interaction; online interactive tutorial could meet a broader range of student with much more dynamic and rigorous needs. Hence, real time IBL is focused even more on the student since more information is flows from the student (client server) to the instructor (web server), for example, chat room conducted between instructor and students online, submission on quiz and distribution of result score, regular announcement from instructor and feedback from students. As a result, learners and instructor could coordinate in a more constructive way and learners could construct their learning in term of pace and content portal; performance of each student during the learning process could also be monitored and these progress feedback data could also be collected for student's evaluation and web site content enhancement. Hence, WBL is then considered to be more active, dynamic and personalized. Again, the data collected revealed that the students welcome CAI using WBL approach, but traditional classroom teaching approach might overcome or compromise some of the disadvantages revealed under the disadvantage category.

We therefore concluded that WBL could be used to supplement classroom teaching but not replacing the traditional teaching method. WBL is particularly useful for long distance learning course where teacher and students are geographically wide apart and chances for human interface is much less. Finally, according to our survey result analyzed, we concluded that CAI using WBL approach is welcomed by students and with these demand ascertained, more sophisticated WBL web site, e-Learning Hub and e-Learning Resources Pack (e-Pack) are foresee and should be developed from the teaching side to further enhance the learning effectiveness on the learning side.

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Multimedia Knowledge Exploitation for E-Learning: Some Enabling Techniques

Yueting Zhuang and Xiang Liu

Dept. of Computer Science and Engineering
Zhejiang University, Hangzhou, 310027, P. R. C.
yzhuang@cs.zju.edu.cn, txlotus@sohu.com

Abstract. Knowledge is embedded in multimedia either explicitly or implicitly. In a practical application like e-learning, more than one type of media will take effect. In this paper, different ways of feature extraction from multimedia are explored. The media being analyzed and retrieved are not only images, but video, audio and even 3D terrains as well. New algorithms and experimental results are presented. As a result of the integration of multi-modal media, we lay down a foundation for exploiting media knowledge effectively, which can greatly enhance the performance of the high-level semantic retrieval desired by advanced applications such as e-learning.

1 Introduction

Currently, people are desirous to digitalize information (family photo albums, say), put it onto the Internet and make it accessible to anybody, from anywhere and at anytime [1]. As the information we receive from the Internet is increasing in terms of multimedia such as images/video/audio/graphics other than plain texts, processing knowledge in the multimedia form becomes necessary and imperative.

The goal for information sharing will be realized more effectively when thousands of digital libraries are put into use in the future. Through the digital libraries, everyone can retrieve shared knowledge easily via the Internet. This method of learning provides a convenient way for people to read, write and communicate what they intend to. Unlike the traditional learning, e-learning is a revolution brought about by the Information Era.

E-learning is a means of becoming literate involving new mechanisms for communications: computer networks, multimedia, content portals, search engines, electronic libraries, distance learning, and Web-enabled classrooms. However, e-learning cannot be feasible before the digitalized information in digital libraries is indexed by knowledge (concept) and can be consequently retrieved efficiently from voluminous digital libraries.

For example, in order to make e-learning effective, we must provide a way enabling people to find “similar images/video/audio according to the example submitted”, to detect “ a semantic event from video”, and etc. In the analysis of multimedia contents, automatically inferring from visual/acoustic features plays an important role [2].

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Essentially, successful manipulation and analysis of multimedia need exploring and assimilating the knowledge embedded in multimedia. Compared to traditional A.I., which uses rules and frames to represent symbolic knowledge, multimedia mainly contains visual/acoustic characteristics rather than symbolic texts. Thus, we need to represent the knowledge of multimedia according to its own characteristics. During humans' learning of concepts, a legible concept is gradually formed by similar cases. In order to extract the semantics (knowledge) implicitly contained in the multimedia, we propose to take the advantages of statistic learning to get the multimedia knowledge [3].

For a given multimedia concept, a model of this concept is first generated aided with collected samples. Then, the knowledge of this multimedia is kept and used for retrieval by e-learning users. Thus, in this paper, we explore knowledge exploitation for e-learning along this direction. We mainly focus on some enabling techniques facilitating knowledge-level (semantic) retrieval of multimedia information.

This paper is organized as follows: in Section 2, the main idea in our approach of multimedia analysis and retrieval is described. The review of our research work is given in Section 3. Our ongoing and current work (i.e. multimedia fusion analysis) is presented in Section 4. Finally, a conclusion is given in the last section.

2 Multimedia Analysis and Retrieval for E-Learning

With the prevalence of WWW, a tremendous amount of information is produced every second, most of which comes in the forms of multimedia. Thus, finding a both efficient and knowledge-based solution to manage so considerable multimedia data and retrieve useful information from WWW becomes an urgent but difficult task.

At the same time, many researchers are engaging themselves in building large digital libraries for e-learning. A digital library is not only a container for digital data, but also a complex and advanced online management system of multimedia information. Efficient information management and retrieval functions are necessary and important. Therefore, how to retrieve information from WWW or any other multimedia databases, such as images, video, audio, 3D graphics, etc. is our main focus.

Raw multimedia data is time-spatial dependent and is always a stream of lower-level data, such as image pixels, 3D triangles (meshes), audio samples and video frames. Since this kind of representation of multimedia by raw data contains too little knowledge for humans to differentiate between the concept-based information in information management, it makes the manipulation of multimedia useless.

However, the retrieval process is concept-based during e-learning, the same as the traditional humans' learning of concepts. What we perceive includes objects, actions, expressions, music, sound events, and etc. Raw media data need to be represented efficiently and semantically from original formats. In the previous works, visual features such as colors, textures, shapes are extracted to express images and other specific features can be adopted for the corresponding media. In our approaches, the knowledge of images/video/audio is represented by independent keyblocks, video objects, and fuzzy clustering centroids from compressed perceptual features respectively. Moreover, the interaction and fusion of multi-modal media are adopted during the extraction of knowledge. All these approaches will be detailed in the following parts.

Once the representation of multimedia is determined, similarity measures will be the criterion to determine how similar objects are to each other. Geometry similarity was widely used in the past, such as Cosine and Euler distance. These methods are classical and effective in most cases, such as to measure similar images. However, it is unimaginable to perform Cosine or Euler measures for two audio clips, which contain hundreds of audio frames. Therefore, statistic learning methods such as Hidden Markovia Model (HMM) and Support Vector Machine (SVM) are implemented to get the knowledge of certain multimedia contents.

