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Advances in Web Based Learning – ICWL 2006

5th International Conference
Penang, Malaysia, July 2006
Revised Papers

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Volume Editors

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Preface

Web-based learning has attracted ongoing attention for its rapid development in recent years. It introduces not just global and distributed, but virtual learning environments to the students. To the educators, it creates a lot of opportunities, and at the same time challenges. Special learning tools/systems, learning resource management, and personalized learning materials, etc., are the hot research topics at present.

After four successful previous annual conferences, ICWL 2002 in Hong Kong, ICWL 2003 in Australia, ICWL 2004 in China, and ICWL 2005 in Hong Kong, the Fifth International Conference on Web-Based Learning (ICWL 2006) was held in Penang, Malaysia during July 19-21, 2006. ICWL 2006 was a continued attempt to address many of the above-mentioned issues. The conference program was organized in a single-track 3-day workshop. It included a tutorial, a keynote talk, and oral/poster paper presentations in several sessions dedicated to specific topics. Session topics included "Personalization in E-Learning," "Designs, Model and Framework of E-Learning Systems," "Implementations and Evaluations of E-Learning Systems," "Tools in E-Learning," and "Learning Resource Deployment, Organization and Management." We received a total of 99 submissions from all over the world. The Program Committee selected 34 papers as regular papers for presentation, an acceptance rate of about 34.3%. Due to the high-quality submissions, the committee decided to further invite nine papers for poster presentations. Finally, 32 papers (including the keynote speech) were selected for this post-conference proceedings.

We would like to especially thank Wan Zhang and Howard Leung, who did tremendous work as the Conference Secretary and Webmaster, and Organization Chair, respectively. We would also like to thank the International Program Committee for their great efforts in the review process and the Organizing Committee for their contributions to making this conference a success.

We would also like to thank the keynote speaker, Won Kim, for his insightful keynote speech. Finally, we acknowledge the support from our sponsors, Hong Kong Web Society and Universiti Sains Malaysia.

July 2006

Qing Li
Timothy Shih
Wenyin Liu
Rynson W.H. Lau
Qun Jin
Ling Feng

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ICWL 2006 was jointly organized by the Hong Kong Web Society and Universiti Sains Malaysia.

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Directions for Web-Based Learning

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Abstract. Web-based learning has the potential to becoming an indispensable part of learning by augmenting traditional in-class, teacher-led education. Although there have been several noteworthy signs of advances and adoption of Web-based learning, there is a long way to go before the full potential of Web-based learning can be realized. In this paper, eight specific directions are given for overcoming the current challenges for Web-based learning.

1 Introduction

One area of major impact of the advances in computing and communications technologies, and the advent of the Internet and Web technologies during the past decade is education and training (collectively to be called learning). Just as e-commerce has become an integral part of commerce by augmenting traditional commerce with various new advantages, Web-based-learning is becoming an integral part of learning. (Terms such online learning, distance learning, and Web-based learning are rather synonymous and will be used interchangeably throughout this paper) Many corporations, especially large, multinational ones like IBM, Samsung, Cisco Systems, etc. have adopted Web-based learning to train their employees on numerous subjects of business relevance. Traditional universities have added online courses to their curricula. There are a fair number of online universities in many countries. Government organizations have started offering Web-based courses to train their employees on various subjects. People on the go have started using mobile devices, such as PDAs and laptops to download books, book readings, and educational television programs from the Web.

From these activities, some trends are clear. Corporations have recognized Web-based learning as a key tool for increasing corporate competitiveness. They have realized that the "learn from anywhere" aspect of Web-based learning substantially reduces the cost of training and informing employees, in terms of lost work hours due to travel, and overcomes scheduling difficulties. Governments have recognized Web-based learning as a key tool for increasing national competitiveness. They have sanctioned online universities in order to educate citizens who have difficulty attending traditional universities for various reasons, including cost, schedule conflict with employment, and also started considering Web-based learning as an element in lifetime continued education programs for their citizens.

Although the importance of Web-based learning is clearly being recognized, and there is a high expectation of the potential of Web-based learning, there is a long way

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to go before Web-based learning can truly take root and its full potential can be realized. Today the ratio of online courses offered in offline universities is pretty low, and the adoption of online courses in k-12 education is even lower. The adoption of online training in small to medium-sized businesses is pretty low, too. The online course contents need to be significantly improved, relative to the best-taught offline courses. The variety of courses needs to significantly expand to give students options and a stronger incentive to take Web-based learning. E-books and e-readers have not really taken off. Many of the vendors that provide consulting services, content-creation tools and learning management systems remain small struggling businesses. Degrees conferred by online universities are not seriously recognized by the employers, and many of the online universities are financially insecure. There is a definite lack of professionals trained to create high-quality contents, and to properly administer Web-based learning management system and address legal and social issues of Web-based learning. Offline universities have yet to figure out how to offer proper incentives to professors to create course contents for Web-based learning. Laws regarding content ownership need to be further tuned to provide proper incentive to the content creators, and laws regarding accreditation of online universities also need to be reviewed to ensure quality of the degrees they confer.

In the remainder of this paper, on the basis of the current status and trends in Web-based learning, directions are suggested on a broad range of aspects of Web-based learning. These include renewed focus on learning, identifying opportunistic subjects for online learning, creating compelling contents, training online education professionals, government's support, online learning as a key element in a strategic total learning program for organizations (that educate and train their people), focused technology development, and creating proper business models.

2 Renewed Focus on Learning

During the peak of the Internet bubble, the late 1990s, many otherwise intelligent people thought that the Internet and the Web would "totally wipe out the then-existing paradigms for most human endeavors," including commerce, education, governance, education, culture, entertainment, grocery shopping, purchasing and payment, etc. This led to the business of giving away PCs, selling pet foods online at a loss, delivering groceries at a loss, etc. In a similar vein, it appears that some people forgot that the purpose of online learning is learning, not an opportunity to test new fangled technologies on some mindless adopters of such technologies, and that learning has been done for at least two thousand years, and as such there must be at least some things that are right about traditional learning. In other words, some people thought that because people can view a course's contents on the Web anytime from anywhere, and are theoretically able to communicate with classmates and teachers via email, Web-based learning can make traditional learning obsolete. It may indeed come half way true at some distant future, but first those who create Web-based courses and those who deliver such courses must pause and realize the simple fact that the Web and other technologies are merely tools to augment learning and that they are not designed to make fundamental changes to the still rather mysterious processes through which human beings learn, innovate, and intellectually grow.

Although it is obvious, it may still be worth mentioning that there are at least a few types of learning, and the contents of a course, and the technologies for use should be matched to the types of learning. There is the in-class, teacher-led learning in traditional schools of all levels. To graduate with a degree, a student must accumulate a specified number of course credits and/or write a thesis, satisfy rules regarding attendance, sometimes even observe school and classroom rules regarding clothing and hair style, and definitely turn off cell phones in class, etc. A typical course includes homework (individually or with some classmates), exercises (individual or group), in-class discussions, quizzes, exams (either open book or closed book), teacher's office hours, after school tutoring, teaching assistants, field trips, occasional invited lecturers, etc. Learning is achieved while doing all these.

There is also an important type of learning which does not require all the tools that are brought to bear in traditional in-class learning. This is informal, self-directed learning. A person or a small group of persons may wish to learn something about a particular topic simply for self-improvement, not for course credit. For this purpose, the person or persons may do the Web search, participate in Webinars, download and read e-books or listen to book readings on some mobile devices, etc. The person or persons may do this anytime from anywhere they have access to the Internet or if they have the mobiles devices on which they had previously downloaded necessary contents.

In Web-based learning, when the purpose is to receive course credits, there is much to learn from traditional learning. In particular, the course may need to include homework, exercises, in-class discussions, quizzes, and exams. The course may be further augmented with such offline elements as in-class closed book exams, lab work, teacher's office hours, tutoring, field trips, occasional in-class lectures, etc.

Learning can be made more effective by making it fun and attention-grabbing for the students. Games, when done right, can be an effective tool for teaching complex scenarios. Movie or drama-like storytelling, if done right, can be fun and attention-retaining, and as such can make learning effective.

It is important to blend offline and online components in individual courses and an entire curriculum. In a single course, some or most of the course may be conducted online; however, there may be some offline elements, as mentioned above. In a curriculum, some courses may be entirely or largely Web-based, while others may be traditional offline ones. People who design a course or a curriculum should think first in terms of learning for the students; afterwards, they may consider such factors as logistics, cost, etc.; and only then think in terms of augmenting learning by leveraging appropriate technologies.

3 Identifying Opportunistic Subjects

It is in general difficult to create great contents for both offline and online learning. However, there are many subjects that are relatively easier to create contents, and they represent the low-hanging fruits for an initial tangible success for Web-based learning. These subjects include foreign languages, many of the required courses for certification (e.g., real estate broker, computer programming, etc.), and many of the cut and dried training subjects in large corporations and government organizations, such as contracts, corporate security, leadership, basic management, basic accounting, project management, etc.

There are also subjects for which there is a compelling audience for online learning. Because of the high competition for college entrance in South Korea, most students attend college-entrance exam preparation schools after regular school every day. The cost of this after-school schooling has become a major burden on every household that has a high school senior. To ease this burden, the government has decided that college-entrance exam questions will be selected from the lessons given on the Education Broadcasting System (EBS). Although it does not appear that the financial burden on the households has been lessened, high school seniors watch the programs live or recorded programs on the television's website, and some of them even watch the recorded programs on mobile devices. Although Web-based learning is not much of a factor in secondary school education, this is one interesting exception.

4 Creating Compelling Contents

The goal of Web-based learning should be to be at least as good as or better than the best in-class teacher-led learning. The first step to achieving this goal is to create compelling contents – contents that are at least as good as or much better than those delivered by the best teachers. The Web-based contents have the potential to be better than those used in offline learning, because of the possibility to leverage technologies. There are at least six aspects to creating great contents for Web-based learning. Two of them were discussed in the previous section; namely, contents focused on learning (not showcasing technology), and blended contents that effectively mix online and offline components. Below, four additional aspects are discussed.

First is to compensate for the limitations of the Web-based learning environment. The limitations are the lack of interactivity and human elements. Impromptu questions from the students, answers and discussions that some questions trigger, adjustments the teachers make to the pace and contents of the teaching, etc. are difficult to replicate in a Web-based environment. The human elements, such as the teacher's gestures, facial expressions, approval and encouragement, etc., are also difficult to replicate in a Web-based environment. Interactivity and human elements play significant roles in learning. Although it is difficult to do, contents for Web-based learning must reflect them somehow. Of course, in blended contents, this becomes far easier.

Second is to leverage the new capabilities afforded by the technology. Such new capabilities are a two-edged sword, however. On one hand, they can augment traditional learning. On the other hand, they add complexity on the part of the students, who must learn to use them. Examples of the new capabilities that can augment learning include collaboration tools such as email, chat room, and bulletin board; Web search; multimedia contents that include graphics, animation, audio and video; multi-modal user interactions; electronic dictionary; computerized testing and scoring; electronic conferencing; virtual classroom, etc. Those who design Web-based course contents must give a high priority to usability. They must seriously consider the profiles of the students in fair detail and incorporate capabilities and user interactions that will accommodate the students best. If they design game-based or movie/drama-like storytelling edutainment contents, they must ensure that the scenario alternatives of the game and the story lines are believable and thought-provoking.

Third is to compensate for the inadequacies of technology. There are many technological inadequacies. These include a lack of broadband, a lack of audio and/or video options on the PC, incompatible software between the content creation platform and content delivery platform, (in the case of mobile devices) tiny screen size, limited keypad, limited battery life, etc. When creating contents, such technological inadequacies or incompatibilities on the content delivery platform must be compensated for. For example, when a course is targeted for students who do not have broadband access, graphics, images, sound, and video in course contents must be either highly compressed or omitted altogether. Of course, when such multimedia parts of the contents are omitted, additional textual explanations would need to be provided. When a course is targeted for students who will access it using mobile devices, because of the limited battery life, it may need to be designed to complete within a shorter period of time than is designed for those who will access it using PCs at home. Further, the interaction menu and content display would need to be specially designed to accommodate the screen size and available keypad.

Fourth is to avoid mindless mistakes when creating contents for Web-based learning. Examples include video of monotonous talking head (students might as well listen to an audio tape), video of a flickering computer monitor or screen that displays the monitor (again, students might as well listen to an audio tape), sparse PowerPoint pages with just headline keywords with no voice-over that effectively threads them together with details, PowerPoint pages jam-packed with words and details with the instructor not covering all the points, images of objects that do not give any clue to their actual sizes, etc.

5 Training Online Education Professionals

In order for Web-based learning to grow rapidly, the variety of courses, with great contents, will need to increase perhaps even more rapidly. As discussed in the previous section, it is difficult to create great contents for Web-based learning, and content creators should be trained properly. Teachers should also be taught on the differences between offline learning and Web-based learning, and be trained to make effective use of Web-based course contents. They should also be trained on some aspects of a learning management system, including administering tests and scoring tests, managing homework and grades, etc. System administrators and education administrators should be trained to expand the scope of their duties to include Web-based learning. System administrators should also be trained to administer learning management systems, including license management, technical support, etc. Education administrators should be trained and continually informed on government policies and incentives, and education-related issues regarding Web-based learning.

6 Government's Support

The government has significant roles to play in promoting Web-based learning. They include support for technology infrastructure, legislation, and funding.

Web-based learning is not possible without appropriate technology infrastructure in place. Technology infrastructure includes Internet backbone, broadband, wireless networks, and supply of PCs to disadvantaged regions. The government, along with major technology corporations, must enable the technology infrastructure. The government of South Korea is a good example. The Ministry of Information Communication actively led the industry to build the technology infrastructure, including a nationwide high-speed Internet backbone, broadband networks, wireless networks, and supported deployment of PCs in elementary and secondary schools and rural communities. As a result, today 65% of South Koreans use the Internet, 70% of the elementary and secondary schools are equipped with 2Mbps communication links, and there is one PC per 5.8 students.

Legislation lays the basis for providing financial support for Web-based learning in traditional universities, small and medium corporations, governmental departments and municipal governments; for providing financial support for lifetime education for the communities and municipalities, for the children of below-minimum income families, and research and development in Web-based learning; for accrediting online universities, and online education training centers; and protecting content ownership. The government of South Korea has passed laws during the past several years to provide legal bases for all these areas. (However, beyond passing the laws and announcing plans, there has not been much tangible action and result. Further, four different ministries are getting in each other's way.)

Financial support for Web-based learning may be targeted to the training of online education professionals outlined in the previous section, to helping small to medium-sized businesses to train their employees, to helping rural communities to better inform their citizens and to improve the quality of life in general for their citizens. It is also needed to promote research and development in certain key technology areas for enabling Web-based learning. (This will be discussed further in the next section.) In certain countries, financial support may be targeted to promoting standards activities, helping universities set up Web-based learning support and training organizations, and even buttressing struggling small to medium businesses engaged in Web-based learning, such as consultancies, developers of content-creation tools, and creators of contents for lifetime continuing education for municipal communities. The government of South Korea, in particular, supports 39 cyber high schools with 200,000 students from below-minimum income families, and reimburses up to US$1,000 for each employee of businesses with under 300 employees for taking online training (from government-certified training centers). The government has also set up a SCORM co-lab.

7 Online Learning as a Key Element in a Total Learning Program for Organizations

There are 4 types of organization that run Web-based courses. They are offline universities, online universities, corporations, and government organizations. Web-based learning should be positioned as a key element in a holistic learning program for corporations, government organizations, and offline universities.

Of the 4 types of organizations that run Web-based courses, large corporations have clearly led the adoption of Web-based learning. Large US-based corporations such as Cisco Systems, IBM, General Electric, AT&T are well-known adopters. There are over 100 large corporations in South Korea that have created and run Web-based training programs for their employees, including Samsung (Electronics, Life, Fire, SDS…), LG (CNS,…), KT, SK, POSCO, Hyundai (Motors, Heavy Industries), etc. Large corporations run about 20 to 200 online training programs (representing about 20-50% of all training programs), and achieved on average about 20-50% reduction in training costs and time. Large corporations and government organizations take a holistic approach to their training programs. In other words, first they would each design an overall training program, and then determine the parts of the program suitable for Web-based learning. For corporations the training programs should be designed to not only train and inform their employees, but also inform and train their business partners, and inform their customers. Government organizations should also design their training programs to not only train and inform their employees, but also inform and train various types of organizations that interact with them (including other government organizations), and inform the citizens they serve. In this holistic context, both the corporations and government organizations should each design a blended overall curriculum, design Web-based courses for those topics where online training can be justified, and set up technology infrastructure and support organizations for the training program.

In universities where there is a good supply of lecturers relative to the number of courses that need to be taught, or where it is easy to recruit temporary hourly lecturers at a very low rate to take the bulk of the university course teaching load, the incentive to adopt Web-based learning on a significant scale is low to non-existent. In universities where the cost of traditional education is deemed excessively high, however, shifting a part of the courses to Web-based learning would be considered. Key complaints from lecturers who prepare and manage Web-based courses in universities include lack of financial incentives to invest the amount of time and efforts needed to create proper contents, too many students to manage (grading and answering questions), and students' tendency to put off learning till certain milestone deadlines. Key complaints from students, on the other hand, include lack of interaction with teachers, lack of interactions with classmates for online discussions, and quality of learning. Beyond addressing these issues, the focus of university adoption of Web-based learning should be on the design of a blended curriculum, and blended individual courses. To properly do this, universities should really set up and operate Web-based learning support and training organizations, at least until Web-based learning takes firm root.

There are a fair number of online universities, many in the United States. Today there are 17 (15 4-year, and 2 2-year) online universities in South Korea. The tuition and fees charged by these universities are 1/3 of those charged by traditional universities. 80% of the students are 20-30 years olds with day jobs. The 17 online universities receive a combined total of US$500,000 a year in financial support from the government. As the current problem is that degrees conferred by online universities do not command the level of trust or recognition as those from well-established traditional universities, the focus of online universities, with respect to those fields where graduates hope to find employment, should be to addressing this problem. One way to do this is simply to try to increase satisfaction on the part of the employers who employ online university graduates by more closely aligning and strengthening the online courses with the job skills requirements of the employers. But this will take a long time. Perhaps one way to compress this time is for the online universities to propose a set of certified standardized tests that can measure how well online university students are trained. Besides this problem, in countries where online universities are largely financially strapped, they may pool resources, by sharing courses, for example, to improve their chances of survival. Of course, it goes without saying that just like any market, the online university "market" will no doubt see a shakeout and the survival of the fittest.

8 Focused Technology Development

There are a few areas with direct relevance to Web-based learning that require special consideration for focused research and development efforts and government funding.

The key to success of Web-based learning is the availability of great contents. However, it is difficult to design learning-focused Web-based contents and learning-focused blended curricula. Learning theory, collaborative learning, and deep consideration of the technologies that may be leveraged should all be pulled together in defining techniques and guidelines for the creation of great Web-based contents and blended curricula.

Just as the rather haphazard designs of user interfaces for the numerous consumer electronics devices have become a source of mental burden for many people today, the need for a simple, intuitive and consistent user interface is strong across the Web-based learning technology chain. The chain includes the course delivery platform (e.g., a mobile device with buttons and menus), course contents themselves (with buttons and other mechanisms to navigate and manipulate the contents within a page and to navigate across the pages), content-creation tools, and the learning management systems. Usability of the course delivery platform and the course contents themselves is particularly important, if Web-based learning is to become a factor at all for the middle-aged and older citizens, and the disadvantaged who have not had much access to the PCs and the Internet.

Such efforts as e-books and e-readers have not really taken off. However, it appears that if there is to be an iPod-equivalent of a Web-based learning device, there should first be a wide array of compelling courses to take, and the course contents should be delivered in a compelling manner.

9 Proper Business Models

Today online support businesses are fragmented and financially struggling. After a period of shakeout, viable business models will emerge. Most likely, the fragmented businesses will be consolidated into a small number of full service providers which will provide consulting services, installation and management of content creation tools, learning management systems, content delivery platforms and networks. These service providers will most likely provide content-creation skills and create contents jointly with the teachers, who have the domain expertise in the subjects of the contents. It is not clear whether these online education service providers will stand on their own or be merged into giant system integrators of today, such as EDS, Computer Science Corporation, Accenture in the US, Samsung SDS and LG CNS in South Korea, etc.

10 Concluding Remarks

Web-based learning has the potential to becoming a very important part of learning in corporations, universities, and government organizations. As education and training are a key factor in determining competitiveness for corporations and nations, strategically designed education and training programs are clearly very important. Learning-focused, blended Web-based courses and curricula can be a very effective and cost-effective component of such programs. In that context, the keys to realizing the potential of Web-based learning are the availability of contents on a wide variety of subjects, usability across the Web-based technology chain, and government's financial and legislative support. There is a long way to go before the potential of Web-based learning will be realized. However, it is worth addressing the issues along the way.

Acknowledgments. Sunah Lee and Eunjung Chun gathered background materials on the status and trends in online education for me. I thank them for their efforts. The materials were useful in confirming my thoughts and tying together pieces of my thoughts.

Courseware Recommendation in E-Learning System

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Abstract. E-learning systems , as an education pattern, are becoming more and more popular. In e-learning systems, courseware management is an indispensable part. As the number of various courseware increases, how to find the courseware or learning materials that are most suitable to users and users of e-learning systems are most interested in is a practical problem. In this paper, we apply the idea of knowledge discovery techniques to make personalized recommendation for courseware. We design the courseware recommendation algorithm which combines contents filtering and collaborative filtering techniques. Also we propose the architecture of courseware management system with courseware recommendation, which is seamlessly integrated in our E-learning system. The experiment shows that our algorithm is able to truly reflect users' interests with high efficiency.

Keywords: E-learning system, courseware management, recommendation, interests.

1 Introduction

As a novel education pattern, E-learning, which characterizes the huge information, the strong interactivity, the great coverage and no space-time restrictions [1][2], has been an important way to resolve the contradictions between the social needs and the relatively inadequate educational resources.

Among various elements in different E-learning systems, courseware management is being attached great importance. Courseware, according to the CELTS (China E-learning Technology Standards)-42[3], is defined as a program that implements a complete teaching process of one or several knowledge points. The conventional methodology of managing courseware is to store the courseware in databases and offer an interface for users to search and retrieve. However, as the amount of courseware is becoming larger and larger, how to find the courseware that users are most interested in and are most valuable to them is a problem faced in nearly every E-learning system. Different users may have different focus on courseware. As for this, inspired by knowledge discovery techniques in [6][7], we propose the idea of courseware recommendation, which recommends courseware that most reflects the true interests of different users. Courseware recommendation system collects and analyzes users' information and behavior in the e-learning system to figure out their interests and then makes an active recommendation on courseware.

About the various recommendation technologies that courseware recommendation system is based on, they are generally categorized into two kinds: recommendation

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based on rules and recommendation based on information filtering. The latter is furthermore divided into two types: filtering based on user contents and collaborative filtering.

Rule filtering recommendation systems use the predefined rules to filter information. The major problem is that the quality of rules cannot be guaranteed and rules cannot be updated dynamically. Moreover, when the number of rules increases over some extent, the system becomes overwhelmingly hard to manage. User contents filtering systems take considerations of the diversity of different users. They analyze the interests and features of users. As a result, the recommendation results are truly relevant to users. The precision and quality of recommendation is fairly good, but the user contents filtering only focus on a single user so that the results cannot be shared among other uses and reflect the comprehensive picture of user interests. Collaborative filtering works by building a database of preferences for items by users. A new user, Neo, for example, is matched against the database to discover neighbors, which are other users who have historically had similar taste to Neo. Items that the neighbors like are then recommended to Neo, as he will probably also like them. Although collaborative filtering is a promising technology, it has two fundamental drawbacks. One is sparsity problem, which is that ,at the very beginning of the system, recommendation system is unable to recommend anything because not enough evaluations are available in the system. The other problem is scalability of the collaborative filtering. As the users and resources increase, the system performance tends to decrease to some extent.

In the paper, we design algorithms to make the correct and effective recommendation of courseware to users. And we propose the courseware management architecture with courseware recommendation that combines the user contents filtering and collaborative filtering. The system has implemented the algorithms. The whole scheme has the following unique features:

- Recommendation algorithm: The algorithms combine the two kind of filtering technology. They not only maintain the precision and quality of recommendation, but also give comprehensive recommendations in view of the users' interests. Furthermore, the algorithms also consider the relations among courseware to improve the quality of recommendation.
- Integration: The whole courseware recommendation architecture and its implementation are smoothly integrated into our E-learning systems, which is the key project of China's Tenth Five-year plan: E-learning key technology and its demonstration. It goes well with other components of the E-learning system: the real-time teaching system, the non-real-time teaching system, the network teaching management system, the e-learning settlement system, the courseware making and intelligent question-answering system, the exercise and examination management system, and the educational resources management system.

The rest of this paper is organized as follows. Section 2 discusses the related work. Section 3 describes the architecture of the courseware recommendation. Section 4 gives the user aggregation algorithm. Section 5 talks about the courseware aggregation. Section 6 gives the detail flow of courseware recommendation algorithm. Section 7 presents some experiment results to show the benefit of the system and an instance of the system implementation. The last section makes a conclusion and talks about future work.

2 Related Work

Since the research on the courseware recommendation is relatively rare, here we briefly present some of the research literature related to collaborative filtering, recommender systems, data mining and personalization.

Tapestry [7] is one of the earliest implementations of collaborative filtering-based recommender systems. This system relied on the explicit opinions of people from a close-knit community, such as an office workgroup. However, recommender system for large communities cannot depend on each person knowing the others. Later, several ratings-based automated recommender systems were developed [8][9][10][11].

Other technologies have also been applied to recommender systems, including Bayesian networks, a Bayesian networks create a model based on a training set with a decision tree at each node and edges representing user information. The model can be built off-line over a matter of hours or days. The resulting model is very small, very fast, and essentially as accurate as nearest neighbor methods [12]. Bayesian networks may prove practical for environments in which knowledge of user preferences changes slowly with respect to the time needed to build the model but are not suitable for environments in which user preference models must be updated rapidly or frequently.

Clustering techniques work by identifying groups of users who appear to have similar preferences. Once the clusters are created, predictions for an individual can be made by averaging the opinions of the other users in that cluster. Some clustering techniques represent each user with partial participation in several clusters. The prediction is then an average across the clusters, weighted by degree of participation. Clustering techniques usually produce less-personal recommendations than other methods, and in some cases, the clusters have worse accuracy than nearest neighbor algorithms.

3 The Architecture of Courseware System with Courseware Recommendation

The architecture of Courseware management system with courseware recommendation is as the Figure 1 suggests. The whole architecture is composed of portal of e-learning system, e-learning login server, portal of courseware management system, courseware search engine, courseware database, courseware metadata database and the courseware recommendation module.

Normally, a typical process of using courseware management system is like this: A user logins on the portal of our e-learning system. After authenticated by the login server, the user enters the e-learning system. And then he visits the portal of courseware management system. On the portal, he inputs some key words to look for the courseware he wants learn. Then he will see some recommendation information about courseware. The information is generated in the Courseware Recommendation Module. There are two kind of recommendation information: ① The Top 5 most popular courseware in the user's major and degree.② The Top 5 courseware that other users in the same interest group of the user recommend. After getting these information, the user can choose to learn the courseware that the system recommends or search the courseware that he is really interested in. And the search engine will search the courseware database based on the key words the user just input. The search process is accelerated by the Courseware Metadata database which is built according to the CELTS-3,42.

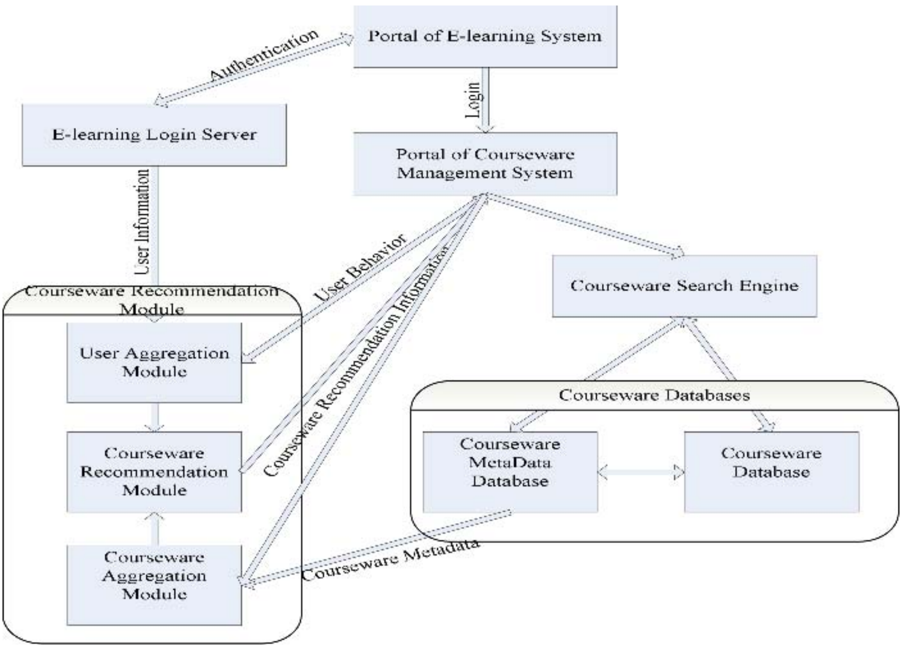

Fig. 1. The Architecture of Courseware System with Courseware Recommendation

The courseware recommendation module is composed of three parts: User Aggregation Module, Courseware Aggregation Module, and Courseware Recommendation Module. User Aggregation Module mainly collects user information from e-learning login server and user behavior from portal of Courseware Management System. After these data have been collected, the module uses User Aggregation Algorithm to figure out users' interests group, user information similarity and user credits. Courseware Aggregation Module takes data from Courseware Metadata Database to make a sort of courseware based on their evaluation by users. These sorting results are handed to Courseware Recommendation Module. Courseware Recommendation Module receives inputs from the two modules and implements Courseware Recommendation Algorithm to obtain the recommendation information about courseware. Then those information are transferred to portal of Courseware Management System.

4 User Aggregation Algorithm

The main function of user aggregation module is to implement user aggregation algorithm. The algorithm forms user aggregation which is the user group with similar interests on courseware. The module also calculates two values as the parameters of the courseware recommendation algorithm: Users Credit and User Information Similarity.

The module obtains user profile information from e-learning login server, courseware keywords and the evaluations of courseware by users from portal of courseware management system. The module also maintains a dataset of user login history and its relevant courseware keywords and evaluations. This dataset offers information for recommendation algorithm.

4.1 Some Definitions for User Aggregation Algorithm

Some definitions of the user aggregation algorithm:

- ***User_Info:*** According to Data Exchange Standard of our E-learning system[4], the user profile information is defined as follows: User_Info={user_id, user_name, name, type, school_id, major, class, station, e-mail, gender, national, language, telephone, address, postcode, birthplace, birthday, preschool, premajor, degree, description}
- ***User_Courseware Associate Matrix:*** Suppose there are *m* users in the list maintained by user aggregation module. And we pick up *n* different courseware key words.(Each user has at least one keywords). We create the User_Courseware Matrix $M_{m\times n}$. Each line vector M[i.] denotes the evaluations user u_i comments on all the *n* different courseware keywords. Each column vector M[.j] represents evaluations from all the users. And the element M_{ij} tells about what user u_i comments on courseware keywords.
- ***User Information Associate Matrix:*** In the same user group with similar interests about courseware, we maintain a matrix to associate users and its user_Info: $I_{m\times 9}$. Each line vector I[i.] denotes all the user profile information of user u_i . Each column vector I[.j] represents the j-th information of all users. And the element I_{ij} is the j-th information of user u_i .
- ***User Credit:*** user credit is defined as the degree of similarity between users about courseware. We define Credit(u_i , u_j) as the user credit between user u_i and user u_j .

User Information Similarity: we define userinfo_sim (u_i , u_j) to denote the similarity between users about their profile information.

4.2 User Aggregation Algorithm

The flow of the algorithm is as follows:

(1) Calculate the similarity matrix of users: $M_{m\times n}^{Sim}$. We calculate $M_{m\times n}^{Sim}$ based on the User_Courseware Associate Matrix $M_{m\times n}$. The element of $M_{m\times n}^{Sim}$ is $Sim(i, j)$ .The formula (1) shows the calculation. In the formula,

$Sim(i, j)$ stands for the degree of similarity between user u_i and u_j about courseware. And $\overline{M_k}$ denotes the average evaluation that all users give to the k-th courseware keywords.

$$Sim(i, j) = \frac{\sum_{k=1}^{m}(M_{ik} - \overline{M_k})(M_{jk} - \overline{M_k})}{\sqrt{\sum_{k=1}^{m}(M_{ik} - \overline{M_k})^2}\sqrt{\sum_{k=1}^{m}(M_{jk} - \overline{M_k})^2}} \quad (1)$$

(2) User Aggregation: giving a threshold value ε. $\forall Sim(i, j)(n \le i, j \le m)$, if $Sim(i, j) \ge \varepsilon$, then we can make user u_i and all the other user u_j in one interest group. Apparently, one user can be grouped into more than one group. The threshold value ε is adjustable. If the user aggregation number is too large, we can increase the value of ε, on the contrary, we can decrease ε to increase number of user interest group.

(3) Calculate User Credit: After we obtain user aggregation group and degree of user interests similarity, we can compute User Credit using Formula(2):

$$Credit(u_i, u_j) = Sim(u_i, u_j) / \max Sim \quad (2)$$

5 Courseware Aggregation

Courseware aggregation module is mainly in charge of grouping courseware according to their metadata and ranking the courseware in each group. And then the module sorts the grouped courseware based on the rating that users give when using these courseware.

As the Figure 1 demonstrates, courseware aggregation module obtains information from Courseware Metadata Database. In our integrated E-learning system, every courseware must comply with CELTS-3 and CELTS-42. Also the CELTS-3 and CELTS-42 are compatible with Dublin Core Metadata Initiative [5]. XML is used to describe courseware. Figure 2 shows part of the XML file of a certain courseware. Primarily based on these metadata standards, we group those courseware.

According to CELTS-3 and CELTS-42, the courseware metadata have some mandatory elements: title, creator, subject, keywords, description, data, type, format, identifier, language, audience. Not every element can be the criteria of grouping courseware. Here we pick two elements that are mostly associated with users' interests. They are subject and audience. Subject is what courseware contents are about. The subject may be mathematics, computer science, etc. Audience is the degree of users. The audience may be bachelor, master, doctor, freshmen, sophomore, etc.

After grouping the metadata of courseware, the module will obtain information about the rating of the courseware and use it as the criteria to rate the various courseware in each groups. And the top 5 highest rating courseware metadata will be sent to the recommendation module to be recommended to the user.

```xml
<?xml version="1.0"?>
<ResourceEncode xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          <Title>物理简史 </Title>
          <Creator>
  <Namepersonal>葛亮 </Namepersonal>
  <namecoporate>东南大学 </namecoporate>
  <postal>210096</postal>
  <email>heavenbuyer@seu.edu.cn</email>
 </Creator>
 <Subject>history</Subject>
 <Keywords>history</Keywords>
  <Description>
  <tableOfContent>物理简史 </tableOfContent>
 </Description>
 <Contributor>
 <Namepersonal></Namepersonal>
 <namecorporate></namecorporate>
```

Fig. 2. Part of the XML Description of a Courseware

The rating of courseware in our E-learning system is based on the users' behavior when they are in courseware system. Different behaviors imply different attitudes of users toward courseware and therefore can be deemed as criteria of rating courseware. The user action and its meaning are shown in Table 1. The rating does not reflect the quality of the courseware but the interests of different users.

Table 1. Meaning of the User Action

User Action	Meaning	Rating value
Watch the courseware and add a mark	Very high positive	5
Watch the whole of the courseware	High positive	4
Watch part of the courseware	Moderate positive	2
Ignore the courseware	Low negative or set to zero	0

6 Courseware Recommendation Algorithm

As the core part of the Courseware Recommendation system, this module basically outputs two kind of information to the portal of courseware system: ① The Top 5 most popular courseware in the user's major and degree. ② The Top 5 courseware that other users in the same interest group of the user recommend.

The first kind of recommendation information is quite straightforward. Courseware recommendation module receives information from the courseware aggregation module about the top 5 most popular courseware in the current user's major and degree (bachelor, master, doctor). The second recommendation information is generated by the courseware recommendation algorithms.

The recommendation algorithm is to generate the second information, which recommends the courseware that is recommended by other users in the same interest group. The algorithm needs two parameters: one is the user credit, which is calculated in formula (2); the other is user information similarity degree, which is calculated in section 6.1.

6.1 User Information Similarity Degree

When users login in e-learning system, the users' profile information are transferred to user aggregation module to calculate user information similarity degree: userinfo_sim(u_i , u_j). Although there are 21 information elements in the user profile, we only pick 9 elements to calculate the similarity degree. The detail element similarity calculation is like the Table 2 suggest.

Table 2. The Element Similarity Degree Calculation

Element	Condition	Similarity Degree
School_ID	same school	1
	different school	0
Major	same major	1
	different major but same field(Arts Science)	0.5
	different major, different field	0
class	same class	1
	different class but same major same grade	0.7
	different class, different major	0
station	same station	1
	different station	0
gender	same gender	1
	different gender	0
birthday	same year	1
	older or younger x year	1-0.1*x
	older or younger 10 years or more	0
working place	Same place	1
	different place	0
Premajor	same major	1
	different major	0
Type	Same type	1
	higher or lower x in type series(*)	1-0.4*x
	higher or lower 3 in type series	0

*Type series: elementary school, junior high school, senior high school, bachelor, master, doctor.

Using Table 2, userinfo_sim can be calculated in formula (3):

$$\text{userinfo\_sim}(u_i, u_j) .= \sum_{k=1}^{9} \{\omega_k \times sim(u_i\_Elem_k, u_j\_Elem_k)\} \tag{3}$$

$u_i\_Elem_k$ stands for user u_i information element k of Table 2. $sim(u_i\_Elem_k, u_j\_Elem_k)$ is the similarity degree of user u_i 's element k and user u_j ω_k represents the weight of k-th element. ($\sum_{k=1}^{9} \omega_k = 1$, userinfo_sim(u_i , u_j)$\in (0,1]$)

6.2 Courseware Recommendation Algorithm

(1) The user u_i enters some keywords on the portal of courseware management system.

(2) Courseware Recommendation Module finds within the same user interest group of u_i the k courseware with the same or similar keywords that others choose. This is done by searching in the history record of portal.

(3) For each courseware p, calculate its recommendation degree R_p like this:

$$R_p = \sum_{m=1}^{L} \{[\omega_m \times userinfo\_sim(u_i, u_m) + Credit(u_i, u_m)]\} \times V(p, u_m) \tag{4}$$

R_p stands for recommendation value of courseware p. $Credit(u_i, u_m)$ is defined in section 3.1 as the trust degree between u_i and u_m . $V(p, u_m)$ is the evaluation of courseware p addressed by u_m . L is the number of users that system find in the same interest group of u_i . ω_m is weight of each userinfo_sim. After calculation, sort the k courseware according to its R_p .

(4) Output the top 5 recommended courseware in the sorted sequence to the portal of courseware management system.

7 Experiment and Analysis

The experiment is carried out in our E-learning system, which is the China national key project of the Tenth Five-year plan. The courseware management system with courseware recommendation is part of the integrated system. Here are some snapshots of the system environment: Figure 3 shows the portal of E-learning system. Figure 4 shows the courseware management system and Figure 5 gives a snapshot of a running courseware.

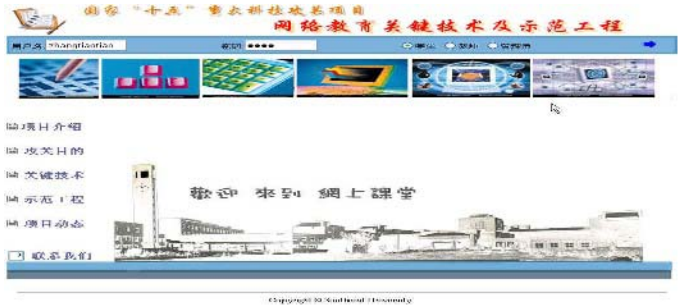

Fig. 3. Snapshot of the Portal of our E-learning System

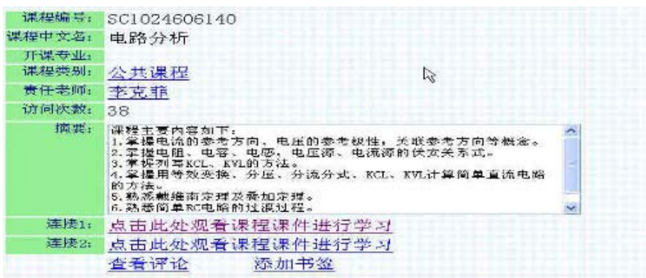

Fig. 4. Snapshot of Courseware Management System

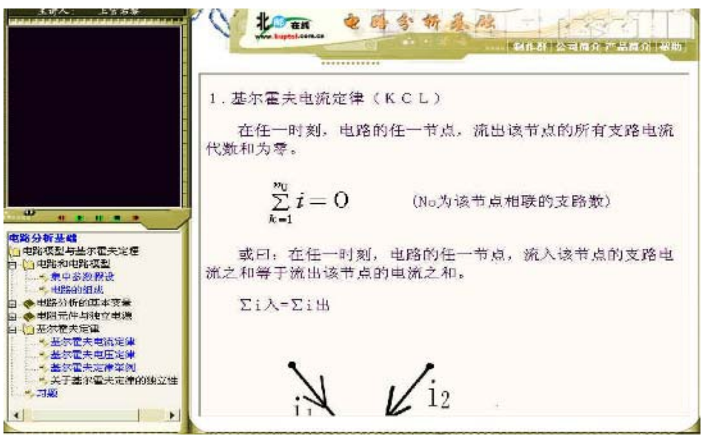

Fig. 5. Snapshot of a Running Courseware

7.1 Experiment Data Source

- **User Data:** From our e-learning system, we random pick up three classes from two distinct stations (station is the place where users are registered to have their distant learning using our system). We name them class A, class B, class C. The total user number is 100, class A has 20 users, class B has 30 users and class C has 50 users. Their user profile information is clearly and fully filled. And users are required to mark the courseware they choose to show whether the courseware reflect their real interests. The mark is ranged from -2 to 2. 2 stands for very interested, -2 stands for not interested at all.

- **Courseware Data:** In our courseware management system, we pick up 50 courseware ranged from computer science, mathematics, Chinese history to Chinese literature, marketing, wireless communication, etc. The users we choose will only pick the courseware that attracts them most from those courseware.

7.2 Evaluation Metrics

As [6] suggests recommender systems research has used several types of measures for evaluating the quality of a recommender system. One of the most widely used metrics is statistical accuracy metrics. They evaluate the accuracy of a system by comparing the numerical recommendation scores against the actual user ratings for the user-item pairs in the test dataset. *Mean Absolute Error* (MAE) between ratings and predictions is a widely used metric. MAE is a measure of the deviation of recommendations from their true user-specified values. For each ratings-prediction pair $< p_i , q_i >$ this metric treats the absolute error between them, equally. The MAE is computed by first summing these absolute errors of the N corresponding ratings-prediction pairs and then computing the average. Formally,

$$MAE = \frac{\sum_{i=1}^{N} |p_i - q_i|}{N} \tag{5}$$

The lower the MAE, the more accurately the recommendation system predicts user ratings. We used MAE as our choice of evaluation metric to report experiments because it is most commonly used and easiest to interpret directly.

7.3 Experiment Procedures

(1) Firstly we use user aggregation algorithm to get user groups with similar interests. The results is shown in Table 3

Table 3. Results of User Aggregation

User group with similar interests ID	Number of group
1	20
2	30
3	24
4	26

(2) Courseware recommendation and feedback: Every user group login to our e-learning system and enter the courseware management system. Initially, there should have some training data set for our courseware recommendation system,

since our system has been used by other users with similar interests, we skip the training phase. When one individual user enters the portal of courseware management system, he will see two kinds of recommended courseware: the top 5 courseware in the user major and top 5 courseware other users recommend in the same interests group. The individual user will mark these 10 courseware. And the marks are collected.

7.4 Experiment Result and Analysis

The results of four interest groups are shown in Figure 6 to Figure 9.

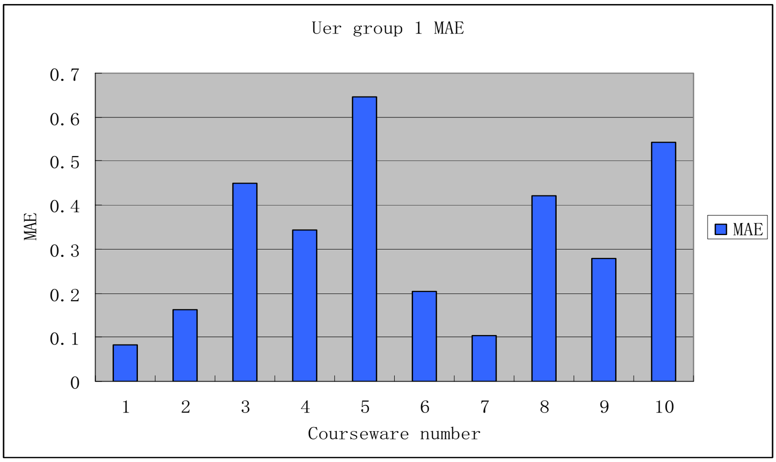

Fig. 6. The Result MAE of User Group 1

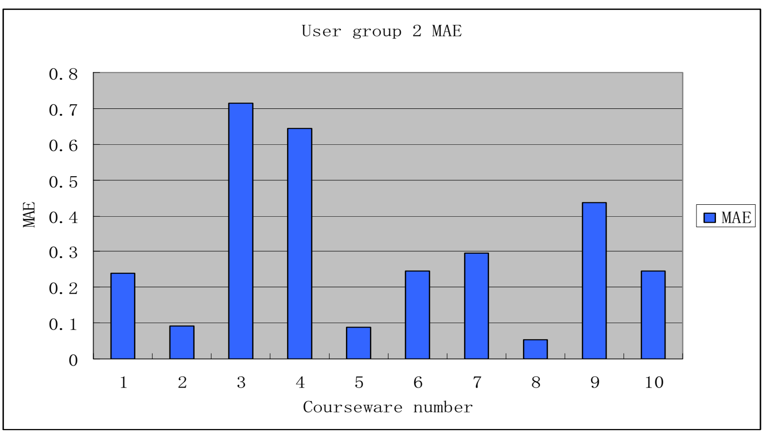

Fig. 7. The Result MAE of User Group 2

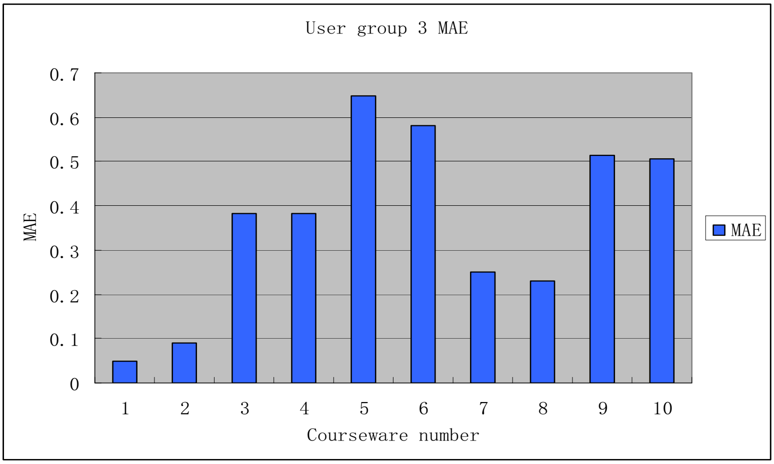

Fig. 8. The Result MAE of User Group 3

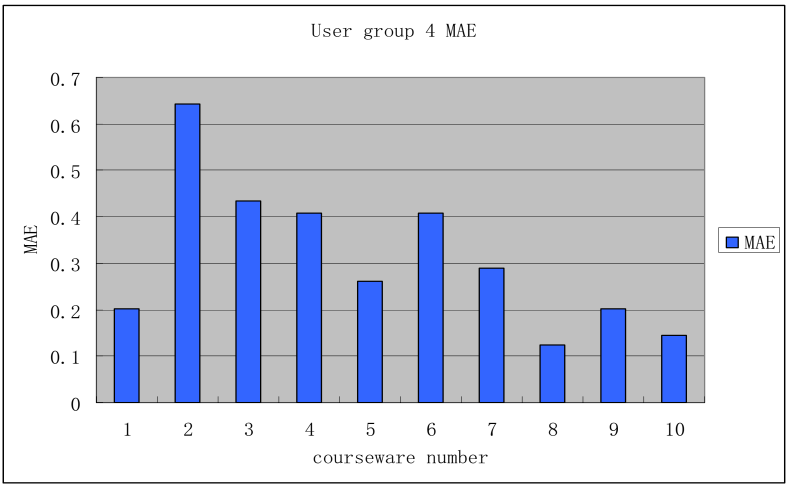

Fig. 9. The Result MAE of User Group 4

The four figures show that each group responds to the courseware in our system to express their interests about these recommended courseware. From the figures, we know that although the MAE towards individual courseware varies, the MAE is well under 1.0, which means that the recommended courseware satisfy users' interests. That is what the system designed for.

8 Conclusions

In this paper, we describe the architecture of the courseware management system with courseware recommendation. We especially present the algorithms that are used in the courseware recommendation module. The algorithms combine contents filtering, which recommends courseware solely from single user information, and collaborative filtering, which recommends courseware from other users perspectives. The experiment and system implementation shows that the system in use is able to reflect user's full interests in courseware selection. And the module is seamlessly integrated in our e-learning system.

Recommendation techniques are based on personalization technology and data mining. With the application of our e-learning system, users of our system will increase enormously and their demand and interests may differ greatly. How to find those diversified interests and reflect in the system is our next-step focus. And also the system performance under the circumstances that user amount is rather large is worthy of future research.

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A Model for Personalized Course Material Generation Based on Student Learning Abilities and Interests

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Abstract. With the ability to connect people and information around the world, the Internet is already having a significant impact on the traditional education. Nowadays, students can easily access the online course materials anytime anywhere. As a coin has two sides, Internet also amplifies the complexity of the course materials development and their provisioning. Since the learning initiative is taken by a student in the e-learning environment, traditional teacher-driven learning model is no longer applicable. Thus, *student-centered* course materials which are prepared based on individual student's *learning expectation* and *individual academic background* become critical. In this paper, we introduce a model for personalized course material generation through 1) student ability test based on Item Response Theory, 2) a Dynamic Conceptual Network for course materials management, and 3) intelligent knowledge base facilities, such as personal profiles, to help understand students' behaviors so as to materialize the concept of personalization.

Keywords: Personalized e-learning system.

1 Introduction

Currently, most e-learning systems follow the structured classroom lessons where a tutor's major responsibilities are to make sure the course materials fit for the students and to monitor their learning processes. Generally the functions include course builder, assignments, personal schedule, chat room, quiz, survey and so on. However, the e-learning environment is quite different from the traditional classroom settings. In an e-learning environment, the initiative is driven by the students where the traditional teacher-based learning model is no longer suitable for online education. Meanwhile we have to realize the fact that users carry different knowledge and goals. So "*One course material for all*" approach is inappropriate for e-learning. To focus on online education, understanding individual student's background knowledge and learning needs so as to provide proper course materials for their own study becomes critical [2]. In response to the above-mentioned issues in the e-learning, some preliminary works in the context of a Personalized eLearning System (Peels) [3, 4] have been done previously. In this paper, a model utilizes *Item Response Theory*, *user profiles*, and *dynamic conceptual network* is developed to actually provide personalized course materials to students.

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To facilitate the individual students learning on the Internet, we introduce in this paper an innovative mechanism that utilizes Item Response Theory [8], user profile, and dynamic conceptual network to provide the personalized course materials. Through designing the model for personalized course materials generation, we aim to address the following main topic in this paper: *How to effectively provide personalized course materials to meet individual student needs based on student learning abilities and interests*? The rest of this paper is organized as follows: Section 2 reviews the peers' works on e-Learning systems. The specific features of the proposed conceptual framework and algorithms are detailed in sections 3 and 4. The final section concludes this paper and makes suggestions for future research.

2 Related Works

Over the past decade, some researchers have focused on the adaptive approaches for e-learning systems. For the adaptive approaches of online course materials, WebCT [5] has been widely used in education sectors to produce online courses or to act as a tool for publishing supplementary materials for existing courses. A WebCT course is mainly created by using a series of linked HTML pages which are defined as paths or "road map", and all these interactions take place through a web browser. InterBook [6] is based on a specific concept-based approach to develop an adaptive Web-based LISP textbook while NetCoach [7], an authoring system, allows the users to create adaptive and individual course modules without programming knowledge. The concepts used in InterBook are basically elementary pieces of knowledge for the given domain, with a more advanced form of the domain model being a network. Each page has a set of outcome concepts and a set of prerequisite concepts associated with it to support adaptive navigation and hyperlink annotation.

Computerized Adaptive Testing (CAT) is a well-known technique using for student assessment. Currently, Item Response Theory (IRT) [8] is usually applied in CATs for selecting question and estimating student knowledge based on the probability of a student's answer in a given question correctly. Generally, systems that implement CATs use dichotomous IRT based models and questions (called "items") are positioned one at a time. That means student answers to a question can only be evaluated either as "correct" or "incorrect". In the case of a student providing a correct response, a more difficult question will be followed. On the contrary, an easier question will be administered next by receiving an incorrect response.

Many large scale examinations have been conducted in computer-based sometime ago and currently this assessment approach of CAT has been successfully applied to replace the traditional computer-based tests. Examples include Graduate Management Admission Test (GMAT), Graduate Records Examination (GRE), Test of English as a Foreign Language (TOEFL), and Microsoft Certified Professional (MCP). However, CATs contain some drawbacks such as requirement of the availability of huge item pools, techniques to control item exposure as well as to detect compromised items. Apart from the above, item parameters must be calibrated. A large number of student performances are required in order to accomplish this task, however, this is not always available.

However, individual or tailored instruction based on learners' needs and background has not been supported very well yet. As a matter of fact, the integration of user profiling [9] and multimedia technologies into a collaborative learning environment supporting personalization remains a very challenging issue. In the following sections, the proposed model for personalized course materials generation based on student abilities and interests will be elaborated.

3 Personalized Course Materials Generation

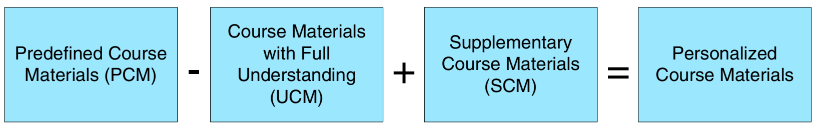


Fig. 1. Formula of personalized course materials

In this study, the personalized course materials are defined by the "formula" in Figure 1. As shown there, *personalized course materials* are generated by the *predefined course materials* minus *course materials with full understanding,* added by *supplementary course materials*. Detailed explanation of each component is given immediately below.

Predefined Course Materials (PCM): It represents a set of course materials that are predefined based on a course syllabus, so as to meet the specific requirements of a course and to unify an assessment requirements for all enrolled students. This PCM is similar to the traditional e-learning materials that are designed for all students.
Course Materials with Full Understanding (UCM): It represents a part of PCM which should be removed based on the result of an ability test. Normally, this test is performed before commencement of a new course and the test scope is designed based on the pre-requisites of the new course. Meanwhile, it is assumed that if a student has achieved a high score in the test, it implies s/he understands the relevant learning domain(s) of the test very well; in this case, the related learning domains in PCM should be removed. UCM helps students avoid spending learning time on those course materials that they are already familiar with and thus, facilitate reallocation of learning time to study other supplementary materials.
Supplementary Course Materials (SCM): It represents a supplementary course materials that are required based on the same ability test. Theoretically, SCM can be defined into 2 types as follows:

- The first type of SCM is for a student who has achieved a score below the standard, implying that s/he has not got enough knowledge and ability to learn the new course. Thus, supplementary materials of pre-requisites are provided for his/her improvement. This type of supplementary course materials is called **SCMP**.
- The second type of SCM is for a student who has achieved a high score in the test, implying that s/he has a high probability to understand the new course very well. Thus, more advanced topics of the course could be provided for his/her learning. This type of supplementary course materials is called **SCMA**.

3.1 Workflow of Personalized Course Materials Generation

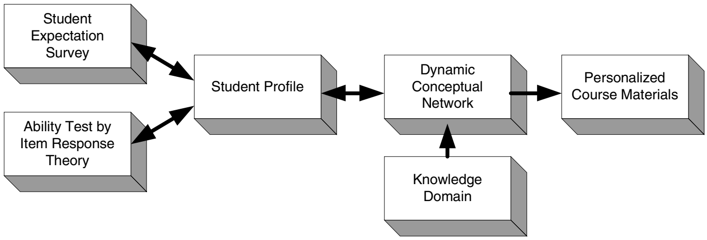


Fig. 2. Workflow of personalized course materials generation

The overall processes of our proposed model can be best described through workflows. In Figure 2, the components for the workflow of personalized course materials generation includes *Ability Test by Item Response Theory, Student Expectation Survey, Student Profile, Dynamic Conceptual Network, Knowledge Domain,* and *Personalized Course Materials*. Basically, the workflow of the mechanism is as follows.

Step 1. A student makes a request to the system to enroll into a new course, and the system provides a student-expectation survey for collection of expected learning time and expected assessment result. This information is stored in the Student Profile and can be retrieved for the student's update.

Step 2. In order to provide personalized course materials, ability test by the Item Response Theory (IRT) [8] is employed to test the student knowledge level and learning ability. In particular, some items (i.e. questions) will be selected to test the student's ability on the pre-requisites knowledge of the new course, in order to estimate his/her learning ability. The detailed mechanism will be discussed in section 3.3.

Step 3. The ability test result and student expectation information are stored in the Student Profile for future use. Here, a student profile ***SP*** is designed as:

$$\boldsymbol{SP} = (Sdt, CharID, CharValue\ ) \tag{1}$$

where *Sdt* is a set of student identities (ID), *CharID* is a set of students' characteristics for each *Sdt*; and *CharValue* is a set of characteristic values for each *CharID*. In this paper, *CharID* consists of *Expected Learning Time ET, Expected Assessment Result ER* and *Enrolled Course EC*.

Step 4. *Dynamic Conceptual Network* (DCN) is to manage course materials by a hierarchical tree and to generate the personalized course materials through some pre-defined rules and mechanism. The detailed mechanism will be discussed in section 3.2. The relevant course materials are extracted from the Knowledge Domain in providing a suitable lesson to the students. To implement the DCN, XML (Extensible Markup Language) is adopted to prepare the concept node (i.e. course materials) based on the standard of SCORM [1].

Step 5. Finally, the personalized course materials are delivered to the student, and the related course materials are also recorded in the *CharID EC* in ***SP***. The implementation and algorithms will be discussed in section 4.

3.2 Dynamic Conceptual Network (DCN)

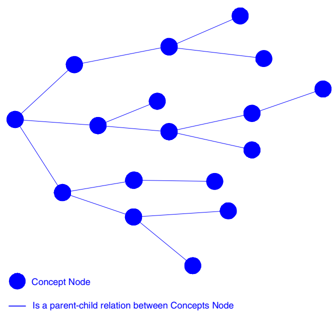


Fig. 3. Dynamic conceptual network

Definition: The Dynamic Conceptual Network (DCN) is a *hierarchical tree* to develop *dependent-relationships* among *learning concepts*. More specifically, *DCN* = (*V, E*) where *V* is a set of concept nodes; *E* is a set of edges between the concept nodes $E = \{(z, v) \mid z, v \in V\}$. In our system, each learning concept is stored as a *concept node* (Figure 3) of the DCN.

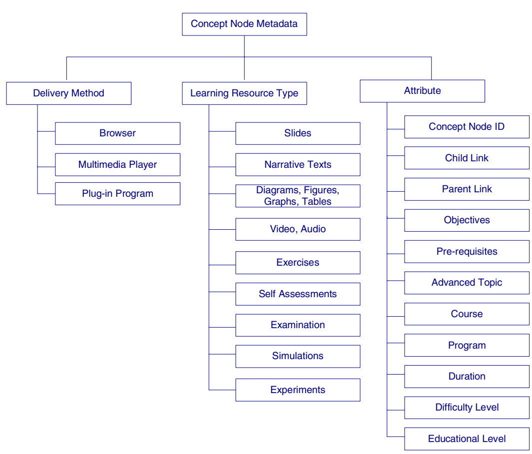


Fig. 4. Metadata of concept node

To facilitate the implementation of DCN, metadata of concept nodes is proposed as shown in Figure 4. It includes 3 categories: *delivery method, learning resource type,* and *attribute*. The delivery method is mainly to identify which kinds of tools (such as browser and multimedia player) to deliver the contents. The learning resource type is to identify the type of learning materials such as narrative text, slides, video, exercises, and so on. And the attribute is to facilitate the interoperation among the concept nodes. The semantics of the major attributes for the concept node mapping is explained as follows:

- Parent-child Relations. The dynamic conceptual network is built up by these inter-concept links. Each relation contains a *parent link* and *child link* that refer to the identities of other concept nodes.
- Objectives. This represents the information which to identify the relevant concepts of a particular learning objective.
- Difficulty Level. To serve the concept of personalization, this attribute is a parameter to decide whether the level of course materials is appropriate for a targeted student.
- Advanced Topic. This represents the information to identify the next level knowledge of the concept node.
- Pre-requisites. This represents the information to identify the previous knowledge to be required of the concept node.
- Duration. The expected length of time is required to complete the concept node.

Figure 5 shows three possible scenarios among the concept nodes. Scenario 1: no relationship between concept nodes A and B; scenario 2: concept nodes A and B with a relationship at an equal level (difficulty level), and scenario 3: concept node B is based on concept node A.

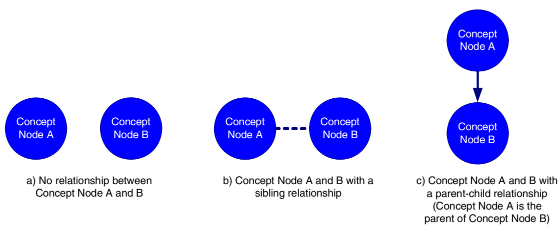


Fig. 5. Rules of association for the concept nodes

A rule-based mechanism [10] is employed for the concept node's mapping by using the following rules.

Rule A: // Figure 5a shows no relation between concept nodes A and B.
IF <no equal of parent-child attributes for the concept nodes A and B>
THEN <No relation between A and B>

Rule B: // Figure 5b shows that concept nodes A and B are of a relationship at an equal level.
IF <the parent links of concepts A and B in their parent-child attributes are of the same object reference>
THEN <A and B are of the relation at an equal level>

Rule C: // Figure 5c shows that concept nodes A and B are of relationship and concept node B is based on concept node A.

IF <the parent link of concept node B is of the same object reference as that of concept node A's child link >
THEN <A and B are of the parent-child relation; concept node A is the parent and concept node B is the child>

Based on these mechanisms, the course materials can be built up as a hierarchical framework for manipulation. To easily identify the relevant concept nodes for the learning subject is one of the advantages of DCN. For example, a scope of an ability test can be identified based on the attribute of pre-requisites for each concept node in the newly enrolled course. Likewise, it can easily provide the advanced learning materials based on the attribute of advanced topic for each concept node in the newly enrolled course.

3.3 Ability Test Mechanism

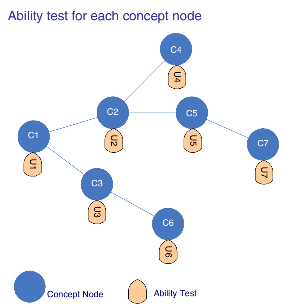


Fig. 6. Ability test for a particular learning domain

To facilitate the assessment of a student, DCN identifies the relevant concept nodes for the test based on the pre-requisites attributes of the concept nodes from the newly enrolled course as shown in Figure 6. The concept nodes (i.e. C_1 to C_7) are provided. Then, the ability test (i.e. u_1 to u_6) will be performed upon each concept node. The testing mechanism is discussed in the following sections.

3.3.1 Item Response Theory

Item Response Theory [8] is adopted as a core component in our proposed model. Normally, IRT is applied to CATs as a response model, in which item selection, as well as finalization criteria are based on two principles: 1) A student's performance in a test can be expressed in terms of the knowledge level which is measured as an unknown numeric value; 2) After an estimated knowledge level is defined, the performance of a student can be predicted when s/he answers an item, through a function called *Item Characteristic Curve (ICC)*. It explains the probability that a student with certain knowledge level θ has to answer the item correctly. Let us use θ as the trait (ability, skill, etc) to be measured. For a dichotomous item, the item response function is simply the probability $P(\theta)$ of a correct response to the item. A common assumption is that this probability can be represented by the three-parameter logistic function [8] as follows:

$$P(\theta) = c + \frac{1-c}{1+e^{-1.7a(\theta-b)}} \tag{2}$$

where

a is *discrimination factor*. It is proportional to the slope of the curve, *c* is a *guessing factor*, indicating the probability that a student is completely lack of ability ($\theta = -\infty$) but still answer the item correctly; *e* is the mathematical constant 2.71828; and *b* refers to *item difficulty,* meaning that when there is no guessing, *b* is the ability level where the probability of a correct answer is 0.5, whereas when there is guessing, *b* is the ability level where the probability of a correct answer is halfway between c and 1.

Under the proposed testing mechanism, *b* is a fixed variable so that the $P(\theta)$ can be changed from different students under the same situation. Moreover, the $P(\theta)$ will be applied to estimate learner abilities; the formulas are discussed in the next section.

3.3.2 Estimation of Learner Abilities

In order to estimate the ability θ of a given student, the ability test adopts the modified iterative Newton-Raphson method, using the formulas defined in [8], i.e.,

$$\theta_{n+1} = \theta_n + \frac{\sum_{i=1}^{n} S_i(\theta_n)}{\sum_{i=1}^{n} I_i(\theta_n)} \tag{3}$$

where

$$S_i(\theta) = [r_i - P_i(\theta)]\frac{P_i^{'}(\theta)}{P_i(\theta)[1-P_i(\theta)]} \tag{4}$$

$$I_i(\theta) = \frac{P_i^{'}(\theta)^2}{P_i(\theta)[1-P_i(\theta)]} \tag{5}$$

and θ_n is the estimated ability after the nth question. $r_i = 1$ if the *i*th answer was correct and $r_i = 0$ if the answer was wrong. For the initial ability $\theta_0 = 0$ was adopted. The Newton-Raphson model was chosen due to its easier implementation. Then, a satisfactory level of the previous study knowledge level is estimated based on $\theta_{n+1} \geq k$ where $k (0 \leq k \leq 1)$. If the value of *k* is closer to 1 then the satisfactory level is also increased. The determination of the *k* is based on the student pool and the item difficulty *b*. So *k* may be modified for different student pool and item difficulty.

4 Implementation and Related Algorithms

In this section, we discuss how to select the concept nodes for providing personalized course materials to individual students. As shown in Figure 7b, the system provides the concept nodes of a newly enrolled course with *Predefined Course Materials* $\{N_1, N_2, .., N_m\}$. In addition, all related concept nodes of SCMP $\{D_1, D_2, .., D_s\}$ are

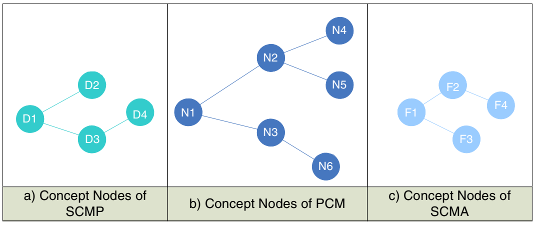


Fig. 7. Related concept nodes for the course of "Introduction to database"

provided for pre-requisite topics selection (Figure 7a) and all related concept nodes of SCMA $\{F_1,F_2,..,F_q\}$ are also provided for advanced topics selection (Figure 7c). For simplicity of our discussion, it is assumed students A, B and C have enrolled in a course called "Introduction to database". It is also assumed that *D_4.objective* = *N_6.objective*, *D_1.AdvancedTopic* = *F_1.Pre-requisites*, *D_2.AdvancedTopic* = *F_2.Pre-requisites*, *D_3.AdvancedTopic* = *F_3.Pre-requisite*, and *D_4.AdvancedTopic* = *F_4.Pre-requisites*. The duration of each concept node is assumed to be one hour.

The student expectations about the learning time and expected examination results are captured in Figure 8. The test result $\{u_1,u_2,..,u_n\}$of each $\{D_1,D_2,..,D_s\}$ (where s=4) is shown in the item response patterns of Figure 8, in which 6 questions are provided to all the students for each concept node (1 is correct, 0 is incorrect). The value of k is assumed to have at least 5 correct answers out of 6 questions. Based on these parameters, the construction of course materials algorithms can then be performed. The detailed algorithms will be explained in the coming section.

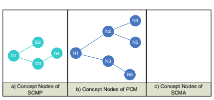
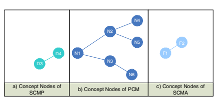
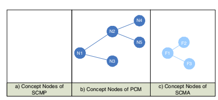
	Student A	Student B	Student C
Learning Expectation	***SP***(*A*, *ET*, 10 hours) ***SP***(*A*, *ER*, Pass)	***SP***(*B*, *ET*, 12 hours) ***SP***(*B*, *ER*, B)	***SP***(*C*, *ET*, 8 hours) ***SP***(*C*, *ER*, A)
Item response patterns (u)	u_1=(1 0 0 0 1 0) of D_1 u_2=(1 0 0 1 0 0) of D_2 u_3=(0 1 0 0 1 0) of D_3 u_4=(0 0 1 0 1 0) of D_4	u_1=(1 1 1 1 1 0) of D_1 u_2=(1 1 1 0 1 1) of D_2 u_3=(1 1 0 0 1 0) of D_3 u_4=(1 1 0 0 0 1) of D_4	u_1=(1 1 1 0 1 1) of D_1 u_2=(1 0 1 1 1 1) of D_2 u_3=(1 1 0 1 1 1) of D_3 u_4=(1 1 1 1 1 0) of D_4
Personalized course materials based on the proposed algorithms			

Fig. 8. Related parameters and results of the students A,B,C

4.1 Construction Course Materials Algorithms

To facilitate the course materials generation, a number of algorithms are proposed based on the formula of personalized course materials (cf. Figure 1).

4.1.1 Reduction of Concept Nodes from PCM

In this algorithm, reduction for concept nodes from the PCM is implemented. The purpose of this algorithm is to reduce student learning time and reallocate the time to other learning materials.

According to the ability test $\{u_1,u_2,\ldots,u_n\}$, it builds a rule that if $u_n >= k$ and the objective of concept node D_s is equal to the objective of the concept node N_m, then these concept nodes will be removed. The pseudo code of this algorithm is shown in Algorithm 1. As a result, only D_6 is removed from the PCM because only Student C has $\theta_{n+1} \geq k$ and $D_4.objective = N_6.objective$.

```
Begin RemovePCM ( )
 for i=1 to n do
    if ui >= k then
          for j=1 to m do
           if Di.objective = Nj.objective then
              Remove Nj from the PCM
           end
          end for j
    end
 end for i
End RemovePCM ( )
```

Algorithm 1. Removal of concept nodes from the PCM

4.1.2 Identification of Required Concept Nodes from SCMP and SCMA

For the purpose of identifying required concept nodes, our proposed algorithms need to cater for concept nodes of SCMP (Figure 7a) and concept nodes of SCMA (Figure 7c). The pseudo codes of the two algorithms are as follows.

```
Begin RemoveSCMP ( )
 for i=1 to n do
    if ui >= k then
          Remove Di from the SCMP
    end
 end for i
End RemoveSCMP ( )
```

Algorithm 2. Removal of concept nodes from the previous learning concept nodes (SCMP)

```
Begin RetainSCMA ( )
 for i=1 to n do
    if ui >= k then
      for h=1 to q do
        if Di.AdvancedTopic == Fh.Pre-requisites then
           Retain Fh from the SCMA
        end
      end for h
    end
 end for i
End RetainSCMA ( )
```

Algorithm 3. Removal of concept nodes from the additional learning concept nodes (SCMA)

According to Algorithm 2, the concept nodes (SCMP) can be removed if $u_i >= k$. For student A, all test results u are below k, so all the concept nodes of SCMP should be included. For student B, the test result (u_1 and u_2) of concept nodes D_1 and D_2 is equal to k so that D_1 and D_2 will be excluded, but the other test results (u_3 and u_4) of concept nodes D_3 and D_4 are below k, hence D_3 and D_4 should be included. For student C, all test results are equal to k, so all the concept nodes (D_1 to D_4) should be excluded.

According to Algorithm 3, the additional learning concept nodes (SCMA) can be identified if $D_i.AdvancedTopic == F_h.Pre\text{-}requisites$ and $u_i >= k$. For student A, all test results u are below k, so all the nodes of SCMA should be excluded. For student B, the test result (u_1 and u_2) is equal to k, hence F_1 and F_2 will be included; as the other test result (u_3 and u_4) are below k so F_3 and F_4 should be excluded. For student C, all test results (u_1, u_2, u_3 and u_4) are equal to k, so F_1 to F_4 should be included.

4.1.3 Adjustment Based on Student Expectation

In order to motivate student learning, the proposed concept nodes (based on Algorithm 1 to 3) should be adjusted based on student expectation. The following two algorithms are based on the student expectations to increase the exercises (Algorithm 4), so as to increase preparation works for the examination or reduce the proposed concept nodes based on the expected learning time (Algorithm 5).

If *proposed total learning time*† < *student expected learning time* **then**
  Step 1. *Additional exercise time = student expected learning time – proposed total learning time*
  Step 2. Additional exercises will be provided based on *Additional exercise time*
End

†proposed total learning time = duration of SCMP with Algorithm 2 adjustment + duration of PCM with Algorithm 1 adjustment + duration of SCMA with Algorithm 3 adjustment

Algorithm 4. Providing additional exercises based on student expectation

According to Algorithm 4, additional exercises will be provided if the *proposed total learning time* < *student expected learning time*. Based on the result of Algorithms 1, 2, and 3, the proposed total learning time for each student is as follows.

Student A = 4 (SCMP)+6 (PCM)+0 (SCMA) = 10 hours (It is equal to expectation)
Student B = 2 (SCMP)+6 (PCM)+2 (SCMA) = 10 hours (It is below the expectation)
Student C = 0 (SCMP)+5 (PCM)+4 (SCMA) = 9 hours (It is over the expectation)

Thus, additional exercises should be provided only to student B.

```
If proposed total learning time > student expected learning time then
   Step 1. Removal of the proposed concept nodes from Algorithm 3 (SCMA)
         Step 1.1 remove the qth concept nodes
         Step 1.2 proposed total learning time = proposed total learning time - Fq.duration
         Step 1.3 q = q – 1
         Step 1.4 if proposed total learning time > student expected learning time then
                        If q <> 0 then repeat step 1.1 to step 1.3 else go to Step 2 end
                  else
                        exit
                  end
   Step 2. Removal of the proposed concept nodes from Algorithm 2 (SCMP)
         If  proposed total learning time > student expected learning time then
         Step 2.1 remove the sth concept nodes
         Step 2.2 proposed total learning time = proposed total learning time - Fq.duration
         Step 2.3 s = s – 1
         Step 2.4 if proposed total learning time > student expected learning time then
                        If s <> 0 then repeat step 2.1 to step 2.3 end
                  else
                        exit
                  end
         end
end
```

Algorithm 5. Removal of concept nodes based on student expectation

According to Algorithm 5, the proposed concept nodes from Algorithms 3 and 2 may be removed if *proposed total learning time* > *student expected learning time*. Thus, F_4 is removed based on the expected learning time of Student C. Finally, the personalized course materials are identified as shown in the last row of Figure 8. The sample course materials are shown in Figure 9. In Figure 9, the DCN organization of the concept nodes is shown on the left hand side and the sample screen of the text-based, video-based, graphs-based materials are captured on the right hand side.

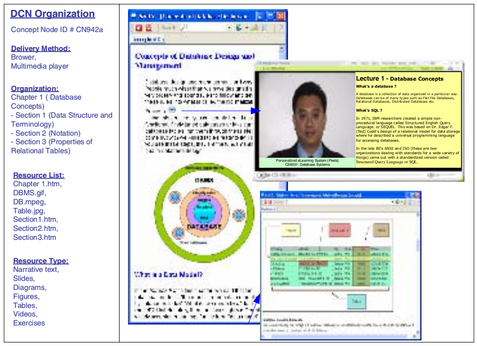


Fig. 9. Sample of personalized course materials

5 Conclusion and Future Research

In this paper, we have presented a model for personalized course materials generation based on student learning abilities and interests through a hybrid use of ability test, dynamic conceptual network, user-profiles, XML, and SMIL. Among the many desirable features offered by the proposed mechanism, the following ones are worth particular mentioning:

- **Ability test and learning expectation survey.** It provides a channel to let the system understand the students' abilities of the relevant learning subjects and their expectations. Therefore it helps reduce the expectation gap among the students and the teachers/system. In addition, the system can provide the tailor-made media-based course materials to the individual students to motivate their study continuously.
- **Dynamic conceptual network.** It provides a hierarchical tree for developing the inter-relations among individual courses. It facilities the course materials development dynamically based on the students' learning abilities and interests. Through the course materials generation mechanism, it can also identify individual students' weaknesses and then provide relevant materials in order to achieve their learning goals.

Currently, we are working on the proposed model to collect real user comments and perform user analysis on the Internet. The evaluation framework will be based on two groups of students in a class, where the first group of students will adopt our proposed model and the other will use the traditional e-learning materials. Evaluation will be focused on the learning ability, learning time, assessments scores, and etc.

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Taking Blog as a Platform of Learning Reflective Journal

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Abstract. Thinking is as important as learning. It is one of important and effective learning approaches by recording and reflecting student's own learning attitude and learning performance and referring to others' learning portfolio daily. Although many of students know this approach, but seldom of them put this approach into action owing to the problem of preserving content of reflection and learning portfolio. In this paper, a networked learning reflection mechanism based on blog service is presented. Students can make their learning reflection and view others' with ease. An experiment was conducted at an Institute of Technology upon system completion. The experimental results show that there is a positive correlation between students' learning performance and attitude of learning reflection. It reveals that students who have better learning performance tend to make more reflection on their learning. More than 80% of students express this mechanism has positive affection on their learning.

1 Introduction

People usually acquire knowledge through education. The competitiveness of a nation relies heavily on its citizen's educational or knowledge level. How to provide an adequate learning environment and system to its citizens is a very important part of the function of government. Researchers and educators have proposed and advocated many educational practices and theorems in the last century in an attempt to make student learning more successful.

In computer nomenclature, logging is a process used to record all events that have occurred on a computer or web system. This logged data, which is arranged in a chronological manner, serves as useful information to trace activities of system, such as system alerts, user login/logout time, or system malfunction records. Occasionally, computer users record their working diary in a similar manner. Information exchange became simple and convenient when the web became public. A computer user can easily share his/her logging information with others, and vice versa. In 1997, John Barger and Robot Wisdom coined the term "Weblog". They defined it as "A Web page where a web logger 'logs' all the other web pages he/she finds interesting" [1]. Since then, the term weblog has assumed various other identities, such as "web log", "blog", or "edulog". The most commonly used term is blog.

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Von Glasersfeld claimed that knowledge is constructed actively by individuals. Knowledge that isolates from people's own experience will not have any meaning to people [2]. Chang & Lo [2] view from this point and conclude that if learners do not actively participate into learning activity, the learning process is hardly to happen no matter how teachers work hard to teach. From learner's point of view, learners should adjust their learning direction by understanding their learning behavior through reflection on reflective journal during knowledge construction process. In such a way, the predefined objectives are likely achieved. This viewpoint conforms to Yancy's viewpoint [3]. Yancy described reflection as simultaneously looking forward (to goal that might be obtained) and looking backward (to see what has been accomplished) [4].

Educational institutions have been implementing reflective journals for more than a decade around the world [5]. Occasionally, people use some other similar terms such as learning reflection, learning reflection, log-book entry, diary writing, or simply personal journals. Woodward [5] developed an assessment procedure through the use of reflective journals and portfolios that allows final semester students to track their growth. In this settlement, students who have completed this assessment have commented that they have learned more through this assessment than from any other such activity. Kember et al. clamed that successful professionals need to reflect upon their actions has been widely accepted [6]. The reason is that most tasks they perform involve novel elements to which there are no defined solutions. Accordingly, develop students' abilities to reflect upon their actions is one of points course educating professionals should aim to.

Shuman, Besterfield-Sacre, & Miller claimed that reflective journal could be kept electronically and code using qualitative analysis software [4]. Lin & Kuo took a preliminary study on using blog as a platform for learning reflection and found that students are willing to use such a networked based platform [7]. To investigate how such a networked mechanism affect on student learning, another blog system was built and a serial experiment were conducted.

2 BLOG

Web-based learning came into vogue with www service. The emergence of blog lets everyone have an opportunity to become a journalist. With the convenient editing tools of weblog and the expansion of network connections, people can share their own thinking and comments with others around the world. Blog is a kind of media in which people can spontaneously express their own viewpoints and get support from others holding the same viewpoints. Chou [8] stated that "weblog is a more delicate record of learning, thinking and working. The author may improve writing skill and thinking performance through daily data sorting and writing". We believe the greatest advantage of blog is sharing and interaction, which further promotes professional sharing and cooperation. Blogspace is a plentiful and versatile social environment in which different layers of learning are allowed. At the bottom are the individual bloggers, who can be defined in terms of age, geography, and interests. In the middle is a web of friendships between pairs of bloggers. At the top is the evolution of activity that can be tracked over time [9].

Generally speaking, there has been no official definition of a Blog term or a Blog website. If a website constructor (called webmaster) wanted to share information and website content with others in a convenience and public way, then it was a kind of Blog. There was no clear limitation or definition about how to share. The owner of a blog shared content in the form of text, digits, symbols, graphics, or audio/video. Nowadays, there are more rigorous definitions. They refer to some articles which satisfy the following conditions:

Aggregation: These articles must be processed and deposited in a specific manner. They may be strictly organized by time, or they may be classified in another way.
Static link: These articles must be publicized on the network, to let other readers directly access them through fixed and invariable website links (URL). This implies that accessing these articles is direct and public.
Timestamp: these articles should carry a timestamp which is the time of publishing.
Date heading: These articles must have a date heading; this means they could be in succession, or the content will possibly relate to certain space or time background.
Generally speaking, a blog has following features:
Trackback: Trackback, which was introduced by Movable type in 2001, automates cross blog talk. Trackback allows bloggers to ping other weblogs, placing a reciprocal link (a trackback) in the entry they have just referenced.
Syndicate: Import other's blog into bloggers own blog.
Ping: When people cite an article, Ping will inform the author of this article simultaneously that his/her article is being cited. Ping function will also send some of your information to the pinged website, such as URL and timestamp.
RSS: With a blog system, RSS (Really Simple Syndication) is a necessary function. RSS is a simple link for publishing and transferring which transfers information into specific XML format. It is similar to published news. From the readers' point of view, RSS makes a blog system more convenient. If a blog system has RSS functionality, the reader can actively subscribe interesting topics or content through RSS feeds, which in turn reduces the time for searching and querying information significantly.

Cayzer [10] pointed out the following challenges that would be faced by people trying to develop a system which was capable of aggregating, annotating, indexing, and searching snippets in a network community:

- ease of use and capture
- decentralized aggregation
- distributed knowledge
- flexible data model
- extensible
- inference

Nardi, Schiano, Gumbrecht, and Swartz [11] interviewed 23 people, 16 men and 7 women, ages from 19 to 60, who all lived in California or New York and were well-educated, middle-class adults in school, employed in a knowledge based job, or working in an artistic field. They found five major motivations for blogging: documenting one's life; providing commentary and opinions; expressing deeply felt emotions; articulating ideas through writing; and forming and maintaining community.

3 System Implementation

In order to check whether the proposed blog system is suitable for learning reflection blog, a system was constructed with PLOG system. PLOG is a blog platform based on PHP and MySQL. The earliest version of PLOG was made public by Oscar Renalias in June 2003. PLOG has been renamed to LifeType in 2005, the newest version of LifeType is V1.0.3 [12]. The objective of PLOG is ease of use and extensibility. It has a powerful template system built on a Smarty template engine to generate templates for users. Through a program code, the present template separates from PHP program code, which makes the system highly flexible and users can customize their own templates in a safer way. The original PLOG system was not suitable for educational purpose, but some modifications were made to cope with this problem. Bloggers can now customize their own blog in a more personal way with template. Regarding to educational objective, in order to let students view and respect peers' learning reflections and give comments to them with ease, a more uniform and suitable interface was constructed. A snapshot of this interface is shown in Figure 1. On the homepage of this system, several useful links are listed:

- A link to the homepage of Blog;
- A link to all available student blogs;
- A administrative interface;
- A customer service center;
- A full text search for all blog;

Fig. 1. Snapshot of user interface

4 Experiment Design

4.1 Experiment Description

Learning reflection is a part of learning. Students can review their learning status and performance by regular reflection, but it is through reflection on the strengths and weakness illustrated by the portfolio, that effective learning strategies can be developed. However, since reflection requires a higher order of thinking, and most students are not accustomed to using critical thinking in this way, some of the important benefits of the system are lost. The essence of blog exactly fits into this task. In order to study the system's impact on student's learning; an experiment was conducted at a college in Taiwan. The course period was 18 weeks during the fall semester of 2004 and the course title was The Principles of Microprocessing. The students were junior and Automation Engineering major. There were 76 students, 75 of them male. At the beginning of the course, the teacher requested that students record in their learning reflection blog weekly. In addition, every student was to give feedback to their peer's learning reflection. The teacher also encouraged the students to extensively study the learning content, and share with classmates through this mechanism. In order to encourage students to take a chance in reflecting and recording in their learning blog, a reward was promised to all those who participated fully.

The teacher sent students a questionnaire about system usage after eighth week in order to analyze their responses and comments. At the same time, the first assessment of learning performance was conducted. This assessment had two parts. The first part was about the midterm exam and was an ordinary assessment; in the second part, the number of meaningful reflections (messages) or feedback messages each student made were quantitatively counted. The teacher also reminded the students that the activity in the blog was part of the learning activity and would be included in their learning assessment. At the end of course, a second assessment was conducted in which the content was assessed in the same manner as in the first. Data analysis was performed right after the experiment's completion. First of all, the correlation between students' learning performance and student's level of activeness on blog was tested. Learning performance had two levels:

- Learning performance **without** taking the learning reflection into consideration, which is an ordinary assessment (it includes midterm, final term, quizzes, and homework assignments)
- Learning performance **which** took learning reflection into consideration. To quantitatively analyze the level of activeness on blog, the data had to be quantification. Only meaningful and learning content-related reflections which were equally distributed over the whole semester were counted and scored.

Then, the results of the questionnaire survey were analyzed to try to understand the students' feelings and responses about the use of blog and associated reflection activity.

4.2 Experiment Result

By using SPSS 10.0, a Pearson correlation analysis was performed to check the correlation between learning performance **with** taking the score of learning reflection into consideration and the number of meaningful reflections (messages) or feedback messages each student had made. The results are shown in table 1. There was a significantly positive correlation between these two parameters as shown in figure 2. To make detail analysis, another Pearson correlation analysis was performed to check the correlation between learning performance **without** taking the score of learning reflection into consideration and number of meaningful reflections (messages) or feedback messages each student had made. The results are shown in table 2. These results also show a significantly positive correlation between these two parameters as reflected in

Table 1. A comparison between number of reflections and learning performance

		times	score
times	Pearson Correlation	1.000	.653**
	Significance		.000
	count	76	76
score	Pearson Correlation	.653**	1.000
	Significance	.000	
	count	76	76

** Correlation is significant at a significance level of 0.001 (two-tailed).

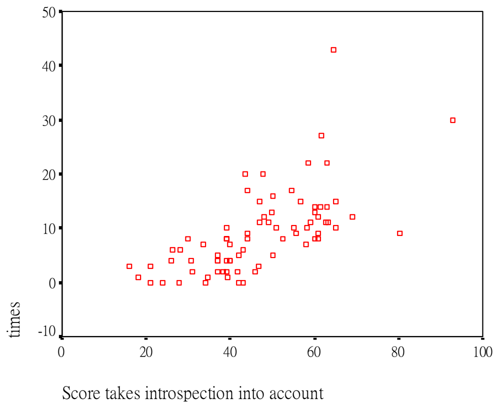

Fig. 2. A comparison between the number of reflections and learning performance

figure 3. We can therefore conclude that learning reflection has a positive effect on students' learning performance (positive correlation). The teacher emphasized that blog activity was to be a part of the assessment in the eighth week. To check to see if this announcement had any influence on student performance, a correlation analysis between the difference of accumulative number of reflections before and after the eighth week and learning performance was conducted. The results are shown in table 3 and figure 4. It shows that for the difference of accumulative reflections there is a positive correlation with learning performance. We can therefore conclude that students who have higher learning performance tend to take more time on learning reflection.

Table 2. A comparison between the number of reflections and learning performance without taking reflection into account

		times	score
times	Pearson Correlation	1.000	.464**
	Significance		.000
	count	76	76
score	Pearson Correlation	.464**	1.000
	Significance	.000	
	count	76	76

** Correlation is significant at a significance level of 0.001 (two-tailed).

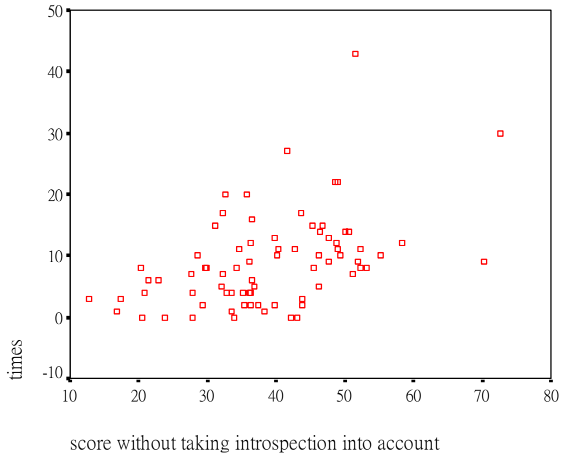

Fig. 3. A comparison between times and learning performance without taking reflection into account

Table 3. A comparison between the difference of the number of reflection and learning performance

		difference	score
difference	Pearson Correlation	1.000	.301**
	Significance		.000
	count	76	76
score	Pearson Correlation	.301**	1.000
	Significance	.000	
	count	76	76

** Correlation is significant at a significance level of 0.001 (two-tailed).

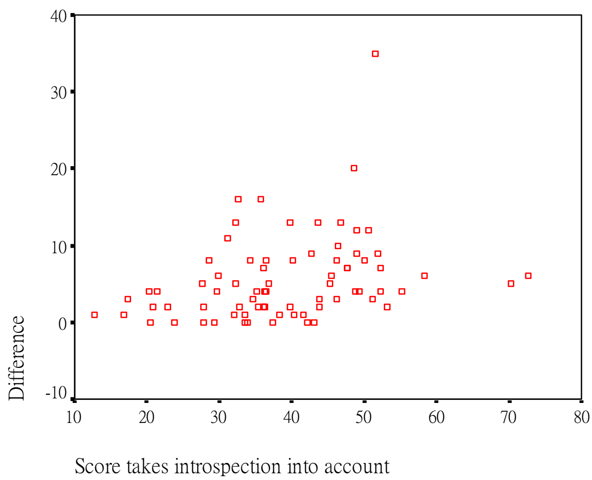

Fig. 4. A comparison between difference and learning performance

4.3 Questionnaire Result Analysis

By investigating the questionnaire results, it was found that most of students do not have very much experience in using learning reflection regularly, especially in such a public fashion. To encourage students to take part in this experiment, a reward was given to students who made meaningful reflections. A special reward was given to students who gave constructive and meaningful feedback or made comments on other classmate's reflections. About 88% of the students felt that expressing learning reflections on a blog was a positive experience. About 88% of the students felt that learning reflection had a positive influence on their learning. Over 90% of the students looked forward to receiving their classmates' comments and feedback on their reflections. More than 86% of the students felt that viewing classmates' learning reflection on blog has a positive influence on their learning. In summary, most of students felt that this system had a positive influence on their learning. They also look forward to receiving classmates' comments and feedback. Finally, they felt this system was easy to use. From the results of the survey, the objectives of this system have been achieved.

5 Conclusion

With the help of information technology, a teacher can more fully understand a student's learning status, and intervene when or where necessary. That students have better learning performance is one of main objectives of every teacher and researcher in the e-learning domain that each does his/her best to achieve. In this paper, the authors have taken popular blog technology and constructed a platform in which each student can express his/her learning reflections, submit homework assignments, and share this information with their peers. 76 junior college students participated in an experiment during the fall semester of 2004. Upon completion of the experiment, a correlation analysis was performed between learning performance and the number of meaningful reflections (messages) or feedback messages each student made during the experiment. The results showed a positive correlation between them. This means that students who had a higher learning performance were also more active on blog. It may also conclude that students who had a higher learning performance tended to have better reflection practices. In order to better understand whether the promise of reward induced students who had a lower score on learning performance to express their learning reflection on blog, another correlation check was done between learning performance **with** taking the score of learning reflection into consideration and number of meaningful reflections (messages) or feedback messages each student has been made. The results also showed a positive correlation between them. Since the teacher emphasized that the activity on blog was to be part of the formal assessment during midterm week, a correlation analysis between the difference of accumulative numbers of reflections before and after midterm and learning performance was conducted. The results showed that there was a positive correlation between them. From this, we can infer that the enticement of score has no significant impact on promoting learning reflection on blog for students who have lower learning performance.

In contrast, about 88% of students felt that learning reflection had a positive influence on their learning. This result seem to conflict with the above conclusion. The research found that students seldom give feedback or comments on other student's reflection. One possible reason is that Chinese students are culturally unfamiliar with giving encouragement or constructive feedback messages on a fellow classmate's reflection or thinking. This situation tends to reduce the impact of blog on learning performance. Some possible explanations are as follows:

The Principle of Microprocessing is a professional subject in which students must not only study hard in order to get better learning performance, but must also have sufficient technical knowledge about digital logic and microelectronics etc. It is not enough to merely express their learning reflections on Blog if students were to improve their course performance, other factors must be considered and supplementary approaches considering those factors must be developed.

Not all of students willingly expressed their learning difficulties in detail on blog. If the number of students who need a teacher's help is large, the teacher may be overextended. In addition, students seldom gave feedback to their peers; therefore insufficient help was provided to them. For this reason, another leaning mechanism should be introduced such as a networked mastery learning system [13] to promote students' learning performance.

Student's learning motivation is a key factor in affecting learning performance. For those students who have lower learning motivation, a well-designed learning assistance mechanism may only slightly improve learning motivation, and may not have a significant impact on learning performance.

In summary, from the results of the questionnaire analysis this system has a positive influence on students' learning performance. Students who have higher learning performance tend to use reflection when learning and this convenient mechanism, Blog, satisfies their requirement. This mechanism also has a positive influence on students who have lower learning performance. We believe that it will provide more assistance to students who have lower learning performance if other learning assistance approaches are incorporated into it, and if teachers can pay closer attention when viewing student's learning reflections. Blogs are one of hottest issues on the web at this time, with many enterprises investing a lot of manpower and finance to improve functionalities of blog. We can expect that blog with more powerful functionalities (such as mobile computing, intelligent, and multimedia functions) will have an even more positive impact on learning.

