

Design and Implementation of Web-Based Intelligent Examination System

Wang Aimin 1 Wang Jipeng 2

1 2 School of Computer Science and Technology, Anyang Normal University, Anyang 455000, China

Abstract

This paper introduces the design and implementation technology of a web-based intelligent examination system. In this system, the random linear algorithm for question selection and intelligent examination paper grouping algorithm based on question bank structure, examination question structure and controlling parameters have been constructed and realized. The system is developed based on J2EE environment. The object oriented software engineering model, UML, Java and XML techniques are used in the system development. The product has been adopted by twenty seven universities or colleges and gained better economic and social benefit.

1. Introduction

How to objectively evaluate the learning effect of university students is a significant theory and practice question which university teachers and administrators need to face. Practice has proved that the “separation of teaching and examination” in teaching reform is a realistic method evaluating student learning effect. Based on domestic universities’ syllabus and various types of examination questions, a web-based intelligent universal examination system has been developed to achieve the goal of objective learning effect evaluation. The system is helpful to the course reform and scientific, standardized teaching evaluation.

2. Functional analysis

This is a general examination management system used in examinations of multiple teaching levels and different subjects. The system uses an open, dynamic system architecture which makes the traditional training mode combine with advanced Internet applications. This can quickly build the examination platform based on characters of each discipline, and achieves efficient management of test content.

2.1. Policy-based paper building models and various test types

The system builds papers based on some policies. Users can define their policy, and create policy items based on the item bank, question type, degree of difficulty and knowledge point. According to the policy items, the system automatically and randomly extracts questions to combine test papers. After papers are built, users can renewably add, modify, and delete the policy items to recombine papers. If users aren’t satisfied with paper or work content which is built in fixed pattern, they can automatically or artificially transfer questions to adjust papers. Users also can add, modify or delete new question items in hand.

Through comprehensive anti-fraud technologies, the system allows administrators to draw questions from item bank to group papers randomly [1]. In accordance with the degree of difficulty strategy of scheduled knowledge points, each examinee’s test paper is different. If the test is fixed, administrators can invert the order of test questions. Then the order of topics for the examinee will be upset. Invert the sequence of multiple-choice questions’ answers and prevent the plagiarism and mechanical memorizing.

The examination paper types include exercises and examinations, examination types can meet different examinations needs, which is shown in Figure 1. In the examinations mode, students have to complete their examination in a limited time. The system will automatically close the paper and record the answer of candidates in detail when exceeding the time [2]. The mode of exercises suits for arranging homework. Candidates finish phased exercise in a limited time, and check the standard answers at the end of practice. Candidates can study with a definite object and improve efficiency though checking answers timely.

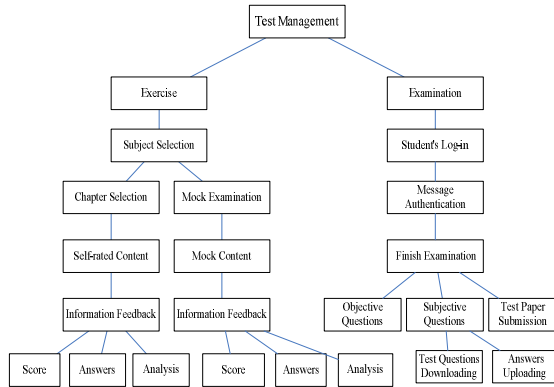


Figure 1 Test management and question types

Based on analysis of various examinations, and the question types include the blank-filling, judgment, single-option, multiple-choice, calculating, short-answer, expounding, reading comprehension and graph drawing question and so on. On the basis of these types, users can set papers questions types according to their own application, different papers can include different questions types and be changed dynamically.

2.2. Multiple paper judgment methods

Judge papers automatically or manually according to the type of papers. If there aren't the short-answer questions and calculating questions, the system automatically judge the test papers and give total scores at the end of tests. If there are short-answer questions and blank-filling in test papers, designated reviewers manually give score of subjective questions through browsers [3]. The system also displays students' answer information, so omissions in the process of judging papers are avoided.