HMM is very powerful in simulating time series similarity, especially in audio clips retrieval [4]. Basically, HMM is a generative model. During the training process, only positive samples are collected to train a classifier for the recognition. In this way, the knowledge of positive features is kept, but the knowledge of negative features is ignored at the same time. HMM is a weak classifier to exclude negative classes.

Compared to HMM, SVM is a discriminant model. It is powerful for the recognition of different classes. It simultaneously retains the knowledge of characteristics of two-classes, positive and negative [5]. Furthermore, if more than two SVMs are integrated, we can keep more knowledge among classes.

Anyway, HMM and SVM are both model-based statistic learning methods to analyze multimedia contents. Trained HMM or SVM reserves the common knowledge of recognized classes, whereas a geometry measure does not keep any characteristic of the multimedia contents. This is the reason why statistic learning is a leading tool used by most of researchers (including us) for multimedia analysis.

Statistic models keep the main knowledge of certain multimedia contents. In practice, however, a major challenge in a retrieval system comes from the dynamic interpretation of multimedia by different users at different time. Thus, adaptive real-time learning and/or classification are required. Neither a geometry nor statistic learning method can precisely match humans' perception during auto-analysis of multimedia semantic contents, for the computers can only detect low-level visual-acoustic features, e.g., color, textures, MFCC features while the users may demand high-level concepts. To bridge this large gap between high-level contents and low-level features, computers should learn users' retrieval perception iteratively on-line. Relevance feedback and on-line learning techniques have been shown to provide dramatic performance boost in retrieval systems [6]. The strategy is to ask the users to give some feedbacks on the results returned in the previous query rounds and try to refine the search strategy based on these feedbacks to come up with a better result-set. Relevance feedback can be done in two levels: the feature level and the object level (i.e. the users can directly change feature weights according to his own query and/or denote the preferred results).

From the view of retrievals, the statistic-learning model of HMM or SVM keeps the common knowledge of certain multimedia contents, while the relevance feedback provides personal preference knowledge for certain multimedia contents.

3 Review of Our Current Work on Enabling Techniques

The major challenge of multimedia analysis and retrieval for e-learning is how to represent multimedia in a form similar to humans' perception.

Focusing on exploring the knowledge from multimedia for content analysis and retrieval, our group have done a wide range of researches. The media that we analyze includes images, video, audio and 3D graphics: (1) In audio retrievals and relevance feedbacks, time-spatial constrained fuzzy clustering is used to generate centroids and audio clips are represented by centroids. Relevance feedback acts as an interface between machines and users, which enables the machines to learn what the users really desire. (2) Broadcast news is a special audio and need to be structured. We propose a HMM method to segment and recognize broadcast contents. (3) Inspired by keyword used in text retrieval, we introduce a novel image retrieval method based on keyblock. For each image, the knowledge contained in this image is represented by several keyblocks like keywords in text. (4) In video stream, objects and caption bear rich semantic meaning. Face is one of the common objects in video, and therefore the video news could be indexed by recognized the anchorperson's face and other faces. (5) We also automatically detect and extract video caption by SVM, which can reduce the region of OCR and thus improve the performance greatly. (6) While content-based image (video) and audio retrieval is progressing, there are few ways to perform similar graphics retrieval, especially similar 3D objects retrieval. We have proposed an algorithm to implement similar 3D object recognition and retrieval.

In the following part, different works will be described in detail.

3.1 Efficient Audio Retrieval and Relevance Feedback

We propose a new and efficient audio representation for retrieval by unsupervised fuzzy clustering. Audio features are extracted from MPEG compressed domain, and we generate fixed number of centroids for each audio clip by time-spatial constrained fuzzy clustering to represent the clip. Thirdly, similar audio clips are quickly matched by measuring their centroids' distance. Finally, relevance feedback is performed to adjust the result according to users' perception. Fig.1 shows a sketch diagram of an audio clip retrieval and feedback system.

Extracting features directly from a compressed domain has two benefits: improving efficiency by saving decoding time and utilizing the acoustic perceptual characteristics in the compressed domain, as the MPEG coding is based on a psychoacoustics model.

The original MPEG audio data is segmented into frames of 20ms long with an overlapping ratio of 50%. A root mean square of the sub-band vector is calculated for each frame as $M[i] = (\sum_{t=1}^{32} (S_t[i]^2)/32)^{1/2}, i = 1,2,..32$, where S_t is a 32-dimensional subband vector, and M contains all the information we need to compute features. Here, four features are extracted based on $M[i]$ from each audio frame:

1) Centroid: $C = \sum_{i=1}^{32} iM[i] / \sum_{i=1}^{32} M[i]$, which is the balancing point of a vector.

2) Rolloff: $R = \arg(\sum_{i=1}^{R} M[i] = 0.85 \sum_{i=1}^{32} M[i])$.

3) Spectral Flux: It is the Euler distance between normalized M vectors of two successive frames.

4) RMS: $RMS = \left(\sum_{i=1}^{32} (M[i]^2)/32\right)^{1/2}$.

Due to the large feature data extracted from each audio clip, we use Clustering method to reduce feature dimensions. As the boundary of audio frame is not clear, e.g. it is difficult to tell if a speech clip with music background belongs to speech or music, Fuzzy Clustering is used to generate centroids, and time-spatial constrained is employed to keep clustering uniformly and avoid centroids repetitive.

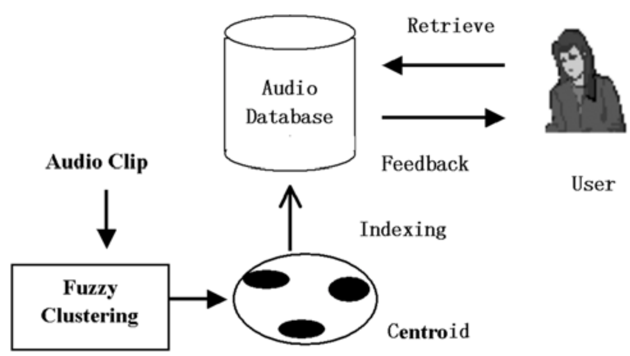

Fig. 1. A sketch diagram of an audio clip retrieval and feedback system

Suppose V and W are two audio clips, which are represented by clustering centroids. V = {v_i, i = 1,…,K} is the example given by the user and W = {wi, i= 1,…,K} is audio clip in the database. The Similarity Measure between two audio clips V and W is defined as

$$Dis(V,W) \equiv \frac{1}{|V|+|W|}\left[\sum_{v \in V} d(v, g(v,W)) + \sum_{w \in W} d(w, g(w,V))\right], \quad (1)$$

where $g(v_i, W) \equiv \arg\min_{w \in W} d(v_i, w)$ is the most similar centroid of v_i from *W*, and $g(w_j, V) \equiv \arg\min_{v \in V} d(w_j, v)$ is the most similar centroid of w_i from *V*.