Finally, there is one thing worthy of mentioning. During the following semester, some students, who had used blogs on previous semester, continued to express their learning reflections week by week automatically. In that course, the teacher does not mention blog; and it was not a part of the formal assessment. We believed they continued to do so because they found that the regular use of reflection had a positive impact on their learning, and can be considered as evidence that this approach does indeed have a positive influence on students' attitude and learning.

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Intelligent Knowledge Recommendation System Based on Web Log and Cache Data

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Abstract. Personalized recommendation service based on the web is the current research focus of intelligent information retrieval and distant education. In this paper, an intelligent recommendation system is proposed. The system depends on the mining results of Web log and cache data, comprehensively evaluates the influence of navigation times, browsing period, and page volume. Through effective classification of the interested pages from Web log and cache data, the interest model of different user groups is established. Meanwhile, a method for recommending the valuable knowledge is put forward, which combines the approach of content-based filtering and collaborative filtering. Experiments demonstrate that the proposed recommendation method is feasible and effective.

1 Introduction

With the development and popularization of Internet technology, Web has turned into the service center of information resources. How to mine and recommend information and knowledge from fully complicated and exponentially increasing numbers of web pages that are appropriate for individual learner has been always the focus of E-learning research. Though searching engines could greatly improve the searching efficiency, the general purpose searching engines could not fully meet the searching demands from different backgrounds, various intentions and distinct times. So, with users' individual information and browsing behaviors, a user interest model could be established through mining user interests and preferences. Thus an agent-based intelligent knowledge recommendation system could be constructed from current browsers to conduct user's browsing and learning processes. The primary task of the knowledge recommendation system is the accuracy of the recommending results, since frequent recommendation of uninterested information to user would affect user's loyalty. The next in importance is that the recommended information should cover the user' actual interest ranges to the best, maximally satisfying individualized intelligent learning.

Currently, there are many individualized knowledge recommendation system [1], within which the Letiaia system [2] developed by MIT is the most influential one. This system could infer user interests and establish user interest model through tracing user's browsing actions. By analyzing the contents of the web pages and comparing the contents with the user interest model, the system could

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locate the web pages that might be interesting to the user and recommend those pages' URLs in a separate window. The LIRA system [3] developed by Stanford has the function of active serving. The system would choose and provider user the web pages with high similarity to his interest model during the process of browsing. Then the system would require user to definitely evaluate those pages. The system would modify the searching and choose the right initial point according to the relevant feedbacks from the user and adjust the user interest model. Personal Web Watch system [4] developed by CMU would speculate the degree of interest of leaf node web pages, mark the hyperlink of pages that user might be interested in and recommend those pages for accessing when the user is browsing the Web. Once the user is offline, PWW would analyze the page contents through visited pages and URL, update user interest model and process page recommendation for guiding the next time browsing.

The technical realization of knowledge recommendation system could be categorized into three methods: association rule method [5], collaboration-based filtering method [6-7] and content-based filtering method [8-9]. Association rule method creates the rules according to user's static features and dynamic attributes, reckon the pages that user has not visited but would have interests by applying rule matching, sort those pages by the degree of rule support and recommend user the first N items of web pages. Collaboration-based filtering method first applies user clustering techniques to locate N most similar neighbors. Then the method forecasts current user's interest and recommends relevant information on the basis of similar users. This method is a relatively successful one of current individualized recommendation systems, but in actual implementation it always encounters the problem of sparseness and extendibility. Content-based filtering method recommends information by comparing resources with user interest model, and its key problem is the extraction of user interest model and the calculation of degree of similarity.

This paper proposes the combined mining of Web log [10-11] and cache data. Through accumulating the pages that user interests in, with the web page classification algorithm based on KNN and SVM, user interest model of multiple aspects could be constructed and similar web pages could be recommended.

This paper is organized as follows. Section 2 presents the preferential path mining based on Web log. From this basis, the web pages extraction based on cache data is presented by acquiring the pages user interested in. Section 3 presents a combined web page classification algorithm based on SVM and KNN. Section 4 describes a knowledge recommendation system and its experimental results. Section 5 is the conclusion, describing problems and possible solutions.

2 Web Log and Cache Data Mining

2.1 Web Log Mining

Web log contains information about the pages, time, ID when user browses web pages. By mining those web log data, user browsing interest could be discovered. Web log Mining includes data preparation and interest model mining.

Data Preparation. Data preparation focuses on transforming web log into reliable data to be mined, including data reduced, user identification, session identification, transaction identification, and etc.

Data reduced is the process to eliminate redundant information in the web log which is irrelevant to data mining, such as the records of GIF, JPEG and CGI suffixes, request method, error code, transmission protocols, and etc. After the processing, only the information relevant to user's browsing interests are retained, such as the IP address, user ID, requested URL, access time and bytes.

Since the involvement of user privacy, user identification could not simply depend on the ID number. Considering the existence of firewall, local cache and proxy server, currently user identification is realized by using cookies and IP address with distant agent binding technologies [13]. Besides those methods, web topology and web page classification information are fully utilized to improve the efficiency of user identification.

Session identification refers to the continuous web page requests from the same user, and it aims at categorizing the pages every user has visited into pairs of user browsing actions. Now, time stamp is widely used to process the session identification. If the time difference of user page accessing exceeds a certain time stamp, then it is regarded as the beginning of a new session.

Transaction identification further categorizes the session into transactions of certain semantics. Transaction is composed by multiple navigation pages and a content page. Navigation pages are the path to reach the content page, or could be composed solely by content pages. A transaction is determined by the number of hyperlinks in the page and user's browsing time. At the end, all the user transactions are stored in the transaction database of user browsing for further mining.

Interest Model Mining. After synthetically considering the browsing frequency and browsing time, document [11] proposed an algorithm on mining the user interest path correctly. But our research discovers that user browsing time could not accurately reflect user interests and user browsing time is directly related to the text length of the web page. So this paper comprehensively takes browsing frequency, browsing time and text length into consideration, and proposes a modified preference method to accurately reflect user browsing interests.

Preference. Let us denote U as the set of URLs of all web pages, and denote W as the set of all browsing sub paths. If there exists $w \in W$, for $\forall x \in w$ ($\mathcal{X}$ is the browsing sequence of pages composed by $\forall u \in U$, where the jth browsing pages is called j bit.) the first m bits of those pages are identical, but since there are n different browsing pages for the $m+1$ bit, called n different choices for bit m, and the preference of kth ($k = 1, 2, \cdots, n$) choice is defined as:

$$P_k = \frac{C_k \cdot V_k}{\left(\sum_{i=1}^{n} C_i \sum_{i=1}^{n} V_i\right) / n^2} \tag{1}$$

Where C_i represents the support of the ith choice, meaning the number of times entering next page through the ith choice. V_i is defined as: $V_i = \lfloor URL.T_i / URL.S_i \rfloor$, where $URL.T_i$ represents the sum of discrete time entering next page through the ith choice. Discrete time refers to applying discrete technology to the representation of user browsing time, dividing time attributes into intervals and using the index of intervals to denote real time. Suppose that the time spent on a certain page could be categorized into four types: passing, simple viewing, normal viewing and interest viewing, then $URL.T$ could be discrete into:

$$URL.T = \begin{cases} 1, & 0 < t \leq URL.T_{max\_passing} \\ 2 & URL.T_{max\_passing} < t < URL.T_{max\_simple\_viewing} \\ 3, & URL.T_{max\_simple\_viewing} < t < URL.T_{max\_normal\_viewing} \\ 4, & URL.T_{max\_normal\_viewing} < t \end{cases} \quad (2)$$

Where $URL.T_{max\_passing}$, $URL.T_{max\_simple\_viewing}$, $URL.T_{max\_normal\_viewing}$ represent the predetermined maximum passing time, maximum simple viewing time and maximum normal viewing time respectively. $URL.S$ represents the text length browsed.

Take P_k as the evaluation for the corresponding URL that user has accessed and construct the user access matrix.

$$\begin{bmatrix} & URL_1 & URL_2 & \cdots & URL_n \\ USER_1 & P_{1,1} & P_{1,2} & \cdots & P_{1,n} \\ USER_2 & P_{2,1} & P_{2,2} & \cdots & P_{2,n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ USER_m & P_{m,1} & P_{m,2} & \cdots & P_{m,n} \end{bmatrix}$$

Where the row vector represents the evaluations made by the same user for different web pages, while the column vector represents the evaluations made by different users for the same web page.

2.2 Cache Data Mining

Under common circumstances, browser uses high speed cache to store the recent and most visited web pages in the local machine. When user revisits those pages, browser would search the corresponding pages in the local cache first. Once the page is located in the cache, the browser would check whether there have been any updates of the page on the Web server. If there have been no updates, then the browser would read directly from the local cache, otherwise the browser would send requests to the Web server.

In order to improve the efficiency and speed of cache data mining, the cache data should be processed under similar operations that performed on Web log, such as data cleansing, namely deleting irrelevant scripts, images of GIF and JPEG suffixes. Since it is not suitable to perform online forecast through cache data mining, mining to find the pages that user would be interested in could only be done at regular times on historical cache data after cleansing.

3 SVM-KNN Web Page Classification Algorithm

Taking the above-mentioned web pages extracted from web log and cache data that user would be interested in as source data, we adopt SVM-KNN web page classification algorithm and construct the user interest model of multiple aspects. Following is the discussion on key techniques of the algorithm.

3.1 Web Page Representation

Web page information is mainly composed by two typical types of information. One type is the long text of page content, which is the main content of the page and normally should not be neglected. But the length of the text to be considered as long text is a problem of experiences without definite conclusions yet. Another type is the content between tags. For example, the words between <Title> and <Title> represents the title of the web page, which is the title for the whole page; the words between $< h_n >$ and $< h_n >$ is the paragraph title (n is an integer between 1∼6), representing the page contents from various aspects; the words between tags such as <B>, <I>, <U> show different levels of importance; the attribute Keywords of tag <Meta> provides the keywords for the web page, representing the content scopes the web page related to; and the attribute description provides the description of the whole web site made by the web provider.

This paper uses vector space to describe web page information. Let us first denote the tag set S=$\{$TITLE, H_1, H_2, H_3, H_4, H_5, H_6, B, U, I, URL, Meta, Normal Text$\}$ and the weight set $W = \{W_\Lambda | \Lambda \in S\}$, then we calculate the absolute word frequency for every word according to the occurring times in various vectors of the tag set and the relative weight defined in the weight set. After that we use the following TF-IDF formula to calculate the relative word frequency.

$$W(t,\overline{d}) = \frac{tf(t,\overline{d}) \times \log(N/n_t + 0.01)}{\sqrt{\sum_{t\in\overline{d}}[tf(t,\overline{d}) \times \log(N/n_t + 0.01)]^2}} \tag{3}$$

Where $W(t,\overline{d})$ is the weight of word t within web page $\overline{d}$, $tf(t,\overline{d})$ is the absolute word frequency of word t within web page $\overline{d}$, N is the total number of web pages used for training, n_t is the number of pages in the training set with the occurrences of word t, and the denominator is the normalization factor.

3.2 Feature Extraction

Since the dimensions of the vector space obtained from the above-mentioned web page representation method is too huge, and would definitely influence the system efficiency. Thus the words without any contributions to the classification procedure should be eliminated, such as various modal particles. This paper adopts mutual information to perform feature extraction, and the calculation formula is listed below:

$$
\begin{aligned}
I(C;W_t) &= H(C) - H(C|W_t) \\
&= -\sum_{c\in C} P(c)\log(P(c)) + \sum_{f_i\in[0,1]} P(f_t)\sum_{c\in C} P(C|f_t)\log(P(c|f_t)) \\
&= \sum_{c\in C}\sum_{f_t\in[0,1]} P(c,f_t)\log(\frac{P(c,f_t)}{P(c)P(f_t)})
\end{aligned}
$$

Where $P(c)$ is the number of web pages labeled c divided by the total number of web pages of the training set. $P(f_t)$ is the number of web pages containing W_t divided by the total number of web pages of the training set, and $P(c, f_t)$ is the number of web pages with label c that contain Wt divided by the total number of web pages of the training set.

3.3 SVM-KNN Algorithm

SVM classification algorithm is a relatively effective algorithm available for text classification. The primary error points are located near the separation interface of the sample space. According to SVM theory, the samples near separation interface are basically support vectors, and concurrently SVM could be considered as the Nearest Neighbor (Nearest Neighbor, NN) classification container [12] with only one representation point for every class. So, through the combination of SVM and NN, calculate the distance between the sampling x to be distinguished and the optimal hyperplane. If the distance is bigger than the predefined threshold, then apply the SVM classification; otherwise, apply the KNN classification. The detailed classification algorithm is as follows:

Step 0: use any types of SVM for classification; get the corresponding support vector, coefficient and constant b.

Step 1: define T as the test set, T_{sv} is the set of support vectors$K$ is the number of KNNs.

Step 2: if $T \neq \phi$, set $x \in T$; if $T = \phi$, stop.

Step 3: using the following formula to calculate $g(x) = \sum_i y_i \alpha_i K(x_i, x) - b$

Step 4: if $|g(x)| > \epsilon$ simply calculate $f(x) = sgn(g(x))$ as the output. if $|g(x)| < \epsilon$, substitute into KNN classification algorithmtransfer the parameters x, T_{sv}, k, and the returns would be the output.

Step 5: $T \leftarrow T - \{x\}$, go to step 2.

4 Experimental System

4.1 Architecture of Knowledge Recommendation System

In order to effectively evaluate the above algorithm, an individualized intelligent knowledge recommendation system is established. The intelligent agent could trace user actions, actively gather user cache data and send them to the server. Then the user model learner on the server side could extract relevant user interest model from those data, combined with the web log. The architecture of the system is showed in Figure 1.

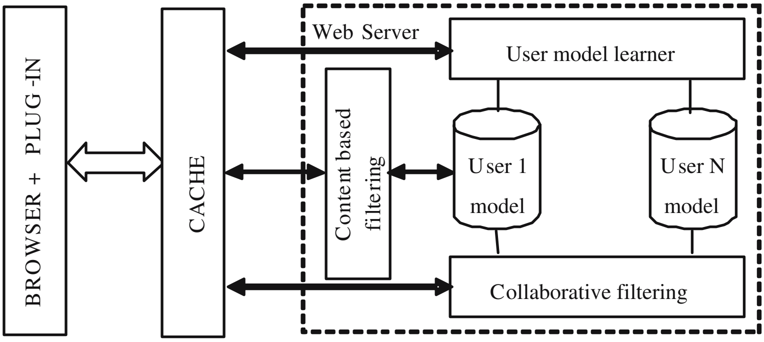

Fig. 1. System Architecture

Experimental system could match the active user's short period visiting with the user interest model of multiple aspects obtained from the last section, thus realizing the content-based collaboration filtering. In the meantime, the system could forecast the next most possible web pages to be visited through collaboration filtering among multiple users. The system sorts the sequence of those pages according to the scores obtained and attaches the list of those pages to the user requested page for recommendation.

4.2 Experimental Results

The experiment is divided into two steps. The first step would be a test on an Intranet prototype system, while the second step would be a test conducted on an educational web site for undergraduates and teachers. The experiment procedures and results are shown as follows.

Step 1. This experimental system takes Hangzhou Tourism web site (http://www.gotohz.com) as prototype. The system was set up in the Intranet environment within the laboratory, but this system was simultaneously updated with the real portal web site. There were totally 83 participants, two classes of juniors majored in computer science and technology. The experiment demanded that within 2 months, each participant must browse the web site with no less than 60 hours on the basis of individual interests.

During two months' experiment, there were totally 61 participants who had spent over 60 hours on browsing. After another two weeks, most web contents had been updated, and we took those 61 participants once again under test. The test was separated into two steps and three topics, namely travel information, history and culture and amusements. The first step demanded that each participant freely browse each of these three topics for 15 minutes. After that, everyone scored the top five texts recommended by the system, a full mark meant a completely match of browser's intention. The second step was to perform the same experiment after 30 minutes' browsing. The scores were 71.4 and 84.3 for the first step and second step respectively. The experimental results are relatively satisfactory, making the proposed algorithm feasible.

Step 2. The accuracy of the recommendation system is tested on an educational web site for undergraduates and teachers. The web log on the server is segmented into 6 testing samples with the size of 500KB, 1000KB1500KB, 2000KB, 2500KB and 3000KB respectively, and the standard of 5 recommendation pages and 10 recommendation pages are adopted respectively. The experimental results of the comparison of the average page views between cluster-based recommendation and the recommendation presented by this paper is shown in Fig 2.

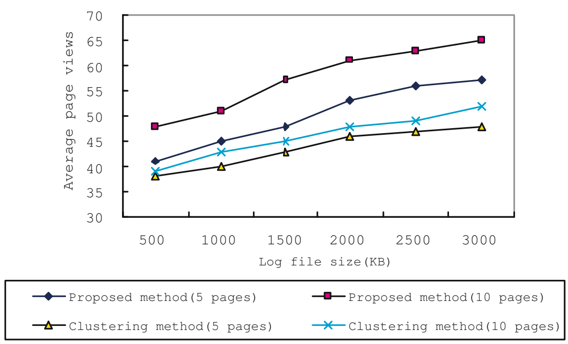

Fig. 2. The comparison of the average page views of two recommendation systems

The experimental results show that for every testing sample, the algorithm proposed by this paper has higher average page views. With the increase of the recommendation pages, the average page views of different algorithms also increase.

5 Conclusions

With the rapid development of web applications and web scale, applying data mining technology to web individualized recommendation system is a challenge for further research. This paper makes a systematic research on web log and cache data mining, discusses mainly the user interest models based on web log and cache data, and classifies the interest models. The system could recommend similar content-based pages with the help of short period visiting history. The system could also recommend other pages that users might be interested in through user collaboration and realize the content-based filtering and collaboration-based filtering. The experimental results show the feasibility and effectiveness of this algorithm.

Because of various limitations, the algorithm could not be tested on other large-scale portal web site. The algorithm described in section 4.2 may have certain subjectivity, so further research would focus on improving the efficiency of the algorithm and conducting comprehensive test of the system. Meanwhile, visualized analysis of web log mining and model discovery of multiple web sites and realization of collaboration filtering and content filtering of multiple web sites would be the further research emphasis.

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Learning Patterns: A Mechanism for the Personalization of Adaptive E-Learning

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Abstract. E-learning through the web began as a service, by publishing some educational materials at websites. At the early stages, the learning process was carried out by browsing such a collection of educational materials and its effectiveness was based on the **presentation** of content in those materials. Customizing the presentation and interactivity of an e-learning application based on the users (which we call here personalization), should be done based on each learner's knowledge and learning experience. A learning pattern, mechanism presented in this paper, is a meta-level piece of information that can be used to achieve low coupling personalization in an e-learning courseware. A learning pattern, which is modeled on different levels of abstraction, is constructed based on the interaction of a learner with relevant materials and it is depreciated when he/she stops accessing such materials. In this paper, we also present how a learning pattern supports to define domain knowledge in SCORM compatible environment.

Keywords: Personalization, Adaptive e-Learning, Navigational Path, SCORM and Knowledge Modeling.

1 Introduction

Learning is the only thing next to breathing that we do continuously from the day we were born to the day we will die. By everything you do, say or think, you learn something. People have different definitions and views on learning but ultimately you will have to end up with a common phrase, "You cannot live a single moment without learning something." The methods of learning have evolved over time and they have come a long journey from the exercise book to the palm top computer with the advancement of technology. However, the basics still remain the same.

E-learning is a process of learning that takes place through a network, usually over the Internet or an intranet of an educational institute or a company. It has its roots in the not-so-attractive world of computer-based training (CBT), which appeared in the early '80s and used CD-ROMs to teach mostly technical skills to technical people. Lately, e-learning has evolved into a tool widely used in both the corporate and academic worlds. With the rapid expansion of the World Wide Web and other Internet based services, e-learning is becoming a tool for everyone's lifelong learning.

Learning is a highly personalized activity which varies based on the background knowledge of the subject, previous experiences (general and specific), motivation,

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preferences, context and other activities in which the user is engaged. Personalization is a process which would affect the learning of an individual at different levels [7]. First, it should identify specific skills and knowledge gaps and direct learners to the appropriate lessons or modules. Once a particular learning activity is started, it is possible to customize the presentation of learning materials according to factors given earlier in order to maintain an effective, efficient and continuous process of knowledge transformation. When the learner undergoes this change due to the knowledge acquisition, the values of all influencing factors of learning activity are also modified and such variations should be communicated to maintain an effective personalization process.

In this paper, we discuss a metadata based description which they name as a learning pattern, and how it can be built and utilized to achieve low coupling personalization while protecting the learner's privacy. In many traditional applications, personalization is considered as a tightly bound process which undertakes monitoring the user's activity and maintaining the user's profile. But if the learning service is provided by an unknown third party the learner will probably refuse to provide personal information that is simply needed for the personalized service described earlier.

Generally, the personalization is provided as an interface service to the user in a circular process. The success of this service depends on the corporation of three parties namely, the learner, author and facilitator. The author, who defines the sequencing order of lessons, should include enough metadata with each lesson in order to provide multiple sequences of presentation. The facilitator, who is the publisher of the copyrighted learning materials, will have to interpret the learner's learning pattern in order to decide the most effective sequence of the presentation in an e-learning course.

This paper is organized as follows. Section two describes issues with respect to learning content and packaging. In section three, we define learning patterns and section four illustrates how learning patterns can be used to realize personalization in an e-learning package. We then discuss details of SCORM standards and how learning patterns can support to define low coupling domain knowledge for the personalization of adaptive e-learning in section five. Finally, we conclude the paper stating benefits, limitations and the future of learning patterns in section six.

2 Learning Content and Packaging

If the content of a particular entity/object is supposed to provide learning to the people who will access or interact with that, it should provide information that could generate new knowledge in the learner's mind. However, this process is more complicated than what we anticipate, since the process of transforming information into knowledge heavily depends on the learner's personal status and the form of communication.

The learning content in a particular courseware should be structured according to learning objectives specified at the very beginning of the course [10]. Number of modules in a courseware is determined based on these overall objectives and each module is specified with number of sub-objectives. The advantage of these objectives is that the author can modify the courseware to add/delete new content when he/she wants to create a different version of the courseware for a new offering. Based on the sub-objectives of each module, the relevant number of lessons is determined. Generally, a sequence should be specified when lessons in a module are combined.

According to the instructional design principles [8], a lesson should not communicate many ideas in a single visual display. A single visual display is referred as a page in the e-learning courseware and a lesson may consist of one or more pages depending on what extent the author wants to present the relevant materials to the learner.

2.1 Learning Styles

A learning style is a mechanism to deliver a particular content in a lesson, based on the user's preferences and/or the most effective way to do so. This can be based on the learner's background knowledge and skills. In some other works, the personalization is discussed as the selection of a suitable learning style [8]. However, personalization should go beyond the mere selection of a suitable learning style.

Identifying and categorizing learning styles into a common set of styles have been done by a number of studies. The process of personalization can be started by selecting an appropriate learning style in a lesson such as visual/verbal, visual/nonverbal, Auditory/Verbal, Tacktile/Kinesthetic.

2.2 Learning Path

The structuring of learning content based on different levels of objectives, which is known as packaging is usually done by the course author. A package, which is the technical representation of an e-learning course, usually contains additional information about how amalgamated learning content should be sequenced in a presentation and some additional metadata to describe related learning resources. The learning path is a specific sequence of learning content [5][6]. Hence, a package may contain a number of learning paths depending on the author's metadata specification.

Sometimes, a particular learning path could be considered as a version of the course defined for a specific user group while still supporting common learning objectives. A simple knowledge pre-test could be used to determine which learning path is the most suitable at the beginning.

The size and scope of learning content that are combined to form an e-learning course is also a key consideration. For example, if a package is comprised of only a few learning assets, then it may not make any sense to define different learning paths. This issue is also very important in the reuse of learning content [2].

3 Learning Patterns for Personalization

A pattern is an abstract representation of knowledge in a particular context. It could be used to document a group of entities/objects at different levels of abstraction. At the same time, it could be used to identify a solution in a particular context. A learning pattern corresponds to such a representation with respect to an individual in the domain of his/her e-learning space. A learning pattern which has an XML type representation carries all information required for the personalization of the learning experience.

Since learning, which takes place with the interaction in the e-learning space, modifies the learner's knowledge, the corresponding learning pattern will also grow. This learning pattern is different from the static representation of the user's profile which just gathers metadata with respect to a pre-defined structure.

At the same time, it could provide information at different levels when required. In addition, the learning experience is interpreted to specify its content. A single user may have a lot of learning patterns with respect to the stream of subjects he/she is learning. This categorization can be done with respect to the scope of subject or classified interests of the learner. Hence, a learning pattern would be initiated whenever he/she takes the first course in a classified area of study/interest. The level of abstraction in learning patterns will be high at one end and it gives more details at other end.

Whenever the learner takes a related course in those classified areas, the corresponding learning pattern will be updated. But, with time it will be depreciated, since people usually forget what they know with the pass of time. Generally, someone's learning experience can be described as a collection of such learning patterns organized in a triangular model as shown in Fig. 1. It divides a learning pattern into three meaningful sections.

A learning pattern has three levels, namely upper, middle and lower levels. In the upper level, the abstraction is very high and it describes a particular learning experience in a summarized way. The middle level of a learning pattern extends the previous abstract definition using a structured description. The lower level organizes the user's learning experience captured based on his/her active learning [4] activities.

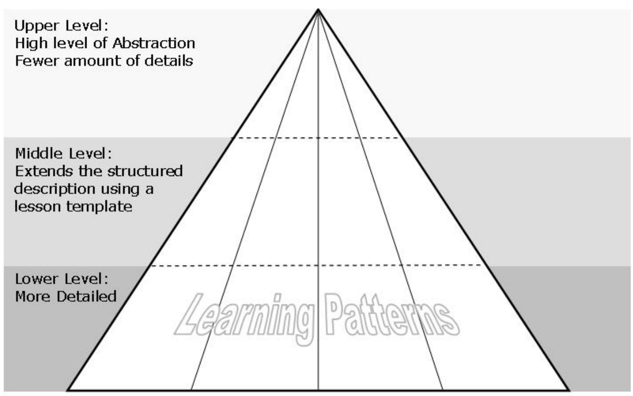

Fig. 1. The triangle represents a collection of learning patterns to show one's learning experience

3.1 Upper Level

The upper level includes some abstract details about the subject area using keywords and phrases. Usually main titles and other sub headings of the courses followed are used as phrases in the upper level. Author specified metadata or a sampling technique [3] could be used to identify relevant keywords. The upper level also defines the user's learning experience using a statistical counter (tag named 'success factor') and a classification based on the possible modules. When a learning pattern is initiated, modules are inherited from the first course but later they are split, merged or expanded based on the user's interaction with related other e-learning packages.

When a learner follows a course, he/she has to take multiple choice questions or other interactive assignments for which he will be given marks. The success factor is calculated by amalgamating these marks using a weighted average scheme with respect to the whole course as well as in module level.

3.2 Middle Level

The middle level further extends the description of modules given in the upper level. A module is described as a collection of lessons. Then a number of lessons simply specify the scope of a particular module and it is a useful heuristic when two packages are compared. A lesson is defined using keywords, phrases and success factors.

3.3 Lower Level

This is the level which describes the user's interaction with respect to each lesson given in the upper level. A single lesson could be presented in different styles (Section 2.1) in order to provide the most suitable way for each individual learner to absorb the content of the lesson. Passive reading, watching and listening could hardly deposit a new knowledge in a learner's mind. The success factor is a good quantitative measure to evaluate the level of absorption but it doesn't depict the knowledge structure. The actual knowledge structure in a learner's mind is not visible but the user's activities such as underlining, highlighting and commenting could be used to approximate the outline of a structure. Some other applications can use the lower level to provide a quick revision to refresh the learning experience.

4 Realizing E-Learning Personalization

In the previous section, we discussed how to build learning patterns and their technical infrastructure. As we have described, these learning patterns are used to provide low coupling based personalization. In this paper, we are only discussing how these learning patterns could be used to provide a customized learning sequence.

By matching relevant keywords and phrases, the system that facilitates browsing e-learning packages, first tries to identify whether a relevant learning pattern exits whenever the user selects a new course. If such a pattern is identified, it calculates a depreciation considering the date the learning pattern was created, the last date pattern was updated, and the current date of the system.

$$Depreciation = \frac{LastDate - CreateDate}{CurrentDate - CreateDate}$$

The depreciation value can be used to approximate the current value of the success factor. Rules are defined for different levels of personalization based on the current value of success factor. The common rule is that if the value is less than 45, then there will be no personalization of learning sequence in the new e-learning course. If it is less than 75 and greater than or equal to 45, then a medium level personalization will be considered. A higher level personalization is applied, if it is greater than 75. These common rules can be modified according to the learner's preferences by specifying different levels of personalization.

The next step is to identify matching modules in the learning pattern and e-learning courseware. This is done by matching the most relevant keywords and phrases used to define each module in the learning pattern with modules in the e-learning package. If a module in the package can be matched with a module in the pattern, the scope of these two modules are compared considering the number of lessons. Hence, three possibilities are identified "less than", "equal" and "larger than". The success factor is calculated considering the depreciation of the pattern and the recorded success factor for the module. Rules for the sequence modification are as follows.

Module Current Success Factor (msf) = Depreciation* (Recorded Success Factor for the module)

IF (msf < **45%**) **THEN** {no_sequence_modification}

IF (*msf* ≥ **45% AND** *msf* < **75%**) **THEN**
{
CASE OF "*ModuleScope*"
"less": *learning path discarded in whole module*
"equal" **OR** "large": *obtain user's direct response*
}

IF (*msf* ≥ **75%**) **THEN**
{
CASE OF "*ModuleScope*"
"less" **OR** "equal": *learning path discarded*
"large": *only advanced lessons considered*
}

In the comparison of keywords and phrases declared between modules in the pattern and modules in the package, if there is a mismatch, then it is investigated considering the following possible cases. In case of such a mismatch, the module is considered to be a new module and is inserted into the pattern. If only a subset of keywords is matched, then it would be considered as a module with the less scope and the same rules will be applied to determine its personalization in the learning path. On the other hand, if it is verified that the scope is covered by two modules in the pattern, then the personalization is carried out at the lesson levels.

5 SCORM and Domain Knowledge

SCORM (Shareable Content Object Reference Model) is a standard for developing e-learning content. This standard uses learning objects or SCO's (Sharable Content Objects) as the basic components. It has three sections/books.

The CAM (Content Aggregation Model) describes the content package as a learning object. It provides a standard way to reuse and share learning objects and to describe the structure and behavior of the content. Each package contains a manifest.xml file and relevant the physical files [1] and this file can implement personalization to some extent. It contains metadata, content structure, resource declarations and submanifests to describe logically linked content packages. Metadata is the main technique for enabling personalization when learning objects or content packages are presented to the learner. For example a general tag can be defined to select appropriate language. The educational tag defines the type of learning style as described in Section 2.1.

The type of learning resources can be narrative text, an exam, an experiment, an exercise, a diagram, a simulation, a graph, etc. The level of interactivity can also be set from high to low depending on the extent to which the learner can influence the behavior of the object. The intended end user can be classified into four categories. The context element describes the main environment that the SCO is to be used in a learning process whether it in school, higher education or training. The age group can also be declared if it is necessary. The level of difficulty can be declared in relation to its target learner, such as beginners, advanced and experts. An approximation of the amount of time it would take to complete the content can also be defined within a duration tag. The objective of each learning objective is given in the description tag. The annotation tag can be used to describe the purpose of the object.

The next section of SCORM that implements personalization is the run time environment. A LMS (Learning Management System) must have a technique for tracking learner interactions with each individual content package. This is handled by a data model which contains metadata to hold information about the learner, their interaction with the learning object and task/test result information. When a certain content package is called by a learner and initialized, it is a data model to log information about the learning experience between the learner and content package. It will generally hold the following information: Learner ID and name, Comments from the learner, Test results, Progress results, Progress Measurements, Learning style of object and Total time the learner has used the object.

Sequencing and Navigation are the final sections in the last part of the SCORM specification. SCORM Sequencing uses a simple sequencing specification to deliver "discrete learning activities in a consistent way", This is implemented using the organizations metadata tag in the manifest.xml file discussed earlier. Here the current learning objects position in respect to a learning experience is defined. If it is the most basic unit of instruction, then the organization metadata will provide the LMS with the next logical learning object to enable the learner's learning to progress. Each learning experience has a content structure which is known as an activity tree with each leaf representing an individual and independent unit of instruction. However this does not include personalized learning or collaborative learning activities. The learner is the only user that is considered, the roles and sequencing events of the tutor, instructor or peer learners are ignored. SCORM navigation is used to monitor "learner and user initiated sequencing events" in order to provide a unique delivery of learning activities.

SCORM may use metadata to define a great number of attributes that complement personalization but it does not define the user's domain knowledge. This is key information to personalizing content, without it the learner can be presented with irrelevant information [9] At the same time, SCORM specification does not implement assessment objects or user profiles. In our study, presented in this paper, learning patterns can complement this missing gap to achieve low coupling as well as privacy protected personalization.

6 Conclusion

In this paper, we presented a model for personalization, named learning patterns, for e-learning courses. This model is defined by extending the conventional approach of user-profile which is usually used in personalization of many applications, by especially considering the structured learning process.

Learning is a highly varying process from person to person depending on the individual skills and abilities. As a result of this process, the learner's level of knowledge grows giving him more power to interact with a learning environment. We introduced the learning pattern concept to depict such changes in learning environment. A learning pattern is supposed to grow, freeze or die with time depending on the learner's interaction with corresponding learning materials.

One of the main limitations of the approach is that these learning patterns heavily depend on the keyword matching algorithms and metadata provided by the author. A learning pattern is initiated when the user takes his/her first relevant course. If the first package doesn't provide a suitable structure, it could badly affect the maintenance of the pattern.

In the future, we will work to extend the functionality of learning patterns to provide different types of personalization. We emphasize personalization as not only providing what the user wants but also providing it just in the way he/she wants. Hence, we hope to integrate active learning and learning patterns while adhering to immerging standards for e-learning ADL SCORM.

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Using a User-Interactive QA System to Capture Student's Interest and Authority About Course Content

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Abstract. A method for capturing the interest and authority of students about course content is proposed and implemented as a user modeling approach in a Web-based user-interactive question-answering (QA) system. An instructor has to define a topic ontology (or concept hierarchy) for the course content so that the system can generate the corresponding structure of boards to hold relevant questions. The students can interactively post questions, and browse, select, and answer others' questions in their interested boards. The users' log data are accumulated and organized as the users' historical data, which are used to build the association space containing the association relations between the users' historical data and the topic ontology. From the association space, the interest and authority of students about the questions in each board can be computed first and the interest and authority of students about each topic in the ontology can be computed based on the corresponding parameters of its offspring (sub-topics or questions). These user models (interest and authority) can be used to automatically and properly distribute relevant questions and answers to relevant students to enhance learning efficiency and help instructors design suitable teaching materials to enhance instruction efficiency.

1 Introduction

Traditional educational approaches are usually teacher-centric, not student-centric, since they do not sufficiently take into account the difference of characteristics between different students [1]. In order to enhance the student-centric learning and instruction efficiency, the instructors should know the implicit requirement of students so as to prepare and design their teaching materials. However, it is usually difficult for instructors to capture the student's model about the course content, such as knowledge background, interest, authority, and so on.

A Web-based user-interactive question-answering (QA) system named *CuteAid* [2,3,4], has been proposed and developed for users to interactively post and browse questions/answers (Q/A). The users can exchange their knowledge

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by posting their questions on the related boards, and browsing to find interesting/favorite questions to answer. The system can record all the historical data for all users, including browsing records, questions and answers. All of these historical data contain tremendous amount of information about user's interest, authority, and so on. Besides knowledge exchange between users, *CuteAid* can be used to promote collaborative learning between students and instructors [5]. As another application of *CuteAid* for instruction, we propose a method to capture students' interest and authority about course content, which can be used to automatically and properly distribute relevant questions and answers to relevant students and help instructors organize and design their teaching materials. With this method, an instructor can expediently capture the interest and authority of students about the course content. The capturing process is also easy to realize, since it only needs the instructor to define a topic ontology (or concept hierarchy) for the course content. After the topic ontology is defined, the corresponding board structure can be generated to permit students to interactively post questions and answer other's questions on their favorite boards. With the accumulation of the historical data, we can build the association relations between Q/A and the topic ontology. Based on the association relations between the topic ontology and the accumulated data, the students' interest and authority about the topic ontology can be computed. Experiments show that the user models generated by our method reveal the students' true background (interest and authority) to certain extent.

The remainder of the paper is organized as follows: Section 2 presents related work. Section 3 gives the system architecture of *CuteAid*. Section 4 presents the process and method to capture students' model about course content with *CuteAid*. Section 5 shows the experiments and analysis. Section 6 discusses potential applications and Section 7 concludes the whole paper and discusses future work and potential issues.

2 Related Work

There are lots of research reports on user models and user modeling for students for intelligent tutoring systems. Machine learning is used to construct a student model for an intelligent tutoring system in [6], which can learn on a per student basis how long an individual student requires to solve the problem presented by the tutor. The model of related problem difficulty is learned within a "two-phase" learning algorithm. First, data from the entire student population are used to train a neural network. Second, the system learns how to modify the neural network's output to better fit each individual student's performance. A learning agent is constructed to model student's behavior for a mathematics tutor in [7], which determines how likely the student is to answer a problem correctly and how long he will take to generate this response. The traces from previous users of the system are used to train the machine learning agent. This model was very accurate at predicting the time a student required to generate a response, and was somewhat accurate at predicting the likelihood whether the student's response was correct.

With the development and application of Web technology, modeling user's behavior from the Web logs has also been an active research area [8,9,10,11]. The generalized method is to construct a user's profile from his/her interest-focused browsing history. A tree-like hierarchy of interests is proposed in [8], the root being the user's general interest and leaves representing domains the user is interested in. User interest hierarchies are built using a form of hierarchical clustering on a set of Web pages visited by the user. Constructing a user profile is used to analyze the user's browsing history and applied for modified collaborative filtering techniques in [9]. Algorithms are presented for learning and revising user profiles that can determine which websites on a given topic would be interesting to a user in [10], in which the authors describe the use of a naive Bayesian classifier for this task, and demonstrate that it can incrementally learn profiles from user feedback on the interestingness of websites. Recently, user profiling for interest-focused browsing history has been proposed in [11], which presents a system incorporated into the Internet explorer to maintain a dynamic user profile in a form of automatically constructed topic ontology. A subset of previously visited Web pages is associated with each topic in the ontology. By selecting a topic, the user can view the set of associated pages and choose to navigate to the page of his/her interest.

These existing approaches aim to mine a user's model from a large-scale accumulated data set or a large training set. It usually takes a long time to accumulate necessary data and the training method is usually complicated. In fact, the model about an individual including interest and authority may change after a long time, so the existing methods to mine students' model are not adaptive for student-centric instruction in the traditional class. In this paper, we propose a method to capture students' interest and authority about course content from the historical data accumulated in a Web-based user-interactive QA system.

3 *CuteAid*—A User-Interactive QA System

Fig. 1 shows the system architecture of *CuteAid* [2,4], which contains the User Interface for users to interactively post and browse questions/answers, the Content Analyzer, the Search module, the Answer Clustering and Quality Assessment module, the User Management module, the Pattern Database, the Current Q/A Database (storing all unsolved questions and their current answers arranged in different boards/categories), the Accumulated Q/A Database (for historical questions with correct answers), and the Knowledge Base.

A typical user scenario is as follows. A user uses a pattern (or not) to post a question using the User Interface. The Content Analyzer accepts the question and distributes it into the corresponding boards in the Current Q/A Database. The user can also manually select a suitable board to host this question. At the same time, it also automatically sends the questions to the Search module, which first tries to obtain an answer from the Knowledge Base by searching

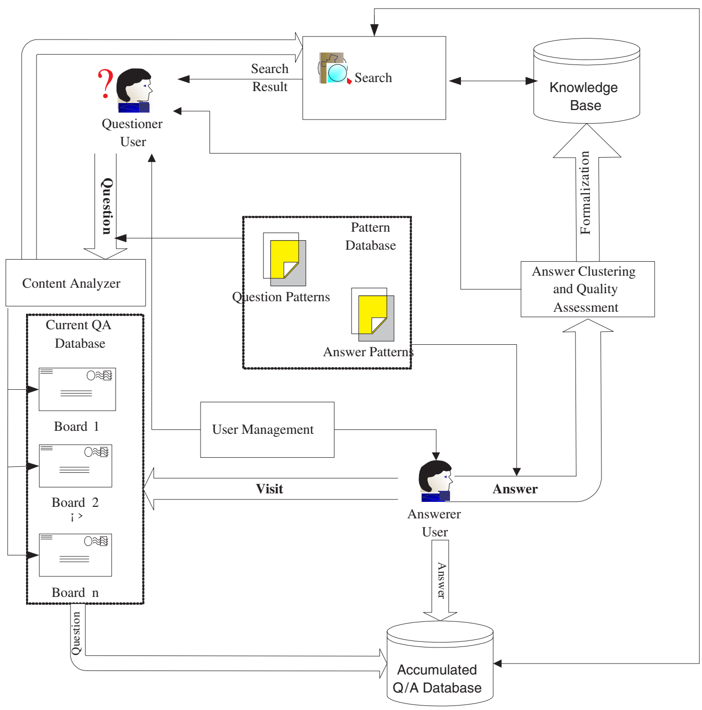

Fig. 1. System architecture of *CuteAid*

and inference, and if fails, tries to search similar questions in the Accumulated Q/A Database and return their associated correct answers. The answers automatically obtained are associated to the questions and displayed in the corresponding board. All other users can visit the boards and see this question, and if they want, can manually post their answers to this question, using the suitable pattern or not. The asker user can browse all the answers (both automatically found by the Search module and manually posted by other users) to his question and select the first/earliest correct answer (or several correct answers) as the final correct answer based on his judgment. The answer clustering and quality assessment module help group similar/relevant answers into several groups and provide an overall quality for each answer and each group based on the answerer's capability, reputation and timeliness. The clustering and fusion result can greatly facilitate the asker to browse the answers and select the correct answer quickly. The question and its correct answer(s) determined by the asker are associated and stored in the Accumulated Q/A Database as a pair. Hopefully, these high quality question-answer pairs are converted and formalized into formal knowledge and stored in the Knowledge Base for future auto-answering. The User Management module is responsible for computing and managing all users' interest, authority (capability and experience), reputation, etc.

4 Capture Students' Models About Course Content Using *CuteAid*

Within the system architecture of *CuteAid*, the Accumulated Q/A Database is an import component of *CuteAid*, which stores all the pairs of question and answer from different users during the running of the system. The Accumulated Q/A Database as well as the user log of other activities, e.g., browsing, are used as users' historical data to capture students' interest and authority about course content in this paper.

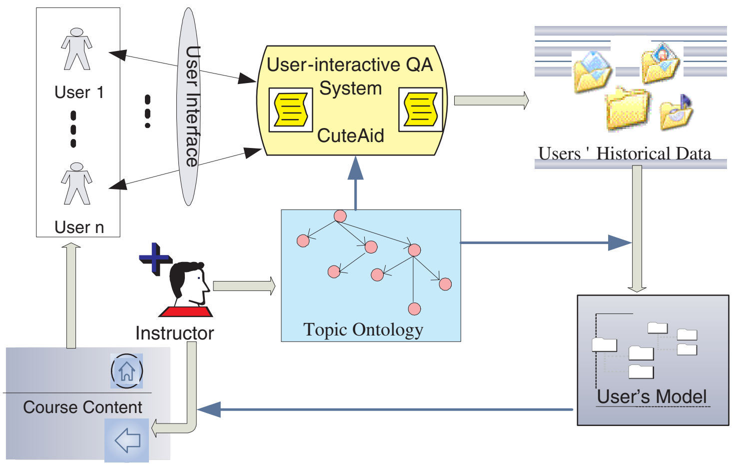

Fig. 2. Framework of capturing user's model about course content

4.1 Framework of the Capturing Process

Fig.2 presents the framework of the capturing process. The whole process includes the following main steps:

1. Topic ontology (or concept hierarchy) definition: The topic ontology presents the structure of the course content and is defined by the instructor with suitable granularity and scale.
2. User-interactive QA process: Based on the defined topic ontology, the system can generate the corresponding board structure in *CuteAid*. Within their favorite boards, students can post their urgent questions about the corresponding topics, and browse and select to answer other's questions. The *CuteAid* system can record and accumulate students' browse activities, questions, and answers as historical data.
3. User modeling: With the accumulated historical data, the system builds the association relations between the questions and answers and the topic ontology. Based on the association relations, it computes the students' interest and authority about the topic ontology.

With the useful and visualized information of the students' model about the topic ontology defined, the instructors can adjust or redesign their course contents to satisfy students' requirements. Next, we will introduce the related technologies within the capturing process, including topic ontology, association space between topic and historical data, and the methods to compute the students' model.

4.2 Topic Ontology

Before capturing the students' model, it is necessary to define the related topic ontology (or concept hierarchy), which presents the outline or skeleton about the course content. Firstly, we propose the formal definition for topic ontology.

Definition 1. *A topic ontology is defined as a directed tree-like graph* $TopicOnto = (TS, R)$*, where*

- *The set of nodes* $TS = term_1, term_2, \ldots, term_n$ *represents a set of terms.*
- *The set of edges* $R \subseteq (TS \times TS)$ *represents the binary relations on the set* TS*. If two terms satisfy one of* IS_A*,* $Component\_Of$ *and* $Part\_Of$ *relations, then there is a direct edge between the two terms.*

In the topic ontology, a term can be the name of a chapter, section, or key concept of the course content, which is decided by the instructor. We do not take into account all kinds of relations among the terms. Three kinds of well-known relations between terms in the ontology, namely, IS_A, $Part\_Of$, and $Componetn\_Of$ relations [12], have been considered since they are the most important to capture user's model about course content. If $term_1$ and $term_2$ satisfy $IS\_A(term_1, term_2)$, $Part\_Of(term_1, term_2)$, or $Componetn\_Of(term_1, term_2)$, it means that $term_2$ is a (part of, or component of) $term_1$ and there is a direct edge from $term_1$ to $term_2$. A node is named as a $leaf$ if its out-degree is zero. The scale of the topic ontology is decided by the term set, which is defined by the instructor based on the course content. To capture the students' model about the course content, each of the leaves of the topic ontology is regarded as a board. Students can interactively post and browse questions/answers within the corresponding boards.

4.3 Association Space

We build the Q/A space from the historical data to describe the relations between questions and answers. The association space is defined and used to express the relations between Q/A space and topic ontology.

Definition 2. *A Q/A space is a five-tuple* $QASpace = (QS, AS, f_B, f_A, f_{CA})$*, where*

- QS *is the set of questions.*
- AS *is the set of answers.*
- $f_B : QS \to Z$ *is a function from* QS *to* Z*, where* Z *is the integer set.* $\forall Q \in QS$*,* $f_B(Q)$ *is the browsing frequency (or, the number of times being browsed) of question* Q *and is nonnegative.*

– *$f_A : QS \rightarrow AS$ is a function from QS to AS. $\forall Q \in QS$, $f_A(Q)$ is the set of answers about Q.*
– *$f_{CA} : QS \rightarrow AS$. $\forall Q \in QS$, $f_{CA}(Q)$ is the set of correct answers about Q.*

In Definition 2, it is obvious that $f_{CA}(Q) \subseteq f_A(Q)$. We can use a directed graph to represent the relations between QS and AS. QS and AS are represented by different nodes, and there are directed edges from answers to question Q if $f_A(Q) \geq 1$. We illustrate the graphic representation in Fig. 3.

Based on the functions f_B, f_A, and f_{CA} on QS, we give a classification of all the questions.

Definition 3. *Let $QASpace = (QS, AS, f_B, f_A, f_{CA})$ be a Q/A space. $\forall Q \in QS$,*

– *Q is a hot question if $f_B(Q) \geq \delta$, where δ is a threshold.*
– *Q is a closed question if $f_{CA}(Q) \geq 1$.*

Different kinds of questions play different roles to capture the users' model about the course content. The hot questions are used to compute interest of a class of students in the topic ontology. The threshold δ for hot questions is used to filter unrelated or useless questions in the historical data. We assume that if the browsing frequency of a question is smaller than δ, this question is not an interesting question for the students and therefore it does not contribute to the interest model of students. The value of δ can be adjusted by system administrator. The closed questions are used to compute authority of a class of students about the topic ontology. If a question is closed with correct answers, it means that the students have mastered the related knowledge about the question.

Given the topic ontology, we can build the association space to express the relations between the historical data and the related topics. The formal definition for the association space is presented in Definition 4.

Definition 4. *An association space between a Q/A space and a topic ontology is a three-tuple $AS = (QASpace, TopicOnto, R_{AT})$, where*

– *$QASpace = (QS, AS, f_B, f_A, f_{CA})$ is a Q/A space;*
– *$TopicOnto = (TS, R)$ is a topic ontology;*
– *R_{AT} is the relation between QS and TS. If question Q is posted on the board corresponding to T, then $(Q, T) \in R_{AT}$.*

We can use a directed graph to represent the association space between the Q/A space and the topic ontology. Fig. 3 shows a sketch map of an association space.

4.4 Capturing Method

The association space between the Q/A space and the topic ontology indicates the relations between the historical data (browsing activities, questions, answers, and correct answers) and the topic ontology. For each student, we can build his/her own association space between the Q/A space and the topic ontology

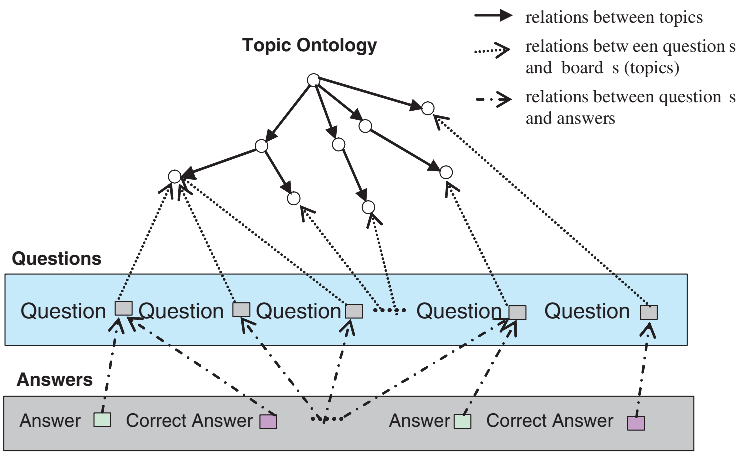

Fig. 3. Sketch map of an association space

to obtain his/her interest and authority. We can also capture the model about all the students in a class as an entire object using all the historical data accumulated for all the students. Next, we present the capturing method using the historical data for all the students in an entire class.

First, we compute the interest and authority of students about every question, which are determined by the related parameters of each question including the browsing frequency, number of answers and number of correct answers.

Definition 5. *Let* $AS = (QASpace, Topic, R_{AT})$ *be the association space between the Q/A space and the topic ontology, where* $QASpace = (QS, AS, f_B, f_A, f_{CA})$ *is the Q/A space of all students. For any question* $Q \in QS$*,*

– *the interest of students about the question* Q *is ,*

$$Interest(Q) = \begin{cases} 0 & f_B(Q) \leq \delta \\ \frac{\arctan(\frac{f_B(Q) - Mean_B + |f_A(Q)| - Mean_A}{\theta})}{\pi} + \frac{1}{2} & Otherwise \end{cases}$$

where δ *is a threshold,* $Mean_B$ *and* $Mean_A$ *are respectively the mean of* $f_B(Q)$ *and* $f_A(Q)$ *of all questions, and* θ *is a linear transformation parameter determined by the system administrator to adjust the slope of the function.* $f_B(Q) \leq \delta$ *means that* Q *is not a hot question.*

– *the authority of students about the question* Q *is,*

$$Authority(Q) = \begin{cases} 0 & |f_{CA}(Q)| \leq 0 \\ \frac{\pi - 2\arctan(\frac{|f_A(Q)|}{\beta |f_{CA}(Q)|})}{\pi} + \frac{1}{2} & Otherwise \end{cases}$$

In Definition 5, we can see that the interest of students about a question Q is mainly determined by the browsing frequency $f_B(Q)$ and the number of answer $f_A(Q)$. The bigger of $f_B(Q)$ and $f_A(Q)$, the more interest do the students have about the question. The authority of students about one question Q is mainly determined by the ratio of $\frac{|f_{CA}(Q)|}{|f_A(Q)|}$. A bigger $\frac{|f_{CA}(Q)|}{|f_A(Q)|}$ value means higher authority of the students about the question.

Definition 6. *Let $AS = (QASpace, Topic, R_{AT})$ be the association space between the Q/A space and the topic ontology, where $QASpace = (QS, AS, f_B, f_A, f_{CA})$ is the Q/A space of all students, and $TopicOnto = (TS, R)$ is the topic ontology about the course content. For each $term \in Ts$,*

$$Weight_j(term) = \frac{\sum_{i=1}^{n} Weight_j(Son_i)}{n} \times \log_{10} n$$

($j = 1, 2$), is the interest and authority of students about term respectively, and Son_i ($1 \le i \le n$) is the son (term or question) of term term. For each term $term \in TS$, we denote $Interest(term) = Weight_1(term)$ and $Authority(term) = Weight_2(term)$ directly.

With Definition 6, the interest and authority about each leaf term in the topic ontology are computed respectively by the interest and authority of all questions on the corresponding board, where a question is also named as a son of the term if the questions is on the corresponding board of the term. The interest and authority about each non-leaf term are computed respectively from the corresponding interest and authority of its sons.

Algorithm 1 presents the method to compute students' model about the topic ontology.

Algorithm 1. *Compute students' model about the topic ontology*

INPUT: Topic Ontology $TopicOnto = (TS, R)$ defined by the instructor

OUTPUT: Students' Model about the Topic Ontology

Step 1: generate the board structure of CuteAid *based on the topic ontology $TopicOnto = (TS, R)$.*

Step 2: construct Q/A space $QASpace = (QS, AS, f_B, f_A, f_{CA})$ of all the students by asking students to post and answer questions on the corresponding boards and to close their own questions if correct answers occurring.

Step 3: classify all the questions into the hot and closed questions based on functions f_B, f_A and f_{CA}.

Step 4: construct the association space $AS = (QASpace, TopicOnto, R_{AT})$ between the Q/A space and the topic ontology.

Step 5: compute the students' interest and authority about each question in the Q/A space $QASpace = (QS, AS, f_B, f_A, f_{CA})$.

Step 6: compute the students' interest and authority about each term in the topic ontology based on $AS = (QASpace, TopicOnto, R_{AT})$.

Step 7: output $(term, Interest)$ and $(term, Authority)$ for each $term \in TS$.

5 Experiment and Analysis

We have done experiments to prove the proposed method in this paper using the course CS3343 "Software Engineering Practice" at the City University of Hong Kong with *CuteAid*.

Before the experiments, we first define a topic ontology shown in Fig. 4. The topic ontology contains three sections of the course, which are Software Requirement Specification (including two topics: Joint Application Development, and Prototyping), Software Design (including two topics: Designing for Change, and Code Review) and Software Testing (including four topics: Testing Techniques, Soft Test Package, Test Plan & Test Cases, and Test Report & Bug Reports).

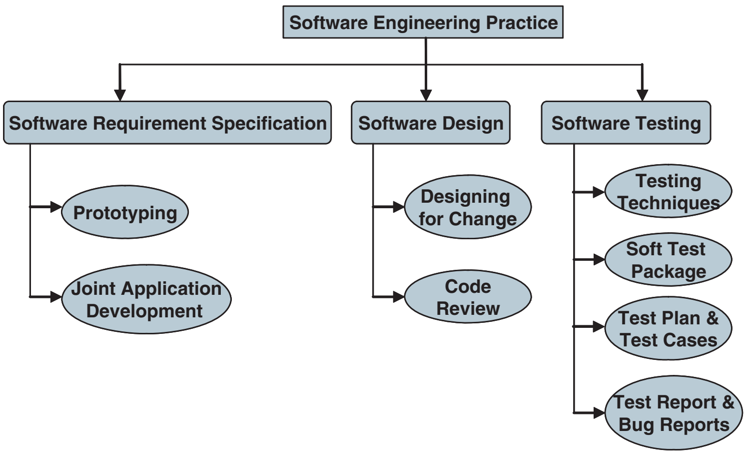

Fig. 4. The topic ontology for the experiments

There are 12 terms in the defined topic ontology, four of them (Software Engineering, Software Requirement Specification, Software Design and Software Testing) are non-leaf nodes, and other eight are leaf nodes. Hence, eight corresponding boards are generated on *CuteAid*.

After preparation of the experiments, all of the students registered in the course are encouraged to post at least 5 urgent questions on their favorite boards. Then, they are asked to browse all the questions and select at least 5 favorite questions to answer. They are also asked to pay more attention to their own questions. They must close their corresponding questions if at least one correct answer occurs based on their judgment. Otherwise, they will be complained by others.

After the scale of the historical data is enough for the experiments (the data used for experiments are shown in Table 1, where the threshold for the hot question is $\delta = 3$), the association space between the Q/A space and topic ontology is built, from which the model of all the students in the class about the topic ontology is computed. The interest and authority of the students of

Table 1. The data information about each board

Board Name (Leaf-terms)	Number of Questions	Number of Answers
Prototyping	19	22
Joint Application Development	39	28
Designing for Change	34	24
Code Review	24	23
Testing Techniques	43	24
Soft Test Package	9	8
Test Plan & Test Cases	13	10
Test Report & Bug Reports	14	7

Table 2. The user model about each board

#	Term	Interest	Authority
#1	Prototyping	0.656824829	0.404350536
#2	Joint Application Development	0.800441521	0.202653753
#3	Designing for Change	0.769930287	0.448449328
#4	Code Review	0.699843435	0.402084560
#5	Testing Techniques	0.819143459	0.301959706
#6	Soft Test Package	0.503029648	0.547475421
#7	Test Plan & Test Cases	0.575045662	0.260217096
#8	Test Report & Bug Reports	0.585603818	0.331952878
#9	Software Requirement Specification	0.728633175	0.303502145
#10	Software Design	0.734886861	0.425266944
#11	Software Testing	0.620705647	0.360401275
#12	Software Engineering Practice	0.694741894	0.363056788

CS3343 about the topic ontology shown in Fig.4 are shown in Table 2, and their histograms are shown in Fig.5 and Fig.6, respectively.

To examine the reliability of the model computed by the proposed method of this paper, we conduct an E-survey through *CuteAid* to collect students' real model by the feedback. Participants are limited to the registered students

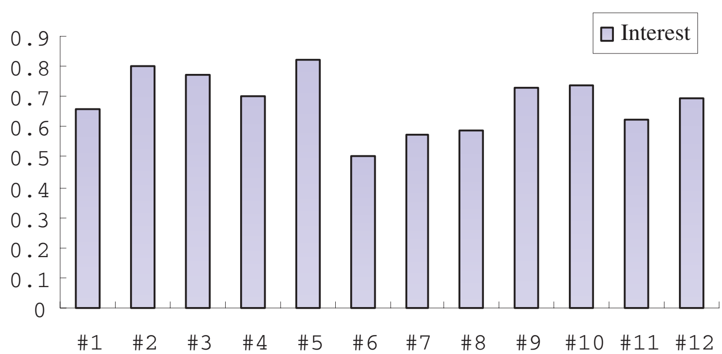

Fig. 5. The interest of the students about the topic ontology

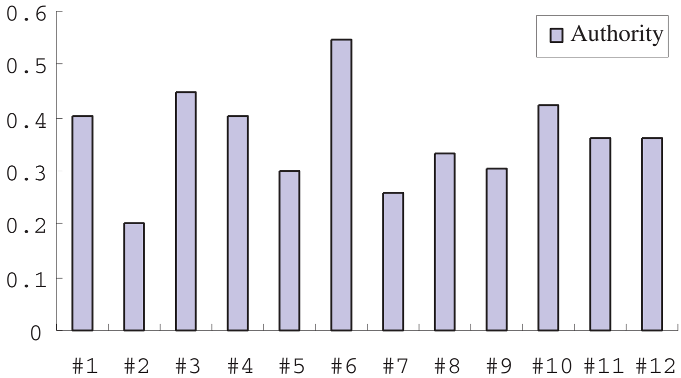

Fig. 6. The authority of the students about the topic ontology

Fig. 7. The user interface of E-survey

of CS3343 attended the experiment. Each participant is required to provide serious feedback about the result. The user interface and the E-survey questions about the students' interest of the eight leaf terms in the topic ontology are shown in Fig.7. In the E-survey process, all the students of CS3343 attending the experiment are asked to select their favorite topics form the eight terms.

The feedback data from E-survey on the interest about the eight leaf terms collected from the students of CS3343 are shown in Table 3.

In order to compare the computation result and the E-survey result, we compute the interest percentage of each topic in all eight topics. The comparison between the computed users' model and the E-survey result is shown in Fig.7. With the histogram in Fig.7, we can see that the difference between the computed users' model and the E-survey result for most of the eight leaf terms within the topic

Table 3. The E-survey result about the interest of each topic

#	Term	Number
#1	Prototyping	13
#2	Joint Application Development	24
#3	Designing for Change	8
#4	Code Review	19
#5	Testing Techniques	21
#6	Soft Test Package	6
#7	Test Plan & Test Cases	18
#8	Test Report & Bug Reports	21

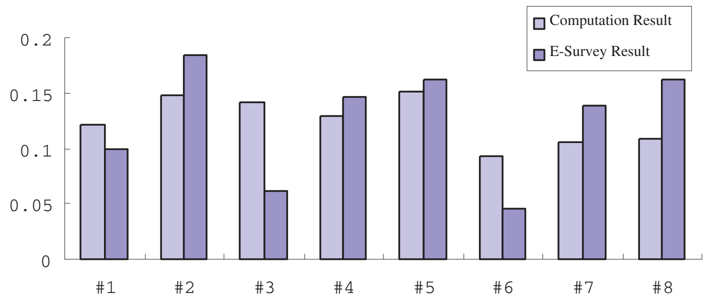

Fig. 8. Comparison between the computation result and the E-survey result

ontology is not big. Hence, the proposed method can be used to find the true interest of the students.

The authority result is not as easy as the interest result to evaluate. The computed authority of the students about one topic is the evaluation about their historical behaviors about the topic. For the students themselves, it is difficult for them to know their own real authority about one topic, since they only compare their authority among several topics. One method to evaluate the reliability of the authority model is role-based multi-Agent simulation, which has been used to evaluate the reputation model in *CuteAid* [13]. We can define different Agents to complete question and answering actions in the simulation system, acted as students with high, middle or low authority in the *CuteAid* system. The reliability of the authority model can be verified by the consistency of computed authority and predefined roles of all the Agents. More discussion about the role-based multi-Agent simulation to prove reliability of users' model can be seen in [13].

6 Potential Applications of the User Models

Once the students' interest and authority models are known, there are many potential applications within *CuteAid* for adaptive teaching and collaborative learning. The potential applications include but are not limited to the followings.

1. **Course Content Design.** At the beginning of a semester, the instructor can use this method to capture the students' model and then design or

reorganize the teaching materials to satisfy the real requirements of students to enhance the student-centric instruction efficiency based on their interest and authority. During the semester, the instructor can also check the instruction effectiveness using the same method.

2. **Question Recommendation.** When a new question is posted in *CuteAid*, it can be automatically sent to the students with interest and especially with high-authority.
3. **Learning from Q/A.** After a correct answer occurs and is chosen, the *CuteAid* system can send it with its question to students with low-authority. The students can learn knowledge from the question and its corresponding answers to enhance their learning.

7 Conclusion and Discussion

During the running of our Web-based user-interactive *CuteAid*, tremendous amount of useful information about the behaviors and characteristics of users have been accumulated. As an application of *CuteAid* in teaching and learning, a method to capture students' interest and authority about course content is proposed in this paper, which is helpful to instructors to enhance student-centric instruction. This method is convenient for instructors to use, which only needs the instructors to define a topic ontology for the course content. It is not necessary to spend additional time to capture the model of students with the method proposed in this paper. The model of students can be captured during the process of exchanging knowledge between students.

As discussed in Section 4, the method proposed can be generalized to compute the interest and authority of an individual student, if the accumulated data about the student is sufficient. The model for individual user is also very useful in *CuteAid*. Based on the user's interest and authority model, the system can recommend related questions to users with high-authority, and send new answers to users with interest.

Acknowledgement

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Designing Learning Styles Application of E-Learning System Using Learning Objects

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Abstract. The emergence of Learning Objects in learning technology has had a big impact on the learning environment and its community. Teachers and students have more facilities for using the E-Learning system, which has made the learning process more effective and beneficial. This paper presents an application framework for using Learning Objects in the learning styles application of an E-Learning system for an Object-Oriented C++ Programming subject. The project's end-user is a higher learning institution student or anyone who is learning the subject. The focus is on the reusability aspect of the note—either content or database. The framework is explained by using SCORM-based architecture design, context diagram, database design, and interface design.

1 Introduction

Learning is a process of gaining knowledge, skills, experience, or values through study, experience, or training [1]. It is a part of human life. No matter what the subject, everything requires a minimum learning process to get know that subject better. The learning process may vary from person to person, depending on their learning styles. Learning styles are ways of learning about a topic, or how people concentrate, process, and memorize new information [2]. There are several types of learning styles, which include visual learning, auditory learning, and tactile/kinaesthetic learning [3]. Visual learners learn best when information is presented visually and in a written language, picture, or design format. Auditory learners learn best when information is presented in an oral language format. And tactile/kinaesthetic learners learn best when the learner is physically involved in an activity.

The widespread use of computers over the past few years, in addition to the integration of the learning process and ICT, has impacted the education system and students respectively. Students can learn more easily through a combination of learning styles, including hearing, seeing, writing, reading, and illustration, where all of these are applied accordingly in electronic learning. Electronic Learning or E-Learning developers and practitioners have found a way to improve E-Learning usability and performance by introducing an enhanced E-Learning method, which is called Learning Objects.

These days, in this age of information technology, E-learning plays an important role in education. Based on the survey [13], most learners prefer to learn in a

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traditional learning setting rather than in a digital environment because of the lack of learning aid software available in the market. A lack of functions like the ability to jot down notes and search for information in the E-Learning system is another reason why learners do not want to study in a digital environment. Although learners have access to information on the Internet, they need to print out the information as a hard copy or save it as a soft copy and bring along the information whenever they need it. In addition, some of the E-Learning courses do not meet the required attributes of E-Learning, like developing content, storing and managing content, packaging content, student support, and assessment. Although this problem can be overcome with the Learning Objects approach, some of the contents are preset and can only be modified by the moderators.

2 Learning Objects

Learning Objects (LOs) was popularized by Wayne Hodgins in 1994. It has become a popular topic in recent years in the computer-mediated learning field [5]. There are several of definitions of LOs. For example, the National Learning Infrastructure Initiative describes LOs as modular digital resources, uniquely identified and meta-tagged, that can be used to support learning [5]. According to David A. Wiley, LOs are as any digital resource that can be reused to support learning. Wiley claims that the main idea of LOs is to break educational content down into small chunks that can be reused in various learning environments, in the spirit of object-oriented programming [6]. However, according to the Learning Object Metadata Working Group of the IEEE Learning Technology Standards Committee (LTSC), LOs can be described as any entity, digital or non-digital, which can be used, re-used, or referenced during technology and supported learning [7].

LOs are divided into three categories: practice, informational, and integrated. The practice LOs category is when a learner learns or studies by repetition, rehearsal, or carry-out exercises. This category is for tactile/kinesthetic learning style learners. The second category is informational LOs. This means a learner learns or studies from a collection of facts, data, and knowledge derived by study, experience, or instruction. This category is for visual and auditory learning style learners. The last category is integrated LOs, which is more effective for the learning style learners. It combines both practice and informational LOs into one, which not only stresses exercises, but also knowledge. Therefore, it suits all types of learning styles, including visual, auditory, and tactile/kinesthetic learning styles. According to Solvig, Kilby, and Lim [8] [9] [10], the characteristics and features of LOs are as follows:

1. Small
The Learning Object is usually comprised a smaller unit of learning—that is, compared to a course.

2. Interoperable and self-contained
Each Learning Object is self-contained and can used independently or with other Learning Objects. It should be independent of the delivery media and knowledge management systems and its instructional units.

3. Reusable

Learning content is modularized into small units of instruction suitable for assembly and reassembly in a variety of instructional contexts. The same Learning Object can use in multiple contexts for various purposes.

4. Aggregated

The Learning Object can be grouped into larger collections of content to create more substantial units of learning.

5. Accessible or retrievable by tagging with metadata

Learning content will be tagged with metadata so that it can be stored and referenced in a database. This way, it will be available anywhere and at any time, and it can be located and reused across networks.

6. Durable

Units of instruction will be able to withstand evolving delivery and presentation technologies without becoming obsolete.

7. Digital format

Since it uses web services to support its application, LOs will use a digital format for all its contents.

3 Objectives

The project is named LOOOP, which is taken from Learning Objects for Object-Oriented Programming Subject. Its main objective is to provide a flexible learning style using the reusable contents of an electronic learning system. The reuse feature exists in two parts of the system: database and content. The existing data in the database can be reused for other subjects or courses within the system. This is because the data are stored not by chapter or topic, but by element (i.e., text, image, and audio). Reused content refers to content that has been modified or enhanced by the first user and can be viewed by a second user (the analogy: a senior member gives his notes to a junior member).

4 Scopes

The project is more focused on the development of the reused content than the database. The content can be reused by a user with regard to any subject or chapter in the system environment. This includes text, image, audio, or animation where the data are kept separately in small tables (in order to apply the 'small chunk' concept of LOs [6]). In addition, the project domain is Object-Oriented C++ Programming subject.

5 How Learning Objects Applied in the System

In LOOOP, LOs are saved as a single record in the database. The database of the system acts as an LOs repository. The database contains several tables, including a single table for sharable LOs. Sharable LOs are LOs that can be shared between users, and the contents of LOs can only be modified after another user saves it as his or her personal LOs in his or her own table. Besides sharable LOs, a user can create new LOs by using the system from a blank slate or by saving data from information searching. The LOs in this system can be viewed and modified when they are retrieved from repository and the content showed to the user. In addition, the animation file, multimedia file, or image file associated with the LOs can also be played using the system. Thus, a user can also employ traditional learning styles such as highlighting text and jotting down notes on the currently viewed LOs. The modification of the contents can be saved in the repository for future review.

6 System Architecture

The LOOOP system's architectural design is based on an established standard, known as SCORM. The SCORM standard was selected because it was designed specifically for a browser-based delivery of learning content. On LOOOP, the learning content is retrieved on demand. First, the LOOOP user chooses a specific learning content from his or her learning contents list. After receiving the command, the LOOOP system sends a command line that is written in LOOOP language to a LOOOP socket that is placed on the server. The command line contains instructions on what types of data should be retrieved from the database and returns the appropriate data to the LOOOP client system. Every single record from the learning contents database is similar to SCO (Sharable Content Object) in SCORM. The records will then be sent back in a package that is in LOOOP language to the LOOOP client system according to the command line or instruction that was sent to LOOOP socket earlier. The LOOOP client system, which is a learning management system, extracts the SCO from the package and displays the learning content to users. Figure 1 illustrates the LOOOP standard.

Overall, the LOOOP system can be divided into two parts: the client-side and the server-side. The client-side application is the main operating system for LOOOP. The server-side application is a socket that receives the required information from the client-side application and sends back the results to the client-side application. The server-side application is only operated when LOOOP-registered users choose to save their learning contents online. Figure 2 illustrates the overall system architecture for the LOOOP system.

In order to communicate with the online database that is located on the server, the required information that passes to the server-side application is the SQL statement, the purposed statement, and related data. After the server-side application performs the SQL statement and retrieves the data from the online database, the results are sent back to the client-side application. The required information is delivered to the server-side application and the results are sent back to the client-side application. These results are in LOOOP language, a language that was designed based on the SCORM concept for use in LOOOP data passing. This language is similar to Extensible Markup Language (XML). The difference between the languages is the tag. For example, XML language uses <CHAPTER> and LOOOP language uses {|CHAPTER|}. Figure 3 illustrates the difference between XML and LOOOP language.

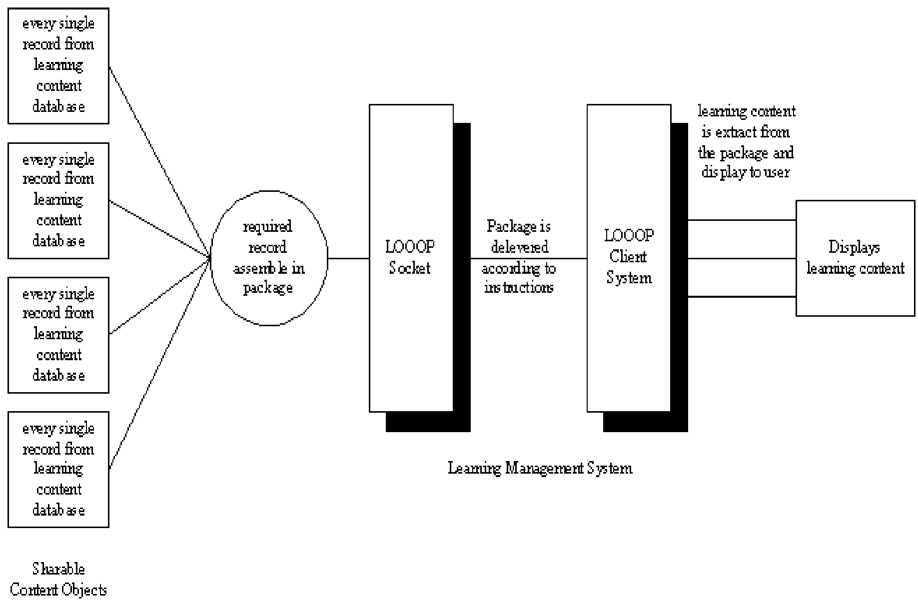

Fig. 1. LOOOP Standard

As mentioned earlier, the client-side application is the main operating system for LOOOP. Besides performing as a client-server application, the client-side application also serves as a standalone application when LOOOP-registered users choose not to save their learning contents online. An offline database that has the same data structure with its database on the server is installed in the client-side machine. The client-side application communicates with the offline database through a self-created DLL file. Not only was the DLL created for communication with the LOOOP database, but also for the purposes of reusability and interoperability. LOs developers can communicate with the contents of LOs placed inside the database using this DLL file.

Besides the DLL file, the system was developed as an ActiveX control. This has increased the reusability, interoperability, and durability of the system. The ActiveX control can be merged and used with other applications or web pages. The accessibility of the system can also increase while the control merges with the web page. In this project, the control is merged with the client-side application.

There are five main feature tools in the client-side application. They are as follows: the learning contents editor, the information searching agent, the file viewing tool, the reader agent, and the communication tool. The learning contents editor is a tool for viewing or editing the learning contents. This tool was developed using DHTML editing control. This ActiveX control was selected because this control allows for HTML page editing where the learning contents are saved in HTML format.

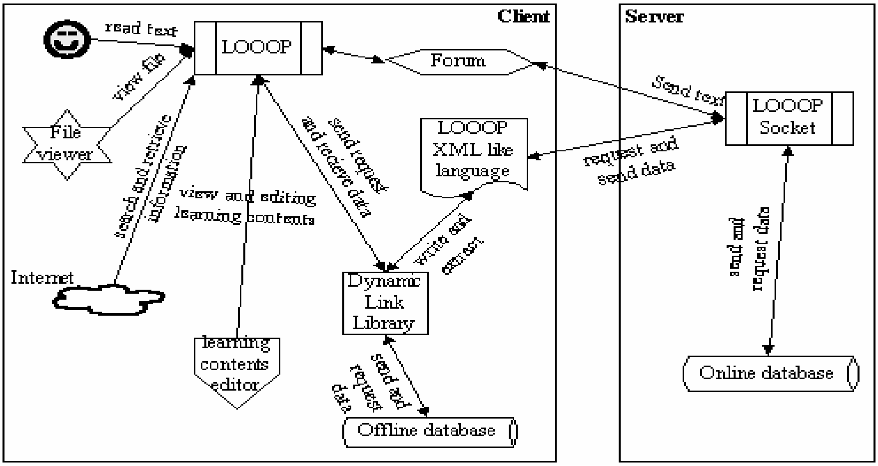

Fig. 2. System Architecture

The information searching agent is another featured tool for LOOOP; this agent extracts the search results page from Google.com and lists the records found on a tree view control. In addition to searching for information from the Internet, this agent also searches for keywords from the sharable contents of LOs.

The file viewing tool is a simple tool that opens and plays files. Currently, this tool is able to open six types of files, including picture files (GIF, JPEG, BMP), multimedia files (WAV, AVI), and shockwave flash files (SWF). Two ActiveX controls were used to play the files, including Shockwave Flash control and Windows Media Player control.

The reader agent is an agent used together with the learning contents editor. This agent is used to read the text with regard to the learning contents. This agent was developed using another ActiveX control, Microsoft Voice Text control. The communication tool is a forum that is similar to the chat application that can be found on the market, such as ICQ, mIRC, and MSN Messenger. This tool was developed using Microsoft Winsock control. This communication tool is not designed for one-on-one conversation; every online user can read the sender's message.

XML	LOOOP language
`<?xml version='1.0' encoding='utf-8'?>`	`{|LOOOP|}`
`<LOOOP>`	`{|LTITLE|} Title {|/LTITLE|}`
`<LTITLE> Title </LTITLE>`	`{|LCONTENT|} Learning content {|/Content|}`
`<LCONTENT> Learning Content </Content>`	`{|LNOTE|} NOTE {|/LNOTE|}`
`<LNOTE> NOTE </LNOTE>`	`{|/LOOOP|}`
`</LOOOP>`	

Fig. 3. XML and LOOOP Language

7 Context Diagram

A context diagram is a simple top-level diagram that only has one process that represents the entire system and shows its relationship with the system environment. In order to represent the entire system, the Yourdon symbol set was chosen in for this project. Figure 4 illustrates the context diagram for LOOOP.

This context diagram was drawn with the assumption that the learner is using an online database to save his or her learning contents. For the learner who is using a standalone application and is not connected to the Internet, the entity Google.com and the entity LOOOP Socket are eliminated because LOOOP requires an Internet connection to access the entities Google.com and LOOOP Socket. For the learner who is using a standalone application and is connected to the Internet, only the entity LOOOP Socket is eliminated because the learning contents are saved in the learner's computer.

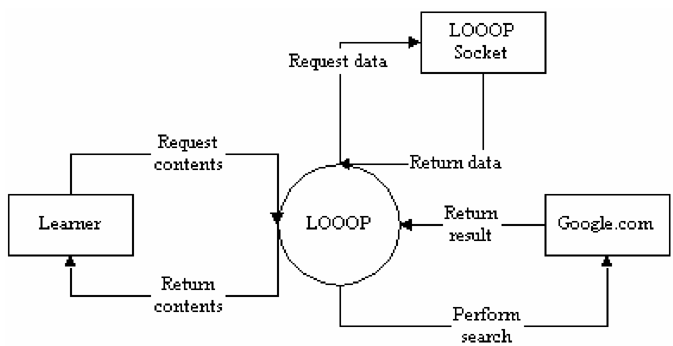

Fig. 4. Context Diagram

First, the learner requests the learning contents from LOOOP. LOOOP receives the command and sends the requested message to the LOOOP Socket, which is located on the server, in LOOOP language. The LOOOP Socket retrieves the related data from the database and returns the results to LOOOP in LOOOP language. The results that are in LOOOP language are extracted before being displayed to the learner on LOOOP. For information searching, LOOOP sends the terms to Google.com and retrieves the results page from Google.com. The results page is extracted to get the records' URL and descriptions. The URL and descriptions are displayed to the learner through LOOOP.

8 Database Diagram

The database and metadata are important components in LOOOP. A database is a carefully organized set of data stored on a computer and managed by a special application called a database management system (DBMS) [11]. Metadata is data that provides information about, or documentation of, other data managed within an application or environment. In this project, the metadata is the field name of every table created in the database. For example, the metadata for tbl_Register_User are User_Name and User_Password.

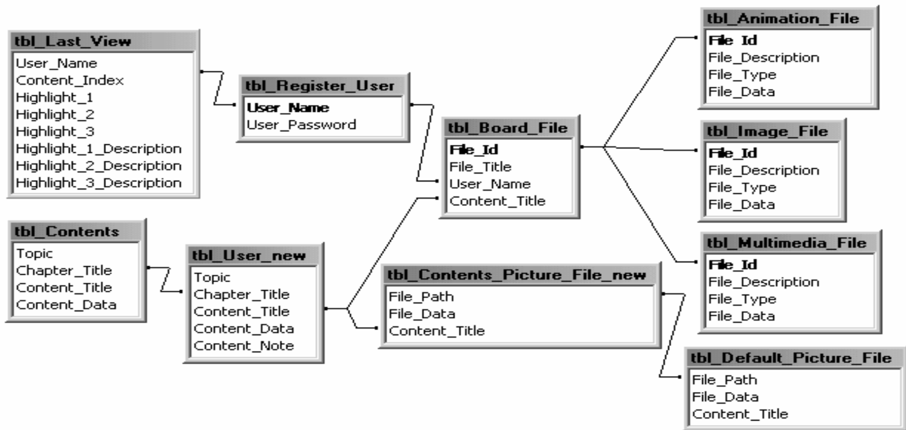

Fig. 5. Database Design

There are several tables in LOOOP database, such as tbl_Register_User, tbl_Contents, tbl_Board_File, tbl_Animation_File, tbl_Multimedia_File, tbl_Image_File, tbl_Contents_Picture_File, tbl_Last_View, user-defined tbl_User_(new), and tbl_Contents_Picture_File_(new). The table 'tbl_Register_User' is used to record the registered users' details. The table 'tbl_Contents' is used to record the sharable learning contents or contents of LOs, such as content title, chapter title, and contents. The table 'tbl_Board_File" is used to record external files such as animation file, multimedia file, and image file identification and information. The table 'tbl_Animation_File' is used to record the file data of an animation file. The table 'tbl_Multimedia_File' is used to record the file data of a multimedia file, such as a video file and an audio file. The table 'tbl_Image_File' is used to record the additional image file data that are associated with the LOs. The table 'tbl_Content_Picture_File' is used to record the picture file that is found inside the learning content. The table 'tbl_Last_View' is used to record the chapter that the user last viewed and other information. User-defined tables 'tbl_User_(new)' and 'tbl_Contents_Picture_File_ (new)' are created when a new user registers in the system. The table 'tbl_User_(new)' is used to record the user's personal learning contents. This table is an instance for table 'tbl_Contents'. The table 'tbl_Contents_Picture_File_(new)' is used to record the picture file that is found in the learning contents page. This table is an instance for table 'tbl_Contents_Picture_File'. The (new) table is renamed with a user name when a new user registers in the system. The number of user-defined tables increases when a new user registers.

9 User Interface Design

The LOOOP graphical user interface (GUI) is the place where the system interacts with the learner. The LOOOP GUI is designed with a WIMP (Window, Icon, Menu, and Pointer) interface based on the template shown in figures 6, 7, and 8.

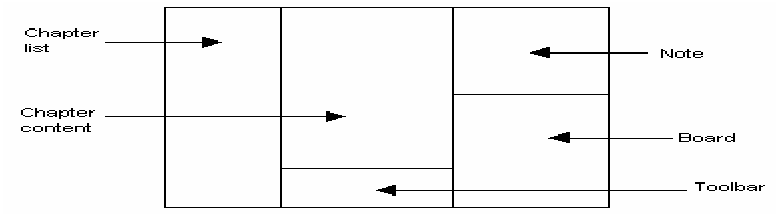

Fig. 6. GUI for Learning Contents Module

Figure 6 illustrates the GUI template for the learning contents page. There are five parts that are drawn in this template; they are the chapter list, the chapter content, the toolbar, the note, and the board. The chapter list is the list of all the content titles in the learner's personal learning contents. The chapter content is the displayed content page. The toolbar is the editing tool for the learning contents page. The note is an additional note that is written by the user. The board is the list of external files that are associated with the current content.

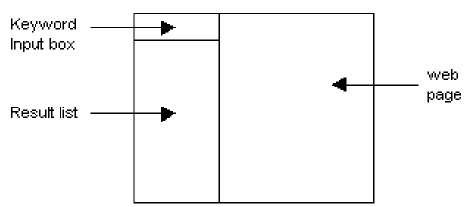

Fig. 7. GUI for Searching Module

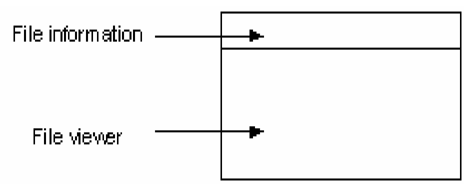

Fig. 8. GUI for View Module

Figure 7 illustrates the GUI template for the search information page. There are three parts in this template: the keyword input box, the results list, and the web page. The keyword input box is the place for the user to key in the term, phrase, or keywords that are needed for the search. The results list is the list of all records found, including the search from the database or the Internet. The web page is the place to display the selected results page.

Figure 8 illustrates the GUI template for the view file page. There are two parts to this template: file information and file viewer. File information is the place that shows the details of the currently displayed file. File viewer is the place that displays or plays the file.

The actual LOOOP GUI was designed based on the templates that were designed earlier in this project. The entire system has four pages and two external windows. The four pages are the login page, the learning contents page, the search information page, and the view file page. The two external windows are the forum window and the help window.

10 Comparison with Other System Architecture

LOOOP architecture was compared with DSpace architecture to get a clear view of the architecture that was designed. DSpace is an open source that was designed to run on a UNIX platform in JAVA programming languages. DSpace consists of three layers of architecture, including a storage layer, a business logic layer, and a service layer. The storage layer is a layer consisting of a relational database for saving metadata and a 'bitstream' module for saving content data. The business logic layer contains the modules to perform the business logic of the system (i.e., the search function, the browse function, content management API, and the administration toolkit). The service layer contains the web user interface. Each of the layers links with the API (Application Program Interface) interface. For the storage layer and the business logic layer, the API interface is called a storage interface. For the business logic layer and the service layer, the API interface is called DSpace in-process application interface [12]. Figure 9 illustrates the DSpace system architecture.

The system architecture of LOOOP is designed based on the SCORM standard. There are only two parts in the LOOOP system architecture, including the client-side and the server-side. The client-side is the part that contains all the functions needed to communicate with LOs, including the search function, the browsing function, and information searching. The server-side is the part for storing LOs in a relational database. As a comparison, the client-side of LOOOP is similar to the combination of business logic and service layers for DSpace. The server-side of LOOOP is similar to the storage layer for DSpace. Besides, DSpace consists of a relational database for storing metadata and a 'bitstream' module to save contents data. LOOOP consists of a relational database to save LOs, and the field name for the table is the metadata for LOs. Thus, DSpace uses JAVA programming language that is one of the object-oriented programming languages in its implementation, and LOOOP uses Visual Basic programming language in its implementation. The system architecture design based on the SCORM standard was selected for use in this system because the SCORM standard is simple to use when constructing a new system architecture, and the method of dealing with LOs is more direct than with the DSpace system architecture. Besides, LOOOP uses a relational database as the LOs repository that contains all the created LOs and their metadata while DSpace uses a relationship database for storing metadata and 'bitstream' to store contents data. These are the reasons why LOOOP used the architecture based on the SCORM standard in implementation.

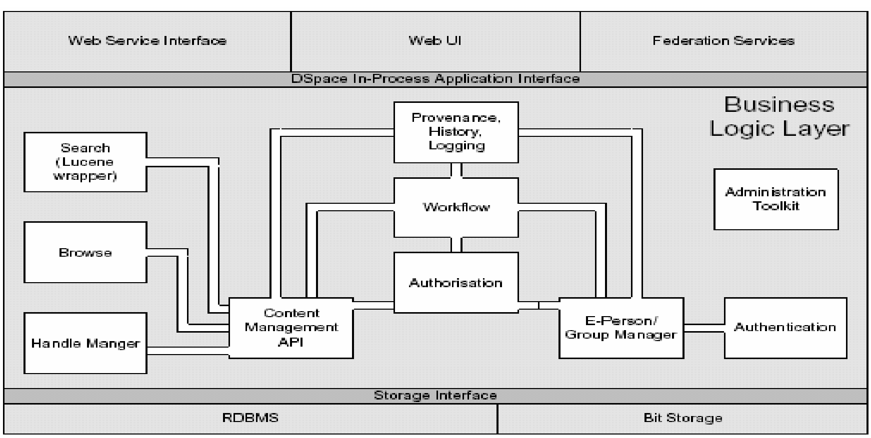

Fig. 9. DSpace Architecture

11 Evaluation

The significance and justification of the project are as follows:

1. Flexibility in the learning style of an e-learning system is important to ensure that the students benefit from using the system. Even though there are a lot of multimedia e-learning systems that can attract students' attention, students also need the system to become part of their life, like a normal textbook where they can scribble their notes.

2. Reusability in terms of learning contents is a good way of sharing knowledge from one generation to the next. This e-learning system can be reused by other students where the next generation of students will have access to more notes than they might have expected.

12 Conclusion

This paper presents an application framework used in developing an E-Learning system for an Object-Oriented C++ Programming subject. The development used the LOs concept where the focus is on the reusability of the notes. The reason for developing the framework is to ensure all the data (as notes) in the system can be reused by other subjects where relevant. Therefore, it can reduce the need for expansion and enlargement of the database over time. It also is allows students to add-in additional information to the notes, just as they might do with a normal textbook; for example, they might want to write down extra information and highlight important keywords to the notes.

The system has four main sections: user verification, learning contents, searching, and files. The concentration is on the second section, which is learning contents, where students can read the available notes and edit the content by, for example, searching the Internet and getting information by having a discussion with their friends online. The notes database is divided into several tables, which are text, image, and audio. In the future, the database will be enhanced to include other multimedia elements or other file types and will be distributed accordingly to cater to the large size of the notes content.

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A Semantics Based Information Distribution Framework for Large Web-Based Course Forum System

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Abstract. We propose a novel data distribution framework for developing a large Web-based course forum system. In the distributed architectural design, each forum server is full equipped with ability to support some course forums independently. The forum servers collaborating with each other constitute the whole forum system. Therefore the workload of the course forums can be shared by a group of the servers. With the secure group communication protocol and fault tolerance design, the new distribution framework provides a robust and high performance distributed architecture for the large course forum system. The forum servers can be settled in anywhere as long as a broadband network connection to Internet is provided. Our experimental performance testing results show that the large forum system is a high performance distributed system with low network overhead cost. In addition, a semantics based clustering algorithm is developed to classify the courses by the content relevance of their teaching material. Relevant course forums can be arranged on the same forum server together. Hence our distribution framework also provides a knowledge-based taxonomic storage solution to build a large course teaching material digital library.

1 Introduction

Rapid advance of the Web technology has changed not only the initial role of the Web as the media of information communication but also human life in various ways. Web learning becomes one of the hot research topics in recent years. Many Web-based education application systems have been introduced and affected the traditional teaching-learning concepts, models and methods. Without the limitations of the time and geographic location, these systems provide synchronous or asynchronous interactive learning environment between the teachers and students as well as among the students themselves. We started working on the online Web-based Bulletin Board System (BBS) forums in 2003, and developed a Web-based BBS forum system named Teaching Assistant System (TAS) [5]. This forum system has been used to provide online tutorials for the students in several teaching courses these years. Currently we are planning to extend the BBS forum system to a large course forum system to support all teaching courses in our university[1]. We reviewed our original TAS system design

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and devised an innovative information distribution framework to build a large Web-based course forum system as presented in this paper.

Nowadays, almost all Web-based BBS forum systems use quite similar conventional client-server database design in Fig.2. The kind of design produces a tight system architecture. The biggest benefit from this architecture is the lower forum maintenance cost, which mainly covers the forum data backup, system update and ordinary forum management. However, the tight architecture apparently has its limitation as all forum servers must be allocated in a protected local network. Our approach is focused on overcoming the limitation to develop a robust and high performance large course forum system which can work over the Internet.

In our approach, each forum server (named a *node* in this paper) consists of two system modules as shown in Fig.1 (a). The Forum Processing Module on a *node* is a full equipped Web-based BBS forum system which can work independently to support the forums locating on it. Node Communication Module is responsible for the data exchange and synchronization among all *nodes*. Therefore the *nodes* can collaborate with each other to form a large forum system and hold up all courses' discussion forums. Certainly the collaboration needs assigning a particular *node* as the coordinator for managing the communications among the *nodes.* We call the coordinator as a *main node*. Then we can derive a group communication model from the distributed system architecture as shown in Fig.1 (b).

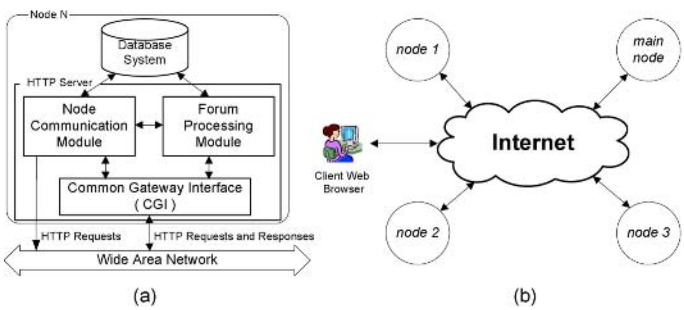

Fig. 1. System Architecture of the Distributed Web-based BBS Forum System

We believe that fault tolerance capability is a crucial issue for the distributed forum system. As a mature system design technique which we are using in the Forum Processing Module development, the conventional client-server database design is common used in developing Web-based forum system applications, e.g. XMB, DVBBS (www.xmbforum.com, www.dvbbs.com). Their successful products have been proven by over ten thousand online commercial or nonprofit BBS forums on the Internet. Thus we can assume that each *node* in our forum system has sufficient stability in handling all local forum operations and against the security attacks. On the other hand, nobody can guarantee that the network between two *nodes* will never be broken or jammed if and when two *nodes* are located in two different cities, where the network packets from one *node* have to go through over hundreds of miles to reach another *node*. To ensure that each *node* can provide adequate forum services even if it loses network connections to the *main node* or other *nodes* temporarily, the fault tolerance for temporary network interruption is the major concern in our work. We solve the problem with two methods. First, we apply a partial data replication in the database model design, the essential data for maintaining the local forum services are replicated in each *node*. Second, a secure group communication protocol is developed to keep the consistency of the replicated data in all *nodes*. Therefore our forum system can provide a robust and scalable distribution framework to meet the demand and nature characteristic of Web distance education.

Besides considering above design issues in the technical aspect, we also consider the behavior and interests of forum members as the important issues to affect the networking and computing overhead cost in the distributed forum system. Let us imagine an ordinary scenario: a member is currently interested in the topics of two discussion forums located in two different *nodes*. He may shift himself between the two forums and *nodes* frequently. Such these actions of forum members inevitably increase the cost for replicated user data update and synchronization. In fact, the majority of the communication overhead costs in the distributed forum system are involved in the replicated user data update and synchronization. Moreover, we also consider the forum system as a big digital library to store all course teaching material. We introduce a semantics based clustering algorithm to classify the relevant courses into a same group according to their semantic similarities. Then we can allocate the relevant course forums to the same *node* according to the clustering results. The initial semantic similarities of the courses are computed with the introduction syllabus of the courses. We believe that this allocation strategy is helpful in reducing the networking and computing overhead cost for the replicated user data update and synchronization. The statistical data we collected from real online forum communities proves that most people have strong preference in choosing their favorite topics and joining the corresponding forum discussions. Further, this strategy also speeds up the information assessment and distillation, and eliminates the complexity of work for the topic-oriented summary in constructing the knowledge digital library. Because we have already provided a knowledge-based taxonomy storage framework to settle the information and knowledge before the contributors (teachers and students) submitting them.