The system uses two paper-judging modes (course judging mode and class judging mode, which is shown in Figure 2) to reduce workload of teachers effectively. In the course judging mode, teachers can judge test papers of students which take part in the same test, but belong to different classes. In the class judging mode, teachers can judge test papers and inquire corresponding practice of students which belong to the same class. The two models can help teachers finish complex work effectively.

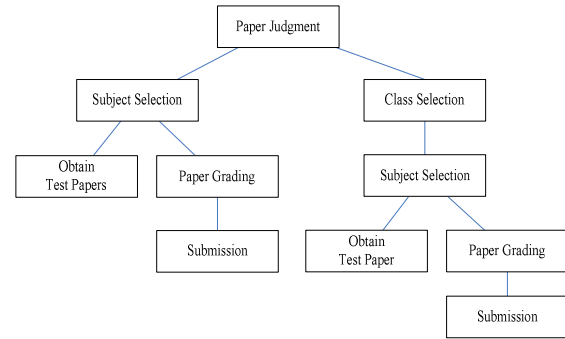


Figure 2 Paper judgment function

2.3. Strong functional statistical analysis of answering papers

The system provides powerful statistical analysis function of answering papers (shown in Figure 3) to grasp the situation of answering, including the answering condition statistics, passing rate statistics, achievement analysis, knowledge point analysis and accuracy rate analysis. The score inquiry function allows students to inquire their own scores and papers. They can inquire the percentage of their correct answers and know their weaknesses. Teachers can query the test result, or conduct the multi-conditions combination query according to the course, class, student number and achievement.

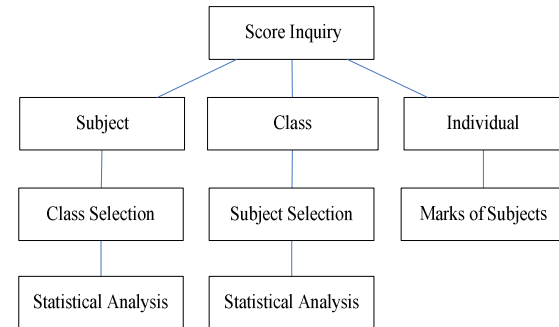


Figure 3 Score inquiry and analysis function

Teachers can also carry on the statistical analysis of the examinee score, population, passing rate and so on. The statistical result is shown in the way of the figure, text or graphics (such as the histogram, pie chart and curve). The statistical graphics can be saved as external image files for other demands. The knowledge point analysis is based on knowledge point, question type and degree of difficult. The analysis result can be displayed in charts. The professional printout program of report card can print out report card form according to user-defined program and printing parameters, and also allows users to export the results to Excel format files to more analyze scores.

2.4. System architecture, authority management and stability

The B/S system architecture realizes the flexibility, high-performance and stability. Because all functions, such as students' examination and check points, checking paper by teachers, query, etc, are completed using B/S mode, the system is used without installing clients, which is easy to maintain and upgrade and able to integrate with the existing Intranet. Authorized users can logon in through a browser and upload their papers by themselves at the end of the examination. In the way of distributed management to item banks and examinations, administrators can designate item banks; set the given item banks the degree of security and sharing. The general managers can arrange and manage examinations of their institution, which make the system management easier by transferring administrators' authority and task to lower levels.

The hierarchical authorization management realizes the separation between resources sharing and resources management, which is shown in Figure 4. Each operation of the background management system was set authority, which can dynamically be granted to or recovery from general managers by the highest-level administrator. Every general manager can establish and maintain their own examination accounts, item bank, test paper (homework or practice), and can't see similar data established by other managers without authorization. When the general manager was authorized, he can see and use data established by other managers, but can't modify or delete them, which insures the data integrity and consistency and security.