According to this definition, the computation complexity is $O(K^2)$. Since the clustering only provides common knowledge of audio, different users have different preference for acoustic perception. In order to catch users' retrieval knowledge, we use two levels of audio relevance feedback to match users' perception:

Audio Feature: Users adjust the weights of the four low-level features defined above directly. Those features include *Centroid, Rolloff, SpectralFlux,* and *RMS.*

Audio Clip: Low-level acoustic features are not intuitional for users, who know little about the feature. Therefore, adjusting features' weights is not a good way of relevance feedback. More directly relevance feedback is to let users choose the preferred clips instead. Then relevant features can be deduced by users' satisfaction degree of the audio clips among the results.

3.2 Broadcast News Analysis

Raw broadcast news is just a stream of audio samples. It has no structure and thus has to be browsed in a subsequent order. In fact, broadcast news consists of some kinds of media scene, such as commercials, weather forecast, and etc. We can structure broadcast news by segmenting and classifying it into four regular class scenes. Those scenes are commercials, weather forecast, anchorperson's report, and detailed report.

Generally, audio can be recognized as speech, music and others. It is also the same for broadcast news. Retrieval by Humming is one kind of music analysis. For specific music, the pitch is extracted to index it. During the retrieval, the Hummed song or music is digitized first, and the pitch is analyzed and measured with audio clips in the database. The results are given according to the rank of similarity. Finding a robust pitch of music is a difficult task in music analysis. Pitch is a more perceptive characteristic of music and it influences the retrieval performance greatly.

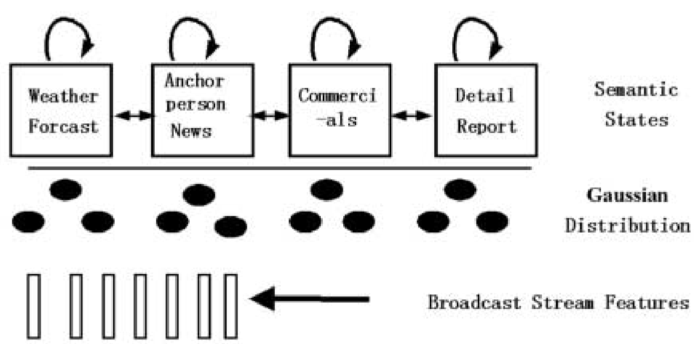

Fig. 2. HMM with semantic states

Recently, HMM has been widely used in speech analysis for speaker recognition and identification. It is also adopted in non-music analysis, such as environmental sound recognition and retrieval.

In our approach for broadcast news analysis, it is needless to distinguish speech and music. We just assign semantic to each hidden state in HMM. As shown in Fig.2, each circularity indicates a Gaussian distribution. Features of broadcast stream and semantic states are separated by these Gaussian distributions. This is the main reason why we call that states *Hidden*. According to the extracted features, each audio clip is set in one state. In this way, the broadcast stream can be classified and segmented by finding the best state sequence.

Without performing music analysis and speaker identification, we can classify every broadcast audio clip into one semantic state. The whole broadcast news can be structured in terms of *anchorperson's report*, *commercials*, *detailed report* and *weather forecast* media scenes (four semantic scenes altogether).

The automatic segmentation and structuring of broadcast offer users a fast way to browse and retrieve audio contents.

3.3 Image Retrieval: Independent Keyblock Method

It is well known that the knowledge of a text document can be represented by several keywords. Based on extracted keywords, text retrieval can be conveniently performed. Although content-based image retrieval stems from the text retrieval, many effective text retrieval methods cannot be employed in the image retrieval. The success of $tf \times idf$ index model in text retrieval inspires us to apply it in the field of content-based image retrieval.

Keywords are used in text retrieval. Do images have keyblocks as well? If they have, we can represent the knowledge in images by keyblocks. In our approach, a novel image retrieval method based on independent keyblocks is proposed.

If an image is considered as a common text document, we must extract keyblocks from it, just like extracting keywords from a text file. To extract keyblocks, we need to construct a learning machine. Three issues must be taken into consideration during the construction of such learning machine. First, the extracted keyblocks should be mutually independent as much as possible. If there are lots of correlations between input keyblocks, the performance of recognition will be deteriorated. Secondly, how large is the training sample base suitable for the construction of learning machine? Too many samples will lead to "over-fit" problem and too few samples cannot achieve good performance. Thirdly, the trained learning machine should have good self-generalization ability.

Recently, Independent Component Analysis(ICA) is used for Blind Source Separation (BSS). *ICA* is a linear transform method the same as Principal Component Analysis (*PCA*). *PCA* can only eliminate two order correlation of input data, whereas *ICA* can eliminate high order correlation of input data. For image and speech classification and recognition, the most important characteristics of extracted features are hidden in high order statistics. Using *ICA* methods makes features high order independent [7].

In our approach, image independent keyblock space is obtained by ICA at first. Fuzzy SVMs are then used to recognize independent keyblocks from each image and we can therefore measure image similarity through keyblocks the same as keywords retrieval in text information.

The detail is given as follows (as shown in Fig. 3): Segment each sample image into $N \times N$ sub-blocks, get independent keyblocks space through ICA algorithm, map all the sub-blocks into independent keyblock space, select suitable sub-blocks to train SVMs for each keyblocks, and identify the sub-blocks in an test image by the trained SVMs. Then the images can be considered as common text files, and a tf×idf index model is used to retrieve similar images.

After each sub-block of an image is identified by the trained SVMs, the image is represented by $image_i = [\varpi_{i1},...,\varpi_{ik},...,]$ $\varpi_{ik} = ikf * iif$, where ikf is the independent keyblock frequency, and iif is the inverse image frequency. Then, any similarity measure used in IR, such as Cosine distance can be applied in image retrieval.

