An Introduction to Network-Training Collaboration in Europe and China (NCEC)[1]

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1. INTRODUCTION

Network-Training Collaboration in Europe and China (NCEC), as the name suggests, is a joint effort between China and Europe in Internet-based distance education in China. NCEC project was originally proposed to the European Union (EU) by Tongji University, EVITech, the University of Paislay, Fujian Economic Information Center (FEIC), and New Service Development and Research Center (NSDRC) affiliated to the Ministry of Information Industry (MII), in the summer of 1995. It was finally approved by EU in late 1998 and is to be completed by June 2001. Network Research Center (NRC) of Tsinghua University became a major participant of the project in early 1999 from its original role of the Internet infrastructure provider and the technology advisor.

Distance learning in China has evolved through three generations: correspondence-based education; broadcast/TV-based education since 1980's, an educational program known worldwide; and Internet-based distance learning since mid 1990's. NCEC is the first Internet-based distance-learning project proposed in China. It is also the first joint-research project in distance education between China and Foreign countries. A chronicle of distance education evolution posted by CERNET's web site is:

- 1996, Tsinghua University started to advocate Internet-based distance learning;
- 1997, Hunan University, in cooperating with Hunan Telecom, established China's first on-line university;
- 1998, Tsinghua University launched on-line master programs;
- September 1998, Ministry of Education officially entitled Tsinghua University, Beijing University of Post and Telecommunications, Zhejiang University, and Hunan University as the pioneer educational institutions in pilot distance learning programs;
- 1999, Ministry of Education promulgated the Comments on Developing Advanced Distance Learning in China, which expatiates the guidelines, aims and tasks of Distance Learning in China;
- August 1999, Beijing University and the Central Broadcast and TV University were added to the pioneer list for Internet-based distance learning;

[1] The NCEC project is a project funded by the EC/Directorate General XIII, Telecommunications, Information Market and Exploitation of Research Cooperation with Third Countries and International Organizations, Scientific and Technological Cooperation with Developing Countries.

- September 1999, *CERNET High-speed Backbone Project* was approved;
- July 2000, Ministry of Education released the *Provisional Administration Methods* for Educational Website and On-line Schools, exhibiting the jurisdiction of the Ministry over educational websites and Internet-based schools;
- Soon later, the Ministry granted the distance learning licenses to Tsinghua and another 14 universities, and expanded the pioneer list to include 31 universities and colleges;
- Then the Ministry promulgated the Several Comments on Supporting Some Universities and Colleges to Set up Internet Education Schools and Pioneer Distance Learning.
- July 31 2000, the 31 pioneers assembled a consortium called *Coordination Team for Advanced Distance Learning in Higher Education*, aiming at enhancing inter-pioneer communication and cooperation and facilitating exploitation and sharing of educational resources;
- September 2000, some pioneers kicked off their on-line campus programs;
- October 31 2000, *China Advanced Distance Learning Satellite Broadband Multimedia Transmission Platform* came into operation, allowing simultaneous transmission of decades of video and multimedia channels at different rates; and the Internet access service provisioned on the platform enables high-speed interconnection with CERNET, forming a satellite-land consolidated bi-directional education network;
- In 2000, according to the Ministry of Education, the 31 pioneer universities in online distance education have offered seats to nearly 190,000 registrants, most of whom are destined to degree programs.

Although NCEC project is not the largest in funding and scope now, nor it has been completed yet, its effects are significant and profound, because it is the pioneer distance learning project in China and carried out jointly there by the leading Internet application researchers who are empowered by China's major Internet services and the European institutions who have successful experiences in this field. The main ideas in NCEC proposal have been accepted or replicated in other follow-up Internet-based distance learning projects. Research outcomes from NCEC have also been applied to other relevant projects. In this chapter, we will discuss the motivation of NCEC project and present NCEC's design, development and management issues.

2. THE INTERNET IN CHINA

NCEC project is to be developed and operated on China's Internet which is composed of four major networks operated countrywide.

ChinaNet is the leading commercial Internet in China, which is operated by China Telecom. Based on its predecessors, ChinaDDN and ChinaPAC, ChinaNet has been the largest Internet service in China. Its 163, 169, and 8163 Internet connection services have provided great convenience to local users in Internet connectivity than any other

countries, such as the US. It owns more than a half of Chinese Internet users and more than 65% of international Internet connection bandwidth.

CERNET (China Education and Research NETwork), headed by NRC of Tsinghua University, connects more than 750 education and research institutions, 800,000 PC's and 4 million users have connected to CERNET through its 10 regional centers and hubs (Figure 2.3). CERNET's strength is in that its users are mainly in education sector, either students or educatio n employees, and it has strong research and application development capability. It has the second largest Internet population in China. Up to present, the bandwidth over most segments of CERNET backbone has reached 155Mbps. Some connections between NRC and regional centers have been upgraded to 2.5Gbps.

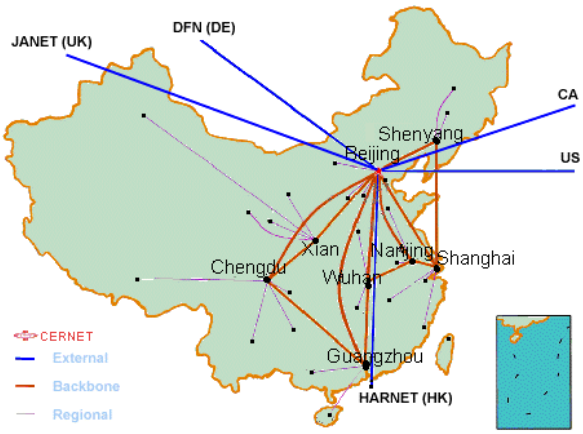

Figure 2.3. CERNET network structure[2]

Figure 2.4. ChinaGSN network structure[3]

[2] Recited from http://www.cernet.edu.cn

ChinaGBN (China Golden Bridge Network) is the outcome of the Golden Bridge Project launched in 1995 to serve governmental organizations and now operated by Jitong Communications Co. Ltd. affiliated to the Ministry of Information Industry of China (Figure 2.4). ChinaGBN is ranked the third largest service in China with the second largest international Internet connection bandwidth.

CSTNET, the network for China Science and Technology, is based on the pioneer effort by IHEP (Institute of High-Energy Physics), in connection with the research institutes of China's Science Academy.

Five newer China Internet service providers that contribute about 20% China's International bandwidth are:

- UNINET (China Unicom Network)
- CNCNET (China NetComm Network)
- CIETNET (China International Economic and Trading Network)
- CMNET (China Mobil Network)
- CGWNET (China Great Wall Network)

Overall, both the Internet hosts and the Internet user population in China have been growing explosively with a 300% increase rate before June 2000 and has reached 8.9 million and 22.5 million respectively in December 2000 (Figure 2.5). The rapidly expanding user body has launched ever-increasing application demands onto the Internet, particularly in business and education. Also CERNET, the non-profit making service, has been facing a high pressure to reclaim benefits from the investment to the infrastructure construction since 1994. Thus, Internet-based distance learning has become the strategic focus in CERNET's application development agenda. In conjunction with the consideration of west development launched recently, Chinese government is to spend 360 million yuan (US$43 million) on developing distance education in its western part, according to an official from the Ministry of Education[4]. The central government in 2000 has allocated 80 million yuan (US$9 million) from the state revenue to start the program, and the rest of the investment will be made next year. The program will focus on expanding the existent Chinese Education and Research Network (CERNET), and help provide access to the CERNET for colleges and schools in the west, especially those for students of ethnic minorities.