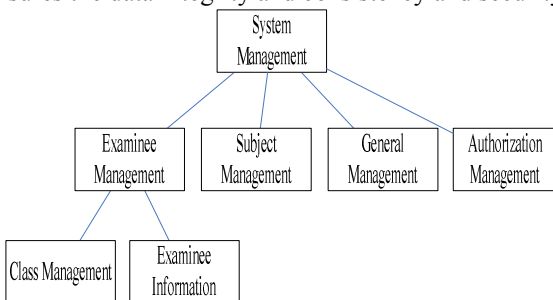


Figure 4 System management

The system provides advanced protection to test papers. If unexpected situations (such as abnormal shutdown, artificial incorrect manipulation) happen in examination, the system will automatically store information of candidates and test papers. When candidates login system again, the system recovers all stored information and candidates can continue answering papers without any mistakes. When candidates finish test papers, the system will store all

answers on servers, and teachers can inquire, analyze answers using a client.

The system uses a variety of technical solutions to guarantee the stable system run. The fault-tolerant processing ensures that the examination process can be controlled orderly and users' disoperation can be shielded effectively. Examinees are prohibited refreshing browsers to prevent the loss of answers. The limited operation of the right mouse button guarantees the integrity of user interface. Page caching technology is adopted to save the answers, by which examinees are allowed to re-submit their answers if network faults happened in the process of submitting answers, examinees can also know the remaining time of examination though the countdown function provided. The system will remind examinees to preserve their answers to prevent loss at the one minute and ten seconds before the end of the test. If the examinees do not submit their papers at the end of the test, the system will automatically collect the papers to ensure the seriousness and fairness.

3. Algorithm design and realization

3.1. Question bank structure and controlling parameters

The question bank saves the number of each examination question and answer, and also encodes each examination question with knowledge category, item type and difficulty degree. Based on the above analysis and testing, each examination question saves in the format of hypertext separately. Such a system design increases the development and implementation efficiency.

Examination papers are grouped according to requirements raised by users such as the item type, difficulty degree and coverage scope. The requirements should coincide with the actual question bank; otherwise, the system will tell users that their requirements can not be met. Three key elements are the item type, difficulty degree and question bank situation.

To meet a variety of examination paper grouping requirements, each kind of item type of each knowledge point in question bank should be an even distribution. The number of questions with the same knowledge point; item type and difficulty degree needs to obey the normal distribution.

3.2. Intelligent examination paper grouping

3.2.1. Problem description. As the system needs to provide the flexible paper grouping function, and also

compiles many examination papers with the same requirement and different contents every time, a number of parameters defined are as follows:

Total difficulty degree parameter: N ;
 Question type parameter: $A[i]$;
 Parameter of item type quantity: $B[i]$;
 Parameter of item type score: $C[i]$;
 Parameter of question difficulty degree: $D[i]$.

3.2.2. Questions selecting algorithm. To take a random linear programming algorithm, suppose that the total score is G , the total degree of difficulty is N , the corresponding quantity of question item type $A [1]$, $A [2] \dots a[k]$ are $B [1]$, $B [2] \dots B [k]$ respectively, the score and degree of difficulty of the i th question type respectively are $C [i]$ and $D [i]$. So the calculation formulas are:

$$\sum_{i=1}^k B[i] * C[i] = G ; \quad \sum_{i=1}^k D(i) = N .$$

The design algorithm is as follows:

- ① Parameter initialization;
- ② Determine the questions situation. If completed, generate and save examination papers, transfer to ⑨, otherwise, continue to carry out ③;
- ③ Select the question type needed;
- ④ Select the degree of difficulty;
- ⑤ Generate the random number $[1 \dots n]$;
- ⑥ Draw questions randomly;
- ⑦ Shield the selected question and mark questions which belong to the same knowledge point. The shielded and marked questions will not be re-selected in this paper, and can be selected in next paper. Use variables to preserve the knowledge point of selected questions, compare after each random selection. If repeat, return ⑤, re-generate the random number and select questions again, otherwise, continue the next step;
- ⑧ Determine the amount of current question type. If enough, return and execute ② again, otherwise return ⑤;
- ⑨ Display(available in FrontPage or Word) and print papers(use the IE print function).

4. Development environment and technical analysis

According to the standardized management pattern of colleges and universities and object oriented software engineering, the J2EE-based intelligent examination system has adopted Java, XML, and three-tiered Browser/Server structure [4]. Unified

Modeling Language (UML) has been used in the system modeling and design. The web-based system can enhance its flexibility and greatly improve users' working efficiency.