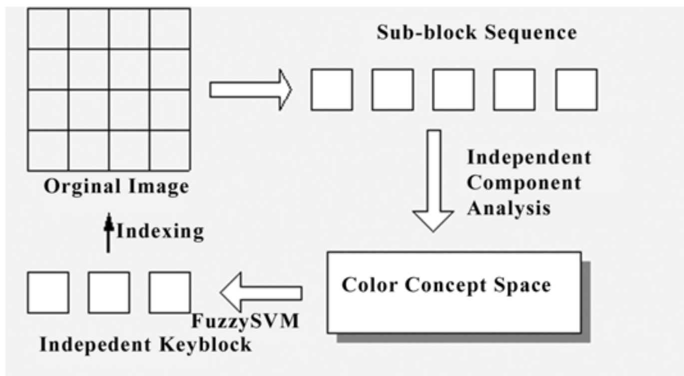

Fig. 3. Overview of generating independent keyblocks

In our experiment, in order to obtain image independent keyblock space and train SVM, training samples including bright images and dark images are selected at first. The purpose of our experiment is to retrieve images having similar color characteristics with example images from the image database. The experiment result shows that knowledge representation of images by keyblocks works well when training samples are appropriate.

3.4 Automatic Caption Location and Extraction in Digital Video Based on SVM

Video caption is a semantic knowledge and can be used to index video stream with high-level semantics. The prior work of caption location and extraction considers how to define good caption features, neglecting the self-generalization of classifier machine thereof. Because SVM follows the Structural Risk Minimization principle, it holds excellent generalization of classification with insufficient samples. At the same time, SVM keeps characteristic of both negative and positive classes, and hence it is suitable for two classes recognition (Video caption/ Non video caption). Our approach proposed to localize and extract video caption using SVM automatically.

Each sample video frame is segmented to sub-blocks, and each sub-block's size is $N \times N$. Then each sub-block is labeled as caption or non-caption. Labels and features extracted from these caption and non-caption sub-blocks are used to train the SVM. For each test frame, it is also segmented into sub-blocks first, and then each sub-block is judged as caption or non-caption by the trained SVM.

In one frame, the size of a text may be different. If the size is very large, one character may exceed the $N \times N$ sub-block. Pyramid Model is adopted to solve this problem, in which p-step pyramid means shrinking the original frame for p times. That is, 3-step pyramid shrinks the frame 3 times, each time by a factor of $\sqrt{2}$. Frames on each level are tested by the SVM, and results on all level are combined to obtain the final result.

It is needed in the end to remove some mistakenly determined block and to merge sub-blocks to get the caption region.

By automatic detection and extraction of video captions, OCR can be applied to index video's semantic meaning. The automatic detection and extraction of video caption improve the performance of OCR by avoiding examining all regions in the frame.

3.5 Video News Semantic Clustering and Indexing Based on Face Recognition

While people are enjoying the video, what they perceive are objects rather than low-level visual or acoustic features. And the same objects can be clustered together no matter how much the visual or acoustic features of background have changed. For instance, although the background is different, video frames having the same legible face can be clustered together.

The faces in video and images imply lots of semantics, thus we can use faces to index and analyze video content, especially video news. In order to realize such goal, human faces must be detected and recognized from video streams. If all legible faces are detected and clustered into the anchorperson and the interviewee, the clustered result can be used to index video. In this way, Video news can be indexed as *Anchorperson News*, *Interviewed News* and *other News.*

In our algorithm, skin model is used to detect possible face location firstly. Then video faces are detected and recognized from face object space rather than pixel space. Both Eigenface and Independent Face convert image pixel space into face object space. Eigenface is obtained by PCA and is two order independent, while Independent Face is obtained by ICA and is high order independent. By comparing the two, we find Independent Face is better than Eigenface, and we use Independent Face in later process.

Having more semantic meaning, a legible face is more important than an illegible one. To recognize legible faces, face organs need to be recognized. Trained SVMs are used coarse-grained to recognize faces and face organs respectively based on face independent component features from possible face location. In this way, we get legible and illegible faces. In the end, according to legible faces, video news is classified into anchorperson shots, interviewee shots and other shots through mixture Gaussian clustering. Experiment shows that the algorithm works well for video news structure.

Not only faces, but also other objects such as expressions can be used to represent the knowledge of video. Our approach above presented a generic method for object-oriented video analysis.

3.6 3D Terrain Recognition and Retrieval

While content-based images (video) and audio retrievals are attracting great research interests, less attention is paid on graphics retrievals, which in fact is also very important. We have proposed an algorithm to implement similar 3D object recognition and retrieval. In the algorithm, 3D features are first obtained after 3D object' meshes are reduced through a "Level of Detail". Since the extracted 3D features are of huge quantity, PCA and ICA are used to reduce features respectively, and the recognition of similar 3D objects are realized by SVM. The proposed algorithm works well when it is used to recognize and retrieve 3D terrain.

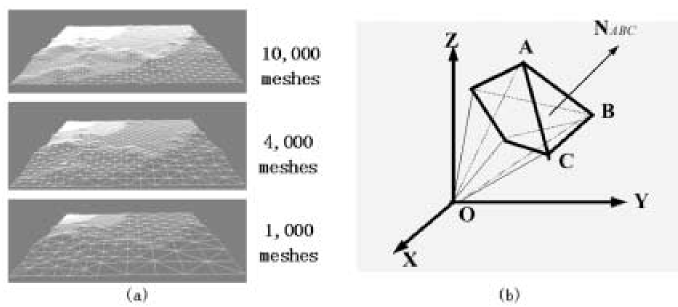

Fig. 4. (a) Level of detail keeps 3D object's original characteristic; (b) 3D features for each mesh

3D data is always voluminous. For example, in Stanford Digital Michelangelo Project, a model is represented by 2billion Meshes [8]. To extract 3D features from these 2billion meshes is both time consuming and unnecessary in most cases. Features extracted from certain level of detail are enough and meshes are reduced firstly. We call it "Level of Detail". In this way, 10,000 meshes of an object can be reduced to 4,000 meshes or even 1,000. Appropriately reduced object remains the same characteristic as the orginal one and is enough for retrieval as shown in Fig. 4(a). In each mesh (e.g., ABC in Fig. 4(b)), three kinds of features are extracted: Angle between Z vertex and ABC normal, Volume of tetrahedron OABC and Moments of ABC. These features can describe the main characters of 3D Terrain perfectly.