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[3] Recited from http://gbnic.gb.com.cn

[4] People's Daily, ¡¡, 06/13/2000

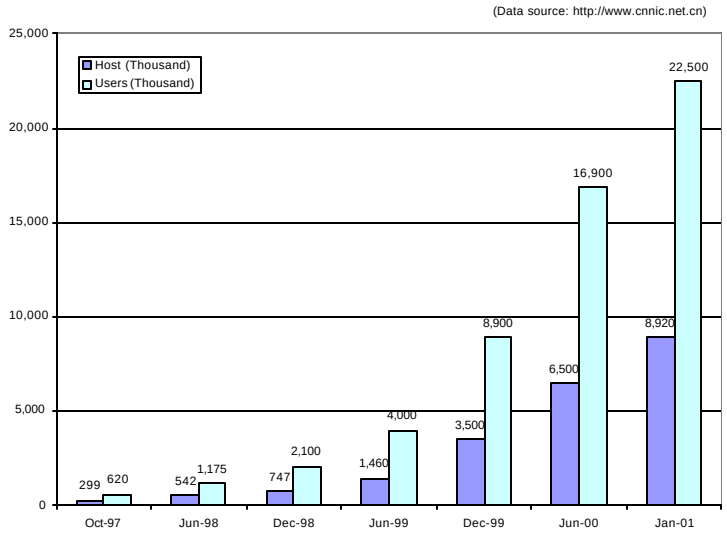

Figure 2.5. China's Internet user and host growth

3. NCEC OBJECTIVES

NCEC's objectives are rooted in demands from China's professional training market:

- The demand on re-training the workers who were laid off from many state-owned enterprises. The economic reformation in China has reached the stage that majority of state-owned enterprises will have to cut off their employees to improve their production efficiency and therefore, to be able to survive in the competitive market. The change of industrial structure requires new labor skills not being able to be obtained from ordinary professional educations.
- The demand on vocational professional training for those people who are holding a job and need to be more competent in the job market. This trend is also affected by the change of industrial structure in China.
- The demand on re-training government employees who are reduced to simplify the governmental administrative structure. About 50% government employees have been or will be transferred to industrial sectors. The re-training will help them to adapt new working environment.

Internet-based distance learning will provide the useful facilities to the above professional training in addition to those traditional approaches, such as TV-based education.

According to the above demands, NCEC project has been aimed at designing and developing network-based course production, delivery and presentation systems for China to improve the utilization of the Internet (Gordon et al. 1997; Gordon et al. 1999; Lin et al. 2000). The specific objectives include:

- Developing methods and an integrated set of tools for cost-effective production of electronic course materials. The tool set is designed in accordance with the principles of courseware engineering to enhance the productivity and maintainability of the course materials. In particular, course material reuse and customization will be supported by adopting the new international (EU and IEEE) standards for course material description. The courseware production and delivery systems adopted will enable the production and use of Chinese electronic learning materials.
- Carrying out experiments by describing a set of training exercises and delivering pilot courses within the network-based learning environment. The first courses will be in the areas of information and communication technology and management, reflecting the current perceived needs of China.
- Implementing a pilot of the network-based collaborative learning environment for training, teaching, tutoring, assessment, and for providing feedback to the learners. The environment will be accessible to the users (trainees, trainers and tutors) via appropriate Internet connection, and some of the project partners are in the position of providing such connections in China.
- Developing a set of training needs templates, which will allow us *to* assess the trainee needs in the NCEC environment in order to support trainee profiling for customized production and delivery. This set of training profiles will also allow us to test the pedagogic and production model. The outcome of trainee needs assessment will be a set of training programs to realize these needs.
- Promoting research in Chinese courseware management—developing Chinese information processing technology and knowledge management for Chinese information.

NCEC project may also utilize and adopt results from other European and Chinese projects that the partners are involved in, which may provide the basic research results to be deployed in NCEC's applications.

During 1995–1999, several distance education projects in China were carried out in light of the idea from NCEC project. For example, the Network Research Center of Tsinghua University started a pilot distance education research project in 1997 sponsored by the *Focal Research Projects in the Ninth Five-year Plan*. A distance learning system with TV and Web technology has been developed and tested (Li, Geng, and Li 1998). Recently, Tsinghua University has launched a generic distance education project, *Demonstrative Multimedia Distance Education System on the High-speed IP Network in China* (DMDES)[5]. The objective of the project is to build up virtual classrooms available on the 155Mbps CERNET backbone to provide electronic courses to the universities participating in the pilot operation.

NCEC project will as well link to a number of ongoing projects in Europe. These projects include ARIADNE (in which the University of Paisley and EVITech have been partners), a research and technology development project in the "Telematics for Education and Training" sector of the 4th Framework Program for RT&D of the European Union. NCEC project will complement the development of the broker-based

[5] Project#: 863-317-01-04-99

"University for Industry" of the UK as well as the broker systems in some other EU funded projects (such as the INCO-COP KNIXMAS project) in which the European partners are intimately involved.

There are three major strategies in NCEC planning and development:

- In functionality, NCEC is to be focused on Internet-based technology exploitation in China. It will use other means of distance education to complement itself, such as radio, TV, print, audio and video materials, etc.
- In international cooperation, NCEC project will supply a well-tested system for the transfer of training support from Europe to China. It will also provide a clear pattern for the development of collaboration between the training systems of China and the EU. The lessons learned and the systems built will be of significant interest to future EU-CN projects.
- Technologically, the repository technology being built with NCEC project will be a direct exploitation of the standards being developed in the USA and the EU, in particular the ARIADNE standards and the developing standards of the IEEE, for the collation and distribution of learning objects.

4. NCEC SYSTEM DESIGN

4.1 A Four-Layer Architecture for Distance Learning Systems

Architecture of application system, as a kind of software architecture, is the research about structure of software system and mutuality among basic composing in order to define standard and specification of software program and realization.

During the early 1990s, traditional model of software development began shifting from the two-tier, client-server application model to more flexible three-tier and multi-tier application models. The new models separated business logic from both system services and the user interface, placing it in a middle tier between the two. The evolution of new middleware services - transaction monitors, message-oriented middleware, object request brokers, and others - gave additional impetus to this new architecture.

Distance learning is a dynamic process, made up of school, excise, quiz, and management module, which realize delivery, presentation and interactivity of information resources on network transportation service platform. During the whole process of distance learning, it is required to verify identity of user who participates various application systems and confirm access right of the user to specific systems. While an authorized user makes all kinds of learning behavior, requested resource maybe not locate with the direct service system, so the request should be forwarded correctly to the site of target resource. Because of the isomeric environment reliable and uniform data transportation among various application systems is very important. According to above analysis, the architecture of distance learning system is presented based on three-tier and multi-tier distributed application models to fulfill various requirements.

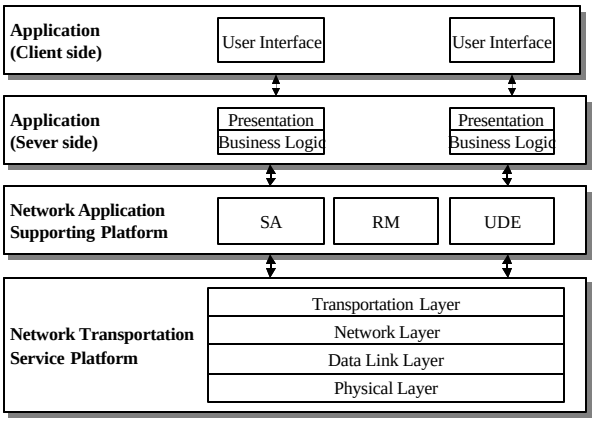

Figure 4.1 The architecture of distance learning systems

In the architecture shown in Figure 4.1, there builds a middle layer between application system and computer system. From the viewpoint of system operation mode, a supporting platform that makes idiographic application system interconnected is established. When client put service request to a application system, to complete response to the request possibly needs chain-reacting of some systems. And the interconnection and service response among these systems depend on the application-supporting platform. Therefore, there founds distributed computer environment not only between client and a special server but also among different application systems running on different servers to realize transparent access to distributed application resource. And the effort to build distributed application of distance learning is simplified because only interface to the application-supporting platform should be considered, regardless of isomeric characteristic of each application system. The architecture presented in this paper aims to enhance agility, flexibility and expansibility of distance learning system.