2 Related Work

Bulletin Board System (BBS) first appeared in the middle of 70s and was essentially "a personal computer, not necessarily an expensive one, running inexpensive BBS software, plugged into an ordinary telephone line via a small electronic device called modem" [10]. With advent of the Internet, the World Wide Web (WWW) brought more new multimedia technologies to the BBSs. Millions of BBSs sprang up across the world. BBS online community also becomes an interesting research topic attracted many social researchers. Bieber's paper [9] studies some research questions about knowledge management and learning in virtual communities, and proposes a set of tools for examining community development and participant's interactions. Leug observes the importance of growing information and knowledge sharing activities, and points out that theses activities in online communities are becoming increasingly important to the companies conducting business electronically [8]. Their work inspires us to pay more attention to think about how to motivate students in a distance e-learning environment during the forum system development.

In the technical aspect, Data Grid [4] [11] presented a distributed database management system for the mass replicated data accessing in the large scientific computing community. We meet the same problems in handling data replication and synchronization over a WAN as well as Data Grid, however the replicated data in our work are formalized relation tuples stored in a RDBMS. We prefer to use a distributed database model to represent the architecture of our distributed forum system than a middleware infrastructure, although we use similar system design idea in the similar working environment. There are some relevant research work exploring the important role of BBS forum system in their e-learning approaches [1] [12]. However, like that in our previous work [5], they just used a BBS forum system as an interactive platform in their e-learning approaches and never concerned the performance problem in forum system. While developing the forum system, we studied the codes of two Web-based BBS forum systems (XMB and Discuz! Board). We also observe that some world class IT companies such as Yahoo!, Google are launching their large online BBS forums this year. However, until we write this paper, there is no research paper or technical report proposing a system design as similar to our approach.

3 Semantics Based Information Distribution Framework

3.1 Background and Motivation

Our original TAS forum system uses a conventional client-server database design as shown in Fig.2 (a). The forum system consists of a HTTP Web server and a SQL database server. The Common Gateway Interface (CGI) of the HTTP Web server works as a broker to pass data carried by a HTTP GET or POST request to the corresponding CGI program. Then the corresponding program is triggered to process the data, finally the corresponding database data are updated and a HTML page is generated and returned to the client. In the client-server architecture, the Web server acts as a pre-processor to process the data carried by the HTTP requests, and the database server handles all data storing and accessing. Fig.2 (b) illustrates a popular clustering system design. It uses a workload balancer to dispatch the HTTP requests into two Web servers, each Web server cooperates with its database respectively. The data consistency is kept by the database cluster technique. Thus the workload is shared by two similar forum systems. This design provides a robust and scalable capacity to the Web-based forum system to meet the demand of a large BBS forum. The particular clustering technique is also helpful in enhancing the reliability of the entire forum system. However both system architectures have a limitation: all servers have to be located in a high speed internal network because of the heavy data communication among the servers.

The major objective of our work is to build a high performance distributed Web-based BBS forum system with least hardware cost as possible. We find that the above system solutions are not suitable for building the large course forum system. Firstly, there are 3983 different kind of courses in our university, covering 157 programmes

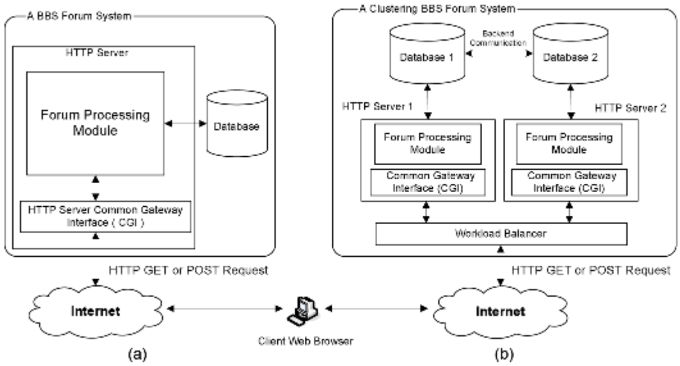

Fig. 2. System Architecture of Popular Web-based BBS Forum Systems

in sub-degree, undergraduate and postgraduate levels in 2005/2006 academic year. To fulfill the demand of supporting these courses, at least two expensive enterprise grade servers are needed if we choose the centralized system design. Secondly, when we consider that some course forum servers will be located in Community College outside the main campus, the clustering system architecture also presents its server settling limitation even if it can provide a cheaper solution.

In our approach, the distributed forum system consists of several server *nodes*. We are planning to choose 8 Small Business grade Rack-dense servers at price below US$2,500/pc (e.g. DELL SC1425) as the *nodes*. For *main node*, we choose two higher grade servers at price US$5,000/pc (e.g. DELL PE-2850). Then the hard-ware budget of the whole system costs no more than US$30,000, it is around 25-30% for purchasing one 8 way enterprise grade server (e.g. SUN Fire 890, or IBM eServer 570). However the computing power we can obtain at least doubles such a server, both the CPU power and disk storage capacity.

3.2 Horizontal Fragmentation Database Distribution Model

The original TAS system was developed with PHP, Apache Web server and MySQL database server on the Linux system platform. PHP is configured as a module embedded in Apache Web server to improve the code performance. At the beginning of designing the new semantics based information distribution framework, we reviewed the codes, database structure of the TAS system and investigated the ordinary operations of forum users in participating in the forum discussion. Two results have been derived from the investigation.

1. The forum system uses a catalog tree to arrange the discussion forums, the topic threads and the posts. The tree structure is hidden to the human users by the URL links in the HTML pages. To visit a discussion forum, all a user has to do is a click of the corresponding URL link in a page. Even an experienced user might not perceive the URL link has led him to visit another forum site if the two forum sites use the same user interface. This hidden URL link technique makes using multiple servers to construct a large forum system feasible and user friendly.

2. Despite the forum management operations (which is seldom occur in these tasks), the ordinary operations of a user in TAS forum system can be concluded as viewing courses index, viewing the topics list in a forum, reading the posts of a topic thread, and writing a post to disseminate information. Inside the corresponding forum programs, the data tuples manipulated in a forum are also limited to those tuples with "belong to" relationship to this forum.

Based on the above results, we can use horizontal fragmentation schema [7] to partition the relevant database tables by the course identity. In theory, this partition schema will absolutely not affect the data integrity of whole forum database. Hence, each *node* of the distributed forum system only maintains the partial database data belong to the forums supported by itself.

3.3 User Data Partial Cache Mechanism for System Fault Tolerance

The user authentication for a Web service is quite different from other network services, since HTTP protocol is a stateless application protocol. Almost all web servers cannot track a user's progress over the HTML pages. Most of Web-based BBS forum systems reply on a HTTP session technology to solve the user authentication problem. The forum system generates a unique session identity (ID) for a user when he logs in. The session ID is returned and kept in the user's Web browser locally, thereafter the Web browser will combine the session ID in every HTTP request sent to the forum site, then the forum system can validate the member's HTTP requests by the session ID. Consequently the *User* table becomes the busiest table in the forum database. That's why we have to replicate the data of this table over all *nodes*. On the other hand, there are few users visit every forum in the forum system, and few or no users will submit their posts in every forum. For example, a student of CS department might never visit the course forums of Physics department. Thus a partial tuples replication for the *User* table may be reasonable to reduce the cost for the user data update and synchronization in whole forum system.

This partial tuples replication is called "user data partial cache mechanism" in our work. The cache mechanism is implemented as follows: The *main node* maintains a full copy of the *User* table, and other *nodes* keep an empty *User* table at the initial stage. When a course forum moderator (the course lecturer or tutor) uploads a student list of his course, the corresponding *node* sends a "pull" request to the *main node* to fetch the corresponding user records of these students, and keeps them into the *User* table locally. For other registered users, the *node* will send a "pull" request to the *main node* to fetch the record at his first login on the *node*.

The user data partial cache mechanism allows all *nodes* to obtain a capability of tolerating the temporary network breakdown or traffic jam. Each *node* can keep on providing normal forum services to the users whose records have been cached locally when it loses the network connections to *main node* or other *nodes*. For other registered users, they can also read the posts in all public discussion forums by sharing a guest account temporarily.

3.4 Group Communication Model for Data Update and Synchronization

We consider all network communication traffic among the *nodes* as the communication overhead cost. However, the network communications play an essential role of the data update and synchronization to the entire forum system. We studied the network communication problem by a distributed group communication model abstracted from the entire forum system as shown in Fig.3.

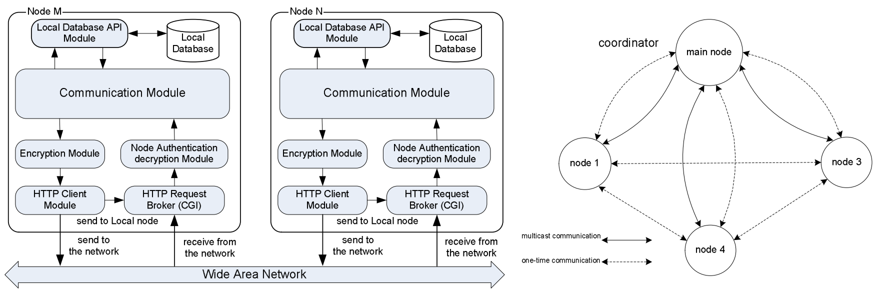

Fig. 3. Group Communication Model for the Distributed Forum System

We classify all group communications into two types: multicast communications and one-time communications. The multicast communications are major involved in global forum management and global user data synchronization. They are launched and coordinated by the *main node*. The global forum management operations such as adding a new node or a course forum are not frequent in normal forum manipulation. On the contrary, global user data synchronization is a regular multicast communication to provide an exact user data update for all active registered users. The one-time communications are mainly involved in the individual user authentication and data update. When a registered user visits a *node*, the *node* perhaps has to fetch his user record from the *main node*, or require his current session ID from the last *node* he left. A partial user date update operation is also counted in on-time communications, which is developed as a complement for the global user data synchronization to reduce the user data update latency.

We implemented all group communication protocols with HTTP CGI technique by "push and pull" methodology. When a *node* wants to send or get data from another *node*, it sends the corresponding *node* a POST request with its sending data. The server-side program in the corresponding *node* accepts the request and processes the data, and finally returns a XML file containing the required data. The biggest benefit of this approach is only one network port (normally 80 or HTTP port) is opened to serve both Web and group communication service. It helps to improve the forum system security, as HTTP Web service is considered as the strongest and most common networking service on the Internet.

In terms of the distributed forum system security, we introduce a RSA+3DES encryption solution to secure the group communications among the *nodes* on the Internet. 3DES symmetrical encryption schema is used to secure the transmission data by the *node*'s session key. Each session key is only valid in a prescribed period (2 days in the current system). The *main node* periodically generates a new set of session keys for all *nodes*. The set of session keys is transferred to each *node* with a 2-phase commit protocol to guarantee that every active node has received the new session key set before using them. RSA private-public key encryption schema is used to protect the session key transmission. Thus we implement not only a secure channel for each group communication, but also a solution for the *node* authentication in the distributed forum system.

4 Semantics Based Course Clustering

The usage and role of the course clustering has been discussed in Section 1. In this section, we will focus on describing the semantics based clustering algorithm in details.

In City University of Hong Kong, each teaching course has provided a course introduction Web page. We can get all these pages from the university Website (http://www6.cityu.edu.hk/puo/arro/AtoZIndex.aspx). The plain text content in each page can be divided into three parts: course title (d_t), course aims & objectives (d_o), and keyword syllabus (d_s). Then each part is processed respectively to extract all keyword terms as shown in Fig.4. We use Vector Space information retrieval (VSD) model to represent a document [2] [3]. In this model, each document is represented by the weights of all keyword terms (w_i) as the following.

$$\vec{d}_i = (w_1, w_2, ..., w_t) \qquad where \quad w_i = tf(i) \times idf = tf(i) \times \log \frac{N}{df(i)} \tag{1}$$

$tf(i)$ denotes the term frequency, the number of times of keyword i occurs in a document. idf is the inverse document frequency of keyword i. N is the total number of documents in the corpus, and $df(i)$ is the total number of documents containing keyword i. Then the similarity of a pair of documents i and j is computed by

$$sim(\vec{d}_i, \vec{d}_j) = \frac{\vec{d}_i \bullet \vec{d}_j}{|\vec{d}_i| \times |\vec{d}_j|} \tag{2}$$

When we apply the similarity in our course documents, we derive the following formula to compute the semantic similarity of two course documents.

$$sim(\vec{d}_i, \vec{d}_j) = \alpha \times sim(\vec{d}_{i,t}, \vec{d}_{j,t}) + \beta \times sim(\vec{d}_{i,o}, \vec{d}_{j,o}) + \gamma \times sim(\vec{d}_{i,s}, \vec{d}_{j,s}) \tag{3}$$

where α, β, γ is the coefficient weight to satisfy $\alpha + \beta + \gamma = 1$. They are currently set to *0.2, 0.3, 0.5* respectively in our final clustering algorithm.

Finally, all these pairwise similarities of course document constitute the distance matrix (we simply use $1/sim(\vec{d}_i, \vec{d}_j)$ for the hierarchical clustering [6]. The result derived from the clustering algorithm is used to partition the courses, so that the relevant course knowledge and information content can be settled on the same *node*.

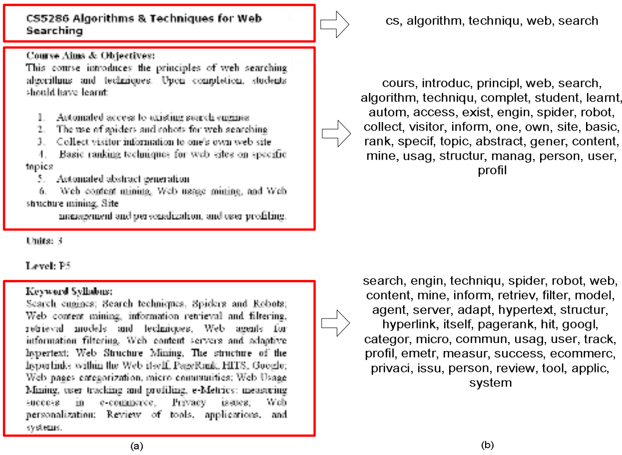

Fig. 4. Sample: A Course Introduction Document and the Extracted Keyword Terms after Removing Stopwords and Stemming Process

5 Experimental Result

To investigate the human user's behavior in online forum community, we need large amount of real forum data in large online forums. The old TAS system can not provide this kind of data due to its limited capacity to support a large course forum. To collect the data, we chose two online forum sites for our study. One is Apple Discussions Community (http://discussions.apple.com), a commercial technical support forum for the products of Apple Company (we call the forum as *apple*). Another site *bsd* is a nonprofit forum community for BSD UNIX fans (http://www.freebsdforums.org). We wrote a Web crawler to download the posts of 61 discussion forums in *apple*, and all posts in *bsd*. There are a total of 189,926 posts in *apple* submitted by 46,599 different registered users, and a total of 159,419 posts cover 36 different topic forums in *bsd* submitted by 7,784 different registered users.

The statistic results are illustrated in Fig.5. The results provide an evidence for the partial user data cache mechanism design: most people have strong preference in choosing their favorite forums, and they seldom join in the discussions about topics they are not interested in.

We choose CentOS Linux 4.2 to set up the experimental forum system for performance testing. All performance tests are conducted in a forum system with 10 server *nodes* connected with a 100M Fast Ethernet LAN. Two DELL PE-2850 servers (Dual Xeon 3.8GHz CPU with 4 GB RAM and Raid 1 73GB SCSI disk) work as the *main node* and *backup node*. 8 Pentium D 3.0GHz PCs with 1 GB RAM and a 80GB SATA disk work as the *nodes*. We set up 10 courses in the course forum, and each course has four discussion forums respectively. Then every *node* serves one course and its four forums independently. We also develop a multithread HTTP client program to simulate all ordinary forum operations of a Web Browser.

The below two figures in Fig.6 show two system throughput benchmark results briefly. The single node throughput benchmark declares that a single *node* (PE-2850)

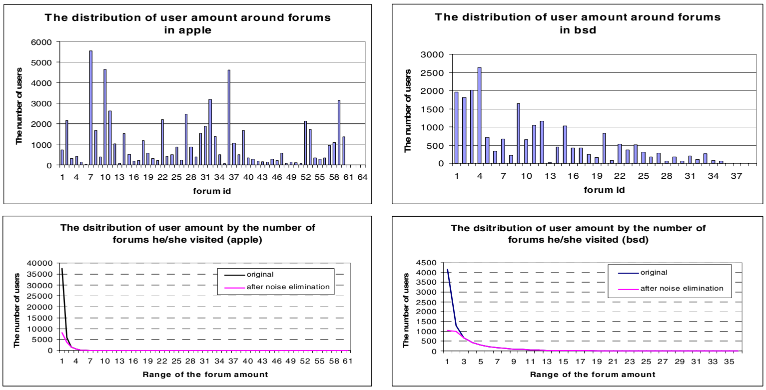

Fig. 5. The Statistical Analysis Results for Two Online Web-based Forum Communities

can handle at least 2500 forum operations within 1 *minute*. The user authentication throughput benchmark compares the response time of two user authentication methods in the distributed forum system. The results of *local log in* operation are obtained in the *main node* with 40,000 users, the results of two *remote log in* operations are obtained in the *backup node* with an empty *User* table initially, consequently the *backup node* has to get the corresponding user record from the *main node* remotely. The result shows the cooperation of two server *nodes* can increase the system performance and achieve a much shorter response time than that of a single server *node*.

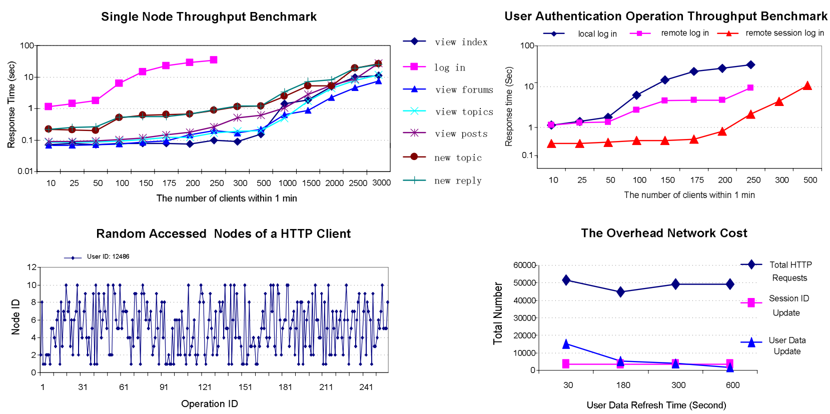

Fig. 6. The Performance Benchmark Results in the distributed forum system

To evaluate the maximum communication overhead cost in the distributed forum system, we simulate an extreme case: 400 registered users are doing nothing except walking around the 10 *nodes*. In fact the actions of theses users are involved in two forum operations, getting the index page of a *node* and randomly choosing a course link (a *node*) to get the forum list page. Within 20 minutes of the simulation, the total number of HTTP requests handled by all *nodes* is 48,650 in average. When we set the data refresh time to 30 *seconds* (close to real time user data update), there are 15,103 requests for partial user data update, and 3,600 requests for session ID update. When we set the data refresh time to 10 *minutes*, there are only 1,805 requests for partial user data update, and 3,600 requests for session ID update. The below two figures in Fig. 6 illustrate the results for four data refresh times. The maximum computing overhead cost is *29.18%* for 30 *sec* data refresh time, and *7.627%* for 10 *min*. The maximum network overhead cost is *1.084%,* and *0.441%* respectively. The results declare that we have built a high efficient forum system with a low computing overhead cost and trivial networking overhead cost without the user preference optimization.

Table 1 shows a result for verifying the precisions of the semantics clustering algorithm. Two clusters are listed with respect to course CS5286 and CS3102 when all courses are clustered into 300 clusters. There are 3983 course documents in the corpus as we mentioned in Sec 2.1. Readers who are interested in the result can check it at the Website.

Table 1. A demo result of the semantic based clustering algorithm

Cluster ID	Course Code	Course Title
cluster 183	CS 5286	Algorithms & Techniques for Web Searching
	CS 4395	Web Publishing
cluster 240	CS 3102	Operating Systems
	CS 3103	Operating Systems
	CS 3161	Operating System Principles
	CS 4183	Advanced Operating Systems
	CS 3151	Computer Systems
	CS 3171	System Software
	CS 3185	Computer Architecture
	CS 5102	Operating Systems
	CS 5101	Computer Organization and Architecture

6 Conclusion

We believe that a Web-based course forum system not only provides a dynamic interactive learning environment for teachers and students to allow off-class discussion beyond the limited classroom teaching, but also conducts a knowledge collaboration to build a big teaching materials digital library. We summarize the contributions of our work in four points. First, through analyzing the member's behavior in a forum community, we investigate the possibility of designing and implementing a distributed forum system. Second, we present a taxonomy storage framework to partition the forum database. This partition is based on the knowledge and information relevance of the courses' content. Third, we design a partial data cache mechanism based on the analysis results of the behavior of forum members. The data cache mechanism makes the forum system become a robust and high scalable distributed forum system with fault tolerance to the failure of network and computer hardware. Fourth, we implement an innovative secure group communication approach for the forum data exchange on the Internet. In fact, the distribution framework in this paper is not only suitable for implementing our distributed course forum system, but also a promising business solution for a large commercial forum application product.

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An Efficient Illumination Framework for Web-Based Lighting Engineering Education

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Abstract. Although the interactive web-based learning environment enriches the study of lighting engineering, it relies healthy on realistic rendering and illumination calculations of 3D scenes. These operations are typically very expensive in kernel computations and content distribution. Hence, they are not applicable to dynamic scene. Our objective in this work is to address this problem through a multi-resolution approach in order to provide a real-time feedback to the students as they modify the lighting conditions or the geometry of the scene. We apply progressive and selective data transfer of 3D models with geometry and illumination attributes. The experimental results show that the proposed solution provides better user experience to the students.

Keywords: Lighting Engineering, Global Illumination, Web-based Learning, Dynamic Scenes.

1 Introduction

Along with the rapid progress of economic development, the demand for modern urban planning is greatly increased. In recent years, people are paying more attention on the issues such as environment conservation, energy efficiency and functional harmony, especially in the areas of lighting engineering as well as building engineering. The project NumeLite (launched in year 2001) has involved academic and industrial partners from 6 European countries to work for a new solution in urban lighting. It integrates the techniques in lighting calculation, visual perception and social psychology to produce an innovative and economical urban lighting system. The ideas developed and lessons learned can help many people around the world, with the advance in Internet technologies.

Those web-based services enable students to learn from the lighting planning and demonstrations on a remote site at any time. They also allow them to communicate and cooperate with each others to work for a new design or 3D simulation. However, the learning environments of lighting engineering mainly rely on rendering and illumination calculations on 3D models, which are generally time consuming in kernel computation as well as in content distribution. For a moderate virtual city of such an environment, there may be a large number of buildings and vehicles distributed on the roads, well lighted. It will take a rather long waiting time just to download the entire database of geometry models and to update the scene

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illumination as the vehicles move around. The resulting delay severely degrades the user experience of such an environment.

To overcome the current limitations of 3D lighting simulation, we propose a new scheme to support web-based learning environments of lighting engineering, especially urban lighting planning. It extends the radiosity solution [1] in lighting simulation to timely update a dynamic scene containing moving objects, and utilizes multi-resolution modeling techniques in rendering and content distribution to address the latency problem.

The rest of this paper is organized as follows. Section 2 reviews relevant work. Section 3 presents the framework of our proposed method. Section 4 presents more details of the radiosity solution for dynamic objects. Section 5 shows the performance of our method with some experimental results. Finally, Section 6 briefly concludes the work presented in this paper and discusses possible future work.

2 Related Work

Content distribution is a common problem for distributed applications, such as online games and web-based learning. A few solutions have been proposed to allow the users to download only the content of a selected region [2], or of current interest [3]. Based on our multi-resolution modeling technique [4], a framework is proposed to allow a server to prioritize the content for progressive transmission to the clients according to the needs of individual clients [5]. It is the underlying approach of this framework to optimize data transfer of 3D content under different network bandwidth conditions, which can be extended and applied to the work presented in this paper.

Global illumination (GI) is an important technique in current applications for simulating real-life lightings, as in VRay (a rendering engine for 3D Studio MAX) or Brazil (a commercial renderer from SplutterFish). However due to its high computational costs, majority of traditional GI algorithms were designed for rendering static scenes. To support dynamic environments, which are more practical for most real-time applications, some new methods have been proposed. In Line-Space Hierarchy [6], a novel structure is proposed to accelerate the identification of geometry changes. A time vs. quality trade-off is also provided to support interactive update. However, the visual quality of all affected parts will be degraded to the coarser level and it is hence not accurate enough for simulating lighting effects. Selective Photon Tracing [7] uses the graphics hardware to estimate the illumination by a controlled photon tracing path. Although it provides better visual quality, it relies on graphics hardware and there is no support for web-based applications. By decoupling GI computations from image rendering, Shading Cache in [8] utilizes an object-space caching structure and multi-processing to achieve real-time display of dynamic scenes. However, when more users participate in the application, the server can be quickly overloaded.

3 Our Solution

Although existing GI approaches attempt to provide high quality photo-realistic images for static or even dynamic environments, none of them is suitable for use in a web-based learning environment with a client/server architecture. Our scheme is to solve the problem in two aspects. One aspect is about the data transfer of selected models with geometry and illumination attributes. We have adopted the distribution framework presented in [5] with multi-resolution models to optimize the visual quality and user experience at each client. The other aspect is the illumination solution, which is based on the same model for transportation. We adopt a radiosity method to simulate diffuse lighting (the primary component of urban lighting) and then extend it to support dynamic scenes and progressive update. Since the details of the first aspect are well illustrated in [4] and [5], we mainly focus on the illumination techniques in the following subsections.

3.1 Solution Ideas

In our web-based learning environment, the server is always working on the full content of a given scene while each client manages its own part of the scene. In addition, a shared object at the server and at the client can be represented by two separate meshes. To ensure real-time response, the new scheme should incorporate the following features:

- The resolution of the mesh at the client should be adjusted according to the view changes, through progressively inserting or removing details from the mesh.
- The resolution of radiosity computation for a given mesh should be determined by the update rate – reducing it when the update rate is not high enough and increasing it otherwise.
- The method should match the partial results from illumination calculation with whatever the resolution of the mesh used to represent the object.

To optimize the performance of the overall system, in our framework, the server is responsible for computing the GI solution. This allows the results to be shared by multiple clients. Each client is responsible for constructing its own mesh representation of each object at the appropriate resolution for rendering. This allows the client to optimize the model resolution according to the view parameters of the client. The operations include:

- ***Progressive illumination computation at the server:*** To achieve a complete illumination update with limited computational resources during dynamic update, we should compute the illumination of the relevant objects at the lowest resolution and process those with higher update priority first. This priority is determined in a perception-driven approach, including factors such as object motion and object distance. The illumination resolution can be progressively increased when time is available.
- ***Optimizing the rendering performance at the client:*** While the server is progressively updating the illumination, the results are distributed to the clients and illumination synchronization is performed on relevant meshes. Since the meshes at the clients may have different resolutions to the one in the server, the synchronization process is to redistribute the computed radiosity values to more detailed levels. It is based on knowledge from the refinement procedure of multi-resolution models and their geometric attributes.

With the above scheme, a client may move a dynamic object in the environment and the major illumination changes in each client's view are updated first. Even if the number of dynamic objects might be changing, the computation time and memory cost at sever can be kept almost constant. However, our current implementation only supports rigid objects and all the dynamic objects must be marked in advance.

3.2 System Overview

Our solution is composed of two processes, the pre-process and solution process, as shown in Fig. 1. The essential part of our system lies on the server side.

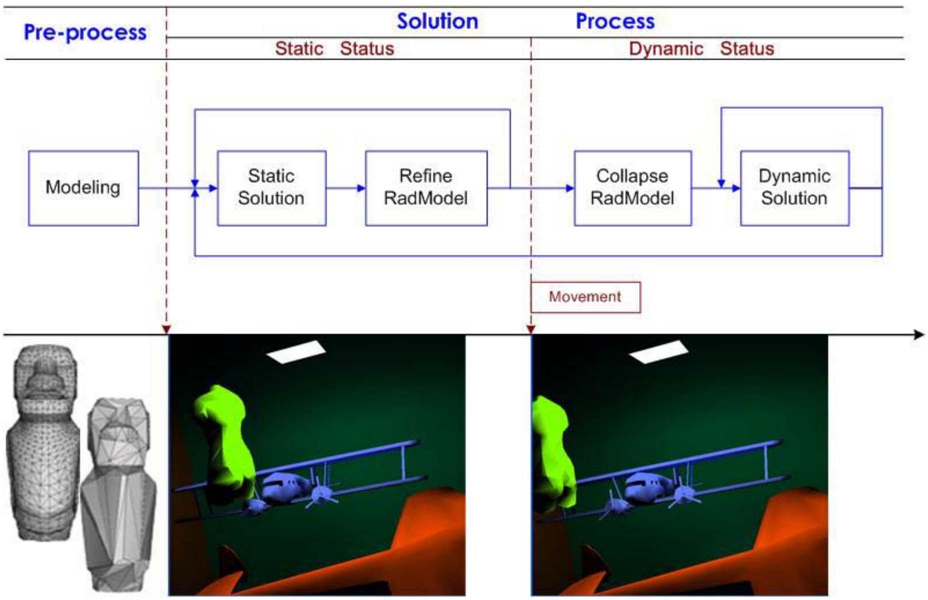

Fig. 1. Overview of the solution

The pre-process is performed before the main solution process. The server first determines the initial resolution of each object model for radiosity solution, called the *RadModel*. Each client selects the objects in visible range and the rendering resolution of each object model, called *RenModel*, according to the user configuration.

The solution process then begins with the given environment parameters. The solution for all the objects at static state is computed first at the server to provide the basic illumination values and collect necessary shooting information. The server will then progressively send more accurate illumination values to the client and the transfer function of radiosity redistribution is determined.

When a client is synchronized with the server, it can initiate any movement of dynamic objects. This will interrupt the current solution cycle at the server and turn it into Dynamic Status immediately. The control scheme in Dynamic Status aims to support efficient update while maintaining the visual quality of objects acceptable.

The complexity for computing radiosity is reset to minimal, consisting of objects with higher update priority. This solution cycle lasts while the objects are moving. When the motion stops, it will go back to the Static Status and generate more accurate illumination.

3.3 The Learning Environment

To construct a complete web-based learning environment, all scene descriptions and 3D models need to be acquired and stored in a central server. A registered user, i.e., a student, can select a given scene to work in. Initially, this selected scene is illuminated by a basic lighting scheme to represent the static situation of the scene. All students in one selected scene may cooperate to design a new lighting plan and implement it step by step. The scene can be segmented into different groups, and a student may freely adjust any objects or light sources within his/her own segment. The relevant changes in illumination will then be updated instantly, initially at low accuracy and gradually improved into higher accuracy. Such instant feedback allows the student to quickly evaluate the lighting conductions. Thus, the whole application provides the students an interactive environment to learn the techniques and skills in lighting engineering.

4 Radiosity Solution for Dynamic Objects

As stated above, the efficient illumination update is achieved within the solution loop illustrated in Fig. 2.

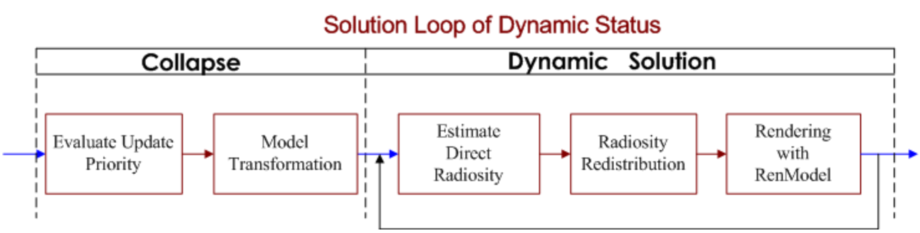

Fig. 2. The solution process during the dynamic status

A collapse procedure is first performed at the server, which evaluates the update priorities of objects and selectively unrefines those involved in radiosity recomputation. There are three major aspects that determine the priority of scene elements in a dynamic environment: visual perception, motion, and physical illumination. They can be represented in either object scope or patch scope, as shown in Table 1.

The objects or even patches can be prioritized for dynamic update with the metrics of above factors. Then a fast radiosity update is performed on selected models containing a proper number of patches. The update follows the basic steps below:

1. Delete old shadow of the object by shooting additional light onto its old shadow area.
2. Place the object at the new position.

3. Update patch radiosities of the object.
4. Add new shadow of the object by shooting negative light into the new shadow area.

Table 1. The results of noise assessment on certain images

Scope	Dominate Factors		
Scene	**Visual Perception**	**Motion**	**Physical Illumination**
↓ Object	*Visible Range*	*Move Direction* *Move Speed*	*Occlusion* *Existing Energy*
↓ Patch	*Directional Visibility*	*N/A*	*Color Difference*

The overall update speed of the above operations mainly depends on the efficiency of steps 3 and 4. Their efficiency can be guaranteed with the control of computational complexity using our methods presented above. The illumination update is then distributed to the clients and synchronized to the rendering mesh with radiosity redistribution immediately for rendering at the clients.

5 Results and Discussion

We have implemented the proposed scheme into two modules, the server module and the client module. In our experiment, both modules were run on the same machine. To illustrate the performance of our radiosity solution for dynamic objects, we have conducted two groups of experiments on the basic indoor scene as shown in Figure 1 with different configurations of object complexity and scene composition.

5.1 Scene Complexity

This experiment compares the performance of the radiosity solution with and without dynamic update priority under diverse scene complexities. There is only one dynamic object (consisting of 2,000 patches) moving in a constant direction and speed, while other objects are fixed in their positions. The composition of accelerating methods adopted is shown in Table 2 below.

Table 2. List of test conditions

	Dynamic Radiosity Estimation	**Dynamic Priority in Object Scope**	**Dynamic Priority in Patch Scope**
DP0	*N/A*	*N/A*	*N/A*
DP1	YES	*N/A*	*N/A*
DP2	YES	YES	*N/A*
DP3	YES	YES	YES

Fig. 3 shows the computational complexity of each approach for one dynamic radiosity update, in terms of $\log_2$(*Patch No.*). As described above, the result of DP0 shows the original update complexity without any accelerating methods, DP1 shows the acceleration with recomputation and estimation on unrefined models of all objects, DP2 provides the improvement with a limited number of objects, and DP3 illustrates the update cost with the minimal set of patches.

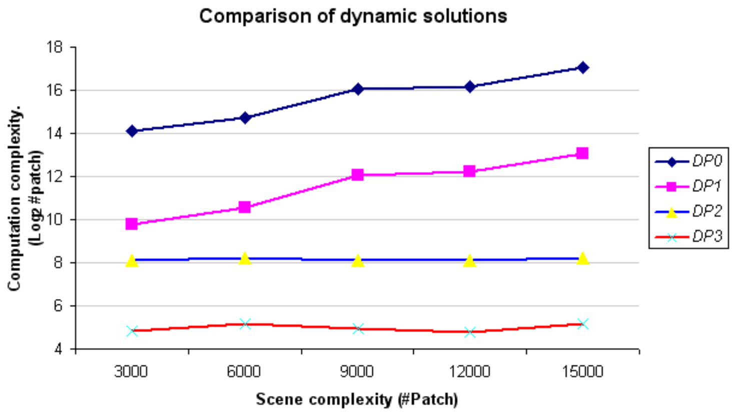

Fig. 3. Experiment 1 on scene complexity

We can see that with dynamic estimation and update decision, the update cost of DP3 is quite low and almost constant in spite of the increase in scene complexity. DP2 is close to constant but higher than DP3 because it selects similar objects with highest priority under different scene complexities. DP1 uses previous results to accelerate the solution procedure on the same set of objects as in DP0 so that they have similar increase rate.

5.2 Dynamic Object Complexity

Experiment 2 compares the performance of radiosity solution with dynamic update decision, in terms of computational complexity. The rendering complexity is approximately 10,000 patches and the dynamic complexity is increased by allowing more objects to move.

Fig. 4 shows the average computational complexity of one single dynamic radiosity update, in terms of $\log_2$(*Patch No.*). For DP0 and DP1, the computation costs are always the same as the full complexity of all objects. Hence, they are constant in this experiment. The cost of DP2 is increasing as the number of dynamic and affected objects is growing, while it is the same with DP3 but much lower in actual complexity. We must note that the threshold of priority decision is fixed in this experiment. However, it can be controlled by the dynamic object complexity. Hence, its cost will be lowered to save processing time while the illumination error will increase.

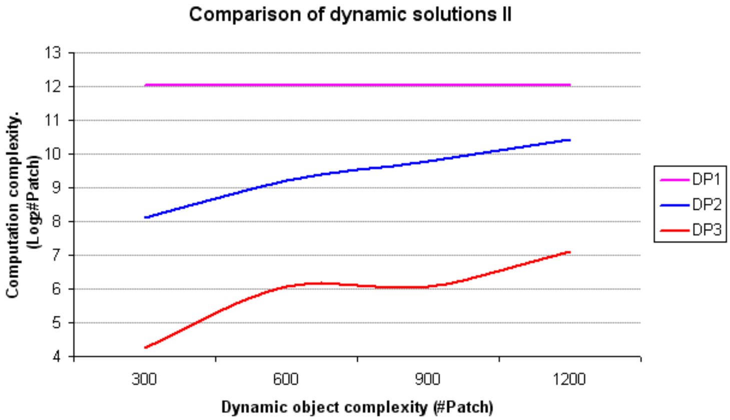

Fig. 4. Experiment 2 on object complexity

Note that the performance of updating the radiosity as an object moves from one location to another does not really affected by the number of concurrent users, since the update process is performed at the server.

6 Conclusion and Future Works

With the experiments discussed above, we have shown that our radiosity solution can efficiently reduce the computational complexity in dynamic environments, though temporally introduce limited errors during the update stage. The improvement in performance becomes more significant when the test scene is further expanded in space and geometry complexity. With multi-resolution modeling techniques optimized for content distribution, only the necessary results of radiosity update at the server will be transported to the clients and then synchronized to the rendering meshes efficiently. Hence the participating students will be more satisfied with the lighting effects on moving vehicles inside the web-based virtual urban environment, and actively learn more under the interactive mode that we provide.

However, the current prototype implementation is restricted to simple scene geometry and not yet applied to a complete environment on client/server architecture. We will further improve the illumination solution for complex outdoor urban systems and the visual quality at the clients with progressive update information from the server.

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The Database Model and the System Architecture of a National Learning Objects Repository for Cyprus

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Abstract. This paper presents the database model and the system architecture of a National Learning Objects Repository for Cyprus (NLORC). The NLORC will provide a web-based application allowing indexing, uploading and downloading of e-learning resources, creation and modification of Learning Objects (LOs) and querying. The proposed database model underpins the development of the NLORC. The model caters for the creation, storage and manipulation of LOs. After careful consideration and studying of the existing LOs Metadata Standards, it has been decided that the NLORC application should be developed using a database system supporting object-orientation and temporal database features. Thus, the proposed model suggests an object-oriented database structure as a basis for the application. This structure caters for the *relation* property of LOs (defined in most of the LOs Metadata Standards). The proposed structure caters for the storage of these objects, keeping a record of the relations between them and allowing their retrieval and manipulation. The proposed database structure has been designed based on existing LO Metadata Standards and a survey we carried out amongst academicians in Cyprus.

Keywords: Learning Objects Repositories, Databases, System Architecture.

1 Introduction

A huge number of learning resources is available either on stand-alone machines, or on local networks or on the Internet. Some are restricted to particulars users and some are available without any restriction to anyone interested in using them. Learning Objects Repositories (LORs) are web-based applications allowing the sharing of learning resources over the web. These learning resources are better known as Learning Objects (LOs). A Learning Object (LO) is basically any digital asset which can be used to enable teaching and learning [10]. Learning Object Repositories (LORs) [1, 7 ,9, 12, 14] allow the storage and manipulation of LOs. A comparison analysis of the various LORs models can be found in [31], where various models [2, 3, 6, 8, 13, 32] are explained and analysed. LORs are underpinned by database

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applications that provide the data structure representation of LOs. The properties (metadata) of the data structure representing the LO entity have been standardised across different countries and regions through Learning Objects Metadata Standards (LOMS) [5, 7, 30] which provide a data dictionary for LOs.

This paper presents a National Learning Objects Repository for Cyprus (NLORC). Currently, there is no strategy for e-learning in Cyprus. A recent attempt towards defining such strategy was made in [4]. Our current research work involves the collection and centralisation of information regarding e-learning in our country. This will help us later to identify the main participants of the e-learning National network which will be supported by the NLORC. Herein, we present a simple model that will underpin the development of the NLORC. The model is an extension of the model proposed in [29] and was presented in [21, 28]. After careful consideration and studying of the existing Learning Objects Metadata Standards, it has been decided that the NLORC should be developed using a database system supporting object-orientation and temporal database features. Thus, we propose herein an object-oriented structure to form a basis for the database application. The database structure caters for the *relation* property of LOs (defined in most of the Learning Objects Metadata Standards). The structure can also be extended to support other properties that need complex representations that can only be supported by object-oriented database structures (such as temporal data). One such property is the one which specifies the duration of the availability of a LO.

The work presented herein is part of a project [11], which attracted (December 2004) a grant of 80000 Euros from the Cyprus Research Promotion Foundation (CRPF) and is in line within the e-learning applied research work carried out at our College[15-28]. This project is divided in (a) a comparison evaluation of e-learning services in Cyprus and (b) the creation of a NLOR. The main stages of part (b) are given below:

1. Literature Survey and Research on LORs.
2. Investigation of the current status of distance-learning education in Cyprus.
3. Survey to analyze the attitude of academicians in Cyprus towards a National LOR. Statistical analysis of results.
4. Design of an initial Data Dictionary for the LOs data structure based on the research of (1) and the results of (3).
5. Survey to get feedback on (4) from the same user groups as the ones in (3).
6. Finalization of Data Dictionary based on 5.
7. Design of the database application based on 6.
8. Development of the web-based database application and recording of data. Development of the Learning Network between the institutions taking part in the network. Development of the NLORC.
9. Development of NLORC graphical interface.
10. Post implementation evaluation.

In the rest of this paper, in Section 2 we present an implementation model for the creation of LOs. In Section 3, we propose the object-oriented database structure, which provides the underlying structure for the development of the database application and underpins the development of the NLORC. This structure was presented in [21] and subsequently enhanced based on the results of our survey amongst the academicians in Cyprus which were presented in [28]. We also give the running example of the paper. In Section 4, we present the system architecture of the NLORC. Finally, we conclude by discussing our current and future work.

2 An Implementation Model

In this Section we explain how the proposed implementation model caters for the creation of LOs. The proposed model is an extension of the simple model proposed in [29] and was presented in [21, 28]. In [29] a LO is defined as being either an atomic LO or a composite LO (consisting of other parts). All parts of a composite object are computed by (recursively) taking the union of all parts of the LO. In our model, LOs are built from scratch or by using existing LOs or by modifying existing LOs or by a combination of all the aforementioned ways. More specifically, a LO can be created in one of the following ways (a,b,c,d):

(a) From scratch (without using an existing LO)

Fig. 1. LO1 is created from scratch

(b) By using existing LOs (line shows component relationship)

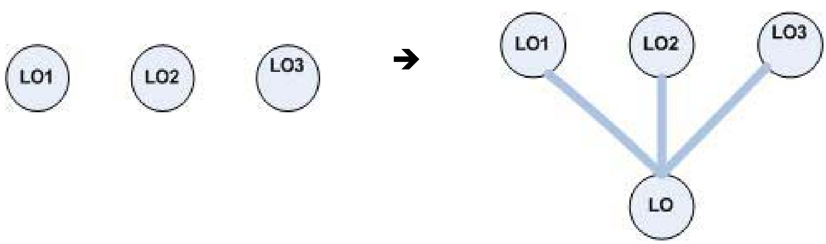

Fig. 2. LO is created by using LO1, LO2 and LO3

(c) By modifying an existing LO (arrow shows modification relationship)

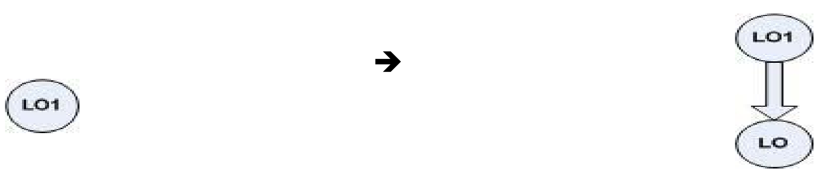

Fig. 3. LO is created by modifying LO1

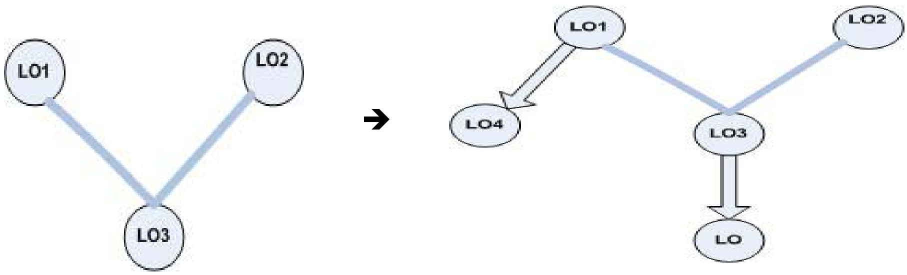

Fig. 4. LO is created by modifying LO3 by modifying LO1 (LO2 has been deleted – not shown)

(d) By a combination of (b) and (c) above

When a LO is modified through a modification of another LO to which it belongs to (as a direct or indirect component), all the LOs to which it (directly or indirectly) belongs, are also modified. As a result of this, a new LO is created for each LO modified. This is better explained through the given example. Given the LOs shown in the left part of Figure 5, we consider a user wanting to create a new LO as a version of LO7 with LO2 and LO1 modified and LO4 deleted. We also consider a user wanting to create a version of LO5 with LO2 and LO3 modified and LO1 deleted. The result of these changes is the creation of 4 new LOs, namely LO8, LO9, LO10 and LO11 for the first user and 3 new LOs namely LO12, LO13 and LO14 for the second user, as shown in the right part of Figure 5.

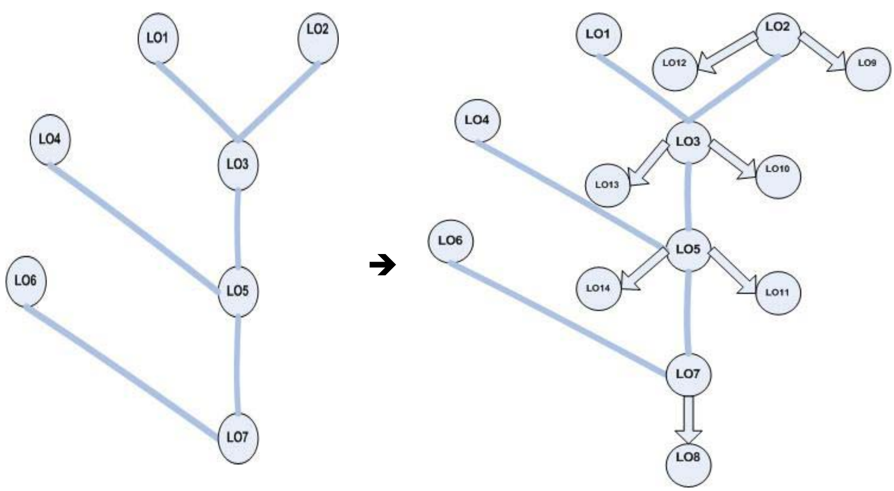

Fig. 5. Creation of Learning Objects

3 The Object-Oriented Database Structure for the NLORC

In this Section we present the first version of the object-oriented database structure of the database application for the NLORC. This structured has been designed based on most Learning Objects Metadata Standards [4, 14, 15] and the results of our survey amongst academicians in Cyprus with regards to their needs for a NLOR [28]. We focus however on the properties needed for the identification of the *relation* property, which keeps a record of which objects have used which objects as components (LOCompo-nents, LOCKind) or as modified versions (LOModified, LOMKind). The object-oriented database structure is given below, using abstract object-oriented notation:

Learning-Object

LOURI:	String
LOTitle:	String
LOCreator:	Creator
LOType:	String
LODescription:	String
LOCreation Date:	Date
LOLanguage:	String
LOSubject:	String
LOKeywords:	String
LODuration:	Time
LOAudience:	String
LOAccess (Read/Write):	String
LOModified:	Learning-Object
LOMKind:	String
LOComponents:	Set of [LOC: Learning-Object, LOCKind: String]
LOALLComponents	Method

Using the Learning-Object object-oriented database structure we can build the database application for the NLORC. In order to show how the LOs could be stored and hence manipulated using this structure we give, in Table 1 (next page), the LOs of Figure 5, stored as class instances of the Learning-Object structure. We only list the properties needed to exemplify our model. When LOs are created as modifications of existing LOs or using/referencing other LOs, the LOMKind and LOCKind values are generated by the system based on the kind of modification/usage.

The LOALLComponents is a method which returns **all** the components of a Learning Object (not only the LOModified LO and the other LOs which are stored in LOComponents) and is described by

Given a Learning Object LOX

LOX.LOALLComponnets = {LOX.LOModified} **Union**
LOX.LOComponents.LOC **Union**
(LOXI.LOALLComponents, where LOXI $\in$ LOX.LOComponents.LOC)

The above method basically implements the *relation* property of LOs as it returns all the LOs used in the construction of a LO. The method can be made more generic by introducing a variable to specify the depth up to which we want to calculate the components of a LO. We can also extend the method to return only the components which are associated with particular type(s) of modification (LOMKind) and/or particular type(s) of components (LOCKind).

Table 1. The Learning Objects of the Right Part of Figure 5

LOURI	LOTitle	LO Creator	LOModified	LOMKind	LOComponents
LO1	Data Manipulation	C1			
LO2	Data Model	C1			
LO3	RDBMS Theory	C1			
LO4	Intro to RDBMS	C2			
LO5	RDBMS	C3			
LO6	OODBS	C4			
LO7	Databases	C5			
LO8	Intro to Databases	C6	LO7	isversionof	[LO6, ispartof], [LO11, ispartof]
LO9	Data Model Basics	C6	LO2	isformatof	
LO10	Database Theory	C6	LO3	isversionof	[LO1, ispartof], [LO9, ispartof]
LO11	RDBMS Basics	C6	LO5	isversionof	[LO10, ispartof]
LO12	Data Modelling	C7	LO2	isformatof	
LO13	RDBMS Theory	C7	LO3	isversionof	[LO12, ispartof]
LO14	RDBMS Basics	C7	LO5	isversionof	[LO4, ispartof], [LO13, ispartof]

4 System Architecture of the NLOR

The NLORC implements a typical three-tier architecture (Figure 6). The core part of the NLORC is a Database tier, accessed and managed by means of the Application Server. The front-end of the system is built on the WEB servers. Another prominent part of the system is the NLORC storage. The NLORC storage must allow storing wide range of LO implementations covering the most popular ones. For this reason

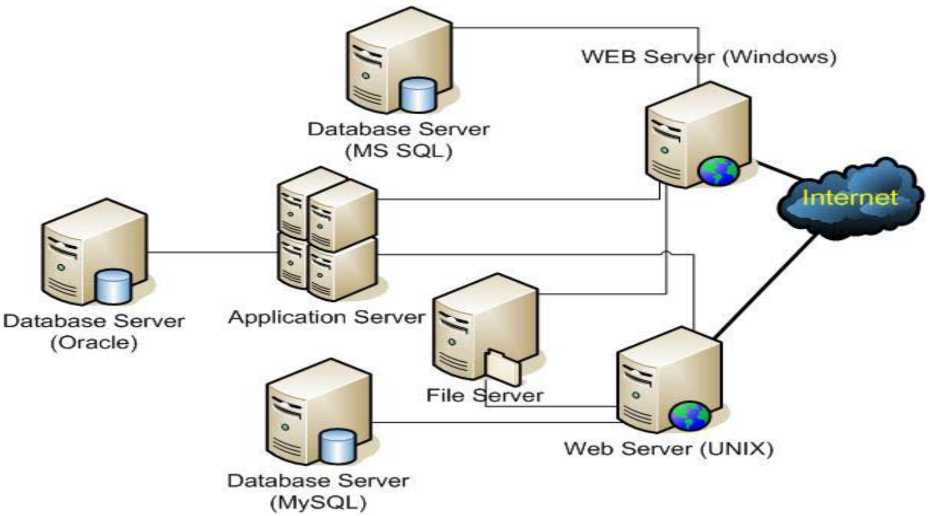

Fig. 6. The Three-tier Architecture of the NLORC

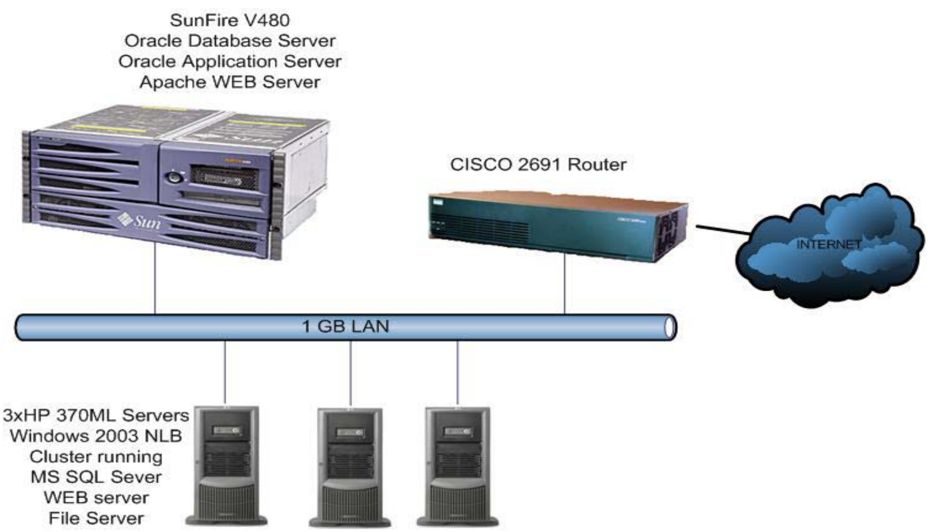

Fig. 7. The SunFire Server of the NLORC

the system also includes the file server, Apache WEB server, as well as the other database servers (MS SQL and MySQL). Thus, the NLORc storage can be used for storing various types of interactive and non-interactive LOs. The NLORC is physically built in the following way: The SunFire V480 server (Figure 7) is running the following components of the NLORC: Oracle Database Server, Oracle Application Server, Apache WEB server, J2EE, Java Server, MySQL Database Sevrer.

5 Conclusions

This paper has presented the object-oriented database model and the system architecture for a database application for a National Learning Objects Repository for Cyprus (NLORC). The NLORC will provide a centralised repository for a national network of e-learning service providers. The model has been designed based on existing LO Metadata Standards and the results of a survey amongst academicians in Cyprus. We are currently implementing the NLORC based on the proposed model and using the proposed architecture. After developing the NLORC, we will develop a graphical interface which will enable ease of access to end users.

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Collaboratively Shared Information Retrieval Model for e-Learning

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Abstract. Nowadays, the World Wide Web offers public search services by a number of Internet search engine companies e.g. Google [16], Yahoo! [17], etc. They own their internal ranking algorithms, which may be designed for either general-purpose information and/or specific domains. In order to fight for bigger market share, they have developed advanced tools to facilitate the algorithms through the use of Relevance Feedback (RF) e.g. Google's Toolbar. Experienced by the black-box tests of the RF toolbar, all in all, they can acquire simple and individual RF contribution. As to this point, in this paper, we have proposed a collaboratively shared Information Retrieval (IR) model to complement the conventional IR approach (i.e. objective) with the collaborative user contribution (i.e. subjective). Not only with RF and group relevance judgments, our proposed architecture and mechanisms provide a unified way to handle general purpose textual information (herein, we consider e-Learning related documents) and provide advanced access control features [15] to the overall system.

Keywords: Collaborative Share, Information Retrieval, Personalized e-Learning, Search Engine, Subjective Index.

1 Introduction

Research on Information Retrieval (IR) deals with several data management issues, which include data representation, storage, organization, indexing and retrieval [40]. The ultimate objective of IR research is to provide user-interested information. Conventional IR approach is to (a) extract the context from the documents, (b) segment the context into blocks, (c) analyze the blocks of context using pre-defined analyzers, and (d) index the tokens (i.e. vocabularies or terms) which are generated by the analyzers. This technique, by which indexes are purely constructed from the documents, is so-called content-based approach (herein, we claim "objective"). Some enhanced techniques were proposed to make terms more semantic by clustering them into concepts automatically, where concepts are associated with the Knowledge Bases (KB). However, in regard to have better ranking of user-interested results, user relevance

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judgment cannot be neglected. This open problem makes IR research more complicated by moving the focus towards the research areas of Human-Computer Interaction (HCI) and Groupware, and re-considering IR with the issues such as user motivation, user behaviors, social group formation and interactions. User relevance judgment has been one of the hot topics and it has been investigated for decades ago. Past research has been focusing on the topic of Relevance Feedback (RF) [1], [2], [3] e.g. RF interfaces [4], [5], [6], user interaction through RF [5], [7], etc. Recent research more or less investigates on capturing both explicit and implicit user behaviors and intentions [8], [9], [10], [28], [31], [32], [33] and on making relevance judgments by group [12], [13], [14], [26], [27], [29], [30], [34].

Nowadays, the World Wide Web offers public search services by a number of Internet search engine companies e.g. Google [16], Yahoo! [17], etc. They own their internal ranking algorithms, which may be designed for either general-purpose information and/or specific domains. In order to fight for bigger market share, they have developed advanced tools to facilitate the algorithms through the use of RF e.g. Google's Toolbar. Experienced by the black-box tests of the RF toolbar, all in all, they can acquire simple and individual RF contribution. They have to put more efforts to design the algorithms behind the scenes. As to this point, in this paper, we have proposed a collaboratively shared IR model to complement the conventional IR approach (i.e. objective) with the collaborative user contribution (i.e. subjective). Not only with RF and group relevance judgments, our proposed architecture and mechanisms provide a unified way to handle general purpose textual information (herein, we consider e-Learning related documents) and provide advanced access control features [15] to the overall system. Section 2 discusses the related work. Section 3 gives an overview of the proposed collaboratively shared IR model. Section 4 describes the subjective and objective indexing mechanism. Section 5 brings out the implementation issues. And finally, section 6 concludes the paper and suggests future directions.

2 Related Work

An important part of Information Retrieval (IR) research is query reformulation, and the most effective and proven technique is Relevance Feedback (RF) [1], [2], [3]. RF refers to a user interaction cycle, in which the system revises the original query by using the features derived from a small subset of query-relevant documents. The revised query is then executed with the return of a new set of documents. Regarding our proposed system, several aspects relating to RF e.g. RF interfaces [4], [5], [6], user interaction through RF [5], [7], user behaviors and intentions [8], [9], [10], [28], [31], [32], [33] and group relevance judgments [12], [13], [14], [26], [27], [29], [30], [34] have to be considered and to be discussed below.

In standard RF interfaces, three basic options are provided for users to mark the documents: "relevant", "irrelevant", and "no opinion". In some cases, a relevance scale [4] is offered to indicate the degree level of the relevant results. The system can then either re-weigh the query automatically and re-execute the search, or generate a list of terms for user to select from [5]. Another approach is to provide a simple "one-click" interface with an option of "more like this" [6], rather than requiring users to rate a small number of documents for re-ranking.

Besides standard RF interfaces which require users to specify relevant documents, some interfaces allow of adding terms to the queries. Users can take control of the query refinement process in either one of the following situations [5], [7]: (a) Control – no RF at all, (b) Opaque – standard RF (i.e. select relevant documents for re-ranking), (c) Transparent – refinement by the use of terms (i.e. add terms for re-ranking but without reweighing), and (d) Penetrable – refinement by the use of terms with user interruptions. Standard RF requires explicit user involvement, where there were some researches investigating on how to capture user behaviors and intentions for prediction [8], [9], [10], [28], [31], [32], [33] using machine learning techniques [11] or collaborative recommendations (cf. group relevance judgments).

Group relevance judgments [12], [13], [29], [30], [34] allow groups of users to rate and rank information of special interests e.g. some specialized-domain recommendation systems [14], [26], [27].

3 Proposed Architecture

Fig. 1 shows the architecture of the proposed collaboratively shared information retrieval (IR) system, which combines the conventional IR mechanism with the proposed subjective IR components and proposed personalized e-learning components. For a typical IR mechanism, documents are crawled by crawler and then stored in a

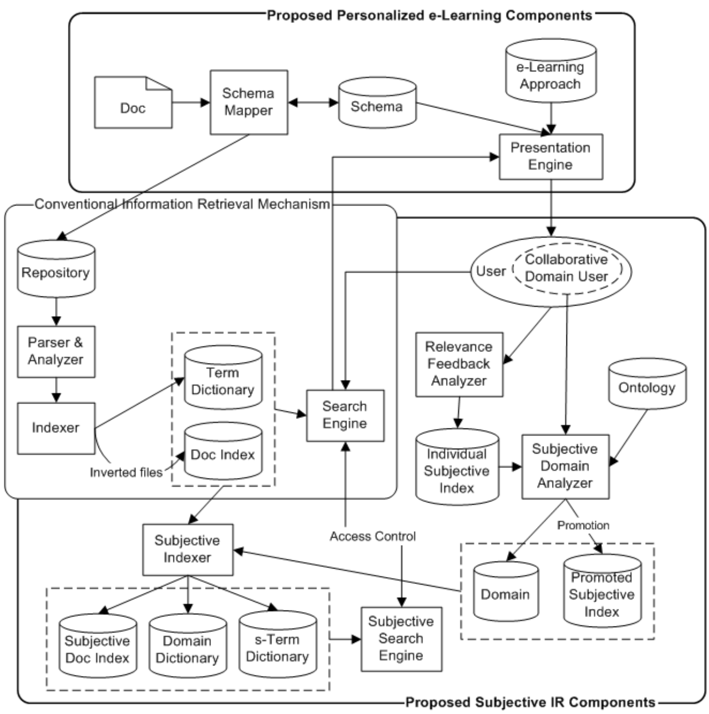

Fig. 1. Architecture of the proposed collaboratively shared information retrieval system

Repository. Parser & Analyzer are used to extract the required content and to generate tokens from the documents. Afterwards, Indexer makes the inverted indices (i.e. Doc Index) and the associated dictionary (i.e. Term Dictionary). Both types of indices are the access points of a search engine. In general, anchors are extracted by the Indexer for further analysis. For our case, e-learning documents are pre-processed by the Schema Mapper[1] in order to map the pre-defined schema (i.e. Schema) for the personalized presentation (i.e. Presentation Engine and e-Learning Approach). Therefore, search results can be tailor-made for different user's learning schemes e.g. traditional learning or interactive learning, PC-based learning or mobile learning, etc.

3.1 Proposed Subjective IR Components

Regarding the proposed subjective IR components, there are four main processing components: Relevance Feedback Analyzer, Subjective Domain Analyzer, Subjective Indexer, and Subjective Search Engine (SSE), and six more data repositories: Subjective Doc Index, Domain Dictionary, s-Term Dictionary, Individual Subjective Index, Domain, Promoted Subjective Index, and Ontology. Users (incl. Collaborative Domain Users) are necessary to be registered with user profiles indicating their preferences, knowledge and groups (ref. Sect. 3.2 for details) in order to use our subjective search service. They can submit queries along with their profiles to the Search Engine (SE), which will then check whether the users can access the SSE. If the users cannot obtain permission from the SSE, queries will be processed in SE only. Otherwise, queries will then send to SSE in order to search the domain of the documents (i.e. Subjective Doc Index, Domain Dictionary, and s-Term Dictionary) as well as the conventional indices (Doc Index and Term Dictionary) (ref. Sect. 4 for details). After the users get back the ranked results, they can give relevance feedback to the system, no matter which groups they are belonging to. Relevance Feedback Analyzer is used to collect and analyze the feedbacks with user profiles, and then store them in a "private" repository (i.e. Individual Subjective Index). Those information are stored with the pending status and are waiting for the Collaborative Domain Users to do further analysis with the use of Ontology (ref. Sect. 4.2 for details) through the processing component of Subjective Domain Analyzer. After collaborative filtering, useful Individual Subjective Index will be promoted[2] to the repository of Promoted Subjective Index. Subjective Indexer can then update the promoted indices to its associated repositories (i.e. Subjective Doc Index, Domain Dictionary, and s-Term Dictionary). By default, Collaborative Domain Users should initially construct common domain profiles (Domain) for their corresponding groups.

3.2 Collaboratively Shared IR Model

Fig. 2 shows the collaboratively shared IR model, which consists of the following sub-models: (a) Collaborative User (incl. User, Group, Session, and Role), (b) User Rewarding (incl. User, and Motivation), and (c) Subjective Index (incl. Domain,

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[1] Schema Mapper analyzes the structure of the e-learning documents via tags and hyperlinks.

[2] In fact, a promotion scheme is used to govern the promotion of Individual Subjective Index (private) to the Promoted Subjective Index (promoted), and in turn to the Subjective Doc Index (public and/or group).

Ontology, and Term). Access control can be realized by the use of Collaborative User sub-model, where users are restricted to be group-user-role and/or session-user-role [15]. User consists of user profile, which stores user-specified preferences (Domain), a list of joined group/role pairs (Group and Role), currently joined session/role pair (Session and Role), and a motivation-reward scheme (Motivation). When a group is formed, it should associate with a unique/default domain (Domain) and the content of the domain of a group could be changed later on. Session is similar to Group except that it is formed temporarily, therefore, Session (members) $\subseteq$ Group (members). It is necessary to subsume the properties of Session and Role because we need to keep track of the histories of the construction of the Individual Subjective Index and promotion/judgment can be performed immediately if at least one of the members has the privilege to do so. Role has a static profile which keeps the "degree" of privilege used by Group and Session.

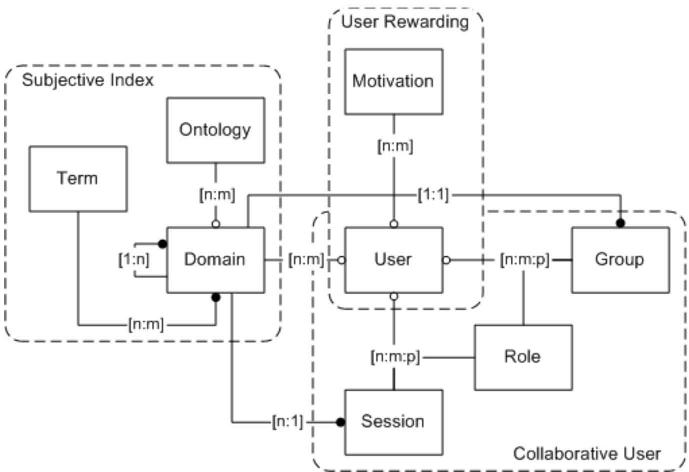

Fig. 2. Collaboratively shared IR model

Since the proposed system requires user contribution, a motivation-reward scheme is needed to encourage user motivation (Motivation). Motivation keeps the information of the physical reward scheme[3] and the conceptual reward scheme of which users prefer. For the conceptual reward scheme, we can simply upgrade the degree of privilege of the group that the user belonging to. All domain information is derived by Domain and Ontology and it is a template for User, Group, and Session. Ontology is a hierarchical structure of concepts and knowledge, where Domain is composed of sub-domains and a set of indexed terms (Term) to form a hierarchy (ref. Sect. 4.2 for details).

Collaborative User Model. In the collaborative user model, there are classes: Group, Session, Role, and User. A common domain knowledge base is proposed to link with

[3] Physical reward scheme is out of the scope of this paper.

Group and User, such that it can provide a unique platform to process classification of both intra-relationship and inter-relationship. Preferences and knowledge can be specified by groups and users explicitly; internal clustering algorithms can do the implicit classification. The following table shows the possible context [41] that should be included in the collaborative user model.

Table 1. Context information of the collaborative user model

Category	*Attribute*	*Relationship*
Technological	Device, Application, Service, Communication	
Personal	Age, Gender, Seniority, Background, Job skill, Knowledge, Interests, Motivation	In-group, Out-group
Organizational	Rule, Team size, Objective	Role
Cultural	Individualistic, Collectivist, Language	
Location	GPS, Time zone	
Web Behavioral	Read time, No. of Visit, Print, Bookmark, Target	
Web Navigational	Browsing, Searching, Clicking, Basket placement, Payment	

4 Subjective and Objective Indexing Mechanism

Since our proposed system has to deal with two kinds of search engines, the architecture of the conventional one, its associated data structure and ranking algorithms should not be altered. Therefore, virtual links should be adopted to make cooperation with the new type. The following tables show the data structures used by the proposed system.

Table 2. Data structure of Doc Index (inverted files)

<Vocabulary, {Occurrence}>

Table 3. Data structure of Term Dictionary

<Vocabulary, {DocID}>

Table 4. Data structure of Individual Subjective Index

UserID	SessionID	GroupID

<User Domain, {Vocabulary}>	<Group Domain, {Vocabulary}>

Query	<DocID, Score>	{<DocID, Score>} for comparison

Distinct {Vocabulary} from ranked result	Potential {Domain}

Number of votes for group sharing	Threshold	Group sharing?

Table 5. Data structure of Promoted Subjective Index

SessionID	GroupID	Finalized <Domain, {Vocabulary}>
Query	<DocID, Score>	{<DocID, Score>} for comparison
Number of votes for public sharing	Threshold	Public sharing?

Table 6. Data structure of Subjective Doc Index

<Domain, co-existed {Vocabulary} in Doc Index, {Vocabulary} from Domain>		
Public sharing?	GroupID	Boost

Table 7. Data structure of Domain Dictionary

<Domain, {DocID}>

Table 8. Data structure of s-Term Dictionary

<Vocabulary extracted from Domain, {DocID}>

4.1 Virtual Indexing Mechanism

Objective Index. Doc Index stores the inverted files of documents as shown in Table 2. It consists of a set of terms (i.e. vocabularies), of which each term may occur inside the document representing by a list of positions. In general, a set of terms can be used to deduce the overall concept of a document. Term Dictionary is built to facilitate the retrieval of terms among the documents. It consists of a set of terms, of which each term may occur in a list of documents, as shown in Table 3.

Subjective Index. As mentioned before, our proposed system utilizes a promotion scheme in order to govern the promotion of Individual Subjective Index (private) to the Promoted Subjective Index (promoted) and in turn, to the Subjective Doc Index (public and/or group). Table 4, Table 5, and Table 6 show the data structure of Individual Subjective Index (ISI), Promoted Subjective Index (PSI), and Subjective Doc Index (SDI), respectively.

ISI stores the information of the collaborative users (i.e. UserID, SessionID, and GroupID). SessionID is the key to group the records (i.e. histories) of the current session. Domain knowledge are collected and stored in a list of vocabularies of user domain (i.e. <User Domain, {Vocabulary}>), a list of vocabularies of group domain (i.e. <Group Domain, {Vocabulary}>), and a list of distinct vocabularies which are extracted from the ranked result (i.e. <Distinct {Vocabulary} from ranked result}>). These information will then be finalized to a list of vocabularies of a specific domain of PSI (i.e. <Domain, {Vocabulary}>). Note that there is a list of potential domains (i.e. <Potential {Domain}>), which can be used to give suggestions to other groups of domains.

A counter is used to record the votes polled by the group members. Once it reaches the threshold, the information stored in ISI can be promoted to PSI; in turn, PSI requires other votes in order to allow public sharing of knowledge. No matter of the status of public sharing, information stored in PSI will then be updated to SDI. In SDI, “Public sharing” is the indicator to show the status of public sharing, the value of

Boost is calculated by a list of boost values and scores, which can be retrieved by the current document's boost value and its score (i.e. <DocID, Score>) and a list of relevant documents with boost values and scores (i.e. {<DocID, Score>}) from both ISI and PSI. If the value of boost in SDI is zero, that means the subjective index will not be shared publicly. As the ranking results will finally boost up by this value, it can be used to "re-rank" the objective document index with the subjective one. GroupID is another indicator to show the status of group sharing.

For the voting mechanism, in brief, members of a group are assigned with roles and each role is associated with a degree of privilege (i.e. weight). With the adjustable sets of weights, votes can be measured from a quantitative approach to a qualitative approach. Hence, the setting of degree of privilege in Role is significant.

Subjective Doc Index is a collection of inverted files. It is composed of a list of domains, of which each domain is represented by a list of vocabularies along with a boost value (Boost) and a GroupID. Vocabularies in Subjective Doc Index have been classified into two categories: (a) Co-existed in Doc Index, and (b) Extracted from Domain. Term frequencies of (a) can be calculated by the use of Doc Index. However, subjective terms (s-Term) are added to the proposed indexing mechanism regardless of its occurrence in the documents, therefore, default value has to be set for (b). Hence, Domain Dictionary and s-Term Dictionary are needed to be built to facilitate the retrieval of domains among documents and subjective terms among documents, respectively, as shown in Table 7 and Table 8.

4.2 Use of e-Learning Ontology and Knowledge Classification

Fig. 3 shows the ontology construction tool with the WordNet plugin. Ontology is a promising tool to represent semantics. It can be used to define the structure/schema of

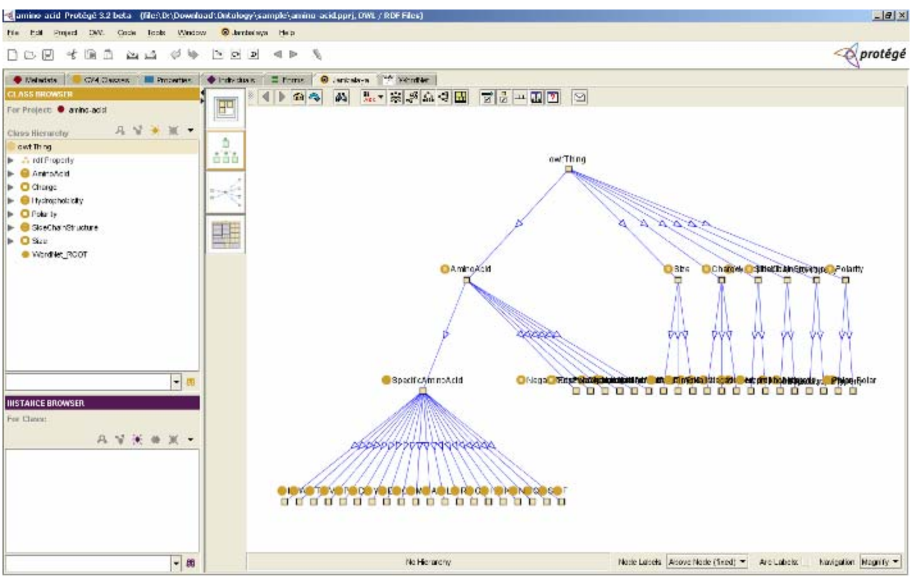

Fig. 3. Ontology construction tool with WordNet plugin

the content, associated with attributes and relationships. We enhance the use of ontology by mapping the content with indexed terms. Therefore, documents can be classified by semantics and similarities of documents can be measured by the concrete indexes. Most importantly, with this enhancement and technique, adaptive classification and annotation of documents can be done automatically.

5 Implementation Issues

As documents can be classified by semantics and annotated with the subjective indexed terms, they can be ranked by this type (i.e. subjective indexes) and the original objective indexes. Fig. 4 illustrates three cases of user interface design of the proposed system: SE access (top left diagram), SSE group access (top right diagram), and SSE public and group access (bottom diagram). For general SE access, only objective terms are used to calculate the scores of the documents. For SSE group access, there is an additional search result, in which group-domain information is used to extract the documents by the subjective IR components. For SSE public and group access, both objective and subjective terms are used to calculate the scores of the documents (though the frequencies of the subjective terms are ones, by default).

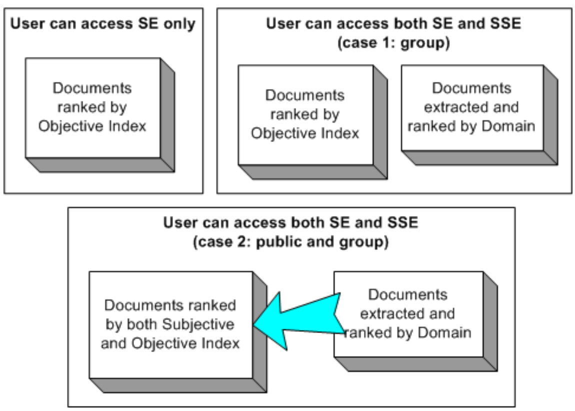

Fig. 4. Three cases of user interface design of the proposed system

6 Conclusions and Future Directions

In this paper, a collaboratively shared Information Retrieval (IR) has been proposed to complement the conventional IR approach (i.e. objective) with the collaborative user contribution (i.e. subjective). Not only with the relevance feedback and group relevance judgments, our proposed architecture and model provide a unified way to handle general purpose textual information (herein, we consider e-Learning related documents) and provide advanced access control features [15] to the overall architecture. Architecture of the proposed system has been illustrated along with its associated data model and mechanisms. The design strategy of the Subjective and Objective Indexing Mechanism is to make both kinds of indices virtually integrated.

Ontology is a promising tool to represent semantics; however, currently it is still not mature enough. We plan to construct a comprehensive and meaningful ontological domain structure and to design a user-motivation reward scheme in order to encourage user contributions, as our continuing work. Next challenging issue is to model user and social behaviors for further analysis.

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<e-QTI>: A Reusable Assessment Engine

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Abstract. <e-QTI> is a highly modular and extensible engine that simplifies the assessment cycle in terms of generation, execution, presentation, grading and archiving. <e-QTI> is based on the IMS QTI specification but it is able to export and import assessments represented in a wide range of formats, and also to maintain a pool of questions that can be reused in a wide variety of authoring situations. The engine is especially suited to be integrated in web-based learning platforms using well-defined interfaces, both Java-oriented and service-oriented. In this paper we describe <e-QTI>, its internal architecture and its most relevant implementation details.

Keywords: Assessment Engine, QTI, Learning Management System, Learning Platform, IMS.

1 Introduction

Traditionally, teachers have made use of exams to evaluate learners during the educational process as a requirement for the fulfilment of a course or simply as a measurement of the assimilation of concepts presented in a lecture/class/course. This assessment style has also been adopted in the e-learning context of modern LMSs (*Learning Management Systems*) [3,13], which usually include in their toolsets an assessment tool that not only enables the teacher to create the exams but also facilitates the grading task since many types of questions can be evaluated automatically. For this purpose, the LMSs must face several technological challenges. On the one hand, the significant variability in the formulation of the exams must be addressed. Typical exams can include many different types of questions (e.g. essays, true/false, multiple choice, matching/ordering lists, hot-spots, fill in the gaps, etc), and these questions can involve many different content formats (e.g. text, images, audiovisual content, etc). On the other hand, many different evaluation strategies (e.g. automatic correction, different grading algorithms, instructor intervention, etc) must also be contemplated. Moreover, from the learner's perspective, exams must accommodate many different solution styles. Finally, exams must be represented in standard formats that ensure their independence from any given LMS, thus promoting their durability and portability, and also the reusability of individual questions in the formulation of new exams. The correct management of individual questions can

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facilitate the production of exams on-the-fly by an intelligent LMS in order to evaluate the skills of a particular learner in the context of custom learning paths.

In this paper we describe <e-QTI>, an assessment engine that addresses most of the aforementioned challenges. The architecture of <e-QTI> is driven by the IMS QTI (*Question and Test Interoperability*) specification [19], and the engine provides native QTI support. Nevertheless, this engine is very flexible and can be extended with pluggable import/export facilities, therefore being able to accept and produce exams in many other different formats. <e-QTI> has been developed in the context of our <e-Aula> experimental LMS [1,15,34]. However, it is an independent, robust and open tool that can be used standalone or integrated in different learning architectures or applications.

The structure of the paper is as follows: Section 2 describes some of the aspects of IMS QTI needed to understand the rest of the paper. Section 3 describes the basic functionalities of the <e-QTI> engine. Section 4 details the internal architecture of this engine. Section 5 presents some related work. Finally, section 6 gives some conclusions and outlines lines of future work.

2 IMS QTI

IMS QTI is an IMS specification for enabling the exchange of data related to questions, tests and results of the assessment process between heterogeneous IMS-compliant systems and tools [19]. This interchange is usually performed using a binding of the IMS QTI abstract models with XML (*eXtensible Markup Language*) [9]. In this section we summarize the concepts of QTI that are relevant for the present work.

In QTI jargon, questions are called *items*, while tests/exams are called *assessments*. QTI also introduces an intermediate structuring construction called *section*, which is used to group individual items or other simpler sections together. In addition, IMS QTI defines the concept of *object bank*. Objects banks are used to package a set of individual items or sections to be exchanged between LMSs or question repositories to create question pools, so that teachers can reuse these pools when creating new exams.

QTI also enables the declarative description of many relevant dynamic features of the assessment process. For each structural element it is possible to attach a set of *rules* used to process learner responses. These rules can, for instance, trigger the presentation of some feedback. Their formulation can be based on a set of control switches, which are also included in the description of the corresponding structural element or their neighbors. In addition, with sections and assessments it is also possible to attach a set of *selection* and *ordering* rules enabling instructors to decide the sequence in which sections and/or items are presented to the learner and also how he/she can interact with them. Finally, IMS QTI also enables the description of how the aggregate scores at the assessment and section levels can be derived. This derivation is described using *scoring rules*, which establish how to synthesize the score of an assessment/section from the scores of their child sections and/or items. It is important to note that scoring rules do not specify the internal details of particular scoring algorithms. Instead, the type of algorithm is specified and the necessary parameters are supplied. The implementation and execution of the corresponding algorithm is relayed to the assessment engine. Although QTI defines the most common types of scoring algorithms and their semantics, the specification does not force the use of any of these, and therefore other domain-specific algorithms can also be readily supported by a particular engine.

Finally, IMS QTI is related to other IMS specifications. In particular the IMS Content Packaging (IMS CP) [17] and IMS Metadata / IEEE LOM [16] specifications are closely related to <e-QTI> development. IMS CP, which defines how to aggregate the educational contents into packages in order to let different heterogeneous systems interchange these contents, is used in <e-QTI> as a mechanism for packaging items, sections, assessments and object banks with their related files. In its turn, IEEE LOM metadata is used in <e-QTI> to classify items and sections from an educational point of view.

3 The <e-QTI> Engine

<e-QTI> is a highly modular and extensible QTI assessment engine. The engine allows instructors to author QTI assessments, as well as deliver them and make them accessible to learners. Instructors can also import and export assessments from/to other representation formats, and store and retrieve items in/from a question pool. In this section we describe the main functionalities of the engine, while the architectural and implementation details are relegated to the next section.

3.1 Authoring

<e-QTI> allows instructors to produce and maintain QTI assessments by using a special-purpose editor, therefore relieving them of the complexities behind QTI XML binding. Instead of coping with XML files (perhaps using a general-purpose XML editing tool, like [23]), instructors can use the more user-friendly and domain-specific authoring artifacts provided by <e-QTI>. This way, acceptability and productivity are greatly increased, as we have realized during our preliminary experiences with <e-QTI> in the Complutense University of Madrid.

The authoring process in <e-QTI> is driven by the QTI information model. Using <e-QTI>, the author can create, edit and delete assessments and their different inner elements. The edition of each informational element comprises the edition of all its relevant properties. Each item may be associated with suitable presentation materials, definitions of objectives and processing rules, and selection and ordering rules. Finally the authoring system also permits the recovery of items from the question pool maintained by the engine (see subsection 3.4).

The authoring of items is the main part of the authoring system (Fig. 1). An item comprises several aspects that can be edited. This amount of information can overwhelm the instructor, so the <e-QTI> authoring tool deals with this problem by offering a more comfortable, more friendly and well known user interface based upon of the type of question. <e-QTI> now supports the authoring of the following question types: *True/False*, *multiple choice*, *fill in the gaps*, *matching lists*, and *essays*.

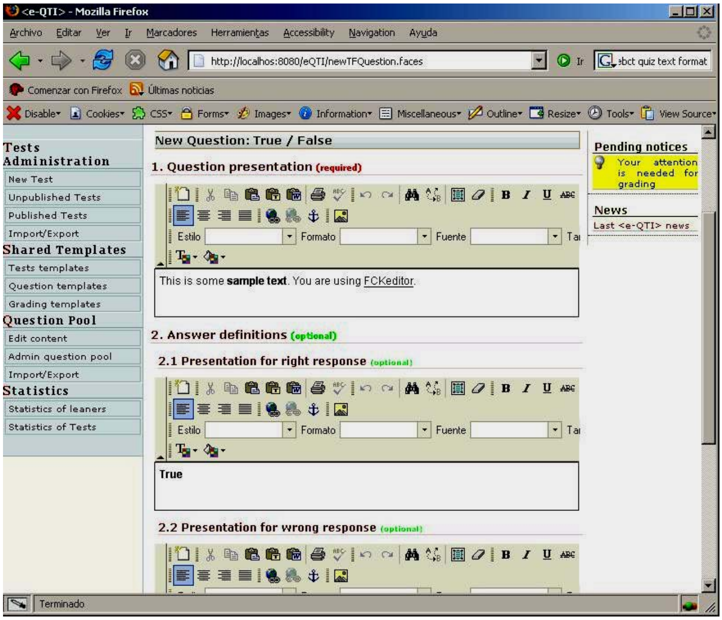

Fig. 1. Edition of a True/False item of a Test in <e-QTI>

Finally <e-QTI> offers the possibility of adding more detailed information to items, sections and assessment by allowing the instructor to add metadata information, objectives and rubrics.

3.2 Delivery

<e-QTI> also controls the presentation of the assessments to the learner, as well as the interaction between the learner and these assessments (Fig. 2). The engine supports the interaction with learners while they are taking the test, displaying relevant information such as time remaining in a time-fixed test or allowing him/her to partially complete the assessment and finalize it later. It also allows learners to review the evaluation and displays feedback materials added by the instructor once the test or survey has been graded.

The behavior of the <e-QTI> engine during delivery is heavily driven by the processing rules attached to the assessment's structural elements (the assessment itself, its sections and its items), and also by the selection and ordering rules attached to this assessment and their sections. Therefore, the engine lets instructors customize this behavior to better fit the special needs of each particular learning scenario.

3.3 Grading

<e-QTI> engine gives support to the evaluation of assessments completed by learners. The engine is highly flexible and extensible, in order to accommodate different evaluation styles. These styles range from the automatic correction of simple items to the explicit involvement of the instructors when human assistance is required. For

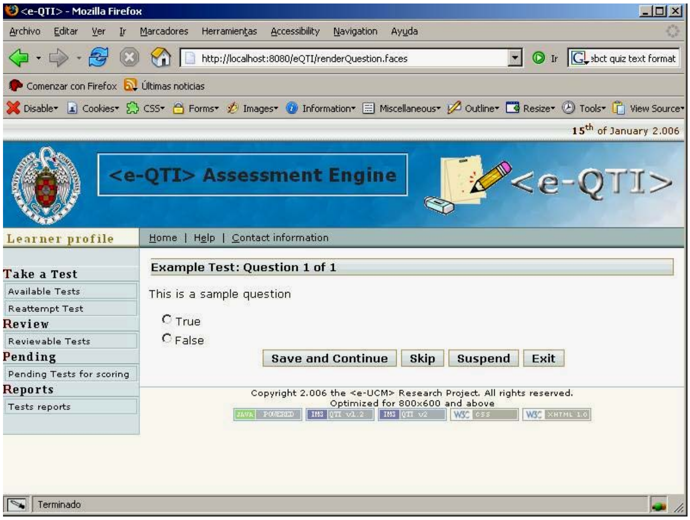

Fig. 2. Presentation of an item made by <e-QTI>

example, <e-QTI> delegates evaluation of essays to the corresponding tutor, so global evaluation needs to wait for the response of the tutor. Finally, the engine also presents the final report to the learners.

As with delivery, grading in <e-QTI> is highly configurable by instructors. The engine makes use of the grading rules included in sections and assessments in order to produce the final scores. As described in section 4, the grading algorithm can be chosen from the available algorithms and bound to an assessment or section. The predefined algorithm templates offered by IMS QTI are the ones most commonly used by the e-learning community, but the test creator usually needs to provide a set of values to instantiate the template. <e-QTI> offers the possibility of instantiating preconfigured templates so that the creator does not need to know the meaning of all parameters, which is particularly useful when applying organizational grading conventions. Also, it is possible for the instructor to tweak the grading algorithm parameters as needed.

3.4 The Question Pool

<e-QTI> maintains a question pool containing items that can be used while authoring new assessments. The system allows the navigation of this pool in order to retrieve items during the authoring process. <e-QTI> also offers the possibility of adding new items to the question pool. To facilitate later search and navigation, the question pool is organized by using a classification system. Currently, <e-QTI> uses a simple classification, fixed by the system administrator. Nevertheless, he/she can easily edit and change this hierarchy when necessary. This classification information is added to the item or section using the IEEE LOM classification category.

3.5 Importation/Exportation

<e-QTI> allows instructors to import and export exams from/to the IMS QTI format. This feature is especially valuable in turning <e-QTI> into a tool capable of working with third party applications, like authoring tools such as Canvas Learning [10] or Respondus [31]. This feature allows authors to use other alternative authoring tools in the creation of assessments that can be played in <e-QTI>.

(a)

```
:TYPE:MC:N:C
:TITLE: Another question
example
:QUESTION:T
This is another question
example
:ANSWER1:100:T
This is the first response
:ANSWER2:0:T
This is the second response
:ANSWER3:0:T
This is the third response
```

(b)

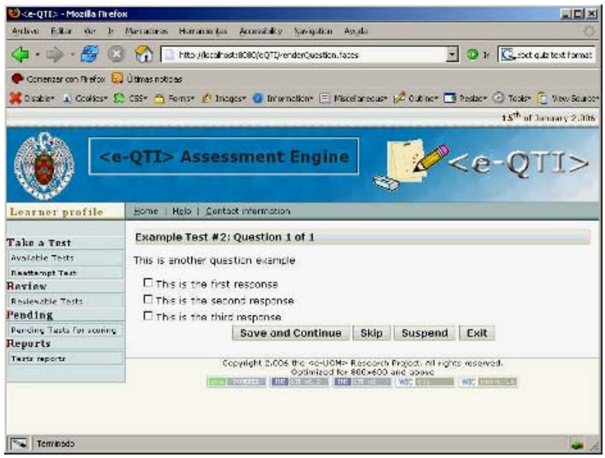

Fig. 3. (a) WebCT multiple choice quiz format; (b) <e-QTI> preview

The system itself is extensible by nature in order to accommodate other formats that can be reinterpreted and mapped using the extensibility features provided by <e-QTI>. For example, <e-QTI> now supports the WebCT [30,38] quiz format (Fig. 3). We have also included facilities to import and export assessments bundled according to the IMS CP specification.

4 Architecture of <e-QTI>

The current <e-QTI> tool is an evolution of a previous prototype embedded in our <e-Aula> research LMS. As we have realized during the maintenance of this former tool, since the QTI specification is open to changes, the system should be as flexible and scalable as possible.

The design of <e-QTI> was created while keeping in mind that it should be possible to integrate this tool as a whole into an LMS, so the LMS calls <e-QTI> when the assessment service is needed. This means that an internally complex monolithic engine should be avoided, instead promoting modularity in order to assure maintainability and facilitate the integration task.

The next subsections details the architecture of <e-QTI>. Subsection 4.1 gives an overview of this architecture. Subsection 4.2 summarizes how this architecture is implemented in <e-QTI> using well-known development standards.

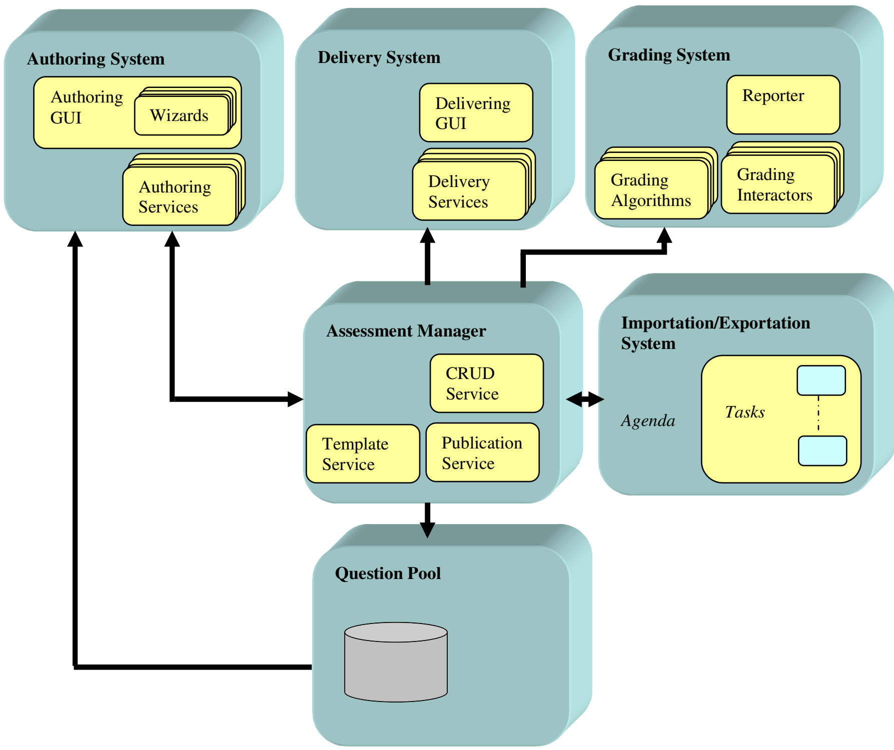

Fig. 4. <e-QTI> Architecture overview

4.1 Overview of the Architecture

Fig. 4 depicts the architecture implemented in the <e-QTI> tool, which we have been testing as a standalone application in several courses at the Complutense University of Madrid (Spain) as a support learning tool for the weekly evaluation of learners.

The <e-QTI> architecture covers all the requirements described in section 3 with a distinct system dedicated to each one of those functionalities. All of these systems are internally divided in a set of services to simplify the development of the entire engine. This division into services permits the modification, tweaking or entire re-writing of each system without affecting the rest of the application. The systems integrated in the architecture are:

– The *assessment manager*, which comprises all services needed to handle the <e-QTI> model of an assessment. The services included in the module are: (i) a CRUD (Creating, Retrieving, Updating, and Deleting) *service*, which supports the <e-QTI> model, (ii) a *publication service*, whose job is to process the authored assessment, take a snapshot of the current state of the assessment created and add any additional information needed before publishing, and (iii) a *template service*, which is in charge of the management and instantiation of the different types of templates used by <e-QTI>.