If there are 4,000 meshes after Level of Detail (LOD), we will get 4000*n features. Using PCA and ICA, 4000*n feature can be reduced to n*n. Thus original 3D features are mapped into 3D eigenspace for retrieval. Using SVM, 3D terrain example can be recognized as *Plain* or *Mountain* first. Then similarity measurement is applied in retrieval process.

4 Multimedia Fusion Analysis

The knowledge fusion of multimedia analysis can be done through four approaches: Feature Fusion, Probability Fusion, Media cross-indexing and Multimedia Synchronous Analysis.

When we put video (image) and audio features together for analysis, there is an assumption that audio features and video features can contain all the multimedia feature information. However, the synchronized information is lost. Furthermore, the sampling rate of video is 20-25 fps, while that of audio is 11.4kHz. It is hard to fuse these two features harmoniously. In practice, Feature fusion is seldom used since this approach cannot integrate multi-modality knowledge well.

In probability fusions, several media results are considered altogether to make a final decision. This is called the *confidence accumulation* in A. I. For instance, we can guess what the multimedia scene is about to some extent when we only hear its audio part. After we see the scene, and integrate with the previous guess, we can decide what this scene really is with more confidence. The probability is obtained from each media. By fusing each probability, we can get the final result.

Multimedia contents are expressed by multi-modal media knowledge especially audio and video. We realized a *real-time recognition of explosion scenes based on audio-visual hierarchical model* prototype for probability fusion. It can detect explosion scenes from Mpeg stream. First, a coarse SVM is used to discriminate explosion and explosion-like audio from others, several fine-grained SVMs are then used to extinguish explosion audio from explosion-like one. From these coarse-to-fine-grained SVMs, the audio explosion candidates are selected. The corresponding video is checked to get the final result, as most explosion scenes have obvious visual changes.

The above prototype distinguishes from others in the following fields: (1) It combines acoustic-visual bi-modal knowledge together for real-time content detection. The acoustic knowledge of explosion is represented by statistic model SVM, the visual knowledge of explosion is caught by histogram bins; (2) The fine-grained SVMs classify negative samples into sub-class, and different negative samples are paid with different concern. Since we group negative samples into sub-groups instead of mix all of them together, the detection is more precise according to experiments done before.

In multimedia analysis, other process is used to index the contents when one media cannot be effectively analyzed, e.g. using audio to index video and vice versa. This is called *media cross-indexing*. We use exciting commentary and audience's cheer audio to extract soccer highlights. In our approach *the Detection and Extraction of Soccer Highlights based on Compressed Audio Features*, audio compressed features are directly extracted first and segments commentary audio clips are detected. After detecting the exciting commentary audio clips, the final results are got through probability fusion of the audio clips and subsequent crowd cheering clips. The corresponding video clips are chosen as soccer highlights. Our approach is essentially a mixture of probability fusion and media cross-indexing.

However, the three methods described above for multimedia fusion usually process audio and video respectively and combine the processed result together. In order to perform better multimedia fusion, we propose to couple more than one HMM together and use more states to denote the interaction between video and audio, which is fundamental to such e-learning activities such as lecture video compilation and retrieval.

5 Conclusion

Multimedia itself contains knowledge either explicitly or implicitly. In a practical application like e-learning, more than one type of media take effects. In this paper, some of our latest researches performed on exploring multimedia knowledge exploitation are reported. The main challenge is how to represent multimedia knowledge out of low-level features. Once we are able to represent digitalized multimedia information *by concepts*, digital libraries will make learning outside of classes feasible, and e-learning will be more popular and convenient. Statistic learning models (HMM and SVM) prove to be powerful tools.

At the same time, when analyzing multimedia, we also consider the knowledge fusion of multi-modal media. In this paper, new algorithms and experimental results are presented. As a result of the integration of multi-modal media, we have laid down a foundation for exploiting media knowledge effectively, which can greatly enhance the performance of the high-level semantic retrieval desired by advanced applications such as e-learning. Currently, we are working towards building a single platform upon which all the above-mentioned functions can be integrated and supported for versatile e-learning activities.

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Web-Based Interactive 3D Visualization for Computer Graphics Education

Li Yang and Mustafa Sanver

Department of Computer Science, Western Michigan University
Kalamazoo, MI 49008, USA
{yang, msanver}@cs.wmich.edu

Abstract. Instead of web-based course development using an off-the-shelf web authoring tool, we believe that a better way to show principles and techniques in computer science is to have the related algorithms running "live" in background and to allow students interact with them within a web browser. We have chosen computer graphics as an example course because of its demand for visualization and its challenge for 3D rendering. This paper presents the visualization techniques and a set of web-based demos designed to demonstrate the computer graphics concepts and OpenGL functions. We have ported the popular Nate Robins' OpenGL demos on the web and have also developed our own demos. The main idea of the approach is to put a real world scene and a rendering result side by side together with a set of corresponding OpenGL functions to produce the rendering result from the real-world scene. Animation, user interaction, manipulation, and virtual navigation are supported in the sense that functions and the parameters of each function can be changed interactively and such changes will be reflected immediately in the rendering result. The demos are written by using Java and GL4Java, an OpenGL Java binding to ensure the deployment on the Web. The result is a set of interactive web-based tutorials with rich visualization driven by underlying algorithms to demonstrate the subject principles and techniques. Although the contents of the demos are specific to computer graphics, the presented methodology represents a generic approach which is discipline/course independent and can be applied to various other computer science courses.

1 Introduction

The rapid development of the web technology has brought new learning methods from web presentation to distance education. Easy usage, location and time independence, system independence, minimum software requirement, huge participation and the flexibility in allowing students to control their learning paces are among the major advantages of web-based learning. With the advances in web-based learning over the last decade, the traditional teaching format of having an instructor lecture to a class of students has been supplemented and, in some cases, replaced by the rapid development and the implementation of new distance learning methods. As technology changes rapidly, on the other hand, the importance of educating and training diverse populations of students becomes more critical than ever. In addition to all the short-

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comings of the traditional lecture-format learning in computer science, traditional lecture-format learning in computer graphics sometimes fall short of conveying the 3D geometric principles that need to be mastered by students. When one author taught the model-view transformations in computer graphics, for example, he felt that the thumbs and fingers of his both hands together are not enough to illustrate the model coordinate, the view coordinate, the relationships between these two, and the changes to be made to the corresponding transformation matrix. This is an example of huge demands of using visualization in undergraduate education. When the theories are exemplified through visualization with animation, interaction, and manipulation, we expect that web-based technological instructional methods will certainly promote and enhance students' conceptual understanding.