The network application-supporting platform, which is above network transportation service platform, provides uniform and standard computer and communication services for each specific application system that is constructed on the supporting platform. The main services of the supporting platform include:

- Security Audit (SA). Security is a paramount issue in the application system of distance learning. The Security Audit service realizes uniform identity authentication and authorization based on role applied to different application.
- Request Management (RM). Aiming at these above problems, Request Management service provides users position-transparent access to distributed application resource through setting up one or more Request Management center. The RM center acts as a router in application layer. When a system need access some application resource, it is not necessary for the system to have idiographic formation (such as location, way, etc) of the target resource. What the system should do just is to send the

request to a RM center, and after analysis to the request the RM center will forward it to an appropriate system or another RM center

- Universal Data Exchange (UDE). UDE service carries out a universal and reliable way for data share and exchange among specific applications.

4.2 The Structure of NCEC System

Our basic model for the NCEC system is to develop an environment which allows the NCEC system to support the expansion of relationships between suppliers of training and users of training over networks with the supply being demand led (Figure 4.2). Although we have chosen the Internet to underpin the research and development of the NCEC system, the system will later utilize a combination of technologies, including satellite TV, mobile telecommunication systems, and Internet-based environments.

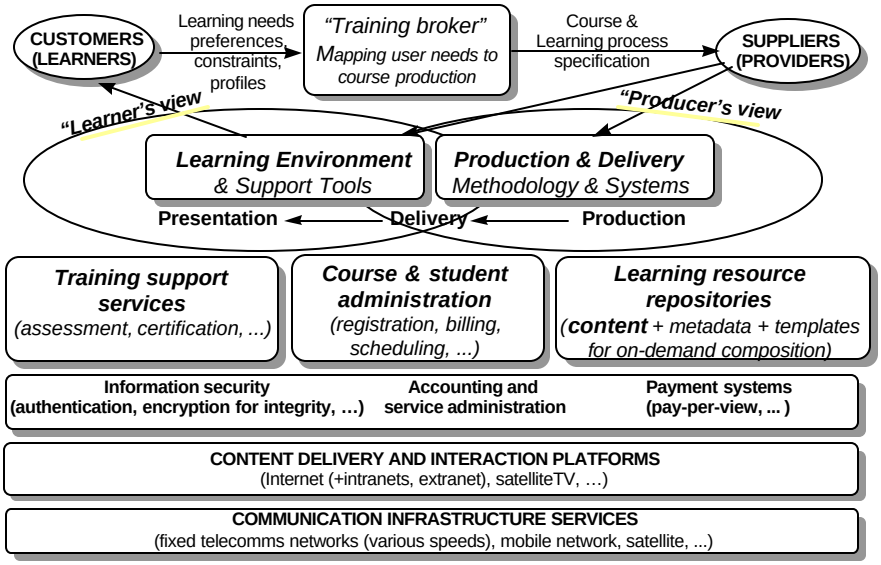

Figure 4.2. The Elements of Course Production, Delivery and Presentation

This component will apply the results of complementary research in related projects, where the model is based on the development of course material repositories of reusable elements, accessible via the network. The databases may be distributed on different servers and partially duplicated for local use. The special techniques for Chinese information processing will be utilized for search and retrieval, including Chinese word separation, automatic indexing of Chinese information, and Chinese information storage, transmission and display.

The NCEC project will provide an on-line education system that offers courses both in English and in Chinese. This is not only a difference in language, but also in cultural and socio-pedagogical aspects. Considering the huge population in China and the type of the students, one of the major strategies is to switch pedagogical patterns from conventional paper-and-classroom-based delivery to computer-and-network-based delivery of courses. The on-going China Internet construction will provide a supportive

environment for this effort. On the other hand, continuing and distance education will become one of the major services, adding value to the network infrastructure.

The NCEC system is planned to have three major subsystems (Figure 4.3):

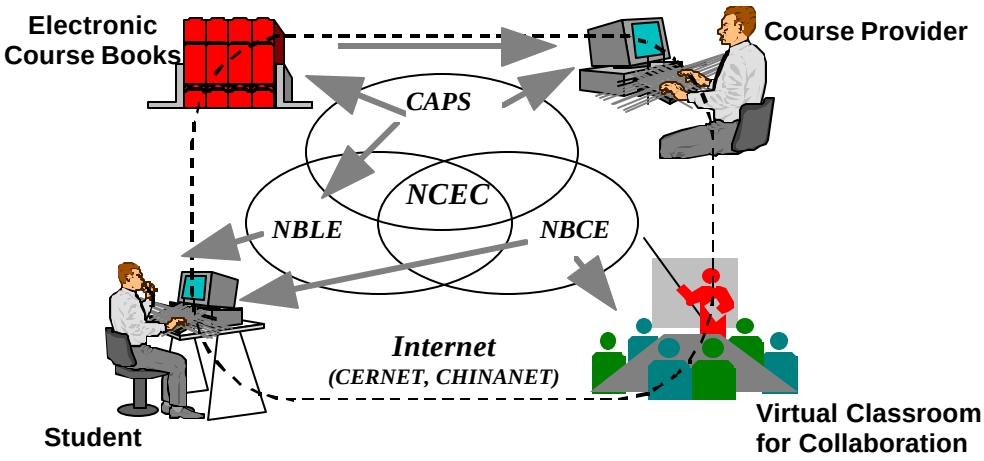

Figure 4.3. NCEC System Structure

Courseware Authoring and Production System (CAPS)

CAPS will support the authoring and production process (Figure 4.4). It will supply users with a set of tools capable of supporting courseware development tasks such as authoring electronic textbooks, updating courseware, maintaining course element repositories, and providing other complementary elements. The elements are authored with office tools and other common tools. NCEC specific authoring tools will be developed only when necessary. Document-structure templates for each tool will be used to ensure consistency of materials. Courses are produced according to selected structure templates by using elements in the repository. CAPS will apply the results of complementary research in related projects. The course material repositories of reusable elements, which may be distributed on different servers and partially duplicated for local use, are accessible via the Internet.

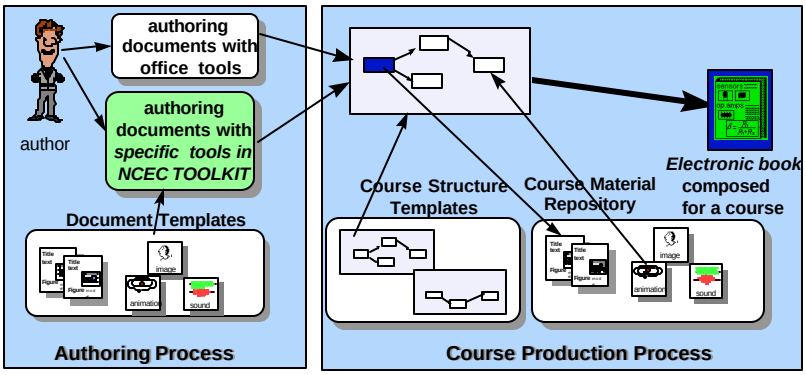

Figure 4.4. The Authoring and Production Process

Network-Based Learning Environment (NBLE)

NBLE makes full use of the hypermedia features of the WWW, providing a good environment to present users with a versatile interface and content (Figure 4.5). The learning resource is presented as a *virtual library* with *electronic books*, which can be annotated and shared by groups of students and tutors on the network. The electronic books contain course materials, such as texts and learning tools, available either locally or remotely, and customized to the needs of groups of trainees. The virtual library contains relevant external/internal information resources linked to electronic books. In addition, there are assessment and feedback tools for self-evaluation as well as for instructor assessment and feedback. It is important to note the system will support individualized electronic books, delivered to the learners based on their actual needs. These needs may be determined using pre-exams to tailor the content. The approach of knowledge management is to be applied to the courseware material search and retrieval.