- The *delivery system*, which is intended to collect from the learners who interact with the tests and surveys proposed by teachers all the information required by other parts of the engine. This system is divided into two main components: (i) the *delivery* GUI, which renders the elements of the assessment by using the XSLT transformation language [12] to process the XML representation of the IMS QTI test, and (ii) the *delivery services*, which comprise all the functionalities needed to play the assessments, including the rearrangement of items and sections (using selection and ordering rules) and the extraction of information from the delivery GUI to be used later by the grading service. It is important to remark that the delivery services are independent of the delivery GUI. Therefore it is possible to change the GUI while maintaining the same set of services. Thus, a system that integrates <e-QTI> can use its delivery services but it can provide its own user interface.
- The *authoring system*, which is intended to create and edit assessments, sections and items used inside <e-QTI>, including elements that are part of the question pool. This system comprises the following elements: (i) an *authoring* GUI, which also includes a set of *wizards* that can be used in a fast and straightforward manner by the instructors, and (ii) a set of *authoring services*, which represent all the available commands that are necessary to author an IMS QTI test. As with the delivery system, authoring services are GUI independent. Therefore, third-party systems integrating <e-QTI> can provide their own authoring GUIs as long as these user interfaces are properly connected to the existing authoring services.
- The *grading system*, which processes the learners' responses gathered by the *delivery system*. It makes use of three mayor components: (i) a *reporter*, which is responsible for the final generation of the learner result report including all the automatic and manual evaluations of questions, (ii) a set of *interactors*, which are responsible for the interaction with instructors during grading operations, and (iii) the *grading algorithms* that can be used by the corresponding QTI's scoring rules.
- The *importation / exportation* system, which deals with the importation/exportation of assessments from/to other representation formats. To cope with the complexity and the potential variability of these tasks, we have adopted for this system an *agenda-based* organization similar to that proposed in [35] to architect the <e-Aula> importation system, which in turn is inspired by the solution described in [2] for the simulation of discrete systems.
- The *question pool*, which is offered as a central repository of questions to be shared between instructors that use <e-QTI>. This repository is organized internally as sections and items classified according to the classification hierarchy mentioned in subsection 3.4. Thus, each classification entry corresponds to a section, so the classification is mapped onto a section hierarchy. This particular organization facilitates the exportation and importation of the content question pool using the IMS QTI format.

4.2 Implementation Details

<e-QTI> was developed using Java technologies in order to maximize the maintainability, extensibility and robustness of the resulting implementation. In particular, a multi-tier organization has been adopted, where the following tiers can be distinguished:

- *Client tier***.** We adopt a thin-client approach where we only need a web browser with XHTML, CSS and JavaScript support. This also facilitates the replacement of this tier in order to accommodate the GUI skin to particular authoring and learning scenarios.
- *Web tier***.** <e-QTI> uses a new Java technology called Java Server Faces [7] which facilitates the organization of this tier by using the classical Model-View-Controller (MVC) design pattern [25], as well as the development of reusable web components.
- *Business tier***.** It was created by using the POJO (*Plain Old Java Object*) approach [32] instead of adopting EJBs (*Enterprise Java Beans*) [8]. This allows <e-QTI> to be integrated in a web-based application by using a Java Servlet container, like Apache Tomcat, and also its business tier to be integrated inside a Java Desktop application. To facilitate the management of services and dependencies, <e-QTI> uses the Spring Framework [22], which greatly simplifies the creation of Enterprise Applications by using the POJO approach.
- *Persistence tier***.** <e-QTI> uses the Hibernate framework [6] inside the persistence tier to simplify the development of persistence onto a relational database. This choice decouples this tier from the particular database infrastructure. For instance, it is possible to use an in-process Java database to embed this tier inside a Java Desktop application in a transparent way.

<e-QTI> also exhibits a service-oriented programmatic interface [11]. The different services introduced in the conceptual architecture are exhibited as web services, and they can be effortlessly integrated in third-party e-learning systems using SOAP (*Simple Object Access Protocol*) regardless of their underlying implementation technologies.

5 Related Work

As has already been mentioned, it is common to find an assessment mechanism in the toolset of a LMS (e.g. WebCT/BlackBoard [30,38], Moodle [26] and others). The assessment system in these tools is completely embedded. Therefore it can only be used inside these tools. However, it is sometimes possible to import and export resources in some tools, although they often use a proprietary format. Nonetheless, there are renowned tools that actually support standardized formats, such as Moodle's multi-format support, which includes IMS QTI.

Regarding the architecture of the system, some LMS implementations are truly modular. In particular, SAKAI [33] includes the Samigo module as an assessment tool that can be extracted and used as a standalone application. This module supports IMS QTI specification in both versions (1.2 and 2.0). There are other projects such as

Technologies for Online Interoperable Assessment (TOIA) [36] established in 2003 to provide an advanced online assessment management system free of charge to all UK Further and Higher Education institutions.

Web services have been successfully used to address the integration of QTI and other IMS-compliant functionalities. Among such initiatives, it is interesting to point out the ASSIS Project [5] of Hull University, which has succeeded in integrating an IMS QTI v2 player, a reduced version of the viewer developed by the APIS Project [4], with an IMS Simple Sequencing [20] engine. In the resulting integration, the engine is used to sequence the items presented to learners. A similar experience was adopted in the last version of the IMS Learning Design (IMS LD) [18,24] engine Coopercore [14,37], which integrates the APIS Viewer using services, so now an IMS LD Unit of Learning can launch an assessment service.

6 Conclusions and Future Work

In this paper we have described our effort at building <e-QTI>, an assessment engine, and the architecture that supports it and allows it to be easily integrated in different environments.

From the point of view of the users, <e-QTI> improves the usability of our previous prototypes due to its focus on simplicity demanded by most users by hiding the IMS QTI specifications details and making intensive use of templates to improve the productivity.

From the architectural point of view, <e-QTI> is based on a highly extensible and modular architecture. This architecture makes the extension and/or the replacement of the different GUI parts possible without affecting the rest of the components. Also new delivery and authoring services can be added and existing ones can be replaced with equivalent counterparts in a transparent way. This is also true for grading algorithms in the grading system, and also for importation and exportation tasks in the agenda-based importation/exportation system.

From the implementation perspective, the Java-based implementation of <e-QTI> allows us to create a robust architecture which, in spite of being implemented with plain Java objects, becomes powerful and scalable due to the use of powerful frameworks in their different tiers, like Spring and Hibernate. In addition, <e-QTI> adheres to a service-oriented approach, and therefore the engine is powered with a web service-based programmatic interface, which facilitates its integration with many other heterogeneous e-learning systems.

Currently <e-QTI> has been successfully integrated into the <e-Aula> LMS. As future work we are planning to integrate <e-QTI> into other environments. In particular, we are interested in the integration of the assessment engine into SAKAI and in exploring potential interactions with Coopercore. Our research line on the evaluation and implementation of potential standards will also explore other specifications such as the IMS Tools Interoperability Guidelines [21], Open Knowledge Initiative Open Service Interface Definitions (OKI OSID) related to the assessment management [27, 28] and also specifications more related to question-bank querying like Remote Question Protocol (RQP) [29].

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Using VRML and JAVA to Build Virtual Game-Based Learning Environment for Addition and Subtraction Operation

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Abstract. How to make elementary mathematics education vivid and interesting? In this paper, we describe how to use VRML and JAVA to build a virtual game-based learning environment (VGBLE), in which children can learn addition and subtraction operation through games and hence children's interesting in learning and effects will be improved.

Keywords: game-based learning (GBL), virtual game-based learning environment (VGBLE), addition and subtraction operation.

1 Introduction

Addition and subtraction operations are important content in elementary mathematics education [1]. However, to children in lower grades, addition and subtraction operations are very difficult to understand because children's thinking mainly depends on concrete objects while traditional instruction is in a symbolic way. For example, children often fail to give the correct answer when they are asked what the result of 9-4 is. But if children are given 9 eggs and then teachers take 4 eggs away, it is much easer for children to understand the subtraction operation.

Aiming at this characteristic of children in lower grades, many scholars suggest learning by doing [2] is an appropriate pedagogical method. But when putting learning by doing into addition and subtraction instruction, we find some problems: firstly, children usually cannot decide what to do themselves. Children's actions must accord with the rules, principles, and steps predefined by teachers; secondly, teachers cannot observe student's learning processes individually so that they cannot provide students with personalized instruction; thirdly, teachers often waste much time in preparing for learning tools, and the kind of learning tools are very few. To solve these problems, we adopt VRML and JAVA to build a VGBLE for addition and subtraction instruction.

VR is a three-dimensional, participatory, multi-sensory, computer-based simulated environment occurring in real time [3]. Applied to instruction, it has the potential to revolutionize teaching and learning processes. It has been defined as a highly interactive, computer-based, sensory experience by using computer graphics, sounds, and images to reproduce electronic versions of real-life situations.

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For many researchers, VR has the potential to be a powerful new tool in the classroom [4]. It can extend the classroom via new windows into other realities. By reflecting the real world, the simulation gives a participant the chance to try out different options without the dangers, expense, or time consumption that doing the 'real thing' might involve. One may also try out scenarios that are actually impossible to do in the real world and determine which scenarios present the best chance for success.

2 Related Works

Much research and many developing works have been done in the specified fields discussed above. We will present some typical works.

In Game-Based Learning: How to Delight and Instruct in the 21st Century (Educause Review: September/October 2004), Joel Foreman interviews 5 leading thinkers about videogames in educational environments[5]: individual conversations with James Paul Gee, J. C. Herz, Randy Hinrichs, Marc Prensky, and Ben Sawyer are melded into a single simulated discussion, focusing on these topics:

- The dysfunctions of conventional instruction.
- The power of simulations.
- The importance of game-based learning communities
- The reasons videogames promise a better learning future
- The changes necessary for the new paradigm to take hold.
- The practical steps that colleges/universities and influential academics can take

NICE [6] is a cooperation result by the Interactive Computing Environments Lab (ICE) and the Electronic Visualization Lab (EVL) at the University of Illinois at Chicago. It is a learning environment for young children, implemented in the CAVE environment. Children can collaboratively construct artifacts in the CAVE and, in doing so; build an underlying narrative that is driven by constructivism.

"Games, Simulations, and Learning" [7] is an EDUCAUSE NLII 2004 Key Theme. Key themes are chosen annually from the larger domain of the transformation of teaching and learning with technology. The "Games" key theme is exploring whether games and simulations have changed how students learn and whether there are principles and practices from games that should be integrated into collegiate learning environments.

3 The Design of VGBLE for Addition and Subtraction Operation

3.1 Design Theory: The Laws of Children Cognition

According to Piaget's theory, children's cognitive development can be divided into the sensory motor period, preoperational period, period of concrete operations, and period of formal operations orderly [8]. Children in grade one are in the period of concrete operations, so their thinking depends on concrete objects. For example, when a child who is learning addition and subtraction within 10 is asked what the result of

4+5 is, he will use hands or other objects as tools to assist with the calculation. So, it is unfeasible to teach children in lower grades addition and subtraction in a symbolic way. Carpenter, an famous American mathematical educator, has proved learning tools play an important role in the learning of children in lower grades, because they are helpful to broaden children thinking space and relate knowledge with everyday life. In fact, using learning tools is a basic approach in elementary mathematics education.

Based on the cognitive characteristics of children in lower grades, teachers should pay attention to the two points in mathematic operation instruction: firstly, enforcing the use of learning tools, so that children can learn mathematic operations through practical operatives' activities. For example, when teaching operation within 10, teachers may provide some objects and let children arrange them and count them, thus children can understand addition and subtraction in a practical way. Secondly, teachers should utilize children's life experience. Teachers should induct children relate their life experience with mathematic operation; thereby children can understand the practical meaning of the mathematic operation.

3.2 The Design of VGBLE for Addition and Subtraction Operation

In the VGBLE, we designed a number of virtual objects and learning activities, and children are allowed to freely choose individual learning modes or cooperative learning modes. (See fig.1 and fig.2) For example, in individual learning mode, VGBLE may show 10 eggs before a child; then, the child may put 3 eggs into the box and choose practice addition; afterward, VGBLE will produce a random number (e.g. 5); so, the equation 3+5 is provided to the child. If the child answers it correctly, VGBLE will give him an egg as prize; if not, the child may press the button labeled "answer" to ask for help. While in cooperative learning mode, operation numbers are determined by two children respectively, and the VGBLE decides addition or subtraction. What should be mentioned is that the VGBLE must ensure the equation is within 10.

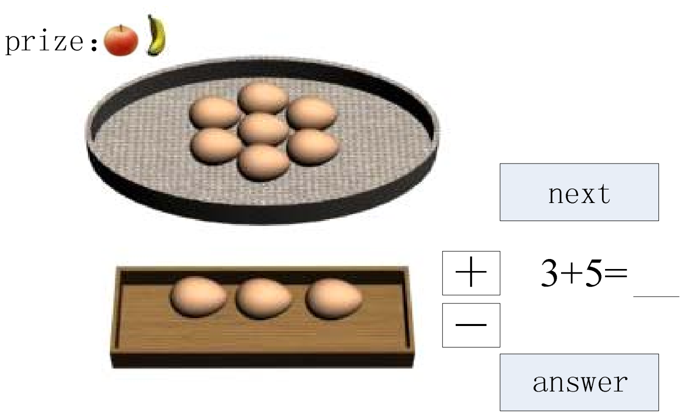

Fig. 1. Individual learning scene

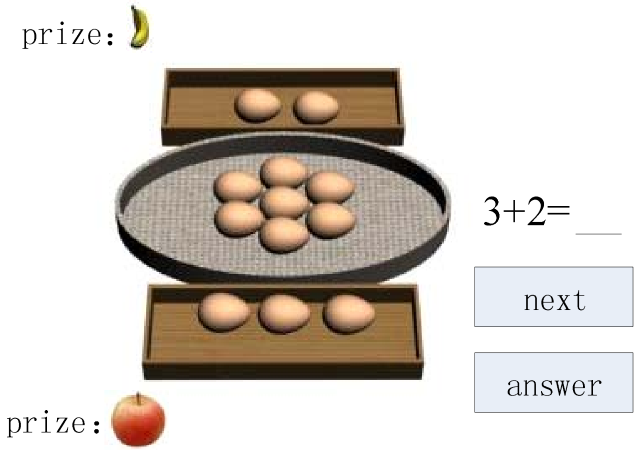

Fig. 2. Cooperative learning scene

The architecture of VGBLE is showed in figure 3. The student-end provides a friendly interface, through which children can interact with the system. The server contains a scene base and student-info base. The scene base stores all kind of virtual objects and learning activity, and the student-info base records students' basic information and learning history in VGBLE. When receiving a request message from student-end, the server will configure personalized learning scene and activities dynamically. The teacher-end is responsible for monitoring the learning process and maintaining scene-base and student-info base.

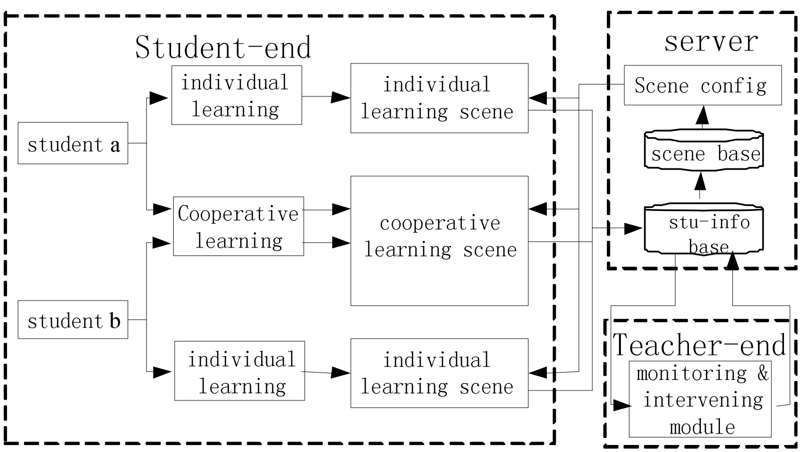

Fig. 3. The architecture of the VGBLE

4 Implementation Considerations

4.1 Modeling of the Virtual Entities

Combining VRML with 3Dmax modeling tools is an effective way in practice [9]. VRML is a good tool for constructing, distributing, and rendering 3D objects over the Internet. And VRML provides programmers a variety of nodes such as interaction, animation, and sensor to serve different purposes. With external nodes, we are able to create special objects. 3DMax is used to model complex realistic objects and the models should be optimized before exporting VRML files. Environment construction is based on coordinates since points in 3D models are presented by a group of space coordinates like (x, y, z).

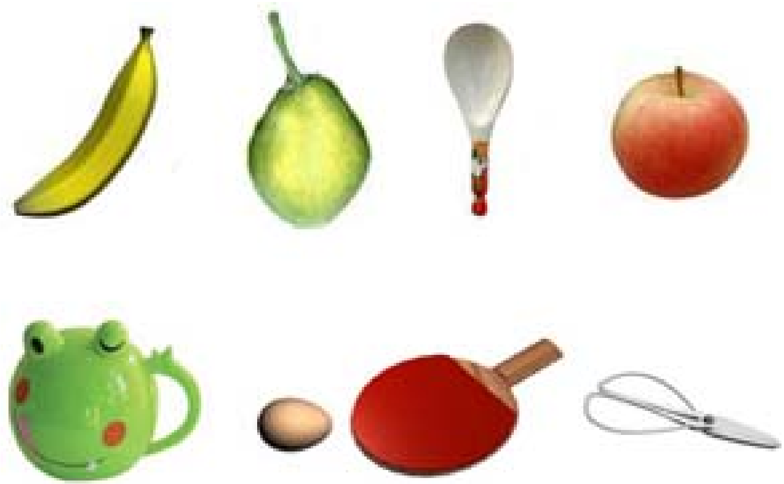

Fig. 4. Some 3D models

4.2 Using PROTO Mechanism to Copy the Visual Entities

Nodes predefined in VRML are finite. In the VGBLE, we need to create many new nodes, which have their own fields and functions. To improve code efficiency and reusability, object-oriented thinking is necessary that is new nodes should be encapsulated and inheritable. So we can create nodes based on the proto mechanism.

Proto mechanism includes three parts: declaration, implementation and instance. The keyword proto is used to declare the node type defined by developers. The definition of a node type contains field, exposedField, eventIn, eventOut and nodebody. Proto can be defined as:

```
PROTO<node type name>[<interface list >)]{<node body>}
```

4.3 Level of Detail (LOD) for Real-Time Walkthrough

In order to accelerate rendering speed in real time walkthrough, we employ LOD to optimize VRML files. VRML provides an LOD node, which can explicitly change different leveled detailed versions of model. LOD is a system feature for optimizing the amount of details rendered in a scene. There are three general rules used in determining whether LOD should be applied to a graphical object: 1. The object appears to be small in the scene. 2. The object is moving within the scene, or 3. The object is in the observer's peripheral vision. In these types of instances, better use of memory can probably be made through the reduction of object LOD. The goal to optimize VRML files is reducing the number of polygons in each level to simplify models. Four different ways is used to reduce polygon count [10]:

Remove hidden polygons: This is especially important for interiors of the models, such as the floor and any interior walls.

Make the model more 2D rather than 3D: As the distance to a model increases, it becomes harder to distinguish depth, so 2Dversions of a feature can stand for 3Dversions.

Replace complex shapes with simple outlines: Complex polygons or multiple polygons can be replaced with simple polygons.

Use textures to replace detail: Many modelers use this technique; make the most complex version of the model first, then take screen shots to make an image file. These images can then be used to make lower levels of detail.

4.4 Use JAVA to Control Visual Entities

To improve interaction in VRML scenes, SONY has raised a solution called JSAI (Java Script Authoring Interface) [11], which has realized advanced script function of VRML and provide a new way to control objects in VRML. JASI consists of three packages: vrml、vrml.field and vrml.node.

- vrml package, which contains field, ConstField, MField, ConstMField, Browser, Event and BaseNode;
- vrml.node package, which contains script class and node class. These two classes are inherited from vrml.BaseNode class;
- vrml.field package contains various classes to define data type of fields in VRML. These data types are used to describe position, rotation, and time and so on. To every data type, JSAI provides a special class to describe. Browser navigates according to the url field of script node. For example,

```
Script{
     url"../scripts/vrmlscript.class"
}
```

After a browser loads java script (e.g. vrmlscript.class) successfully and when the script node receives a group of eventIns, vrmlscript.class will call the method ProcessEvents() of script node automatically. To every event object, getName(), getTimeStamp() and getValue() can be used to get the name of the eventIn, the time when the event is sent and the value of the event respectively.

Fields defined by users in script nodes can be read and written through field names by script program, and the method getField() provide a way to refer interface fields.

4.5 Communication Mechanism

In a C/S mode communication system, the accomplished communication is restricted to communication based in sockets (classes ServerSocket and Socket) and threads. The user, through the browser Web, requests connection to a server that is executed in a determined host [12]. A connection confirmation message is sent if the server is running correctly, and then the client applet invokes an event to the server in order to be processed. The event is in a way consistent to system protocol (in terms of eventID). The server receives the eventID and sends it to event dispatcher. Later, the application server responds to the client applet according to the eventID. By the moment the client establishes a connection to the server, a new thread is created to serve such a client and the new client's information is also sent to other clients, such as clientID, user information etc. If other clients receive information, they will update their status.

4.6 Shared Objects

There are various kinds of interaction among shared objects and participants within the learning environment. Sometime, one simple interaction between an avatar and an object may cause very complicated chain-reactions in the world. It is necessary for programs at server sites to manage each shared object, store their states, and authorize their control rights to clients. In VGBLE, we implement lock method based on timestamp. If the status of shared objects is locked that means it cannot be operated because another client is operating this shared object. If the status is unlocked, any client has the right to request operating it. There is also a potential danger to be in the "deadlock" state. This indicates that shared objects cannot be operated forever. This is because the client who is operating the shared object is thrown off by error exception, but the client doesn't give up his or her right. We define a maximum timestamp to hold right to operate shared objects. If the timestamp is over, any client should give up its right. This method can avoid deadlock.

5 Conclusion and Future Work

This paper describes how to use VRML and JAVA to build VGBLE for addition and subtraction operations. Through present experiments we find that children's' learning interest, attention and the effects are improved in the VGBLE. And also there are some problems. For example, children may indulge in the VGBLE so that they will lose interest in traditional course. Another problem is it is harmful to eyes for children to learn with the VGBLE over a long time. In the future, we will improve the VGBLE and overcome these problems.

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An Easy-to-Use eLearning Web Authoring System for Educators

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Abstract. This paper aims to present the development and implementation of a dynamic web authoring system for eLearning, a new type of web authoring system, designed for educational purpose. This system is mainly assisting the educators for creation of online exercises that enables close user interaction and supports frequent change of its content. Combination of the strength of Internet--availability and flexibility--and its nature--a worldwide information provider and a medium communication--achieves creation of such web authoring system. The online exercises are dynamically created by following simple instructions provided by this system. The simple usage of the system benefits educators who are not familiar with creation of web learning materials but wish to create them with complicated functions. Furthermore, the learners can take the advantages of doing the online exercises.

Keywords: authoring system, online exercises, easy-to-use.

1 Introduction

Part of the shortcoming of the existing web learning pages comes from the lack of sufficient knowledge of educators who create it. Nonetheless to say it is not merely their fault. It requires specific knowledge and skills to create web pages which function as information provider equipped with user interaction functioning. Most of educators do not have time to learn such skills as they have other duties of their own. What if there is a tool such as web authoring system, helping educators who desire to create efficient and satisfying web learning pages? Both educators and learners must be greatly benefited from usage of the tool. Educators can create online exercises, which serve their purpose of providing sufficient information and effective learning method without taking time and pain. Learners can use the online exercises easily and effectively without constraint of time or place. The biggest advantage of having such a web authoring system is its user interacting function between educators and learners since the deep understanding of knowledge cannot be gained without "teacher-student" interaction. This "teacher-student" interaction between remote areas can be practiced to the possible extent on Internet.

In order to create such web authoring systems, there are some goals we need to achieve. The seven main goals for the web learning material generators are: accessibility, portability, reusability, dynamic web page generation ability, flexibility, statistics monitoring, and communication. Figure 1 shows the architecture of the system:

W. Liu, Q. Li, and R.W.H. Lau (Eds.): ICWL 2006, LNCS 4181, pp. 154 – 164, 2006.

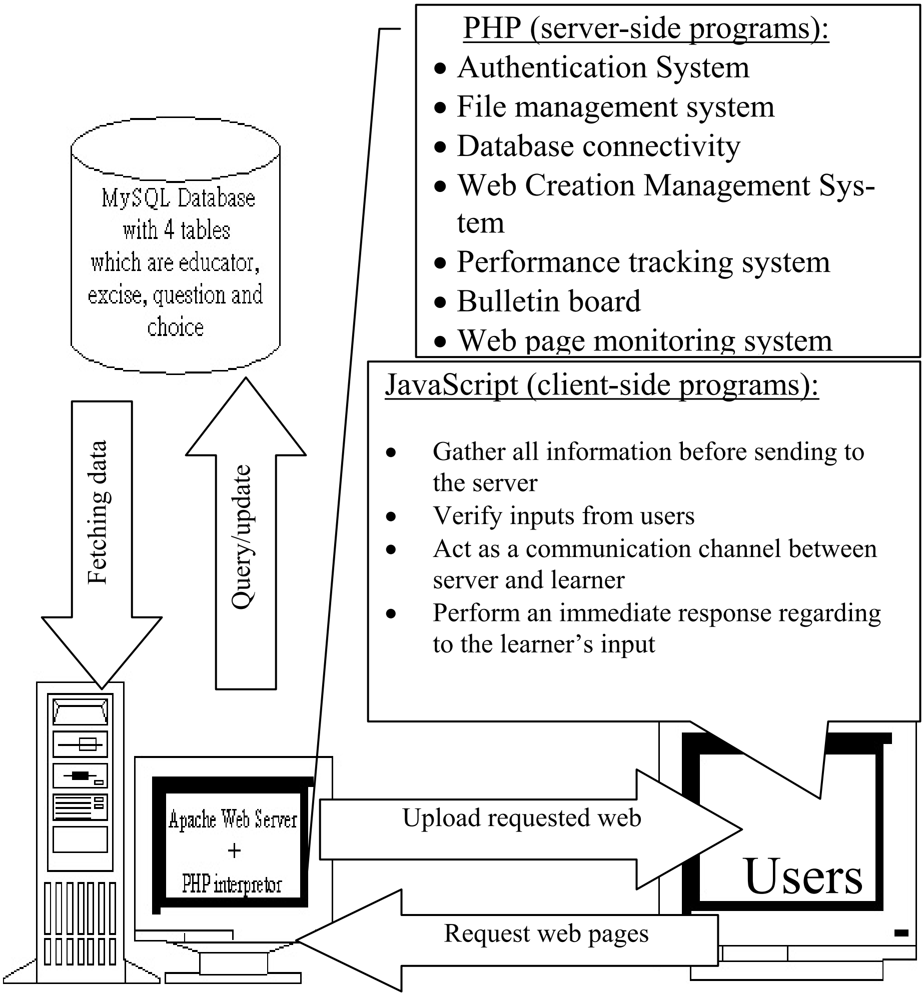

Fig. 1. System Architecture

Relation Educator (<u>id</u>, password, email, identity)
Relation Exercise (<u>eid</u>, ename, description, ng, filename, footer, *id)
Relation Question (<u>qid</u>, description, content, type, action_c, action_w, random, hints, continue, *eid)
Relation Choice (<u>aid</u>, content, correct, correct, type, action, *qid)
Note: underlined are primary keys, and "*" prefixed are foreign keys

2 Methodology

The system features enable this tool to be highly powered, fully scalable and completely customizable. The following will explain each feature with its algorithm.

The first feature is the User Authentication – Before the user start working with this tool, the user must login to the system first by providing the necessary information: the login id and the corresponding password. They must register to the system first by filling out the registration form via the online registration system (http://educator.hk-elearning.com). Once the educators successfully registered to the system, they can start to enjoy the nice features served by this system. This system provides five main services to the educators – “Web Creation”, “File Management”, “Help”, “User Profile” and “Personal Forum”.

```
Algorithm:
Begin If the user is a new user?
      Then Begin If the login id does exist
                  Then upload the login page to the user with error message
                   Else register and upload the main page to user with confirmation
            End
       Else If  login id and password are valid
            Then upload the main page to the user regarding with confirmation
            Else upload the login page to the user with error message
End;
```

The second feature is Web Creation – It is to retrieve information from the database and to display all the information of the current login user, and is the main component of this system. It is designed for dynamic web contents creation with simple steps and clear instructions. It also supports renewal of contents from the existing ones. Educators are also granted the ability to perform administration activities such as activate/deactivate, delete, copy and modify the web contents.

```
Algorithm:
Begin    Query the database by login id;
         Format the output;
         Upload the formatted data to users' web browser;
End;
```

The third feature is the Web Creation Management System – This feature is for the educators to manage their online exercises with the following functions:

- ***Create new subject*** – allow educators to set up new online exercises. This process consists of three steps:

Step 1: create a new record and generate a new eid
New Subject: By clicking on the “New Subject” button, educators can start to make new web contents. There are mainly three steps: cover page, questions and choices.

First Step: Cover page
Subject, Topic and Webpage ID have to be filled in order to start making the web contents. The rest of the fields are optional. Subject is like category categorized the web contents. Topic is the title of this web content. Webpage ID is the name of the web page just like filename. This ID has to be a unique ID since the learners will visit

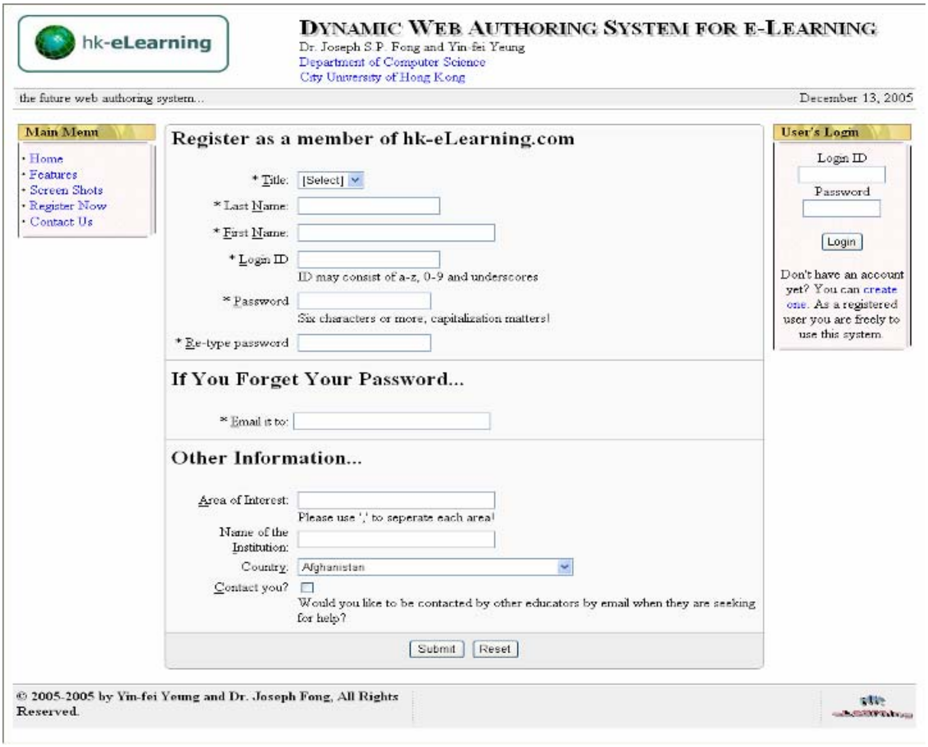

Fig. 2. Online registration form (Educator only)

the web contents by providing this ID. The rest of the information is to enhance the look of the front page of the web content except the “Restricted” field. For security or privacy purpose, educators can setup a key on the web content so that only authorized people can see it. For example, in semester 1, the educator defined a key and distributed it to students A, so that A can browse the web contents. However, in semester 2, the educator redefined the key and distributed it to students B, so that only B can browse the web contents. Even though A knows the webpage ID, A does not have the newest key; hence A cannot do the exercise. This way, educators can control the accessibilities of the web contents. This is useful if we want to compare the performance of the students in each semester.

By default, only one question shows on each page, the educator may change this by specifying the number of “Questions/page”. Description will be shown as part of content on the web creation page right underneath the topic. Any other information such as due date, contact channels, and remarks can be stored as additional information. The footer is what the learners will see when they complete the exercises. The “Show” field may be useful if the educator do not want the subject shown on the front page. Once everything is ready, click the “Start” button to record the filled in information and process to the second step.

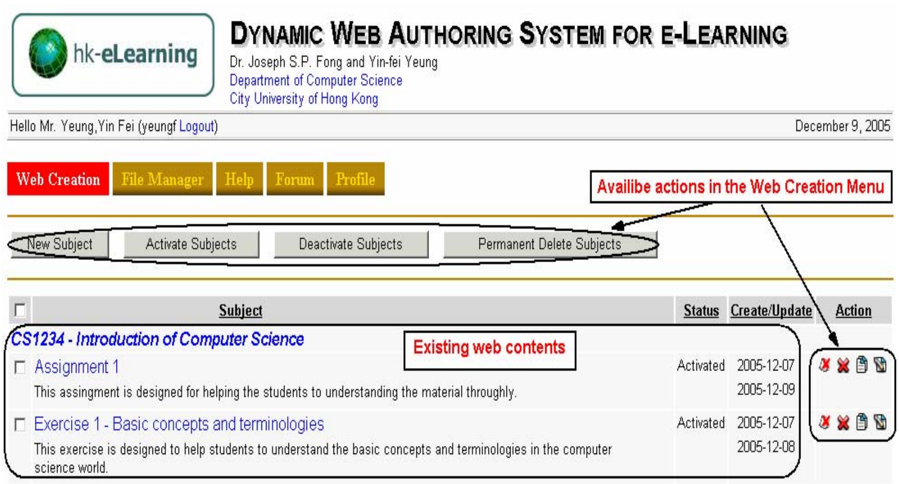

Fig. 3. Web Creation

Algorithm:
Begin Create a new record in the excise table with information and explanation;
A unique id will be generated upon the successful record creation;
Upload the question page to the web browser embedded with a unique id of eid;
End;

Step 2: create new question and generate new qids

Second Step: Questions
In this step, two pieces of information must be filled: Question and Number of Choices. Question is the question itself. Number of choices is the number of possible answers for this question. As the educator may notice that, for the rest of the fields, there is default value except "Description". The educator may give a brief description or related content before asking questions. The description can be either type in manually or choose from others questions, which have description.

This system provides six kinds of answer type. Depend on the answer type, the third step will response differently.

Single answer – only one correct answer showed as radio buttons

Multiple Answers – more than one correct answer, can be all correct, showed as check boxes

Matching – two groups of choices matching each other showed as two separate columns and one column for each group

Sequence – arranging the orders showed as drop-down box with numbers in it

Grouping – arrange the choices into groups showed as drop-down box with numbers in it

True/False – only two choices either right or wrong showed as two radio buttons.

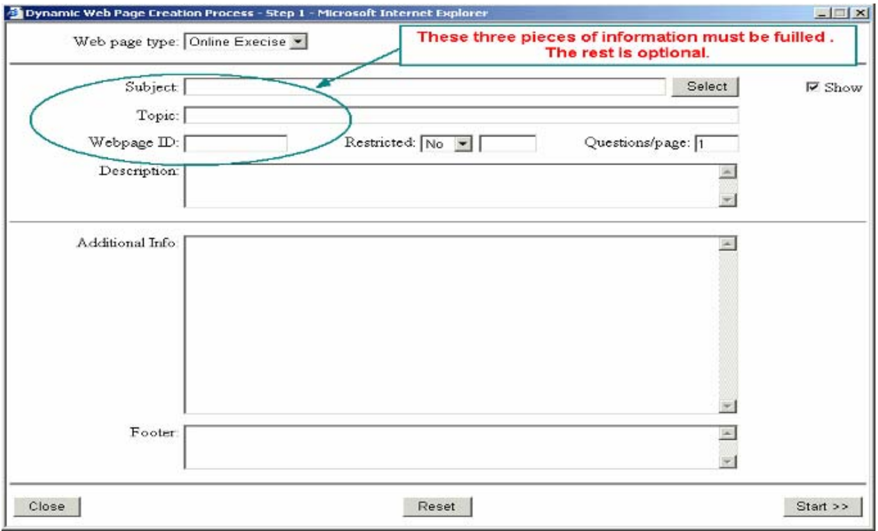

Fig. 4. First step of dynamic web page creation process

By default, number of choices shown on each row is one. The educator may change this by specifying the "Number of choices per row". To make the exercise even more difficult, educators can specify the ordering of the choices as random so that learners cannot just memorize the position of the correct answers; they really need to remember the content of the answers as well. When the answer is submitted, this system can give intermediate response corresponding to the correct or wrong answer. To do so, educators have to specify what action should be carried out by specifying the wrong answer and correct answer actions:

Message – pop up a new window with messages. Note that the message itself can mix with attachment such as images. To do so, educators only need to click on the attach buttons. An attachment tools will show up, then choose the file which you would like to attach and click on the "Attach" button to upload the designated file to the system and show as reference.

Web page – Pop up a new window to link to the specified web address e.g. http://www.cs.cityu.edu.hk. When it is ready, we can go to the next step by clicking on the "Next" button. Note that: we can preview the web content by clicking on the "Preview" button; however, the information just filled on the current step will not be displayed until we go to the next step, we can go back to the previous question or the first step at anytime by clicking on the "Back" button. We can complete the whole web creation process by clicking on the "Finish" button.

Algorithm:
Begin Create a new record in question table with the input information;
A unique id will be generated upon the successful record of creation;
Format the choice page with n number of rows;
Upload the choice page to the web browser embedded with a unique id of qid;
End;

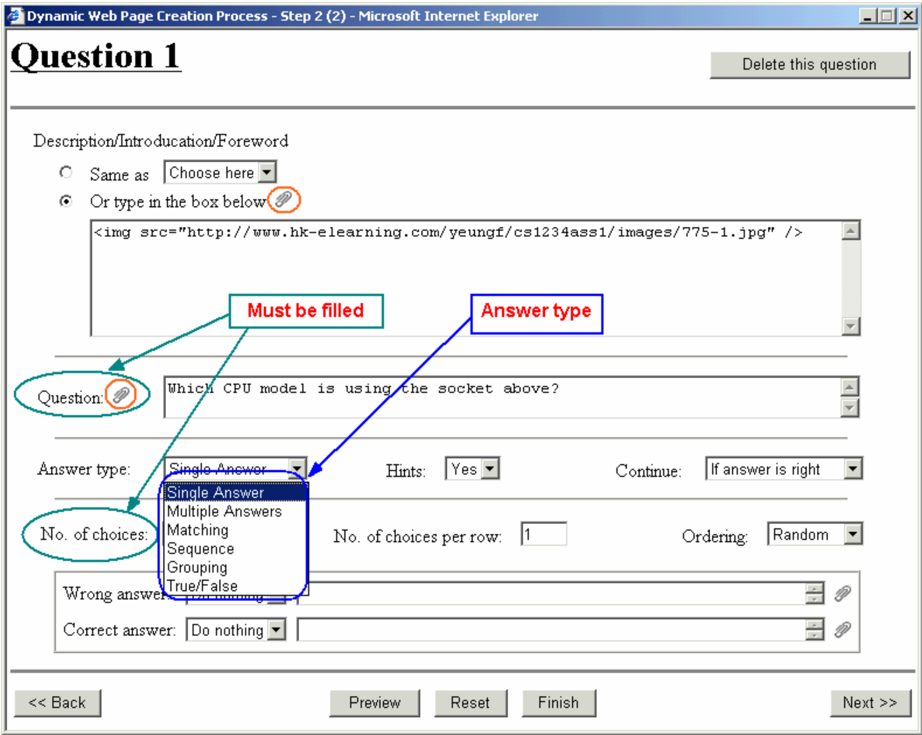

Fig. 5. Second step of dynamic web page creation process 3

Fig. 6. Action Panel on step 2

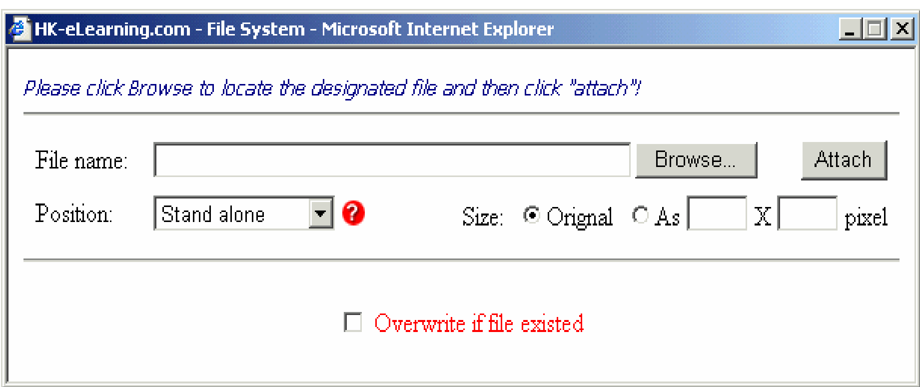

Fig. 7. Attachment panel

Step 3: create new choice and generate new aids

Third Step: Choices
In this step, there are two to three pieces of information must be filled depending on what the answer type is. In general, Match type requires three and the rest requires two. Here is the outlook of each answer type: Single Answer, Multiple Answers and True/False.

Algorithm:
Begin Create a record in the choice table for each answer;
If this is the last question,
Then trigger the last function to generate the web pages
Else go back to step 2
End;

- ***Copy subject*** – Educators may want to create new subjects based on the existing one. With this function, educators can reuse and add new exercise on top of the existing ones to save time in typing everything again.

Algorithm:
Begin Check the existing of the subject;
Make a copy of subject including its questions and answers as well as all related materials such as image files;
If it is successful
Then send a successful message
Else Revise all the changes and send a failed message
End;

- ***Activate and Deactivate subjects*** – Before an exercise can be viewed by the learner, educator must activate it first. On the other hand, if the educators want to disallow people view the exercise, they could either delete the exercise from collection OR just simply change its status from activate to deactivate. This function gives a better access control to the educators to managing the accessibility of their web contents.

Algorithm:
Begin check the existing of the subject
If it is currently activated,
Then change to deactivate
Else change to activate
If it is successful
Then send a successful message
Else revise all the changes and send a failed message
End;

- ***Delete existing subject*** – Educators may want to remove old excise from the system. So this feature allows educators to perform house keeping. Note that once an exercise is deleted, its related database records and web pages will be deleted from the system. Moreover, the related web materials such as images are removed out from the system as well.

Algorithm:
Begin Retrieve file name by querying the exercise table associated with key eid;
Execute an SQL statement to delete all records in exercise, question and choice tables associated with the key eid;
Execute a cgi problem to delete all files related to this exercise;
End;

- ***Modify existing exercises*** – Educators may find typing mistakes, wrong sequence of questions, or inappropriate questions after web pages are created. After a period of time, some questions may be outdated. The exercise should be modified or regenerated easily. This can be done by simulation of the creation of new exercise. In the simulation process, the system automatically fills-in the necessary information by querying the database. This allows the educators to change contents of the web page by minimum information input.

Algorithm:
Begin Verify the existence of the exercise by query the exercise table;
If it exists
Then upload all the related information to the user's browser for viewing make appropriate amendment if any
Else send an error message
End;

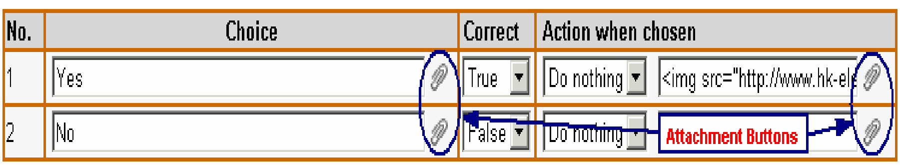

Fig. 8. Panel for Single answer, multiple answers and true/false in step 3

Matching – two group of data match to each other

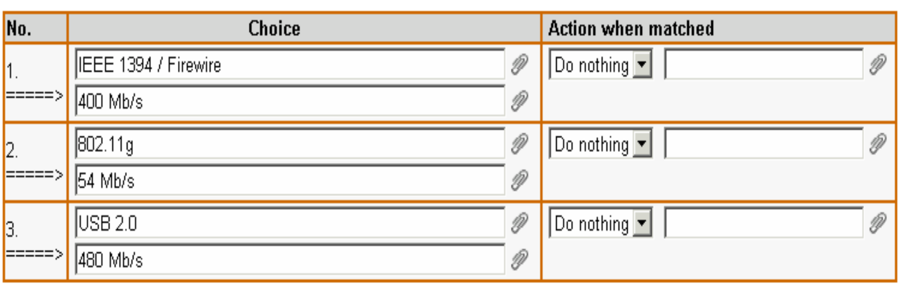

Fig. 9. Panel for matching in step 3

Sequence

No.	Choice	Sequence	Action when chosen	
1	Center Process Unit	1	Do nothing	
2	Central Processing Unit	3	Do nothing	
3	Computer Progress Unit	4	Do nothing	
4	Control Production Utility	2	Do nothing	

Fig. 10. Panel for sequence in step 3

Grouping

No.	Choice	Group #	Action when chosen	
1	PCI Slot	1	Message	These are called expension
2	RAM	2	Message	Memory
3	CD-Rom	3	Do nothing	
4	ISA Slot	1	Do nothing	
5	Hard Disk Drive	3	Message	IDE products
6	Cache	2	Do nothing	

Fig. 11. Panel for groping in step 3

3 Conclusion

This paper shows how to develop a dynamic Web Authoring System for eLearning, namely Dynamic Web authoring System for eLearning. It helps educators to create online exercises for their students to do exercises via the Internet regardless of time and their location.

The first technical issue is statistical analysis. This system provides statistics monitoring. The statistics report of this report helps educators to make decision on which subjects they should spend more time on with the students. With simple steps and clear instructions, educators can save great time in designing the layout of the web contents, designing and writing program codes for data verification and proper response, access control, analysis on student performance, and implementing personal forum.

The second technical issue is user friendliness. We have visited many web sites especially those doing the similar kind of systems ([5][11][12][13]). We are experiencing that their steps are quite complicated and require a quite amount of studying on how to make use of them. Our system is easy to use because web creation can be so easily done by educators who are not familiar with programming. The screen design is simple yet containing all necessary information required for web content. The simplicity makes it so easy for users to follow the steps. Also, this system offers so many alternatives for creation of different type of web content by simple clicking. For example, users can create various answer type just by choosing from given selections. They need not to do extra work to change their answer type from multiple choices to matching. In addition, this system is equipped with File Manager for the users to upload or modify files without knowing any specific command.

The third technical issue is performance. The big issue here is the interaction. We have to make sure that the question-level action and choice-level action are carried out properly and correctly. We could command the server with every little action of the learner and ask the server response to those actions. During the peak hour, the internet traffic is heavy. If the learner needs to wait for the validation from the server on every single movement especially with the choice-level action, the learner sit for hours and eventually may give up completing the exercise. To resolve this problem, we attach the answer with the web pages. We find a way to know if the learner chooses a correct answer or not without adding extra information. For each choice, we assign a value to an object with an object name embedded with the choice number. When the learner clicks on that choice, the Java script will immediately check the value of the object. The system can efficiently create a web contents by easy (minimal) operation. There is no extra programming skill required for creating forum. In short, this system provides a whole package for the user who wishes to create an efficient web content with minimum effort.

In summary, a methodology of developing a web authoring system for eLearning is presented in this paper, and which is simple enough to be easy for usage for educators as shown in its implementation. The future enhancement of this research paper is to add multi-media content into the Authoring System.

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An Implementation of a Case-Based Learning System*

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Abstract. Learning programming is an important part of learning and teaching of computer science. Case-based learning is becoming more and more welcomed by students when learning programming. Since there is no easy-to-use dynamic case generating system, to generate dynamic cases costs a lot of work, and is difficult to be reused. We have developed and implemented a generalized interactive case-based learning system with multimedia support, which is easy to generate and play cases. The cases generated can be played on-line interactively, or taken home to study off-line after learners download the packages. These packages can be transferred to standard eLearning objects and organized to standard content packages with our learning content management system, which greatly enhances the reusability of the learning resources.

1 Introduction

Case-based learning is more and more widely used by many courses, including the teaching of programming. Case-based learning means learning by examples which are designed to solve real problems. Case-based learning allows students to tackle problems set in realistic environments, which becomes case-based reasoning when more than one case is provided. [1] Teaching programming courses with cases is a good approach to improving students' practical ability.

Case-based learning system is a subsystem of e-Learning environment. With the help of e-Learning specifications, these cases can be shared by all the e-Learning systems that support China E-Learning Technology Standards (CELTS). [2]

In general programming teaching, designing cases requires extensive reading of actual programs as well as coding. Unfortunately, the cases from books are limited and static. Some of the cases contain audio, animated files to make them more dynamic. The programming cases, however, are actually more dynamic when executing. Whether students learn well or not mostly depend on the dynamic teaching process, and the interacting process between students and teachers in class. In web-based distance education, it is more difficult for the learners to grasp the programming lessons well without a single teacher to interact with. The educators

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find it even more challenging to run a case-based programming course and interact with each of the students through web. So a good approach is to give more dynamic demonstration of cases to make the learners feel as if the teacher were right there nearby speaking to them.

There are some powerful authoring tools that could generate dynamic cases, such as Microsoft Office PowerPoint and Macromedia Authorware. There are some similar projects that generate or use dynamic cases for teaching, such as ELP [3], Exploratories [8] and E-Slate [9].

Both Microsoft Office PowerPoint and Macromedia Authorware are widely used to generate common coursewares, but the problem is that a lot of time is spent making dynamic programming cases one by one. Even when the cases have much in common, it is still a tough job. ELP is a programming study environment, students only need to write the code through web, and then they would get an executable jar file after submitting, which can be executed under JRE environment, and there is no need to install JDK for the students. But this platform is only limited to studying java programming While teaching CPP, a new platform has to be developed. Exploratories is an interactive Web-based educational research project at Brown University, which uses the introductory undergraduate computer graphics course as a test bed. An exploratory is an java applet which provides an interactive environment that models objects, phenomena, and concepts. Students can learn different computer graphics theories by clicking, dragging or drawing on different applets, though which they could find the results by themselves and get an intuitional view of the theories. In Exploratories, each applet can be considered as a standalone courseware. The applets can not be changed. E-Slate is a component-based environment for constructing Internet-aware learning activities for exploration. In addition, it provides a platform for the development of educational component libraries. The courseware E-Slate generates supports rich multimedia. But it's too general for program teaching to use.

In all, the tools and systems above are either too general or too limited for our requirement.

The actual requirements are as follows.

- **Generalized:** Educators of case-based programming teaching need a generalized case-based programming learning system for all programming teaching;
- **Efficient:** Educators can generate and edit dynamic cases conveniently and fast;
- **Interactive:** Students always prefer to get intuitive presentation of information, personalization and individual guidance to improve their efficiency, so they want to interact with the cases;
- **Debugger-like:** The cases generated have uniform format to make them easy to play on-line by steps like debugging process, which is defined by teachers;
- **Downloadable:** The cases can be packaged and downloaded to play off-line.

Based on the requirements mentioned above, we have developed and implemented a generalized case-based programming learning system, which is web-based with multimedia support. This system can be used for teaching all programming languages. We use xml to describe the information of cases, including the case's title, problem, analysis, playing sections' information, and path information of all the files (program files, text, audio, video, image files) in the database. Our system is implemented by

Struts framework with oracle as its database. All cases are packaged in zip format. These packages can be transferred to standard eLearning objects and organized to standard content packages with our learning content management system (LCMS), according to CELTS-3 (Specification for Learning Object Metadata) [4][5] and CELTS-9 (Specification for Packaging) [6] so that the standard cases can be used by all the e-Learning systems that support CELTS, which greatly enhances the reusability of the learning resources. Students can use LCMS to assemble study packages as their wish.

The organization of this paper is as follows. Section 2 of this paper shows the system architecture. System implementation is described in Section 3. Section 4 and Section 5 are discussion and conclusions respectively.

2 System Architecture

In this section, we will describe the architecture overview, case generating module, playing module, management module and LCMS module. The description will highlight the design of the system.

2.1 Architecture Overview

Fig.1 shows the overview of the architecture of our system. Our system contains 3 tiers like J2EE, which are client tier, web tier and data tier with browser/server mode. The users such as Teachers, Students and Administrators can use the system through web browsers (Internet Explorer, Mozilla Firefox, etc). The web tier is the same as the business logic tiers compared to J2EE architecture, which runs on a web container (like Apache Tomcat, Resin, JBoss, etc). The web tier is a set of logic modules, which are generating module, playing module, management module and LCMS module. Web tier uses XML, JSP, Servlet, HTML as the implementation languages, under struts MVC framework. The last tier is Data tier, which contains database and file system.

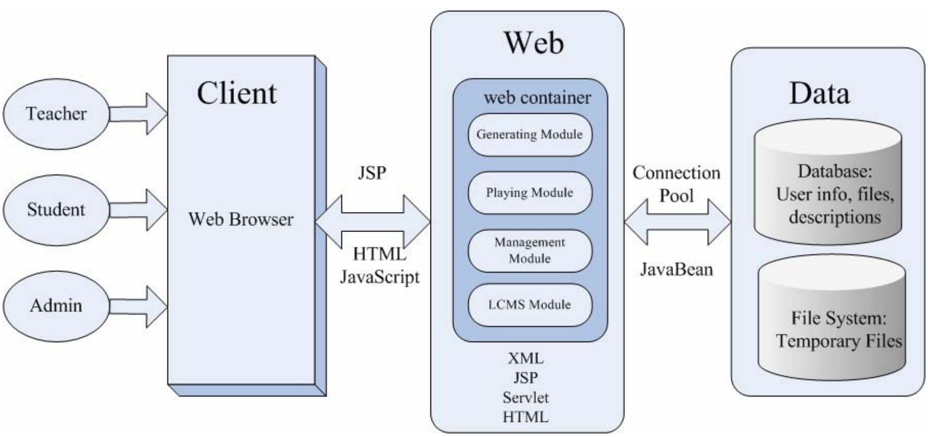

Fig. 1. System Architecture

With JSP, HTML and javascript languages, users can interact with the system at client tier. Their requests are sent to web tier, which deals with the requests and gives responses. Data tier contains oracle database and file system to store and load necessary files (text, audio, video, image, xml files) and other information (user and group information, file description, etc). Connection pool and java beans are used to connect web tier with data tier.

2.2 Case Generating Module

Fig. 2 shows how the teachers create a dynamic case demonstration by this system. Teachers select a template first. There are two templates. One is for creating simple example, which does not need any multimedia support, only text description is enough. The other template is provided multimedia support for more lively teaching. Obviously the first one is faster.

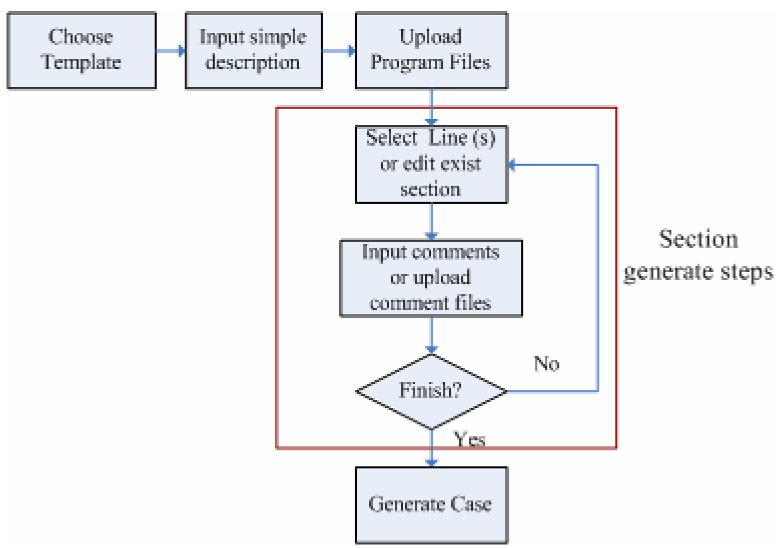

Fig. 2. The flow of creating a new case

After choosing a template, teachers can input the title, description and analysis for the case. Then comes the uploading step, which enables teachers upload the program file (s) used for this case. Next, select code line(s) that teachers want to explain and input comments or upload audio, video, image file for explanation. In this way, a section of the case is generated. Teachers can go on adding more sections in order to teach more, or editing, deleting the existing sections. At last teachers can finish editing and generate a new case courseware.

2.3 Case Playing Module

Fig.3 shows how to play a case in this system. The students can view the list of all the coursewares exist, and select the case they want, and play it.

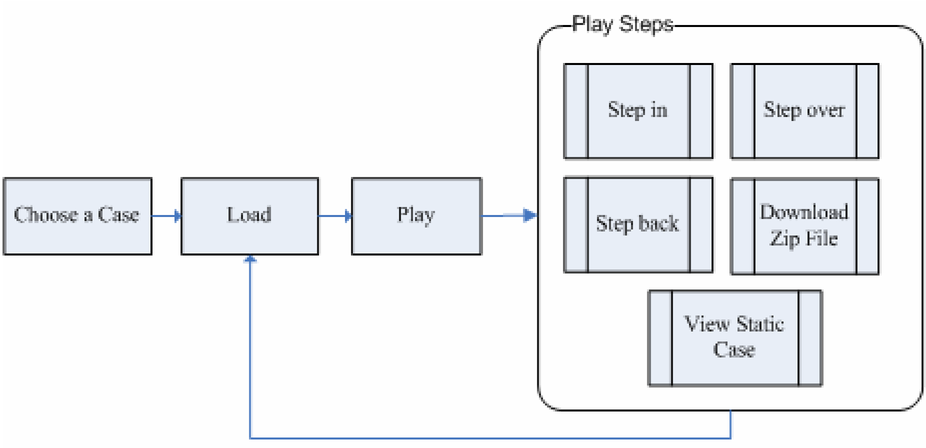

Fig. 3. The flow of playing a case

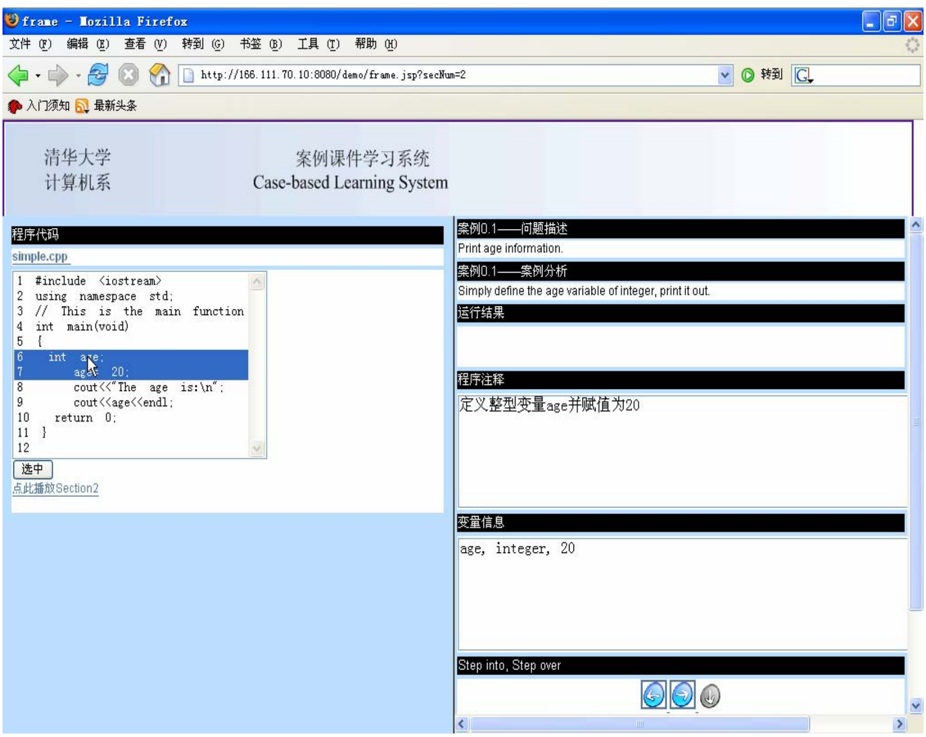

Fig. 4. Play a case by clicking on the step into, step over and step back buttons

While playing, this system enables students to interact in three ways, i.e. step into, step over and step back, similar to use a debugger. All the steps were inputted by teachers during generating process described above. Students can directly double click the code line(s) they don't understand, than the corresponding step would appear for them to play.

After loading the selected case, a package of the case is generated, which can be downloaded as an independent zip file and then viewed as an e-book after being extracted.

Fig.4 shows the interface of playing a case courseware. The case's description and analysis are listed at the right side of the scroll bar. The execution result till that step is listed right down the analysis, with black background. Students can also double click on the line they don't understand, then the corresponding step appears.

2.4 Management Module

The management module is in charge of account management and case management. The functions of account management are similar to many other systems, including registration, authentication, permission, modifying account information, deleting account. Case management provides two functions: query and delete. Since there are lots of cases in the database, it may be difficult to find a specific case. Through the query interface, users can rapidly get the case(s) they want, by looking for the keyword of the title, problem, analysis and date. Delete interface provides an easy way to delete a useless case and all its correlative files in the database.

2.5 LCMS Module

LCMS Module is used to transfer all the zipped cases to standard eLearning objects and organized to standard content packages with CELTS-3 (Specification for Learning Object Metadata)[4] and CELTS-9 (Specification for Packaging)[6]. The standard cases can be used by all the e-Learning systems that support CELTS, which greatly enhances the reusability of the learning resources. Students can use LCMS to assemble study packages as they wish. Fig.5 shows the LCMS workflow.

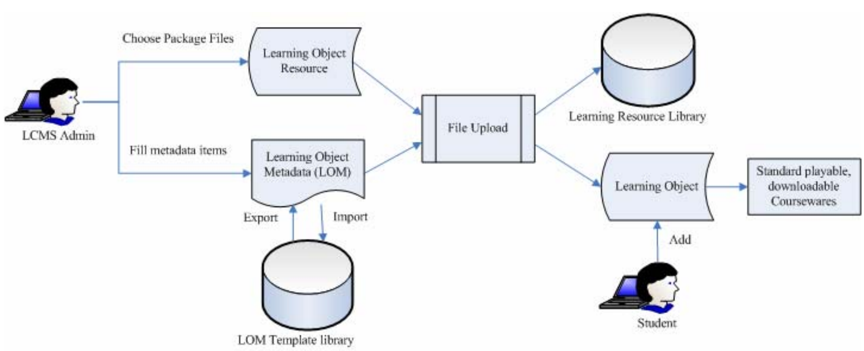

Fig. 5. LCMS Workflow

3 System Implementation

This section describes system implementation, including playing design, xml structure, data store, dynamic simulation, packaging, query and delete functions and exporting standard learning objects.

3.1 Playing Design

Our system plays like a debugger, but it doesn't need any real compiler inside. According to the requirement, the system should be used to teach various programming languages,. To do this language-less debugger simulation, we divide each case into several sections. The content of each section is filled by teachers. When students are playing cases, they are actually interacting with our system to get learning procedures defined by teachers in the case-generating process. The simulation consists of 3 ways: step into, step over, step back, which are just what they mean in common debugging process.

3.2 XML Structure

The cases must be played by steps like debugging, and the resource changes as step changes. So it's a good way to use xml to describe the uniform structure of the cases.

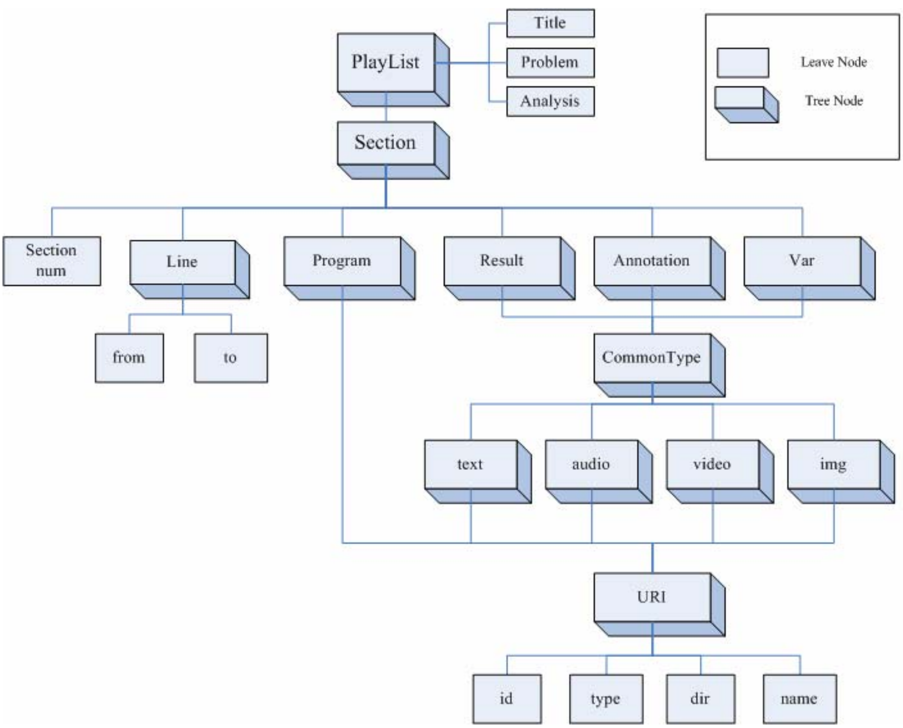

Fig. 6. XML Structure

Fig.6 shows the xml structure design. The root node, called PlayList, represents the play list of the dynamic case, which contains the information about title, problem, analysis and several sections. Section node is just like a step in debugging process, containing section num node to determine the order, program node to get the right program file, line node to get the code line(s) taught in the current section, Result, Annotation, Var nodes to get the comments about what the teachers want to tell the students in this section.

Result node stores the output of the program, Annotation node stores the comments and knowledge points of the current section, Var stands for variables which stores the variable's information. As can be seen from Fig.6, Result, Annotation and Var nodes are all CommonType nodes. A CommonType node consists of 4 optional sub-nodes: text, audio, video and img, which give teachers multimedia support to teach the case, and help students understand the section better than pure texts. The program, text, audio, video and img nodes are all kind of URI. URI node contains the path information of the files stored in database, including id, type, dir and name, with which the system can export the corresponding files used in this section from database when loading and playing.

By means of xml, we can describe all cases in uniform format with multiple kinds of resources, which builds a bridge between database and cases.

3.3 Data Store

We use Oracle database to store six kinds of data: xml, program, text, audio, video and image, each with a specific corresponding table. All the data files are stored as BLOB (binary large object) in the database, with id, name, date, type and description columns, which are recorded to find the file.

When loading a case from the database, we store the files into a temporary with uniform directory structure in order to play on-line.

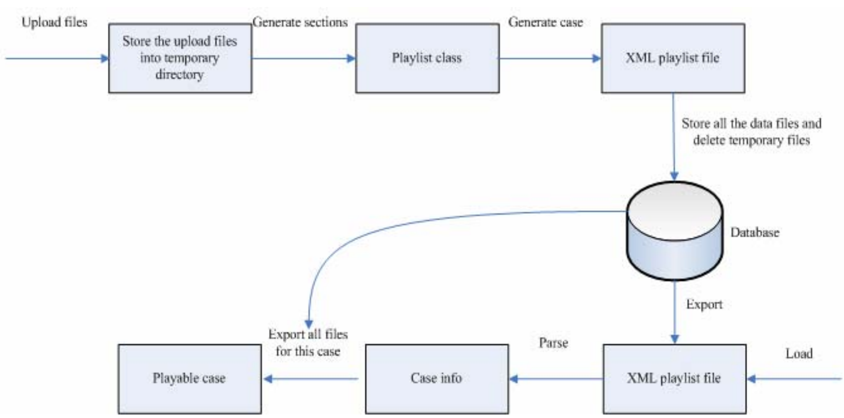

Fig. 7. Dynamic Simulation Process

3.4 Dynamic Simulation Process

Fig.7 shows the dynamic simulation process when teachers generate and students load a case. When loading a case, the xml file is exported from the database first. After parsing the xml to get the play information, the system exports all the files needed to the right directory for this case from the database through the path parameters got from the xml file. Then the case can be played.

3.5 Package Cases

We use HTML template to generate the packages while loading. Each section is written in a single HTML file, linked with other resource files needed. Then, the HTML files with related resource files are compressed into a zip file, which can be downloaded by clients. The zipped package keeps the original directory structure of the case. Students can view the static case to study off-line with the original on-line contents.

3.6 Query and Delete

Query function helps navigate the case needed rapidly. Since all the useful information is stored in xml files, the best way is to query from these xml files. We first access the database to get the xml files through title column, export the xml files and parse them to get further information of the cases.

Delete function is used to delete all correlated files of the case in the database. We find the xml file, export and parse the file to get all the file path information in this case, delete the files. Finally delete the xml file.

3.7 Export Standard Learning Objects

Each case has its zipped package. Each package can also be called learning object. In order to make the learning objects reusable in other systems, we use Metadata (CELTS-3) to describe them, which is a label placed on each learning object. Our system generates a specific metadata xml files from the content filled by teachers after a case is uploaded into LCMS. The xml files are stored in the database as CLOB (character large object), while the learning object files are stored in a public directory. Then we can export and download the standard learning objects – with metadata described. [7]

3.8 Assemble Individual Learning Content Packages

With the standard learning objects, we implement a learning content package function in LCMS, following Content Packaging Specification (CELTS-9), which could use these learning objects to assemble standard learning content packages. We use a tree-like interface to help users do assembling by adding, modifying or deleting nodes. After assembling, a file named “celtsmanifest.xml” is generated, which lists all the learning objects used in this content package. Fig. 8 gives an example of playing a standard learning content package.

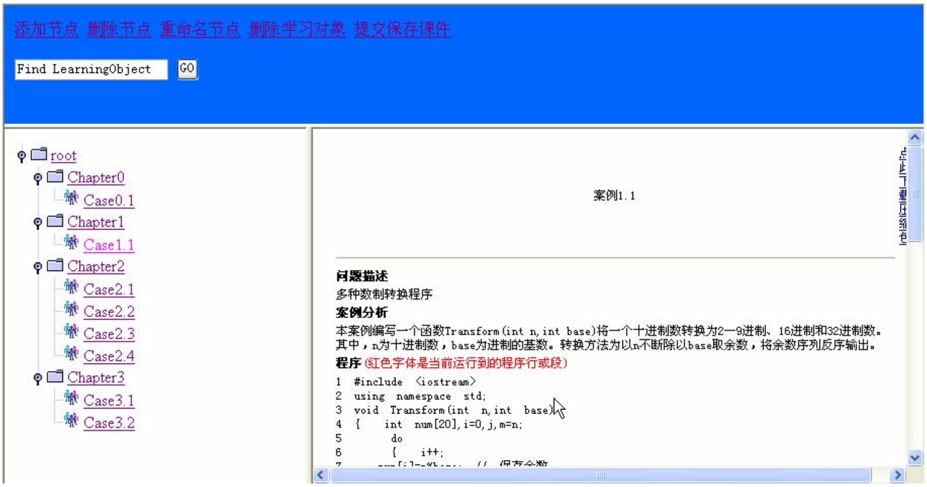

Fig. 8. Playing a Learning Content Package

4 Discussions

We used the system as an online, interactive case-based learning platform with multimedia support to help teach and study programming languages by cases. We use J2EE architecture to implement the system for portability. Since there're no easy-to-use authoring tools for teachers to generate lots of dynamic cases, we introduced an approach to speed up the process of generating cases. Our system acts as a debugger when playing cases for all programming languages. But no compiler is used in this system. For one thing, this would cost a lot of time to design and develop. Secondly, it would be hard if other systems need to use it. Instead of multiple compilers, we use xml to describe the cases and store the step information, which also contains path information of resource files stored in database. Since students always prefer to view the cases off-line, this system generates static html files and packages them with the resource files in zip format for each case, which can be downloaded and viewed as an e-book. For reusability, the zipped packages can also be exported as standard learning objects according to CELTS-3 with our learning content management system (LCMS). With the help of specifications of learning content packaging (CELTS-9), the standard learning objects can be assembled individually by students with LCMS. The standard learning objects and learning content packages can also be used by all the other systems supporting Chinese E-Learning Technology Standard (CELTS).

5 Conclusions

The proposed system provides a generalized web-based and interactive environment for teachers and students to generate and learn programming at distance. Teachers can easily generate dynamic programming cases and package the cases into coursewares. Students can interactively learn the programming cases step by step. The system is like a language-less debugger, which facilitates the teaching and studying of all kinds of programming language. There is no need to install any programming environment (like JDK, GCC, active Perl, Pascal, etc) for clients. The cases can be downloaded as zipped format, which can be exported as standard learning objects and assembled individual learning content packages with our LCMS. The standard learning object and content packages can also be used by other systems supporting CELTS.

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A Web-Based Chinese Handwriting Education System with Automatic Feedback and Analysis

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Abstract. We propose a web-based Chinese handwriting system that allows students to learn Chinese handwriting at anytime and anywhere. The system combines technologies such as electronic ink, database, Flash animations, and pattern recognition technique to provide students with an intelligent and effective learning environment. In particular, our system contains an Automatic Feedback and Analysis (AFA) tool that can check multiple kinds of handwriting mistakes and provide useful feedback to the user. Survey results show that most users agreed that our proposed system can help them to learn Chinese handwriting more efficiently as well as reducing teachers' workload. The user evaluation results suggest that it takes less time for users to learn Chinese handwriting with our system than with traditional teaching method.

Keywords: Chinese handwriting education, stroke production, stroke sequence, web-based learning, automatic feedback and analysis.

1 Introduction

Traditionally, students learn handwriting by following the way the teacher writes on the blackboard and then practice through writing on the exercise books and/or copy-books. A teacher can only check whether a student's handwriting looks spatially correct but is not able to evaluate the correctness of the stroke order from the static logograph written by the student. Law et al. [1] reported that students often write certain Chinese characters in wrong stroke sequence and make stroke production errors that include missing strokes, extra strokes, broken strokes, and concatenated strokes. In a time-limited lesson, it is impossible for a teacher to check every student's handwriting. However, in order to maintain a good learning progress, it is desirable to provide immediate feedback to every student each time he/she learns to write a new character. This motivates our work to develop a web-based system to assist teachers in the Chinese handwriting education.

Web-based learning has been a hot topic in the e-learning field and many researchers worked on systems to assist students to learn through the Internet [2][3]. Some researchers focused on methods in Chinese handwriting education but most of the contents are designed for viewing only so learners cannot practice handwriting through the systems [4][5][6][7]. As the pen-based devices are becoming more popular [8], some researchers suggested that the learner can write in a guided manner as in copybook [9] and even should be able to write freely. A robotic arm is

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developed to help a learner to write and force feedback is provided if the movement of the learner's hand deviates from the planned trajectory [10]. An interactive interface for handwriting education application is described in [11]. Most of the existing Chinese handwriting education systems focus on checking the stroke order [12] and stroke spatial features (such as stroke length and stroke position) [13]. Approaches proposed for character recognition may be applied for identifying stroke production errors but they require the user to input the character in correct stroke sequence [14][15]. Some approaches analyze the global features of the handwriting [16][17] but they require the users to write the characters in the correct shape. For novices or young children, they are often unable to write a Chinese character in the correct stroke order and shape. Other approaches focus on evaluating the beautifulness of the handwritings [18][19][20].

It is beneficial to have a system that allows students to learn at anytime and anywhere through Internet. In our system, template characters are stored and animated in a stroke-by-stroke manner for students to follow the correct way of handwriting. With this concept, we have developed a web-based handwriting education system with a 3D virtual teacher [21]. We have also developed a PDA system which can evaluate the qualities such as size, orientation of the handwritten character and its strokes [22]. In this paper, we propose a system with which students can learn the correct stroke orders and formation by practicing the handwriting on an electronic whiteboard using a tablet, which is a pen-based input device. We introduce an Automatic Feedback and Analysis (AFA) tool that can check multiple handwriting errors using pattern recognition technique. The users are not constrained to write the character in the correct stroke sequence for the automatic analysis to function. The AFA can give feedback which is displayed in both textual and graphical forms with animation in order to give the user a clear illustration of handwriting mistakes. The proposed system is described in section 2. The description of AFA is given in section 3. The user studies are presented in section 4. Conclusions and future work are provided in section 5.

2 Our Proposed System Description

We have made use of the world-wide-web technology to implement the system. The web interface enables the teacher and students to communicate with each other

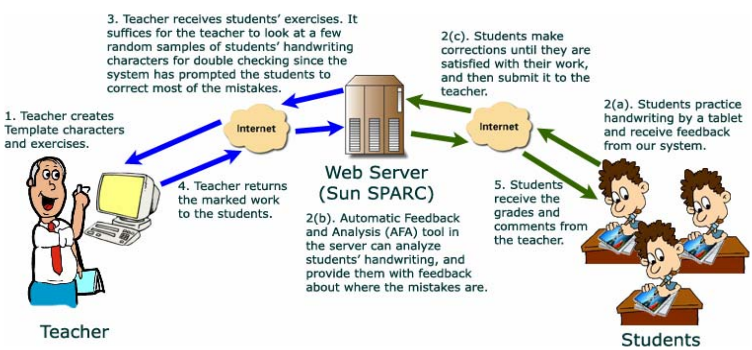


Fig. 1. The system diagram

asynchronously. The interactivity is provided by integrating electronic ink, database and Flash animations into our proposed system.

The flow of our system is illustrated in **Fig. 1**. A student can practice handwriting with a tablet. While practicing, he/she can use the Automatic Feedback and Analysis (AFA) tool to check if he/she has any handwriting mistakes. The student can practice handwriting until he/she is satisfied with his/her work. Then he/she can submit the handwriting homework to the teacher. The feedback result from AFA can give the teacher a quick evaluation of student's work. It not only enhances the progress of the student, but also eases the teacher's workload.

We host our system in a SUN SPARC server with the webpage http://vache.cs.cityu.edu.hk/ccls/. In our system design, The AFA tool is a server side application since we want to make use of the powerful computing resources at server in order to reduce the loading on the client side.

2.1 Functions of the Teachers

Create a Chinese character template. The teacher can simply write a Chinese character once and the system will store it as the template for students to follow. While the teacher writes on the whiteboard, the system will automatically update the number of strokes as the character is being written. To confirm and save the input character, the teacher should type in the corresponding Chinese character in the textbox below the stroke counter (Fig. 2). The template characters created by the teacher are useful for students to follow in the handwriting exercises. More importantly, these templates are used for character analysis and identify student handwriting errors. The created characters can be shared with other teachers in the same school or can be reused in future. It reduces teacher's workload and enhances the efficiency in preparing exercises.

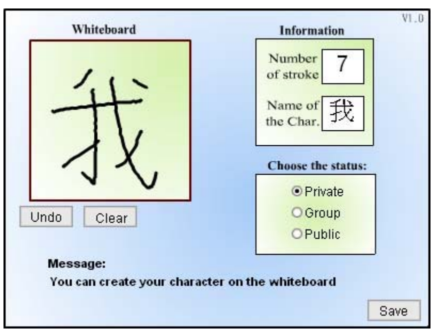


Fig. 2. Teacher creates a new template character

Create a handwriting exercise for students. An exercise is composed of several Chinese character templates. In our system we have created 100 Chinese character templates in the database (Fig. 3). Firstly, the teacher can search for the desired characters. If the characters are not found, he/she could create on his/her own. The number of characters is still expanding and we keep adding more frequently used

Chinese characters. A character template listing is provided for the teacher to select the characters needed for the exercise by simply clicking the checkbox next to the corresponding characters.

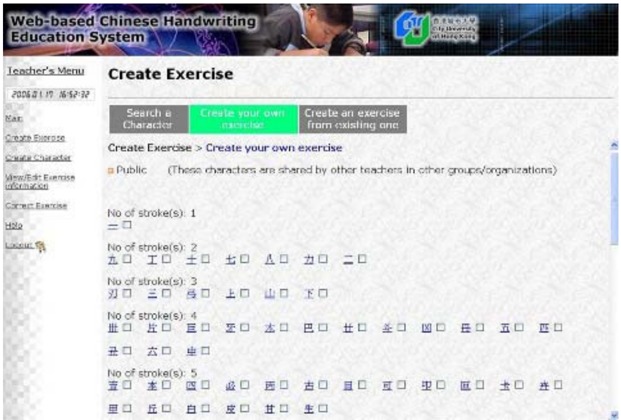


Fig. 3. A snapshot of the character database

Give comments to student. After the student had submitted his/her exercise, the teacher can view and evaluate the student's work. The results generated by the Automatic Feedback and Analysis (AFA) tool could help teacher to find out any wrong stroke order and production errors quickly. As a result, the teacher may not need to manually inspect every character written by each student. In addition to the automatic feedback, the teacher can mark in red on the whiteboard using a tablet to provide comments to students (Fig. 4).

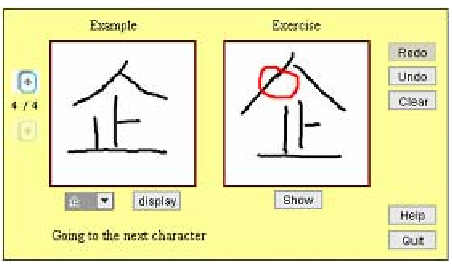


Fig. 4. Teacher views and evaluates student's work

2.2 Functions of the Students

Practice handwriting. Student can choose any exercises created by the teacher for handwriting practices. Through the whiteboard (Fig. 5), he/she can view teacher's template handwriting on the "Example" box (on the left hand side). The template character could be displayed with stroke-by-stroke animation, and hence the student can follow the stroke sequence and write the character accordingly. Students can

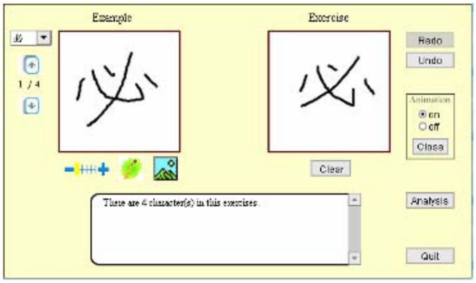


Fig. 5. Student practices handwriting on whiteboard

replay the template handwriting animation until they are clear about how a character should be written.

Receive immediate feedback from the system. After the student has written a character, he/she can check the correctness of his/her handwriting by clicking the “Analysis” button to invoke the AFA. More details about the AFA will be described in the next section.

Review the final comment from teacher. After the handwriting exercise is finished, the student can submit his/her work to the teacher. Once his/her work is received and marked by the teacher, he/she can view the teacher’s marking and comment for improving his/her handwriting skill.

3 Automatic Feedback and Analysis (AFA)

The aim of the Automatic Feedback and Analysis (AFA) tool is to enhance the Chinese handwriting education by analyzing a student’s handwriting and providing immediate feedback to the student.

Analyze student’s handwriting. To analyze the handwritten characters, pattern recognition technique is applied. Our proposed method takes online character data as input. Unlike offline data, which is always referred to a static image, online data contains more useful information such as the stroke sequence, the coordinates and directions of the data points on each stroke.

Based on the online information, we determine the stroke correspondence of template and user input characters by using the Hungarian method [23]. The Euclidean distance and direction similarities of each stroke pair are used as the constituent of the stroke matching cost. Hence, the user can write the character in any stroke order, and we can verify the stroke sequence by the stroke correspondence.

In addition to stroke order error, stroke production error may also occur. Hence we look for problematic strokes which are the sources of production errors. Problematic strokes are unmatched strokes or stroke pairs which have an unacceptable high stroke matching costs. They may appear in both template and user input characters. By removing and/or merging different problematic strokes, two sets of character instances (for template and user input characters) are formed. Each character instance represents a single case of production error. Finally, we match each user input instance with each template instance and search for the most similar instance pair, which help to identify exactly what production errors are made by the student. Fig. 6 shows the case when two strokes are missing in the user input character. In this case, the problematic strokes appear in the template only.

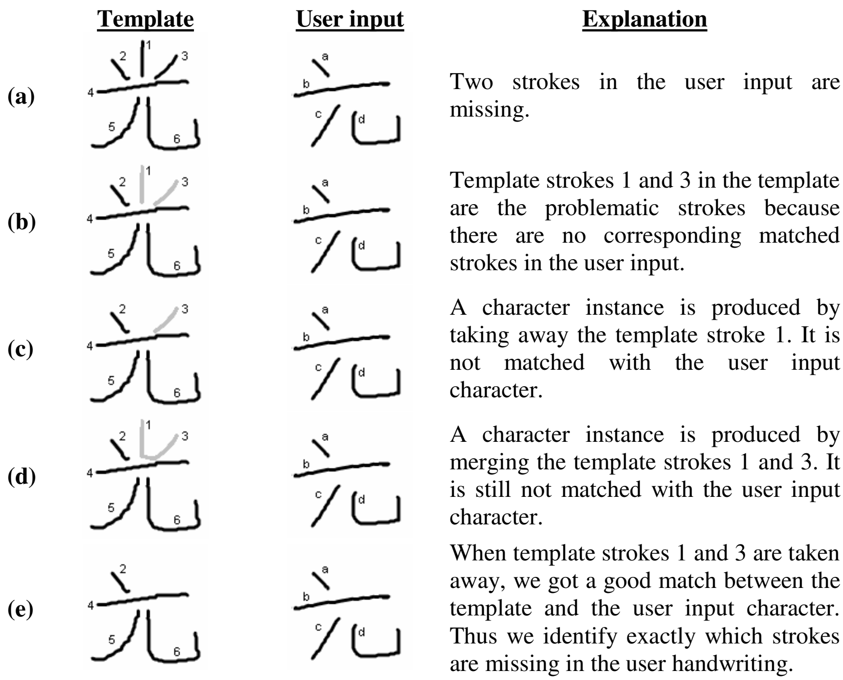


Fig. 6. An example illustrates a wrongly written character with two missing strokes

Give immediate feedback to student. Students usually expect an immediate feedback from the tutor. Immediate feedback is hence an important part in our proposed system. The AFA tool performs analysis through comparing student's handwriting with the template objectively and automatically, and the AFA returns a descriptive result. The flash whiteboard not only can let someone to write on but also can display the feedback indicating the problems regarding the stroke order, extra/missing stroke, and/or broken/concatenated strokes. The flash whiteboard can receive the automatic feedback from the AFA tool and then visualize the handwriting problems committed by the students in his/her handwriting. Not the least, the feedback information could also help the teacher in evaluation and in monitoring the progress of the students.

Different kinds of feedback may be presented depending on the scenario. No matter the handwriting is correct or wrong, AFA can give feedback to the user. If the input handwriting character is correct, the whiteboard will display a congratulations animation as shown in Fig. 7. Otherwise, another animation will be displayed to cheer up the student and encourage him/her to try again. In the latter case, AFA will instruct the whiteboard to give appropriate feedback showing what and where the problems are. When stroke production errors are detected, the AFA tool can identify the problematic strokes. Our proposed system can check multiple stroke production errors at each time. The whiteboard can highlight the missing/extra strokes, and it can circle the locations with wrongly merged strokes or wrongly broken stroke in red colour (Fig. 8).

Fig. 7. Feedback for correct handwriting

(a) Concatenated strokes

(b) Missing and concatenated strokes

(c) Broken and concatenated strokes

(d) Extra and missing strokes

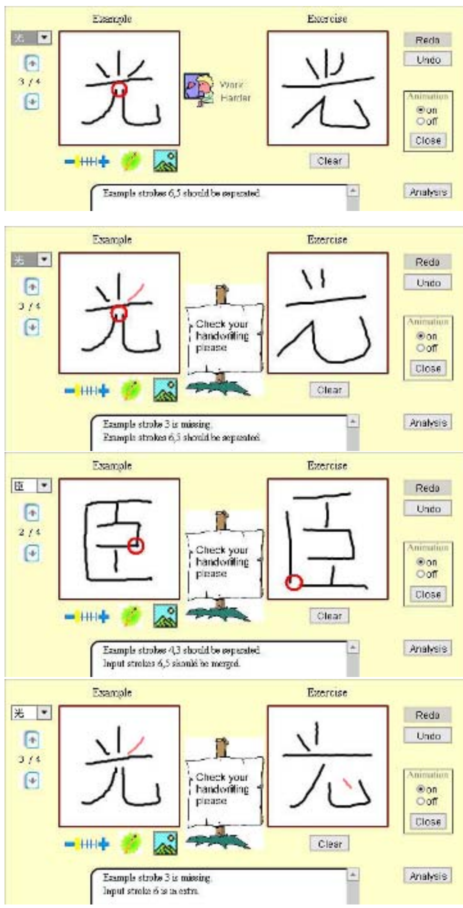


Fig. 8. Some cases showing the feedback on production errors

Fig. 9 illustrates some difficult cases of production errors which our system can identify, such as (a) one stroke is missing while two separate strokes are concatenated, and (b) two strokes are concatenated while another stroke is broken into two parts.

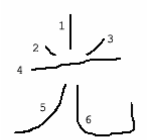
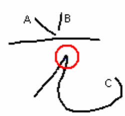
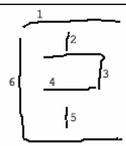
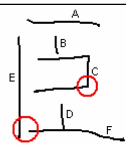
	Template character	Sample character	Problems in Sample character
(a)			Template stroke 3 is missing in the sample character; the sample stroke C should be broken into separate strokes like template strokes 5 and 6.
(b)			Sample strokes E and F should be merged like template stroke 6; sample stroke C should be split like template strokes 3 and 4.

Fig. 9. Some difficult cases of production errors

Fig. 10 shows the correct stroke sequence of Chinese character "光", while Fig. 11 shows a wrong stroke sequence input by a student. If we want to tell the student the correct stroke order, animating all strokes in order is the simplest way. However, it is difficult for student to notice which strokes are written in the wrong sequence. Using a minimal feedback method [12], we can group the strokes according to the matched sub-sequences and animate the correct order of each group with different colours (Fig. 12). The student can thus get a better perception of the errors he/she has made.

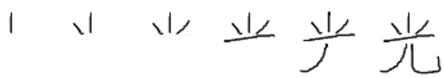


Fig. 10. Correct stroke order of the character "光"

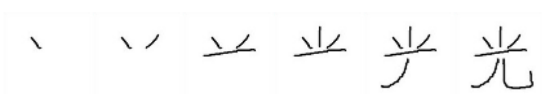


Fig. 11. User input with the wrong stroke sequence of the character "光"

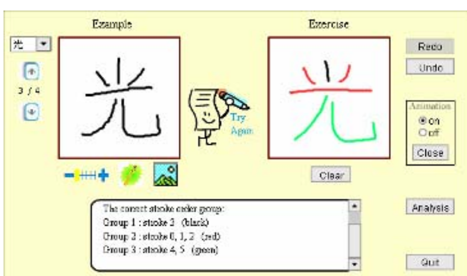


Fig. 12. Minimum stroke order feedback

4 User Studies and Evaluations

We have invited 70 public users to try out our system and conducted a survey in order to collect the user feedback. Questions concerning different aspects of our proposed system are listed in Table 1. Users were told to rate the aspects according to their degree of satisfaction scoring from 1 to 6. The higher the score the more satisfied is the user. Scores ranging from 1 to 3 indicates that the users are dissatisfied with the proposition, while scores ranging from 4 to 6 indicate that the users are satisfied. Score 6 indicates that the users are highly satisfied.

Table 1. The questions in the user feedback survey

Question number	Questions
Q1.	The system can help you to know what and where mistakes (missing/extra strokes; or broken/ concatenated strokes) are in your handwriting.
Q2.	The system can check the stroke order of your handwriting and help you know the correct stroke order of a Chinese character.
Q3.	You are satisfied with the accuracy in checking mistakes of your handwriting.
Q4.	You are satisfied with the speed of checking mistakes in your handwriting.
Q5.	The Automatic Feedback and Analysis tool can reduce teacher's workload.

We have received 51 filled questionnaires. Fig. 13 presents the survey result in a bar chart, and Table 2 shows the numeral results. In Fig. 13, we can see that most users are satisfied with our proposed system after they have tried it out. In general, about 94.9% respondents have given score 4 or above, while a small number of users was not satisfied with the system (5.1%) and they have given score 3 or below.

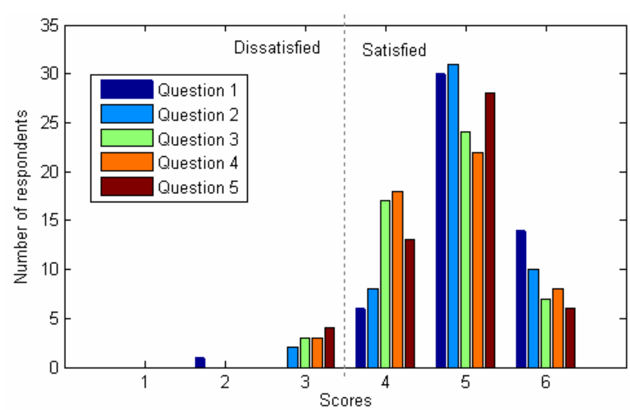


Fig. 13. The bar chart of the survey result

According to the feedback, Questions 1 and 2 reveal that the system can help users understand whether and where the production errors are, as well as the stroke order error. It also shows that most users agreed that the Automatic Feedback and Analysis (AFA) tool can give them clear and useful clues to improve their handwriting skills. In terms of verification accuracy (Question 3) and handwriting checking speed (Question 4), 48 out of 51 (94%) users expressed satisfaction. Moreover, Question 5 reveals that 47 out of 51 (92%) users agreed that our system can assist teachers to evaluate students' handwriting and reduce their workload.

Table 2. The survey score distribution

Question	Scores					
	1	**2**	**3**	**4**	**5**	**6**
Q1	0	1	0	6	30	14
Q2	0	0	2	8	31	10
Q3	0	0	3	17	24	7
Q4	0	0	3	18	22	8
Q5	0	0	4	13	28	6
Sum	0	1	12	62	135	45
Overall Percentage	0.00%	0.39%	4.71%	24.31%	52.94%	17.65%

We have conducted another test to evaluate whether our system can help users to learn Chinese handwriting more effectively. We have invited 18 university students as users. Nine of them are selected in the test group and the rest are in the control group. Students in both groups are told to learn the standard writing of five pre-selected characters which are often written wrongly even by adults. These characters are "弟", "晃", "男", "媽", and "舅". Students in the test group learnt through our system, while those in the control group learnt under a teacher's guidance individually. We record the exercise time and the number of attempts until all characters were written

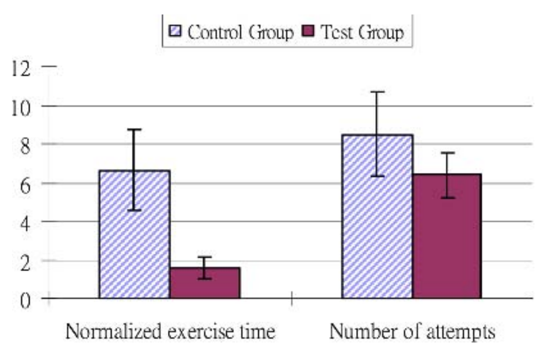


Fig. 14. User evaluation result

correctly. Since the writing speed of every student varies, the exercise time is normalized by dividing the time required for each student to finish writing the five characters with their normal writing speed. Fig. 14 shows the result.

The user evaluation result (Fig. 14) shows that our proposed system can let the student learn faster (much less exercise time) than traditional teacher guidance method. In real lesson, the availability of teacher is far less than in the control experiment so we believe that the exercise time would be much longer as each student has to wait for the teacher to give feedback to him/her. On the other hand, subjects using our system require fewer trials to write all the characters correctly. This observation can be explained by the fact that our system gives concise and informative feedback to the students.