One of the key issues in turning technological instructional methods into student-centered ones is the introduction of interaction into the learning process [5]. There do exist nice interactive computer graphics demos [6, 8]. However, they are written in C and cannot run directly in a web browser. On the other hand, most of the off-the-shelf web authoring tools are designed for business presentation. While they are good for narrative general-purpose online lecture, they are not capable of illustrating important techniques interactively in computer science courses where principles, which the design of a web authoring tool is based on, need to be illustrated by the tool.

We have chosen CS527 - Computer Graphics at WMU as an example course that is expected to benefit from the supplementation of web-based tutorials. This course is chosen because of its demand for visualization and its challenge for 3D rendering. In [10], educators have given the major points of the philosophy of the first computer graphics course. Some of these points are: (1) Computer graphics is inherently 3D and courses should be also; (2) Computer graphics is intrinsically visual, and even the most technically-oriented graphics practitioner must be aware of the visual effects of algorithms. Unlike algorithms in other areas of computer science, algorithms in computer graphics must be considered not only for time and memory usage, but also for their visual effects; (3) Computer graphics education should be interactive. In sum, computer graphics is a particular subject that primarily depends on geometric perception and physical interaction, and every effort should be made by educators to enhance this ability.

Traditional lecture-format learning methods sometimes fall short of conveying the complex principles to meet the above philosophical considerations. There is a range of problems in this method of instruction. Some of these problems are:

- Lack of teaching aid to vividly explain the intricacies of the 3D geometric transformation principles.
- Inadequate visual learning environment to learning OpenGL functions.
- Inability to excite students to study concepts interactively.
- Difficulty in teaching students to make connection between theory, programming, application, and final visual effect.
- Inability to address students who do not actively participate or view the traditional teaching as a chore.
- Inability of individualized tutoring due to increasing student numbers.
- Inability to provide education anytime and anywhere.

Acknowledging the above problems, we think that there is an identifiable need to establish alternative sources of information and modes of learning for students in augment to classroom lecture. From two years ago, we have consistently encouraged students who took CS527 to create web-based interactive tutorials as course projects supported by a WMU Teaching and Learning with Technology grant. For our students, this gives them an interesting challenge in an exciting area, requiring creativity and imagination as well as knowledge and systematic thinking. To ensure the quality and consistency of results, the instructor gives the basic idea and the layout design. However, students are strongly encouraged to add additional features that they think are useful to learning. The result is a set of web-based interactive 3D demos to show concepts and techniques in computer graphics. These interactive demos are designed for undergraduates who take the first course in computer graphics.

The initial purpose of writing these demos is to bring OpenGL tutorials to the web so that students can access them within a web browser anytime and anywhere. There are a lot of OpenGL demos, for example, the popular Nate Robins' OpenGL demos [8] are written in C. Our demos are different from them in a few ways: First: our demos run directly in a web browser, which is available on almost every computer. No special software is needed. We think this is very important for novice undergraduate students. Second, we believe that the best way for students to learn computer graphics and OpenGL is to try each OpenGL function interactively. We have designed our demos "live" such that they keep the style of Nate Robins' demos. Functions and parameters can be interactively modified and the visual effects will reflect the changes immediately. Third, we have designed our demos with pedagogical considerations in mind. For example, we emphasis the pedagogical differences between model transformation and view transformation although, in OpenGL, they have no difference and are kept in a single model-view transformation matrix. These demos are designed as supplementary material to in-class lecture. Students are instructed on which demo to try after each class to reinforce what they learn in class.

This paper discusses the design methodology and the visualization techniques used in our demos. These demos cover major parts in computer graphics, including transformation, projection, light effect, material effect, fog effect, and texture mapping. Each demo demonstrates a set of related OpenGL functions. Combo demos are also developed to address our pedagogical concerns. These demos innovate with new and novel techniques for 1) demonstrating concepts and algorithms by actually running them backend; and 2) presenting and visualizing principles and techniques in a way that is impossible by any web authoring tool.

2 The Design Methodology

Teacher-centered classroom denies the student the opportunity to be more self-directed, autonomous, and creative. A major advantage of interactive computer-aided learning is that it allows a student to proceed at his/her own pace, motivated by a curiosity about "what happens" interactivity and "the need to know" the principles. Unlike classroom learning, on the other hand, the teaching computer has no way other than through the content to keep a remote learner active rather than dozing over the keyboard or running away. Therefore, an essential attribute of computer-aided learning is to hold students' attention, and furthermore, autonomy and creativity [2].

One effective way to attract students' attention is to use rich and creative visualization. In computer graphics, visualization provides much more than attracting students. It makes easier the explanation of 3D geometric concepts and helps students to understand the concepts that are difficult to understand in other ways. To get students involved into the learning process, it is important that the visualization is interactive. The important advantages of interactive visualization over the other computer based teaching tools are that it enables the user to interact in real time with the subjects to conceptualize relations that are not apparent from a less dynamic representation. Interactive web-based teaching with rich visualization of contents has great value in computer science education because of their illustrative and interactive nature, seamless integration of the subject technology into education, and instant wide availability.

One design objective of the 3D interactive demos presented in this paper is to create an innovative visualization methodology for computer graphics education in a web-based interactive learning environment. Fig. 1 shows an explanatory graphics pipeline used by most graphics architectures [7]. This diagram serves as an overall framework to organize and integrate our live demos.