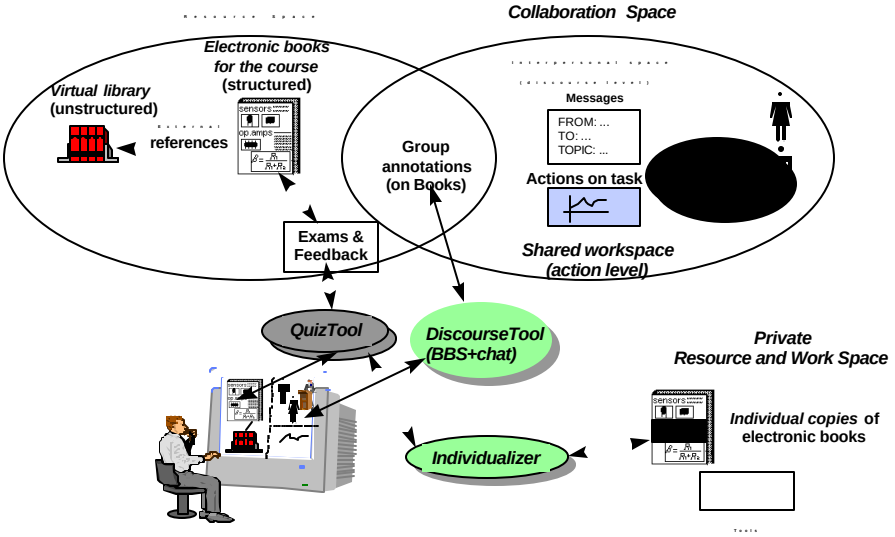

Figure 4.5. The Network-based Learning Environment

Network-Based Collaboration Environment (NBCE)

NBCE will provide the users with an integrated network-based collaborative workspace. This includes an electronic conference (in English and Chinese), a virtual classroom, a tutoring facility, and collaboration support. Currently, the collaboration facilities available on the Internet include e-mail, audio- and video-conferencing and whiteboard, IRC, ICQ, interactive Web-systems (annotations), etc. These allow users to communicate by voice, images, video and text. The NCEC research group will analyze the basic requirements for the training in sharing and exchanging information, and NBCE will be designed in accordance with a set of interactive scenarios for the activities. While several delivery platforms and interaction methods are available to support distance education, such as TV, radio and CD-ROM, we have chosen the

Internet to underpin the research and development of the NCEC system. However, the system may later utilize a combination of technologies, including satellite TV, mobile telecommunication systems, and Internet-based environments.

NCEC's structure does not contain a virtual class module. This is because that numerous text, video and audio-based groupware are available and they have been evolving very fast. Therefore, virtual classroom design is an integration of such groupware which can be handled as an independent system considered separately. In this way, the budget for NCEC development can be reduced.

5. NCEC SYSTEM IMPLEMENTATION

Tongji University and Tsinghua University are the leaders in NCEC system implementation. Under the guidance of NCEC gross planning, Tongji University is in charge of CAPS and NBLE systems and Tsinghua University is in charge of NBCE system. A protocol of data interface between systems developed by Tongji and Tsinghua separately has been established to guarantee the mutual compatibility of all systems. To ease system tune-up in different cities, two development teams have to work out some complementary modules, which are redundant in the whole NCEC system and will be merged together later in system integration.

5.1 Gross Technical Considerations

Development platform

NCEC system development platform adopts web-based client/server architecture. Its software environment includes:

- Linux, Windows NT, and OS2 Warp
- Apache Web Server with SSL support
- DB2 with XML Extenders/ Oracle 8i
- Java Development Kit
- Email Server
- FTP Server

Figure 5.1 shows the hardware configurations for NCEC system development and operation.

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Figure 5.1. Hardware configuration for NCEC system development and operation

Courseware data modeling standard

NCEC courseware data modeling adopts meta-data model, mainly LOM (Learning

Object Metadata) using XML (eXtensible Markup Language). The meta-data modeling standard is capable of implementing highly individualized features in order to satisfy diversified user needs with reusable learning components. NCEC system can provide broad online services to facilitate individual learning and group collaboration, and facilitate user's self-planning, self-assessment and self-regulating of learning materials and learning processes. It conforms to LOM, XML, CORBA and other international standards including DOM (Document Object Model) level 1 and 2 as well as SAX (Sample API eXtension) when processing XML and HTML documents. NCEC project applies mainly server side technology like Java servlets, JSP and XSP (eXtensible Server Pages), and uses revised OMT and UML methodology in system analysis and design. In the systems implementation and programming, Java technologies including RMI, JDBC, EJB and JMS are used. It also has necessary components to support system deployment and exploitation.

Chinese information processing

NCEC applications are both Chinese and English language enabled. The Chinese information processing— input, indexing, tagging and displaying—has three issues: the encoding of Chinese characters, the platform of Chinese information input/output, and the techniques of separating and automatic indexing Chinese words. There are three most common Chinese character-encoding sets: GB2312-1980 (the National Standard of the People's Republic of China), Big5 (used in Taiwan and Hong Kong), and Unicode (which encodes about 21,000 simplified and traditional characters). Adopting these Chinese character encoding schemas automatically suggests that Chinese Microsoft Windows (95/98/NT) is preferable. Other Chinese shell software programs for Windows are also able to process Chinese characters coded in GB or BIG5. For example, RichWin and NJ Star are popular in supporting web browsers such as IE 4.0 (or later version) and Netscape 4.7x. IE with a Microsoft Windows supported Chinese font set is more stable than Netscape and has been widely accepted by Chinese users. Linux installed with the Chinese font set is also recommended.

Chinese word separation is a special technical issue in Chinese information input and indexing. Since the LOM (Learning Object Metadata) schema, based on XML, has been adopted as the basic documentation standard, manual Chinese text tagging in accordance with predefined DTD (Data Type Declaration) files has become a basic approach. However, to convert existing Chinese text files into courseware repository elements, automatic Chinese word separation is also needed and will be implemented accordingly.

5.2 Courseware Data Modeling

NCEC data model is shown in Figure 5.2, where the critical portion is the courseware data model in the right-hand side. Other relevant data modules, such as exams, curricula, and user accounts, are built in the courseware data modules. The deployment of these data models is presented in Figure 5.3, where the larger boxes represent computer hosts.

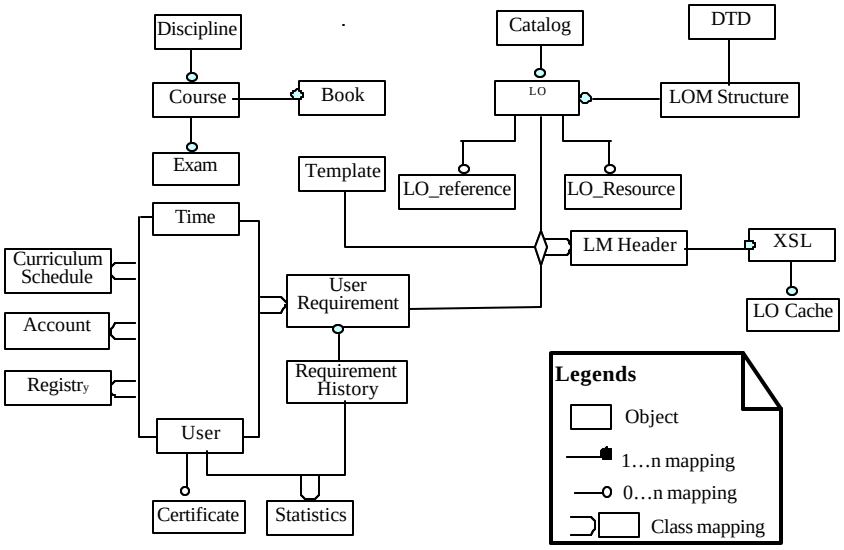

Figure 5.2. NCEC Data Model

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Figure 5.3. NCEC Data module deployment

The course content has a hierarchical structure from top down: discipline, course, textbook (LM) and LO, where a LO is an elemental pedagogical unit, and a LM is an online textbook dynamically built up with LOs. The online electronic version of a textbook is a LM built upon LOs using a template. The presentation styles of the LM are combinations of related LOs according to predefined templates or user requirements, and translated into HTML by XML processors incorporated in Web servers. Each textbook is allowed more than one static template in the form of XML. The presenting style of the LM is defined by XSL (eXtensive Server Pages). Different XSL files can be used for each LM in order to make it have different presentation-style-supporting means on user browsers, such as one presentation with multimedia support and the other without it may be applied for the same LM.