5 Conclusions and Future Work

We have proposed a web-based Chinese handwriting education system supporting automatic feedback. Our system allows the student to practice handwriting according to the given template character. Our system provides an "Automatic Feedback and Analysis" function for automatically checking whether and where one makes any handwriting mistakes. The system gives appropriate feedback, such as animating the stroke order, highlighting the problematic strokes and circling wrongly broken/ merged points. Our system can check multiple production errors simultaneously as well as stroke sequence error, while existing handwriting education system cannot check more than one kind of handwriting errors at the same time. Through the user feedback survey, most of the users are satisfied with our system in terms of accuracy and feedback speed. They are also convinced that our system can assist them in learning Chinese handwriting and reduce teacher's workload. User evaluation results show that our system can help students learn handwriting faster.

For the Automatic Feedback and Analysis (AFA), we do not perform matching qualitatively because we want to tolerate the handwriting variations among different people. Although the results of stroke matching and error identification are not yet perfect, this is not an absolute requirement as people may have assumed for education purpose. If we are confident about the kind of errors made by the student, we can give more specific feedback. Otherwise, we can just replay the animation of the template.

As future work, we will check the Chinese handwriting qualitatively after the student has made corrections on the input character according to the feedback from our system. We will continue to improve the accuracy in error checking. In addition to checking for stroke order error and stroke production errors, relationship between strokes can also be analyzed for providing feedback. Moreover, instead of simply writing a character each time, users could practice writing a sentence so speed becomes a more critical issue. We are also studying how to generate character templates automatically from Chinese calligraphy images.

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Endowing LOs with a Social Dimension

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Abstract. Repositories of learning objects have the potential to support teachers' work and diffuse innovation in the school, nevertheless they did not arouse much interest from the teachers so far. We argue that this problem could be overcome by adding to repositories possibilities of focused interaction and collaboration among teachers, so as to foster reflection and value teachers' experience. To this end, we modelled the re-use process as a constructive activity. We implemented this view by means of a collaborative environment explicitly oriented to work with learning objects. In this paper, we describe our pedagogical view of re-use and the environment we realized, highlighting the interplay between individual reflection and social dimension. We also summarise the outcomes of the first use of the environment in a teacher training course.

1 Introduction

Learning Objects (LOs) [1] can be used to diffuse pedagogical innovation among teachers through the creation of digital libraries, that is, specialised repositories of catalogued educational materials, supposedly of high quality and easy to re-use [2], [3]. For this reason they have been receiving increasing attention in the educational research in the past decade, yet remaining scarcely diffused among school teachers, who often find it difficult or uninteresting to work with them. In this paper we argue that this situation could be improved by enriching repositories with wide possibilities of focused interaction and collaboration among teachers working with them, so as to value and share teachers' pedagogical experience. In this way, LOs result enriched by the points of view of different teachers, and become ductile and varied objects. We worked out this approach as a way to endow LOs with a social dimension and to add meaning to their use in education.

LO technology was initially proposed to make the educational production process more efficient, by providing ready-to-use, self-contained chunks of educational material which could allow teachers to save time during course preparation, rather than as a pedagogical support. Many potentially re-usable objects, though, (such as problem texts, tests, etc.) having a simple structure, are not difficult to be produced from scratch. Selecting and integrating them in a pre-existing pedagogical course design may result for teachers more time-consuming and difficult than building new ones. Retrieved materials, moreover, require to be checked in order to assure their

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quality and consistence with the pedagogical approach of the course in which they should be re-used. All this makes the re-use of simple materials scarcely appealing for teachers. On the contrary, objects on complex tasks may result very interesting for teachers because of features such as the embodied educational orientation, content articulation or novelty of the proposal. They, however, may result difficult to re-use without pedagogical support and suggestions for practical application.

In order to make LOs more effective and appealing for teachers, approaches of different kinds are currently the object of different studies. From a technical point of view, for instance, some architectures are proposed to efficiently realize networks of repositories [4], and metadata apt to answer school needs are worked out [5]. From a pedagogical point of view, the instructional implications of the LO paradigm are analysed, its role in the educational process is explored [6], conceptual and methodological indications on different types of LOs are given [7], as well as possible ways to expand the metadata to support the complex interactions entailed by the so-called “meaningful learning” [8]. From the point of view of didactical practice, issues like teachers’ perceptions and difficulties in searching for, and adapting, resources to be used in face-to-face courses are currently considered [9], together with issues emerged in the construction of LOs to be included in course production [10].

We think that LOs’ repositories should be conceived not simply as collections of educational materials, but as learning environments for teachers, where their professional experience can be valued and shared and new pedagogical ideas can emerge from collaboration and comparison with peers. This can be achieved by integrating LOs repositories within Communities of Practice, that is, groups of peers working online who share goals and engage together in activities and reflections on the work done [11]. Such communities are currently increasingly considered an effective way to cope with professional teacher development and life-long learning, since in these environments learning proceeds from action, expertise is distributed and knowledge is socially constructed. This appears to be beneficial for training and professional development in that the knowledge constructed through discussion is richer than that which a teacher can construct on his / her own [12].

A community of practice, however, should be structured so as to result interesting and useful for the teachers, otherwise teacher’s appreciation and involvement are not granted. As Parr and Ward [13] point out, there is the danger that communities may be perceived by teachers as requiring of them more than what they give, rather than apt to help solving their teaching problems.

With all the above issues in mind, we formulated a proposal for a collaborative environment devoted to working with LOs, which addresses the issue of re-use from the point of view of teachers’ needs. The idea underlying our proposal is that the use of LOs should give rise to pedagogical and epistemological reflection and act as a source to renew education. This entails enriching LOs with the pedagogical meaning that derives from the experience of use of different individuals in various contexts. In this view, teachers share not only materials but also, and foremost, experience, so that their activity with LOs can actually become a way to socially construct knowledge and improve their didactical practice.

In this paper, we describe our approach to the re-use of LOs and a prototype environment, LODE (Learning Objects Discussion Environment), that we realized to put into practice this approach. We also outline the outcomes of a first application of this environment in a pre-service teacher training course, which show appreciation for the environment and for the approach it implements, as well as a positive influence on trainee teachers' learning.

2 Modelling the Re-use Process as a Constructive Activity

From the point of view of education, *re-use* should be conceived differently than in technology-oriented environments. From a technological point of view, *re-use* generally indicates a mono-directional process, that is, the transmission of some material from a source to one or more users. This implicitly entails having a static view of the re-used object and considering it as a final product. By such a view, re-use simply aims to save time and labour to the re-user. From an educational point of view, on the other hand, re-use should refer not only to material to be employed or activities to carry out with the students. It involves also, and mainly, the experience gained by the teacher-producer who has been using the considered material in one or more occasions. This pedagogical view of re-use is schematized in Fig.1, which highlights the relation between experience and knowledge in a pedagogically-oriented re-use process.

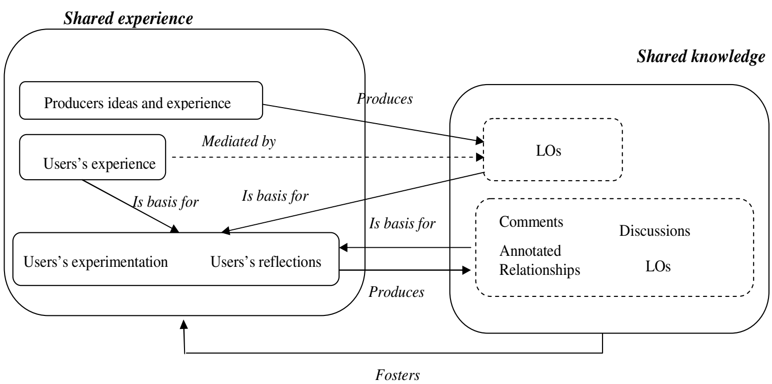

Fig. 1. A pedagogical view of the re-use process including teacher's experience

Since a same educational material obviously gives rise to different experiences of use, depending on the situation where it is applied, it appears, in this perspective, as constantly in evolution. If different people make use of the same material, then, the experiences originated differ not only for the influence of different contexts but also for that of different pedagogical orientations and personal teaching styles. Reflecting on the variety of experiences carried out starting from a same material constitutes for the teachers an occasion of learning. Reflection on the work done and comparison with that of others, moreover, are key points of self-regulated learning. This is a cross-curricular set of activities and competencies that allow people to make the most of their learning by controlling all its aspects (cognitive, motivational/emotional and behavioural) throughout its phases (planning, execution and monitoring, evaluation)

[14]. Several authors (e.g. [15]) point out the importance to set up for this sake social environments that provide support for reflection, self-assessment and revision. This means that engaging in a re-use activity that pays attention to individual and collaborative reflection on both knowledge and experience can foster teachers' self-regulated learning and hence result particularly effective as a tool for self-directed, life-long professional development.

Re-use of educational material in a different context, moreover, often leads to the re-elaboration of the initial view of the material itself and can result useful also to the initial producer, leading her/him to take into consideration a different perspective on her/his own work. Thus, re-use constitutes a knowledge transfer process in which both users and producers can take part actively, with mutual advantage. This can help creating a deeper sense of community and overcome the problem pointed out by Parr and Ward [13] of teachers feeling scarcely inclined to share their own productions since they don't perceive the participation in a community of practice as useful and rewarding.

The above considerations led us to model the re-use process as a constructive activity, apt to induce teachers' learning [16]. We remark that three different kinds of knowledge must be taken into consideration in the re-use process of a given educational material:

1. The initial intentions of the producer, together with hints to guide prospective re-users. This knowledge should be organised so as to lead the users to reflect on their own educational view, make comparisons with the view of the initial producer, highlight analogies and differences among different intentions.
2. The producer's experience with the material, which includes the original intention and suggestions for possible modifications of the initial proposal.
3. The experience deriving from other teachers' re-use of the material. This includes the pedagogical intentions at the basis of different re-use experiences and, if available, information about new materials possibly worked out to adapt or complement the original material within a different educational situation.

Each view of an object emerging from its re-use forms a new learning object which constitutes a pedagogical variant of the initial proposal. Reflecting on these variants and on their different uses constitutes a learning occasion for the teachers. This conception of dynamic and constructive creation constitutes a way of endowing LOSs with a social dimension, in that new LOs are created as the results of comparison and integration of the reflection and didactical experience of several teachers. Hence, starting from an initially given LO, entities of two different kinds are created, that should be collected in *ad hoc* collaborative environments, together with the original material that gave rise to their development:

- Educational material, which includes both the initially considered LOs and a number of 'pedagogical variants' of them, produced by the community of teachers based on different pedagogical points of view and re-use experiences. It is very important that each LO be connected with all LOs derived from it, since this helps the user-teachers to gain perspective on the material and understand different possible points of view and modes of use. Hence, it puts them in a better position to exploit their peers' experience.

- Comments created by the community of teachers interacting with the LOs repository, which include pedagogical considerations, suggestions for application or modification, and so on. These should not be considered simply as optional appendices to the educational materials, but keys to stimulate and express teachers' reflection. Moreover, their presence allows teachers to exploit the synergy of working in parallel with their colleagues on the same educational material and to compare the results of different approaches, hence realizing a connection between individual and social of learning. Comments introduce a "reflection level" on the work done within a repository.

Connecting with each other these two kinds of entities gives rise to a conceptual network of educational material on a given topic, as shown in Fig. 2. This is the expression of the collective learning of a group of teachers, in that it is developed by several authors by integrating their colleagues' productions with their own reflections and experience. On the other hand, individual comments and variants are the expression of individual learning, in that they represent the outcomes of individual work on a repository's content.

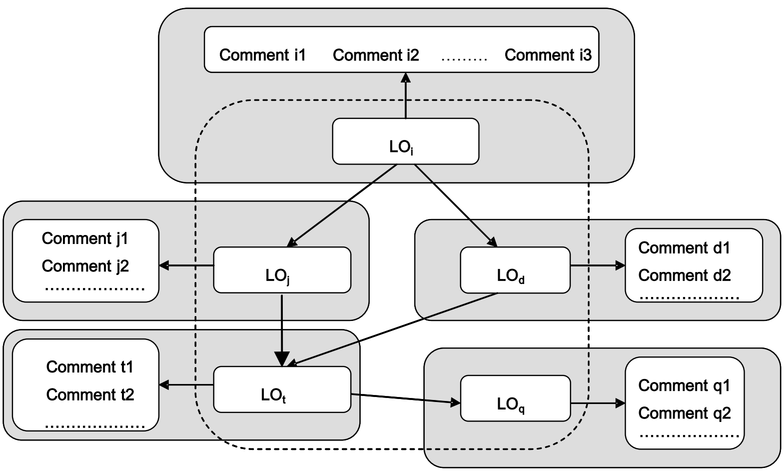

Fig. 2. The conceptual network of educational materials originated by variants and comments to an original LO

The presence of two different kinds of materials (LOs and comments), together with the many interconnections among them, increases the application range and educational power of the content of a repository.

3 A Collaborative Environment Oriented to Learning Objects

LODE (Learning Objects Discussion Environment) was designed according to the above conceptual approach to re-use, in order to support the development of communities of teachers working on LOs. A prototype, available in Italian and in English, was implemented by suitably adapting *ATutor*, an open source, fully inclusive, web-based Learning Content Management System designed so to result particularly accessible and adaptable (http://www.atutor.ca/). The implementation was made mostly by suitably configuring the *ATutor* platform so to allow a simple and uniform use of its features for managing LOs in accordance to our educational view of re-use. Only a few modifications of the database and the code were necessary.

From a technical point of view, LODE inherits the basic features of *ATutor*. LODE supports the users in expanding the knowledge contained in a repository by providing functions for the creation of new objects, the re-elaboration of old ones, the definition of connections among concepts and experiences, the retrieval of materials, ideas and methodologies.

LODE's main characteristics with respect to the environments currently in use for collaborative work is that it is specifically oriented to sharing pedagogical experience related with the definition and application of LOs. Hence, not only does it allow the usual variety of means to support interaction (i.e. communication and file sharing possibilities) but also provides facilities for inserting and cataloguing LOs, as well as comments on them. The environment also supports the definition of connections among LOs as part of the metadata.

3.1 Representation of Learning Objects

Each LO is represented as an *ATutor* course. The course creation template was modified so to make it suitable to our LOs and allow the user to specify at this level the values of metadata and the connections with other LOs. As a consequence, the home page of our LOs gives a synoptic view of all elements associated with them, that is, title, metadata and comments (see Fig. 3).

We defined our own metadata, and kept them limited to the information strictly necessary to characterize a LO with respect to the educational practice. Our metadata, include: author, language, date, key words, pedagogical approach, technical requirements, school topics, school level, producer's intention, educational role, connections with other objects (see Fig. 3).

We paid only limited attention to standards for metadata, both because interoperability issues are outside the scope of our research, and in our view they add a level of unwanted complexity as concerns the applicability of the pedagogical model we propose. After considering the most acknowledged metadata standards and specifications developed by international organizations [17], we selected a set of LO metadata mainly from the LOM scheme [18], but we moved away from it as regards the LOM category "Educational", in order to realize a proposal specifically oriented to the school pedagogical context.

Comments can be added by many authors for every LO, including the LO creator, who has in this way a tool to specify her/his intention for building the LO and to describe her/his own use experience. Though existing only in association to a LO, comments result as independent items, so that each of them can be modified only by its author. Comments' metadata include only author, date of creation, key words and LO associated. These metadata are visualized when a comment is opened. The content of the object is accessed by means of a link to one or more files, that can be stored in the LODE's repository or external to it.

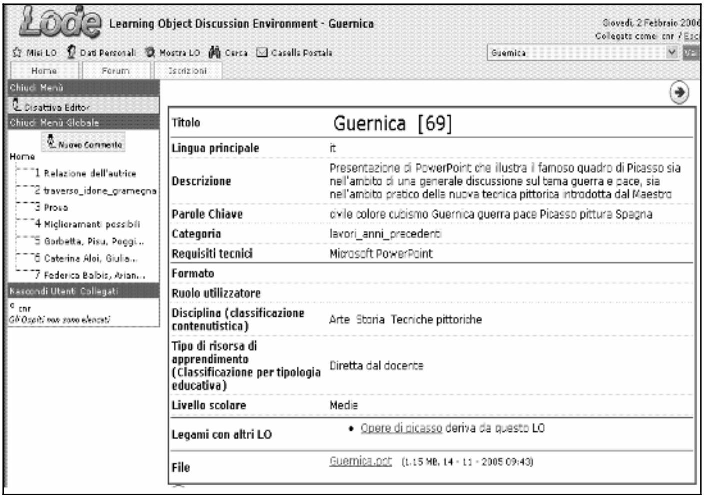

Fig. 3. The home page of a LO in LODE, showing the metadata and the comments available (on the left hand side). The number near the title shows the order of insertion in the repository.

Comments are inserted in the platform by exploiting *ATutor*'s possibility to upload a number of different documents associated to a course. Comments include:

- points of views of different users on the corresponding LO,
- outcomes of experimentations or proposals for pedagogical and operational changes,
- reflections on the work done and on different applications.

Each LO has two forums associated, where the author and the interested users can, respectively, exchange information on the corresponding LO or discuss technical issues related to its use. These forums are automatically started when a LO is created. Forums are conceptually different from comments in that they aim to focus the user's attention on particular aspects or issues and hence to start a deeper reflection process apt to give rise to the contributions in the Comment area or to the proposal of new LOs.

The possibility to define forums associated to each of our LOs is a feature of *ATutor*; the automatic creation of two of them in connection with any new LO is a choice of our configuration, aiming to encourage the users to share knowledge and ideas concerning each LO they are working on. The presence of individual forums for each LO, and the fact that interested people must register to use them, create smaller sub-communities interested in a given topic within the global community working on a repository. This aims to improve communication among the users interested in a topic by limiting the number of people with which one is talking and to make one feel the group closer and more real, hence avoiding the feeling of indeterminacy that people often experience in virtual group situations. Hence, forums on LOs constitute another means, besides comments, to bridge individual and collaborative activity and reflection.

3.2 Connections Among LOs

Users can define connections of different types between the objects they create and the existing ones. Connections are listed among the metadata shown on the home page of each LO. Thanks to the comments and connections, teachers accessing an object can easily track the experience of their colleagues who have worked with it. At present, four pedagogical categories of connections are provided :

- *derives from*: the considered object, was built by including some aspects of the linked one, transformed by the adoption of a different pedagogical approach (this could be, for instance a class on the same topic of the connected LO organized in different way);
- *substitutes*: the considered object was built as a transformation of a previous one, by taking into account different pedagogical needs determined by a different context of application (for instance a same class arranged to be suitable for students who differ as for age, grade, level of knowledge and cognitive development);
- *specializes*: this LO could be used to deepen or exemplify the content of the connected LO (e.g. a module on the planet Mars could be a specialization of a module on the Solar system);
- *complementary:* the object under consideration could be advantageously used together with the connected object (for example by referring to it for further deepening, or by offering a different view of some aspects of the initial one).

Each LO can be connected with more than one LO, as concerns both originating from and giving origin to, according to the conceptual scheme presented in Fig. 2. The connection field in the metadata shows all kinds of connections in both directions. When defining a connection, the user can associate to it a short note, to explain in what sense a LO e.g. derives from another one.

3.3 Other Facilities of the Environment

Besides the features mentioned above, the environment includes

- a help facility, including a glossary for the terms used in the metadata;
- a general forum, where general issues concerning the use of LOs for teaching can be addressed;
- a forum for free talk and socialization;
- a technical forum for questions on technical problems and difficulties;
- a FAQ section (answers to Frequently Asked Questions);
- individual and group email communication.

The help facility is realized as a LO, which contains, in the main page, a general characterization of the LODE environment, while information on different aspects are listed as associated contents (by exploiting the same feature that is used for regular LOs to attach comments to a LO). This LO is reserved, so that users can read it but not add comments. For users' observations, another LO was created, linked as "complementary" to the help facility, where users can add comments on the environment and suggestions for use or improvement.

The general forums are created, by exploiting an *ATutor* feature, as forums associated to the help facility. The FAQ section is realized also by means of a forum, again associated to the help facility, where only the system administrator can post items. Personal communication is based on *ATutor* functions. These choices allowed a simple and uniform (from the user's point of view) management of all data within the environment.

It is possible to browse through the complete list of objects and related comments. It is also possible to browse by following the semantic connections among objects and comments. Finally, it is possible to search for material in the environment by the metadata (using a single one or a combination of them) on both LOs and comments. This search function required a modification of the search facility provided by *ATutor*, to take into consideration our LOs' metadata.

Users must register to take part in the community. This feature was added both to stress the presence of a community around the repository, and to avoid disturbing intrusions. A few different user roles are defined, with different rights as concerns inserting educational materials and comments or participating in forums, according to the level of experience and integration in the community of each participant. An automatic notification service, based on an *ATutor* facility, communicates to forum members the insertion of new entries. We added an automatics communication also as concerns the creation of new comments on LOs of interest and of connections between one's contributions and those by other authors.

3.4 The Knowledge Formation Process in the LODE Environment

The above description highlights that the community's knowledge formation process in LODE relies on three kinds of activity, that is, exploring the repository's content, adding new content through individual reflection, building content through interaction with other teachers. The overall knowledge construction process is schematized in Fig. 4.

Content exploration constitutes a phase of individual reflection, while interaction with peers obviously corresponds to collaborative work. Content is not always a purely individual activity but can also raises from pairing individual reflection and comparison with peers' work.

The knowledge formation process is supported by the environment in several ways:

- defining and exploring semantic associations between LOs allows the users to conceptually structure the pedagogical knowledge and its evolution;
- the uniform and contextual handling of small networks originated by the conceptual connection among LOs and pertinent comments (as shown in Fig. 2) allows their use independently of the other contents in the repository; it also supports the formation of sub-communities interested in some particular pedagogical issue, which remain anyway in touch with the teachers' community at large through the general discussion forum and for the fact that most teachers will likely take part in more than one sub-community;

- the (automatic) personal notification of changes in LOs of interest, together with the help function, the FAQ and the glossary, aims to stimulate and ease teachers' participation.

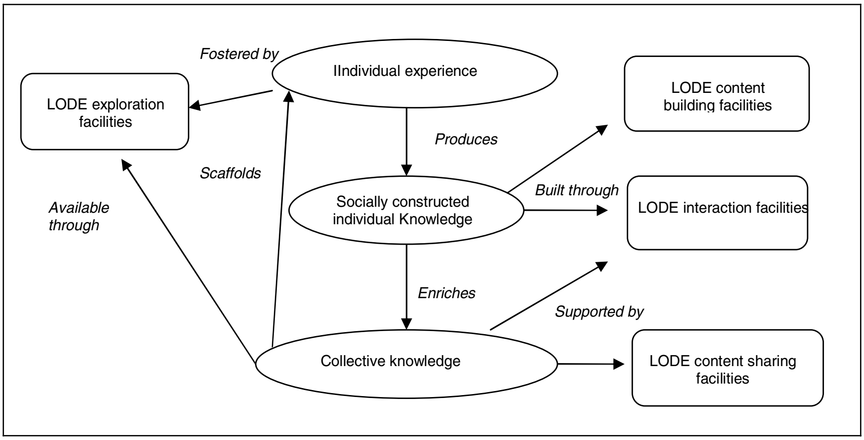

Fig. 4. A schematization of knowledge construction in LODE as an alternation of personal reflection and collaborative work

4 A First Use of LODE with Teachers

In order to check if the LODE environment could result interesting, useful and easy to use for teachers, we experimented it within a pre-service training course on Multimedia in Education for teachers of secondary school of all disciplines, at the University of Genoa, Italy, in the winter semester 2005. Before carrying out the activity with LODE, the trainees had a class on knowledge management and communication/collaboration systems, one on LOs and a concise presentation of the LODE environment. Some materials were initially uploaded in the environment, chosen among educational modules produced by the trainees of the same course in the previous years, so that work could start with some examples at disposal. Trainees were asked to: explore the environment and write a description of their understanding of it; choose a LO to analyse; write a comment of it; analyse the diversity between their description and the initial presentation made by the author; discuss possibly different opinions with the classmates who had chosen to analyse the same LO; work out a new LO and upload it in the environment, specifying (and justifying) the pedagogical metadata and connections with other LOs.

We evaluated the experience based on: 1) the answers to an anonymous questionnaire; 2) the observation of trainees' involvement; 3) the trainee's productions.

The questionnaire included several groups of questions, concerning: 1) interest for the environment, 2) ease of use and learning, 3) effectiveness of feedback and support received, 4) usefulness of the communication facilities. There were 30 closed questions, asking the respondents to evaluate some feature of the environment on a scale from 1 (very low) to 5 (very high). Seven open questions were also given, concerning difficulties experienced and aspects of the environment most or least appreciated. All questions were answered by 106 people. The average value obtained on all answers resulted 3.74, median 4, variance 0.92, standard deviation 0.96. The total percentage of answers greater or equal to 3 (average value) resulted 88,81. As concerns the groups of questions proposed, average values were: for the interest of the environments, 3,97; for ease of use and learning, 3,60; for feedback and help functions, 3,54; for communication facilities, 3,97. A graphical representation of these data is given in Figure 5.

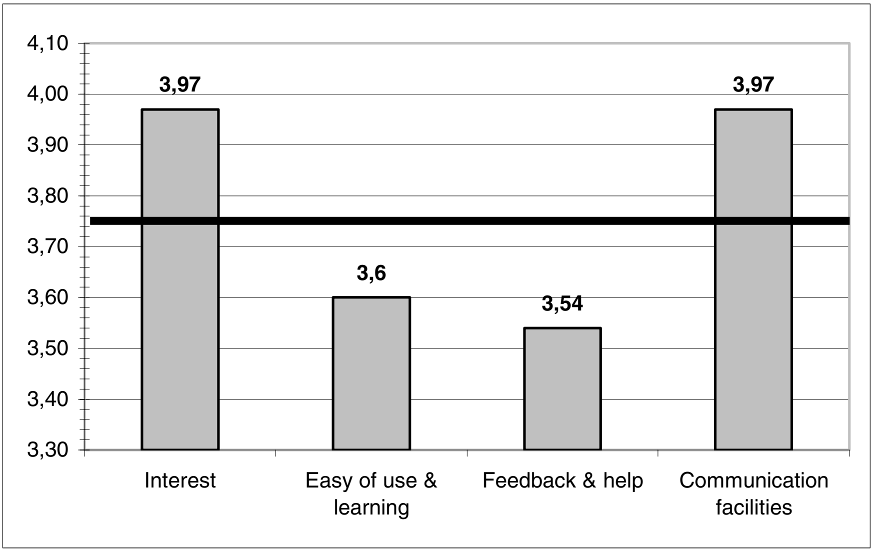

Fig. 5. Average of the answers given by the trainees to the four group of questions. The black horizontal line represents the average of all answers.

The answers to the open questions and the observation of the trainees' behaviour showed both appreciation for the environment and a positive influence on trainees' attitude and learning. The trainees became operative in a short time, used the environment to a wide extent and showed a good understanding of it from both a technical and conceptual point of view. They often carried out more than the work assigned, which suggests a high interest on their part. Several of them even asked us to leave the environment in use after the end of the activity so to be allowed to work with it longer. They showed to understand and appreciate the aims of this kind of activity in relation with their teaching profession. They appreciated in particular the possibility to express their own comments on the materials in the repository, as a tool to reflect on their own work, share pedagogical experience and learn from each other. They acknowledged, without being prompted on doing it, the potential of such an environment for teachers' support and professional development. The variety of comments and LOs' variants proposed by the trainees on their peers' work supports our hypothesis that the pedagogical re-use is a creative process where also re-users contribute to the creation of new knowledge.

The activity carried out by the trainees within the LODE environment appeared also to influence the quality of their work during the course, and hence likely also of their learning. This is suggested by the fact that the educational modules that this course participants are requested to work out for final evaluation resulted to be more careful, articulated, innovative and not trivial than they usually were in the previous years of the course. We attribute these better results to the reflection on peers' work that led the trainees to consider with more attention the pedagogical and communication aspects of their own productions.

The study also highlighted, though, that some aspects need to be improved. In particular, the metadata used to cataloguing the material should be revised, trying to find items which result in line with the standards presented in the literature but at the same time take into consideration the meanings usually given to labels by the beginning teachers, in relation with the different school topics. This issue, though, appears to be of difficult solution since keywords are often used in different ways in different disciplines.

5 Concluding Remarks

The aim of this paper was to discuss the possibility to successfully apply an educational approach to the re-use of Learning Objects and to check the appreciation of teachers for it. For this sake, we described the structure and function of the environment LODE, a communication/collaboration platform merged with a repository of educational material; we also outlined the main outcomes of its first application with novice teachers.

The positive response of the trainee teachers highlights their availability and interest to get involved in the sharing of educational material and collaboratively reflecting on its practical use. The good outcomes obtained suggest that our approach to the re-use of LOs is feasible and very likely effective.

Though most of our trainees had already some teaching experience, their opinions can certainly not be considered as representative of those of all teachers. The result of a similar study carried out with in-service teachers with many years of teaching experience would probably give different results, since this kind of activity with Learning Objects is very likely not in line with the habits developed during a long teaching activity in a traditional setting. Nevertheless, the appreciation of beginning teachers who are not yet biased by the current school culture, where collaborative activity and sharing of resources are not valued nor considered a way of professional development, underlines the feasibility of our approach.

Introducing trainee teachers to work with LOs in an environment like LODE is, in our opinion, very useful to help prepare them to a different model of teaching, more open to:

- exploit the support of information and communication technology to deepen their pedagogical competence and understanding of the learning process,
- improve their activity,
- diffuse innovation.

Inducing old and new teachers to take part together into communities of practice on LOs could result beneficial for both groups. Experienced teachers would have a means to keep their experience in circulation in the school system, leaving an inheritance of competence before retiring. They would receive in exchange from the beginning teachers a contribution of enthusiasm for the use of web-based technologies in education.

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Reusability on Learning Object Repository

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Abstract. We propose a mechanism, as well as an implemented prototype system, that can be used to support searching and reusing of learning objects. This paper discusses part of the Hard SCORM project developed in Taiwan to support asynchronized distance learning. We developed a SCORM 2004 compliant authoring tool and a LMS. The authoring tool is associated with a metadata wizard to help users to build metadata, which can be used while learning objects are searched and reused. The underlying repository to store learning objects is constructed based on the architecture defined as CORDRA. We integrate the authoring tool, the LMS, and the repository as a total solution to SCORM-based distance learning. The discussion has a focus on the analysis of metadata wizard as well as the analysis of IEEE LOM. The MINE Registry serves as an instance of CORDRA-based repository is also discussed.

Keywords: SCORM, IEEE LOM, CORDRA, Learning Object Reuse, Metadata, Distance Lsearning, Repository.

1 Introduction

Distance Learning is considered as a new type of business which has its recent impact to our society and Internet. One challenge issue is to develop good contents that can be delivered and used in instruction and distance learning. The issue is also related to how to find suitable and reusable learning objects before sharing of these objects can be promoted. The IEEE LOM (Learning Object Metadata) [9] has defined a category of data entries associated with a set of common vocabularies to describe the contents of learning objects. Via the common description, learning objects can be searched and reused if proper supports are developed. The IEEE LOM is now adapted as a standard for distance learning by the ISO. The Sharable Content Object Reference Model (SCORM) [3] adopts IEEE LOM as part of the specification. Started in early 90's, the Advanced Distributed Learning (ADL) initiative [1, 2, 3] proposed the SCORM specification. ADL divides an e-Learning environment into three components according to e-learning product functionality. These components are Authoring Tools, Learning Management Systems (LMSs) and Repositories [4]. In the specification, the Sharable Content Object Reference Model (SCORM) [3] is composed of three parts: a Content Aggregation Model to ensure the reusability of learning objects and to pack

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the learning objects, a Run-Time Environment to deliver contents and to support learning activity, and a Sequence Specification to provide an adaptive learning mechanism. SCORM covers features of Authoring Tools and LMSs. However, the definitions of repository are popular and not unique. Various platforms, schemas, and frameworks [11, 13, 15] increase the difficulty of interoperability in repository systems, while an indirect drawback of low interoperability is that it reduces the shareability and reusability of learning objects.

The Academic ADL Co-Lab designed questionnaires [7] in three phases during 2004 to solve this problem. These questionnaires had two significant aims, discovering whether the perception of a Repository is restricted to the understanding that "A repository is a system providing storage for electronic learning objects and their own metadata," and clearly defining the fundamental and essential functionality of Repository. Besides, ADL and others proposed the Content Object Repository Discovery and Resolution Architecture (CORDRA) model [1] at the first international Plugfest conference in 2004, and have attempted to find an integrated solution for various and tangle content repository architectures [2, 10].

Although the integrated SCORM framework builds an interoperable environment that can exchange learning objects unrestricted by data models, platforms or business strategies, the framework cannot meet the reusable and searchable requirements from ordinary users. For a learning object to be reusable, not only the contents need to be searchable and accessible, but the learning object itself must also contain sufficient descriptions to determine whether the purposes of using learning objects are satisfied. Whether a suitable learning object can be searched and retrieved from diverse repositories depends on whether the description can adequately represent these learning object characteristics. Hence, the standardization and completeness reflect the degree of reusability of the learning objects, the usability of the repository, and the validity of the retrieved data. Some metadata standards [5, 8, 9] and cross-standard approaches [12, 14] already exist. However, current authoring tools enforce users to fill in metadata elements one by one after editing a learning object. Such complicated demands lead most course creators to abandon this important process, affecting the searchability of repository. This problem explains why learning objects are difficult to share and reuse. Therefore, our investigation proposes a framework that can simultaneously lower the creators' overloading and address the completeness of metadata. By building a Metadata Wizard, the proposed system can automatically generate the metadata for each learning object. In addition to the Metadata Wizard, we propose an instance of the Content Object Repository Discovery and Resolution Architecture (CORDRA). The implementation of our repository uses a commercial database management system based on XML. Several computers are used to realize the protocol of registration and learning object accessing.

We discussed metadata proposed by IEEE (i.e., IEEE LOM) and how we see it can be automatically generated. The next section addresses the implementation of our Metadata Wizard within our SCORM 2004-compliant authoring tool. We then discuss the instance of CORDRA in section 3, before we point out what should be improved and our future work.

2 The IEEE LOM Revisited

2.1 Categories of Metadata

ADL has established a Content Aggregation Model based on nine categories of the IEEE 1484.12.1-2002 Learning Object Metadata (LOM) standard. Typicailly learning objecta are separated into different Content Model Components, namely Asset, SCO, Activity, Content Organization, and Content Aggregation. Each SCORM Content Model Component has corresponding requirements for each of metadata element as shown in Table 1. Therefore, the total number of metadata items is 77 in each type.

Table 1. Distributions of Metadata Items

CMC / Element type	Content Aggregation	Content Organization / Activity / SCO	Asset
Parent	19	19	19
Mandatory	0	11	8
Optional	58	47	50
Total Number	77		

Table 1 reveals that the number of mandatory elements of the Content Aggregation is zero, implying that all metadata elements in this layer are optional. In other words, a learning object without any metadata is also acceptable. Therefore, the learning object creator will not fill in the complete metadata actively and it results in repositories are difficult to search and to be found. This decreases reusability.

Parent elements in the table act as "containers" for other elements. That is, parent elements have no values associated with them. Hence, there are 58 elements need to be filled. Among the Mandatory elements, *1.1.2 Entry* and *3.1.2 Entry* (see SCORM 2004 specification) [3] are reserved elements with values assigned by a Handle System [6]. After removing the parent items, the optional items, and the reserved elements from the total, each SCO and Asset should at least have nine and six elements, respectively. However, the efficient reusability of learning object and accurate retrieval ability of repository depends on the completeness of the metadata (i.e., 58 elements). As shown in Figure 1, the more complete the metadata, the higher it's filling-in cost, but the lower the overall searching costs.

Filling in the 58 elements is merely a time-consuming task for metadata specialists. And even badly, it is a challenge for creators who are not familiar with the metadata definitions. The learning curve of metadata will never be an easy task for general users such as elementary school teachers. This is the main cause of low reusability of learning objects. Therefore, this investigation attempts to generate metadata automatically for each learning object by constructing a Metadata Wizard. The approach reduces the total cost by lowering the cost of filling in metadata. The dotted lines in Figure 2 denote the fall in Total Costs and Overall Filling-In Metadata Costs. Additionally, ensuring that each learning object has complete metadata helps for creating a practical repository environment.

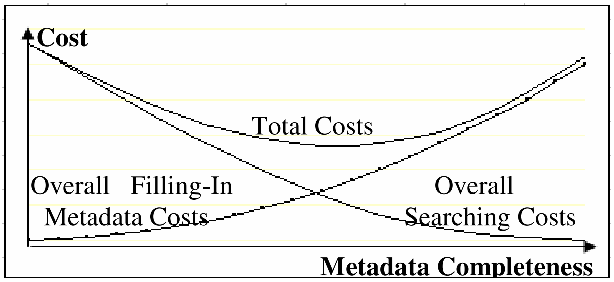

Fig. 1. Trade off between Searching Costs and Filling in Metadata Costs

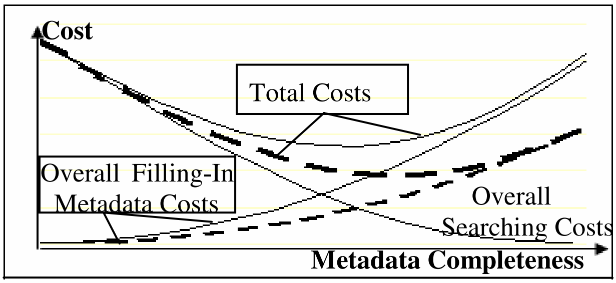

Fig. 2. The Decrement of Total Costs when Metadata Wizard Applied

2.2 Framework of the Metadata Wizard

The metadata elements are split into two categories User-Defined and System auto-Filled. The creator sets the values of User-Defined elements depend on subjectivity of creator. System auto-Filled are generated by the Metadata Wizard. Figure 3 depicts the Metadata Wizard Framework, which has two kernels, the Metadata Wizard and the Deduction Engine. These kernels are described in detail as follows.

The Metadata Wizard obtains information directly from the Environment Agent and the User Profile. The Metadata Wizard can obtain the values of environment and platform dependent elements via the Environment Agent. Considering platform-dependent variables, the Metadata Wizard maps the system default language to *1.3 Language*, and the system time zone and current date to *2.3.3 Date*. The values of environment-dependent variables, such as *4.1 Format*, *4.2 Size* and *4.3 Location* can be obtained from learning object files. Information about users is stored in User Profiles in the Learning Content Management System , and is provided at login time to assist the Metadata Wizard map to elements with the Vcard data type, such as *2.3.1 Role*, *3.2.2 Entity* and *8.1 Entity*.

If the information cannot be provided from the system, then Metadata Wizard fills in the elements based on system deduced. In other words, the Metadata Wizard obtains the deduced information from the Deduction Engine. The Deduction Engine infers data from three sources, the Question Agent, Mandatory Element and Content Organization.

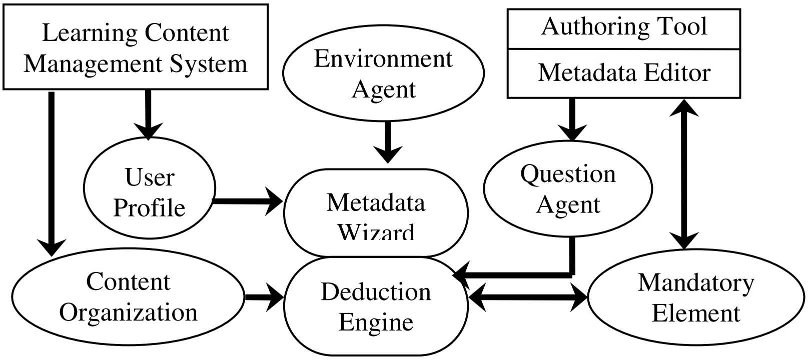

Fig. 3. The Metadata Wizard Framework

Deduced from Question Agent. The Question Agent has some intuitive questions to create interactive dialogue with users. One question might be, "Who is the target learner of this course?" The answer is clearly related to the learner's context. Therefore, the Metadata Wizard can fill the value in *5.6 Context, 5.7 Typical Age Range* according to the results from the Deduction Agent.

Deduced from Mandatory Element. As seen in Table 1, both SCO and Asset have some mandatory elements that must be fed with some values. The Deduction Engine can analyze and processe these values when they are obtained from the Metadata Editor of the Authoring Tool. For instance, *1.4 Description* is a mandatory element. After obtaining this value from the Metadata Editor, Deduction Engine processes those value using techniques such as natural language analysis, then extracts the useful data to fill in *1.5 Keyword.*

Deduced from Content Organization. A Content Organization is a map representing the content through structured units of instruction. As mentioned above, each Content Model Component describes itself with its metadata. The Deduction Engine, after obtaining metadata of low-level units of instruction (such as Asset), can then map or operate to corresponding higher-level component of instruction (such as Content Aggregation). The easiest of structural relations deduction approach is to aggregate the lower level units to their higher level units. Moreover, structural relations deduction can be operated by mathematical operations as well as aggregation. Considering *4.2 Size* as an example, if an Activity has three Assets, then each Asset *Size* can be summed and the value assigned to Activity *4.2 Size.*

Every rule in the Deduction Engine is either a Copy Function or If-Then Function. Notably, If-Then Functions can only be applied to valid sets of tokens in the SCORM Metadata Standard.

Additionally, to provide a more elastic and powerful deduction engine, the Deduction rules can be designed by professionals and customized to individual needs. That is, the Deduction Engine permits the users to alter all deduction rules.

2.3 Implementation of the Metadata Wizard

In the implement, each component in the Metadata Wizard Framework is a component program in DLL form. To perform the implementation, the Metadata Wizard was integrated into the Hard SCORM Authoring tool [16]. The development environment is under Microsoft Visual Studio .NET 2003 with C#.

A creator designs a new course, which may inserts some existing learning objects from the resource pool. The bottom-left corner of Figure 4 displays a resource pool. Resources with metadata are revealed. On the top-left side of Figure 4, the window illustrates how to arrange a course structure. The creator, after dragging the learning objects from the resource pool to the content aggregation tree, can fill out all metadata elements for each learning object with the Metadata Editor, or to allow the Metadata Wizard to help. Figure 5 depicts the relevant Metadata Wizard selections in the "Metadata" drop-down menu.

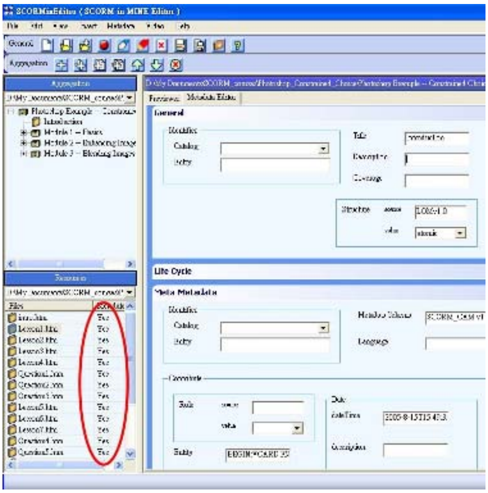

Fig. 4. MINE Authoring Tool (partial interface)

Fig. 5. The "Metadata" Drop Down Menu

The "User Profile" and "Questions" functions allow users to modify their personal data and their answers to improve the accuracy of deduction. The "Options" function enables the user to disable particular deduction rules. The left window of Figure 6 illustrates the Question Agent interface, which allows users to design their own interactive questions and corresponding deduction rules. All rules in the Deduction Engine, including the Copy and If-Then Functions, can be modified in the right side window. After design the deduction rules, they can be saved as a rule template for sharing. In addition, the "Metadata" drop-down menu has "Generate" and "Completed generation" functions. The "Generate" function generates individual learning object metadata, and the "Completed generation" function generates all learning objects metadata under the content aggregation. Finally, the "CA metadata editor" can be applied to display and edit the generated Content Aggregation Metadata. After a course is created, the "Completed generation" function is embedded in the "Save" function to regenerate and double-check all metadata.

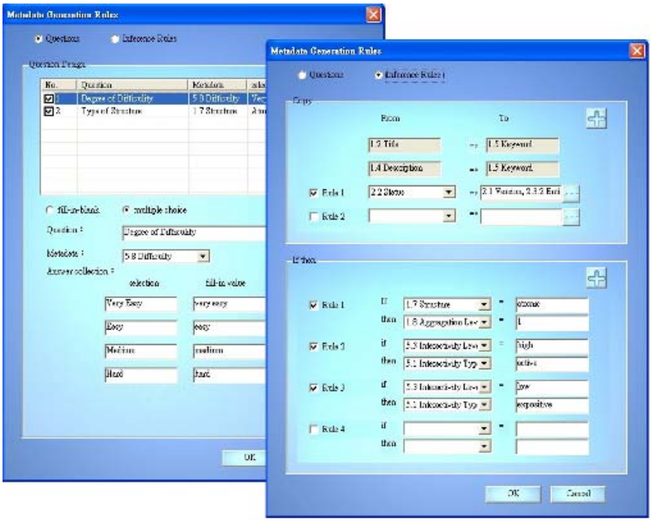

Fig. 6. The Question Agent and Deduction Engine interface

Table 2 lists the "System Provided" element, which represents information obtained directly from the Environment Agent and User Profile. "System Deduced" means information extracted form the Deduction Engine. After reserved and parent elements are subtracted from the total number of elements, 54 elements have to be filled out. The automatic generation rate is at least 61% when the Metadata Wizard Framework is implemented. The result indicates that the Metadata Wizard decreases the creator loading in absolute terms.

Table 2. Automatic generation of Content Model Component (CMC)

CMC / Catalog	Content Aggregation	Content Organization / Activity / SCO	Asset
Reserved	4	4	4
System Provided	15	15	20
System Deduced	20	20	13
Generation Rate	65%	65%	61%

3 The MINE Registry – An Instance of CORDRA

3.1 Learning Object Repository and CORDRA

As we have explained in the previous section, metadata is very useful when one is searching for reusable objects. Ordinary Internet-based searching engine may not fit the particular requirement of finding course materials in distance education. IEEE LOM was precisely designed for the purpose. However, there still remain problems before learning objects can be found and reused. Since it is unlikely that a user only use learning objects in his/her own resource pool or database, the first question raised is how to find who else has another database where learning objects are incorporated with metadata for searching. In addition, assuming that someone is creating a new learning object, how this new learning object become known by others is also questionable. Fortunately, the Content Object Repository Discovery and Registration/Resolution Architecture (CORDRA) provide a solution for these problems.

CORDRA, as defined by its proposing organizations, is described as "an open, standards-based model for how to design and implement software systems for the purposes of discovery, sharing and reuse of learning content through the establishment of interoperable federations of learning content repositories." The CORDRA specification is a joint development among ADL, CNRI (Corporation for National Research Initiatives, USA) and LSAL (Learning Systems Architecture Lab, CMU, USA). The architecture aims to provide a way to resolve the conflict of name space by means of providing a unique handler (i.e., initiated by CNRI) for each learning object. The architecture also provides a way to allow discovery and sharing of learning objects. Thus, CORDRA addresses the questions discussed above by providing promised technical solutions.

According to CORDRA specification, key operations include registering a content object in the *content catalog* for later search and retrieval, as well as searching the *content catalog* to return content objects (via their IDs) and metadata. On the other hand, from a higher level perspective, CORDRA should allow registering a content repository in the *repository registry* by specifying descriptive data and rules, as well as providing queries to the *repository registry* for the operational, policy and business rules. Conclusively, the federated CORDRA is considered as a global infrastructure to encourage multiple instances of CORDRA implementations. For instance, ADL has an implementation of CORDRA instance, known as ADL-Registry. Similarly, Tamkang University has another instance know as the MINE Registry. The MINE Registry follows the definition of common architecture defined in CORDRA. However, it is the decision of a particular implementation to allocate different computer servers to establish the common architecture. That is, the MINE Registry has to decide how computers are used in the implementation of several services described below:

- **Local Content Repositories.** Stores contents created by a local organization, with possible extended functions such as media streaming server, catalog server, etc.
- **System Repositories.** Be divided into three portions.
  - *Master Catalog*: stores a copy of metadata for all contents created in the federation.
  - *Repository Registry*: allows all Local Content Repositories to register.
  - *System Registry*: stores additional system information and maintain service logs.
- **Identifier System.** Provides a common solution for name space of all learning objects created.
- **Common Services.** Allows additional techniques and services such as authentication or digital right management (DRM).

- **Applications.** Includes individual computers where authoring tools are installed and queries for searching learning objects are initiated.

Obviously, MINE Registry is an instance of CORDRA implementation which should not cover all servers/systems addressed above (e.g., System Repositories, Identifies System, and Common Services are not part of MINE Registry). Since the federated CORDRA architecture is still under construction, a temporary alternative should be considered to implement the MINE Registry. However, the alternative should be designed general enough such that the implementation can be easily adapted to the federated CORDRA in the near future. The consideration can be taken from two perspectives: searching and register, as we should discuss below.

3.2 Implementation of the MINE Registry

The implementation of MINE Registry uses the same underlying software platform as the Metadata Wizard, since it is easier for the integration. However, since the XML-based metadata will be stored and retrieved, to facilitate the implementation, a XML-based database is used. The distributed architecture to implement the MINE Registry incorporates several servers, as we should discuss below.

- **Register a Learning Object.** As illustrated in the distributed architecture in Figure 7, registering a learning object requires seven steps to complete. Usually, a client computer installs an authoring tool which is integrated with the registry. There are 4 additional computers used in the local environment illustrated in Figure 7. The Content Object Registry maintains a table which associates each learning objects (by an Object ID, or OID) with a Metadata ID (MID). The Master Catalog is local in Figure 7 since each instance of CORDRA will need to maintain a catalog to store the description of learning objects stored in the local repository. The catalog will be searched by the global registry if necessary. In addition, the Content Server stores the physical multimedia objects for the learning contents. This server can be incorporated with multimedia control functions such as a real-time streaming service or another for media synchronization. Finally, the Local Handle System will communicate with the global naming facility.

  The procedure of registering a learning object thus takes seven steps, as illustrated by the numbers in Figure 7:

1. The Client Computer provides a course object ID and uploads the contents associated with the ID to Content Object Registry.
2. The Content Object Register requests the Local Handle System to generate a handle for the newly created course object.
3. The Local Handle System provides the handle to the Content Object Registry. Alternatively, if the course object ID is duplicated, the handle is not created and the client computer should receive an error message to reassign a new object ID.
4. The Content Object Registry extracts the metadata from the uploaded course content. Types of metadata include metadata for Content Aggregation, Content Organization, Activity, SCO, and Asset. Each metadata definition is associated with a MID.

5. The Content Object Registry then store the physical multimedia objects for the learning contents in the Content Server.
6. The Content Object Registry modifies the URL stored in the Local Handel System. The URL is incorporated with the address of the Content Server.
7. The Content Object Registry then stores the metadata in the Master Content Catalog, and update the association between the OID and MID in the Content Object Registry.

The distribute architecture illustrated in Figure 7 involved 4 service programs. However, it is not necessary to install all of these programs in different computers. For instance, except the Content Server, the rest services can be installed in the same computer.

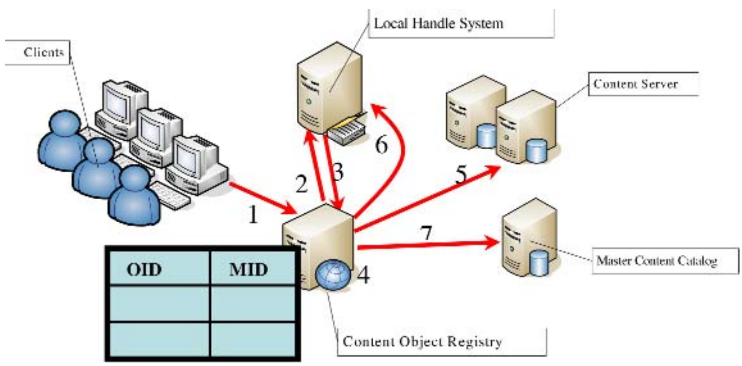

Fig. 7. Procedure and Architecture for Registering a Leaning Object

- **Searching for a Learning Object.** After a learning object is registered in the MINE Registry, the object can be searched and reused by others. Figure 8 illustrates the procedure. A Global Handle System is included and multiple instances of Local Handle Systems can be used. At the time this article is written, a standard global repository is not available. Thus, we implement an emulation of such a system, which contains basic functions such as its communication to a Local Handle System. On important issue is, if the standard global repository becomes available, the Local Handle System should have only a minimal change.

  Similar to registering a learning object, searching for existing objects takes several steps:

1. The Client Computer sends searching criteria to the Master Content Catalog. The criteria should include sufficient metadata.
2. he Master Content Catalog finds one or more objects with matching metadata, and passed the Metadata ID to Content Object Registry.
3. The Content Object Registry finds the associated OID for each MID and pass the OID to the Client Computer.
4. The Client Computer selects the learning objects to be downloaded by providing the OID to the Global Handle System, which finds the physical URL of the object.

5. The Global Handle System uses the Handle ID (part of the OID) and uses a naming authority (provided by the CNRI) to find the Local Handle System.
6. The Local Handle System finds the physical URL of the learning object and passes it to the Client Computer.
7. The Client Computer downloads the learning object from the Content Server according to the URL. The client computer here is not necessary the same as those discussed in the registering procedure.

Note that, the authors in the client computer need to provide detailed metadata as a searching specification. Thus, the Metadata Wizard can be used to fill in additional elements not provided by the author. However, the automatic fill in process should be limited to inference rules and interactive questions. User profile information and system dependent information should not be generated in the searching criteria. This approach will broaden the searching range.

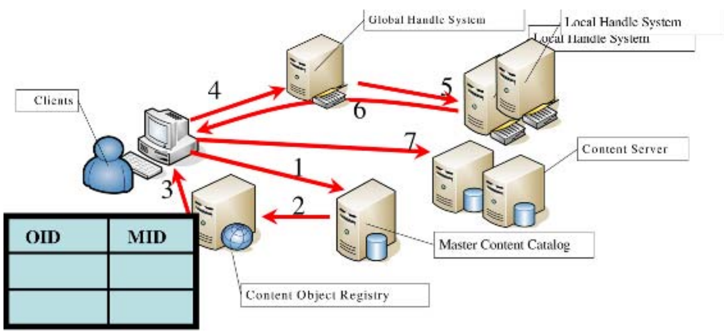

Fig. 8. Procedure and Architecture for Leaning Object Discovery

4 Conclusions and Future Work

Reusability is one of the most important issues in the area of object-oriented computing and database systems. An essential strategy is to provide a mechanism that will help any end users to find objects which can be reused. In distance learning, this strategy is particular important since the sharing of course materials will lower the cost and time of creating high quality learning contents. In most distance learning programs, building high quality course materials is considered as the most effective strategy toward the success of the programs. Thus, the construction of a federal searching and sharing architecture is particular important for distance learning.

The article presents a solution based on IEEE LOM and CORDRA. Firstly, we propose a mechanism to generate tedious metadata elements to reduce the load of a content creator. By using user profiles, interactive questions, system extracted information, and influence rules, our Metadata Wizard is able to assist the person who creates learning objects to provide tedious metadata, which can increase the accuracy while the created learning objects are searched for reuse. We then discuss a distributed architecture as well as its procedures for registering and searching learning objects, based on a specification, known as CORDRA. The architecture provides a way for global users to search for learning objects via a common infrastructure and a generic naming space. The Metadata Wizard is implemented. The MINE Registry is partially implemented, since the construction of a federal repository is not yet completed. In the next version of our systems, we will incorporate the changes of CORDRA definitions as well as the federal repository, to provide a solution for learning object reuse.

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INFERS: An Infrastructure for Experience Record in Smart Spaces

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Abstract. The experience record in smart space is an useful service for education activities, either for the purpose of course review or multimedia courseware creation. In this paper, we present the concept of collaborative experience record according to the new feature of pervasive computing paradigm. A supporting platform is implemented to enable the rapid prototyping of experience record applications in smart space. A group of common functions for experience record are contained in the platform and can be directly used in the application. Standard interfaces are also provided to evolve the information sensoring services in smart space so that they can cooperate with experience record application at runtime. We have prototyped an augmented classroom application based on this platform and user study results are also presented in the paper.

Keywords: Smart Space, Experience Record, Supporting Platform, Live Courseware Creation.

1 Introduction

The aim of pervasive computing paradigm is the transparent integration of technology in the physical environment so as to remove the barriers prohibiting the efficient use of such information services. Smart space is a typical testbed to explore the various techniques relating to this paradigm. With the abundant information services embedded in smart space, future educational activities can be substantially augmented. Experience record, as one thrust of smart space, is an important service in future learning environment since the captured record of live classroom experiences can be employed either for course review or courseware creation.

There has been a considerable amount of work focusing on the experience record in smart space, such as classroom capture 123 or meeting room capture45. However, a major drawback is the lack of reusability of their systems. Closely related to some specific application environment, these works turned to be ad hoc solutions to specific environments. Although it is widely believed that the underlying barriers that hinder the reusability of experience record applications, such the difference in hardware and software or application modes, are not likely to be eliminated in the near future, part of the functional modules are common in different applications. In such modules can be encapsulated in an underlying platform which provides standard interfaces to develop the application-specific modules, the prototyping of experience record application in smart space can be much more efficient.

W. Liu, Q. Li, and R.W.H. Lau (Eds.): ICWL 2006, LNCS 4181, pp. 215 – 226, 2006.

Besides, the unique features of smart space which are likely to effect the experience record are hardly explored in previous works. Thus previous works are not very adaptive or compatible to the smart space environment.

In this paper, we discuss the principles unique to smart space that govern the design of experience record applications, which has led to the concept of collaborative experience record. Based on this concept, a supporting platform, INFERS (**IN**frastructure **F**or **E**xperience **R**ecord **S**ystem) is implemented to enable the rapid prototyping of experience record applications in different smart space environments. To testify the usability of the platform, a classroom application is implemented on the platform as a prototype.

The paper is organized as follows: in section 2 we present a brief introduction of smart space and its unique features that are likely to effect the design of experience record application; the concept of collaborative experience record is discussed in section 3. The implementation details of INFERS are presented in section 4. Section 5 demonstrates the classroom application developed on the INFERS platform and a user study to this prototype is discussed in section 6. Finally, section 7 concludes the paper and outlines the future work.

2 Smart Space

Smart spaces are working 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 computers6. In smart space, the information world is seamlessly integrated with the physical world, where humans can interact with machines through natural, multi-modal interfaces and are served by the information services proactively.

Thus, the pervasive computing paradigm in smart space has brought many new features to the design of experience record applications, including:

- Distributed processing. The information devices are distributed and connected by network and should be coordinated and synchronized.
- Dynamicity and mobility. The environment is highly dynamic: the number and property of information services involved in the experience record may change from time to time and mobile devices are free to join or leave the session at any time.
- Rich sensing services. The seamlessly integration of the information world and physical world require the sensing of human activities by the machine. Multifarious sensoring devices, such as microphone array, location tracker and touchable whiteboard, are thus embedded in smart space. These services can be leveraged by experience record application to capture the information of the live experience.
- Unobtrusiveness. The applications running in smart space should require the minimum of user attention and the services should be provided proactively.

With the above features in mind, we believe the previous design mode of experience record applications are not appropriate to be employed in smart space, especially in terms of mobility support and leverage of the rich sensing devices in smart space, triggering the concept of collaborative experience record.

3 Collaborative Experience Record

Previous experience record applications145789 are mostly designed in stand-alone mode: they are functionally closed and all modules are self-contained, having little or no interoperation with external services at runtime. Stand-alone applications tend to be ad hoc solutions since some of the functions are heavily dependent on the application environment. One example is the data capturing module where the data type and hardware setup must be clearly defined prior to development. When the environment changes, the experience record applications following the stand-alone mode can not adapt to the evolution.

In order to solve the problem, K. Truong et al. in 10 proposed the idea of INCA, an infrastructure for experience capture and access. INCA contains a set of abstractions of the common functions in experience record application and systems can be developed by inheriting the abstract JAVA classes provided by INCA. This idea materially aids the development of experience record applications.

However, if common functions are provided in the form of directly usable modules instead of JAVA classes, the application implementation can be even more efficient. Besides, the rich sensoring services in smart space can also be leveraged by experience record application. These two considerations have informed the concept of collaborative experience record, which emphasize the loosely-coupled cooperation between record application and sensoring services in smart space at runtime. The sensoring services are not necessarily dedicated to experience record For instance, location tracking does not only provide user location data to experience record, but may also be used for other purposes such as context-aware computing and user preference mining. These services, termed as external friend entities, can be employed to provide the functions that are specific to different environments.

Based on the concept of collaborative experience record, we can implement a supporting platform to contain the common modules that will be used across different environments. The supporting platform will also rely on the external friend modules

	Live Record	Access
Application Data Layer	**Capture**	**Storage Access**
Coordination Layer	**Coordination**	
Transmission Layer	**Communication**	

Fig. 1. Layered model and function modules for experience record applications

to minimize the development efforts needed in a specific environment. To put this idea into reality, further investigations are required to clarify the modules and their interrelations. A three layered functional model is thus proposed as in Figure 1.

As we can see, the modules in an experience record application can be divided into five classes: capture, coordination, communication, storage and access. They can be organized in a matrix-like structure according to the function reliance and temporal stages. From Figure 1 we have the following observations. Firstly, only the capture module is directly related to the application data and internally unreusable. Secondly, the data flow is from top to bottom (functional direction) and from left to right (temporal direction) and module functions will only be called by modules in upper layer, e.g., the functions in coordination layer will only be called by modules in application data layer but not by those in transmission layer. In light of these observations, we have the conclusion that all the modules, except the capture module, can be implemented as common solutions in a supporting platform, provided that the data flow has a standard format.

4 INFERS

In this section, we will discuss the mechanisms adopted by the platform design. INFERS adopts multi-agent and is implemented on the Smart Platform1112, a software infrastructure for smart space. To build the supporting platform on the software infrastructure of smart space will facilitate a better interoperation between the experience record application and other smart space services. All the modules involved in experience record at runtime are encapsulated as agents to realize the loose-couple design principle. Figure 2 illustrates the overall architecture for experience record applications built on INFERS, and external friend entities are represented by gray rectangles.

The agents in live experience record can be divided into source agent and sink agent. Source agents function as the data capturing clients, while the server-like sink

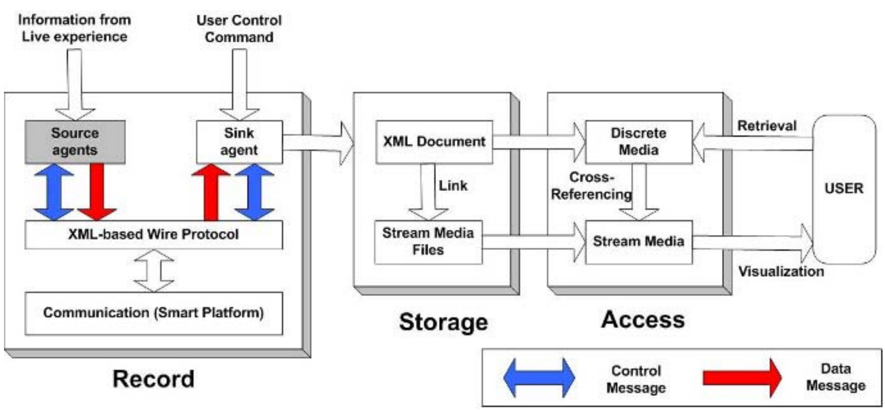

Fig. 2. Overall architecture for applications built on INFERS

agent gathers the data and submit them to persistent storage. To simplify the structure, coordination function is also implemented in the sink agent. Besides the external friend entities, some reusable source agents are also implemented in INFERS, including video/audio capture and computer screen capture.

4.1 Coordination Mechanism

Messages are leveraged for coordination in INFERS and four types of control message are used as shown in Figure 3. Source agents subscribe messages published by the sink agent, and vice versa. The following part describes this mechanism in detail.

After the record is started, the sink agent keeps a timer and at each timeout publishes a <RecordStart> message containing the session information to all agents through multicast. When a source agent receives this message for the first time and decides its data are to be recorded, it publishes a <RecordStartAck> message, which contains the metadata of the source agent, as a reply to register itself at the sink agent, which maintain a list of the registered source agents. When record is stopped in the end, the sink agent will again publish a <RecordStop> message. On receiving this message, the source agent checks whether all the data that are to be recorded have been successfully transmitted to the sink agent. If so, it will reply to the sink agent with a <RecordStopAck> message telling it is ready to quit. The sink agent will keep a timer after publishing the <RecordStop> message and continue gathering the data, until all registered source agents have reported ready to quit or timeout occurs.

As the <RecordStart> message is continuously published, a source agent dynamically joining the session sometime after it begins will also receive a <RecordStart> message. The offset information (it informs how long the record has lasted) contained in the message content enables the data generated by this latecomer

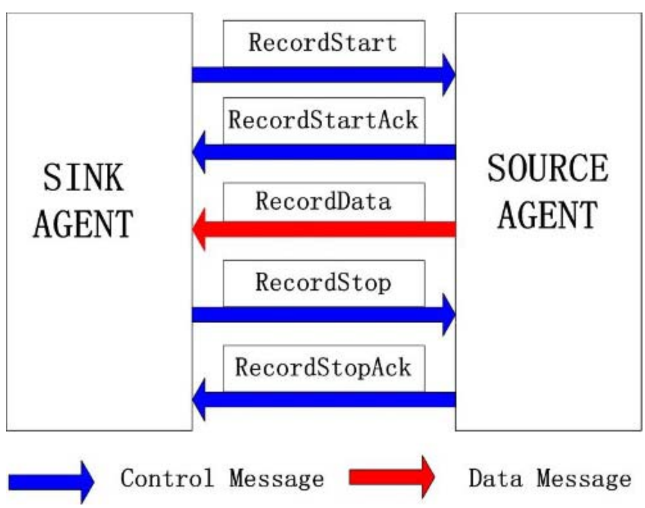

Fig. 3. Hand-shake negotiation and the message exchange

to be synchronized with other existing media. Similarly a source agent can leave before the record is stopped by actively publishing a <RecordStopAck>. Through such a hand-shake negotiation, INFERS can support the unpredicted changes during the live experience, allowing the mobile users to join, participate freely in a highly dynamic fashion.

4.2 Data Modalities

The captured information can be stored in two data modalities: stream media and discrete media. Stream media is a continuous, unstructural form of media, such as video and audio. Discrete media is comprised of structured units, each of which can independently express a semantic meaning, like a multimedia document.

The same information can be represented by both data modalities. For instance, a slide presentation can be captured either as a video clip, or a XML document containing the URLs of the slides. Hence there exists a choice on which media type should be used to present the captured information. Considering the one principle mentioned in last section that data flow should follow a standard format, we argue that stream media be used to visualize the recorded experience and discrete media be used for retrieval. This is because:

- For the purpose of experience rendering, stream media has relatively standard formats like MPEG or AVI. Discrete media is high diversified and there is no standard format or interface to render the discrete media. Thus, stream media should be leveraged for experience rendering to maintain standardization.
- Stream media is more comprehensive and coherent, containing the context information around the important points during live experiences. For instance, from a video showing how a decision is made, we can probably see the reaction of the participants to the decision through their facial expressions. However, discrete media is usually captured without saving the context information.
- A traditional disadvantage discouraging designers from leveraging stream media is its large size. However, this concern is becoming increasingly trivial with the rapid development in data compression and hardware facilities,. For example, while using the TSCC free trial version as the compressor to capture the computer screen displaying presentation slides, the bit rate of the generated video is about 13kbps, meaning that the video file which can visualize the slides of a one-hour presentation will be around 6MB in size.
- While stream media is suitable as the visualization approach, discrete media is ideal for indexing, retrieval and summarization because the structured semantic can be understood and processed by computers.

Due to these reasons, users should retrieve the desired information through discrete media and the retrieval result is used for cross-referencing into stream media based on the temporal synchronization. The indexed clips of stream media will present the information to the user. The interoperations between them are illustrated in Figure 4.

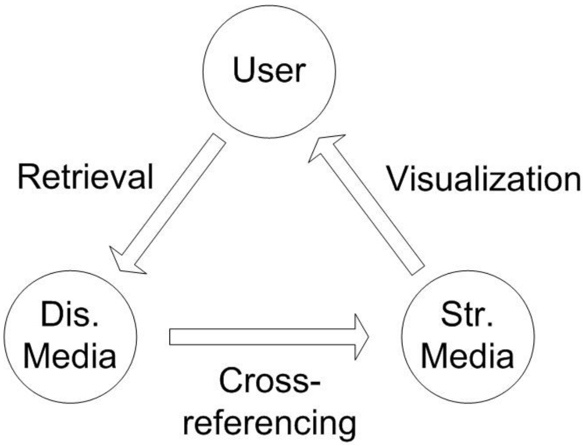

Fig. 4. User, discrete media, stream media and their interoperation

4.3 Communication and Storage

Communication mechanisms in INFERS are provided by Smart Platform, which supports three mechanisms: message transmission, streaming transmission and bulk transmission.

Corresponding to the two data modalities, the communication and storage also adopts two different mechanisms, respectively. Stream media is transmitted to sink agent by bulk transmission which is implemented on the FTP protocol.

```
<Event>
<User>Mike</User>
<Action>annotate</Action>
<Object>Ontology.ppt</Object>
<Begin>41</Begin>
<End>46</End>
<Location>Room527:iBoard</Location>
</Event>
```

Fig. 5. The XML content of an event

Discrete media, mainly the information of meaningful events captured by external friend entities, are sent in <RecordData> messages via XML-based wire protocol. Since the external friendly entities are involved, the data format should be standard, extensible and flexible. Therefore we use the communication service provided by the infrastructure of smart space and the plain-text XML structure as the format. While transmitting event information, source agents generate a XML element containing the information and convert it into binary bytes using XML-based wire protocol. These binary bytes are transmitted as the content of <RecordData> messages and parsed at the sink agent using the same protocol to extract the semantic information of the event. Figure 5 is the XML content of an event.

Similarly, XML is used in INFERS to store live experiences. Each session is represented as a single XML document conforming to a specific schema and an excerpt is shown in Figure 6. XML documents are stored in Berkeley DB XML.

```
<Session version="1.0">
    <Context>
      <Duration>2503</Duration>
     ….
      <SessionName>GroupMeeting2</SessionName>
    </Context>
    <Streams>
       <Stream Src=”D:\video files\2005_12_22_OverviewVideo.avi” Name=”OverviewVideo” />
      …
      <Stream Src=”D:\video files\2005_12_22_13_45_27_eMapVideo.avi” Name=”eMapVideo” />
    </Streams>
    <Events>
       <Event   EventID="0" User="Shi” Action="talk" Object="Schedule" Begin="5" End="17"/>
       <Event EventID="1" User="Chen" Action="openDoc" Object="Ontology.ppt" Begin="36"
End="38"/>
      …
      <Event EventID="4" User="Li" Action="talk" Object="N/A" Begin="99" End="107"/>
       <Event EventID="5" User="Jiang" Action="talk" Object="OWL language" Begin="111"
End="132"/>
    </Events>
</Session>
```

Fig. 6. An excerpt of the record document

The document root contains three child elements: context, streams and events. <Context> element contains the general information about the live experience, including time, place, users involved and the main subject (if there is one) etc, to provide an overview of the recorded experience.

<Streams> element represents links to external media files relating the stream media and the metadata about the stream media. Each of its children, the <Stream> element, is related to one data stream.

The <Events> element represents the discrete media to describe meaningful events which will be used as indices. Each of its children, the <Event> element, contains the semantic information of an event in five dimensions: time, location, user, action and object.

4.4 Access Interface

INFERS provides an access interface, shown in Figure 7, for users to efficiently visit the records. In Figure 7, the left-most window lists all the record documents stored in the database. Two time windows are placed in the upper part: the upper window demonstrates all indexing events in the live experience record as blue icons (the selected event will turn red). The lower window is scaled to present the events in a specific period corresponding to the slider position of the slide bar below, so that users can accurately manipulate the icons. The three windows in the middle are used to render the stream media. By clicking on the window, user can watch the video content in a much larger pop-up window. The three windows in the lower-most part are for retrieval purpose. The left one demonstrates the semantic information contained in the selected event. The middle one lists all the previously stored retrieval queries and the results are displayed in the right-most window.

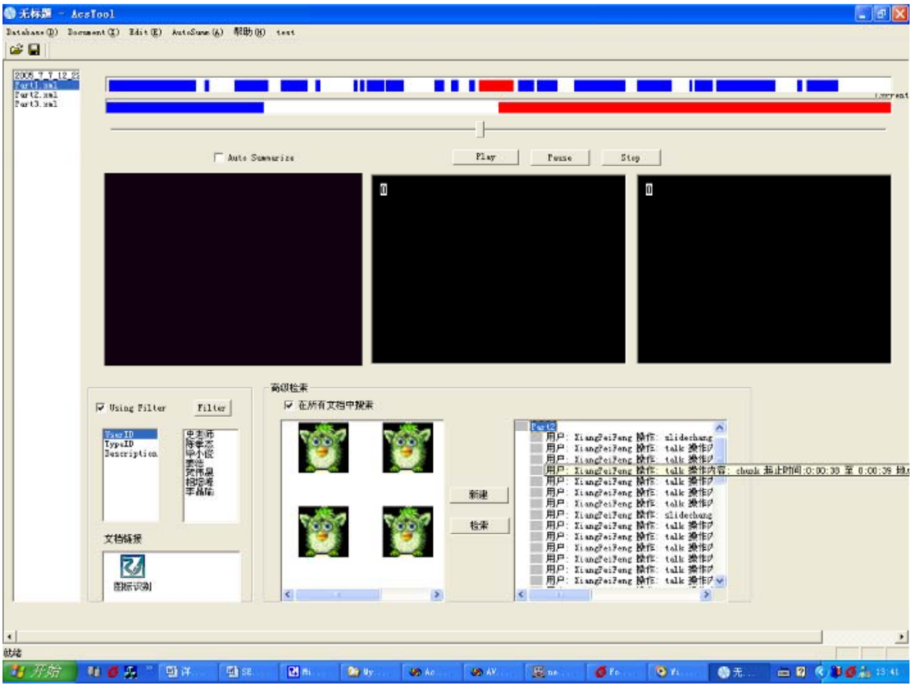

Fig. 7. A snapshot of the access interface

The playback of the record can be sequential as traditional video ad controlled by the slide bar. It also can be fast-forward to rewind to a specific position by the icons in the time window or the entries in the retrieval result window. Thus, users can have flexible methods to access the information.

To further improve the access efficiency, we have also implemented in INFERS an information model for semantic retrieval and an auto-summarization algorithm. Since details of the information model and summarization algorithm are already discussed in other papers1314, we just give some brief introductions here.

The information model has four components: primitive ontology, query expression model, archive expression model and query processor. The primitive ontology, which uses OWL DL 15 language to describe the basic semantic primitives in the application scenario and their interrelations, is the foundation of semantic reasoning in the retrieval. Semantic queries are formalized by the query expression model through SQL-like syntax and can be defined in wizard-like interface. The query expression model structurally stores and expresses the experience information, just as what is described in section 4.3. The query processor matches the user query and experience information formalized by query expression model and archive expression model. A reference engine, the core of the query processor, will make necessary semantic reasoning in the matching process.

The summarization algorithm is based on the previous user access patterns. A statistical model is leveraged to analyze the pattern data to predict the user interests and pick up the important segments accordingly. This algorithm has two advantages: no priori knowledge is required so that it can be used as a common solution in different application environments; the analysis is conducted in a personalized manner so different users can be served with summaries tailored to their own needs.

5 Prototype: Augmented Classroom

Based on the INFERS platform, we have implemented a classroom prototype. This prototype is an augmented version of our previous Smart Classroom 2project. More multi-modal interfaces, which can function as the external friend modules, are embedded in the prototype, including:

- RFID-based Location tracker. The tracker can report location events such as user entering or leaving the classroom. When the tracker detects that a teacher enters, it will publish a control message to start the experience record.
- Microphone Array. The microphone array can detect the events of user speech and keywords contained in the speech. When combined with the location tracker, the identity of the current speaker can be derived (the speaker location detected by microphone array can be matched to the user location data).
- Touchable display. User can open documents and annotate on the display. Predefined icons can be recognized online. All these data recorded.
- Interaction with remote students. Remote students can use either desktop computer or PDA to access the augmented classroom. The access information, including login, logout and interactions with local users are recognized by the software module.

All these modules are established on Smart Platform and encapsulated as agents. Thus, the efforts to evolve them into external friend modules are generally easy. The Smart Platform SDK provides an abstract CAgent class, available both in C++ and Java, for the encapsulation. The necessary operations include instantiating a CAgent object, calling its Register() method at the beginning and Quit() method in the end. About twenty lines of code are added to realize the communication function of external friendly modules.

Other modules involved in experience record, including coordination, communication, storage and access, are contained in the supporting platform and can be directly leveraged in the prototype application. The augmented classroom prototype is then employed to generate multimedia courseware through experience record in authentic environment for some courses.

6 User Study

To testify the usability of the prototype system, a user study was conducted after its authentic use in a course of our department. About 160 undergraduates from our department are involved in the course. Among them, 20 students participated in the live classroom and the rest 140 students used the courseware created through live experience record to conduct self-study. After the class, we distributed questionnaires to the students and asked them if they agreed that the courseware created through experience record were significantly better than the traditional courseware like PowerPoint or HTML. Scores were ranged from 5 to 1, corresponding to "strongly agree", "agree", "neutral", "disagree" and "strongly disagree", respectively.

The average score was 3.7025, which was interpreted as a slight preference for the live-experience-based courseware. The result was out of our expectation since we believed this courseware was apparently more vivid and attractive. To find the reason, we investigate the comments given by the students whose rating was 1 or 2. They mainly complained that the courseware, although powerful and comprehensive, was not easy to use. They had to first install the access interface, then download the courseware and finally learn to manipulate the interface. These requirements greatly discourage the access to the courseware. From this point, we can conclude that the interface should be friendly enough to be accepted by the users. For instance, if the interface can be evolved as controls that are embedded in websites, then it will be much easier for students to access the information since no downloading or installation efforts are needed.

Some major positive comments are as follows:

- Compared with traditional education video, the record of real classroom experience is much more attractive. For instance, when the teacher raises a question, I will reflect by myself, wait for the answer given by other students and compare it with mine. Then I will listen to the teacher's explanation and this process is very impressive.
- I can tailor the lecture to my own needs. I can skip the unimportant part and focus on the difficult questions. I do not have to get up early and still can enjoy the real classroom experience.
- The new mode is not as efficient as ordinary classes since we need some time to adapt to it. But gradually students will accept the new mode. The blackboard data are very useful. In ordinary classroom it is sometimes difficult to watch the blackboard clearly since the classroom is too big. Now I can definitely have a very clear view!

From these comments, we can see that the live-experience-based courseware is advantageous in bringing more reality and comprehensive content. If the problem in user-friendliness can be solved, it is likely to be welcomed by users. Besides, once the experience record system has been mounted, this method is much more cost-effective since no extra effort is needed.

7 Conclusions and Future Work

In this paper, we present our work on a supporting platform for experience record applications in smart space. The supporting platform is the outcome of the collaborative experience record concept, which is proposed so that such applications can comply with the pervasive computing paradigm in smart space. A group of common function modules are implemented in the platform. Interfaces to evolve application-specific modules are also provided.

Given the lessons we have learnt from the user study, our primary focus will be to evolve the access interface so that users will not be discouraged due to the extra efforts needed to access the courseware.

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Decreasing the Stratification Influence to Students' Learning Communities by Asynchronous Learning

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Abstract. In order to explore the effect of the school environment and students' individual characteristics to their virtual learning communities, this study conducts an experiment to observe two groups of students – one from an academic university and the other from a technical institute – taught by the same teacher under the same course and the same online learning system. Findings indicated that: (1) the categorization of higher education institutions in Taiwan indeed created a "differentiating" effect; (2) Both in traditional classroom settings and an asynchronous online learning environment, recognition of school environment and students' characteristics do affect how learning communities are formed; (3) In similar learning environments, an asynchronous online learning environment will lower the impact of the school environment and students' characteristics on interactive models of learning communities, thereby narrowing the gap between dominant and fringe groups.

Keywords: Asynchronous online learning, Learning Community, Students' Characteristics.

1 Introduction

To have the development of higher education institutes meet social needs, the institutes were divided into categories [14]. According to past research outcomes on educational policies, such categorization policy will lead to the result of "division of stratification". Vocational high school students choose technical institutions after graduation. It is implied that they are inferior and should lower their own expectations and career ambitions [6]. Today, information technology creates a new learning environment where rich teaching materials presented through multimedia will break the barriers of substantial space so that students from different schools can have the same course and engage in discussions together in the same virtual classroom [12]. On top of which, schools that do not perform as well may take thus chance to increase their competitiveness [11]. Yet, thanks to the facts such as different teaching goals, administration environment, student characteristics, etc, composition and operation of learning communities were affected directly or indirectly [11], affecting the learning

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performances. So, this study tries to verify the influences to composition and operation of learning community brought by comparing differences of school environment and the individual differences of students with an experiment method both in traditional face-to-face (hereafter referred to as F2F) and asynchronous distance learning (hereafter referred to as ALN) environments.

2 Literature Review

2.1 Interaction Factors That Instigate Online Learning

Swan [17] concluded four relationships between interaction and learning effectiveness in the online environment: (1) Interaction with content: Online learning and discussions are more supportive of students' divergent thinking. They can use forums and open-ended questions to explore multiple perspectives of the problems. (2) Interaction with instructors: The quality and quantity of instructors' interaction with students play a key factor in student learning effectiveness. (3) Interaction with peers: For students, online learning is particularly effective as it engenders a sense of social community and peer support. Activities should be designed to encourage the development of learning communities. (4) Interaction with interface: Interaction factors such as ease of use, avoidance of redundancy, and so on, affect the development of virtual communities [6]. To conclude, factors influencing online learning environment interaction include learner (student), teacher, course design, learning environment, interaction between classmates, etc., and all are affected by the overall goal of the educational institution, which is based on a nation's education policy.

2.2 Interaction Factors Resulting from Stratification of Higher Education: Difference in School Environment and Individual Characteristics

Institutions of higher education usually evolve in relation to a society's job demand, and were classified into four categories: The first two are the major categories; general universities aimed at academic research and technical institutes teaching applied science and skills, contained 90% or above. Categorization of higher education institutions is, in reality, differentiating them into different rankings. Some students were able to enroll in public high schools or universities – the widely acknowledged "golden road" to academic success; other students, like those attending private technical institutes are regarded by society as lower in status and ability and therefore discouraged from pursuing educational or professional goals [5]. Therefore, in the traditional academic environment, the difference between the two types of schools and their student characteristics clearly affects how students learn during their university education.

2.3 Interaction Between Learners and the Class Process

Teachers apply different teaching strategies throughout the interaction process. Similarly, students will apply different learning strategies in response to different teaching strategies initiated by different teachers. Different courses under the influence of these strategies will create different learning cultures so that classes with the same course design may generate different outcomes [2]. For example, cooperative learning has been found to have positive effects on students' achievement [17]. But researchers have argued over which learning environment, whether it be the F2F or ALN classroom, that would be more favorable for collaborative learning. Some authors argued that the face-to-face groups' verbal and nonverbal communication and social exchange produce emotional connections that are hard to achieve in an ALN classroom [3, 13]. Others argue that characteristics of availability, autonomy and anonymous of online learning supported the collaborative learning in sharing knowledge [4]. Empirical study even found no significant difference in perceived social presence, cooperation and satisfaction between F2F and ALN participants [13].

Social presence is a perceptual dimension, influenced by the type of media used, by personal characteristics, and by the context in which the communication occurs [17]. Aside from teachers and physical or virtual classroom settings, the background of students themselves may also affect the pupils' willingness to learn. Mainstream academic institutions tend to have a higher percentage of students who come from wealthy upper class families than those from a lower class background [5]. This indicated that economic and educational status of the parents will affect their children's learning outcomes – a sign of inequality in educational and social status.

2.4 The Diamond Model of Learning Effectiveness Improvement

In this study, we take the Michael Porter competitive advantage of nations Diamond model [15] to figure out the four relationships between interaction and learning of learning effectiveness improvement within online learning (Fig 1). It means that the iterative interactions will accelerate learning effectiveness which will improve the competition competent of whole learning organization. The educational institutes can apply the new technology – e-learning to have more comparative advantage. In order to imitate the environment of students' community in this study, we controlled the variables: teachers, course design and the on-line learning system. Therefore it can more clearly review how students under different systems of higher education react

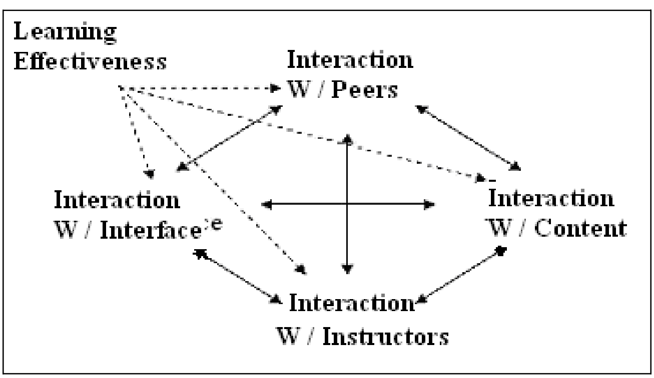

Fig. 1. Diamond Model – Interaction and Learning in Online Environment

within learning communities created in the F2F and ALN environment. Since the composition and operation of learning communities will affect learning effectiveness [18], we try to understand the influence of stratification of higher education on learning communities instead of learning effectiveness in the study. After controlling those variables, our research framework is transformed into Fig 2.

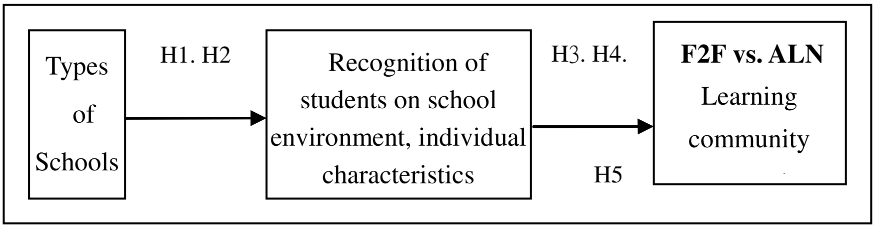

Fig. 2. Causal Model of Decreasing stratification by ALN

According to the above literature reviews, we predicted hypotheses as follows below:

H1: There exist significant differences in school environment recognition between students at research universities and students at technology institutes.
H2: There exist significant differences in individual characteristics between students at research universities and students at technology institutes.
H3: There exist significant effects of school environment recognition and individual characteristics to the connectedness and learning of a learning community in the F2F environment.
H4: There exist significant effects of school environment recognition and individual characteristics to the connectedness and learning of a learning community in the ALN environment.
H5: There exist differences in the connectedness and learning of a learning community between the ALN and F2F environments.

3 Experimental Design

3.1 Focus Group and Experiment Conduct

The study uses students from one research university (hereafter referred to as C) and one technical college (hereafter referred to as T) to be observed. The number of students selecting the course at C is 116 and the total number of students selecting the course at T is 96. The time and duration of experiment is the first semester of 2003 with the courses of Introduction to Computer Science. The courses adopt the two-stage teaching method. To foster the adaptability of the students to online learning, the first stage of the course is to have the same professors teaching basic theory in the traditional F2F method with introduction of online materials to help the students learn. At the second stage, the students were divided into groups for theme exploration and make projects in the ALN classroom. Both schools use the same on-line learning system. After the completion of the first stage and the second stage course, the students were required to fill out surveys in both the 7th and 15th weeks.

3.2 System Structure and Usage in ALN Classroom

The adequate use of a collaborative learning setting that is centred on: student, knowledge, assessment, and community, contribute to the learning quality [8]. In order to support collaborative learning, increase communication, and help the community development, we choose XOOPs as ALN system. It provided strong functions on developing a small to large dynamic community on the web, accessing intra-course content portals, referencing extracurricular resources and so on. All students in the experiment were in one virtual classroom grouped into different project teams. The group members came from the same university. The web site is http://eln.creativity.edu.tw/jeanyu. The key features on usage based on the design instruction are listed as follows [8]:

(1) Database-driven course materials: The knowledge-centred design indicated that the curriculum is only partially fixed and result from a negotiation process between the learners and instructional agents [8]. The instructor can store all teaching materials conveniently in folders. Students could browse, search and download them easily. Students used ftp to share their task with classmates or turn in homework to the teacher in the ALN environment.
(2) Fully modularized user management: Assessment centred design meant that reflection was the basic philosophy of learning and instruction [8]. The system manager (instructor) could choose and arrange the modules, such as to set criteria for group members, to send e-mails or messages, and to facilitate collaborative learning.
(3) WWW supported: Student-centred design meant that students controlled more of his/her learning process [8]. Extracurricular resources on the internet could be easily linked into the teaching materials or text communications among colleagues.
(4) Flexible discussions forum arrangement: Community-centred design shows that technology can drastically alter the social structure of schools [8]. The functions on the forums not only supported team collaboration, but also could secure team workspaces and private discussion. All students in the experiment, no matter which university they attended, were allowed to browse all forums but only allowed to post in their own group forum.
(5) Multimedia supported: For sharing ideas or information efficiently amongst project community members, the system provided multimedia document views, such as graphical or video.

3.3 Questionnaire Design

The questionnaire is divided into two major parts as follows:

(1) Individual characteristics and their recognitions of school learning and administrative environment. Between 2001 and 2003, 185,000 freshmen and seniors

in 649 universities and colleges used NSSE questionnaires to assess the control variable of student engagement [10]. There were originally fifty-seven questions with nine that were irrelevant to this study omitted. Construct validity can be examined through part-whole correlation [9]. The validity of the measurement was indicated as acceptable. The reliability, Cronbach α, were .86、.91、.90、.72、.75、and .73.
(2) Assessment on the development of learning community. Rovai tested and verified the reliability and validity from 375 students in 28 courses with the purpose of assessing the development of the virtual community. The development of the virtual community refers to all the perception and descriptions of the students on the collaborative learning among members [16]. The questionnaire has twenty questions. The concept of a learning community contains two constructs: (1) Connectedness: mutual dependence, trust among members, and the inquisitive spirit of the learning community. (2) Learning: mutual collaborative learning and constructing knowledge to reach the academic goals. Construct validity can be examined through part-whole correlation [9]. All items, except item 14, indicated that the validity of the measurement was acceptable. The reliability, Cronbach α, were .78 and .75.

4 Experimental Design

4.1 School Environment and Individual Characteristics

The Chi-square Test was used to test and verify the differences of the students at two schools on school learning and administrative environment and individual characteristics (Table 1). Please refer to the following explanations:

(1) School learning and administration environment
Factor **I1** refers to the emphasis of students on academic activities. Factor **I2** refers to the support provided by the schools on the development of knowledge, skills, and personal development of the students. Factor **I3** refers to the students' recognition of the overall environment of the school. The analyses verify that "**H1" is valid** (Table 1). There are significant differences between the students at the two schools on "schools providing support of knowledge, skills, personal development, and academic research." They are very different in the participation of learning activities and show major differences on their understanding of overall school learning and administrative environment.
(2)Career plans, time management and personal characteristics of the students
Factor **P1** identifies students' career plans. This set of questions with statistics (Table 1) shows that students from C had significantly clearer career planning than those from T. Factor **P2** focuses on time management in a seven-day week. The results show that students of the two schools demonstrate significant differences in terms of time spent on two jobs -- course preparation and extracurricular activities. Factor **P3-1** refers to other education the students received prior to entering college. Under the education system in Taiwan, most high school graduates choose four-year universities while those from vocational high schools go to universities in the vocational system. **P3-2** refers to the academic achievement up to now. C is definitely a school that high school students with good grades want to attend. **P3-3** refers to the methods of going to school. C is a famous national university. Students will try their best to find a place

to live near the school. On the other hand, students at T tend to find one close to home. P3-4, 5 refers to the educational attainment of their parents. The ratio of above colleges at T and C is significantly different. The verification on hypothesis 2 shows that "**H2" is valid**. The two schools show significant differences in all questions regarding individual characteristics, showing the obvious differences of the source and background of the students.

Table 1. Differences of Individual Characters of Students and School Environment

Individual Characters and School Environment		P
I1	Spending significant amount of time studying and on academic work	0.002**
	Providing the support you need to help you succeed academically	0.003**
	Attending campus events and activities	0.000**
I2	Acquiring abroad general education	0.000**
	Acquiring job or working-related knowledge and skills	0.000**
	Writing clearly and effectively	0.033*
	Speaking clearly and effectively	0.001**
	Thinking critically and analytically	0.000**
	Working effectively with others	0.000**
	Learning effectively on your own	0.000**
	Understanding yourself	0.012*
	Solving complex real-world problems	0.007**
	Developing a personal code of values and ethics	0.000**
I3	Evaluate overall quality of academic advising you have received	0.000**
	Evaluate your entire educational experience at this institution?	0.000**
	If you start over again, would you go to the same institution?	0.000**
P1	Practicum, internship, field experience, co-op experience	0.000**
	Foreign language coursework	0.000**
	Study abroad	0.000**
	Culminating senior experience	0.002**
P2	Preparing for class	0.000**
	Participating in co-curricular activities	0.000**
P3	Which types of schools have you attended other than the one you are attending now?	0.000**
	What have most your grades been up to now at this institution?	0.000**
	Where you are living now while attending college?	0.000**
	What is the highest level of education of your father completed?	0.000**
	What is the highest level of education of your mother completed?	0.000**

**p<0.01

4.2 The Influences of School Environment and Individual Characteristics on the Development of Learning Community

The ANOVA is made with independent variables of six dimensions on "recognition of individual characteristics of students, school learning, and administrative environment" with significant results and with "connectedness" and "learning" as the dependent variables. From the results, we learnt that the overall model (Wilk's λ values) is significant, meaning that this model is proper. Which all the independent variables have significant differences in the overall results of "connectedness" and "learning" in the development of a learning community. (Table 2 and Table 3). Therefore, **"H3" and "H4" are valid**.

Table 2. Influence of the Effects of School-level Environment Perceptions and Personal Differences to Students' Learning Community At F2F Course

Factors of School-level Environment Perceptions and Personal Differences	Wilk 's λ	F	Learning Community (P)	
			Connectedness	Learning
I1. Institution emphasize academic activities	.020*	4789.624	—	.006**
I2. Institution contributed to your knowledge, skills, and personal development	.017*	5117.717	—	.002**
I3. Institution Entire Environment Evaluation	.021*	4445.909	—	—
P1. Personal plan to do before graduation	.021*	4508.083	—	—
P2. Personal time arrangement per week	.020*	4576.745	—	.002**
P3. Individual Characteristics	.022*	4419.377	—	—

**p<0.01, *p<0.05

Check the individual F values; they have significant influences on the sub-constructs of "learning." The significant differences show that the students at the two schools are different in mutual collaborative learning, sharing of values, and working together to construct the knowledge needed to reach learning goals and satisfy the needs of seeking new knowledge in the learning community. From the average, students at C score higher than those at T in this construct.