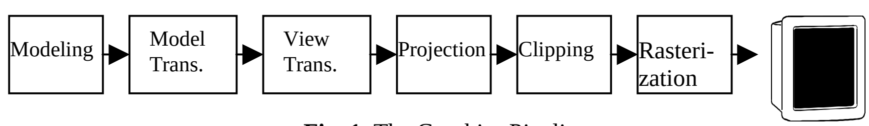

Fig. 1. The Graphics Pipeline

We have ported to Java the Nate Robins' OpenGL demo[8], which was originally written in C. The result is a set of OpenGL demos that can run instantly in a web browser. Each demo is designed to show a concept or technique together with a list of support OpenGL functions. Following the style of the original Nate Robins' demo, we have designed each demo so that its user interface has 3 major windows: a 3D real world scene of geometric objects together with lights and a camera indicating what actually happens in the 3D real world, a 2D rendered image produced on the backplane of the camera, and a list of OpenGL functions. The 3D world scene is modeled and processed by the OpenGL functions to produce the 2D rendered image. When a student moves an object, or changes the values of the arguments of the OpenGL functions, the final image will reflect the change. Fig. 2 gives a screen snapshot of the transformation demo. Other demos have the similar look-and-feel. The screen provides three different views: a world view, a screen view, and a command view. The world view presents objects in the way that they are in 3D real world. This view gives also a picture of the camera/eye position (denoted by x,y,z axes) in the scene and the viewing frustum. Screen view gives the 2D image finally rendered. Command view gives a list of relevant OpenGL functions where a user can change values of arguments of functions and see how they affect the visual effects on screen. When mouse is over an argument's value, an explanation message will appear at the bottom of the command view. To change an argument's value, you just need to press the left mouse button and drag the mouse. The user can choose from a list of different objects to render in order to enhance the understanding. More importantly, the order of these OpenGL functions is also changeable. As we know, changing the order of OpenGL functions may produce a totally different image. These changes are reflected immediately in both world-space view and screen-space view.

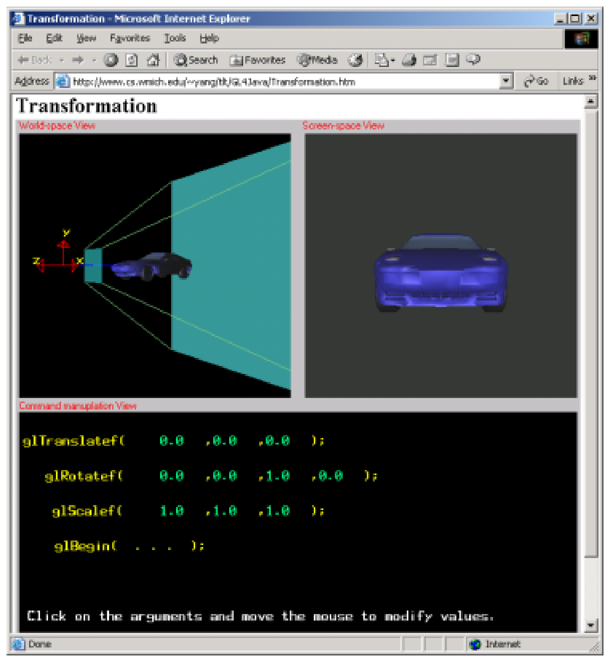

Fig. 2. A screen snapshot of the transformation demo in a web browser

3 Visualization Techniques

One of our major ideas in designing the demos is to have the related algorithms running "live" in background and allow students interact with them within a web browser. Delivering 3D live demos in a web browser is a technical challenge since the current web browsers have no built-in support for 3D rendering. A widely used approach of developing online web-based tutorial is by using Java applets. However, Java itself doesn't support OpenGL functions intrinsically. What is required is a binding of Java to OpenGL through a Java native interface. There are on-going developments for this non-standard interface. Jausoft's GL4Java [3], and JSparrow [4] are two of these APIs. In our demos, we have chosen GL4Java due to its easy installation and wide availability. GL4Java also supports the "glut" library. It is available on Windows and most Unix systems.

4 The Demos

Educators have pointed out [9,10] that geometry is a major part of an introductory computer graphics course and, besides geometry, computer graphics is about light and surfaces, and algorithms to simulate their interplay. *Curricula 91* [1] suggests that introductory graphics courses need to include material about coordinate systems and transformations, material about light and surface properties and material about the distinction between the ways various algorithms present light and surfaces visually. Based on these observations, we have chosen to develop the following list of demos:

- *3D Transformation.* Translation, scale, and rotation are functions of model transformation in order to position and orient the models. Understanding the order of transformations is one of the most important parts in computer graphics. This demo includes geometric transformations, such as translation, rotation, scaling, as well as concatenation of these transformations. The user is able to change the values of the arguments of glTranslate(), glScale(), and glRotate(). The order of these functions can also be changed. Fig. 2 shows a screen snapshot of this demo.
- *Projection.* Projection transformation determines how objects are projected onto the screen. Specifying projection transformation likes choosing a lens for a camera. Students found that projection is a difficult topic because its transformation matrix is not affine. This demo shows orthogonal, oblique and perspective projections. Fig. 3 is a screen snapshot of the demo. A default light is used in the scene in order to make the object viewable. The direction of the light is from camera's center to its *z* direction. The light position changes when the camera moves. Each view has its own popup menu. Right mouse button will trigger these menus. In the demo, the user is allowed to choose from three different projection functions, glFrustum(), gluPerspective() and glOrtho(), and to change the values of their arguments. The pop-up menu in the command view is also shown in the figure.
- *Illumination and Shading.* Interaction with the light sources is the best way to show illumination and shading. In the light source demo, the location of light can be changed and the visual effects of the changing light position can be immediately seen. Material properties affect the deflection and absorption of light. In the light-material interaction demo, we have made many different materials to be applied to an object to reveal the material effects. Light property and Material property of an object can be changed.
- *Texture mapping.* Texture mapping is difficult for students because it has to deal with the mapping among different coordinates and issues like resampling and aliasing. This demo shows what happens to the final image when a 2D texture is applied and its various parameters are changed. Fig. 4 gives an example screen snapshot of the texture mapping demo.