5.3 System Functional Model

In late 1999 Tongji University designed a NCEC function model as the major portion of the gross design. The function model covers all functions for CAPS and NBLE and some functions for NBCE, and consists of the following seven modules:

- *Learning Object* (LO) Authoring
- User Accessing
- User Management
- Learning Administration
- RMI (Remote Method Invocation) Server/Search Engine

- *Learning Material* (LM) Composing
- Repository Accessing

These subsystems are used in two major system operations: LM/courseware production and courseware exploitation.

5.3.1 Courseware Production

Courseware production is a four-step process:

1) Defining tags and the associated DTD files.

Before producing the LOs a set of user-defined tags must be prepared for textbook parsing, and DTDs associated to these tags for serving constraints and validation rules must also be ready. The tags can be defined either in accordance with every kind of courses, namely each of courses has its own set of tags used to tokenize the textbooks, or on the basis of discipline. A discipline may cover several courses which share the same DTDs for all LOs defined in a single DTD file.

2) Parsing textbooks into LOs

A file containing the contents of a textbook can be parsed into LOs and stored into the course material repository. Firstly the text is tokenized into learning objects by using tags being defined. In this step we have to handle several aspects of the LOs:

- Divide the text into small and reusable parts called Learning Objects
- Generate the metadata and their values for each LO according to LOM standard
- Set taxonomies and dictionaries of LOM metadata, which describe attributes of the LOM elements and can be understood by search engines specified to deal with LOs.

The relations of LOs are defined by means of their structures, which are the basis upon which LO hierarchical structures can be established.

3) Designing presentation styles

Setting up LM presentation styles is to combine related LOs and XSLs according to predefined templates or user requirements in XML formats. In previous steps the semantic aspects of LMs, namely course contents, have been defined. In this step the presentation of LMs on users' browsers is to be considered.

The presenting style of the LM is defined by style sheet, namely XSL in our case. We can use different XSL files for one LM in order to make it have different presentation styles on user browsers, such as one presentation with multimedia support and the other with only textual display may be applied for the same LM. But for the LMs from special books, it is also applicable to use a special XSL for them.

4) Validating XML forms

All LOs that are in XML must be validated against the related DTDs, which have been created in the first step. Errors must be corrected before storing the LOs into the repository.

5) Preparing textbook templates

The final step is to prepare templates of textbooks. The templates describe the contents of textbooks being parsed. Each textbook must have at least one static template in the form of XML. In the creating process of a new book, a standard course structure is used as a template for users customization.

5.3.2 Courseware Exploitation

Courseware exploitation can be classified into two categories: learning materials delivering and users' learning management.

1) Learning Materials Delivering

Learning materials delivering consists of *User Accessing subsystem, LM Composing subsystem, LO Search Engine subsystem* and *Repository Accessing subsystem*.

User Accessing subsystem

User accessing system provides users with system accessing interfaces, which are implemented mainly by Server Pages such as JSP, Java Servlets and XML processors including XSP. The system interfaces are selection-driven, namely dialogs between users and system are operated mainly by selecting menus, lists, buttons and various links. The user interface components and their attributes are generated dynamically with names and values coming from repository Catalog, which consists of courses, books, book/LM structures and related LOMs.

User requirements are extracted from user interface components. The requirements are in the form XML and consist mainly of the LM headers that are contents with various LO descriptions expressed by LOM metadata. The requirements then will be stored into repository and sent to the LM Composing Subsystem for further processing. The Composing system will send the requested LM contents with necessary LO links in HTML form to the user, after the LM's being composed and processed with certain XSL file, either in a frame layout of the user browser or in a full browser screen.

LM Composing subsystem

When a request in the form of XML comes from User Accessing system, the LM Composing system will search the cache for the LM at first, or find requested template (in requirement) when the cache can not be found. The LM contents will be sent to the user browser when the cache is found, otherwise the LOs in the template will be replaced by program links indicating LOs addresses in the repository, after a serials of retrievals are performed through LO Search Engine system, which can search necessary LOs and pass their addresses to Composing system. Basing on the metadata contained in requirements, the LM Composing system will generate a LM header that is the contents of the user requested LM with necessary links. The LM header is then parsed into HTML documents that will be sent to user browser, together with the results of the Search Engine.

LO Search Engine subsystem.

This subsystem is implemented by using Java RMI protocol, which is much simpler than IDL server that is full-blown CORBA implementation. The primary concern of this implementation is that searching sites using the same search engine systems would be done locally and more efficiently.

In the process of searching LOs, The local repository and remote sites will be searched in order, by using Repository Accessing system and calling functions of remote instances of RMI servers. The search engine is used specifically for the retrieval of LOs in the repository. It can search LOs by accessing repositories as well as XML documents described by LOM.

Repository Accessing subsystem

This system provides interfaces for accessing of system database tables, caches and directories as well as files. It also consists of modules used to maintain the repository especially the databases and files. The repository accessing interfaces encapsulate all database tables, whose inheritances are realized by using DTAL (Data Table Abstraction Layer).

2) User Learning Management

Users' Learning Management consists of two subsystems: *User Management* and *Learning Administration*. The User Management System provides functions such as user registration, system logon, user authentication, account services, and so on. When a user accesses the system and wants to browse the protected pages, the user must be authenticated by the system and authorized to the requested contents.

The Learning Administration System allows registered users to obtain requested services such as topic-specific searches, examinations, and curriculum creation which incorporates teachers. It is very important for users to have various kinds of online utilities that enable them to make notes on browsing pages, get help from teachers, join mailing lists and BBS, and retrieve recent interfaces by clicking only a button. Users can also get learning and profession advice from some experienced experts dedicated to the system. These subsystems function together to achieve the common objectives: LM courseware production and exploitation.

5.3.3 An Example of LO Authoring

Figure 5.4a-c demonstrate how to use NCEC LO authoring system to create an LO. LO Authoring system allows customized courseware design. After inputting a block of course data in html format, the author can filter out redundant tags and keep those to be used, such as <img>,<a>,<table>. The converted file is displayed in plain text on the screen. Then the author can edit the text by adding in predefined tags or other tags, for example, <BOOK>, <CHARPTER>. In this way the file has been converted from html into xml format. The author can run xmlSpyto to verify if the syntax of the new xml file is correct. The system can parse the file and extract its syntactic tree. The file's tree structure will be saved to the database. At this stage, the file has been converted into an LO and the LO editing utilities can be used to further compile the LO's contents and attributions. Once this has been done the LO can be saved into repository for later use.