Table 3. Influence of the Effects of School-level Environment Perceptions and Personal Differences to Students' Learning Effectiveness At ALN Course

Factors of School-level Environment Perceptions and Personal Differences	Wilk 's λ	F	Learning Community (p)	
			Connectedness	Learning
I1. Institution emphasize academic activities	.027*	3402.675	—	.002**
I2. Institution contributed to your knowledge, skills, and personal development	.025*	3351.866	—	—
I3. Institution Entire Environment Evaluation	.028*	3385.124	—	—
P1. Personal plan to do before graduation	.028*	3304.662	—	—
P2. Personal time arrangement per week	.028*	3284.143	—	—
P3. Individual Characteristics	.030*	3222.957	—	—

**p<0.01, *p<0.05

4.3 The Difference Between F2F and ALN Environment at the Influences of School Environment and Individual Characteristics on the Development of Learning Community

Comparing the F values on Table 2 to Table 3, all F values on Table 3 were higher than those of Table 2. Only emphasis of students on academic activities (I1) has shown significant influence on collaborative learning (Table 3) in the ALN environment, the other two factors: support provided by the schools on the development of knowledge, (I2) and time management, (P2) had no significant influence on collaborative learning. It means that the influence of the school environment and individual characteristics to the development of learning community in ALN are smaller than in the F2F environment which shows that "**H5" is valid**.

5 Conclusion

5.1 The Categorization of Higher Education Institutions Indeed Created a "Differentiating" Effect

Education officials categorize Taiwan higher education institutions so that different institutions pursue different educational functions and goals. These institutions display a variety of size, academic level, student body, and funding sources. The Ministry of Education in Taiwan (hereafter referred to as MOE) hoped to break barriers set by social structures and provided equal opportunities for students regardless of race, class, and social group. Yet this categorization is actually applying methods of division and choice to affect the students' future. Our observation of how students of T viewed their institution's administrative quality and the school's ability to support their learning – including how much they believed the school valued academic events, how well they found the school to support their development in knowledge, skills, and character, and how they evaluated the school's overall environment – showed that they do not believe they received a better education from a technical institute under such differentiation.

A closer look at students' personal traits, including their career plans, time management, and personal background, found that pupils in T demonstrated unsatisfactory academic performance. They had a minimal sense of achievement in learning and therefore devoted much less time to studying compared to students of C. Their lack of self-confidence discouraged them from dreaming about, or planning for, the future. The education level of their parents is also lower than that of the parents of C students. As education level is closely connected to profession, it is predicted that T students come from families of lower social and economic status. Children whose parents are well educated and financially stable enjoy a better chance of entering public universities. Currently MOE provides a larger amount of funding to public universities than to private technical institutes. Whether the current system will create a vicious cycle that benefits the wealthy while putting the poor at a disadvantage is an issue in education worth looking into.

5.2 The School Environment and Individual Characteristics Do Have Effect on How Learning Communities Are Formed

No matter whether it was in ALN or F2F, recognition of school and students' differences was an important factor that came into play. Students with better recognition of school environment, including the emphasis of students on academic activities (I1), or the support provided by the schools on the development of knowledge, (I2) were better on collaborative learning in the F2F class. Students with better recognition on school emphasis of academic activities (I1) were better in collaborative learning in the ALN class. Students with better time management (P2) did better on collaborative learning in the F2F class. These results support the theory that students enrolled at different campuses would have the opportunities to extend their virtual social networks and share their knowledge and experience [4]. Literally speaking, the elements that may affect the development of learning community in higher education should include learning ability, motivation of the learners, class environment, and mutual effects among each element.

5.3 An ALN Environment Will Lower the Impact of the School's Environment and Personal Background on Learning Communities' Interactive Models, Thereby Narrowing the Gap Between Dominant and Fringe Groups

Tools of information technology exist for the purpose of connecting and integrating different social groups. Yet information technology did not put an end to social differentiation. Instead, it created new social stratifications through the change of social presence. Dominant and fringe groups are identified in the field of applying information gadgets and possessing information. Controlling the factors "instructor", "course design", and "online learning systems", we discovered that even though there are significant differences on the understanding of school environment and individual characteristics between students at the regular university and students in technical institutes, such differences had less influence on "development of virtual learning community" in the ALN environment than in F2F environment. The digital divide between educations of the two schools is demonstrated in their desire for informational hardware equipment and the inequality of how the two schools received and treated contents of their informational education programs. The result of this study hinted at a paradox in past researches on how the appliance of online technology widened the gap between the social interactive models of groups with digital divide, created by differences in ethnic groups, urban and rural environments, and social class. The main reason for this is that this study controlled these interaction factors by holding constant the instructor, course content, and online instruction interface. The two schools chosen by this study were both located in the same District Metropolitan online system. No digital divide linked to difference in capitalization of rural and urban areas or ethnic groups are found. Further examination of the two schools' information-based facilities found that aside from using the same internet system, both institutions offered computer labs. No student reported problems in their computer usage. Thus this study showed that ALN could lower the impact of students' stereotypes such as school environment and personal background and narrow the gap between metropolitan schools' performances in learning effort and social cohesion, which is found to vary with school type.

As this study investigates the difference in interactive models of learning communities in ALN by controlling the factors of instructor, course design and on-line learning systems, it is found that the difference has somewhat narrowed as a result of information technology. To this generation of university students, the internet would be an important and necessary media on communication and social contact. Therefore it is hypothesized that in similar metropolitan digital learning environments, ALN could alleviate students from perceiving the stereotypes of their schools' actual environments. When institutions of higher education apply traditional teaching theories to the online learning environment, this hypothesis will help them to take into careful consideration Swan's four interaction factors affecting online classrooms.

Over the years, education officials repeatedly tried to narrow the digital divide between rural and urban areas. Research results such as that of this study could provide a direction for education regulations in the future. Before making it possible to take courses from different schools, the government should improve its basic facilities of information technology infrastructure so that the digital learning environments of the schools are all similar to each other. What is more important is that each school should access equal and proportionate information to make it possible to narrow the gap between students of different school types as categorized under the current educational policy.

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e-Learning Martial Arts

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Abstract. Traditionally, when people want to learn martial arts, they have to go to training clubs and learn under the coach together with the other students. To reduce the tuition fees, there are usually a lot of students under a single coach and hence, it is difficult for the students to get enough suggestions in the class. It would be far easier if the students could practice themselves at home and ask for suggestions from a virtual coach in the computer. Occasionally, in case they find difficulties going to the next step, they may then approach the real coach for suggestions and training. In this paper, we propose such a training system based on the motion capture system. The system automatically analyzes the motions of the player and gives suggestions. The students can also view the martial art techniques stored in the system or their own techniques captured by the motion capture system from various points of view in order to gain objective ideas of the techniques.

Keywords: martial arts, web-based learning, automatic motion analysis, motion capture.

1 Introduction

Millions of people are now learning martial arts at schools, training clubs and homes. When learning at a school or training club, the coach typically supervises many students at the same time. Usually, the students repeat a specific motion with their school- / club-mates until the coach comes to them to give suggestions. The problem of this is that the students may not know if they are practicing in a correct way or not until the coach comes to see them. Even after getting suggestions, the students can still interpret the advice in a wrong way, and again repeat the wrong motions until the coach comes to see them the next time. As a result, only a few of the students who are really desperate to learn may continue to play until they receive enough feedback from the coach to improve their skills. The other group of students, who cannot get enough feedback from the coach, will have difficulties improving their skills, and might be bored, or even have a feeling of being neglected, and finally give up their training.

On the other hand, there are people who are interested in learning martial arts but do not want to join such groups or classes due to some bad experiences or their own busy schedules that they cannot attend classes regularly. Some of these people usually

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practice martial arts themselves at home by watching videos or reading books. However, this is not an efficient way to learn martial arts, as they have no feedback from the coach, and therefore, they may not realize it even if they are moving in a wrong way.

Another disadvantage of learning yourself is that you have no chance to do combinatory practice with other students, which is very important in martial arts. For example, when learning boxing, it is very important to learn how to get away from punches and quickly counteract. In order to learn such movements, it is important that a partner pretends to hit you by lightly throwing a punch at you. By doing so, you can learn the timing to start the defense motion. Unfortunately, unless you actually practice it with a partner, it is impossible to acquire such techniques through imagination.

In this paper, we propose a new methodology to learn martial arts. It is based on a PC equipped with a motion capture system. The user wears the motion capture suit and a head mount display (HMD). The virtual teacher appearing in front of the user through the HMD shows the student how to perform the attacks and defenses, and then asks the student to repeat the motions. The practice menu is set up according to the student's skills. After practicing for a while, if the student's motions are satisfactory, he/she may proceed to the next level and a new set of techniques will be added into the practice menu. When given advices by the virtual coach, the student will see his/her own motions recorded by the motion capture system. This helps the student obtain an objective view of his/her techniques, which was difficult when the students could only be monotonically repeating the same motions without any feedbacks. As automatic analysis of sports performance is still an emerging area, the feedbacks from the system is still imperfect and the students might still need advices/feedbacks from a real coach. Even in such case, this system can help the coach figure out what the problem of the student's motion is. Since the 3D trajectory of the player's motion is recorded, the coach can repeatedly compare the player's motion with those of experts, which are pre-recorded in the database.

The main advantages of our system are as follows. First, the users of the system can practice anytime when they are free as long as they can use the motion capture system. Although this may still be difficult today due to the high cost of the motion capture system, these systems might be available for home use in the near future due to the advance in camera based techniques and the high penetration rate of game systems. Second, the users are able to get concrete feedbacks and to have objective idea of their skills from the system without any time delay. Third, the real coaches can also benefit from this system. In addition to what we mentioned above, as all the records of the users are kept in the database, the coaches can remotely give advice to the students when they are available. The learning curve of the students can be analyzed, after a certain period of time of training, to help improve the algorithm for setting up the practice menu. Previously, all such knowledge was only kept in the mind of the coaches and the know-how could not be recorded.

This paper is organized as follows. Section 2 describes some prior work on related issues. Section 3 presents in detail our proposed system. Section 4 gives a brief conclusion of the work presented here and discusses possible future work.

2 Prior Work

There are various technologies available in the sports/game industry for learning sports. In Finland, a project to combine computers with fitness 7. was started in 2003. They have developed a system that combines an exercise bike with a computer game to motivate the user to do exercises. The system projects a virtual scene in front of the user and generates suitable sound through the speakers. For example, the user can bike through a virtual forest and hear the birds singing. The load of the pedals changes according to the scene – when it is going up hill, more force is required to proceed. The user may choose to compete with other players, who will also appear in the scene, or just have a time trial to check its performance improvement.

Fig. 1. Virku Project concept picture

There are several other systems that are based on a similar idea 1. 5. . Systems such as ergometers can easily be combined with virtual environments and are effective in motivating to the users.

There are also systems for practicing ball games 7. . NicemeetVR is a system to practice baseball. The player can see the virtual pitcher in front of him/her and swing the bat when the pitched ball arrives at the homebase. Photoeletronic sensors behind

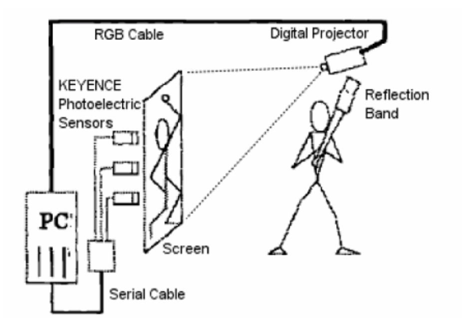

Fig. 2. NiceMeetVR

the screen are used to detect the motion of the bat swung by the player. According to the timing of the swung bat, the ball will fly to appropriate directions.

DanceDanceRevolution (DDR) 3. is a game that the users can enjoy various stepping patterns while hearing the sound of the music played by the computer. A sequence of arrows scrolls through the screen, and the user needs to step onto the right arrows located on the ground at the appropriate times. Although DDR is a game, most people enjoy playing it as a sport, and the home console versions are also used as home-use exercise machines.

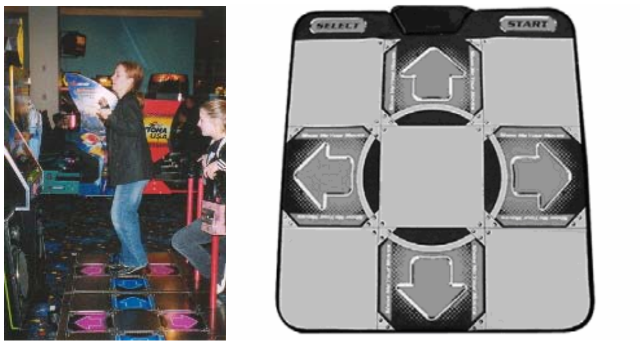

Fig. 3. DanceDanceRevolution: left - A user playing the game, and right - the mat interface

Although various systems are available for training and exercise, there are few systems that are available for martial arts. There are various games, such as Excite Boxing 2. and Mocapboxing 6. , that the user can virtually practice boxing with the virtual fighter controlled by the computer. However, only the motions of the hands or head are tracked, and analysis of the motion of the whole body is not done. This is because the systems are targeted only for game players and not for people who want to practice boxing using this system. There is no digital system that a user can seriously practice martial arts and improve their performance by now. In this research we focus on this point, and implement a system that can be used for improving the various offense / defense techniques of martial arts.

Fig. 4. Mocapboxing

3 System Description

3.1 Overview

The block diagram of our system is shown in Figure 5. The user wears the HMD and the motion capture suit in a studio, as shown in Figure 6.

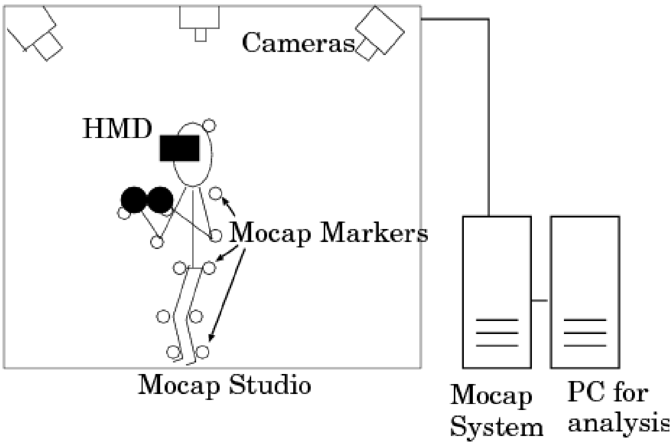

Fig. 5. Configuration of our system

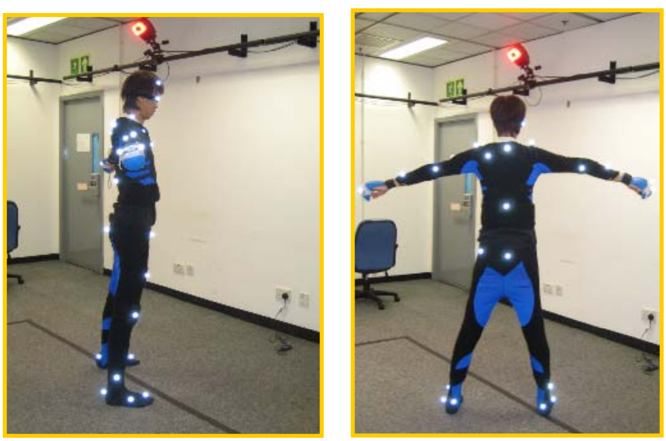

Fig. 6. The user wearing the motion capture suit and the HMD

In our system, we use an optical motion capture system with seven cameras, but any kind of motion capture system can be used as long as the motion can be captured accurately. After starting the system, the virtual coach will appear in front of the user, and inform the practice menu to the user, as shown in Figure 7. The virtual coach will then start to give instructions of every practice to the user.

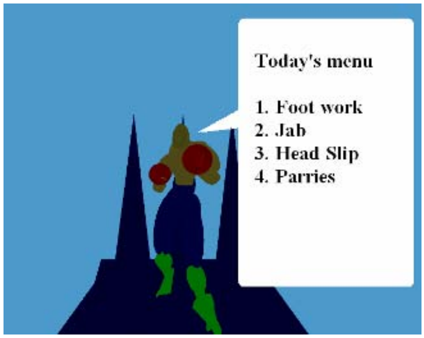

Fig. 7. The virtual coach telling the user the practice menu

3.2 Practice of Defense/Offense

The practice includes the defense as well as the offense, and sometimes both will be mixed. When practicing the defense motion, the virtual coach will throw punches or kicks toward the user. The user needs to defend the attack by conducting defensive motions such as blocking, swaying, or ducking. Since the timing of conducting such motions are important, the virtual coach randomly changes the interval of conducting the attack. The coach will also conduct feint motions, which the user must recognize it and should not start the defense motions in such case. Whether the user could defend the attack is evaluated by detecting collisions of the offender's attacking part with the user's body. In case the body is hit by the virtual master, a sudden flash and vibration of the scene will appear in the HMD screen to indicate the defense was unsuccessful (Figure 8).

When practicing the offense motion, the virtual coach will request the user to perform punches or kicks towards the coach. There are also modes with mixture of defense and offense. In such case, the user needs to avoid the attack and immediately counterattack.

Fig. 8. Flashing the screen in different colors to indicate the user's failure in defending an attack

3.3 Criteria of Motions

In order to give feedbacks to the user, the system needs to analyze the offense / defense motions to find out if there is anything wrong with the performance. We propose several factors to evaluate the performance of the user. Based on these evaluations, the user will be given advice. Each factor is explained below.

Total movement for defense: In martial arts, in general the less a defender moves in order to avoid attacks, the easier for the defender to counterattack. Therefore, it is preferable that the total movement of the defender is minimized. Here, we propose an evaluation criterion to base on the total body movement in the generalized coordinates. This criterion can be written in the following form:

$$\int_{t_0}^{t_f} \sum_{i=0}^{n-1} w_i \left| \Delta\theta_i \right|^2 dt \qquad (1)$$

where $\Delta\theta_i$ is the movement of segment i in the generalized coordinates, n is the number of degrees of freedom (DOFs) of the whole body, and w_i is the weight assigned to each DOF of the body. If a joint is considered as important in a specific defense action, we assign a small weight to it. If it is considered that the joint must not move, then we assign a weight to it. For example, for ducks, the motions of the knees are considered important, and so we assign smaller weights. On the other hand, the movements of the neck or the torso are considered as bad, as the defender may lose sight of the opponent. Hence, we assign larger weights to the neck and the torso joints.

Minimum pre-action for attack: If there is any sign of an attack, the defender would immediately realize it and predict what the offender would do and prepare for such attack. Hence, it is preferably not to show any pre-action of the attack. One way to evaluate such kind of pre-action is to check the motion perpendicular to the frontal vector. Such motions are easier to be recognized by the defender, and therefore, it must be minimized. This criterion can be written in the following form:

$$\int_{t_0}^{t_f} \sum_{i=0}^{m-1} \left\| \mathbf{v}_\mathbf{i} - \mathbf{v}_\mathbf{i} \cdot \mathbf{n} \right\| dt \qquad (2)$$

where $\mathbf{v}_\mathbf{i}$ is the velocity of the origin of segment i, $\mathbf{n}$ is the normal vector of the frontal plane of the offender, and m is the number of segments in the upper half of the body, which are more likely to be observed by the opponent.

Speed: Even though some coaches claim that speed is not an important factor for some martial arts, such as Karate or Kung Fu, it is obvious that in sports like boxing the faster is the better. If the speed of the punches is faster, the defender needs less time to counterattack the opponent, and the opponent has less time to get away from the punches. The criterion for this factor is the total amount of time required to complete the motion, which can be written as: $t_f - t_0$.

In addition to the above criteria, the following two techniques may also be used to evaluate the motion of the player, as they are considered as the fundamental motions which are used in almost any kind of martial arts.

Feints: In order to check whether a player really has acquired the techniques to defend the attacks, the virtual coach would sometimes do some feint attacks, which are fake punches to trick the player. In such case, the coach would pretend to attack by showing the initial motion of the attack. When the player is tricked, he/she will start the defense motion. After the player realizes that it is a feint attack, he/she will relief the defense, and at that moment, the virtual coach will really attack. By using this method, it is possible to evaluate whether the player's defense techniques are satisfactory or not.

Combinations: Usually, a player needs to combine various attack and defense actions in a match, instead of conducting a single motion. Hence, after given the instructions, the player will be asked to perform the given combination of defense and attack actions, as quickly and precise as possible. The criteria mentioned above are calculated for each motion in the combination to evaluate the whole process.

4 Experimental Results

We have conducted two experiments to evaluate the system. The first experiment is to check whether the series of criteria we have proposed are good enough to differentiate the skilled fighters from the novice ones. The second experiment is to see whether the users can improve their skills after repeatedly using our system.

In the first experiment, we asked two players, one an amateur boxer of five-year experience and the other a novice player, to do some exercise menus prepared by the system. The menu includes both offense and defense motions. The evaluation of each criterion is shown in Table 1. In all the factors, the experienced player showed much better performance than the novice player. This means that the criteria that we have introduced in this research can evaluate the experience of the fighters. In the second experiment, we have asked the novice player to do the exercise program several times, once per day. After the training, we have re-evaluated the performance of the novice player. Although the performance is still not as good as the expert player, improvements were found in most of the criteria. These results infer that the system is valid for practicing boxing.

Table 1. Font sizes of headings. Table captions should always be positioned *above* the tables.

	Total movement on defense	Pre-action for attack	Speed
Novice player	0.196	0.88	0.40
Novice player after training	0.140	0.43	0.32
Expert player	0.173	0.20	0.21

5 Conclusion and Future Work

In this paper, we have presented our design of a martial arts training system based on the motion capture system. With our proposed system, students can exercise martial arts at home at anytime they want. A student's practice motion can be captured in digital format with the information in both temporal and spatial domain and the results are automatically evaluated from both the offense and the defense point of view. We have proposed a number of criteria to evaluate the performance of the user. The criteria are kept as general as possible, so that the evaluation can be applied to any kind of martial arts. Using our system, we have conducted two experiments; one to show that the system can easily differentiate the novice from the experienced users, and the other to show that performance can be improved after practicing for a while.

The main advantage of our system is that a user can have combinatory practices, which are considered essential in martial arts, alone at home. The other advantage is that the user can observe the motion of the top fighters from the opponent's point of view, as if they are having a match with them. This is an important advantage, as previously, students had to climb up to a certain level before they could fight with such top fighters. In addition, the users are always safe, as there is no need to worry about being knocked down and injured.

There are several extensions on this work. First, more practicing samples can be collected to further tune up the criteria. Based on such data and further discussions with experienced coaches, it will be possible to improve the criterion or even come up with a new criterion to evaluate the performance of the fighters from another point of view. We can also collect the motion of people from different backgrounds in terms of age, sex, and experience. By analyzing such data, it is possible to know which group of people tends to show better performance under which criteria, and which criteria are difficult to be improved in which group of people. Such kind of information is important when creating the menu of exercise for the students.

Second, by analyzing the learning curve of the player, it will be possible to find out what the strengths and weaknesses of each individual str. Once such features are known, the system can tune the menu of exercise for each fighter. As a result, more time can be spent for overcoming the weaknesses, or enhancing the strengths of individual players.

In this project, we have concentrated on developing a system for practicing predefined motions repetitively, which is a basic way to improve the skills of martial arts. It is also possible to let the users have more practical exercises, such as sparling, using our system. In that case, the virtual coach needs to move randomly as in real matches. The user needs to launch the appropriate defending motion when they are attacked, and also needs to find out the weaknesses of the virtual coach and try to knock down the coach. This is a challenging task, as we need to simulate the fighting strategies of a real fighter. It is necessary to capture the sparling motion of two real players, and generate a model of a player attacking, defending, and counterattacking. Such kind of learning materials will greatly help the players improve their tasks, and by accumulating the data of the top athletes, anybody will be able to practice with the top players anytime in a safe manner. As a result, the idea of developing the e-Learning martial arts will benefit all athletes in various martial arts.

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Web-Based Learning with Non-linear Multimedia Stories

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Abstract. Stories and story-telling are a cultural achievement of significant relevance, even in modern times. Since ancient times stories have served to entertain and teach mankind to "transmit" knowledge from generation to generation. Story-telling ranges from simple aural narrations to traditional inter-generational discourse and, in modern times, workflow-oriented organizational learning. Web-based systems are by nature well-suited to support learning from digital stories in communities of practice. Despite the potential of story-telling to foster knowledge sharing in communities its full power to stimulate community-based learning processes in yet only marginally exploited. Although there are many story-telling approaches, most of them are not suitable for non-linear story creation and consumption. In addition, most of these are not based on a well defined methodology that underpins the story development process. In this paper we present the implementation of a non-linear multimedia story-telling environment based on the movement oriented design (MOD) paradigm. Finally, using a media-theoretic approach, we utilize structural aspects of story telling and identify patterns related to successful non-linear multimedia stories.

1 Introduction

Organizational knowledge management and professional learning are closely connected. The knowledge creation theory by Nonaka and Takeuchi [13] has become widely acknowledged in management theory and practice. Also, in the fields of computer supported cooperative learning (CSCL) and professional learning the most prominent knowledge management theories are those of Bereiter, Engestrm and Nonaka [14]. Especially, the socialization, externalization, combination and internalization (SECI) model by Nonaka and Takeuchi [13] has been accepted as a standard model for organizational knowledge creation. We are building learning environments on the assumption that in organizations informal communities of practice want to share knowledge about their profession. Learning in this setting is primarily a social process [3,25]. We refine the SECI model here by adding

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new distinctions in order to apply more comprehensive knowledge sharing and professional learning strategies based on the community-of-practice approach. We present an overview of these theories in the following, as full coverage of the SECI model, and other knowledge and media theories is beyond the scope of this paper, refer to [8] for a more comprehensive discussion. In Figure 1 we depict a hierarchy of knowledge types with examples. The SECI model makes a basic distinction between **tacit** or **procedural** and **explicit** or **declarative** knowledge [12,13,16]. While even this distinction is under debate, we add one refinement to the SECI model by introducing a distinction between semantic and episodic knowledge [23,24] in a community/organizational context. While **semantic knowledge** represents semiotic and conceptual knowledge such as documentation in organizational charts, business process definitions and so forth, **episodic knowledge** is knowledge about experiences such as episodes and narratives, e.g. war stories. This distinction is also being debated. Nevertheless, our claim is that through a combination of semantic and episodic knowledge can be used more effectively in organizations. While situational context may be lost by externalizing stories, outreach and impact of stories may be enhanced by this process. Documentation as a means of **semantic knowledge** can further be classified as **verbal** (linguistic data) and **non-verbal** (e.g. visual image, video, diagram).

The Digital Storytelling Association (DSA) defines story-telling as follows: "Digital Storytelling uses digital media to create media-rich stories to tell, share and to preserve. Digital stories derive their power through weaving images, music, narrative and voice together, thereby giving deep dimension and vivid color to characters, situations, and insights" [4]. This illustrates that story telling can be used for sharing knowledge, and thus, learning.

While most e-learning and knowledge management systems focus only on **semantic knowledge** of various kinds, story-telling is much more. Story-telling intertwines **semantic knowledge**, i.e. already reified concepts of communities stored as documents, by linking it with the narrative experiences gained from **episodic knowledge**. Thus story-telling can be seen as an approach to develop learning histories [18] by creating knowledge hyper stories [19]. Consequently, story-telling is an important aspect for knowledge sharing and learning in communities of practice. Therefore, telling, sharing and experiencing stories are common ways to overcome problems by learning from the experiences of other members. While story telling is recognized to be important in organizational knowledge creation, there are only a limited number of approaches to improve the influence and impact of story telling by using organization wide information systems. One of the major obstacles may be that authoring of stories is extremely challenging if not supported by a clear and simple methodology. Furthermore, suitable tools need to be in place to support story authors in the use of different media. Thus, the different requirements of authors and recipients of stories can be brought together.

We present a proof-of-concept implementation which enables non-formal communities of practice in organizations to create multimedia narratives, to share

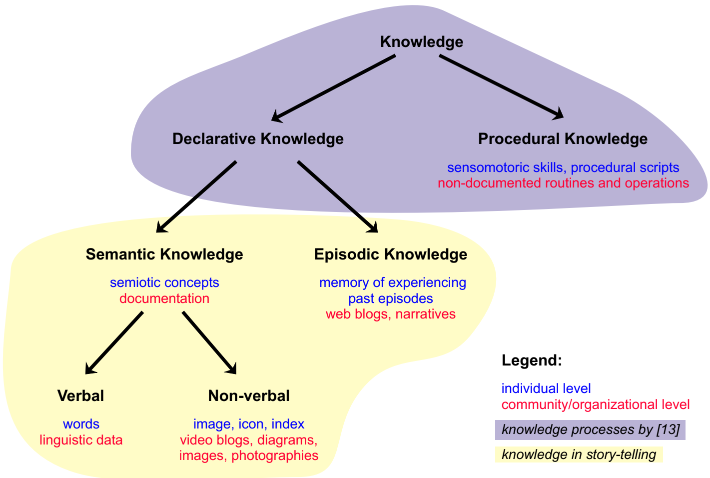

Fig. 1. Individual and community/organizational levels of knowledge processing. (Adapted from Nonaka and Takeuchi [13] with refinements on declarative knowledge done by Ullman [24]).

and to learn from such narratives. First, we introduce (non-)linear story-telling in more detail. Then we give an overview on existing story-telling systems, explain their underlying theoretical methodologies and discuss their suitability to combine semantic and episodic knowledge. Subsequently, we present the Movement Oriented Design (MOD) paradigm and explain its application in creating non-linear multimedia stories. In the following, we'll introduce our implementation of a Media Integrated Story-Telling environment in web-based communities called MIST. We demonstrate the novelty of our approach by combining MPEG-7 based multimedia metadata interoperability for sharing semantic knowledge in a multimedia story-telling environment. From the proof of concept implementation, we present initial test results with an example application for entrepreneurial training. The paper closes with conclusions and an outlook on further research.

2 Linear and Non-linear Digital Story-Telling

Story-telling has a long tradition going back to 330 BC, with the Poetics by Aristotle [1] a seminal work for construction of dramas and epics. Over the millennia a lot has changed in the way stories are produced, in terms of the media used and how they are consumed. With the underlying intention to transfer knowledge and to stimulate learning, the basic idea of story-telling has remained unaltered. However, stories embedded in a story-telling paradigm differ in the way they are produced, consumed and stored. In the next section, we explain the different facets of story-telling.

2.1 Linear vs. Non-Linear Story-Telling

In general, a story might be linear or non-linear. In a linear story, the plot is completely specified during story creation. Here, the author prescribes a linear path the user will have to follow in order to consume the story. Linear means that each part of the content is meant to be seen or heard in the same order every time it is experienced. Therefore, the only point of interaction on the recipient side is to stop or forward the story-process without being able to influence the story's narrative path, or the plot. Thus, the only interactivity allowed to "jump" back or forward on the navigation path. Since there is no opportunity to change the outcome of the overall story, this behavior is still considered linear.

Non-linearity breaches the "classical" sequential narrative. A non-linear story may have different endings depending on the user interactions taking place during story consumption. Therefore, during the story creation process there is not just a single path through the story, but many alternative paths. Thus, the author combines story elements and links them with one of many successor elements. As a result, this may lead to different stories depending on the recipient's selection at the interaction points.

2.2 Web-Based Digital Story-Telling

Another aspect for classifying stories is the way these are processed and consumed. Apart from the "classical" way to present stories, new media allow new means to process and present stories. Digital media allows speedier creation, sharing and consumption of interactive content. What makes digital media most suitable for story-telling it the ability to recombine various media types, making stories more effective and interactive. Web-based systems are the ultimate step in the evolution of story-telling by making interactive multimedia contents not only available 24/7, but also allowing community-wide distribution.

Despite the opportunities offered by story-telling to combine semantic and episodic knowledge, its full potential for knowledge sharing and e learning is thus far marginally exploited. In the next section, we compare different story-telling approaches and discuss their suitability for knowledge sharing and e-learning.

3 Related Work

There are several models of story-telling; most of these are commercial and aim at the creation fiction. Our overview will focus on systems that are suitable for sharing semantic and episodic knowledge in communities.

Dramatica is a comprehensive framework suitable for creating multimedia stories [15]. However, it does not allow any kind of non-linearity. In Dramatica a story represents a particular model called the "story mind". It is left to the creativity of the authors to express their episodic knowledge as a linear story so that dedicated aspects of the story are filled with content. Dramatica is also capable supporting semantic knowledge.

Adaptive Digital Storytelling(Adaptive DST) is a computer-based form of narration that tries to integrate basic principles of narratives and dramatic art into interactive digital stories [5]. Adaptive DST subdivides episodic knowledge into selected- and must-phases, and specifies their interdependencies. Another key concept in Adaptive DST is the option to manipulate the story a priori. Here, a variation of a story can be generated based on pre-defined tags used to specify the level of information a user wants to obtain. Based on a 4-ary classification scheme users can select from a superficial to a fine-grained story adaptation. Thus, non-linearity is only supported to a certain extent: The existing "core story" might not be changed completely in its outcome, but might be altered depending on the user's interest in the topic. While the concept is applicable to knowledge sharing on scholarly level, in general, it is doubtful that such a labor-intense, and mostly unguided creation process might be applicable in a community, or at a larger scale.
Storylining Suspense and **Story Engine** are closely related systems for the creation and consumption of non-linear multimedia stories. While Storylining Suspense is an approach to a new authoring method for interactive storytelling [20], Story Engine is used to capture episodic knowledge by narrating interactive non-linear stories (e.g. created by Storylining Suspense) [2]. The focus in Storylining Suspense is on authoring of non-linear stories based on a set of morphological functions defined by Vladimir Propp [17]. These functions are mapped within the system based on a scene model thus creating variants of a story based on the underlying model and the user's interaction. Additionally, there are options to store semantic knowledge about multimedia contents, but it is left open, whether these contents are available only to support the creation process or will be accessible upon consumption as well. Despite their client/server structure, Storylining Suspense and Story Engine are suited only on a limited scale for multi-authoring.
Hypermedia Novel (Hymn) is a new story-telling approach that extends the classical narration concept of Graphic Novel [6]. Hymn is a modular concept that allows the creation and consumption of hypermedia stories. The main concept of Hymn is the so-called narration module which can be accessed by an authoring tool. A narration module captures the episodic knowledge and stands for a scene within a story. These modules may be linked with other narration modules thus defining the story graph. Despite its clear graph oriented narration structure, Hymn does not seem to apply any theoretical concepts. The "Hymn-player" is a conventional web-browser using the Java Media Framework. Here, different media might be visualized but there is currently no support to store and retrieve semantic knowledge within media related metadata.

The **Digital Storytelling Cookbook** and **Travelling Companion** is considered to be a handbook for the creation of digital stories based on the "heuristics" gathered in a community of users associated with the center for digital storytelling [10,22]. For that purpose, the DSC breaks down episodic knowledge of digital stories into subcomponents and gives practical advices how to make stories out of user experiences. Besides some practical advices on how to find ideas about stories there are seven theoretical elements specified which should be fulfilled in a good story. However, there are no concepts described suitable to process media related semantic knowledge. On the technical level, the DSC only gives hints on how to use proprietary software as a common technical platform to create and share these stories has not yet been developed. In general, the DSC is suitable to support digital storytelling in various areas of application without going into details.

The **Movement Oriented Design (MOD)** paradigm [21] is a new methodology for the creation of linear and non-linear multimedia stories. Its core idea is to bring together different theories, models and tools under one roof. Thus, it integrates features from Dramatica [15] as well as the Aristotelean Poetic [1]. The result is a novel methodology and a formalism in order to create multimedia stories by combining three facets of stories: Motivation (verbal and non-verbal knowledge), Exigency (semantic knowledge) and Structure (episodic knowledge). Thus, the MOD methodology is a comprehensive framework for the creation of non-linear digital stories. However, a prototypical implementation is missing yet.

In the previous subsections we have introduced several implementations and methodologies applied in the area of story-telling. As we have pointed out, current approaches are not suitable for combining community support with a comprehensive methodological concept to process **semantic** and **episodic knowledge**. Table 1 gives a condensed overview on these approaches by highlighting their key features. For the sake of comparing these features, our Media Integrated Story-Telling (MIST) environment, which contains the theoretical concepts of MOD, is included. Since we want to foster community learning from non-linear multimedia stories we will pursue in MIST an approach that combines both: The benefits of the Movement Oriented Design methodology, and a community centric media support.

Table 1. Comparison of existing story-telling environments and methodologies

		Dramatica	Adaptive Digital Storytelling	Storylining Suspense & Story Engine	Hypermedia Novel	Digital Storytelling Cookbook and Travelling Companion (DSC)	Movement Oriented Design (MOD)	Media Integrated Story-Telling (MIST)	
Story concept		n.a.	Must & should dependencies	Morphological functions	Extended Graphic Novel	Community “heuristics”	Motivation, Exigency and Structure	Motivation, Exigency and Structure	*Adopted from MOD*
Semantic Knowledge		Verbal & non verbal	Available	Available	n.a.	n.a.	Verbal & non verbal	Verbal & non verbal	
Episodic Knowledge		???	Linear	Linear & non-linear	Linear & non-linear	n.a.	Linear & non-linear	Linear & non-linear	
Product Type		Commercial	Viewer: Public Editor: Commercial / Proprietary	???	Viewer: Public Editor: ???	Not implemented	Not implemented	Research	
Validation		Advices only	n.a.	Automatic consistency checks	n.a.	Not implemented	Not implemented	Automatic validation of MOD compliance	
Community support	Creation	Individual	Individual	Individual	Community wide	Not implemented	Not implemented	Community wide	
	Sharing	n.a.	Proprietary Webserver	Integrated Story Engine	Proprietary Webserver	Not implemented	Not implemented	Affiliated Community Webserver	

4 Media Integrated Story-Telling (MIST)

As we have introduced in the beginning, the more fine grained distinction of **declarative knowledge** into **semantic** and **episodic knowledge** allows a more appropriate classification of the media especially when used for processing the knowledge via multimedia stories. A key concept of MIST is the combination of "static" media related knowledge captured in multimedia documentations with the "dynamic" knowledge stored in the narrator's memories. Consequently, story-telling in MIST is based on (potentially different) media combined into non-linear multimedia stories. In order to accomplish the management of versatile media types and their "high-level" semantic descriptions we make use of the MPEG-7 multimedia metadata standard [7]. We have adopted a sub-set of this extensive standard to allow sophisticated media specific information to be connected with the MOD story elements. We decompose non-linear multimedia stories into elements that contain structural information and a set of media specific descriptions. Multimedia stories in MIST are decomposed into structural elements and media related contents. At the highest structural level there is the so-called "problem hierarchy" which specifies the problems described by this multimedia story, their interdependencies as well as (potentially many) references to related story elements. **Declarative knowledge** is captured at this level pre-dominantly. Here, the plot of the multimedia story is crafted. In order to achieve a more fine grained decomposition of the **declarative knowledge** of a multimedia story, the second structural level specifies transitions between media. Through this process a non-linear story is created and **episodic knowledge** is depicted. Finally, the semantic knowledge of a multimedia story, such as **verbal** descriptions and corresponding **non-verbal** contents, are connected with the story structure itself. For that purpose, story elements are linked with (potentially many) media files and their metadata descriptions.

In order to allow a fine grained description of the verbal knowledge associated with the non-verbal knowledge of a media file, all media in MIST contain detailed low-level as well as high-level semantic descriptions. MIST extracts all low-level technical information about the media automatically, while the high-level semantic descriptions have to be added manually. The wide range of media related information in MIST is covered by a sub-set of the MPEG-7 multimedia metadata standard [7]. Media files - which contain mostly technical information about a medium such as visual encoding, frame rate, color space, etc. - are linked with five more document types (places, objects, time, agents of action, classification scheme) that might contain additional high-level semantic descriptions about a medium (cf. figure 2). By dividing the high-level semantic knowledge stored in MIST into arbitrary document types we allow users to annotate media with high-level semantic entities that might have been created; thus making the use of MIST easier. Since MIST is a community centric client/server application all stories, media and media descriptions are stored on a central server. Technically, the server functionality is split into to an eXist-DB [11] for the storage of the MPEG-7 metadata and an affiliated ftp-server, which is used for automated uploading or downloading of multimedia artifacts by the community members.

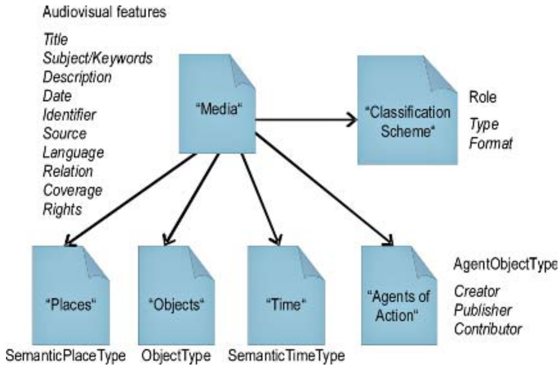

Fig. 2. Low- and high-level media semantics of media captured in MIST

MIST supports the community wide creation and exchange of multimedia stories. Next, we give a formal notation of stories in MIST and then explain its user interfaces.

4.1 Formal Notation of MIST

All stories created in MIST are compliant to the MOD paradigm. Formally, we define two structures: Non-linear multimedia stories $\mathcal{S}$ and their problem hierarchies $\mathcal{P}_{\mathcal{S}}$. The universes of both structures are based on a common set of identifiers defined as follows:

$I \subseteq \mathbb{N}, 0 <\mid I \mid< \infty$

with:

$I = I_{CSU} \mathbin{\dot\cup} I_P \mathbin{\dot\cup} I_M$

where I_{CSU}, I_P and I_M are identifiers for composed story units (CSU), problems addressed (P) and the media (M) contained in a story.

Given the signature $\sigma = \{CSU, M, Rel_{SUCC}, Rel_B, Rel_M, Rel_E, root\}$ with:

$CSU, M \in R^1(\sigma)$

$Rel_{SUCC}, Rel_B, Rel_M, Rel_E \in R^2(\sigma)$

$root \in F^0(\sigma)$

Then, a σ-structure

$\mathcal{S} = (SU, CSU^{\mathcal{S}}, M^{\mathcal{S}}, Rel_{SUCC}^{\mathcal{S}}, Rel_B^{\mathcal{S}}, Rel_M^{\mathcal{S}}, Rel_E^{\mathcal{S}}, root^{\mathcal{S}})$

is a valid story in MIST iff the following interpretations and conditions are fulfilled, cf. table 2. The signature σ and the $\mathcal{S}$ structure have the following semantics given the previous conditions: The universe of $\mathcal{S}$ is the set of existing story units SU.

Figure 3 shows various media transitions possible in MIST following the MOD methodology. Basically, there are three different types of transitions. First, there are transitions from begin to middle or from middle to end [*(B)* $\rightarrow$ *(M)*, *(M)* $\rightarrow$ *(E)*] between two media elements m_i, m_j within a composed story unit c not being decomposed recursively. Next, any transition within a composed story unit c between a medium m_i followed by a medium m_j located in a recursively

Table 2. Interpretation and conditions for stories in MIST

	Interpretation / Condition	Comment
1	$SU = CSU \dot{\cup} M$ where $CSU = I_{CSU}, M = I_M$	The set of story units SU is the disjoint aggregation of the set of non-atomic composed story units CSU with the set of atomic media M
2	$Rel_B, Rel_M, Rel_E \subseteq CSU \times SU$ with $Rel_B, Rel_M, Rel_E \neq \varnothing$	The dependencies between composed story units CSU and their succeeding story units SU are defined as binary relations
3	$\forall c \in CSU : \exists b, m, e \in SU$ having $(c,b) \in Rel_B \wedge (c,m) \in Rel_M \wedge (c,e) \in Rel_E \wedge b \neq m \neq e$	Every composed story unit contains at least one begin *(B)*, middle *(M)* and end *(E)* element, that might be either atomic or composed thus allowing a recursive decomposition of multimedia stories
4	$Rel_{BME} := Rel_B \dot{\cup} Rel_M \dot{\cup} Rel_E$	The set of all existing dependency relations is the disjoint union of begin, middle and end relations
5	Let $s \in SU, a, b \in CSU$: $(a,s) \in Rel_{BME} \wedge (b,s) \in Rel_{BME} \Rightarrow a = b$	The linking of a story unit s with a composed story unit c is unique
6	$root : \varnothing \to CSU$	Dedicated root element
7	$\neg \exists c \in CSU$ with $(c, root) \in Rel_{BME}$	The root element may not be contained within another composed story unit c
8	$\forall y \in SU \setminus \{root\} \; \exists x : (x,y) \in Rel_{BME}$	All story units s except the root may not stand alone and thus be inaccessible from the root
9	$Rel_{SUCC} \subseteq M^2$	Binary relation which is used to link two media m, which are atomic story units
10	$B(c) := \{x \in SU \mid (c,x) \in Rel_B, c \in CSU\}$	Set of story units s succeeding a given composed story unit c in the beginning relation
11	$B^*(c) := \bigcup_{n \in \mathbb{N}} B^n(c)$	Finite closure of all beginning relations given a composed story unit c
12	$E(c) := \{x \in SU \mid (c,x) \in Rel_E, c \in CSU\}$	The set of story units s succeeding a given composed story unit c in the end relation
13	$E^*(c) := \bigcup_{n \in \mathbb{N}} E^n(c)$	The finite closure of all end relations given a composed story unit c
14	$\forall (m_i, m_j) \in Rel_{SUCC}, i \neq j, \exists c \in CSU$ having $(c,m_i) \in Rel_B \wedge (c,m_j) \in Rel_M \vee$ $(c,m_i) \in Rel_M \wedge (c,m_j) \in Rel_E$ $\vee \exists x \in SU :$ $\begin{bmatrix} (c,m_i) \in Rel_B \wedge (c,x) \in Rel_M \wedge m_j \in B^*(x) \vee \\ (c,m_i) \in Rel_M \wedge (c,x) \in Rel_E \wedge m_j \in B^*(x) \vee \\ (c,x) \in Rel_B \wedge m_i \in E^*(x) \wedge (c,m_j) \in Rel_M \vee \\ (c,x) \in Rel_M \wedge m_i \in E^*(x) \wedge (c,m_j) \in Rel_E \end{bmatrix}$ $\vee \exists y,z \in SU :$ $\begin{bmatrix} (c,y) \in Rel_B \wedge m_i \in E^*(y) \wedge (c,z) \in Rel_M \wedge m_j \in B^*(z) \vee \\ (c,y) \in Rel_M \wedge m_i \in E^*(y) \wedge (c,z) \in Rel_E \wedge m_j \in B^*(z) \end{bmatrix}$	A transition between any two media m_i, m_j compliant to the MOD paradigm

decomposed succeeding story unit s is being defined [*(B)* → *(B)*, *(M)* → *(B)*]. Similarly, those transitions within a composed story unit c between a medium m_j with a proceeding medium m_i of a recursively decomposed story unit s are defined [*(E)* → *(M)*, *(E)* → *(E)*]. Finally, any media transitions within a composed story unit c between media m_i, m_j located in recursively decomposed story units s_1, s_2 are being defined. Both transitions are of the same "type" [*(E)* → *(B)*] depending on the position between the recursively decomposed story units s_1, s_2 within the composed story units c. They connect a medium m_i located as an end element of a story unit s_1 with a medium m_j located at a begin position in another composed story unit s_2.

We have now defined the structure of non-linear multimedia stories. The next step is the description of the problem hierarchy within the story plot as follows:

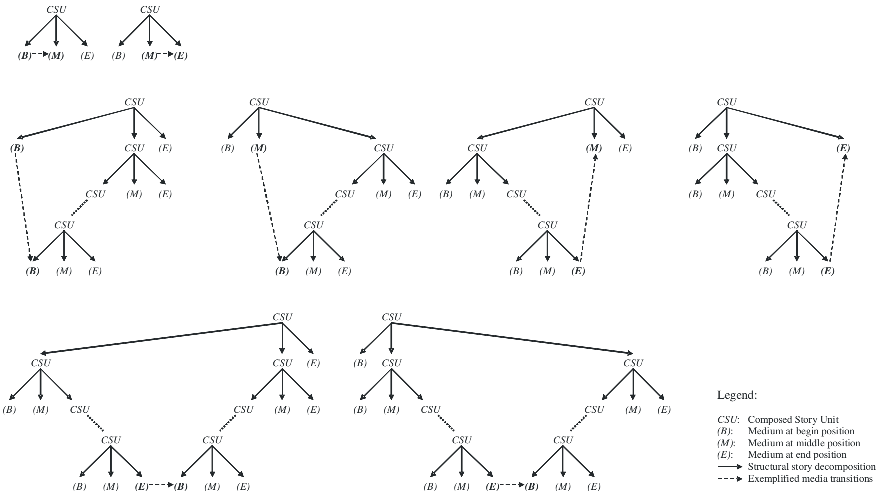

Fig. 3. Possible media transitions in MIST according to MOD as a tree diagram

Given the signature $\pi = \{P, M, L, root, super\}$ with:
$P, M, L \in R^1(\pi)$
$Rel_{PM} \in R^2(\pi)$
$root \in F^0(\pi)$
$super \in F^1(\pi)$
Problems addressed by a story $\mathcal{S}$ are defined given the following π-structure $\mathcal{P}_\mathcal{S}$
$\mathcal{P}_\mathcal{S} = (PS, P^{\mathcal{P}_S}, M^{\mathcal{P}_S}, L^{\mathcal{P}_S}, root^{\mathcal{P}_S}, super^{\mathcal{P}_S})$
defines a valid story-plot of problems in MIST iff the following conditions are fulfilled, cf. table 3. The signature π and a problem structure $\mathcal{P}_\mathcal{S}$ have the following meaning given the previous conditions: The universe PS of $\mathcal{P}_\mathcal{S}$ is the union of problems P covered by a story together with the media M.

After having defined the theoretical basis of stories in MIST we now explain its user interface.

Table 3. Interpretation and conditions for problem hierarchies

	Interpretation / Condition	Comment
1	$PS = P \dot{\cup} M$ where $P = I_P, M = I_M$	The universe of the problem structure PS is the disjoint union of the problems P and the media M of a story
2	$Rel_{PM} \subseteq P \times M$	The dependencies between the problems $p \in P$ addressed by a medium $m \in M$ are defined as a binary relation
3	$root : \varnothing \rightarrow P$	A dedicated root problem $p \in P$
4	$super : P \rightarrow P$, having: $super(root) := root$	Assignment of a tree structure to the problems addressed
5	$L := \{ p \in P \mid \neg\exists c \in P : super(c) = p \wedge p \neq c \}$	The set of leaves L contained in the tree
6	$\forall l \in L, \exists m \in M : (l,m) \in Rel_{PM}$	Every leaf l is linked with at least one medium

4.2 MIST Editor and Player

MIST is a Java implementation and allows the creation (editor) and consumption (player) of multimedia stories. The editor allows users to create new or edit already existing multimedia stories. The viewer is used for the consumption of existing multimedia stories. In the example, we have different entrepreneurial players which were interviewed in the last years. Entrepreneurship is a good topic for non-linear story-telling, since there is no one solution to the problem of starting a company. Besides the explicit knowledge contained in the interviews, entrepreneurs also serve as role models which make other people more sensitive to the topic itself. All interviews were tagged semantically [9]. The interviews deal with different aspects of entrepreneurial activities like finding the right team, identifying the right opportunity, looking for start-up money etc. All these problems can be grouped in problem hierarchies. The story author can now create paths between different parts of the entrepreneurial interviews to highlight certain problematic aspects of entrepreneurship. On different paths different problems may be introduced.

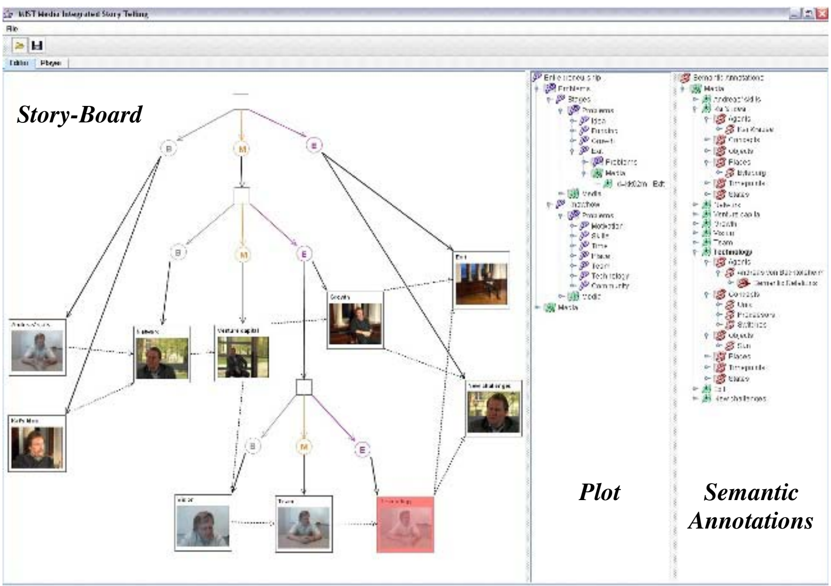

Fig. 4. Non-linear multimedia story on entrepreneurship & new media edited in MIST

The editor is shown in figure 4 and consists of three main elements: Storyboard, Plot and Semantic Annotations. These elements are intended to help the user in creating valid multimedia stories. In the middle, the story plot (**declarative knowledge**) is shown as in a tree hierarchy. The problems addressed in this multimedia story can be specified and can be linked to multimedia contents dealing with them. For that purpose the *story-board* on the left on the hand side visualizes the current paths within a multimedia story. Thus, the *story-board* represents the **episodic knowledge** captured within a story. In addition, the decomposition of stories according to MOD into begin *(B)*, middle *(M)*, and end *(E)* is shown and their correctness is being validated automatically according to the previously defined conditions. Finally, on the right hand side, additional semantic annotations can be added to any multimedia element. Thus, the user may express **verbal knowledge** being associated with **non-verbal knowledge** inherent in any multimedia content. Consequently, the editor in MIST supports the creation of multimedia stories based on the MOD paradigm, covering the complete spectrum of **declarative knowledge**.

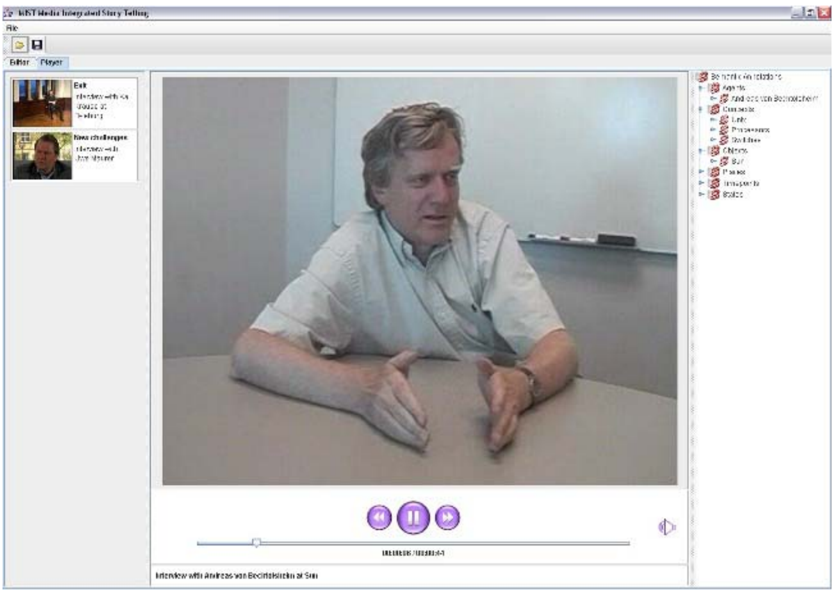

Fig. 5. Entrepreneurship interview with Andreas von Bechtoldsheim in MIST

The multimedia story player of MIST is shown in figure 5. It consists again of three tabs. In the middle, the player is located. Here, the problems addressed by the *plot* are presented as multimedia contents. The player allows the visualization of versatile media such as movies, music, text or images. The tab on the right contains additional *semantic annotations* related with the medium. In the tab on the left the succeeding media are shown in a thumbnail preview. According to the media transitions defined in the editor's *story-board* the user might selected a medium of his choice in case there is more than one available.

5 Conclusions and Outlook

Communities increasingly use digital media such as websites, blogs, forums, movies etc. to exchange knowledge. However, the impact of story-telling in fostering learning by connecting **episodic knowledge** with **declarative knowledge** in organization wide information systems is still marginal. Furthermore, existing story-telling systems are not suitable for a community/organization wide support of non-linear story creation and consumption. While approaches providing learner communities with multimedia technologies are promising, community learning processes supported by multimedia stories are still in infancy. One of the reasons might be that story telling is an extremely challenging task for many people if not guided by a clear and simple methodology. We researched different approaches and tools for non-linear digital story telling. As a result we have to state that most of them are not suitable for organizational/community knowledge creation and professional learning because they lack any theoretical basis or guidelines to support users in the creation of stories or the tool support is limited to authoring. We have demonstrated that MOD is a suitable solution for community learning purposes because it supports both episodic and semantic memory concepts on the one hand and has a clear, simple, understandable and easy to follow story concept on the other hand. To support such an approach and to use to full power of analysis means for distinguishing “bad” from “good” stories, a formalization of the MOD approach is needed. The basis for a sound formalization is realized here.

Also in this paper, we presented MIST for community learning from non-linear multimedia stories. Our proof-of-concept implementation demonstrated the usefulness of MPEG-7 for non-linear multimedia story-telling by capturing **episodic knowledge** inherent in multimedia stories and **declarative knowledge** of multimedia contents. Due to its platform independence and an easy to use user interface, users can now collaborate, exchange knowledge and thus learn anytime and anywhere by exchanging multimedia stories via a common repository. While the reception of non-linear multimedia stories currently is not being evaluated, we are planning to do so in future. Current research therefore, aims at measuring the learning success of multimedia stories. In order to achieve this, we plan to embed user models into MIST. By doing so, we can investigate the story reception process and the factors leading to its success or its failure. Hence, we intend to use graph analysis tools to detect disturbance patterns in multimedia stories. Thus, we will conduct a comprehensive cross-media analysis that might give us a deeper insight to understand media related impacts in learning processes.

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IDSVL: Intrusion Detection System Virtual Lab Based on Component in the Internet

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Abstract. This paper proposed the design model and implementing method of IDSVL (Intrusion Detection System virtual lab system) based on component technique. IDSVL system is implemented with Java language, which makes it independent of operating system. In IDSVL system, all IDS modules, which includes data generator module, event generator module, analyzer module statistic and displaying module and management module, are developed with Java Bean so that it is scalable and gets good performance in software reuse. The client of IDSVL system is implemented with Java Applet, users can not only set the experiment flow visually but also choose the type of simulation attack streams, configure filter rules and detection rules, set the display mode of experiment result. In the whole process of experiment, users participate in configuration and operation of IDS intuitively and this is helpful for the users to understand and master the structure and theory of IDS.

Keywords: intrusion detection system, virtual lab, Java applet, Java bean.

1 Introduction

Intrusion detection is a practical approach to enhancing the security of computer systems. Intrusion Detection System (IDS) is an ad hoc security solution to protect flawed computer systems. As a result of the network security condition worsening, intrusion detection technique becomes the hotspot of network security research. Many universities have the curriculum about network security, but they do not have a network security laboratory for students to do experiments. Even if there is one lab for network security, it also can not be used by the undergraduate for some reasons. So we must find a new method to solve the problem and all students can do experiments about network security.

The steady growth in the development and application of virtual lab technique has supplied a valid method to resolve this problem. This paper proposed an IDS virtual lab system based on component. The software platform supports the simulation of network attacks as well as the main functions of intrusion detection system. The system is implemented with Java language and encapsulates often-used intrusion modes and intrusion detection algorithms in the JavaBean components. Users can

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reconfigure the system parameters, such as the mode of data generator, the type of attack, filter rules, detection rules and detection algorithms. The system will generate the corresponding simulated attack data flow and detect them. At the same time, the system can supply log lists and relevant statistics to show and describe the detecting result. By comparing the detecting results among different attack modes, rules and algorithms, the users may understand profoundly the theory of intrusion detection technique. It will do great favor to the teaching and practice of intrusion detection technology for the users.

The remainder of this paper is structured as follows. In section 2, we introduce the related research work. Section 3 describes the design and the architecture of the IDSVL system. Section 4 describes the particular design of the main modules in the system. Section 5 gives a runtime instance of the system, and the last section is the conclusion.

2 Related Work

The research of intrusion detection can be traced back to 1980s'. From the viewpoint of the system architecture, IDS is generally composed of three parts: data collection (sensors), the detection analysis engine and response unit. The data collection module gathers different kind of data according to the type of intrusion detection, for example, the network data packets, the logs of OS and so on; The detection analysis engine implements the detection algorithms, from the character string matching to expert system, even the NN, it is the hard core of the IDS; The response module receives the determinant result which comes from the analysis engine, and handles the data according to rules defined in the response strategy. Common Intrusion Detection Framework(CIDF) puts forward a common framework module, which divides an IDS into four relatively independent function modules: event generators, event analyzers, response units, event databases. It is the typical structure which is adopted in most intrusion detection system.

Because of the increasing application of the virtual lab environment, many researchers have done a great amount of research works in this aspect. From the view of implement technology, the system design scheme of virtual lab can be divided into two kinds. One is just to use pure software to build virtual lab, and the other is to use the combination of software and hardware technology to do it. As for the former, a lot of popular techniques have been applied, for example, HTML, CGI, Java Applet, Java Servlet etc. Ref.[1] proposed an assistant teaching system in Java for learning the usage of electric instruments, which can be applied in the remote education. The system was composed of four parts: information, instrument, detection, and FAQ. It enables users to learn the usage of oscilloscope, signal generator and logic analyzer; Ref.[2] brings forward a virtual lab which is developed in Java Language. The client of system is implemented with Java Applet and the equipments are implemented with JavaBeans. The lab uses components to implement instrument and equipment models so that the users can visually scheme their experiment personally, dynamically import and set up experiment equipment objects. Ref.[3] gives a especial system structure for the virtual lab, which uses CORBA technology and is based on Web. Ref.[4] brings forward a computer network virtual lab system based on NS2 simulator. In this model, the client part is implemented with Java Applet, the multi-protocol simulator

NS2 is used as computing platform, Nam is used as the tool for displaying in the client, and Java RMI is used for the remote calling of client. In web environment, this system provides an experiment platform for users, which makes users leave out the trouble of studying NS2. By using the powerful system simulation capability of NS2, users can do network simulation experiment and deeply understand the complex behavior in computer network. Ref.[5] introduces the design of the remote programming virtual lab, the client is implemented with Java Applet and the server is implemented with CGI and Java Servlet. The Client sends the codes to the server, the server compiles and executes the codes then return the result to the Client. A Web-based distributed education virtual laboratory discussed in Ref.[6] allows the component database of the server to be distributed on different hosts. The server components are developed on LabView. Ref.[7] described a virtual lab of automatic control theory. The Client takes HTML and Java Applet web pages as UI and the Server takes MATLAB/SIMULINK as background environment. Users can do the experiments through configure the controllers in the MATLAB/SIMULINK environment provided by the Server. Then the Server returns the experiment result to the Client. Ref.[8] described the design and development of a virtual biology lab, which takes JavaApplet as client, realizes the function of experiment component by JavaBean and expresses and records the experiment result by XML; Ref.[9] proposed a digital signal processing virtual lab based on components. In this system, all the virtual instruments are developed as components and implemented in JavaBeans. Another type of virtual lab, which combines software and hardware development, uses HTML, Java Applet technique in Client. And unlike the former, it makes use of real hardware and equipment to perform the simulation. An IP network virtual lab inferred in Ref.[10] uses an Ethernet Switch and multiple PCs with Linux operation system as simulation equipment. The user inputs network operating orders then the server will return the result to the user.

The research of using the pure software to develop virtual lab is very important in computer simulation today. There are a lot of good applications in many fields. Network security is the fundamental course for students majoring in information security. But because of the high cost, the relevant experiment environment is hard to construct. This paper is aimed to provide the learner a good virtual lab to study the theory of network security.

3 IDSVL Architecture

Fig. 1 shows IDSVL architecture, which is mainly composed of two parts -- the client and the server. The server contains the server program entry and the database. We use SQL Server 2000 as database server to save the rules for generating attack data, detection rules, filter rules, and the text describing the detection process and result. The server provides Web service and sends the client the JavaBean components and subclasses according to the client's requests.

The client realizes the functions of the virtual experiment components and generates the experiment results (log files). There are a large amount of JavaBean containers and components, which include data generator module, configuration management module, event generator module, event analyzer module, statistic analysis and display module. The interface of the client is implemented with Java Applet.

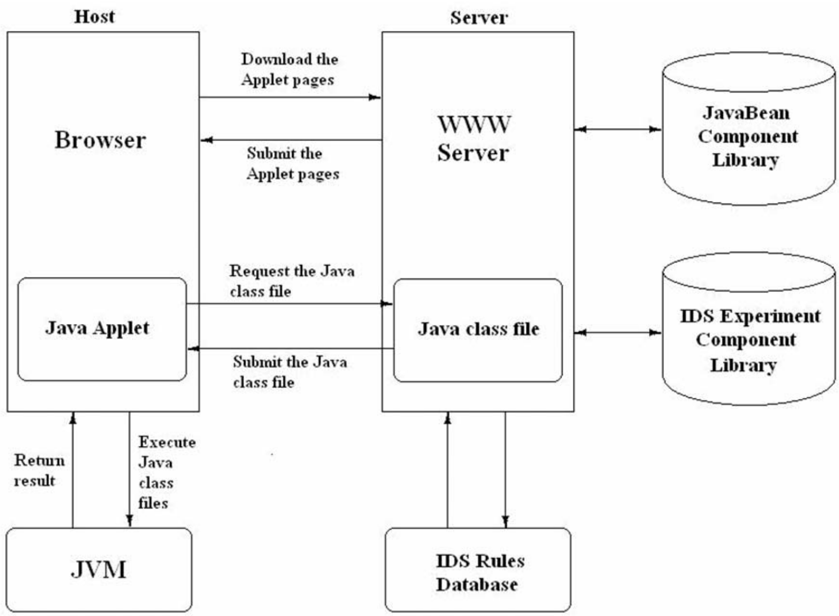

Fig. 1. IDSVL architecture

Firstly, the client uses browser-supported JAVA to create connection with Web server. After entering the virtual laboratory, browser will download the Applet pages automatically from the server to the client. Through the Applet, users can choose the experiment component, configure system parameters and press button "Run". Then the client will submit the configuration parameters to the server and request for the Java class files of corresponding components. Receiving the parameters and request, the server will send these Java class files to the client. Then the codes will be executed on Java Virtual Machine (JVM) at local. At last, the simulation result will be returned to the client.

4 Design and Implementation of the Main Modules

As shown in Fig. 2, IDSVL system is composed of data generator module and virtual IDS module. The IDS module includes configuration management module, event generator module, analyzer module and response module. In IDSVL system, the response module of IDS is responsible for statistic analysis and displaying the experimental result.

Fig. 3 shows the implementation procedure of IDSVL system, which describes in detail the relation between each two modules and the process of intrusion detection. Firstly, users choose the data generation mode through the configuration management module. There are two modes that can be chosen, one is to read the tcpdump file and the other is to simulate the network data by the simulation system. If users choose the

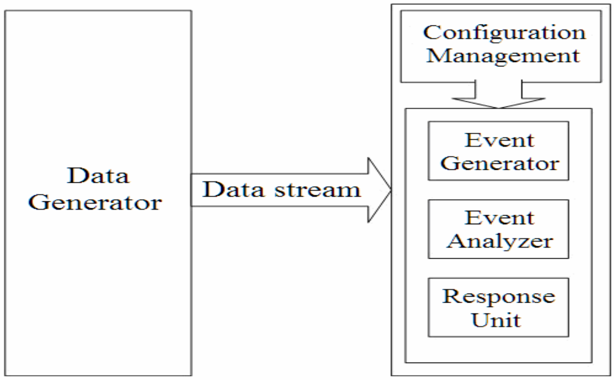

Fig. 2. System modular structure

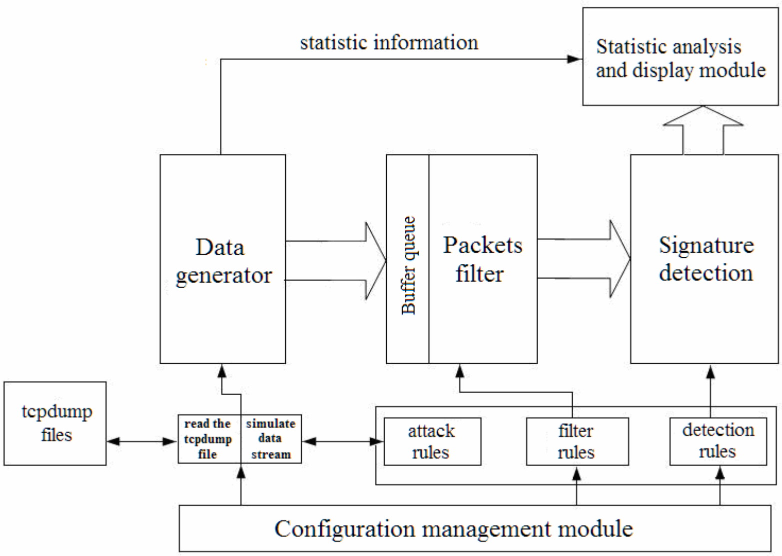

Fig. 3. Implementation of IDSVL system

later, they can specify the type and amount of attacks. At the same time, users also can configure the detection rules, filter rules and the rules of data generating. Secondly, the event generator filters the data information and discards any irrelevant data according to the filter rules. It can reduce the analyzer's workload and improve the efficiency of system. Then the analyzer analyzes the data by feature matching and makes a decision. Finally, the detection result will be offered to the response module (statistic analysis and display module), which will display the experimental result to the users.The following section will specify the design and implementation of the main modules in detail.

4.1 Design of Data Generator

The data generator is used to produce the real time simulation data. The data stream should include legal data and illegal data. There are two data generation methods for users to choose. One is to generate data by the simulation data generator, the other one is to reading the data stream from the tcpdump log file.

When users adopt the first method to generate simulation data stream, firstly they can choose different attack modes in the attack data list, then the data generator will generate the simulation attacks data according to the attack mode. The packets are stored in a byte data type array. The advantage is that we can conveniently search and set the data fields which need to be handled. The data generator will firstly generate an Ethernet header (14 bytes) and an IP header (20 bytes), then generate the header of TCP, UDP or ICMP according to the information of protocol field in the IP header, lastly generate the payload.

According to the characters of different attack modes, the data generator will set each special field of the header of IP, TCP, UDP, ICMP and payload respectively, all of above can constitute given attack packets. In order to guarantee authority and universality of the definition of attacks, the attack characteristics in the database are defined according to the detection rules of Snort[11]. For example, Snort defined one rule of DOS Ascend Route as follows:

alert udp $EXTERNAL_NET any -> $HOME_NET 9 (msg:"DOS Ascend Route"; content: "|4e 41 4d 45 4e 41 4d 45|"; offset: 25; depth: 50; reference:bugtraq,714; reference:cve,CVE-1999-0060; reference:arachnids,262; classtype:attempted-dos; sid:281; rev:2;)

When users want to simulate DOS Ascend Route attack, the data generator will fill corresponded fields according to the above characteristic information, which is defined in Snort.

Users also can specify the file path and replay the normative test data through reading the tcpdump files.

4.2 Design of IDS Event Generator Module

The first step of intrusion detection is to collect data. The role of an event generator is to obtain events from the data which is generated by the data generator module. Generally speaking, the event information mainly includes a log (or audit) of system events, network packets, users' state and behaviors. In this system, event generator is mainly used to receive and filter the network packets which are generated by the data generator module. Users can choose rules in the filter rules list, also can customize the filter rules according to the format which offered by system. When packets are coming, the event generator will firstly store the IP packets in a buffer queue, and then check the packets information and discard the irrelevant packets according to the filter rules. Then, the event generator will transfer the relevant packets to IDS analyzer. The aim of filter procedure is to reduce the workload of analyzer and improve the efficiency of system. Before transferring the packets to the analyzer, the event generator has to execute another important procedure, which is pretreatment of packets. The task of pretreatment is to convert the format of data. Namely, for each packet, the event generator will pick out the key information of the packet and put them into a Vector. Then it stores the Vector in a queue and transfers the queue to the analyzer. The filter process is described as follows:

```
Inductor(Datastream)
{
  Get the number N of IP packet in Datastream;
  Get the defined filter rules from the rule database;
  For each IP packet
   {
     Get the header information of IP packet;
     If IP packet matches the defined filter rules
        Discard the IP packet; }
}
```

4.3 Design of IDS Analyzer Module

The main function of IDS analyzer is to analyze the packets according to the detection rules and the specified algorithm. At present, there are many detection algorithm models in IDS, such as experimental model, mean value and standard difference model, multivariable model, Markov process model, succession model and match model and so on. The majority of commercial IDSs based on misuse model mostly adopt match model, which judges weather the attack is executed by matching some short character string T_i (i=1, 2, …n) in long character string P, where T_i is attack signature. IDSVL system adopted similar detection algorithm based on match model. Detection rules in IDSVL system are defined on the basis of the rules in Snort. In order to help users know more about the process of detection and update the detection rules conveniently, IDSVL system supports the customization of detection rules. Users can easily add or modify detection rules by setting the parameters of detection rules in the rules definition dialog box. When detecting, IDS analyzer will scan the attack signatures library, compare the information of packets with signatures to judge whether these packets contains attack data. The process of how to realize the analyzer is described as follows:

```
Analyzer(Packet)
{

   Get the defined detect rules from the rule database;
   For each IP packet which is kept after filtering
     For each detect rule
       If IP packet matched the detect rule
          Put it into an array and give an alarm;

}
```

For the network attack modes using the flaws which exist in handling IP fragments by the operator system, IDSVL system reassembles the IP datagram fragments and analyzes the relation of them. In IDSVL system we create two queues to process this kind of attack. One is suspicious IP fragments queue (questionable), the other is abnormal IP fragments queue (attack). Each element saved in the two queues is a quintuple (ID, source IP, destination IP, protocol and fragment offset). The previous four fields in the quintuple are used to judge which IP packet does the IP fragment belongs to, and the fragment offset is the evidence of IP fragments' location. Figure 4 shows the process of analyzing the IP fragments.

When an IP fragment is coming, IDSVL system firstly searches the abnormal queue. If the information of the IP packet does not exist in the abnormal queue, IDSVL system will search suspicious queue. If there is not matching information in suspicious queue, IDSVL system will consider that no other fragments of the same IP packet have arrived. The analyzer will draw some key information from the packet in quintuple form and put it into the suspicious queue. Then the analyzer module will analyze the content in the suspicious queue. If some correlate information has existed in the abnormal or suspicious queue, the system will analyze them directly. If any abnormality was found in the process of signature detection, IDSVL system will add the packets' information in the abnormal queue and delete the correlate information in suspicious queue.

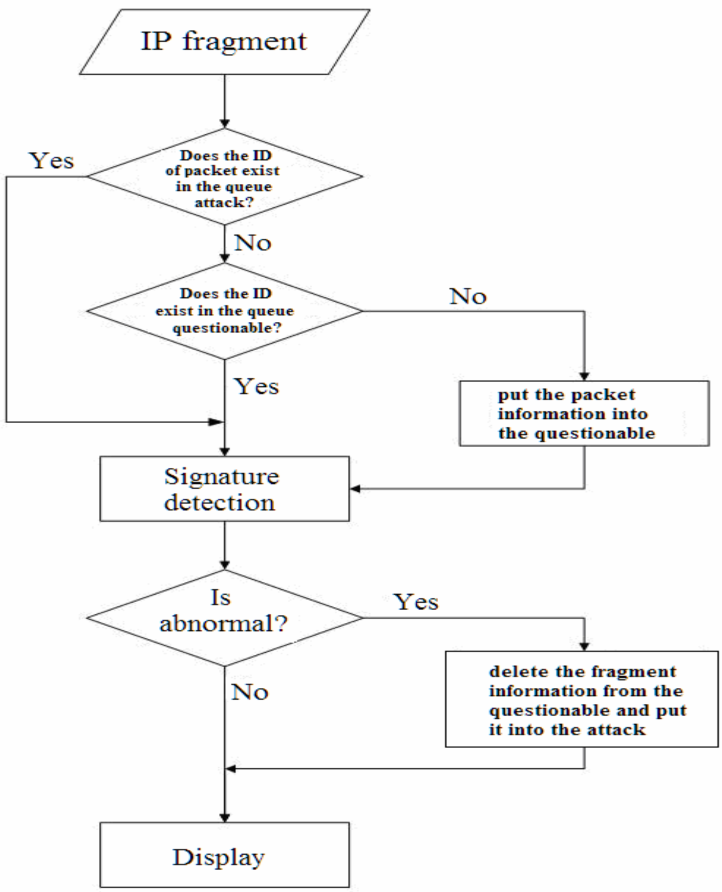

Fig. 4. IP fragments analysis flow chart

4.4 Design of Statistic Analysis and Display Module

There are two missions in statistic analysis and display module. One is the statistic analysis of experiment data, and the other is to display the experiment results. The statistic information includes the total amount of generated packets, the attack packets, type of attacks and so on. Through analyzing the information, the system can reckon out detection rates as well as false alarm rates, and then display these results in table, bar chart or pie chart according to users' requirement. Furthermore, this module also can record the experiment data which is generated by the data generator, and save them in the form of tcpdump file. It is convenient for the users to use these data next time.

4.5 Design of Configuration and Management Module

The configuration and management module is mainly used to help users to configure the parameters of data generator module and IDS module. Through this module users can assign the type of attack, set filter rules and detection rules, also can choose the display mode to show the experiment results.

5 An Example in IDSVL

The system provides some common detection algorithm components and more than 60 types of simulation attack data, such as Backdoor, Dos, DDos, DNS, Exploit, Scan,

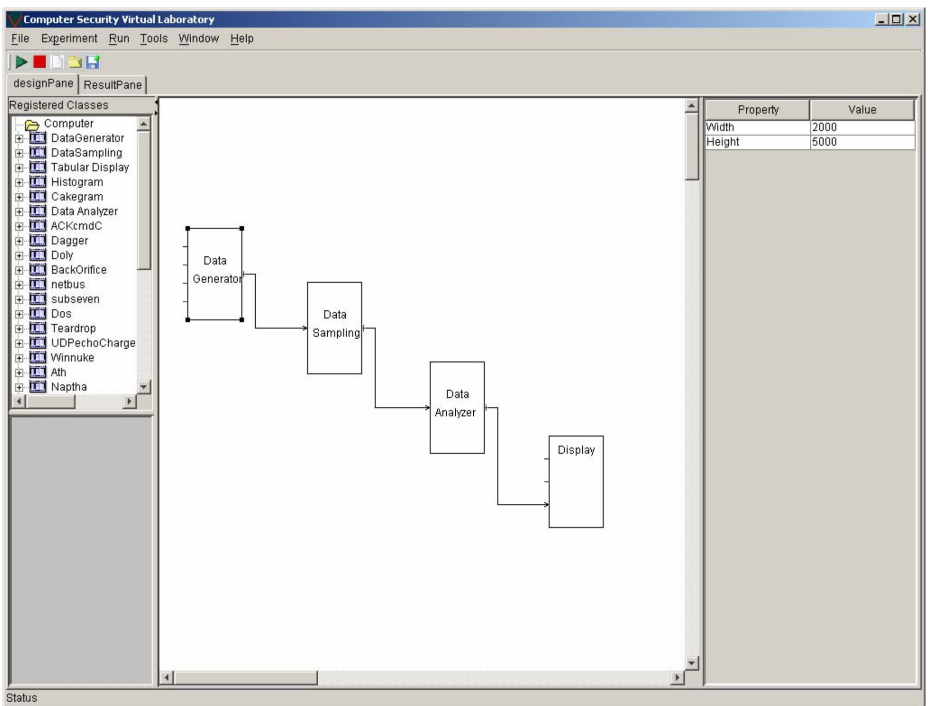

Fig. 5. The interface of IDSVL system

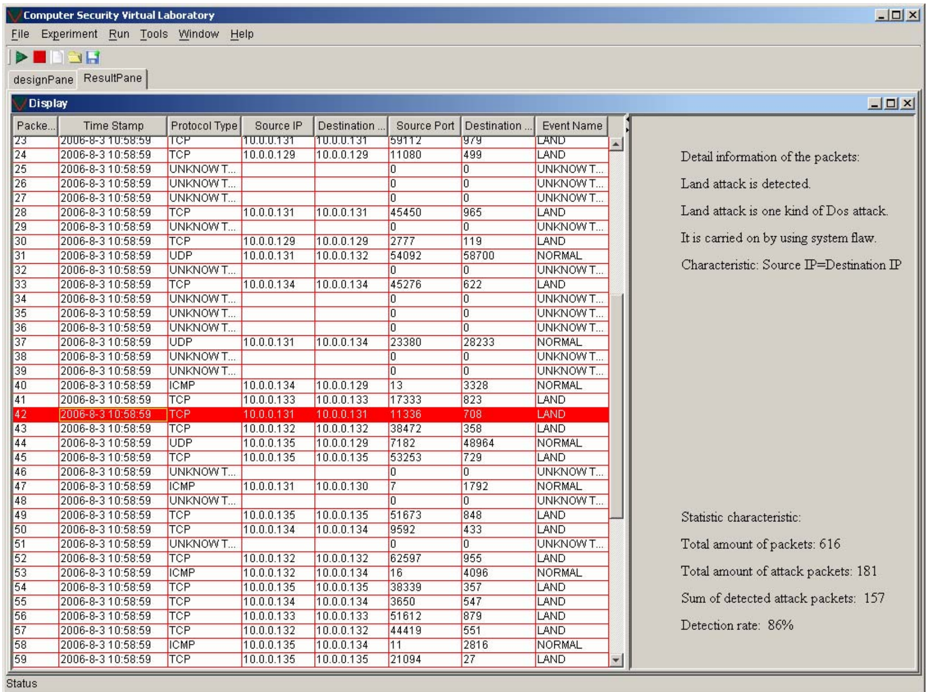

Fig. 6. Simulation result

etc. Fig. 5 illustrates the user interface of the IDSVL system. The left panel is component column, which provides a lot of experiment equipment components for the users to choose. The middle is experiment operation window and the right is attribute editor for components. Here we will take the Land Attack for example to explain the whole experiment procedure as follows.

Step 1: Choosing experiment components. Users firstly choose “data generator” component, “data sampling” component, “data analyzer” component as well as “tabular display” component from the component column, and then drag and drop these components into experiment operation window.
Step 2: Configuring components parameters. Users can choose the selected experiment components and set the attribute of these components in the attribute editor one by one according to their requirement. In the experiment, we choose the simulation data generator to generate data flow, and the attack type is “LAND”. Other components’ attributes are all chosen the default setting.
Step 3: Connecting experiment components. Users connect the selected experiment components above in order. After the step, users can get the experimental flow sheet showed in Fig. 5.
Step 4: Run the simulation experiment. After completing the three steps mentioned above, users can press the button “Run” to start the experiment.

As shown in Fig. 6, the experiment results will be displayed in the result panel. The left frame gives the detection result in tabular form, and the output information in the table includes time stamp, protocol type, source IP, destination IP, source port, destination port, the name of trigger affair, etc. While the right frame gives the event description and some important statistic information, such as the total of generated packets, the sum of attack packets, detection rates and false alarm rates, etc.

6 Conclusion

This paper introduces the theory of intrusion detection technique and the common model of IDS, discusses the architecture and implement scheme of IDSVL system in detail. The IDSVL system adopts virtual lab platform based on Internet so that it can satisfy the requirement of long-distance teaching. There is good interaction between users and system because of the visualized user interface. The client that implements by Java Applet has the platform independence and security of Java language. The virtual experimental equipments are implemented with Java Bean. The equipments library that uses component method is easy to extend, which improves the developing efficiency and achieves the software reuse. Users can understand the fundamental of IDS deeply through attaching themselves to the whole process of intrusion detection emulation.

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Process Control Model in Web-Based e-Learning

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Abstract. Nowadays most web-based learning systems have already utilized advanced technologies like web services and etc., even grid computing to minimize the gap between traditional learning and e-Learning. Meanwhile, there is a trend towards achieving automatic and personalized learning. However, learners may find difficulty navigating through learning resources on their own; process control in e-Learning systems is still not fully considered. This paper proposes the learning path concept and its formal definition method, and then a process control model for e-learning is proposed to implement the process control from e-Learning applications to learners. This work improves the learning efficiency by providing teachers tools for designing courses with learning paths and giving students the opportunities to achieve an orderly learning experience through process control strategy. Some questions in application and future works are also discussed.

Keywords: e-learning, fuzzy Petri net, workflow, process control.

1 Introduction

E-Learning gradually becomes the focus of modern society interests as a new education style, which uses network technologies to break the temporal and spatial limit in traditional education with the hope to offer learners an individual learning experience at anywhere anytime. Web service technology is used to enhance the e-Learning systems to communicate more efficiently and share data more easily [1] [2], even grid computing begins to be considered in improving the computing capability of e-Learning system [3]. With those efforts, e-Learning systems have showed us their breaking the limit in flexibility, distributed computing and storage capabilities so as to provide an open and more efficient learning environment.

Nevertheless, learners are prone to reduce learning efficiency and even get lost during learning activities if they are lack of the strategy of searching and organizing learning resources in great amount of distributed resources. Some crucial tasks done in the traditional classroom have not been completely transferred into e-Learning systems. We believe that a teacher's preparation for lessons is of great importance for his students. In traditional teaching mode, teachers spend much time organizing the teaching contents and adjust them dynamically in the classroom so as to lead students to efficient learning. Some popular products, such as WebCT Vista [4], WBT TopClass [5], Lotus Learning Management System [6], still do not fully consider giving

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instructors opportunities to define a structural course for guiding students to navigate learning resources, although some of them allow assembling several different courses to build a new one. In recent years e-Learning systems have promised to change the way people learn. However open issues still remain, in particular actual e-Learning environments do not consider learning activities as part of the process of learning [7].

Recently, workflow technology is used to design and develop process-oriented courses and trace student process, like Virtual Campus [7], Flex-eL [8]. Liu [9] and Chen [10] also provide Petri net-based formal method solutions. However, they all only integrate local learning resources; do not enable e-Learning services. Though these applications adopting workflow technology can achieve the automation of procedures according to a set of rules, they lack formal definition and analysis method.

Considering those disadvantages in process control of learning activities in e-Learning systems, we proposed a process control model in service environment which allows using extended fuzzy Petri net as formal method to define structural courses and to provide learners an adaptive learning environment for navigating learning resources one by one in sequence. By deploying the defined course in this model, different learning object of a course provided by different services can be accessed regarding to learner's study progress.

This paper is structured as follows: In Section 2 we introduce the concept of learning path, and the related technologies for describing and implementing it. Then Section 3 introduces the formal description of learning path and evaluation method. Section 4 shows the process control based e-Learning model. Section 5 we discuss the algorithm and implementation issues on this model. Section 6 illustrates how the learners can interact with our model through the learning path. Finally, Section 7 draws some conclusions and outlines directions for future work.

2 Concept of Learning Path

In an attempt to implement the process control between e-Learning applications and users, we need workflow technologies which are concerned with the automation of procedures where documents, information or tasks are passed between actors according to a defined set of rules to achieve an overall business goal [11]. Once a workflow template is defined, it can be implemented by deploying workflow management system (WFMS). Generally, in an e-Learning application where courses are defined as workflows, the participators of workflow are instructors and learners, the activities of workflow correspond to learning activities of learners such as searching learning objects, browsing learning objects, taking exams and so on.

In this paper, a learning path relates to the navigation sequence through a structured course and a learning path node is a learning object associates with a learning object service like a chapter or a section of a course. The activity of one node indicates invoking relevant LO service. There are also conditions and strategies for path choice between LOs, which can be added into operations like AND-SPLIT, AND-JOIN, OR-SPLIT, OR-JOIN, etc. Fig. 1 is an intuitionistic view of simple learning path for a certain course. LO B and C must be accomplished after A. LO D, E and F need to be finished after LO A, B and C. LO B and C are synchronous (AND-SPLIT/JOIN) which can be learnt at the same time with no requirements of sequence, while E and F could be chosen alternatively (OR-SPLIT/JOIN).

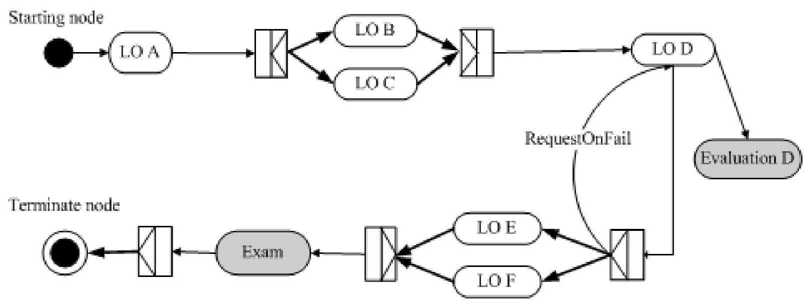

Fig. 1. Simple Sample of Learning Path

As nodes contain the important resources for learner's learning activities, the study result has tight relationship with the complete result of those nodes. In each node, recording its own status value for each learner is needed. There are six status value can be used according to SCORM data model definition[12]: "Passed", "Failed", "Completed", "Uncompleted", "Not attempted" and "Browsed". The initial status value of a node should be set to "Not attempted", then when the status value can be transited from "Not attempted" to "Uncompleted" can be decided by different strategies. For example, the system transits the status value to "Uncompleted" while it ensures that the learner has got the learning object already, etc. After the learner finishes learning a LO, the status value can be changed to "Completed". If there is a test for the learning object, the status value could be changed to "Passed" or "Failed", otherwise "Browsed".

Here we extend fuzzy Petri net for formal description of learning path. Looney [13] first modified the typical Petri nets which can represent the fuzzy production rules of a rule-based system to achieve fuzzy rule-based reasoning. In the e-Learning system, a fuzzy Petri net is associated with a course and path definition with different learning content structures and different transition conditions according to students' learning result of the previous objects.

The implementation description of learning path takes the industry standard BPEL4WS (Business Process Execution Language for Web Services, BPEL for short) [14]. BPEL provides a language for defining workflows between web services which could fulfill different activities such as web service invoking, data manipulation, faults tolerance and process termination so as to combine them all together and build a complex process. These activities could be nested into structural activities defining the running mode of activities within. For example, serial or parallel are determined by certain conditions. BPEL calls service which interacts with it as partner which has a unique name and corresponding WSDL document [15]. Developers can define the relationships between partners through a set of rules. More important, the process can interact between users and services by starting with the "receive" operation in response to the client request and ends with noticing users by "reply" operation.

The deployment and implement of learning path also require workflow management system (WFMS). In WFMS, different instances of the same workflow could run simultaneously where each one has its own status. In e-Learning environment, the same learning activities of different students can be run simultaneously and WFMS helps to maintain their own performance statuses. At present, the interaction between users and

WFMS is based on documents. However, what kind of document should be submitted to WFMS by users when they complete studying a LO and want to know the next step is the problem we must solve. We will discuss it in Section 6.

3 Learning Path Description and Evaluation

After introducing the concept of learning path, we extend the fuzzy Petri net model [16] as learning path (LP) to provide course definition with learning sequence. LP can be graphically presented by two types of nodes which are places and transitions, where each place may or may not contain a token associated with a proposition and a truth value between 0 and 1, and each transition is associated with a certainty factor value (CF) and a threshold value between 0 and 1. Thus an LP model can be defined as an 6-tuple:

LP = (FPN, M, K_p, K_t, E_p, S_p), where FPN is a basic fuzzy Petri net:
$P = \{p_1, p_2, \ldots, p_n\}$ is a finite set of places;
$T = \{t_1, t_2, \ldots, t_n\}$ is a finite set of transitions;
$D = \{d_1, d_2, \ldots, d_n\}$ is a finite set of propositions;
$P \cap T \cap D = \Phi$, $|P| = |D|$;

I: $T \rightarrow P^{\infty}$ is the input function mapping from transitions to bags of places, a directed arc from p_j to t_i exists if $p_j \in I(t_i)$;

O: $T \rightarrow P^{\infty}$ is the output function mapping from transitions to bags of places, a directed arc from t_i to p_j exists if $p_j \in O(t_i)$;

f: $T \rightarrow [0,1]$ is an association function mapping from transitions to real values between zero and one, if $f(t_i) = \mu_i$, where $\mu_i \in [0,1]$, t_i is said to be associated with a real value μ_i;

α: $P \rightarrow [0,1]$ is an association function mapping from places to real values between zero and one, if $\alpha(p_i) = y_i$, where $y_i \in [0,1]$ and $\beta(p_i) = d_i$, then the degree of truth of proposition d_i is y_i;

β: $P \rightarrow D$ is an association function, a bijective mapping from places to propositions, if $\beta(p_i) = d_i$, where $d_i \in D$, p_i is said to be associated with the proposition d_i;

M: $T \rightarrow$exp r specifies the addition modes for firing the transition;

K_p: $P \rightarrow E_p$ is one to one mapping from places to evaluation learning object set E_p;

K_t: $T \rightarrow S_p$ is one to one mapping from transitions to learning object set S_p.

Next we give detail explanation about some elements in LP.

Place: denotes learning object service which can be accessed from service provider, and the token in it maintains the status of the service. The learning object associates with meta-data which describes the learning resources in a common way and facilities the search. There is also a kind of learning object we call it evaluation learning object which is developed according to IMS's Question & Test Interoperability Specification (QTI) [17] to help to evaluate the user's learning performance.

Transition: moves from one learning object to another. A transition t_i is enabled if for all $p_j \in I(t_i)$, $\alpha(p_i) \geq \lambda$, where λ is a threshold value and $\lambda \in [0,1]$. By setting different threshold values whether the user can pass current learning object can be decided. Firing transitions can be considered as firing fuzzy production rules. For example, 5 basic rule types according to 16 can be used to describe the learning path routing, the larger the value of μ_i, the more the rule is believed in:

Sequence R_i: IF d_j THEN d_k (CF =μ_i)
AND-SPLIT R_i: IF d_j THEN d_{k1} and d_{k2} and … and d_{kn} (CF =μ_i)
AND-JOIN R_i: IF d_{j1} and d_{j2} and … and d_{jn} THEN d_k (CF =μ_i)
OR-SPLIT R_i: IF d_j THEN d_{k1} or d_{k2} or … or d_{kn} (CF =μ_i)
OR-JOIN R_i: IF d_{j1} or d_{j2} or … or d_{jn} THEN d_k (CF =μ_i)

In addition, M is a firing mode function: specifies the method how to trigger the firing of a transition. It could be:

Auto: the firing task can be triggered immediately when it is enabled without student's request.

Action: the firing task is triggered by student's actions like clicking a hyperlink on the web when it is enabled.

Delay: the firing task is triggered after a predefined period which can be used to force the student to complete his learning step within a certain time.

To see whether the firing condition is met needs tests for given LOs, because the evaluation results can be used to decide whether a student can move from one LO to the post-condition LOs. According to this consideration, we propose an evaluation learning object set E_p to which different LOs can be mapped by K_p. The evaluation LO includes reusable evaluation information and interfaces for user input and score output. In addition, each transition can be mapped to LOs set S_p by K_t to specify review LO if a student failed a test.

LOs and evaluation LOs have reusability for different courses due to their standard metadata description. Different evaluation LOs can be used for the same LO, but only one evaluation LO can be bound to a LO at the same time. Thus, by setting different threshold values of a transition, even though using the same evaluation LO, the teacher can achieve different difficulty levels for a variety of students. Then comparing the token value as evaluation grade with the threshold value as passing level can see whether a student achieved the requirement. Here we present a simple evaluation procedure for calculating the token value: let the full grade of the evaluation be 1, an evaluation LO includes n evaluation items, their difficulties are $d_1, d_2, \ldots, d_n$ ($d_n \in [0,1]$). The higher the value is, the more difficult the item is. A student's actual grade for each item is $m_1, m_2, \ldots, m_n$ ($m_n \in [0,1]$),

$$m_i = \begin{cases} d_i - \dfrac{\frac{\sum d_j}{n}}{n}, & \text{if wrong} \\ 1, & \text{if correct} \end{cases}$$

then the final score can be assigned to token value: $\dfrac{\sum m_i}{n} \rightarrow y_i$, y_i is the study grade, where $y_i \in [0,1]$. The higher the study grade y_i is, the more the evaluation result of certain part in a course is satisfied.