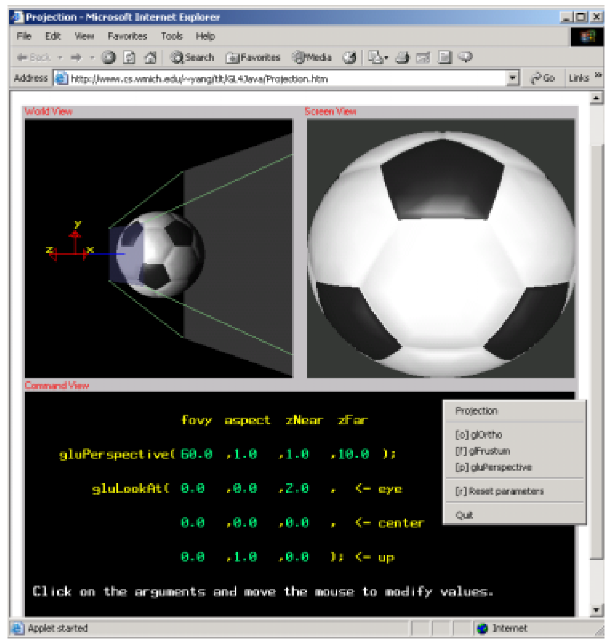

Fig. 3. A screen snapshot of the projection demo

3D geometric transformation is one of the most confusing topics for first-time students. In teaching the computer graphics course, we have found that students are often confused when they have to consider both the world coordinate and the view coordinate. Nate Robins' demos (and also the OpenGL API) did not make a clear distinction of the two. That is probably because these two transformations behave in the same way and are mathematically described by a single model-view matrix. From the pedagogical point of view, however, we think it is easier to understand by separating these two transformations. We have designed and developed a combo demo. Fig. 5 gives a screen snapshot of the demo. In the world view, the world coordinate is marked by *x*-*y*-*z*, and the view coordinate is marked by *u*-*v*-*n*. We have made the demo so that glTranslatef(), glRotatef() and glScalef() will manipulate the geometric object rather than the camera. glLookAt() will manipulate the camera. Again, values of arguments are changeable. Through students' feedback, we know that our combo demo gives them a much better picture of the concept of geometric transformations than Nate Robins' transformation demo.

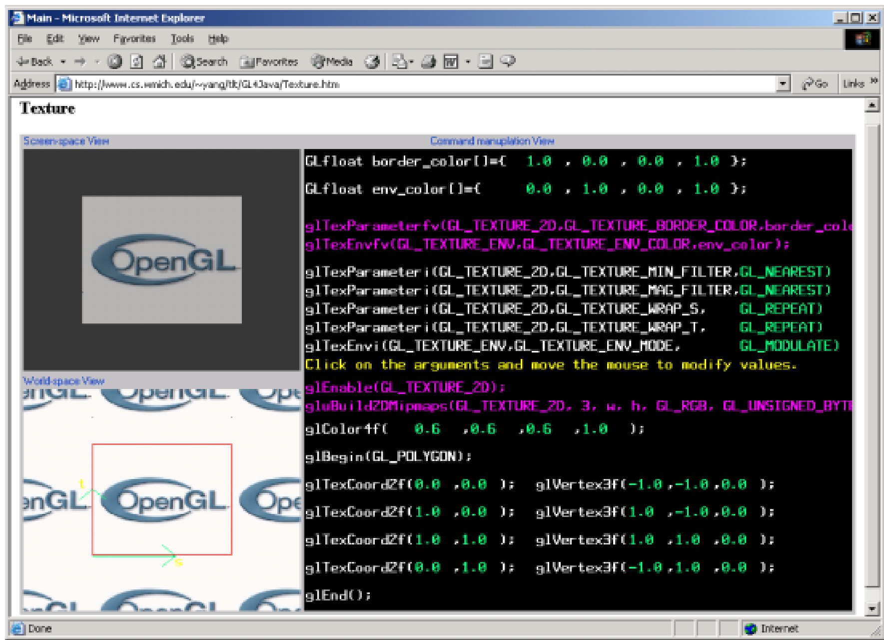

Fig. 4. A screen snapshot of the texture mapping demo

5 Conclusion

Web based teaching and learning has certainly many advantages over the traditional education. Visualization techniques provide an effective way to attract students' attention in their learning activities, which are self-directed, experimental, and personalized for the autonomous learners. We have developed a set of web-based interactive computer graphics demos as supplemental material for our students who take the computer graphics course. These demos have realized our design objectives: OpenGL demos are presented to the World Wide Web. These demos expand the capacity of online learning of the computer graphics course. They are good illustrations of what can be done with OpenGL. The informal feedback from students is positive as being a useful self-learning tool. Although the presented demos are mainly used by our students to reinforce the principles learned in class, these demos are also useful for distance learners. We would also like to point out that these demos represent a generic methodology in tutorial design using web-based visualization, which can be easily adapted to other similar subjects. Lastly, the development of these demos has given good projects for students who took this course.

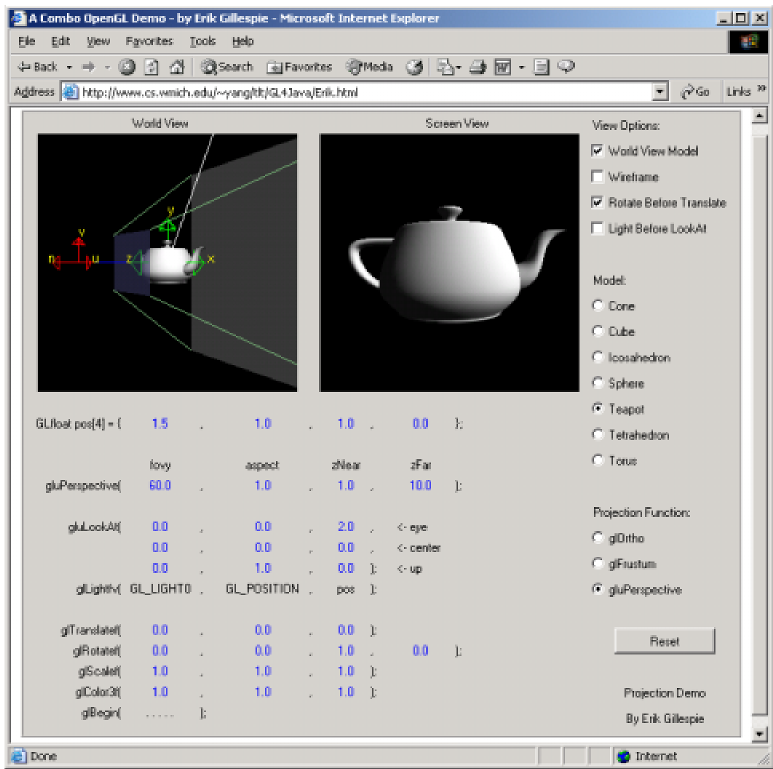

Fig. 5. A combo demo

Readers are invited to try the OpenGL demos presented in this paper. These demos are available at http://www.cs.wmich.edu/~yang/tlt/GL4Java/ . To increase the download speed, each of these demos is handled as a separate Java applet.

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