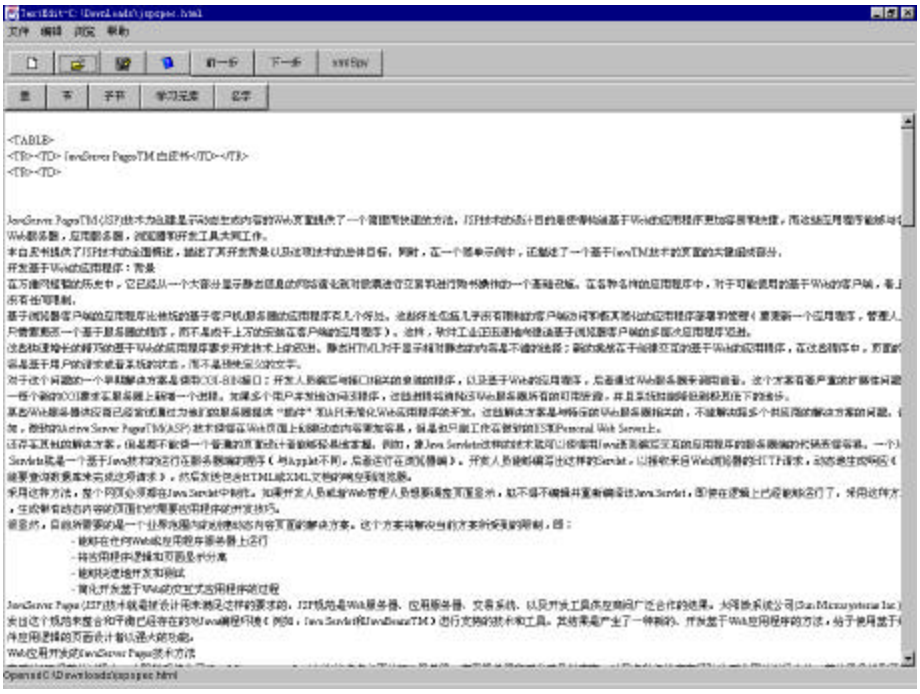

Figure 5.4a. Open a file: c:\downloads\jspspec.html and obtain a plain text file

Figure 5.4b. Adding in <BOOK> and <CHAPTER> tags to the file

Figure 5.4c. Parsing the validated xml file and obtain its syntax tree

5.3.4 Collaborative Learning Environment Design

Tsinghua University designed collaborative learning environment system, i.e. NBLE in NCEC proposal, in 2000 rooted in a pilot version called KWAFU[6]. KWAFU is a prototype of Internet-based distance learning systems developed in 1998 (Figure 5.5). Originally, it is one of the sub-systems for a focal research project in the Ninth Five-Year Plan of China. KWAFU offers individualized learning on demand. Learning materials can be differentially arranged to fit students' qualifications and needs. Students can make use of methods such as bookmarks, notes, etc. to help construct personalized knowledge during the study process. They can take advantage of real time or an asynchronous means, including chat, e-mail, forums, etc, to communicate with teachers or other students. A self-help test is a useful utility of KWAFU for students to check themselves in the mastery of the knowledge learned.

NBLE consists of the following three subsystems:

- User-Oriented Courseware Access System
- Net-Based Collaboration Environment Prototype
- Learner Management Prototype

[6] KWAFU is a name for an ancient Chinese man chasing the sun in a Chinese myth.

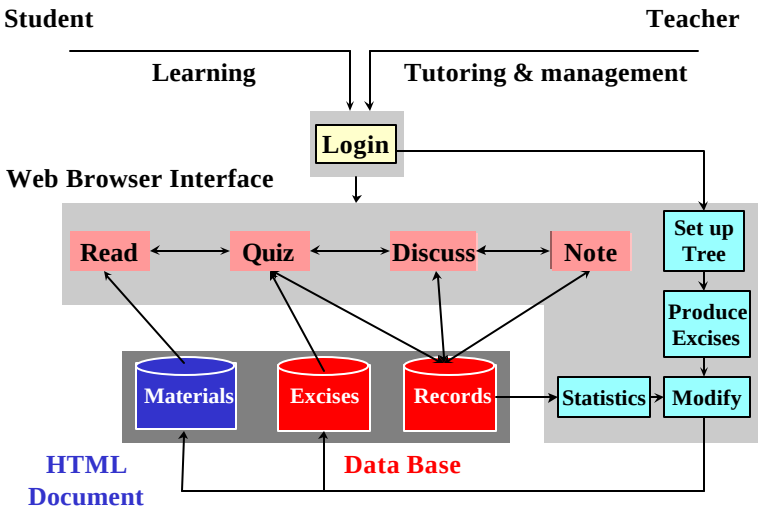

Figure 5.5. KWAFU system structure

1) User-Oriented Courseware Access System (UOCAS)

UOCAS carries out three functions:

- LM Customization
- LM Access
- Behavior Recorder

LM customization allows students to customize their textbook according to their needs. This is a feature provided in NBLE implemented by Tongji University. LM Access is a user-friendly web-based interface for LM browsing, annotating, and quiz taking. Student's behaviors and learning processes are saved in log files to provide original data for pedagogical analyses.

A learner knowledge model has been developed for UOCAS. Figure 5.6a is a complete knowledge tree for a digitized textbook in courseware repository. Its hierarchical structure can be represented by LMs and LOs, the leaves in the tree as indicated as "points" in the figure. Figure 5.6b is a required tree pruned from the textbook knowledge tree. The function of UOCAS is allowing students to customize their own books according to their needs by using a set of utility tools.

<Skipped>

(a) A knowledge tree for a textbook (b) A student-customized knowledge tree

Figure 5.6. A learner kowledge model for UOCAS

Apparently, UOCAS has some functions overlapping to those provided in NBLE system, and interfacing is a critical issue in its design. Figure 5.7 illustrates how this interfacing is done.

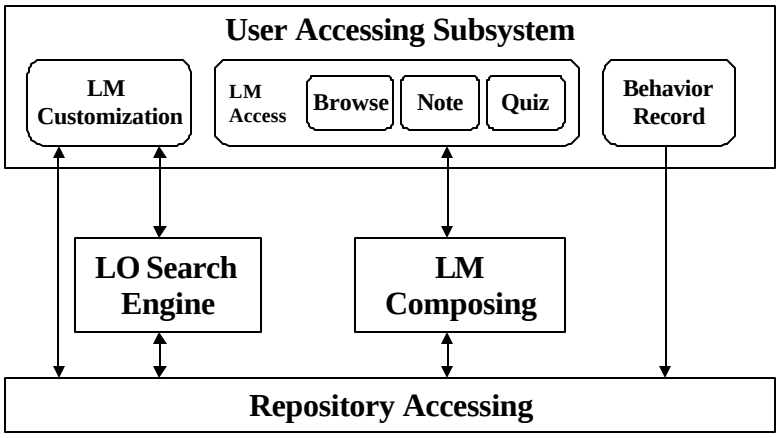

Figure 5.7. Interfacing UOCAS to other systems

The key in the inter-operation of UOCAS and other subsystems is a standardized data model which is designed by Tongji University and described in Section 5.2. Some functions, such as LO search Engine and LM composing are accessible from UOCAS. All these follow the same data structure and data model. Figure 5.8-10 are a group of screenshots explaining how UOCAS works.