Let PR be a set of fuzzy production rules, NPR be a set of fuzzy production rules for normal navigation through the learning path, RPR be a set of fuzzy production rules for reviewing after failure on tests. The ith fuzzy production rule is formulated as follows:

IF $y_j \geq \lambda$, THEN $PR_i = NPR_i$ (threshold value = λ)
NPR_i : IF d_j THEN d_k (CF $=\mu_i$)
ELSE $PR_i = RPR_i$
RPR_i : IF d_j THEN d_l (CF $=\mu_i$, $d_l = R_p(t_i)$)

where y_j is the token value in d_j , its value is between zero and one and will be regarded as learning result from the student. The threshold value of t_i is λ which is used to determine the next reachable place according to using NPR_i or RPR_i. For example, d_j is "LO_j is accessed for learning", d_k is "LO_k is accessed for learning", d_l is "LO_l is accessed for reviewing", depending on the token value d_j and threshold value λ, transition t_i can decide whether fire to d_k for further learning on satisfied test result or to d_l for reviewing on test failure.

4 Proposed Process Control Model

A defined learning path itself cannot run and interact with the learners, so there is need of an open model both for teachers to define, map to composition services, deploy their courses, and for learners to be guided by that model.

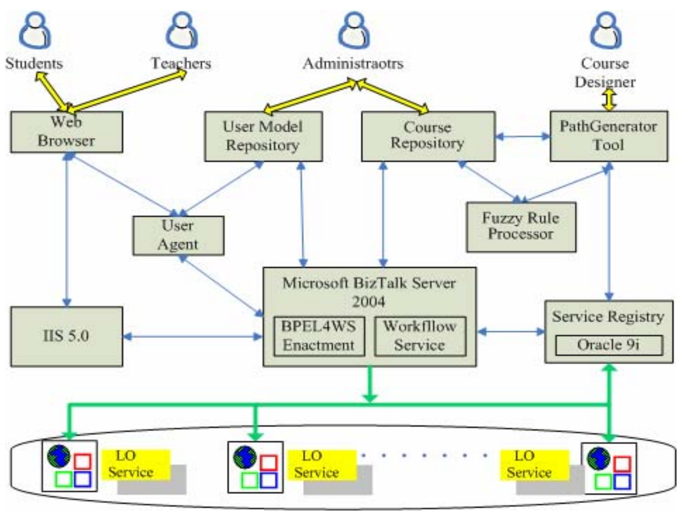

Fig. 2. Proposed Process Control Model

An open and self-centred learning environment not only shares learning objects, but also provides enactment of learning path for various roles. The emerging web service and grid service technology bring us an open environment where learning objects can be searched in registry and accessed through portTypes. Workflow technology can combine services providing different learning objects and implement orderly learning activities by invoking relevant services.

Therefore, we attempted to integrate web service and workflow technology to build a process control model PCM. PCM contains the WFMS, web server, a collection of Web Services, some repositories and other useful tools. Fig. 2 demonstrates the main model of PCM.

LO Service. There is many standards in description of learning object metadata. This model is as a test bed for CELTS (Chinese E-Learning Technology Standard, http://www.celtsc.edu.cn). CELTS standard specifies a data schema for describing the structure of a metadata instance. So we could use CELTS schema to describe the attributes of learning object and the binding language of CELTS schema is XML. The use of CELTS for description of metadata could greatly facilitate searching of learning objects.

As we can see, there are various LO services at the lowest layer of PCM, which are managed by various learning objects providers to provide different learning resources in different areas. These services could be distributed physically and run on different platforms. They also could be web services or grid services (Recent system mainly uses web service. We will offer support for grid service in later research). Each LO service has individual hardware and software environments and organization strategies.

LO services provide functions as follows:

To publish learning objects by uploading metadata XML files to LO service registry;
To manage published learning objects including update and delete operations;
To support searching of learning objects in local area based on metadata;
To support acquisition of learning objects;

LO service registry. LO services publish respective WSDL documents in LO service registry. They also publish learning objects by uploading metadata XML files of learning objects. Meantime, service registry supports searching of registered learning objects with different searching conditions/in different searching ways. Oracle 9i database which supports XML files storage and search is used in this registry.

PathGenerator Tool. PathGenerator is a tool to define courses with learning path. Course designers (When there isn't such special role, it could be competent manager or teacher.) search for the needed learning objects by PathGenerator from LO service registry, define the relationships and orders of them, add in strategy of path choice, and finally establish a course template described by BPEL which will then be transferred to course repository. Course designers can also establish different templates for a single course so as to implement different learning targets for different learners. Fig. 3 is the UI of PathGenerator tool.

Fuzzy Rule Processor. As we know a FPN is associated with a set of fuzzy rules, this rule processor can transit defined rules to learning path, then it validates the rationality of designed learning path, and reasons the learning path to avoid deadlock. We can treat the work procedure of rule processor as solving a fuzzy problem related to a certain learning path.

Course Repository. When a student starts a course, WFMS takes the course template chosen by learners or designated by instructors from course repository and generates an instance of such template. Course repository allows course designers to view course templates available and modify on recently course templates to create a new one while it also permits administrators or instructors to view them.

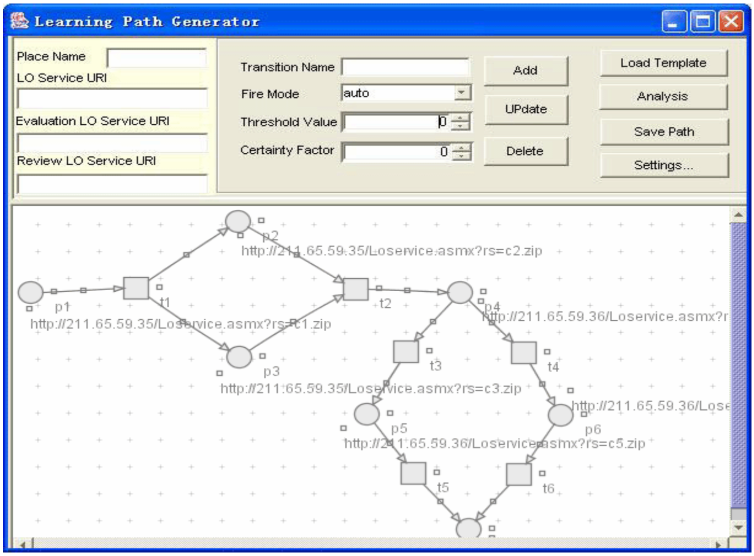

Fig. 3. PathGenerator Tool UI

User Model Repository. A well-designed user model should include a user's knowledge and past learning experiences as an important evidence for system to provide individual education, so that the system can skip the knowledge a student already mastered to help he/she finds the information actually needed quickly. In PCM, user model is designed as a copy of course instance with additional status value in each activity node to track learner's study paces. When an instance of a course restarts, WFMS bypasses completed nodes according to user model and first locates the node the learner needs currently. To users, it seems not to start from the first node. (Actually, workflow instance still begins from the first node but just jumped over some unnecessary nodes).

WFMS. We choose Microsoft Biztalk Server 2004 as the workflow engine in PCM. A course with defined learning path actually determines the process of how and when to get each learning object. WFMS has to follow the course definition to call relevant services. Course learning includes the request to LO service and the interaction with students which are implemented in BizTalk by invoking external services and local service. External services correspond to the LO services while local service interacts between learners and WFMS.

Following Fig. 4 illustrates a typical learning sequence scenario when a learner starts his own learning process according to pre-defined course learning path and his user model.

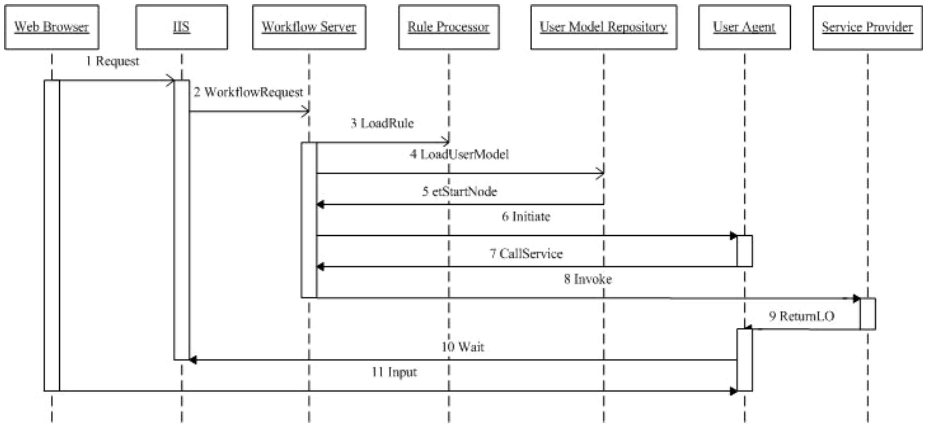

Fig. 4. Typical learning sequences in e-Learning model

5 Generation of Learning Path in PCM

Generations of learning path for a course contains two important steps which are searching for needed LOs from description of published LOs metadata, mapping the LP to combination of needed LO services and publishing them into workflow management system. Now we introduce the design and implementation issues from two aspects.

5.1 Search of Learning Objects

First, we need to find out the relevant learning objects according to description of all learning objects metadata before defining a workflow-based course. In the platform adopts PCM, we need a method to search specific information included in metadata XML in service registry. We choose XQuery [18] as the search method for learning objects because XQuery is the standard designed by W3C for searching several kinds of XML source formats. It is of great importance that it could carry out search with complex condition not only in a single XML file but also among several XML files, rational databases, objects and other non-structural documents. This property does accord with the requirements of cross-searching for relevant LOs in LO service registry.

5.2 Mapping LP to Services Composition

Next, we generate the implementation description of learning path defined by PathGenerator Tool. Considering that each learning object in a certain learning path is provided by learning object service, the idea of choosing BPEL comes from that course is an integration of several learning objects services. As a kind of standard process description language, BPEL does not rely on detail workflow management system which facilitates easy system update or replacement. Thus, BPEL is exactly the suitable standard which integrates the services on Internet in our model. PathGenerator gets the WSDL documents of services where each LO comes from, and then takes defined LP and corresponding WSDL documents as the evidence for the BPEL code. Due to the support of structural activities by BPEL, activities which are to be run could be described as orderly structure. Therefore, fuzzy production rules could be translated into activities in BPEL. Table 1 gives the correspondence between them.

Table 1. Correspondence between fuzzy production rules and BPEL

Fuzzy production rule	BPEL description	BPEL Function
Single rule	Sequence	Including a serial of orderly run activities and a final activity to end process.
"or" rule	Switch	Choosing a branch with *true* condition.
"and" rule	Flow	Synchronization and parallel between activities.

Suppose that we have already had a course defined by LP model, the works that should be done in advance includes:

1) Define each part of a course. Normal propositions $d_1, d_2, \ldots, d_n$ are drawn from the main part of a course, the reviewing propositions $d_{n+!}, d_{n+2}, \ldots, d_{n+m}$, where $n \geq m$.

2) Define the mapping function from LOs to evaluation LOs wherever the LO needs an evaluation procedure.

3) Define the production rules. By setting the threshold value λ to each transition, the relationship between normal propositions and reviewing propositions will be established.

Fig. 5 shows a defined LP according to Fig. 1.

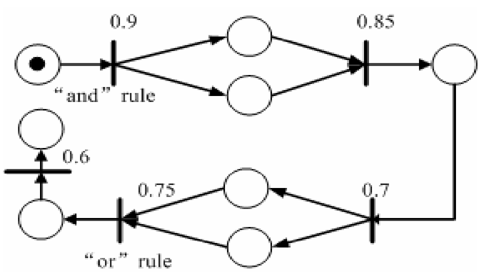

Fig. 5. Simple sample of LP

Now, we propose the brief mapping algorithm as follows, here, a concept introduced by Chen, Ke and Chang 16 can be used, allowing a set of places which is immediately reachable from a place p_i is called the immediate reachable set of p_i and is denoted by IRS(p_i).

Let PlaceActivity(p) be the function which generates codes for invoking the external LO service that provides LO according to p and the associated evaluation LO:

```
if Kp(p) ≠Φ, the token in p has a mapping evaluation LO then
<sequence>
   <invoke> LO service for p </invoke>
        <flow>
              <invoke> LO service for Kp(p) </invoke>
              <invoke> User Agent </invoke>
        </flow>
   </invoke>
</sequence>
else <invoke> LO service for p </invoke>
```

where User Agent service is an internal service. Through its parallel execution with another external LO service, it can interact with the students to receive their input.

Step 1:
Let p_r be the starting place, generate a BPEL process, add <process> element;
let parent place $p= p_r$, where p is the current node to which the BPEL activities will be add
Step 2:
ELN2BP(p) is a recursive function for mapping places, production rules and transitions into BPEL process:
Let t_p be transition whose input place is p , $p \in I(t_p)$;
let PR_t be the production rule mapped to t_p;
First, mapping the firing mode function M to BPEL code before firing a transition between p and IRS(p):
if G(t_p) = auto **then** generate active by PlaceActivity(p);
else if G(t_p) = action **then** generate <flow> activity for PlaceActivity(p) and <invoke> activity which calls the internal User Agent service to receive client's action request;
else if G(t_p) = delay **then** generate <wait> activity which will remain idle for a given time period until firing the transition.
Next, we map different production rules to composition services.
if PR_t contains "and" and $|O(t_p)| > |I(t_p)|$, transition t_p is according to AND-SPLIT operation, **then**
generate <switch> activity, in case of input token value $\alpha(p)$ is more than threshold value, generate <flow> activity, for each $p_i \in$ IRS(p), insert active by PlaceActivity(p_i); in case of $\alpha(p)$ < threshold value, PlaceActivity($K_t(t_p)$) for firing reviewing production rule.
else if PR_t contains "or " and $|O(t_p)| > |I(t_p)|$, transition t_p is according to OR-SPLIT operation, **then**
generate <switch> activity, in case of input token value is more than threshold value, generate<switch> activity, each case is implemented by PlaceActivity(p_i) and case condition is $\alpha(p) - \lambda$, where $p_i \in$ IRS(p), $t_p \rightarrow \lambda$, in case of $\alpha(p)$ < threshold value, PlaceActivity($K_t(t_p)$).
else if $|O(t_p)| = |I(t_p)| = 1$, it's a sequence operation **then**
generate <switch> activity, in case of $\alpha(p)$ > threshold value, insert active by PlaceActivity(p_i), where $p_i \in$ IRS(p), in case of $\alpha(p)$ < threshold value, insert activity by PlaceActivity($K_t(t_p)$).

else if $|O(t_p)| = 1$ and $|I(t_p)| \neq 1$, t_p is either AND-JOIN or OR-JOIN transition, **then** the same procedure as above sequence operation.

Last, for each $p_i \in$ IRS(p), let $p = p_i$, if IRS(p) $\neq \Phi$, call ELN2BP(p), else p_i is either a leaf node or terminate node, return.

Step 3:

In a workflow-based course, the end of the course should be a definite terminate node. So if p is a leaf node, throw an error information to remind the teacher to redefine the LP model, and if p is the terminate node.

6 Interaction Between User Client and PCM

Workflow management system as a backbone of PCM plays an important role as a bridge between students and LO services, but BizTalk is designed for interaction with web services or code plug-ins. However, in a fruitful learning environment, WFMS needs to track students' activities [7]. So, we have built an interaction mechanism based on a designed local service we call it User Agent service. When the WFMS needs to get the user's input, it calls the User Agent service; the User Agent service waits for user's input and transfers it to WFMS. User Agent service is not only a service called by WFMS in PCM, but also responsible for maintenance of user models during the workflow run-time.

As a course template has user models according to it, which give important information for tracking study status and designing personalized course template, a mechanism for tracking user's activities in course study is needed. It is obvious that whether a user has gone through a node in learning path can be decided by checking whether he has accessed the LO related to that node. If a node in learning path doesn't bind any evaluation LO, an access to the relevant LO can be simply considered as having experienced the node. As far as considering a node binding an evaluation LO, as soon as the node status is assigned "completed", the evaluation LO will be called.

Fig. 6. GUI of Learning Path and User Agent

When a user starts a workflow course instance, a local User Agent service will be called at the same time a node active starts, User Agent service gets all node status information from the user model, bypasses all "passed" nodes and locates the node the user currently needs to learn. During the runtime of course learning, User Agent listens to user client's input, calls the corresponding next node activity, and returns the LO to the user. Fig. 6 shows the GUI presented to the user. On the right is the graphic presentation of course structure using Java Applet, and Microsoft Wizard has been chosen to present a vivid User Agent image service to the user.

7 Conclusion and Future Works

In this paper, a well-structured e-Learning model supported by the power of WFMS has been designed. A main contribution of this research is the formal description of learning path and the application of workflow technology in building and implementing workflow course in service environment. Our approach shows that students can benefit from this approach to study on their own pace, with own time arrangement by the guide of learning path.

The following research items need further discussion:

Now the resources in the learning path are related to existing learning objects, we try to design different course templates associated with abstract learning objects, then concrete learning objects are assigned to create different courses.

Design more rules for learning path choosing, support different composition ways for building larger course using existing course templates.

In a typical learning path, retrieving a learning object is achieved by calling a LO service. If the LO service becomes a grid service, a solution should be given to the grid services composition with BPEL.

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Automatic Audio Indexing and Audio Playback Speed Control as Tools for Language Learning

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Abstract. The Gong system has been developed for web based communication. It supports synchronous and asynchronous audio communication and can be embedded in other learning management systems. This paper discusses two novel features which are targeted at language learners using the system. The first is the ability to automatically index an audio recording. After the indexing has taken place the user is able to select one or several words and hear just those words spoken in isolation. The second is the ability to vary the playback speed of any recorded message. The technical details of their implementation as well as pedagogical use of these features are discussed.

Keywords: Audio Indexing, e-Learning Tools, Speech Recognition.

1 Introduction

The Gong system has been created as a tool for web based communication and learning. The system supports both synchronous and asynchronous voice and text communication. The input and display of Unicode characters is supported, as well as specially developed features for the input and display of the Cantonese and Putonghua dialects of Chinese. The entire system can operate in a number of different languages, and can be embedded inside other learning management systems. An API has been developed so that the features of Gong can be accessed and controlled in the web page environment by languages such as JavaScript, VBScript and Flash. A module has been released so that Gong can be used as an integrated component in the popular Moodle learning management system. See [1] for a description of Chinese language features as well as a general overview of the Gong system. Our web site [2] may be accessed for more information about the system including what it can do and how it can be used, and for downloading Gong.

An example of the system being used as a voice board is shown in figure 1. The display shows messages in the voice board. The currently selected message is shown under the message list. A list of currently logged on users is also shown, facilitating real-time audio and text chat.

In addition, special features have been developed which are intended primarily for language learners. The main focus of this paper is on two such features: the automatic indexing of spoken audio, and audio playback speed control.

W. Liu, Q. Li, and R.W.H. Lau (Eds.): ICWL 2006, LNCS 4181, pp. 290 – 299, 2006.

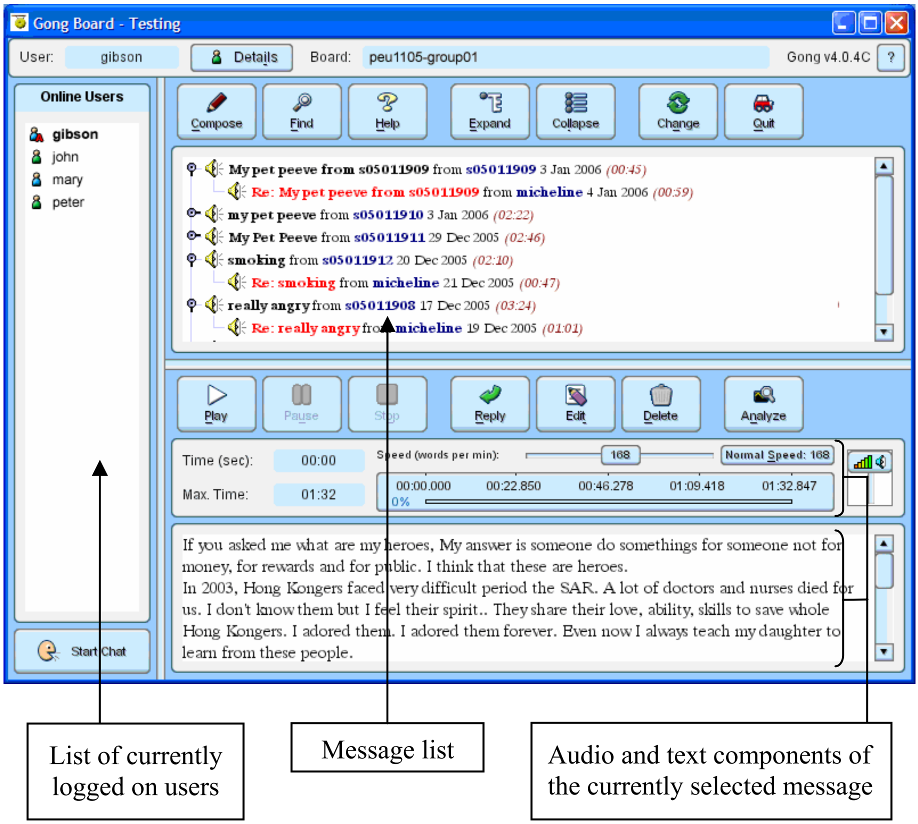


Fig. 1. A typical Gong voice board display

2 The Gong System

The Gong system is built using Java. The system requires the Tomcat server for server side operation. For client side deployment Gong is available as an applet as well as an application. Functionally, both are equivalent. For applet operation the Java run-time environment must be previously installed in the client system. For operation as an application there is no such requirement, as a preferred version of Java is included within the installation. When used as a component in other learning management systems Gong is used as an applet.

3 Indexed Audio

3.1 Overview

In the most common use of the Gong system, a text and/or audio message is created by a user and is posted to a voice board where others can read and give feedback on it.

We have enhanced our system with the ability to automatically index any message. That is, when the text is a transcription of the spoken words of the same message, then we can automatically match the words to their spoken counterparts. The indexing can then be used for a number of pedagogical functions.

From the user's point of view the generation of the word indexing is simple. The user selects a button in order to create a new message. He/she then records the speech component of the message. The corresponding text is entered. Finally, the user selects 'Index'. After a short delay the automatic audio indexing process is complete. The message can then be posted so that any users can use the pedagogical functions that are built upon the results of the audio indexing operation.

3.2 Pedagogical Usage

The indexing results in a sequence of start and end tags indicating the start and end of the corresponding spoken word. Figure 2 illustrates the start of word tags for the four words 'she eclipses and predominates' overlaid on a spectrogram of the speech signal.

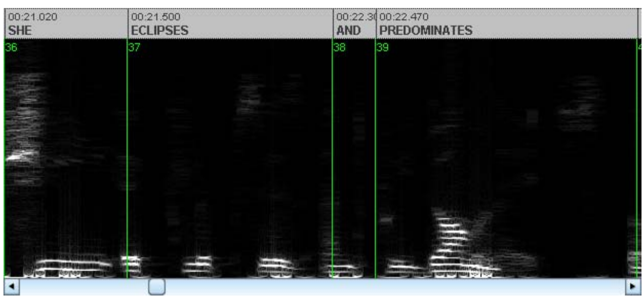


Fig. 2. The display of starting word markers on top of a spectrogram of the speech

From a pedagogical point of view there are a number of ways in which the indexed audio may be used.

- During playback of all or part of the audio the words which are being played at that moment in time are highlighted while they are being played. This greatly assists learners in developing sight reading skills, as there is a clear visual indication of the progress of the speech.
- The user may double click on a single word in order to hear it in isolation, or the user may select any number of words and press play in order to hear those words. This is illustrated in figure 3. In this way the user can concentrate on phrases which require repeated attention, without being required to play the entire speech again.
- The user may search for any word or phrase within a message. All instances of the search term are then shown highlighted, as indicated in figure 4. The words can therefore be easily played and contrasted with each, in order to reveal contextual differences in pronunciation.

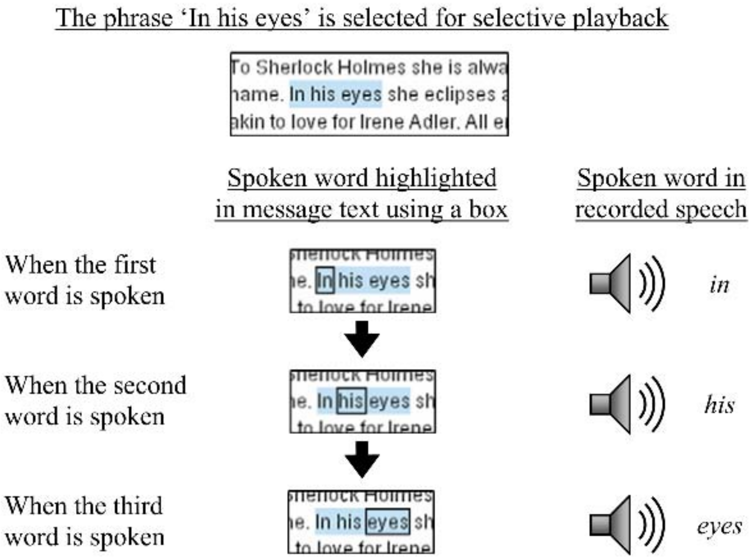


Fig. 3. An example of playing back three selected words, after audio indexing has taken place

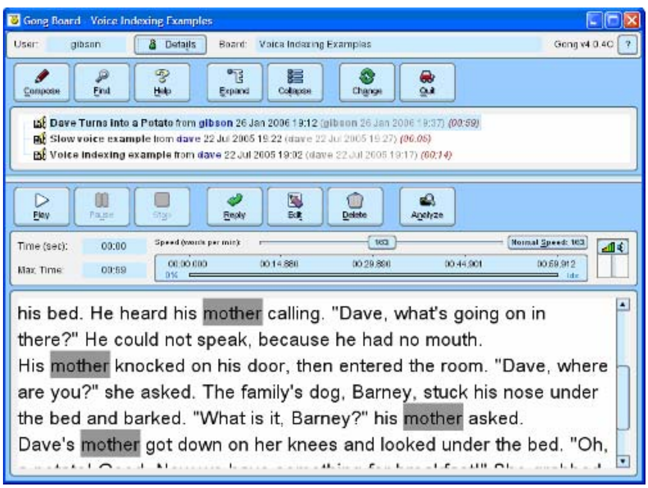


Fig. 4. An example of message text search. In this case four instances of the search term 'mother' have been highlighted by the system, and can be individually selected for audio playback.

3.3 Methodology

The audio indexing is performed by an automatic speech recognition (ASR) system. When Gong is being used as an applet the entire recognition system is downloaded into the client machine when the text indexing operation begins. This dynamic download ensures faster download of the applet, as audio indexing may not be used every time. For the application version of the Gong client side code the ASR is included in the installation.

A simple overview of the automatic speech recognition (ASR) system is shown in figure 5.

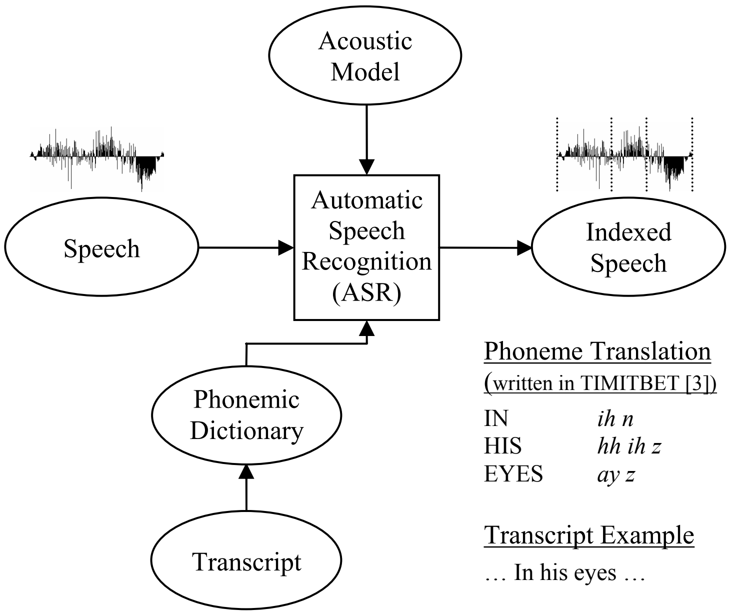


Fig. 5. An overview of the automatic speech recognition system

The ASR system consists of

- A dictionary file. This contains the phonemic transcriptions of more than 100,000 common English words.
- A set of acoustic models, one for each English phoneme. We use a set of 39 English phonemes to label all English words in the dictionary. They are implemented as hidden Markov models (HMMs) [4]. Hidden Markov modeling is the most commonly used technology in today's state-of-the-art ASR systems. An HMM is basically a stochastic finite-state automaton, and the probability that an acoustic observation is generated by an HMM state is governed by a probability distribution. In our system each HMM has 3 states arranged from left to right with no skipping or reversing arcs, as shown in figure 6. The 3 states are used to capture the acoustics at the onset, middle, and ending of a phoneme during its realisation.
- A phoneme recogniser. This can identify the phonemic contents in an utterance. The recogniser in our system employs statistical pattern recognition techniques.

The recogniser in Gong works as follows: the corresponding phonemic transcription is first created by looking up each word within the orthographic transcription (that is, the textual component of the Gong message) with our electronic

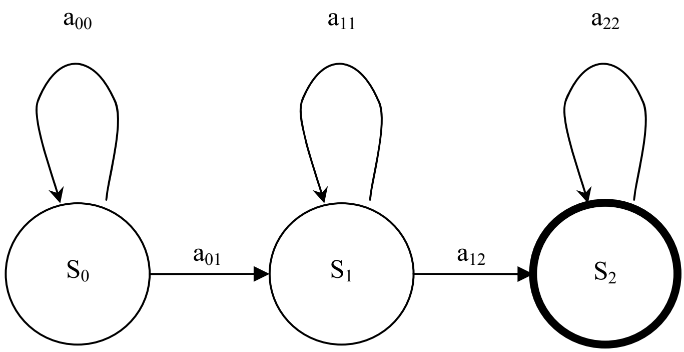


Fig. 6. The three states of a HMM used in our model

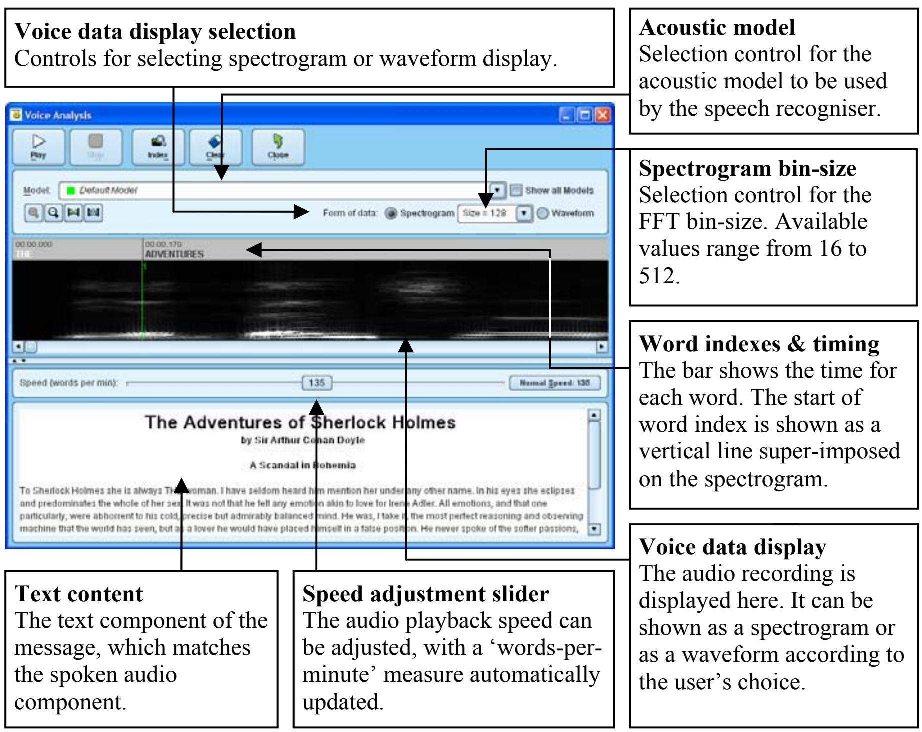


Fig. 7. An overview of the user interface of the automatic speech recognition component of the system

dictionary. Based on the phonemic transcription and with the use of the acoustic models, the phoneme recogniser will find the optimal time alignment between the phonemic transcription and the audio recording. In other words, the recogniser tries to find out the best beginning time marker and ending time marker for each word in the given utterance. The aligning procedure involves warping the acoustic signal dynamically along the time domain to fit the corresponding phoneme models until we get the most likely alignment - in the statistical sense - using a dynamic programming algorithm called the Viterbi search [5].

The Gong system supports any number of models, so it would be possible to support audio indexing of different languages. At the time of writing only one model and phoneme dictionary is used, for the English language.

Figure 7 shows the complete display in the Gong system for interfacing with the ASR sub-system. Controls for the selection of the acoustic model and spectrogram display are shown near the top, followed by a spectrogram display of the speech, and then the textual equivalent. The elements near the top of the GUI which are related to models and spectrograms are kept hidden by default in order not to scare non-technical users of the system.

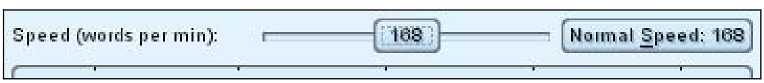
3.4 Words-Per-Minute Metric

After a message has been indexed a words-per-minute value for the message is shown. This is obtained by simply dividing the total number of words in the message by the duration of the spoken message (in seconds), and then multiplying by 60. This value provides an absolute speed measure which by itself can be used to provide an indication of the speed of the speech. For a language learner the difficulty of comprehension of the message is proportional to the number of words spoken per minute. Reference values can be used to help the learner rate his/ her level of understanding. For example, quality presentations are typically given at 120-170 words per minute; a normal conversation by native English speakers is approximately 200 words per minute; auctioneers use around 250 words per minute.

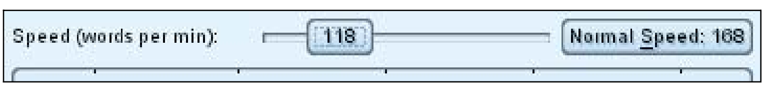
4 Audio Playback Speed Control

4.1 Overview

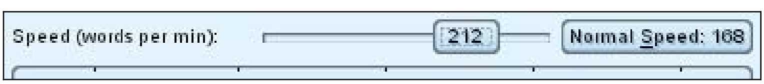
The words-per-minute value is combined with another feature of the Gong client, which is the ability to speed up or slow down playback of the voice recording without



A. A message being played at its recorded speed of 168 words per minute.



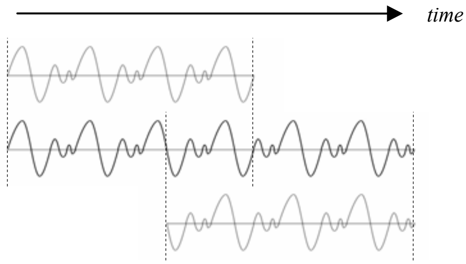
B. A message being played at a relatively slower speed of 118 words per minute.



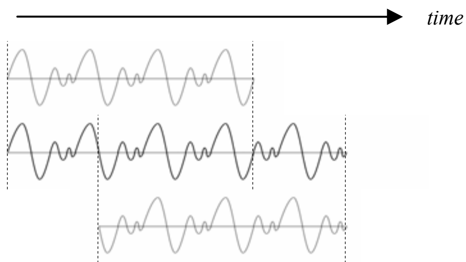
C. A message being played at a relatively faster speed of 212 words per minute.

Fig. 8. An example of the words-per-minute value used as a measure for audio playback speed control

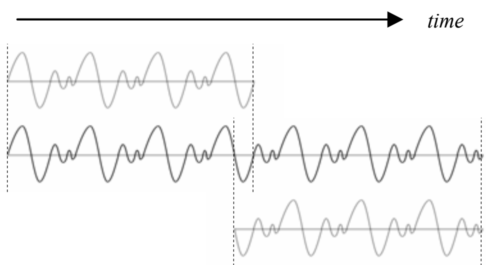
otherwise changing the sound. Usage of this feature is illustrated in figure 8. As the speed control slider is moved the numerical display of the words-per-minute measure is automatically altered to accurately reflect the new playback speed in terms of words-per-minute.



1. The audio recording (the middle trace) is divided into two overlapping sections (the top and the bottom one).



2a. Speeding Up: The second section is moved closer to the first one and therefore the resulting audio (the middle trace) becomes shorter.



2b. Slowing Down: The overlapping region is shortened and therefore the resulting audio (the middle trace) becomes longer.

Fig. 9. An illustration of how the speed of an audio recording is altered without changing the pitch

The playback speed control is a real-time operation meaning that users can interactively select a new speed and immediately hear the result.

4.2 Pedagogical Usage

An example of the use of speeding up the audio would be when a teacher is reviewing a language learning student's recorded voice, and the student is speaking very slowly. An example of the use of slowing down the audio would be when the student is trying to understand the spoken English of a native speaker speaking at a natural speed. The automatically adjusted words-per-minute measure provides a value by which the student can judge his/her progress over time, as increasing words-per-minute speeds become more comprehensible to the student.

4.3 Methodology

The algorithm used to change the speed of the recorded speech without seeming to adversely change the speech is based on the Synchronized Overlap Add (SOLA) method for speeding up and slowing down digital audio recordings [6].

Figure 9 provides an illustration of how this method is used to change the speed of the speech recording. The digital audio is first divided into a series of overlapping sections. These sections are then re-combined by adjusting the size of the overlapping region. The method tries to find the best overlapping position by maximizing a cross-correlation function so that there is minimal distortion in the resulting signal. The overlapping region of different sections is then combined using a cross-fade method.

To speed up digital audio, the size of the overlapping region is increased and therefore the length of the audio result becomes shorter. Relatively shorter length of the audio results in relatively faster audio playback. In contrast, to slow down an audio recording, the overlapping regions among these overlapping sections are shortened so as to increase the overall length of the audio recording. Because of the relatively longer length of the audio it produces a relatively slower playback.

5 Usage and Availability

The features described in this paper have been used as part of Gong by students and teachers at several education institutions including the author's home institute, distance learning institutions and secondary schools. At this stage we have not done a formal study of the advantages of the features, but informal observation shows that they clearly assist language learners in learning English.

6 Conclusions

The Gong system is a web based communication tool with support for learning. We have introduced two features which are especially useful for language learners. The first one is audio indexing. Given a voice recording and its transcript it allows learners to selectively playback a single word or a phrase by simply selecting the words. The second feature is audio playback speed control. Learners can playback a voice recording faster or slower measured by a words-per-minute metric. We have explained the methodology of these two features as well as various pedagogical usages depending on different situations.

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A Survey on Using IT in Administration and Management in Hong Kong Primary Schools

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Abstract. In this paper, we present and discuss the results of a survey on using IT in administration and management in Hong Kong (HK) primary schools after carrying out the implementation of the five-year IT plan in by the HK government. A questionnaire was designed to collect data on five areas: IT competency levels of different school personnel, the level of using IT in administration and management activities, the level of reliance of schools on IT systems and the barriers to the full use of IT systems. Several suggestions are made to exploit the full potential of IT in schools. In particular, we suggest using web-based learning as a mode of training for servcing teachers.

1 Introduction

The primary motivation of integrating information technology (IT) in education is to create an environment for students in engaging meaningful learning and critical thinking and in helping them transcend their cognitive limitations which hinder their learning. Since the introduction of computers into teaching in Hong Kong (HK) in 1982, many schools have expended efforts on computerizing their school administration activities [2].

Different schools devised their own IT plans with different pace to meet their different goals in the early 80's, depending on available resources and implementation constraints [2]. They were using isolated applications which were usually tailored made to meet the unique requirements of different management activities in schools. This ad-hoc approach led to the suffering from problems of application maintenance and interoperability.

The HK government in 1993 approved about 250 million HK dollars on the implementation of the School Administrative and Management System (SAMS). SAMS was centrally developed by the Education Department (ED) and is an integrated system consisting of 12 major applications and connecting all primary and secondary schools in the territory to the ED. It aims to improve administrative efficiency in school management and to provide the ED with data for planning and decision making. SAMS has now evolved into a web-based version which has several enhancements and new features.

Previous studies [1, 3, 7] showed that the introduction of SAMS had great impacts on the school administrative and management but hardly relieved teachers from heavy

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administrative workload. The deficiency in design leading to problems such as not user-friendly, inflexible functions to cater for individual school needs, lack of interface for data exchange between SAMS and individual school systems, and incompatible management workflow when using SAMS are among factors of failing to gain acceptance from teachers.

The HK government launched a five-year IT in education implementation strategy in 1998. Its main objectives are to link up students with the vast network of knowledge and information, to develop students' independent life-long learning attitude and capability, to provide adequate IT facilities to schools, to encourage key players in schools to take up the challenges of their respective new roles due to instructional paradigm shift, to integrate IT into schools and to foster the emergence of a community-wide environment conducive to the culture change [1]. There are four key areas to be addressed in the project, namely access and connectivity, teacher enablement, curriculum and resource support and community-wide culture.

Recent review of the IT plan [1] showed that the provision of computers and connectivity in schools were sufficient and that most teachers had attained adequate levels of IT competency. Noticeable improvement in IT skill, both of teachers and students, was observed in comparison with the situation in 1998. However, the study did not address much on the impacts of the five-year IT plan on the use of IT in school administration and management. It is particularly worth investigating into the changes of using IT in school administration and management and its impacts when the provision of IT resources and teacher trainings are claimed to be sufficient in the review [4].

In this paper, we report the findings of our survey on the use of IT in administration and management in HK primary schools. The rest of this paper is organized as follows. In next section, the methodology used to perform this survey is described. Section 3 discusses the results of the survey and their interpretation. In Section 4, we discuss our observations from the findings. Then we conclude the paper with our suggestions.

2 Methodology

The survey aims to investigate the current status of the use of IT in administration and management in primary schools after the implementation of the five-year IT plan in Hong Kong, to trace changes on the workload of teachers since the introduction of the five-year IT plan, to understand the views of different personnel in schools on the use of IT in school administration and management, to gain insights into the current problems of such use and thus provide a basis of suggestions on possible solutions to the identified problems. The questionnaires were designed to solicit views from different personnel in schools, namely principals, computer-subject teachers, non-computer-subject teachers, IT administrators and supporting staff.

A questionnaire was designed to collect data on five areas: IT competency levels of different groups of school personnel, the level of using IT in administration and management activities, the level of reliance of school on IT systems, the barriers to full use of IT systems, educational background and school background. While we would like to investigate the general status of adopting IT systems in schools, we, in particular, would like to study views of the above-mentioned five different personnel in adoption of IT system in school administration and management.

The questionnaire was distributed to 42 schools, via students from our undergraduate Computers in Education programme. These students are all primary school teachers studying in the same class coming from different schools with different roles. The response to this survey is encouraging. We successfully received 725 questionnaires.

3 Results and Interpretation

In this section, we are going to discuss the findings and interpretation of the survey results in the five areas mentioned in Section 2. For the sake of presentation, OA denotes the overall responses and PR, CS, NT, IT, and SF denote the responses of principals, CS teachers, Non-CS teachers, IT administrators and supporting staff in the following figures.

3.1 Background

The distribution of different personnel's responses is shown in Figure 1, which is quite in line with the percentage of different personnel in schools. The relatively large number of principals (3.39%) responding to this survey indicates their eagerness to express their opinions on this survey. Moreover, supporting staff in schools such as secretary and clerk constitute 9.1% of respondents. This group of personnel was neglected in most related studies on IT in school administration and management but is mainly responsible for using computers in daily operations in schools with insufficient training. However, we believe that their proficiency in mastering IT will greatly affect efficiency and effectiveness of school operations.

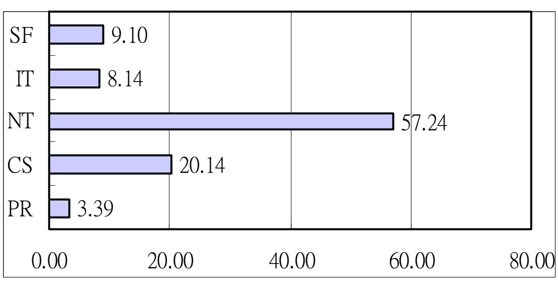

Fig. 1. Different personnel's responses

3.2 Training and IT Competency Levels

Figure 2 shows the percentages of different personnel on whether they have had sufficient training in use of IT facilities. 33.38% of respondents think they have insufficient training. In view of the large spending by HK government in promoting the use of IT in schools and in IT training for school personnel for a decade, this percentage can be considered unsatisfactory and will have operational implications in adopting IT in schools. Most personnel with insufficient training are in the category of supporting staff whilst IT administrators and CS teachers received most training. This situation can be explained by their competency levels as shown in Figure 3, which are the categorical levels in HK government's teaching IT enablement training scheme as part of the five-year IT plan from 1998 to 2003. We can easily see that most teachers have at least attained comfortable level or above, but most supporting staff have just achieved the basic level.

Figure 4 shows that the average points on the confidence and being comfortable in use of IT facilities. The 5-point scale is 1 to 5 representing very much, much, neutral,

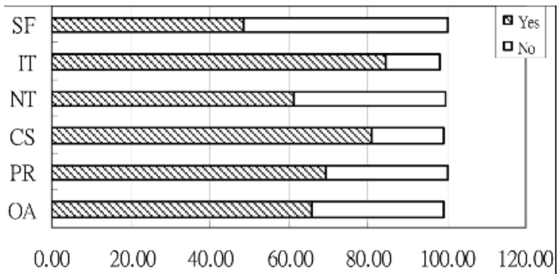

Fig. 2. Sufficient training in use of IT facilities

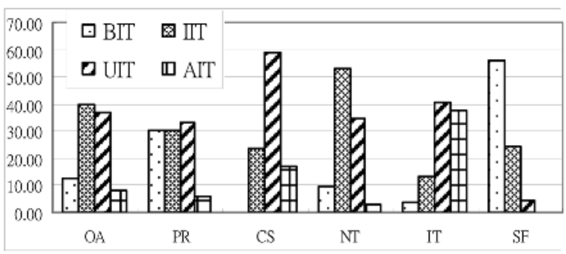

Fig. 3. Competency level

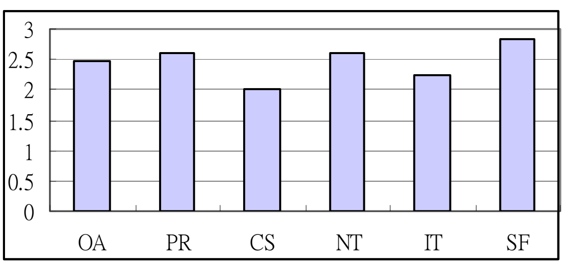

Fig. 4. Confident and comfortable in use of IT facilities

little and very little respectively. Thus a lower point represents a higher confidence in using IT facilities. Again, we can see that supporting staff are the least confident and comfortable in using IT facilities whereas IT administrators and CS teachers are most confident. This observation is quite in consistent with the case of sufficient training. Since supporting staff are lack of sufficient training, they are certainly not confident in performing their tasks by using IT.

3.3 Use of IT Systems

In our survey, it is found that principals, supporting staff and IT administrators are those whose jobs are mainly related to school administration and management (SAM). Figure 5 shows the number of work hours of different personnel in using IT systems in a week and Figure 6 shows the percentage of work hours of using IT systems relating to administration and management. It is clear to see that IT administrators and supporting staff are those who use IT systems the most in schools; and principals, IT administrators and supporting staff are those using most IT in their jobs relating to school administration and management and that most teachers are responsible for other types school administration tasks such as delivering school notices, collecting money for various purposes, etc.

The respondents were also asked to choose more than one administrative or management functions currently supported by their IT systems in schools. Notice that the choices of respondents might be affected by whether they are using those

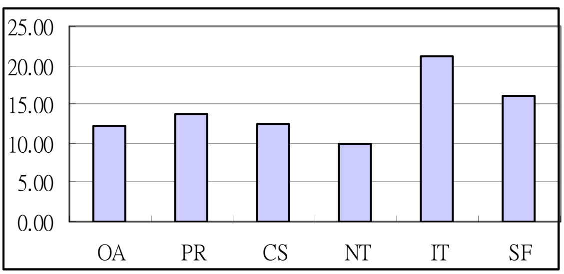

Fig. 5. No. of work hours in using IT systems

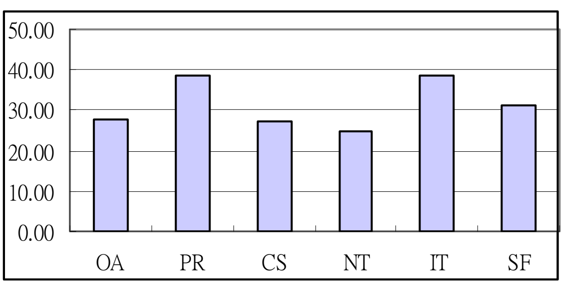

Fig. 6. % of work hours of using IT in SAM

functions. The administrative functions in the order of most use are student administration, personnel management, financial management, timetabling, general school management and resource control. The management functions in the order from mostly use to least use are educational planning, curriculum planning, financial planning capacity planning and personnel evaluation. The educational planning and curriculum planning functions were mostly used probably due to the readiness of information which can be retrieved from student and personnel administration functions. Capacity planning and personnel evaluation functions were least used due to the lack of data in the IT system and in fact, not many schools have an IT system for resources control and administration and personnel evaluation. These findings are quite similar to a study a few years ago [2].

The survey also shows that almost 83% of respondents are using SAMS or Web-SAMS in school administration and management functions which are centrally developed by Hong Kong Education Department. In fact, most schools have also acquired other software for their specific needs. In our investigations, the most frequently used SAMS modules are student management, student attendance and student assessment reporting and they are considered most useful, reflecting on its consistent ranking top 3 by different personnel. Most personnel, except principals, found that the most frequently used modules in their administrative activities are useful. However, student attendance and timetabling functions are only frequently used by principals but not others. Modules like staff management and financial monitoring and planning are less frequently used but still useful to them. The situation may be due to the unique role of principals in schools.

In general, modules like school management, financial monitoring and planning, student management, student assessment reporting and data management are most frequently used and considered most useful, particularly for principals and CS teachers. The most frequently used module for non-CS teachers, IT administrators and supporting staff are student attendance, staff management and allocation respectively. These slightly difference in frequently used modules reflects the nature of their job duties.

A majority of respondents are satisfied with the web-SAMS and considered its functions may help in improving administrative and management efficiency and effectiveness, attributed by the increased IT competency of different school personnel and the new version of web-based SAM system with enhanced features and functions.

3.4 Reliance of School Administration and Management on IT Systems

Figures 7 and 8 show the degree of impact on school administration and management respectively if there are no IT facilities available for use now. The mean values of administration and management reliance are 2.24 and 2.35 respectively. These findings show significant reliance of schools on IT facilities in school administrative and management activities. In particular, principals and IT administrators will consider having more impact on no IT facilities than other personnel. It is a bit surprising to find that non-CS teachers consider having the least impact of no IT facilities.

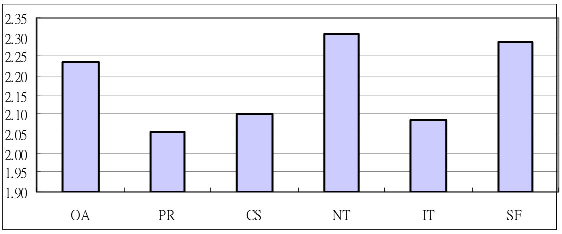

Fig. 7. Impact of no IT on administration

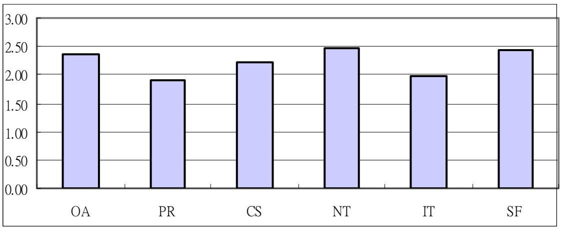

Fig. 8. Impact of no IT on management

Figure 9 shows the respondents' views on the administrative quality improvement after adoption of IT systems. Similar values were also found in the management case. In general, most respondents consider that both the quality of management and administration are improved after adoption of IT systems in schools. This is particularly true for principals and IT administrators. This phenomenon can be partly explained by the fact that principals and IT administrators are mostly responsible for administrative and management tasks in schools. Another reason is that the capabilities of the IT systems in use in schools are more powerful and sophisticated to suit the needs of school operational requirements. Therefore, they can recognize quality improvement in both areas because the IT systems can bring about improved efficiency of school operations and easy access to accurate information.

Figure 10 shows the improved quality of communications in schools by IT systems. In general, the respondents realize the improved quality of communications in schools brought about by IT systems. Almost all the schools have an intranet

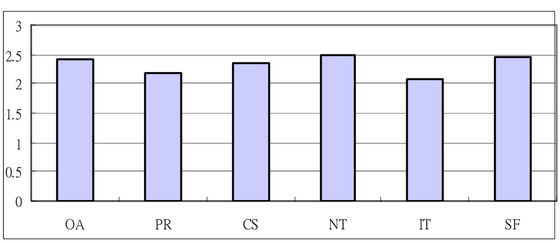

Fig. 9. Administration quality improved by IT

system allowing school personnel to use various forms of communications, such as emails, electronic notice boards, forum and reports. Having a good communication platform can streamline the flow of information in different forms within a school, thus helping improve the efficiency and effectiveness of schools. We can also notice that principals and IT administrators more recognize this improvement than others. Similar results were also found in the improved quality of communications between parents and a school.

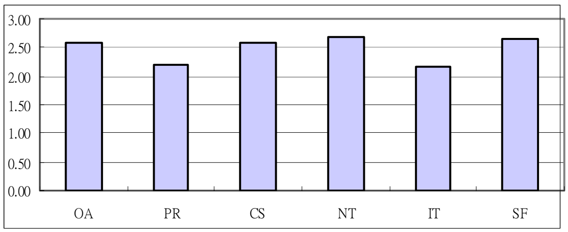

Fig. 10. Improved communication quality in schools

Respondents however have more expectation of IT systems on improving school administrative and management efficiency and effectiveness. This can be reflected by Figures 11 and Figure 12 which show the degree of expectation of IT systems meeting administrative and management efficiency and effectiveness with a mean of 2.53 and 2.62 respectively which are not comparable to those of satisfaction of efficiency improvement of administration and management. The figures show the expectations of respondents are only quite, but not much, satisfied by the capability of IT systems.

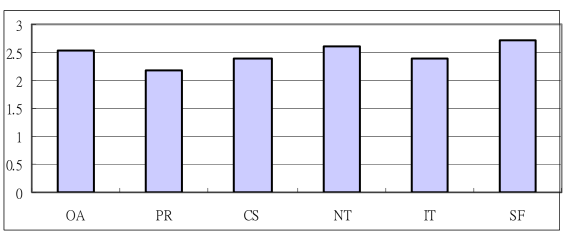

Fig. 11. Meeting expectation of administration efficiency and effectiveness

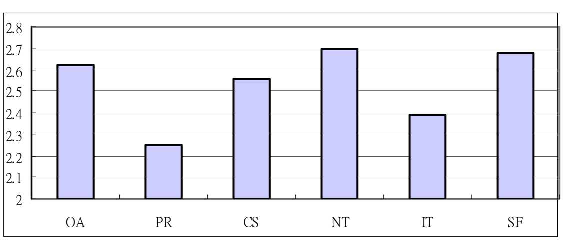

Fig. 12. Meeting expectation of management efficiency and effectiveness

However, we can also see in the figures that respondents do not indicate much negative responses on these issues. This can be explained by their increased IT competency levels and knowledge of the limitations of IT systems in improving school efficiency and effectiveness.

3.5 Barriers to Full Use of IT Systems

Figure 13 shows that the barriers to the full use of IT systems. We can easily see that the main barrier is the need of training which is especially true for supporting staff. This finding may be worth investigation when there are many principals and teachers having sufficient IT competency levels. In these figures, 66% respondents consider to have sufficient training with a confidence mean of 2.53 in use of IT facilities and 70% respondents having comfortable competency level or above. These figures should naturally lead to a conclusion that respondents will not feel having insufficient training. When we investigated into the composition of the need of training barrier further as shown Figure 14, we found that supporting staff constitute a large proportion of these respondents. Therefore, there is a need for supporting staff to receive more training. In fact, supporting staff are those who have always been neglected in most teacher training programmes offered by the government.

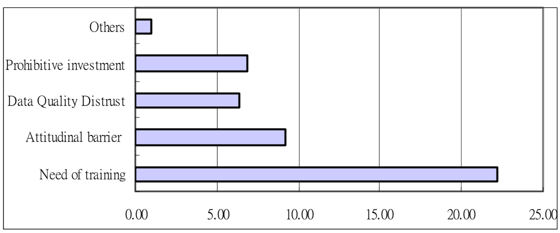

Fig. 13. Barriers to full use of IT systems

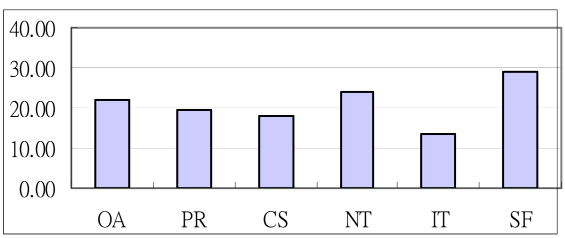

Fig. 14. Breakdown of need of training

A second barrier, the attitudinal barrier, is a non-technological issue. This finding shows that some principals and teachers do not feel comfortable in using IT systems in performing their administrative and management activities. They may be unable to realize the benefits of using IT systems in improving school efficiency; or fear that the adoption of IT systems may incur organizational changes leading to their changing roles in schools.

Another major barrier is the lack of funding to acquire new installation of IT hardware and software. This is especially true for some primary schools which may have no recurrent funding for IT equipment maintenance and upgrade. Distrust of data quality is also another barrier. The quality of data is much influenced by the qualities of IT systems in terms of correctness, consistency and user-friendliness and also influenced by their perception of data semantics and correct use of data. This is a non-technological issue and users should be given more training to have better understanding of functions provided by the IT systems in use.

4 Discussions

In this section, we will discuss the observations from the above findings in terms of training, use of IT systems in school administrative and management activities, and improvement of administration and management qualities.

4.1 Training Needs

In general, sufficient training has been given to school personnel except supporting staff. The competency levels of principals and teachers have been raised significantly. There has been a great improvement in teacher training compared to the findings in previous studies in which most principals and teachers with low IT competency levels did not have sufficient training in using IT systems. Therefore, most principals and teachers feel more confident and comfortable in use of IT systems because of their enhanced competency levels.

However, we found that supporting staff are relatively lack of sufficient training because they are not included in most government teacher training schemes. Since supporting staff are responsible for most of daily administrative and management tasks in schools, their inadequate training and deficiency in IT competency levels will have significant adverse impact on the operational efficiency of schools.

4.2 Use of IT Systems

Many schools have been frequently using IT systems in performing administrative and management activities. The most frequently used administrative functions include student administration, personnel management, financial management and timetabling and general school management with the student administration at the top. The most frequently used management functions are capacity planning, educational planning, financial planning, personnel evaluation and curriculum planning. Conceivably, schools must rely on the use of IT systems in performing administrative and management activities. This reliance can be reflected by the large impact of having no IT systems in use recognized by principals and teachers. The results also show that SAMS has been gaining popularity and acceptance in most schools which was not the case found in the previous study.

Moreover, principals and teachers think that the IT systems in use can generally live up to their expectation on improvement of school efficiency and effectiveness because the capabilities of the IT systems in schools are most fit for the purposes of school operational needs.

4.3 Administration and Management Quality Improvement

Most principals and teachers have realized that the qualities of administration and management have been improved by using IT systems and believe that IT systems can improve the administration and management qualities. Most schools have become confident and comfortable in using IT in their administrative activities. One important aspects of school administration is the quality of communications in schools. Most principals and teachers agree that the quality of internal communications has been greatly enhanced by using various forms of electronic communications means. However, the communication between schools and parents has not as much improved as internal communications do.

However, the extent of using IT in management functions is not encouraging as few schools are using IT in supporting their management activities. There may be several reasons for this phenomenon. First, in most cases, only principals will perform management activities. Other school personnel are only doing teaching and administrative work. Second, principals may not realize the potentials of their school information systems in supporting their management functions such as decision making and planning. Third, principals may not have sufficient skills of using IT in performing management functions. However, one delighting finding is that more principals are aware of the potentials of using IT systems in school administration and management and are looking for the opportunities of exploring the potentials of IT in supporting management functions.

4.4 Barriers to Full Use of IT Systems

The main barriers are lack of sufficient training, attitudinal barrier and distrust of data quality. In terms of training, some respondents said in the open question that they need more training to cope with the fast changing IT technology. They felt helpless because there are not enough technical supports that they can get in encountering technical difficulties. A large proportion of teachers said that they were so busy with their jobs in school that they could not have time to attend trainings even if they found that the trainings might be useful to them and suggested that training sessions be arranged in non-office hours or in such periods that teachers were not busy with preparing examinations and tests. However, with the large groups of teachers in different school environments, it is well understood that it may be practically impossible to arrange trainings so that all teachers would be available to attend them.

Therefore, it is worth exploring the possibility of employing web-based training and learning for teachers. The general benefits of using web-based learning towards teachers include that training is usually self-paced and highly interactive, and that it gives teachers greater flexibility to attend these trainings to suit their available times. Other benefits are that student tracking will be easier and training content can be updated easily, leading to reduced overall cost of these training provisions.

Another major barrier is lack of recurrent funding for acquisition of IT systems. Many schools now are having problems in using out-dated versions of software, in acquiring new software suitable for new curriculum needs, and in maintenance.

Attitudinal issue is another barrier. Some respondents said that some senior teachers and principals are not comfortably and confidently using IT systems in schools. Some teachers are even refusing to use IT systems. Some principals do not support using IT systems in schools, except those SAMS functions necessary for submitting data to the government education department.

5 Conclusion and Suggestions

This survey aims to investigate the current situation of the use of IT in administration and management in primary schools after the implementation of the five-year IT plan in Hong Kong. As shown in our survey study, most primary schools in Hong Kong are largely at the integration stage [6] which is characterized having a more or less integrated system to support administration and management activities and the awareness of the importance of management of information.

Compared to our previous study [3], it is found that SAMS is more accepted by schools and is able to help improve the administration efficiency as the functionalities and user-friendliness of SAMS have been greatly improved. The IT competency levels among personnel in schools have been raised, especially those IT administrators. However, those supporting staff feels incompetent and not comfortable in using IT in their administration work because they are always not included in most government's training schemes. Unfortunately, they are primarily responsible for daily administration of schools.

Most schools are using IT extensively in their administrative activities. However, most personnel feel the need to update their IT knowledge on a regular basis to keep pace with fast advancement of IT technology. Using IT in supporting school management functions needs to be enhanced.

It is suggested that the following areas be enhanced to exploit full potentials of IT facilities in schools.

1. More resources in training should be targeted at supporting staff in schools. They should at least be given training at the comfortable level.
2. Regular training should be provided for school personnel to update them with latest IT technology.
3. Web-based learning should be explored to capitalize its advantages to benefit teachers by giving them greater flexibility to attend training workshops.
4. The Government should have a strategic plan to help schools, especially principals, on how to capitalize the full potentials of information in supporting school management functions. Particularly, features of IT systems for management functions should be enhanced to be more user-friendly and easy to use.
5. Negative attitudes towards the use of IT systems are the major barrier to full use of IT systems in schools. More trainings and seminar should be organized to remove this attitudinal barrier.

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Facial Expression Hallucination Through Eigen-Associative Learning*

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Abstract. As an important human characteristic, facial expression plays an important role in the applications of identity authentication, animation production, human-computer interaction, web-based education, etc. In this paper, we propose a facial expression hallucination approach through eigen-associative learning (EAL). The approach consists of two steps, in the first step, the global facial expression is estimated, and in the second step, we synthesize high-frequency image features to enhance the global face. The proposed EAL approach is adopted in both steps, which can synthesize the imaginary facial expressions of the input face with neutral expression. Compared with existing method, the EAL approach can be easily applied to new test data and retain high computational efficiency. Experiments show that the EAL approach generates reasonable imaginary facial expressions.

Keywords: eigenface, face hallucination, eigen-associative learning, residue patch.

1 Introduction

With the development of web technology, face perception techniques have been widely applied in social life. As an important human characteristic, facial expression plays an important role in the applications of identity authentication, animation production, human-computer interaction, web-based education, etc. Many researchers have engaged in 2D as well as 3D facial expression synthesis. Qingshan Zhang et al. [1] developed a geometry-driven facial expression synthesis system which could generate photorealistic facial expressions through blending sub-region texture images according to the facial feature positions. Liu et al. [2] proposed an expression mapping approach based on expression ratio image (ERI). Combining illumination changes of one person's expression with geometry warping, they mapped an ERI to arbitrary face and generated more expressive facial expressions. Facial expression cloning proposed by Noh and Neumann [3] was to transfer facial expressions from an existing 3D face model to a new model while preserving the emotional feelings embedded in the expressions. Based on informative multi-view input images, Pighin

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[4] synthesized photorealistic 3D facial expressions by stereo vision reconstruction and morphing between several key models.

Besides the analogy, retargeting and reconstruction approaches mentioned above, learning based techniques for face synthesis have also been explored by many researchers. The term "face hallucination" was first proposed by Simon Baker et al. [5], the motivation was to create high resolution version of an input low resolution face image by sample learning. Based on a complicated probabilistic model, Liu et al. [6] built a two step approach to hallucinate human faces, the global parametric model aimed at recovering global face image while the local non-parametric model contributed to generating face details. Recently, face hallucination technique was extended to synthesize facial expressions. In [7], the authors proposed an approach which created reasonable facial expression based on sample images with neutral expression face as input. The approach was based on manifold learning. Though ISOMAP [8] algorithm adopted by the authors helped to capture the global appearance of imaginary facial expression, this operation suffered from great computational cost since ISOMAP is inconvenient to evaluate new test data with trained data.

In this paper, we propose a two-step facial expression hallucination approach through eigen-associative learning. The first step aims at efficient estimation of global facial expression, the second step focuses on compensating the global face with high-frequency residue image. Eigen-associative learning instead of ISOMAP is utilized in both steps. Unlike ISOMAP, eigen-associative learning is fast and easier to be applied to new test data. This paper is organized as follows: detailed description of eigen-associative learning approach is presented in section 2; in section 3, the eigen-associative learning approach is applied to facial expression hallucination; experimental results are given in section 4, and section 5 concludes this paper.

2 Eigen-Associative Learning

Eigenface technique [9] has been used in face recognition successfully. In this paper, we extend the eigenface technique to build an association between two different data sets, and we call this *eigen-associative learning* method.

The eigen-associative learning approach is based on the following assumption:

Assumption 1. Two different data sets with implicit relationship between each other distribute in the low-dimensional feature space in a similar way.

Assume two different data sets A, B and each data set has the form of $m \times n$ matrix, we first apply eigenface technique on both data sets. Denote $\overline{A}$ as the column mean value of A, the registration of data set can be described as $\tilde{A} = A - \overline{A} \cdot ones(1,n)$ where $ones(1,n)$ is a $1 \times n$ row vector with the elements equal 1. Compute the k eigenvectors corresponding to the k largest eigenvalues, we get $[e_{A1},...,e_{Ak}] = eig(\tilde{A}\tilde{A}^T)$ where e_i (i=1,…,k) are the eigenvectors. Given any test data a, the intrinsic feature f of the data in feature space spanned by A can be obtained by projecting the data onto the orthogonal eigenvectors:

$$f = [e_{A1},...,e_{Ak}]^T \cdot (a - \overline{A}) \tag{1}$$

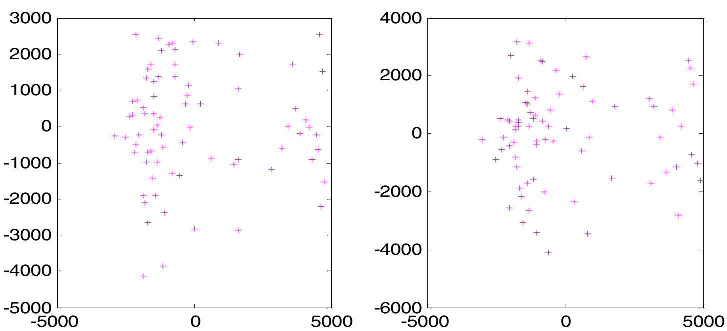
In the mean while, the same operations are imposed on data set B and get the orthogonal eigenvectors $[e_{B1},...,e_{Bk}]$. According to PCA principle, $[e_{A1},...,e_{Ak}]$ and $[e_{B1},...,e_{Bk}]$ maintain the most meaningful underlying information of A and B. Owing to the assumption that there exists a implicit relationship between A and B, we believe that a test data can be represented by the same intrinsic feature in the two spaces spanned by A and B respectively. Thus, a's counterpart b in space B can be computed by:

$$b = [e_{B1},...,e_{Bk}] \cdot f + \overline{B} \tag{2}$$

In eigen-associative learning, two different data space spanned by A and B are correlated by f which is computed by projecting data point onto the orthogonal eigenvectors. The eigenvectors are called eigenfaces and k can be determined heuristically.

3 Eigen-Associative Learning for Facial Expression Hallucination

Facial expression hallucination aims at estimating the corresponding facial expressions given an input face image with neutral expression. The training set comprises a number of image pairs which includes both the neutral face and the expression face of the same person. It's obvious that the neutral and expression faces are tightly connected by the person's identity. As is shown in Fig. 1, the two



(a) (b)

Fig. 1. (a) Two dimensional projections of faces with neutral expression. (b) Two dimensional projections of faces with happy expression.

dimensional projections of training neutral as well as expression faces after PCA dimensionality reduction form similar topology structures. So we can apply the proposed eigen-associative learning approach to perform face hallucination.

3.1 Eigen-Associative Learning for Global Facial Expression Estimation

This step aims at estimating global facial expression corresponding to the given neutral input face, the global face acts as a global constraint that retains the main appearance of the imaginary face. Denote the neutral and expression faces in the training set as I_{ntr} and I_{exp} (both are $m \times n$ matrices) respectively, let I_{in} be the input new face image with neutral expression, and I_{out} be the estimated global facial expression, the eigen-associative learning algorithm for estimating I_{out} is described as below:

Step 1. Register I_{ntr} and I_{exp} respectively. This is done by extracting the mean value $\overline{I}_{ntr}$ and $\overline{I}_{exp}$ from both data sets:

$$\tilde{I}_{ntr} = I_{ntr} - \overline{I}_{ntr} \cdot ones(1,n) \tag{3}$$
$$\tilde{I}_{exp} = I_{exp} - \overline{I}_{exp} \cdot ones(1,n)$$

Step 2. To $\tilde{I}_{ntr}$ and $\tilde{I}_{exp}$, compute the k eigenfaces (eigenvectors) of the covariance matrix corresponding to the k largest eigenvalues respectively.

$$[e_{n1},...,e_{nk}] = eig(\tilde{I}_{ntr}\tilde{I}_{ntr}{}^{T}) \tag{4}$$
$$[e_{e1},...,e_{ek}] = eig(\tilde{I}_{exp}\tilde{I}_{exp}{}^{T})$$

Step 3. Project I_{in} onto $[e_{n1},...,e_{nk}]$ and get its intrinsic feature f in the neutral training space.

$$f = [e_{n1},...,e_{nk}] \cdot (I_{in} - \overline{I}_{ntr}) \tag{5}$$

Step 4. Reconstruct I_{out} by associating f with the eigenfaces in the expression training space.

$$I_{out} = [e_{e1},...,e_{ek}] \cdot f + \overline{I}_{exp} \tag{6}$$

Note that step1 and step2 are needed only once when training the sample image pairs. Then the eigenfaces of both neutral and expression face images are stored for further use. When a new input image comes, we just need to project the data onto $[e_{n1},...,e_{nk}]$ for computing f , and then reconstruct the corresponding facial expression according to equation (6).

3.2 Patch Based Eigen-Associative Learning for Face Image Enhancement

Owing to the linear PCA method, the global facial expression image looks smooth and shows a little discrimination from the ground truth facial expression, see Fig. 2. (b). Single eigen-associative learning method is not enough to yield satisfactory results, so we consider applying the eigen-associative learning method again to compensating the global hallucination result with high-frequency image information which reflects the detailed facial features. The high-frequency information of the face image is often called "residue face" [6][10][11]. In this section, we intend to infer the expression residue face from the input neutral face. The training set also contains a number of image pairs, and each pair includes a neutral face and the corresponding expression residue face. By establishing a relationship between the neutral faces and the expression residue faces, we can estimate the high frequency information of the imaginary global facial expression. The expression residue faces in the training pairs are obtained by subtracting hallucinated global facial expressions gained in section 3.1 from the original facial expressions. Then, the final hallucination face (Fig. 2. (d)) can be achieved by superposing the residue face onto the global facial expression.

As is described in section 3.1, the eigen-associative learning method could be utilized to learning the relationship between the neutral faces and the residue faces as a whole, the final result gained in this way is depicted as Fig. 2. (c). Observe that the face image contains much noise and deviates from the original one in terms of similarity. This indicates that the residue face gained by global eigen-associative learning fails to reflect the detailed features of the input face, so in this paper, a patch based eigen-associative learning method is adopted to achieve this goal.

Consider each residue face as a patch matrix composed of overlapped square residue patches. The patch located at the i_{th} row and the j_{th} column in the patch matrix can be denoted as $P_t(i,j)$. Suppose the square patch covers $n\times n$ pixels and n is an odd number, each patch $P_t(i,j)$ overlaps with its adjacent patches $P_t(i\text{-}1,j)$, $P_t(i+1,j)$, $P_t(i,j\text{-}1)$, $P_t(i,j+1)$ by size $(n-1)/2$. Let I^{ntr} denotes a neutral face while I^{exp} denotes the expression residue face in the training pairs, they both can be divided into patches of the same number and each pair of patches forms a one by one correspondence since the neutral face and the expression residue face denote the same subject semantically. Let $v(i,j)$ denotes the central point of a patch, then the patch based eigen-associative learning method can be described as below:

(a) (b) (c) (d) (e)

Fig. 2. (a) Input face with neutral expression. (b) Global facial expression. (c) Enhanced face by global eigen-associative learning. (d) Enhanced face by patch based eigen-associative learning. (e) The ground truth facial expression.

Training stage

Step 1 Divide the neutral faces as well as the corresponding expression residue faces in the training pairs into $m\times n$ patch matrices, the patches in one training pair are denoted as $P_{train}{}^{ntr}(v(i,j))$, $P_{train}{}^{exp}(v(i,j))$ $(i = 1,\ldots,m;\ j = 1,\ldots,n)$.
Step 2 For each $v(i,j)$, select corresponding $P_{train}{}^{ntr}(v(i,j))$ and $P_{train}{}^{exp}(v(i,j))$ from all the training pairs, compute and store the mean values and eigenfaces denoted as E_{ntr} and E_{exp} of these two sample sets.

Testing stage

Step 1. Divide the input neutral face into overlapped patches. Suppose all the patches also form a $m \times n$ patch matrix, and the matrix can be described as $P_t^{ntr}(v(i,j))$, (i = 1,…,m; j = 1,…,n).
Step 2. For each $v(i,j)$, project $P_t^{ntr}(v(i,j))$ onto E_{ntr} and get its intrinsic feature f, and then the residue face patch can be reconstructed by adding the linear combination of E_{exp} with f as coefficient to the mean value of training expression residue face patch.
Step 3. Enforce the inter-patch relationships by averaging the image patch values in overlapped regions between adjacent patches.

Just like the global face estimation, the training stage is performed offline only once, and the testing stage is needed each time when a new test face comes. Thus, by the two-step eigen-associative learning approach, we yield the global facial expression and the expression residue face representing the high-frequency image information. The final hallucination result is gained by superposing the expression residue face onto the global facial expression. Fig. 2. (d) indicates that the result of patch based approach is reasonable and shares more similarity with the original face.

4 Experiments

Our experiments are performed on the Asian Face Image Database PF01 [12]. PF01 contains 107 persons, 56 men and 51 women representing 17 various images (1 frontal face, 4 illumination variations, 8 pose variations, 4 expression variations) per person. Since our focus is facial expression hallucination in average illumination, we eliminate the images with illumination as well as pose variations and construct a new data set including 321 images (1 frontal face, 2 typical expression variations per person). A normalization process has been done [12] per image enforcing the central points of the eyes at fixed locations, based on this, we further crop and scale the images into 96×128 normalized face images one by one manually.

Among the 107 volunteers, 75 persons are selected for this experiment because there're no glasses appear on the faces. The training set is constructed based on 60 persons, and the rest 15 persons are test data. To perform the experiment, the 60 image pairs of neutral faces and expression faces are first preprocessed by PCA offline, and then the online hallucination can be performed efficiently. On a 2.4 GHz Pentium IV processor, it takes about 3 to 4 seconds to yield the imaginary facial expression. The experimental results are demonstrated in Fig. 3. (b) which maintain the global as well as detailed features of the original facial expression.

5 Conclusion

Facial expression plays an important role in the applications of identity authentication, animation production, human-computer interaction, web-based education, etc. In this paper, we have presented a two-step facial expression hallucination approach through eigen-associative learning. The first step aims at estimating the

(a) (b) (c) (a) (b) (c)

Fig. 3. (a) Input neutral faces. (b) Hallucinated facial expressions by the eigen-associative learning approach. (c) The original facial expressions.

global facial expression of the input neutral face, and the second step focuses on compensating the global facial expression with the high-frequency information of the face image. Both steps are based on eigen-associative learning approach which is more computationally efficient than existing approaches. Experimental results show that the eigen-associative learning approach generates reasonable imaginary facial expressions.

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Live Multimedia System Using Peer-to-Peer Architecture for Distance Education

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Abstract. This paper presents a P2P-based multimedia streaming system, called Live2006, to provide a scalable, robust, and high available live streaming distance education service. Based on the concept of Application Layer Multicast, a tree-based structure is designed to connect the peers, and the peers share the receiving streaming to reduce network traffic. A high level quality of service is maintained even a significant number of individuals are watching the same distance education program. It also enables all users to share their study experiences and achieve "peer-to-peer learning". Live2006 also provides the streaming services for users located behind the firewall or users using the private IP addresses behind an NAT (Network Address Translation). Thus, users can easily access the distance education programs through their devices, including the resource limited handset devices, in anytime and anywhere. Live2006 also supports IPv6 protocol for next generation Internet infrastructure.

Keywords: Multimedia streaming, IPv4/IPv6, Firewall, NAT (Network Address Translation), Peer-to-Peer (P2P), Distance education.

1 Introduction

Advances in network technology accelerate the transmission of distance education via the Internet, conveying the curricula to every necessary corner of the world where teachers and students arrange educational meetings through multimedia appearance. To enhance the educational effect of distance education, it is essential to have a scalable and reliable mechanism to deliver the time-sensitive multimedia materials via the Internet.

As the Internet Service Providers (ISP) are offering larger bandwidth and lower prices to customers, more and more online services have been developed on the Internet. Also the multimedia materials and digitalized contents have captured public imagination. Presumably during the next few years, network based multimedia video and audio, and digitalized content services will replace conventional services such as cable television to become mainstream services. Conventional distance education systems are usually constructed based on the famous Client-Server framework. Each individual user connects to the streaming server to watch the distance education

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programs. This framework is easy to implement but places high demands on the computing power of the streaming server and the available network bandwidth. The quality and scope of the provided services are also limited, making the streaming server into a bottleneck of the system. One of the ways to solve this problem is to group several streaming servers as a cluster so that the loading can be shared and distributed among servers to achieve load balance. Nevertheless, this solution is expensive for a large scale deployment and is not affordable to every distance education service provider.

Apart from the traditional Client-Server architecture, several alternative approaches methods such as IP Multicast [1], Content Delivery Network (CDN), and Application Layer Multicast (ALM) ([2], [3], [4], [5], [6] and [7]) have been proposed provide multimedia services. IP Multicast is based on the Internet Group Management Protocol (IGMP) ([8], [9]), enabling users who request the service to obtain multimedia data more efficiently. A service request is not necessary to deliver to the source server, and the data can be copied from the multicasting router. Hence, multicast technology not only saves network resources, but also reduces the loadings of the source server.

Although IP Multicast can copy data from the router to reduce the load of source server, it still suffers from a couple of problems. For example, the IP Multicast may not operate properly if any router between the source server and the end users does not support or enable the multicast function. Furthermore, the IP multicast router must process a multicast lookup and copy the data to multiple interfaces, which significantly increasing the load. If multiple multicast groups present simultaneously in a router, then the router may become fully-loaded or even crash. This why most Internet Service Providers do not like to enable the IP Multicast functions of the routers. Consequently, the availability of IP Multicast service in the current Internet environment is very inappreciable.

The Content Delivery Network (CDN) has been employed to provide multimedia services. By using proxy and caches technologies, user's information is delivered to near proxy servers to prevent the network from congestion, and to reduce the loading of the source servers. Using CDN to support multimedia service provides a certain level of service quality independent to the computing power of the servers or the congestion of the networks. Nevertheless, the CDN is expensive if only a few users request the multimedia service, explaining why it is used only to support very popular multimedia services.

Due to the IP multicast is not very popular in real environment and the deployment of CDN is expensive, the ALM concept has been proposed in applying the multicasting technique to the application layer rather than the traditional IP layer. Two types of ALM-based schemes were proposed recently, including tree-based topology, such as Splitstream [10] and CoopNet [11], and mesh-based topology, such as CoolStreaming/DONet [12], PROMISE [13].

SplitStream is built on top of Scribe [14] multicast system, which is established upon Pastry [15] overlay network substrate. SplitStream uses k different ALM trees to reduce the bottleneck of node for transmitting data. But one of the disadvantages of SplitStream, compared to other systems, is that each peer has to donate bandwidth for transmission streaming no matter it is watching the program or not. Coolstreaming/DONet is a data-driven overlay network for live multimedia streaming. It does not construct and maintain a complex global structure, and data forwarding is dynamically determined according to data availability. Based on the partnerships and the periodically updated data availability information, the Coolstreaming enables adaptive and quick switching among multi-suppliers, and thus provided a robust and resilient service.

In this paper, a P2P-based multimedia streaming system, called Live2006, is proposed to provide a scalable, robust, and high available live streaming distance education service. Based on the concept of ALM, a tree-based structure is designed to connect the peers, and the peers share the receiving streaming to reduce network traffic. Therefore, a high level quality service can be achieved even a significant number of individuals are watching the same distance education program. Besides watching the selected education programs, each user also acts as a program provider or even as the publisher of his/her own program. Such flexibility enables all users to share their study experiences and achieve "peer-to-peer learning". Live2006 also provides distance education programs to handset devices. Users can receive distance education programs through their handset devices in any corner of the campus. Live2006 can also provide the streaming servers for users located behind the firewall or users using the private IP addresses behind an NAT (Network Address Translation). Live2006 supports both IPv4 and IPv6 [16] protocols. The IPv6 network mobility feature furnishes handset devices better services, and by using the "anycast" [17] function, the system even operates more efficiently.

The remainder of this study is structured as follows. Section 2 describes the infrastructure of Live2006 framework and the major components to construct the P2P-based structure. Section 3 illustrates the operating scheme of the Live2006 system. The implementation of Live2006 system and the system performance analysis are provided in Section 4. Finally, conclusions and contributions are presented in Section 5.

2 Live2006 Infrastructure

The proposed multimedia streaming system, Live2006, is based on the P2P infrastructure to provide a scalable, robust, and high available streaming distance education service. As shown in Figure 1, each domain is equipped with an Agent Keeper (AK), many Agent Clients (ACs) and Client Users (CUs). The P2P infrastructure within a domain is a tree like structure rooted at the AK. The AK serves as the agent of the Streaming Server (SS) to provide a reliable and stable relay the program to other agents in the domain. The AC is client equipped with a Live2006 specific software module and is capable to relay the received programs. The CU is devices (such as handset devices) not or unable to equip with any Live2006 specific software module and only equipped with standard browser and multimedia player to receive the programs. Therefore a CU is not capable to relay the programs. The connectivity degree of an AK or AC indicates how many agents are receiving the program relayed from it, which depends on its available resources and computing power. Furthermore, to provide robust and stable streaming service, each AC also maintains a backup link to a backup parent agent. This is to cover the case when a parent AC leaves the system suddenly (such as system crashed) and the AC can still get the streaming program smoothly from the backup agent. For example, the AC1 shown in Figure 1 receives a program from AK1 and then relays to AC2 and AC3, and AC2 further relays it to CU1. The backup links for (AK1, AC3) and (AK2, AC5) are also depicted.

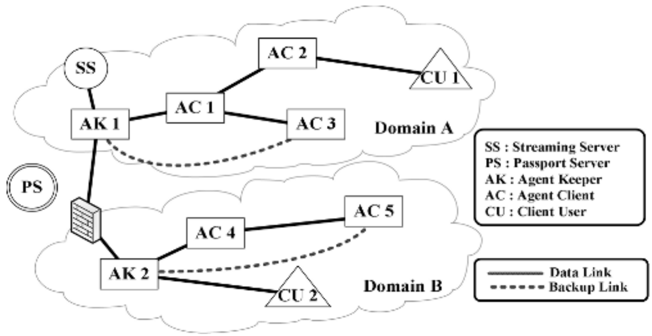

Fig. 1. Example of Live2006 Infrastructure

One of the interesting features of the proposed Live2006 is the ability to provide the service across the firewalls and NAT. The UDP protocol has been widely used to deliver the multimedia traffic for many distance learning systems. The natural of UDP protocol is very suitable to deliver real-time traffic, such as video or audio streaming, to achieve better QoS. Nevertheless, for security reason, most of the enterprises installed a firewall to protect the network resources. The firewall is usually configured to block UDP packets. Only a few UDP port numbers are open for permitted applications or authorized users. Furthermore, many of the UDP-based multimedia transmission applications change the used port numbers dynamically. This causes considerable difficulty for multimedia data transmission through firewalls. In the proposed Live2006 system, an adaptive connection mechanism (ACM) is designed for an agent to resolve this problem. The Connection Component automatically detects the available protocols, and then tries to either use UDP protocol or HTTP protocol to pass through the firewall. If the UDP is blocked by the firewall, then the HTTP with TCP/port80 is used to communicate with the peer outside the firewall. As the TCP/port80 is usually open by a firewall to provide the access of Internet Browser, this enables Live2006 to provide normal multimedia service for the users behind a firewall. For example, as shown in Figure 1, even AK2 located behind a firewall, it can obtain the streaming programs from AK1 to serve the agents within domain B.

Also for the lack of available public IP addresses from the ISP (sometimes for cost consideration), most of the enterprises employ the NAT scheme to save the number of used public IP addresses. In the proposed Live2006 system, only one of the peers behind the NAT is responsible to communicate with the peer outside the NAT to receive the multimedia program. This peer then shares the program with all the peers behind the NAT according to the proposed P2P structure. Based on this mechanism, users behind the firewall/NAT can still access the Live2006 system, and there is only one connection (consume limited bandwidth) passing through the firewall/NAT.

2.1 Agent Keeper (AK)

AK possesses three main functions: (1) it serves as the agent of SS, enabling normal streaming server to smoothly utilize relay service provided by Live2006; (2) through transmission of AK, the system can effectively monitor and distribute network resources, enlarging the service range under the same amount of network resources; (3) since AK was deployed as a dedicated network appliance it is more reliable and stable than other users in the system. The AK consists of five main parts: Media Component, Control Component, Protocol Component, Connection Component and Relay Component. The software architecture of an AK is shown in Figure 2.

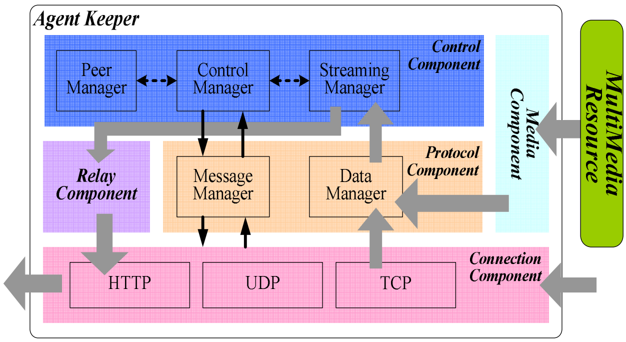

Fig. 2. Architecture of Agent Keeper

2.2 Agent Client (AC)

The AC is a user who installs the Live2006 software package. The AC plays an important role in the operation of Live2006 to simultaneously construct a P2P-based real-time multimedia sharing framework. The AC mainly comprises Buffer Component, Control Component, Protocol Component, Connection Component and Relay Component, as shown in Figure 3. All components, except Buffer Component, also exist in an AK.

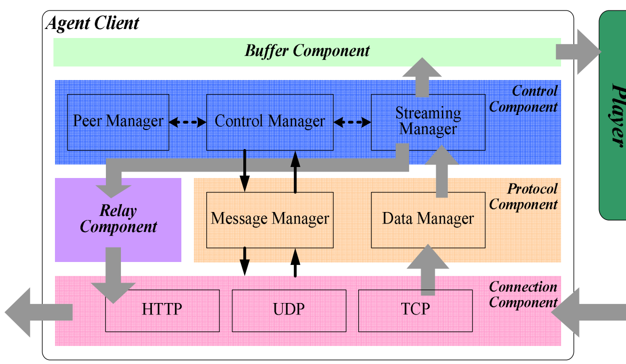

Fig. 3. Architecture of Agent Client

2.3 Client User (CU)

The Client User (CU) is a device (such as Pocket PC, PDA, and other handset devices) which is not or unable to equip with any Live2006 software module due to limited resources. It is only equipped with standard browser and multimedia player to receive the streaming programs. Therefore a CU is not capable to relay the programs. The Live2006 is capable to provide the streaming service to these resources limited but highly mobile clients. This feature makes Live2006 highly accessible to all kind of users, including the handset devices.

2.4 Passport Server (PS)

Passport Server is the only centralized host in Live2006, and is primarily responsible for account management and multimedia program maintenance. Account management is necessary as not all users have the access rights to all distance education programs. Each user can access the programs according to the authorized rights. All the multimedia programs are registered in the Passport Server so that it can provide the programs information to online users for the selection of a desirable program.

2.5 Streaming Server (SS)

The Streaming Server in the Live2006 system can be any server that is capable of providing multimedia streaming. It can be a server already providing multimedia streaming services, or simply be a video camera connected with a software or hardware device capable of producing and encapsulating multimedia streaming.

3 Live2006 Operation Scheme

This section addresses the operation scheme of the proposed Live2006. First of all, the procedure for a user to join the Live2006 to receive a distance education program is introduced. Then that for a joined user to departure from the system is addressed. A Best Agent approach (BAA) mechanism is proposed to select the most suitable parent agent for a new joining user.

3.1 Initialization and Registration of AK/AC

The initialization and registration flow for an Agent Keeper (AK)/Agent Client (AC) to participate into the Live2006 system is described as follows (also shown in Figure 4).

Step 1. When a distance education program is posted to Live2006, the AK will connect to SS (Streaming Server) first to obtain the streaming data.

Step 2. AK performs a registration at Passport Server to notify the available of this new program. At this stage, basic initialization of the AK is finished.

Step 3. An AC makes a registration at Passport Server first. Without the registration, an AC will be is treated as a guest with only limited permissions to access the programs.

Step 4. The AC then sends an anycast request and the AK returns a response to clarify that this AC is now belonging to the domain served by this AK.

Step 5. The AC then receives the information of current available programs via the Passport Server or searches for a specific program. An anycast address is assigned for each available program.

Step 6. After the user selects a program, the AC sends an anycast request with the anycast address of that program. An agent (may be AK) that providing the particular program will be selected as the parent agent of the AC.

Step 7. The AC then connects to the selected parent agent to make an association.

Step 8. The AC makes an authentication with the Passport Server via the parent agent. After authentication, the parent agent now has the access right information, such as ID and authority, of that AC.

Step 9. Finally, AC requests multimedia data from the parent agent. The parent agent then either accepts the request and forwards the multimedia data to the AC, or rejects it if the authorization is denied.

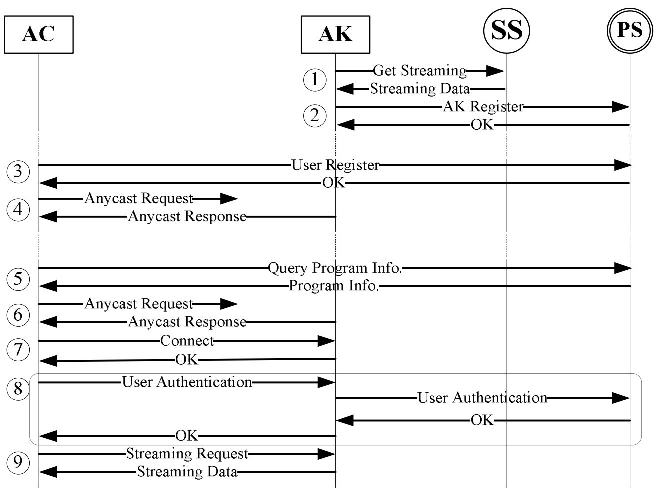

Fig. 4. Initialization and Registration flow for Agent Keeper/Agent Client

3.2 Agent Client Join

The flow illustrated in Figure 4 is a standard procedure for an AC to join into the Live2006 system. Nevertheless, some special environments still need to be considered, such as in case the anycast service is not available in the network, or the selected parent agent is already fully-loaded. For the former case, a top-down strategy is proposed to make the Live2006 operates smoothly even when the anycast service is not available. Moreover, this strategy also helps new users join during Agent full-load period.

The top-down strategy is presented as follows. As we have mentioned, the AC gets the anycast address of the selected program as well as the unicast address of the AK from the Passport Server. If the anycast service is not available, then the AC contacts the AK directly by using the unicast address. If the AK is not fully-loaded, it accepts the request and forwards the program to the AC. Otherwise the AK employs the proposed BAA mechanism to select one of its child agents as the parent agent of the AC. If the selected parent agent is also fully-loaded, then this procedure is repeated until a non-fully-loaded parent agent is found for the AC.

For illustration, let us consider the example shown in Figure 5, where AK1 (Agent Keeper), AC1 (Agent Client), AC2 (Agent Client) are watching the same program with a particular anycast address and AK1 and AC1 are fully-loaded. When a new user, AC3 (Agent Client) wishes to join the group it will send an anycast request with the anycast address of the program. For some reason, assume the AC does not receive any response of the anycast request, and then it connects to the AK1 directly by using the unicast address of AK1 as shown in Figure 5(b). Since AK1 is fully-loaded, the request will be redirected to AC1 (selected by AK1 based on the BAA mechanism). As AC1 is also fully-loaded, the request is redirected again to AC2 which then accepts the request to provide the program to AC3.