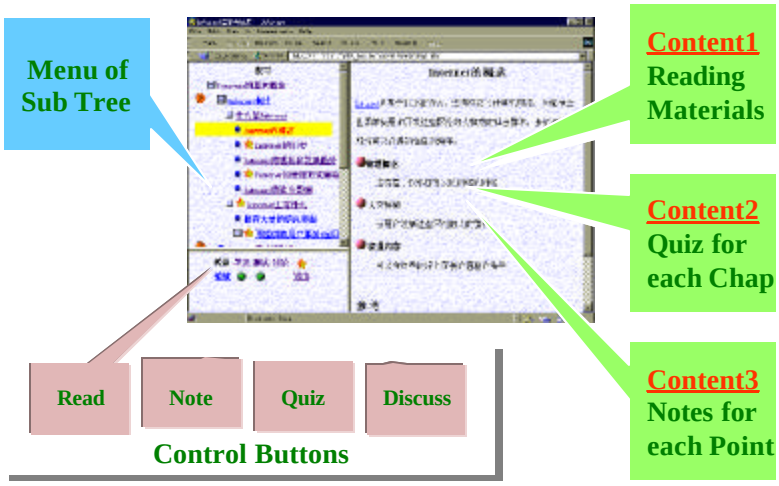

Figure 5.8. A screenshot for the menu of UOCAS utilities

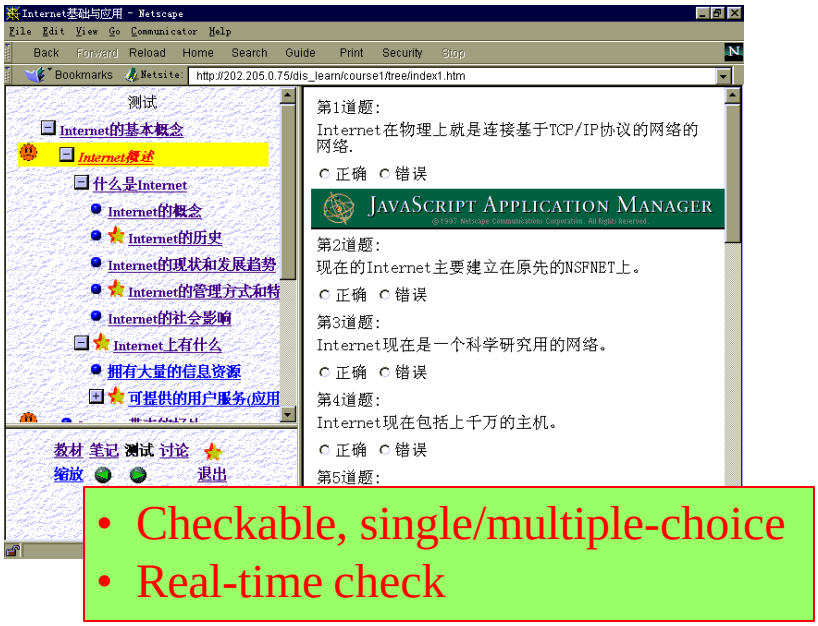

Figure 5.9. A screenshot for an online quiz

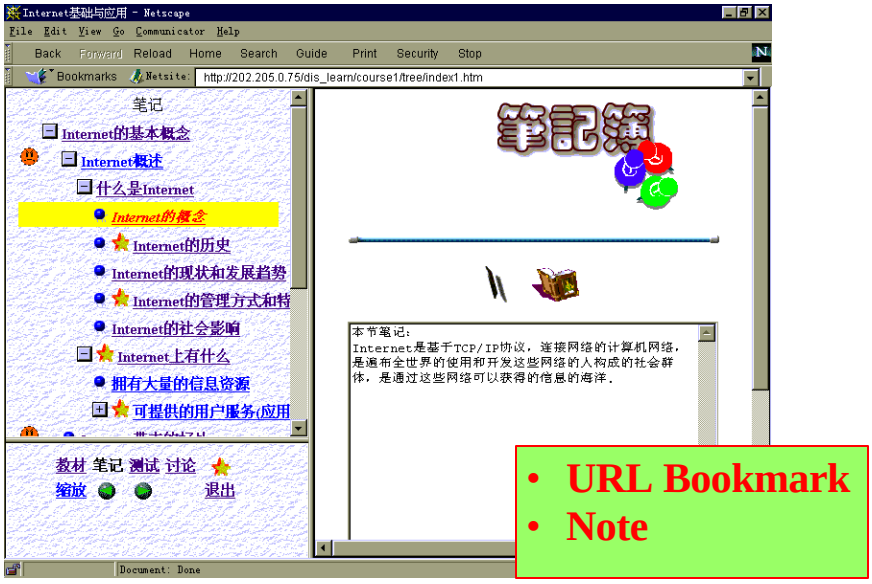

Figure 5.10. A screenshot for the noting and bookmarking utility

2) Net-Based Collaboration Environment Prototype (NBCEP)

The reason this subsystem is called prototype is that there are some many different kinds of network-based collaborative models and it is hard to choose a proper one for NCEC. So, NBCEP will be evolving in NCEC's development process and this evolution will be prolonged to NCEC's operation phase.

Two collaborative modes are considered for NBCEP: asynchronous and synchronous. The so-called asynchronous mode is the one where students communicate not in real-

time. NBCEP provides such facilities as *bulletin board*, *topic discussion area*, *essence area*, and *interior mail service* in the asynchronous mode. With synchronous mode, students can exchange messages in real-time. The basic functions available in NBCEP are *online discussion* and *instant message.*

3) Learner Management Prototype (LEAMP)

LEAMP contains two major modules: *User Management*, which is used for system access authorization and authentication, and *Learning Administration*, mainly a logging and recording system.

User Management handles user registration and system access authentication/authorization (Figure 5.11).

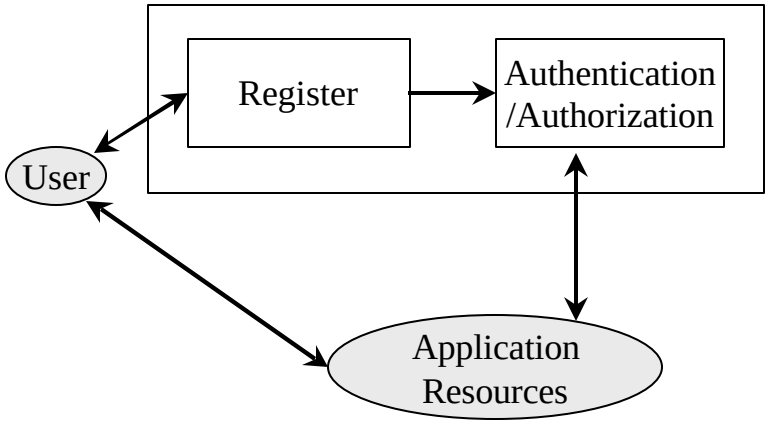

Figure 5.11. NCEC User management

NSDRC has completed a research report on NCEC's security issue. The report proposed a public key infrastructure for NCEC, which is based on the technology developed by Beijing Creative Century Information Technology Co., Ltd, affiliated to NSDRC. The details can be found in [NSDRC, 2000]. At current stage, NCEC is going to adopt a simple scheme, where certificate authority is not used but a regular technique for password-protected user account management has been implemented.

Learning management is a utility for lecturers and courseware authors to perform user behavior analyses. It retrieves records from the log file updated constantly by the behavior recorder in UOCAS, and provides statistics of learner activities as well as the accesses to courseware materials. Ii could be a useful feedback tool to improve the quality of NCEC's services.

6. PROJECT DEVELOPEMNT MANAGEMENT

NCEC project inheres several special characteristics different from any other information system research project or application projects. First, it is carried out by six institutions distributed in five cities geographically located in two continentals. Second, it has a long life-cycle: three year to refine the proposal and get it approved, one year for project "warming-up", and another two years for project development. Third, its major objective is not set to aim at a software product, nor a research issue, but a system design with a demonstrative software. More emphases are placed on the invisible outcomes: the closer relationship between China and Europe in Internet application technology exchange, a more skillful consortium in China for distance education system development. These three characteristcs require NCEC project to adopt a better project development management approach to improve communications: the communication between project consortium and European Union, the communication between Chinese and European partners, and the communication between Chinese institutions.

Project Management Structure

One of the most interesting aspects of the project was the management of a cross country cross cultural project. It was necessary for us to develop a management structure which could handle two discrete teams, one in the EU and the other in China. As well as developing such a project management structure it was also necessary to interface to the EU structures as well. The funding for the project was in Euros, and we therefore also had to work with the difficulties of the poor exchange rate for Euros. So a complicated project with a shifting financial base.

The Project Executive Management Committee (PEMC) has been formed for NCEC with a representative from each partner. The mission of the PEMC is to coordinate the progress of the research consortium across the five partners and monitor the progress of the project, so that the targets of the research will be assured.

The University of Paisley is acting as the coordinator for overall quality management and financial control. Tongji University takes responsibility for the scientific coordination and leadership of the project. Day to day management of the project has two components representing the two geographical areas involved. In the EU, one member of the staff acts as local coordinator. In China, IECC was appointed as a local coordinator. In each case, the scientific coordinator and the two local coordinators report to the PEMC. The management structure of NCEC is shown in Figure 5.1.

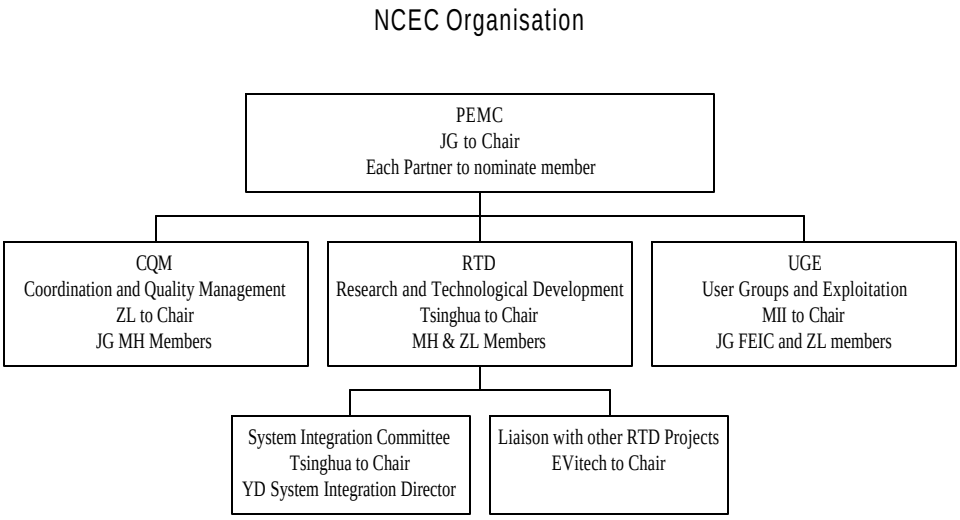

Figure 6.1. NCEC Project Management Structure

Project Quality Control and Internal Assessment

The lifecycle of the NCEC project consists of five phases: initialization, system development, system integration, system customization, and evaluation. The strategy adopted throughout the project lifecycle will focus upon the quality control and the actual products being developed and delivered. This product-oriented approach is particularly meaningful when applied to the development of tools and the experimental phases of the project. Quality criteria have been negotiated with individual partners doing their own initial product specifications and will be applied through to final product realization. The overall project was managed by an agreed nesting of Quality Plans. The resulting quality metrics for each tool, section of research, and instantiation of tests should not only address the technical needs, but also the socio-pedagogical requirements of the end user.

At present, the quality management system for development, production and delivery of course materials has been designed and implemented by the University of Paisley. A set of evaluation methods and standards has been built in complementary European projects. They will be applied to ensure that the project proceeds with due diligence and care. A documentation and report system has already been established to facilitate managerial information exchange and project monitoring.

There was as quality plan generated for the whole project, which was developed from the technical specifications of the initial project bidding document (Figure 5.2). Within the quality plane we developed a schema for work package descriptions. From the Work package we formed a set of tasks, which became the core of the measurable activities of the project. Each partner had to report monthly back to us on the basis of the tasks. This took the form of a table, perhaps nowadays this would form an XML schema.

The partnership experience has allowed it to develop and implement authoring standards and forms for the didactic analysis of learning objects. At present, the quality management system for development, production and delivery of course materials has been designed and implemented by the University of Paisley. Tools have been designed to assist in the implementation of non-generic learning objects to enhance lesson quality. A set of evaluation methods and standards have been built in complementary European Projects (DUCK, ARIADNE). They are applied to ensure that the project proceeds with due diligence and care. A documentation and report system was established to facilitate managerial information exchange and project monitoring (Figure 5.3).

The quality system ensured not only that the individual components were of a high quality, but also that they interrelated in a consistent and reliable fashion. By applying quality management and control on given tools, the project is made more cost effective and efficient. A further advantage of this approach to quality means that scheduled quality reviews can be held at suitably agreed intervals. Such reviews were specific to the particular product being assessed, and comprised of the following: (i) peer assessment review, (ii) walkthroughs, (iii) testing and, (iv) internal reports such as teleconferencing. We established effective communications using an auditable electronic mail system supported by computer conferencing.

7. SUMMARY AND FUTURE PROPECTS

In this chapter we briefly introduced NCEC project's background, system design, current status and development management. For educational institutions, as well as for European and Chinese companies, such a network-based training system forms an excellent basis for the development of joint courses, training systems for industries (both competence development and customer training). Also, NCEC system can effectively be used as a basis for collaboration in research and development projects. The collaborative project between European and Chinese institutions enables all the partners to contribute and share their expertise required to address the specific issues of Chinese information processing and the tele communications and computing environments.

Although the NCEC project has been progressing smoothly, more and more Chinese institutions have caught its pace in last five years in the research and development of distance learning systems. The NCEC project is not, relatively speaking, the largest in funding and scope now. However, its effects are significant and profound, because it is the first distance-education project proposed in China and carried out jointly there by the leading Internet application researchers who are empowered by China's major Internet services and the European institutions who have successful experiences in this field.

NCEC will be focused on two aspects in next stage. The first one is its exploitation. This will bring benefits to both Chinese and European partners (Hämäläinen 1996; Hämäläinen et al. 1996). One of the main features of EU projects is the requirement that the project be self-sustaining. NCEC is very interesting in that while the project has progressed a series of companies have been set up to exploit NCEC and related

technologies. For example, GET Ltd. headquartered in Helsinki was trying to launch an e-business in on-demand education in 1999 based on NCEC's outcomes.

Presently, there are two main routes for exploitation of the NCEC system. The first is the exploitation of the technology by setting up a China side broker. The NSDRC spin out company – Beijing Creative Century Information Technology Co Ltd – has agreed to take on the exploitation rights to NCEC technology and will thus be in a position to act as a localization broker for Western education and training services and products. The second route for exploitation is via the network of partners. In both sides of the world, there are clear opportunities within the developing e-Learning marketplace, both in the public and private sectors. The exploitation plan places emphasis on the following aspects:

- Extending NCEC system to other distance education programs in China.
- Setting up joint distance education programs between European and Chinese universities. These joint programs can be a transfer of the programs in one partner country to another. The applications are also transferable to other countries.

The partners would welcome any interest expressed.

The further research in NCEC will address several interesting topics. The first one is training infrastructure issues. The universities of China will develop an infrastructure for the delivery of training programs to the emergent companies of China and the joint ventures between Chinese and European companies. The research will allow the conversion of European learning programs to a Chinese context by encouraging the collaboration of European and Chinese academics and technicians.

The second topic is the technology transfer between China and Europe. This will provide a test and experimentation capability which will allow us to establish the needs of the final users of NCEC. This will also give us the opportunity to measure the effectiveness of delivery in China from the EU.

The third topic is to study the features of China's distance education market. The distance-education market in China is different from the market in other countries in nature. The relevant regulations and Chinese consumer behaviors with specific cultural backgrounds together will challenge the research effort in this direction.

The fourth topic is technology research. Specifically, knowledge management (Lin et al. 1996) for Chinese information is one of the suggested topics. Conceptualizing metadata in Chinese may lead to organizing textbook knowledge in the way that allows new knowledge discovery and knowledge inference. Therefore, the efficiency of courseware production and modification can be improved. In addition this may provide users a better application interface.

By providing a focused research and development effort on network-based methods and tools in continuing and distance education in China, we view the NCEC project as being potentially one of the relevant contributors, in areas significant to the rapid development of the Chinese economy.

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