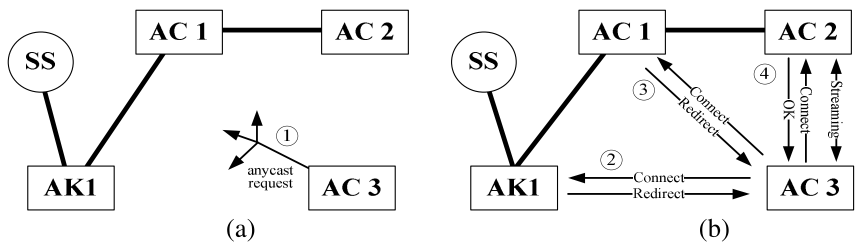

Fig. 5. Example of Agent Client Join without anycast service

Another case needs to be considered is the cross-domain joint. Thus, when a new AC wishes to receive a program that is not available within the current domain, the request may be relayed to another domain that possessing this program. For example, consider the case shown in Figure 6 where AK1 is in domain A and AK2 is in domain B. When AC1 sends an anycast request and receives an anycast response from AK2, it belongs to domain B. Assume AC1 then sends a streaming request to AK2 for a particular program not stored by AK2. Then AK2 executes the join procedure and plays as an AC join in domain A. The AK1 then relays the program to AK2 and AK2 relays the program to AC1.

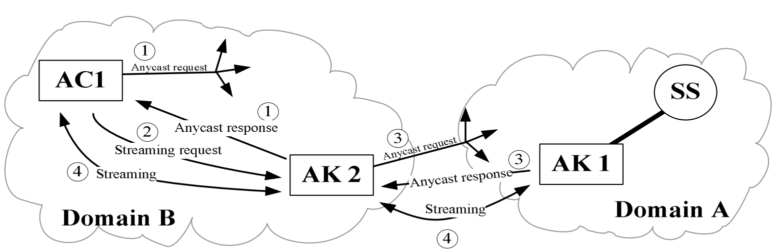

Fig. 6. Example of Agent Client Join (cross-domain case)

3.3 Client User Join

A Client User (CU) is a device that uses standard multimedia player and Internet browser without the software module provided by Live2006. A CU is capable to receive the programs, but not able to further relay the received programs. Thus, a CU is a leaf peer in the proposed P2P structure. It is possible that when a new AC wishes to join into the structure, a new AC is inserted between an already existed AC-CU pairs. This means that the CU will disconnect from the original AC and reconnect to the new added AC via playing the next item in the playlist. For example, the CU1 in Figure 7 original connects to AC1. When a new AC2 joins and connects to AC1, the CU1 disconnects from the AC1 and reconnects to AC2. The CU1 then obtains the playlist from AC2 to access the programs.

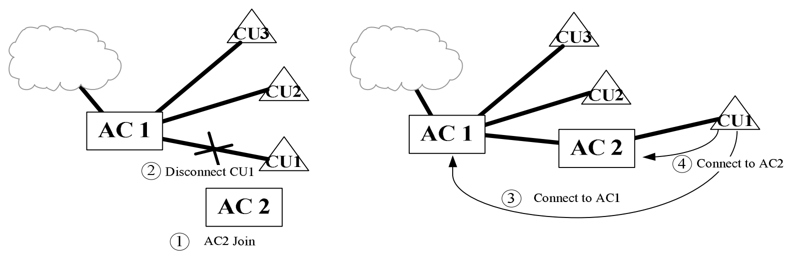

Fig. 7. Example of AC Join and CU Reconnect

3.4 Agent Client Departure

When an AC leaves from the P2P structure, the programs relayed by this AC will also be terminated. To provide a reliable service and minimize the effect on downstream users when an upstream agent departures, a backup agent is assigned to each joined AC. Thus, when an AC joined to the system, the BAA scheme is used to find a best backup agent for the AC and a “logical backup link” is established between them. When an AC decides to leave, it informs a Departure Notification to each of its child agents. The child agent then establishes a real data link with its backup agent to continue receive the streaming program. The AC decided to leave will stop the program relay when a response is received from each of its child agents, or when a timeout event occurs. For illustration, consider the case shown in Figure 8, where AC2 is a child agent of AC1 and has a backup agent AC3. When AC1 decides to leave, it informs the AC2, which then changes the backup link to data link with AC3 to receive the streaming program. The AC2 sends a “stop transmission” response to AC1 which then leaves the system.

Of course, an AC may leave the system suddenly (system crashed for example) before sending out any notifications. To cover this urgent situation, each AC uses a heart-beat scheme to keep watching its parent agent. If the streaming program receiving from the parent agent stops, it then sends an inquiry packet to the parent agent. If the parent agent is still alive, then it waits for the streaming program. Otherwise, the AC will try to connect to its backup agent to receive the streaming program.

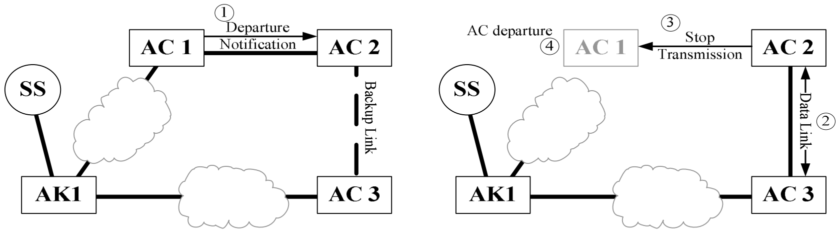

Fig. 8. Example of Agent Client Departure

3.5 Anycast Address

The anycast scheme is employed in Live2006 to provide better performance and shorter service latency. Two types of anycast addresses are designed in Live2006. The first type is the anycast address for all AKs. This is used when an AC completes its initialization process and finds the corresponding AK, it then sends the service request to the AK via this anycast address. The second type is the anycast address used by each streaming program. Thus, all the agents watching the same program keep the same associated anycast address. When an agent wishes to receive a specific multimedia program, it just sends out a request with the anycast address of that program. The agents who are capable to relay this program then will select a parent agent for this new agent.

3.6 Best Agent Approach (BAA)

When a fully-loaded agent receives a connection request from a new AC or CU, it employs the BAA to select one of its connected agents to serve the new AC or CU. The new AC or CU will then try to connect to the selected agent to receive the program. This mechanism is also used for the new AC or CU to find its backup agent.

There are three strategies for the BAA to select the best agent for the new AC or CU: Agent-Based, Performance-Based, and Policy-Based. The agent-based mechanism selects the agent based on some simple strategy, such as random selection or round-robin selection. The performance-based mechanism selects the agent with best performance. The performance of an agent can be measured according to the available bandwidth, CPU loading, other resources utilization, etc. The policy-based mechanism selects the agent according to some particular policy, such as whether the agents have the same length of IP address prefix, the used protocol type (TCP or UDP), or whether the IP address of an agent is public or private (behind an NAT or firewall).

4 System Implementation and Performance Evaluation

A Live2006 system, called Live6@nthu, is developed at National Tsing Hua University (NTHU) to provide the live streaming education program via the Internet. Live6@nthu primarily operates in webpage form to provide user friendly access. When the user clicks, the system directs the user to the multimedia playing page as shown in Figure 9. The video data of the currently running distance education program is played out on this page. Moreover the used slideshow pages are also displayed to improve the learning effect. Upon opening the mentioned webpage, the system will ask if the user likes to install the AC ActiveX component to have better QoS service. A user agreed to install the component is an AC who can relay multimedia data simultaneously while watching the distance education program. Otherwise, the user only plays the role of a CU who can only receive the program with a normal QoS service.

Fig. 9. Web GUI of Live6@nthu for AC Display

For handset devices, due to the limited device resources, only parts of the webpage are demonstrated on the screen. To speedup the data transfer for a handset device, the text mode interface is employed as shown in Figure 10(a). Of course, when the handset device user selected the desired program, the multimedia player is executed automatically as illustrated in Figure 10(b).

(a) (b)

Fig. 10. Text Menu of Live6@nthu for Handset Device Display

To evaluate the performance of the proposed Live2006 system, some experimental tests are conducted. The test focuses on the following three measurements: (1) the impact of using anycast for users to join the system; (2) consumed bandwidth when users join into and leave from the system dynamically; (3) the stability impact of a user departure to other joined users.

First of all, as we have described in section 3.2, a user wishes to join a program will send an anycast request to look for available parent agents. The top-down strategy is then employed. Without anycast supporting, the joining user directly connects to the AK to enact top-down strategy. The first test aims to find out the number of attempts to find a parent agent for the environments with or without anycast supporting. Figure 11 indicates that without anycast supporting, the number of tries to find a parent agent for a new user increases with the total number of joined users. Restated, a longer time is required for new users to join successfully when more individuals are watching the same program. Nevertheless, with anycast support, only a less number of attempts is required to find a parent agent. The impact is more conspicuous for a larger number of joined users. This phenomenon demonstrates that the anycast is valuable to accelerate the search of a parent agent for a new coming user.

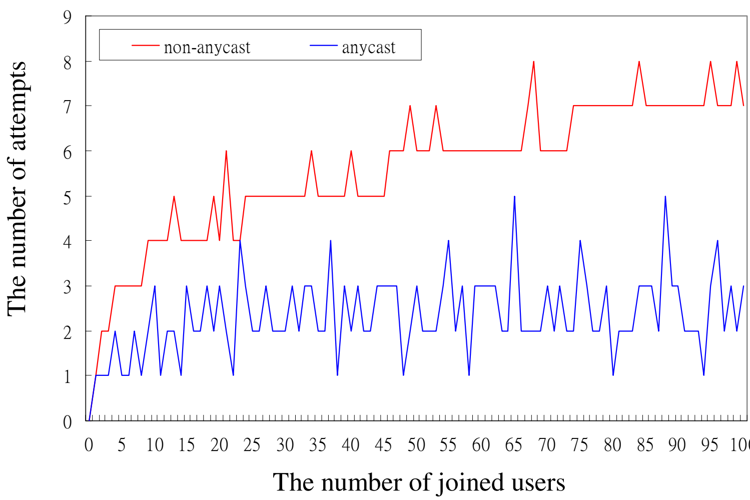

Fig. 11. Comparison of attempt numbers with and without anycast support

The second experiment attempts to observe the change of downloaded bandwidth when LAN users dynamically join to or leave from some certain distance education program. As we have illustrated, the proposed Live6@nthu not only employs P2P relay technology to transmit multimedia data, but also employs the BAA and ACM strategies to effectively use the network resources. The result of this experiment is depicted in Figure 12. Initially, a user (say, A1) joins into the program at time J1 and the downloaded bandwidth from WAN starts to increase to a level of 300-350kbps (a video streaming). Then, three other LAN users join to the same program at time J2, J3 and J4, respectively. We can see that with the proposed P2P relay mechanism of

Live6@nthu, the new users receive the program data from A1 (Agent) without connecting to the WAN, and the obtained data are then transmitted (shared) to others. Consequently, the consumed bandwidth is kept in a stable level even the number of users is increased. The first joined user A1 is then departures away at time D1. Since A1 is currently the Agent responsible for the WAN source, it continually obtains data and notifies one of the downstream Agents, say A2, to take its place. At this moment the downloaded bandwidth increases slightly. When A2 begins to receive data from WAN directly, A1 stops to receive and the downloaded bandwidth returns to the original stable situation. Then after a user joined at time J5, another user leaves the system at time D4. Since this user is not an Agent for the WAN source, the downloaded bandwidth is not affected. Based on these experimental results we can see that with the proposed P2P technology for multimedia data relay, the network resources are used in an efficient way regardless how many users are joined to the system. Moreover, the consumed bandwidth is stable when a user departure from the system, even the departure one is the agent obtaining data from the WAN source.

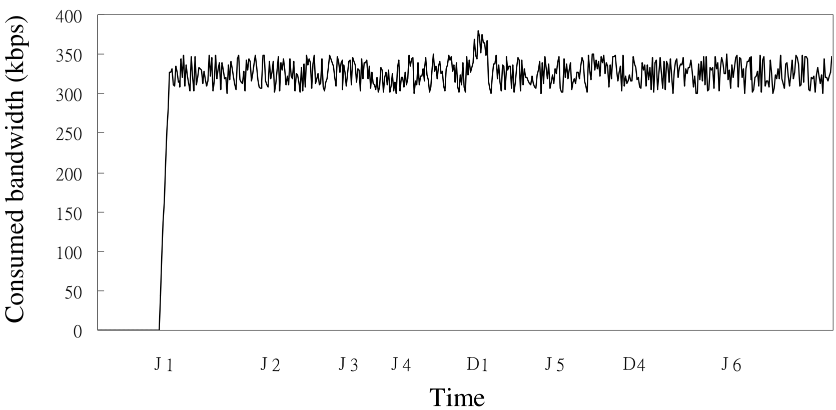

Fig. 12. Bandwidth consuming with dynamic joins/departures

5 Conclusions

Distance education provides a more flexible and efficient learning platform for modern remote education. Traditional client-server based infrastructure faces the scalability problem as the number of concurrent subscribing users the system can support is highly depends on the computing power of servers. And the servers usually become the bottleneck when a large scale of learning system is to establish. Also the bandwidth consumption is another big challenge to support a large number of concurrent users. Although several multicast-tree based platforms have been proposed to reduce the loading of servers as well as the consumed network bandwidth, there are still many technical and policy issues to resolve before such a system can be successfully deployed.

In this paper, a P2P-based distance education platform, called Live2006, has been proposed to provide a scalable, robust, and high available live streaming distance education service. In the proposed P2P infrastructure, peers are constructed as a tree-based structure and share the receiving streaming with each other. Live2006 can not only efficiently reduce the loading of the streaming server, but also minimize the cost of constructing a complete distance education system to support large number of users. Furthermore, in both WAN and LAN environments, the bandwidth consumed by each distance education program is well controlled even there are large number of joined users. The proposed Live2006 system can also be established for home or community networks to reduce the usage of downloaded bandwidth. Two more attractive features of the Live2006 are (1) it is not restricted by firewall or NAT, and (2) it supports handset devices. All handset devices thus can connect to the system any time and any where to access the distance education programs without any constraints.

Additionally, since Live2006 is a multimedia data transmission framework, it is easy to integrate with existing distance education service systems with only a few changes. Live2006 not only operates under IPv4 environment, but also works in IPv6 network. Some Ipv6 features, such as ipv6 mobility (provides handset users better service) and anycast (provides better system efficiency) even perfects the functionality of Live2006.

Acknowledgement

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A Service-Based Framework for Personalized Learning Objects Retrieval and Recommendation

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Abstract. With vigorous development of Internet, especially the web page interaction technology, distant e-learning has become more and more realistic and popular. To solve the problems of sharing and reusing teaching materials in different e-learning systems, presently several standard formats, including SCORM, IMS, LOM, and AICC, etc., have been proposed by several different international organizations. SCORM LOM, i.e. the Learning Object Metadata, enables the indexing and searching of learning objects in a learning object repository by extended sharing and searching features. However, LOM is deficient in semantic-awareness operations in spite of its multifarious fields in describing a Learning Object. It is difficult for a learner, even for advanced learners, to completely specify so many terms when they are searching. This paper proposes a service-based framework for personalized learning objects retrieval and recommendation. The work of personalization harnesses the power of probabilistic semantic inference for query keywords, LOM-based user preference logging, and other users' feedback for recommendation weighting to retrieve the most suitable learning object for users. An ontology-based query expansion algorithm and an integrated learning objects recommendation algorithm are also proposed.

Keywords: Ontology, LOM, Learning Object, Retrieval, Recommendation, Preference, Collaborative Feedback.

1 Introduction

In recent years, distant learning has become more and more realistic and popular owing to the rapid advance in Internet technology, especially in web page interaction. Solving the problems of sharing and reusing teaching materials in different e-learning systems has been an important issue. There have been numerous international organizations, such as IEEE-LTSC [1], Instruction Management System Global Learning Consortium [2], Aviation Industry CBT committee [3], Advanced Distributed Learning initiative [4], and Alliance of Remote Instructional Authoring and Distribution Networks for Europe project [5], that have devoted to building e-learning standards. For the time being, the Sharable Content Object Reference Model (SCORM) [6] is recognized as the most popular standard. SCORM is implemented by the Advanced Distributed Learning Initiative created by the US Department of

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Defense. It aims to foster creation of reusable learning content used as "instructional objects" within a common technical framework for both computer and Web-based learning. SCORM describes this technical framework by providing a harmonized set of guidelines, specifications, and standards developed by several organizations. All of them are adapted and integrated with one another to form a more complete and easier-to-implement mode by ADL. Key contributors to SCORM include organizations AICC, ARIADNE, IEEE LTSC, and IMS.

Learning Object Metadata (LOM) is approved by the IEEE-Standards Association. LOM aims to provide structured descriptions of digital contents, sometimes referred to as "Learning Objects". It is part of the SCORM standard suite, which provides a standard for encoding general information of learning objects. IEEE-LOM uses a pre-defined and common vocabulary to describe the content of learning objects. There are nine categories in the vocabulary including *General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation,* and *Classification.* LOM plays the same role as Dewey Decimal Classification (DDC) in library books catalog. If every learning object in a repository on the Internet is catalogued according to LOM, it would be easy to find a specific learning object. Just like in the libraries where catalogs can guide a user to locate a needed book quickly, LOM can guide a learner to locate learning objects in the Internet by using titles, descriptions, locations and other attributes.

This paper proposes a service-based framework for establishing personalized learning objects retrieval and recommendation. In the proposed framework, Domain Ontology is used for constructing automatic inferring of user intention. The work of personalization harnesses the power of probabilistic semantic inference for query terms, LOM-based user preference logging, and other users' feedback for recommendation weighting in order to retrieve the most suitable learning object for users. An ontology-based query expansion algorithm and an integrated learning objects recommendation algorithm are also proposed. Focused on digital learning material and contrasted to other traditional keyword-based search and recommendation technologies, the proposed approach has shown significant improvement in retrieval precision, recall rate, and recommendation performance. The rest of the paper is organized as follows. Section 2 gives some background of the Learning Objects and ontology. Section 3 describes the personalized learning objects retrieval & recommendation framework. Section 4 describes the approach and the algorithm. Section 5 shows evaluation results and has some discussions, and the final section gives the conclusion.

2 Background and Problem

In this section, the background of Learning Objects (LOs), ontology related knowledge management, and the personalization problems in the current e-learning standard will be addressed.

2.1 Learning Objects and Learning Object Metadata

SCORM learning object – SCO: Sharable Content Objects (SCOs) are collections of one or more assets that are the most basic learning resources, such as GIF images, web pages, HTML fragments, or Flash objects. The term "metadata" means data about data. In SCORM, all SCOs are described by metadata according to the IEEE learning object metadata (LOM) standard. The metadata specification provides a mechanism to describe the content using a pre-defined and common vocabulary.

2.2 Ontology Concept and Ontology Related Knowledge Management

Ontology is a philosophical theory about the nature of existence. A typical ontology has a taxonomy defining the classes and their relationships and a set of inference rules powering reasoning functions [7]. Ontology is now recognized in AI community as a term referring to the shared understanding of knowledge in some domains of interest, which is often conceived as a set of classes (concepts), relations, functions, axioms and instances. Guarino [8] has conducted a comprehensive survey for the definition of ontology from various highly cited works in the knowledge sharing community. While in the knowledge representation community, the commonly used or highly cited ontology definition is from Gruber [9]. For the purpose of this research, we focus on the domain ontology which is a formal explicit description of concepts in a domain of substances (also called classes or concepts), properties of each concept describing the features and attributes of the concept and relationships with other concepts (also called slots or properties), and restrictions on slots (also called facets).

Several technologies have been developed for shaping, constructing, and developing the descriptions of ontologies. RDF/S [10][11] and its extensions, such as DAML+OIL [12] and W3C-OWL [13], have been widely used for defining metadata schemas, domain ontologies and resource descriptions. In the e-Learning paradigm, there are emerging standards which describe learning resources; among them are RDF-bindings of LOM (Learning Objects Metadata [14]) and Dublin Core [15].

2.3 The Problem

In general, a learner may not have any basic knowledge of a specific domain before learning it. The query terms input to a tutoring system for specific subject may only be a learner's surmises and the learning objects retrieved accordingly may be incorrect, or to be worse, misleading.

While in e-learning paradigm, users may have no idea about what they want and what the learning object metadata is. Consider the following scenario: A user who already has programming experience in some programming languages, such as C#, wants to know how Object Oriented (OO) concepts are realized in the JAVA programming language. For that the user may decide to register to an e-learning network in order to search for appropriate learning materials that mentioned about OO concepts in JAVA, and he may use query terms 'class method'. However, in traditional keyword-based search, such query terms may results in lots of JAVA API and code being shown in the list. But, in this case, what the user really wants is the conceptual tutoring material.

It is hard and also unreasonable to ask a learner to be familiar with the LOM standard. Providing a bunch of fields for a user to fill in is a possible solution. However it will make a system inflexible and still a learner has to know various types of metadata. Even though learners can understand the LOM, a system may still be not semantic-awareness. That is, although the titles and the descriptions of a field in LOM is well defined, the contents of learning objects still depend on the usage of languages, glossaries, expert opinions, personal experiences, and so on. Learners' intention & preference awareness is what we called "Personalization". In the proposed framework, this is done by an ontology query expansion algorithm and an integrated LOs recommendation algorithm.

3 Personalized Learning Objects Retrieval and Recommendation Framework

This section describes the proposed personalized learning objects retrieval & recommendation framework. Figure 1 show the proposed framework and all the core processes. The framework provides five major services, which are described as below.

I. Personalized LOs Retrieval Service

The personalized LOs retrieval service provides a graphical user interface for learners to register, sign in, and display personalized search results. This service also acts as a gate to communicate with other components.

II. Query Formalization Service

Query terms come to the Query Formalization Service in the pre-processing phase. The major functions of this service are tokenization, lowercasing, part-of-speech, stemming, stopword removing, and chunking.

III. Ontology Query Expansion Service

The Ontology Query Expansion Service is an inference engine to evaluate a learner's intention through domain ontologies. It expands (modifies, if necessary) the coming in query terms by an ontology query expansion algorithm, a fully automated process with no interactions from the learner. The main function of this service is to infer a learner's intention while the learner may have no idea of what they need, such as the scenario mentioned in section 2.3. The proposed algorithm uses Bayes' theorem for expanding coming in query terms. The main idea of this method is to construct the probabilistic correlations between the candidate expansion terms and LOMs. The details will be discussed in a later section.

IV. LOs Mapping Service

LOs Mapping Service receives expanded query terms and searches in the LOs & LOM repository to find appropriate learning objects. These LOs are returned as query results.

V. Recommendation Service

Unlike traditional Information Retrieval systems, this framework uses a Recommendation Service to rank the query results in a order mostly suitable for a learner. It is believed that the retrieval precision and recall rate has been improved in the query expansion phase. Personalization is achieved by evaluating a learner's preference and collaborative feedbacks from other learners. The functionality of the recommendation algorithm will be described later.

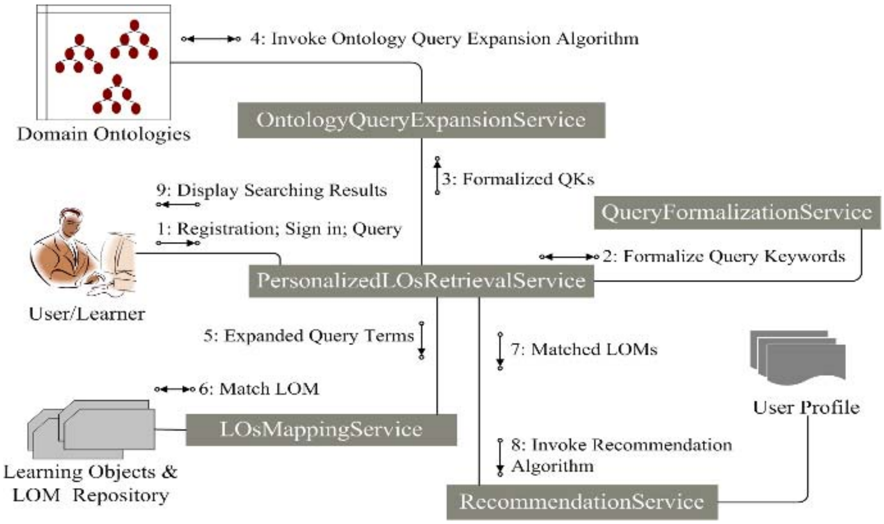


Fig. 1. Service components and the core process of the personalized LOs retrieval & recommendation framework

4 The Ontology Query Expansion Algorithm

The key factor in achieving efficient and user-friendly information retrieval for a search mechanism is to guarantee minimal irrelevant information being delivered (high precision) as well as relevant information not being ignored (high recall). Traditional solutions usually use keyword-based search, such as vector space model. The documents retrieved are those that contain user-specified keywords. But there may be documents that convey heavily the desired semantic of the keywords entered but contain none of these keywords, and thus are not retrieved. This problem is usually eased by using query expansion algorithms, in which additional search terms are added to the original query based on the statistical co-occurrence of terms [16]. Recall rate will be increased, but precision will be down in general [17].

One can ease precision problems by indexing documents on both their context and meanings instead of keywords only. Yet, this requires a method of mapping the contexts and their possible meanings and the creation of such meanings-based indexed databases. Domain ontology, the semantic schema used to build metadata layer upon semantic web, on the other hand, contains the concept hierarchy of specific domain knowledge and the detail features of all concepts type and provides such a conceptual indexing for documents. This research is to build a semantic inference engine to find out relationship between learner queries and learning object metadata in order to retrieve learning objects semantically. It is achieved by using the ontology query expansion algorithm that has two phases, i.e. **constructing User Intention Tree (UIT) from ontology (UIT)** first and then **Expanding query terms from UIT.** The formal definitions are described below.

4.1 Constructing User Intention Tree (UIT)

A ***UIT*** is a sub-tree of an ontology hierarchy that represents a user's intention in a minimal set. This phase aggregates the nodes of a user intention tree containing a minimum conjunction of matched concepts. It represents a semantic tree of a user's query according to the ontology defined.

Def. 1. Query Keywords and Concept Keywords
The set of query keywords that have been pre-processed by the Query Formalization Service for a query is called the *Query Keywords (QK)* and $QK = \{QK_1, QK_2, ..., QK_m\}$. In domain ontology, each concept is described by a set of *Concept Keywords (CK)*. For a concept *i*, CK^i is defined as $\{CK^i_1, CK^i_2, ..., CK^i_m\}$.

Def. 2. Basic Concepts and Basic Concept Score -- BCS
For a concept *i*, if $CK^i \cap QK \notin \varnothing$ then the concept *i* is treated as a "*Basic Concept (BC)*". In other words, basic concepts are those concepts in the domain ontology that match one of the query terms. For a certain query, the algorithm first evaluates Basic Concept Score for each Basic Concept. *BCS* represents the degree of matching between concepts and query terms. A set of modified TF-IDF formulas, described below, is used to measure *BCS*.

$$TF_{QK_k, CK^i} = \begin{cases} \dfrac{Fre_{QK_k, CK^i}}{\sum_{l=1}^{|CK^j|} Fre_{CK^i_l, CK^i}} = \dfrac{1}{|CK^i|} & , QK_k \in CK^i \\ 0 & , otherwise \end{cases} . \tag{1}$$

TF means '*Term Frequency*'. The numerator of Eq. (1) is the number of times the query term QK_k is mentioned in the concept descriptions CK^i of concept *i* (if matched). The denominator of Eq. (1) is the number of elements in the concept descriptions CK^i. Eq. (1) defines the degree of matching between the query term QK_k and concept *i*.

$$IDF_{QK_k, CK^i} = log \frac{\#\ of\ concepts\ in\ ontology}{\#\ of\ concepts\ that\ match\ QK_k} . \tag{2}$$

IDF denotes the '*Inverse Document Frequency*'. The numerator of Eq. (2) is the total number of concepts in the domain ontology, and the denominator is the number of concepts in which the query term QK_k appears. Thus, the modified term-weighting is given by Eq. (3) as:

$$W_{QK_k, CK^i} = TF_{QK_k, CK^i} \times IDF_{QK_k, CK^i} . \tag{3}$$

Eq. (4) is the normalized term-weighting of Eq. (3).

$$NW_{QK_k,CK^i} = \frac{TF_{QK_k,CK^i} \times IDF_{QK_k,CK^i}}{\sqrt{\sum_{x=1}^{|CK^i|} \left(TF_{CK_x^i,CK^i} \times IDF_{CK_x^i,CK^i}\right)^2}} \,. \tag{4}$$

$$BCS\,(i) = \frac{\sum_{k=1}^{|QK|} NW_{QK_k,CK^i}}{|QK|} \,. \tag{5}$$

Finally, the Basic Concept Score of concept *i* that denoted by *BCS(i)* is the summation of total normalized term-weighting of the Query Keywords. The denominator of Eq. (5) is to normalize the *BCS* between 0 and 1.

Def. 3. Weighted Basic Concept Score – WBCS, and Propagated Basic Concept Score -- PBCS
When there is a user-defined relation between Basic Concept *i* and *j*, it should be weighted for each other by the following formula (denoted by *WBCS (i, j)*):

$$WBCS\,(i\,,j) = BCS\,(i) + BCS(i) \times BCS(j)\,. \tag{6}$$

We can then define the Propagated Basic Concept Score, *PBCS(i)*, as the summation of total *WBCS(i,j)* that weighted by all related Basic Concepts, in a general form:

$$\begin{aligned} &PBCS\,(i\,,j) \\ &= BCS\,(i) + \{[BCS(i) \times BCS(j_1)] + [BCS(i) \times BCS(j_2)] + \ldots + [BCS(i) \times BCS(j_n)]\} \\ &= BCS(i) + BCS(i) \times (BCS(j_1) + BCS(j_2) + \ldots + BCS(j_n)) \\ &= BCS(i) + \sum_{all\text{-}related\text{-}concept\text{-}j} BCS(\,j\,) \end{aligned} \tag{7}$$

Eq. (7) defines what is so called the semantic weight. In Eq. (6) and (7) multiplication is used to weight each other instead of summation of their score. This is because the direct matched score (*BCS*) is regarded as the most significant score, and the multiplication would lower the weighting factor (the value of *BCS* has been restricted to 0~1) of *PBCS*. After the *PBCS* of each *BCS* has been evaluated, the *UIT* can be constructed and it is the minimum conjunction of BCs.

Def. 4. Degree Function (Deg), Impact Score (IS), and Total Impact Score (TIS)
The Degree Function **Deg** in Eq. (8) defines the number of sub-concepts that a concept has.

$$Deg\,(i) = \begin{cases} \#\ of\ all\ descendants\ (includes\ non\text{-}direct\ link\ node),\ i \notin leaf\ node \\ 1,\ i \in leaf\ node \end{cases} \tag{8}$$

Each *BC* in an ontology hierarchy is also semantically related to its parent concept to a certain degree. Further more this relationship will trace back all the way to the root. The impact score *IS(i,k)* denotes the degree of semantic impact a Basic Concept *i* may have on its parent concept *k*. The formal definition is:

$$IS(i,k) = \left\{ PBCS(i) \times \frac{Deg(i)}{Deg(k)} \quad \middle| \, concept \;\; k \notin base \;\; concept \right\} \tag{9}$$

Thus we can define the total impact score of a concept *i*, *TIS(k)* from all its descendants:

$$\begin{aligned} & Total \;\; Impcat \;\; Score: \\ & TIS(k) = \left\{ \sum IS(i,k) \;\middle|\; \begin{array}{l} concept \;\; i \in BC \;\; and \;\; is \; a \; child \;\; of \;\; concept \;\; k, \\ concept \;\; k \notin base \;\; concept \end{array} \right\} \end{aligned} \tag{10}$$

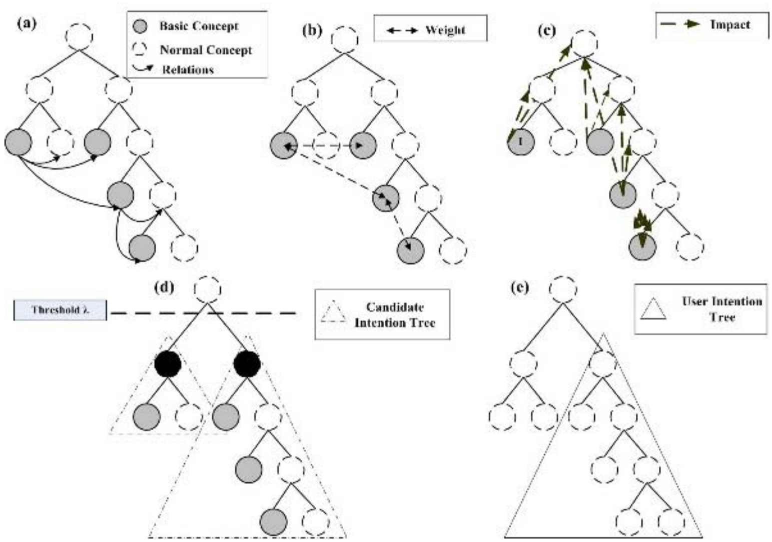


Fig. 2. The basic process of constructing UIT

Figure 2 shows the basic process of constructing *UIT*. Figure 2-(c) illustrates how a *BC* impacts on its parent.

The work remained is to find a top level concept that is the root of the final intention tree associated to a user's query. A variable λ is used as a threshold to the upper bound of a *UIT*. As shown in Fig. 2-(c) and Fig. 2-(d), the algorithm calculates the total impact score of all *BC*s' parents. If along the way of tracing back there exists an ancestor concept, whose *TIS* is the smallest larger than λ, then it is set as the root and all its descendants are constructed as a ***Candidate UIT***. While several candidate *UIT*s may be constructed, the one with the highest *PBCS*s will be selected as the final *UIT*. This step is equal to remove semantic ambiguities.

4.2 Expanding Query Terms from UIT

This phase expands the query terms from the selected *UIT*. Since the proposed algorithm is intended to be a domain-independent query expansion algorithm and a *UIT* constructed may be one big sub-tree in the case of a huge or heterogeneously integrated ontology, the final expanded terms will be determined by their correlations with Query Keywords. This section discusses how to determine the degrees of correlations between the candidate query expansion terms and Query Keywords. Finding the correlations between a candidate query expansion term and Query Keywords is equal to calculating the conditional probabilities between them [18]. That is, the degree of the correlation between a candidate expansion term and a query keyword is the probability of a candidate expansion term's appearance on condition that the query keyword appears in LOM. The notion is denoted as $P(CK_x^i \mid QK_y)$, where the Concept Keyword $CK_x^i \in$ *UIT*. The Concept Keyword CK_x^i denotes the *x-th* element of the Concept Keywords of concept *i*. The Query Keyword QK_y denotes the *y-th* element of the Query Keywords of user query. Let S be the set of LOMs in the learning objects repository, according to the Bayes' theorem, the conditional probability $P(CK_x^i \mid QK_y)$ can be defined as follows:

$$
\begin{aligned}
&P(CK_x^i \mid QK_y) \\
&= \frac{P(CK_x^i, QK_y)}{P(QK_y)} = \frac{\sum_{\forall LOM_k \in S} P(CK_x^i, QK_y \mid LOM_k) \times P(LOM_k)}{P(QK_y)} = \frac{\sum_{\forall LOM_k \in S} P(CK_x^i, QK_y, LOM_k)}{P(QK_y)} \\
&= \frac{\sum_{\forall LOM_k \in S} P(CK_x^i \mid QK_y, LOM_k) \times P(QK_y, LOM_k)}{P(QK_y)} = \frac{\sum_{\forall LOM_k \in S} P(CK_x^i \mid LOM_k) \times P(LOM_k \mid QK_y}{P(QK_y)} \\
&= \sum_{\forall LOM_k \in S} P(CK_x^i \mid LOM_k) \times P(LOM_k \mid QK_y)
\end{aligned} \tag{11}
$$

In Eq. (11), $P(LOM_k \mid QK_y)$ is the conditional probability of the LO_k is selected in case that QK_y appears in the Query Keywords. $P(CK_x^i \mid LOM_k)$ is the conditional probability of occurrence of CK_x^i if the LO_k is selected. The evaluation of the conditional probability $P(LOM_k \mid QK_y)$ and $P(CK_x^i \mid LOM_k)$ are defined as follows:

$$
P(LOM_k \mid QK_y) = \frac{Fre(LOM_k, QK_y)}{Fre(QK_y)} \tag{12}
$$

$$
P(CK_x^i \mid LOM_k) = \frac{NW_{CK_x^i, LOM_k}}{\max_{\forall T \in LOM_k} (NW_{T, LOM_k})} \tag{13}
$$

In Eq. (12) & (13), $Fre(LOM_k, QK_y)$ is the frequency (times) that QK_y and LOM_k appear (LO_k is selected) together. $Fre(QK_y)$ is the query frequency (times) that contain the Query Keyword QK_y. The two factors were statistically obtained from the system logs. $NW_{CK_x^i, LOM_k}$ is the normalized TF-IDF weight of the term CK_x^i in LOM_k. The denominator of Eq. (13) is the maximum value of term weights in LOM_k. By combining the probabilities of all Query Keywords, we can get the joint weight for each concept keyword in the following formula:

$$W(CK_x^i, QK) = log\left\{\prod_{y=1}^{|QK|}(P(CK_x^i \mid QK_y) + 1)\right\} \text{ , where } CK^i \in UIT \tag{14}$$

Thus we can get a list of candidate expansion terms as well as the conditional probabilities between each terms and user query. The top-ranked terms are selected as the expansion terms.

5 Integrated Recommendation Algorithm

As mentioned above, the personalization harnesses the power of probabilistic semantic inference for user's intention, LOM-based user preference logging, and other users' feedback for recommendation weighting. The probabilistic semantic inferring for user's intention is realized by the ontology query expansion algorithm. Unlike traditional information retrieval technologies, the ranking of the query results uses also user preference logging and feedback from other users for recommendation weighting. This section describes how the integrated recommendation algorithm ranks the query results.

Currently, most of the recommendation algorithms can be classified into three catalogs: content-based [19], collaborative-based [20], [21], and hybrid-based[22]. The proposed recommendation algorithm in this paper is based on both the content-based approach and the collaborative feedback. The first step is to extract LOs' characteristics from a user's profile.

5.1 LOM-Based User Preference

To achieve personalized recommendation, it's necessary to analyze the characteristics of learning objects first. A LOM's characteristics are expressed as a set $\Phi_{LO} = \{E_1; E_2; ...; E_n\}$. Assume there are n kinds of characteristics selected from a LOM. In the implementation, every useful characteristic from each category (such as "Language") is picked up. Once a user uses a LO, the characteristic values of the LO will be recorded in his user profile, which is named as User Preference Pattern (*UPP*). *UPP* is defined as follows:

Def. 5. User Preference Pattern

$UPP = \{\Gamma_1; \Gamma_2; ...; \Gamma_n\}$, where $\Gamma_i = \{(e_i^1, \psi_i^1); (e_i^2, \psi_i^2); ...; (e_i^k, \psi_i^k)\}$.

In definition 5, each Γ records a specific characteristic of a LO with certain elements, each of them is a value-times pair that records the characteristic value and the number of times this characteristic value ever appears in the past. For example, if a user have used English materials five times and Traditional Chinese materials eight times in the past, and assuming that Γ_1 records the characteristic of 'Language', then $\Gamma_1 = \{(en, 5), (tw, 8)\}$. The correlations between a specific characteristic Γ_i of certain learning object E_i is defined as the conditional probability of Γ_i of E_i appears on the condition that Γ_i exists, which is denoted by $P(E_i \mid \Gamma_i)$. The evaluation uses the following formula:

$$P(E_i \mid \Gamma_i) = \begin{cases} \dfrac{\psi_i^x}{\sum_k \psi_i^k} & , \forall e_i, \exists e_i^x = E_i \\ 0 & , otherwise \end{cases} \tag{15}$$

Thus for each retrieved learning object, the preference value of the LOM and *UPP* is defined as:

$$\text{Preference}(\Phi_{LO}, \text{UPP}) = \log \left\{ \prod_{i=1}^{|UPP|} \left(P(E_i \mid \Gamma_i) + 1 \right) \right\} \tag{16}$$

5.2 Collaborative Feedback

Users of the system are asked to give a feedback optional score between 1 and 5 for each used learning object. Higher feedback score implies higher preference to the LO for a user. The recommendation algorithm evaluates feedback scores to determine a user's neighbors that have similar point of view. The idea is that if learners A and B always select same LOs and gives similar feedback scores in the past the algorithm can infer that A and B have similar interests and they are neighbors. For a specific LO that A have used before and that are being recommended for B, the recommendation score should refer to A's feedback score. Such a notion is called the collaborative feedback in this paper.

For each user, the system records her/his personal profile that contains *UPP* mentioned above, feedback score for selected LOs, and her/his neighbors. The first step is to find out those users who are neighbors to the target user.

Def. 6. Similarity Evaluating Function

$$Similarity(L_1, L_2) = \frac{\sum_{LO \in CommonLO_{L_1,L_2}} \left[(FS_{L_1,LO} - \overline{FS_{L_1}}) \times (FS_{L_2,LO} - \overline{FS_{L_2}}) \right]}{\sqrt{\sum_{LO \in CommonLO_{L_1,L_2}} (FS_{L_1,LO} - \overline{FS_{L_1}})^2 \times \sum_{LO \in CommonLO_{L_1,L_2}} (FS_{L_2,LO} - \overline{FS_{L_2}})^2}} \tag{17}$$

Eq. (17) is the similarity evaluating function. L_1 is the target user and L_2 is another user of the system who is considered as L_1's neighbor. The $CommonLO_{L_1,L_2}$ are the learning objects that have been used by both L_1 and L_2. $FS_{L_1,LO}$ is the feedback score of a LO that are given by L_1 while $\overline{FS_{L_1}}$ is the average feedback score of L_1. In this step another parameter δ is used to control the number of neighbors. If $Similarity\ (L_1, L_2) \geq \delta$, then L_2 is regarded as L_1 's neighbor. The set of L_1 's neighbor is denoted by $Neighbor_{L_1}$. After L_1 's neighbors for each LO retrieved by L_1 are found and recorded, the next step is to collect the feedback scores from all L_1 's neighbors. Eq. (18) is the evaluating function for this purpose.

Def. 7. Collaborative Feedback Evaluating Function with Relative Error Revise

$$\Re_{LO}(L_1, \text{Neighbor}_{L_1}) = \frac{\sum_{L_2 \in \text{Neighbor}_{L_1}}^{|\text{Neighbor}_{L_1}|} \left[(FS_{L_2,LO} - \overline{FS_{L_2}}) \times Similarity\ (L_1, L_2) \right]}{\sum_{L_2 \in \text{Neighbor}_{L_1}}^{|\text{Neighbor}_{L_1}|} \left| Similarity\ (L_1, L_2) \right|} \tag{18}$$

Eq. (18) is the collaborative feedback evaluating function with relative error correcting. Relative error is a common problem in most recommendation systems. Consider the simple scenario when if the target user A always gives higher feedback score for LOs such as 4-5, B always gives lower feedback score such as 1-3, and others may prefer to give a middle score such as 2-4, then it's irrational to combine all the neighbors' feedback score directly. In the numerator of Eq. (18), relative error is corrected by the $FS_{L_2,LO} - \overline{FS_{L_2}}$ statement, and also multiplied by the similarity to control the impact to a normalized level.

5.3 Integrated Recommendation Strategy

For each retrieved LO, both the preference scores and collaborative feedback scores are calculated. The final integrated recommendation strategy combines these two scores as a single recommendation score to rank the retrieved LOs. The formula is shown below, and a parameter α is used to adjust the relative ratio of the two scores.

Def. 8. Recommendation Score

$$\text{RS} = \{\alpha \times \text{Perference}\ (\Phi_{LO}, \text{UPP}_{\text{L}}) + (1-\alpha) \times \Re_{LO}(L, \text{Neighbor}_{\text{L}}), 0 \leq \alpha \leq 1 \tag{19}$$

6 Evaluation

In order to evaluate the proposed approach for semantic learning objects retrieval and recommendation, we developed a web-based framework. The server side applies the proposed ontology query expansion, evaluates user preference & collaborative feedback, sends the optimized query to the learning objects repository, and returns quality results. In this prototype the ACM Computer Classification System (see http://www.acm.org/class) is used as the upper layer ontology.

6.1 Upper and Domain Ontology

The ACM CCS is chosen as our top-level (upper) computer science ontology (upper ontology). The WORDNET (http://wordnet.princeton.edu/) was used for building synonyms and keywords set of the ACM CCS ontology. We have also built an introductory java programming ontology as the experimental domain ontology in the proposed framework. This ontology is based on the Computing Curricula CC2001 of the ACM and IEEE/CS [23], and is designed for providing a Java learning object knowledge base. Please refer to [24] for more details.

6.2 Learning Objects

For evaluating the proposed approach, we collect over 1200 learning objects from various learning objects repositories (COL http://www.col.org; ARIADNE http://ariadne.unil.ch/; NEEDS http://www.needs.org; MERLOT http://www.merlot.org) and web sites (The Java™ Tutorial http://java.sun.com/docs/books/tutorial/; IBM Redbooks http://www.redbooks.ibm.com/) (we collect the metadata and links instead of the physical files).

6.3 Evaluation Methodology

The effectiveness of an information retrieval system is usually measured by two quantities and one combined measure, named *"Recall"* and *"Precision"* rate. The normal definition of *"Recall"* is the number of retrieved relevant documents divided by the number of all relevant documents (which previously identified by domain experts), and the definition of *"Precision"* is the number of retrieved relevant documents divided by the number of all retrieved documents. For measuring our ranking (i.e. recommendation) algorithm, another measurement is used, namely the Mean Average Precision at a Given Document Cutoff Value *k* (MAP) [25]. The MAP is defined as follows:

$$MAP_{cutoff\_k} = (\#\ of\ Query)^{-1} \sum_{i=1}^{\#\ of\ Query} \left(N_i^{-1} \sum_{R=1}^{N_i} Top_{i,R}^{-1} R \right)$$

Among which N_i represents the number of documents that are relevant to $Query_i$ at the *top-k* results, and $Top_{i,R}$ is the location of *R-th* relevant document in the ranking list.

In this experiment, we asked assistance of 10 volunteer users, all of them familiar with computer science and search engines. We assign 30 information needs to the 10 users. Each information need was executed in 5-10 runs with similar or different query set, and each query set has 2-8 keywords. The first five runs were taken as the training set to collect the LOM characteristics and query log. In this experiment, the parameter δ was set as 0.

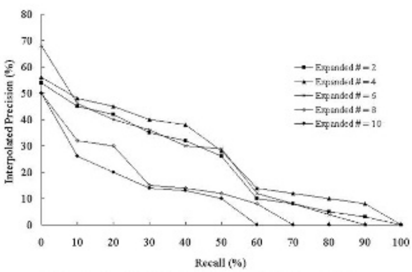
6.4 Experimental Results

This section describes the experimental results. The retrieval & recommendation effectiveness was quantified through standard measures of average recall, precision, and MAP. This experiment employed two aggregate metrics: (1) interpolated 11-point average precision and (2) mean average precision over the cutoff value 2, 4, 6, 8, and 10.

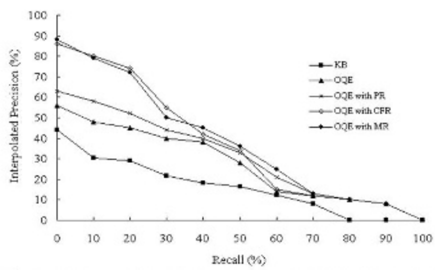
Fig. 3-(a) shows the interpolated 11-point recall-precision curve for our ontology query expansion (OQE) algorithm (without recommendation). The result shows that, in general, the algorithm performs well while the expansion number equals to 2, 4 and 6. However in the query expansion phase, the average precision is more important than the top-ranked precision. This is because the top-ranked precision will be improved by the recommendation phase. In the later part of this experiment, the number of expansion terms was set as 4.

Fig. 3-(b) shows interpolated recall-precision curve for different strategies. Obviously the ontology query expansion strategy performs better than keyword-based approach. In this experiment at least 66% improvement was achieved in average precision, and all of the OQE strategies yield better precision than keyword-based approach, regardless of the recall level. The result shows that the OQE with integrated recommendation ranking yields the largest gains in average precision. Fig. 3-(c) shows interpolated recall-precision curve for OQE-MR over $\alpha = 0.0\sim1.0$. Figure 3-(d) shows the average MAP in document cutoff value k = 2, 4, 6, 8, and 10 for OQE-MR over $\alpha = 0.0\sim1.0$. $\alpha = 0.0$ means that the recommendation strategy just concern about the collaborative feedback score. And in the contrary, $\alpha = 1.0$ means that the recommendation strategy just concern about the personal preference score.

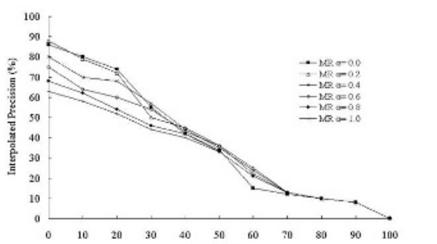
The results of Fig. 3-(c) & 3-(d) show that collaborative feedback yields better performance than personal preference in the top-ranked LOs. By observing the data we found that many LOMs just provide a little information. However, we believe that, the importance of the personal preference would increase with the popularization of the LOM standard.



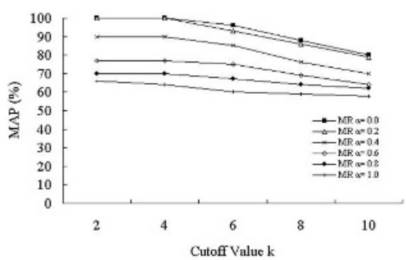
(a) Interpolated Recall-Precision curve for 2-10 expanded terms



(b) Interpolated Recall-Precision curve for the Keyword Based (KB), the Ontology Query Expansion (OQE), the OQE with Preference Recommendation (PR), the OQE with Collaborative Feedback Recommendation (CFR), and the OQE with Integrated Recommendation (MR)



(c) Interpolated Recall-Precision curve for the Integrated Recommendation over= 0.0~1.0



(d) Top 2-10 ranked MAP for the Integrated Recommendation over= 0.0~1.0

Fig. 3. Experimental Results

7 Conclusions

The purpose of this research is to realize personalized learning objects retrieval and recommendation. Our approach is distinct because of the query intention inferring and the personalized LOs recommendation strategy. An ontology query expansion algorithm and an integrated learning objects recommendation algorithm were proposed. We have built a web-based framework and tested our method in this environment. Focusing on digital learning material, contrast with traditional keyword-based technology, this research has experimentally shown that our model can achieve significant improve of the precision and provides quality learning objects.

This research argues that using ontology technology & distinguishing features of LOM in the e-learning paradigm, tutoring systems can also be more intelligent, powerful, and adaptive.

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Internet-Enabled Tangible User Interfaces for Distance Learning

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Abstract. The advent of Internet technologies since decades ago has propelled distance learning drastically. In this modern world, knowledge develops so fast that the amount of intellectual information that needs to be learnt before it becomes obsolete again is so huge. Distance learning through the use of Internet technologies has the advantage of being able to get across the information to the students remotely and effortlessly. The other advantage, which is the main focus of this paper, is that students are able to learn from their instructors on an entirely new media platform - the Internet-enabled tangible user interface. This paper discusses the two main new media, multi-modal Internet technologies, namely remote physical interface and remote augmented reality technology.

Keywords: Distance learning, Tangible user interface, Multi-model, Augmented reality.

1 Introduction

In an attempt to provide increased educational opportunities to their present students and to attract new students who are working or have other constraints on their time or mobility, many colleges and universities are developing distance education programs [1]. However distance education before the Internet age was painstakingly ineffective. First of all, there was the lack of interaction between the instructors and the students. Then there was the issue of delay in communications. Today the distance learning is supposed to provide a rich, "almost classroom experience" to distance students. It is a big challenge. Distance education offers freedom from space and time constraints, increased interactivity, improved delivery of multimedia, broadened curricula, and personalized learning [1]. Many tools have been developed to facilitate distance learning since its inception, such as traditional mails of printed material, videotape, CD-ROM, DVD, and the more recent Web-based methods, which includes live video streaming, video conferencing and interactive graphical user interfaces (GUI).

The advantages of distance learning have been mentioned briefly. There are far more disadvantages to be discussed. Later sections discuss how our proposed

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Internet technologies could help overcome these shortcomings. One of the major concerns is that students who are learning at a distance from the instructor and other fellow students may suffer from lack of interaction. Usually students have little or no means of communicating with each other; even those who have the means of communicating with others in their class via online chats or email may not have any motivation to do so. Both students and instructors are affected if they do not have enough effective communication with each other. The instructor is unable to judge a student's progress and is unable to adapt the lesson to successfully meet the needs of the learners. The students are more likely to feel confused or angered by assignments when they do not understand their significance. In, addition, if communication between student and instructor is not timely, much of the value of feedback on assignments and tests is lost [1]. The other major concern of distance learning is that, often there is a loss of visual and physical experience. In other words, students sometimes could not visualize the physical objects or models as illustrated by the instructor. This shortfall is more prominent when teaching subjects which are best taught using physical artifacts. Instructors believe that visual enhancement helps students learn [2]. Moreover, the feel of physical presence in front of the instructor or in the classroom also enhances the learning process. So the current distance learning suffers from, but not limited to, lack of interaction, loss of visual experience and absence of physical presence. In this paper we propose a few enabling technologies that we envisage will change the distance learning process altogether. We propose the use of Internet-enabled tangible user interfaces (TUI) which encompass augmented reality and remote physical interaction. Using these enabling technologies, we develop practical tools to enhance the students' experience in remote learning. The tools, which will be described in later sections, are the 3D Live Technology [3], Mixed Reality Classroom-based Education Systems, and Touch Internet System.

2 Development Systems

2.1 3D Live Technology and Magic Land System in Education

3D Live is the technology for capturing a person and, at the same time, displaying his/her 3D images in mixed-reality environment in real time. The technology (Figure 1) has been presented in [4] and [3] with its application in distant communication in mixed-reality spaces, where the user can see 3D images of his/her collaborators in mixed reality scenes when talking with them.

Basically, nine Dragonfly FireWire cameras are used to capture the subject from nine viewpoints, including the top view and those captured images are then processed by three Capture Server machines to eliminate the background scenes and retain the foreground silhouettes of the captured subject only. After that, the processed images are sent to the Synchronization machine, which then synchronizes the 9 streams of images so as to guarantee that each selected sets of 9 images from 9 cameras were captured at approximately the same time. In the next step, those sets of 9 synchronized images are streamed through the

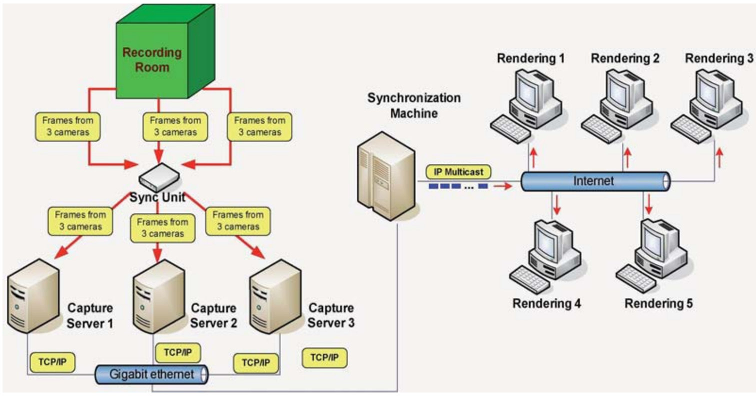

Fig. 1. Hardware Architecture of 3D Live System

Internet using IP multi-cast or RTP protocol to all the Rendering machines placed at different places. At the Rendering machine, the position of the virtual viewpoint is estimated when the user look at the marker through an head-mounted display (HMD) with an attached camera. Basing on that estimated position and the 9 synchronized silhouettes of the subject received from the Synchronization machine, a novel view of the captured subject from this viewpoint is generated and superimposed onto the mixed reality scene. The novel image is generated such that the virtual camera views the subject from exactly the same angle and position as the head-mounted camera views the marker. And finally, this simulated view of the remote collaborator is then superimposed on the original image and displayed to the user. The result gives the strong impression that the model is a real three-dimensional part of the scene.

We applied 3D Live technology in Magic Land system, an interactive mixed reality application for art, story-telling, and entertainment, where players can have themselves capture and then play with their own 3D capture avatars and other 3D virtual characters in mixed reality environment [3]. The set-up mainly includes a large table with markers on top and the 3D Live recording system. On top of the table have several cups with marker on top. When looking at the table through the HMDs, users will see a virtual land on top of the table and virtual characters inside the cups (Figure 2). Users can have a capture of themselves inside the recording room for 20 seconds, and when the capture is finished, their 3D images will be rendered inside one of those cup. They can use their own hands to interact with the virtual characters, including their own 3D avatar, by moving the cups around the table, and the virtual characters will interact with each other when they are near together (Figure 3).

The 3D Live technology and Magic Land system can both be applied effectively in remote education and training, including in areas such as cultural, dance, and sports training. The remaining part of this section will explore the uses of 3D Live and Magic Land technology in remote education and training, including in areas such as cultural, dance, and sports training.

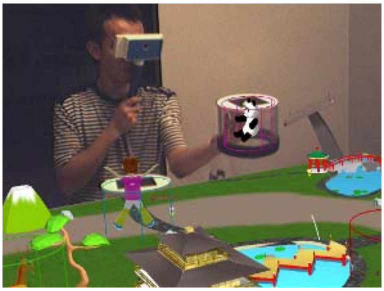

Fig. 2. System overview

Fig. 3. 3D Live user character interacting with witch inside cups

Firstly, 3D Live technology can provide the real-time capturing, transmitting and rendering the 3D images of the captured subject. Consequently, similar to 2D video-conferencing technology, 3D Live is suitable for use in any remote applications that need to display live captured images in real-time. However, 3D Live overcomes the limitations of 2D video-conferencing by allowing people to see the 3D capture images at anywhere in physical space. Furthermore, with 3D Live, gestures, body motion and any 3D details of the capture subject are transmitted completely in full 3D, thus creating the full satisfaction of people's perception of sight. Consequently, 3D Live outperforms 2D video-conferencing in some live video applications where details of 3D capture objects or 3D complicated actions are important to the viewers.

It is very often in education that the learners need to observe their teacher's actions very carefully so as they can do exactly the same thing. It is necessary in normal classes like physics, chemistry or biology where teachers instruct their students doing some experiments. In these cases, not only the detailed views of 3D experiment tools and subjects but also the instructors' actions are very important for the students. In areas where physical action is essential such as sports, dance, or cultural education, it would be highly advantageous to have a real time 3d image of the teacher. For that reason, 3D Live is very suitable to be applied in these contexts. The instructors with their experiment tools and subjects can be captured inside the recording room, and students at other places can observe the experiments fully in 3D as if they were happening in front of them, anywhere in the world.

We have developed an application of 3D Live in dance training, where the full 3D body motion is the main important thing that the trainees need to learn. Figure 4 is the example of one of the scene that we captured. It can be seen in the figure that, 3D Live technology allows users to see the capture subject in its real size, and it is flexible to view the lessons at any places. Obviously, 3D Live can be applied not only in dance training but also in sports training, where full body motion and player's actions is critical in learning process. Figure 5 is an example of 3D Live application in Karate training. As one can see, it is very much advantageous for the trainees to see the Karate actions clearly and easily from any angles in full 3D. Using this technology, students anywhere in the world can learn and have a sense of presence with dance or sports masters in another country or even another continent.

The record and play back features of 3D Live also enables people to preserve the old cultural values from being missed or destroyed throughout the time. For example, the old traditional dances can be recorded, stored and displayed for younger of any of our next generations in the future. Streaming over the internet allows these 3D cultural icons to be viewed remotely from the teacher.

Fig. 4. 3D Live dancers

Fig. 5. 3D Live Karate training

Fig. 6. 3D Live Hamlet

Not only 3D Live, but also Magic Land system can be effectively applied in education too. The game itself, which stimulates the players' imagination and creativity, is a good play-to-learn set-up for children. Moreover, the table top can be rendered with historical architectures and characters in history or architect or design lessons. We have developed books using 3D Live which teach about Malaysian culture, and also Hamlet, as can be seen in (Figure 6). Such a system is especially suitable for children, who are too active to sit at one place in front of a desktop for a long time, but like to run around, play and experience the lessons tangibly using their own hands.

2.2 Mixed Reality Classroom-Based Education Systems

Introduction. The ability to overlay computer graphics onto the real world is commonly called Augmented Reality (AR). Unlike immersive Virtual Reality, AR interfaces allow users to see the real world at the same time as virtual imagery attached to real locations and objects.

Several applications for education have been developed. Woods et al have set up several educational exhibits for Science center, Museums etc. [5]. Stanton et al collaborated with children and teachers in designing a tangible interface for storytelling [6]. In the Education Arcade project [7], researchers from MIT proposed a new concept - Games to Teach and they have developed three prototypes for electromagnetic, environment and history educations. FlatWorld [8] created in USC can be used for education and training. Shelton et al [9] developed a system to teach Earth-Sun relationships to undergraduate geography students. It is similar to our mixed reality solar system, but it focuses on earth and sun related knowledge such as equinox and solstice to give students an AR experience.

All these systems are used as supplements to enhance the traditional teaching method and are not really classroom-based educational tools. Based on similar goals, we collaborated with teachers from a primary school in Singapore and developed the Solar System and Plants System.

System Overview. In order to make the learning process more interesting, attractive and to allow students to learn in a more intuitive way, we build two classroom-based augmented reality teaching tools. First of all, the contents are acquired from the teachers of the primary school to ensure that they are precise.

Secondly, as a classroom-based system, it must be suitable for the classroom environment and at same time also suitable for self-learning and distance teaching. By projecting the display on a big screen, a teacher can use this system as a general teaching tool such as picture etc. For self-learning, texts and sounds are added in this system to help students to better comprehend the contents. Quiz is also included in this system for students to review how much they have learnt. Students can also get help from teachers via the Internet without needing to be physically co-located.

Thirdly, robustness and ease of use for the personal user are important characteristics of such a system. Simplicity must be accomplished, as in everyday interaction with the environment; virtual objects can be easily picked up and moved without touching a conventional keyboard, mouse or joystick. By pressing buttons, different knowledge points can be chosen and displayed.

Finally, education through entertainment is another important aspect. We can achieve this by introducing Mixed Reality technology into the educational area. It goes to the heart of our universal love of libraries, books, films, and museums. We love knowledge, and we love to learn in the most fun and entertaining way. We now describe the actual system using this concept.

System Design. Using Solar System as an example, we introduce our system design here. The mixed reality solar system has a main operation table, where users (pupils) can sit around and look at the virtual solar system together. Users view the system through a head mounted display (HMD) with a small camera mounted on top. Several cups are used for the interactions between the users and the virtual objects. The teacher can be in a remote location and can view the various viewpoints of the students through a computer.

In order to view the virtual system on the table, the users need to hold the Head-mount-display (HMD), and point to the boards. He will see the virtual system land on the base board (Figure 7).

Using the cups, user can pick up and move the virtual object to different planet to observer as shown in Figure 8.

A quiz is provided to help pupils to review the knowledge they learnt. As shown in Figure 9, pupil need use the cup to pick up the correct object and put it at the answer area (the square).

Distance Education Using these Systems. The methodology of the mixed reality classroom provides the basis for distance education. By connecting through

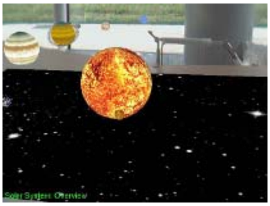

Fig. 7. Solar System overview

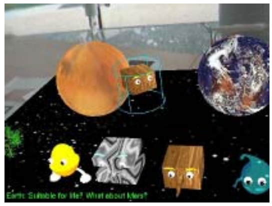

Fig. 8. User Interaction

Fig. 9. Quiz

the Internet, these systems support distance education. There are two ways for distance education to be conducted:

1. Remote-teaching: the teacher operates the system in one classroom and all his/her operations are sent to systems in other classrooms and students in those classrooms can see what the teacher does in real time.
2. Self-learning with remote supporting: students who use these systems to learn themselves can get help from teachers online. In this case, students can send their questions as messages to the teacher and at same time show their operations to teacher. In the same way, teachers can answer these questions by instant messaging or giving a demonstration to students.

2.3 Touch Internet System

Extensive research has been done in exploring the potential of the human body and applying this in human computer interaction. Human interact with their environment by using several modalities via several communication channels. Regarding perception, the visual channel (i.e. the sense of sight) is the most important one, but other modalities like hearing, smelling or feeling are important as well [10]. However, the haptic modality is clearly undeveloped compared with the traditional visual (screen based) or auditory interfaces. Actual researches propose tangible interfaces as step further to bring the gap both between cyberspace and the physical environment [11]. New developments pursue the use of touching objects to provide haptic feedback to the user.

Haptic or tactile is one of the most useful modes of human communication. It is also true in educational learning, in particular physical education. We must emphasize that distance learning in a broader sense is not limited to just purely academics, it also encompasses physical education as well, though it is not common. For example, people learn how to do Yoga, dance or even play table-tennis through Internet. We propose the Internet Haptic System which is the enabling technology behind this to allow remote education using haptics through the Internet.

Poultry.Internet. In [12] a Internet-enabled haptic pet jacket was develop for the purpose of letting human to interact with her pet remotely, in real time manner, through the Internet. The pet jacket, as shown in Figure 10 is worn by a live chicken; and the jacket consists of several vibration motors which, when vibrate, create a sense of mild touch to the chicken. There was a doll avatar located at a different corner of the world, and inside the hollow body of the doll avatar there were touch-sensitive sensors and wireless transmitter. As the human chicken owner touches the outer shell of the doll, the touch signals are being picked up by the electronics and sent through the Internet to the haptic pet jacket. In this manner remote haptic was achieved.

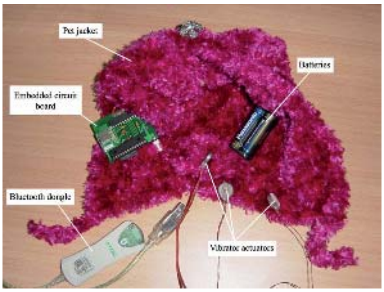

Fig. 10. Haptic pet jacket

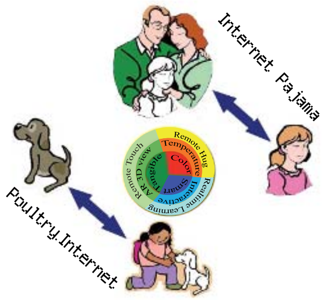

Fig. 11. Concept of Internet Pajama and Poultry Internet

A variant to this pet jacket system is the Internet Pajamas. It is a haptic pajama which is supposed to be worn by a human. The concept of pet jacket and Internet Pajama is shown in Figure 11. The Internet Pajama is similar to the pet jacket, except that is can be inflated and it changes color. The pajama consists of many inflatable air compartments on the inside of the pajama as shown in Figure 12. These compartments can be inflated by an air compressor which is electronically controlled. The advantage of this is that the air compartments can be inflated very quickly and thereby producing a haptic sensation to the human almost immediately. With this pajama people can be hugged over the Internet, as depicted in Figure 13. Another feature is that the Internet pajama can change color according to the action of the remote collaborators. It can be seen these remote haptic systems provide a rich multimodal interaction for people over the Internet.

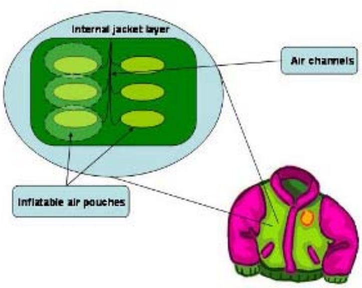

Fig. 12. Inflatable Internet Pajama

Fig. 13. Remote hugging

Proposed Application of Internet Haptic Systems for Distance Education. As mention earlier the feeling of physical presence of the instructor can enhance the learning process, this is particularly true in physical education. For instance a table-tennis expert could teach a student how to play over the Internet, in real time. Both the instructor and the student would wear special haptic jacket, and thus remote action or movement synchronization can be achieved. Another example is the teaching and learning of dancing over the Internet.

2.4 User Studies

Mixed Reality Classroom-Based Education System. A survey was carried out at the Ministry of Education (MOE) Excel Fest, an educational festival open to members of the public. The system was set up at a booth. It was also running the Plant program, teaching students about plants. Students from a primary school were running the booth and explaining the plant topic to audience using the system as a tool. The survey was carried out on three groups of users, students, educators and the general public. The third group comprised general visitors to the booth at the MOE Excel Fest, for example, parents interested in viewing new developments in schools and education.

A summary of the results and analysis of the survey based on different groups is presented here.

Students

In general, students gave a very positive response towards the use of the system. Almost all the students found the system useful, with 40.9% of those surveyed expressing agreement and 56.8% expressing strong agreement that the system was useful for learning about plants. However, students were slightly less positive towards ease of use of the system. 50% reported agreement and 31% strong agreement that the system was easy to use. The remaining students were either neutral (13.6%) or disagreed (4.5%) that is was easy to use.

With regards to the intention to use the system, 86.3% wanted to have the system in their school while the remaining 13.6% were neutral. 90.9% said that they would use the program if it were available in their school.

Some students gave comments or suggestions. The comments and suggestions generally expressed that the program was useful and interesting and that more topics should be covered. The need for improved sensitivity of the system was also mentioned by one student.

Educators

Similar to the response from students, the overall response was positive and perceived usefulness received a more positive response that perceived ease of use. All of the 16 educators surveyed felt that such a system would be useful for teaching. However, based on the demonstration of the system, only 12 of them felt it was easy to use while 2 of them found the system not easy to use.

With regards to the intention to use such a system, 12 reported that they would like to have such a system in their school, but 15 would use such a system in their teaching if it were available.

11 of the educators gave comments or suggestions. They generally expressed positive sentiments on the usefulness of the system and their good impressions of the student presenters. Concerns mentioned included system quality and cost constraints.

Non-user Group: General Public
This group was surveyed incidentally, that is, when the opportunity arose to gather another point of view.

The members of the public appear to be overall receptive towards the use of mixed reality in education. They generally felt that this technology would be useful in teaching and were interested in it being used to teach concepts that were hard to visualize, such as the internal body system. Although not the actual target users of mixed reality systems in education, the positive responses gathered here show that parents and the general public would likely be accepting and supportive of such innovations in education.

3 Conclusion and Future Works

In this paper, we introduced related interactive media technologies and their usage in distance education. Concerns of the students' learning process focus not just on specific subjects in classroom, but also on their preparation for learning and reviewing the knowledge at a distance. With the fast development of new technologies, adults need to learn new knowledge constantly. It is not so easy for everyone to go back school to learn new knowledge. Many new technologies are being introduced to distance education, but which technologies should be chosen is decided by the needs of students. The technologies we mentioned in previous sections have been or will be tested in real classroom and over the Internet. We would like to combine these technologies to develop more distance education applications. For example, we can combine the above 3D live technology with mixed reality technology to let students see how the teacher is operating the solar system.

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The Realization and Evaluation of a Web-Based E-Pedagogy Approach for English Second Language (ESL) Learning in Elementary Schools

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Abstract. With the fast pace of innovations and development in Internet technologies, Web-based learning has become a major mode of dissemination of knowledge within modern educational setting. However, the effectiveness of using new technologies in education is increasingly controversial in the absence of a flexible E-pedagogical model that underpins the learning process. Addressing the pedagogical principles with formal classroom teaching practices, this paper presents the results of applying our proposed E-pedagogical model that has been incorporated into a Web-based English Learning System (WELS) for elementary English Second Language (ESL). Particularly, we compare the effects of guided and unguided learning through a web-based learning platform as well as demonstrate the effects on students' participation and learning patterns through the design of suitable motivating schemes. Teachers' feedbacks on crisscrossing pedagogy and students' experiences on multi-dimensional learning opportunities with WELS will be explored and the potential values of a flexible E-pedagogical approach for web-based learning will be discussed.

1 Introduction

As e-learning systems have become popular tools for teaching and learning, the requirements of these systems are not limited to solely providing a web-based learning tool or environment for the teachers and students. We cannot leave out nor forget the primitive motivation of developing e-learning platforms. "IT in education" should be distinguished from, and is more than, "education in IT". IT can be a tool, a channel, or an assistance that expands and overcomes the limitation of time and space in conventional classroom teaching and learning. Advanced IT education platform enables teachers and students to shift one's own paradigm more easily and effectively. Hence, the teaching and learning processes that go hand-in-hand with a web-based learning platform are critical and deserve special attention. Teaching as a profession requires profound knowledge and skills which IT would never substitute. To utilize and optimize the use of the ever growing technologies for education, educators have to examine alternative ways (i.e. different pedagogies / instructional strategies) that teachers and students can be benefited most so that they can teach or learn better with the aid of IT in general and, in particular, web-based technologies.

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Learning theories and technologies for designing web-based learning environment have been widely studied. Many advanced e-learning systems, such as WebCT, Virtual – U, Click2learn, FirstClass, Cyber University of NSYSU and Web-based virtual online classroom (WVOC), are being used to deliver various kinds of learning materials in different formats (i.e. text, audio and video), e-mail, conferencing, forums, quizzes and assignments [1]. Most existing Course Management System (CMS) provides similar tools of enabling communication through the Internet between instructor and learner. Common features include providing navigation tool telling student the lesson schedule, keeping track of students and their records, managing data security, providing assessments to learners and allowing instructors to upload and organize material and create discussions. To explain student intention of using an e-learning system as a supplementary learning tool within a traditional class or a stand-alone distance education method, [2] highlights specific system factors that purport to promote system use. These include functionality, interactivity and respond time. These system characteristics not only influence the belief factors but also directly impact student use. Regarding different learning mode, [3] has conducted a study on the relative effectiveness of two different types of Web-learning environments: *distributed passive learning* (DPL) versus *distributed interactive learning* (DIL) environments. They show that the DIL environment is superior to the DPL environment in terms of both the learning process and the learning outcomes. While the DPL environments are used to deliver learning material that the learners can access at their own convenience, the DIL is used not only as a delivery medium but also to *foster free exploration of information* and to allow the learner to interact with the materials and, more importantly, with other learners. The external variables considered to be an important factor that would affect both teachers and students are: i) the ability to cope with technical difficulty and ii) technical skills in computer operation and Internet navigation [4].

Although e-learning systems are well developed and increasingly being used, pedagogically driven e-learning systems and extant literature addressing how to take the advantages of technologies to provide learning guidance through web environment are still not widely available. Addressing the pedagogical principles with formal classroom teaching practices, this paper presents the design and implement-tation as well as the evaluation results of our proposed E-pedagogical model that has been incorporated into a Web-based English Learning System (WELS) for elementary English Second Language (ESL) teachers and students. Teachers' feedbacks on crisscrossing pedagogy and students' experiences on multi-dimensional learning opportunities with WELS will be exploited and the potential values of a flexible E-pedagogical approach for web-based learning will be discussed.

2 Designing E-Pedagogical Models with WELS

Since most of the existing web-based systems that support learning focus typically on a single aspect of the learning process, e.g. either in drill-and-practice exercises, learning content, question banks, or learning games, etc. Such platforms do not provide a holistic approach to support the diverge range of activities involved in effective teaching and learning. For example, a typical lesson would involve a sequence of activities supported by IT tools that serve to motivate learning, assist teaching via multimedia presentation, enable the application of learnt knowledge through games or quiz, assess and evaluate learning outcome. WELS [5], on the other hand, provides a broad spectrum of IT tools and functions to support various learning activities (or called "learning dimensions" in WELS) that range from internal reading materials, games, exercise, student progress tracking and monitoring, as well as hyperlinking to appropriate external learning materials.

WELS stands for a **W**eb-based **E**nglish **L**earning **S**ystem. The design of WELS integrates in addition to the two prevailing computer assisted learning approaches (i.e. the directive tutor-centered (DTC) style of traditional Intelligent Tutoring Systems (ITSs)) and the flexible learner-centered browsing (FLCB) approach of Hypermedia systems. WELS also incorporates the two prevailing language learning approaches, namely the high interactive communicative language teaching (CLT) and the task-based learning approaches to foster individual learning, and to promote, enrich and enhance the learning experiences in and out of the conventional classroom. These learning pedagogies (approaches) have underpinned the design of the seven learning dimensions that represent and support various types of learning task for students to learn by doing and self-reflective thinking. In the following, we briefly summaries the functionality of these seven dimensions. (1) ***Reading Room*** creates a story telling environment and reinforce self-learning for students; (2) ***Study Room*** provides an drill and practice environment for students to get familiar with the grammar and provides on-line assessment for teachers; (3) ***Playground*** stimulates students' interest and to apply their knowledge in an effective way; (4) ***Book Shop*** recommends useful English learning web sites and gives appropriate guide or suggestions for students before they get into the web; (5) ***Bulletin Board*** offers the experience sharing room for students and teachers to share their feelings or experience in their learning (6) ***My homework*** provides a guided learning environment in which, teacher can guide their student to accomplish certain tasks and (7) ***My achievement*** evaluate students' performance, student can set up a goal and check to see if they have completed their learning objectives or not. Figure 1 shows an overview of WELS. Further detail of WELS functionality and architectural design can be found in [5].

Fig. 1. WELS Learning Dimension

In this study, we have focused on deploying WELS and evaluating the effectiveness of using WELS augmented with a flexible E-pedagogical approach for (a) teachers to experience and reap the potential values of using IT in teaching and (b) students to enjoy learning in their own pace. More importantly, this study highlights the relations between technologies, students and the teachers' needs in the cyberspace.

3 The Realization of E-Pedagogical Model

Objectivism and constructivism are two well known learning theories. Objectivism, which has been adopted by most teachers in traditional classes in Hong Kong, is a teacher-oriented learning method whose goal is to represent and transfer objective realities from the teachers to the learners. Passive learning method is the characteristics of this learning environment, students are passively receive instructions, acquire common understanding from teachers. In contrast, constructivism is a learner-oriented approach which is gaining much attention in many recent education reform exercises due to the need empower our students with the capability of life-long learning in the modern world. In constructivism, learners control their learning process and constructing their own knowledge while the role of teacher focuses on placing suitable guidance in the learner's learning process.

WELS has been designed to provide supports for a range of activities in language teaching and learning. In order to develop and experience suitable e-pedagogical models that adapt and embed conventional pedagogical approaches together with the flexibility of web-based learning, THREE commonly used instructional/pedagogical approaches for English Language learning has been adopted for this study. They are *shared-reading*, *guided-reading*, *KWL and retelling* approach. The following figures and sections illustrate in concrete terms how these instruction approaches within our e-pedagogical model can be realized on a web-based learning platform such as WELS. Figure 2 shows the instruction design of one particular teaching module that has incorporated a variety of web-mediated multimedia teaching and learning activities. And Figure 3 shows the corresponding details of the instruction steps.

It should be noted that the many education portals which contains mainly raw learning content can be considered as an education warehouses. These warehouses alone, by nature, are not particularly useful, especially for elementary students since many of them don't even know what they should learn or which materials inside that warehouse are relevant to their needs, let alone how to find the right materials even when they know what they need. It is well recognized that students can learn effectively when following teachers' teaching strategies that are based upon certain teaching philosophy. Normally, teachers' guidance could only be experienced within classes. Students could hardly revise or experience the same learning strategies repeatedly outside of the classroom. The strength of the E-pedagogical model in WELS is the flexibility of experiencing various pedagogical approaches and enables teachers to *specify* the teaching resources, *organize* the sequence of materials and *define* the shared scheduled progress for the target group of students according to the adopted teaching approach. Tasks are assigned according to the teaching schedule which embodies the teaching philosophy and the teacher's professional knowledge. The tailored activities are organized in the same learning sequence as formal lessons

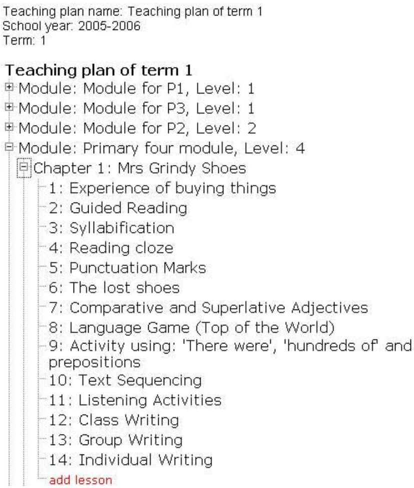


Fig. 2. A Typical Module setting

Fig. 3. Lesson design

within WELS. Students can follow the designed learning cycle to establish their knowledge even at home or in a self-learning environment. To enrich the effectiveness of the designed pedagogical model, a number of data analysis tools will help teachers identifying students' weaknesses and offering reinforcement or encouragement for students who fall behind schedule. For the slow learners, teachers can assign tailored remedial materials and activities to assist and reinforce their learning, such as assigning additional activities for learning syllabification, vocabulary building, identifying sentence structure and guided writing through the system. Such remedial activities are definitely helpful to students who have fallen behind. However, in practice, due to resource implication teachers do not have extra time to look after these students given such a tight curriculum schedule during school hours. This is the gap that Information Technology can provide a remedy.

4 Research Methodology

The weight-bearing point of our project is a Web-based language learning environment that incorporates various teaching pedagogies to guide and strengthen students' language learning strategies for improving their learning. Our work involves 2 years of research and development based on a repetitive cycle of design, testing, data collection, and analysis [6]. Also, user perceptions on the teaching and learning effectiveness of the provided environment have also been evaluated through focus group interviews.

Our study is divided into 3 phases, each last for 3 months. In Phases I, there is no specific pedagogy embodied into the usage of the learning platform. All the contents are freely accessed by students. Teachers place no monitoring or guidance on the students' access on the learning environment through the web. In Phases II, learning items are scheduled according to teachers' designed module, including reading texts, learning activities, assessments, discussion topics and writing practices etc. The learning items are matched with the weekly lesson topics and also arranged to live up to the teaching pedagogy. Teachers use WELS as their instructional media for in-class teaching and assign homework through the system for students' self learning at least once per week. Students can explore in the system freely to acquire new knowledge but they have to, at least, complete the (compulsory) learning items assigned by their teachers. To illustrate a complete view of our proposed E-pedagogical model in WELS, the proceeding of a lesson had been designed according to Gagne (1985) nine essential instructional events as shown in (Table I). WELS learning dimensions can be flexibly and effectively assisted teachers' preferred teaching styles. For instance, a book in the Reading Room can be used in different ways to fulfill a number of objectives. The teachers' responses with respect to the different classroom activities facilitated by WELS will be discussed in next section. Phases III Post training period is scheduled during in the summer holiday, students' exploration within WELS is purely driven by their initiative. Students' learning effectiveness regarding to their participation and commitments to the online homework is observed and compared.

Instead of studying only the difference in performance for those using and not using IT in their learning, WELS gives teachers the flexibilities in the organization of in-class and after-class activities. More importantly, it provides a unique opportunity to study and uncover the range and the sequence of learning activities taken by various groups of students (e.g. males vs female; academic strong students vs academic weak students; etc.) through the system usage logs [7]. This invaluable information enables us to discover student's individual learning behaviours as well as their relations with respect to the degree of teachers' involvement. To evaluate the usefulness and

Table 1. Typical proceeding of a lesson with WELS and the associated learning objectives (pedagogical underpinning)

Objectives	WELS Dimensions	Teaching Activities
Motivation/Speculation	Reading Room/Playground	Sing a song/Play a game
Present Material & Inform learner of the objectives of the lesson	Reading Room, Study Room or Book Shop	Read out the text, Highlight the grammar, Listening task or comprehension task.
Provide Guided Learning/Elicit Performance	Reading Room, Study Room or Playground	Individual work or group discussion
Provide Feedback/Assess Performance	Study Room or Bulletin Board	Practicing, Assess performance or Discussion
Enhance Retention and Transfer	Bulletin Board	Discussion, Guided Writing, Free Writing

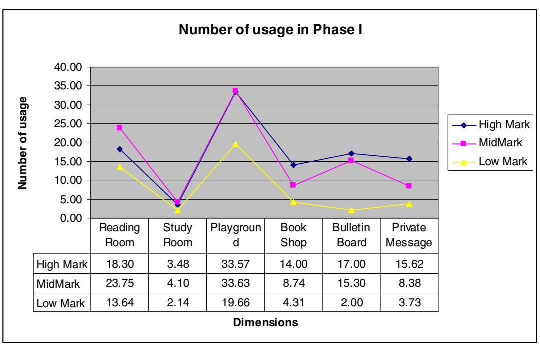
effectiveness of WELS, an implementation study plan has been designed from the pedagogies perspectives and technologies perspectives respectively.

5 Comparison of Guided and Unguided E-Learning

Figure 4 shows students' participation rate in Phase I. The usage logs show that all students preferred playing games most. Second to games, they also like to read curriculum-based e-books. The access patterns are similar for most students except for low mark students who do not like to participate in the communication activities. Although the preferences of students are similar, the rates of participation among these three groups of students are different. High mark students and medium mark students have a very similar participation rate (i.e. the number of click logs in each dimensions). High mark students tend to read external readings provided in the Book Shop section of WELS. They also participate more actively in communication and sharing than medium mark students while medium students focus more on reading curriculum-based materials. (Figure 4) The participation rate of low mark students is significantly lower in comparison to other students in all of the dimensions. Their participation in each dimension is the lowest within the groups. This implies that slow learners experience difficulties in achieving normal learning progress. Although they follow the same trend as high and medium mark students in Reading Room, Study Room and Playground, low mark students are found to be less participated in reading external books or communication with others. They show resistance in posting their English writing on the bulletin board. Their messages only contain simple and single sentence or even meaningless sentence. Hence, building up confidence in writing English for this group of students is an important issue.

Our study has shown that teachers' involvement is identified as one of the most important factors that affect students' learning motivation and strategy in a web-based environment.

Overall, it can be seen that without teachers' participation or guidance during Phase I, students mainly played with the games and they seldom work with the exercises, read external books and join discussions. Moreover, it can also be observed that they do not participate in drill and practice exercises that share the same learning objectives. Students do not know their language weaknesses and treat the web-based learning platform as a plaything in the absence of teachers' guidance.



	Reading Room	Study Room	Playground	Book Shop	Bulletin Board	Private Message
High Mark	18.30	3.48	33.57	14.00	17.00	15.62
MidMark	23.75	4.10	33.63	8.74	15.30	8.38
Low Mark	13.64	2.14	19.66	4.31	2.00	3.73

Fig. 4. Students' Participation Rate in Phase I

In phases two, with teachers' participation and guidance, students' participation is highly stuck to teachers' guidance.

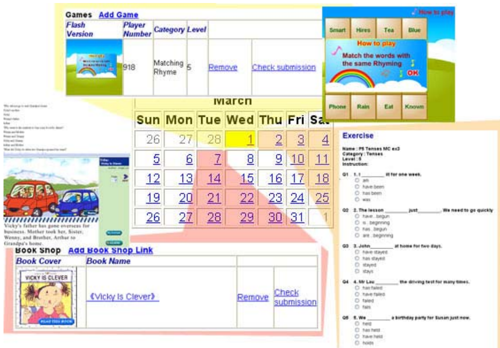


Fig. 5. Tailoring learning sequence for students

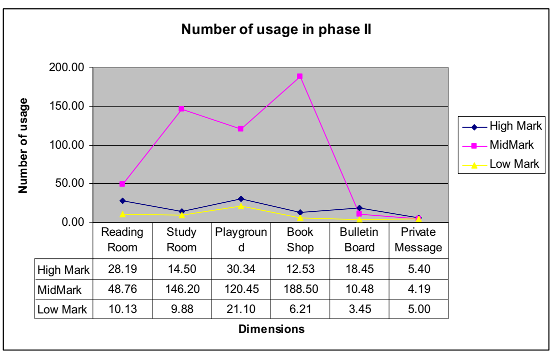
The common teaching steps adopted by teachers in WELS are motivation, drill and practice and reinforcement. First of all, teacher assigns a learning game to motivate the students on, say, 1st March as indicated in the screen shot shown in Figure 5. Then, exercises and tests are assigned to students in their learning period so as to provide repeatable learning environment to students. Students, on one hand, can practice and get immediate feedback from WELS. Teachers, on the other hand, can monitor student's learning progress and design appropriate learning tasks according to students' performance through WELS. When students have achieved the learning objectives, teacher starts to provide extended reading or tasks to reinforce and broaden students' knowledge. Once the learning cycle is defined, students can revise or perform self learning whenever they want. During Phase two, most of the students, more than 87%, complete teacher assigned homework regularly. Students who are not able to complete the online homework are those lacking of computer facilities or internet connection at home. This indicates teachers' involvement guarantees students' participation as well as performance in web-based learning environment because most students will follow teachers' instructions to perform the assigned tasks.

Learning should not be limited within school hours nor only under teachers' guidance, should learning opportunities be made available for students' individual learning. Six weeks summer holiday is the watershed between consecutive key stages while there is no normal schooling in this time period. Teachers and students are isolated, students revise learning materials on their own or with assistance from their parents. Common revision activities are reading the text book passages and working out the grammar exercises. This kind of learning lacks focus and strategy though students may still be benefited. With the availability of WELS and students' training in Phase II, students have developed good practices with regard to their learning through the WELS platform. Students could identify their weaknesses and place more efforts in the remedial areas. Slow learners read more books, do more exercises and play less game in the summer holiday. They would revise the teaching contents according to previous teachers' instructions for improving their English standard in the summer holiday and a web-based environment is definitely a useful tool for them.

6 Effects of External Stimulator

Web-based learning system is not useful unless learners use it. It is very hard to force learners to participate in web-based learning system if they do not have the initiative. Drawing support from stimulator, such as a system Using Scheme, to arouse students' self learning motivation is found to be effective. Using Scheme competition is introduced in our Phase II study which awards prizes to students who attain highest participation in WELS. Moreover, different scores are assigned to different learning dimensions so as to evaluate its effects on students' browsing pattern. In phase I, the usage logs show that all students preferred playing games most and seldom participate in working exercises. So, the using scheme allocates 5 points for doing exercises, 3 points for reading books and only 1 point for playing games.

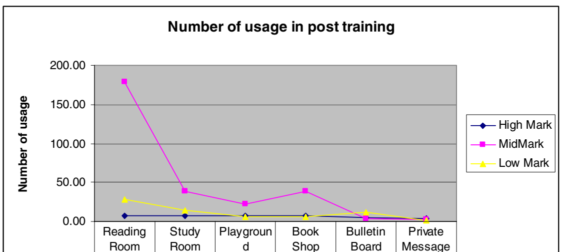
The introduction of the Using Scheme results in a big boost in the participation rate of the medium mark students in Reading room, Study Room, Playground and Book Shop (See Figure 6). For those dimensions are not included in the award scheme, i.e. bulletin board and private message, medium marks students did not show great interest in them. Students' browsing pattern in Phase II is obviously different from Phase I. Students prefer playing game most and did not do exercise in Phase I. However, they participate in working exercises more frequently than playing games in Phase II when different weights are put into the various learning dimensions during the Using Scheme. *Thus it can be seen that such a scheme can be used to train students towards a correct learning habit by adjusting the weights in each dimension.* Interestingly, the Using Scheme competition has produced positive changes in the participation rate of both high mark and low mark students, though to a lesser extent. Specifically, high mark students have been observed that they like to conduct discussions on the bulletin board while low mark students seldom post a message on the bulletin board.



	Reading Room	Study Room	Playground	Book Shop	Bulletin Board	Private Message
High Mark	28.19	14.50	30.34	12.53	18.45	5.40
MidMark	48.76	146.20	120.45	188.50	10.48	4.19
Low Mark	10.13	9.88	21.10	6.21	3.45	5.00

Fig. 6. Students' Participation Rate and Distribution in Phase II

In the post training period, it is observed that medium mark students participated in web-based learning more than high and low mark students especially in the Reading Room. This shows their preferences in reading multimedia animated stories. One significant and encouraging observation is that this work uncovers is that the changes in participate rate of low mark students during the summer holiday is very positive, which is quite different from that of the high mark and medium mark students. While high mark and medium mark students have a lower participate rate in post training period, the participation rate of low mark students has increased during this summer holiday period. We compare the participation rates and usage patterns for low marks students in phase one, phase two and the post training period, *it is observed that low mark students gradually read more books, do more exercises and play less games over the period of the study*. (See Figures 7) As a result, one can conclude that low mark students are motivated to revise the teaching contents according to teachers' instruction to improve their English during the summer holiday and a suitably designed web-based environment is definitely a motivating and useful tool for enhancing and to improving the learning habits of the weaker students. And most importantly, teachers' involvement and instructions could correct and guide students' towards a more effective learning pattern and habit through WELS.



	Reading Room	Study Room	Playground	Book Shop	Bulletin Board	Private Message
High Mark	7.31	6.60	7.42	7.50	4.44	3.00
MidMark	179.00	38.50	22.76	38.78	3.00	1.80
Low Mark	27.50	13.67	5.50	5.75	12.00	1.00

Dimensions

Fig. 7. Students' Participation Rate and Distribution in Phase III

7 Pedagogical Effectiveness

Incorporating teaching pedagogy with a web-based learning environment that supports multiple learning dimensions such as WELS is a new challenge to school teachers. It is interesting to note that school teachers are generally skeptical and unconvinced about the potential values of adopting web-based learning before the study. It is because, without actual hand-on practice, it is difficult for school teachers to appreciate, at first hand, the potential benefits of a flexible learning platform such as WELS that serves to facilitate content delivery, promoting of correct learning habit, monitoring and tracking of students' progress and the various sharing tools. Before the study, they are not equipped with knowledge and skills for embodying and integrating teaching strategies with web-based teaching and learning approaches. After the teachers have become familiar with functionality and IT tools of the web-based platform and learnt the concept and skills of implementing teaching strategies with WELS, they found that WELS is a very supportive environment for both teaching and learning.

The obvious transition of the teachers' attitude towards web-based teaching and learning as shown in our study points out that teachers' continuous professional development (CPD) training is a key issue in the process of embedding IT deeply in education. Initially, teachers exhibit resistance to adopt new technologies and teaching methods into their daily teaching not because they could not catch up with the pace of the technology, but rather because they are not familiar with the use of appropriate strategies and are not confident in using different / multiple strategies with a web-based learning platform. As a result of the training sessions and practical experience, teachers would discover and recognize for themselves the potential value of using technologies/virtual learning environments for teaching and learning.

8 Conclusion and Discussion

Single teacher-oriented methodology simply considers the *common needs* of the majority of student, it limits the potential values of teachers' instructional design. In this study, we have shown that the multiple learning dimensions and the various learning pattern analysis functions of WELS can help to assess and motivate learning. More important, by designing appropriate using schemes and IT-mediate instructional plan, teachers can help guide and improve student's learning behaviour and facilitate the student's ability to conduct self-learning and to perform self-initiated learning through a web-based environment. This study also indicates that teacher training is one of the most important issues to enable teachers to embed IT deeply into their teaching process and to really bootstrap IT in Education into action. Exploration studies on improving training effectiveness for teachers would be a key issue in the future works.

This study has also shed light to a number of aspects of web-based learning in elementary schools. This includes several interesting observations and effects of guided or unguided learning, integration of conventional teaching strategies with web-based learning, and suitable organization and sequencing of learning resources, etc. Although it could not be proven conclusively that cognitive development had occurred, positive interdependence, shared responsibility, social skills and enhanced learning were evident. In evaluating the effectiveness of WELS, special considerations had been focused on learners' learning needs and the pedagogical strategies of using ICT to enhance teaching/learning effectiveness. Our study has shown that flexible E-pedagogical models derived from the essential features of WELS could serve as a reliable yardstick to measure the extent of learning in relation to these essential features.

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