4.1. Three-tiered computing model

The system uses the three-tier computing model which is shown in Figure 5. The three parts are: ① client tier, as the user interface sending requests and receiving responses, the typical application is a web browser and fat clients; ② server tier, the typical application is a web server and application server which run business code; ③ data tier, the typical application is relational database and other back-end data resources.

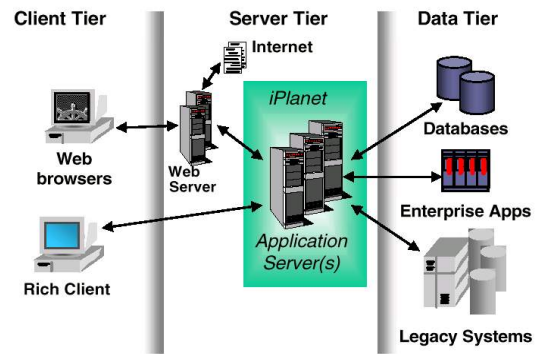


Figure 5 Three-tier computing model

In the three-tier structure, customers (request for data), procedures (process the request) and data (operated) are physically separated. The flexible three-tier architecture separates the presentation logic from application logic. The middle logic tier does not need to concern the types of users request data, and can maintain the relative independence with back-end system. The three-tier structure has better portability, and allows users to request load balancing. The method that application procedures separate with users improves better security. The application server provides the environment storing and running the code, separates the logic with the client side and data resources physically, and enables a system to be developed and deployed simply and rapidly.

4.2. J2EE technical standard

J2EE used in the examination system is one kind of technical architecture that uses the Java 2 platform to simplify complex problems related to the development, deployment and management of application solution. J2EE consolidates advantages in standard edition, also provides full support to EJB (Enterprise JavaBeans),

Java Servlets API, JSP and XML. J2EE provides a middle layer integration framework to meet the application needs of high usability, high reliability and extensibility [5]. By providing a unified development platform, J2EE reduces the cost and complexity of multi-tier application development, while it provides strong support to existing applications integration and JavaBeans.

The J2EE platform has some characteristics: cross-platform deployment, integration with existing heterogeneous systems, high scalability and security. As a development framework based on standardized, modular, reusable components, its API automatically processes a number of applications.

4.3. UML and object-oriented software engineering

The object-oriented software engineering and UML has been adopted in the project management and system modeling respectively. As a standard object-oriented modeling language, UML has drawn new ideas, methods and technologies in software engineering field, and supports the whole software development process beginning from the requirement analysis.

UML consists of a number of graphical elements and diagrams. UML elements have their semantics and notations. The UML definition refers to the semantics and notations of elements. ① The UML semantics are precise meta-model definition based on UML. The meta-model provides a simple, consistent and general explanation in the syntax and semantics for all the UML elements. ② The UML notations define UML element symbols and provide the standard to model systems with the graphic symbols and text syntaxes for developers.

5. Application

The examination system is designed according to the actual curriculum teaching and teaching reform. Compared with similar systems, the system covers all functions which appear in the similar systems, and also has some advantages. The well-designed B/S system structure and reasonable, simple program structure

raise the system efficiency. Full use of high-performance servers and users' computer resources avoids the network crowding and low-speed [6]. The system design takes into account user management and makes full use of the server own security, which makes the system's security be ensured.

Closely combined course characteristics of higher education, the examination system emphasizes subjective questions in order to objectively evaluate the learning ability of students, and also gives attention to objective questions to more effectively evaluate academic achievement of students. The system design is aimed at the "C Programming Language" course, but it has better versatility and expansibility. Based on the design structure of the system, it can be used for building questions bank of other courses only by changing related materials. We have established the "Computer Application Foundation" questions bank, "Electronic Commerce Technology" questions bank and "Logistics Management Foundation" questions bank. For the past two years, the system has achieved good effect and received users' high praise.

References

- [1] He Haitao, Li Chongzhen. The Design and Implementation of Genetic Item Bank Management System [J]. JOURNAL OF YANSHAN UNIVERSITY, 2003; 27(3):241-243.
- [2] Mo Xiaoyu. Design Outline of General Questions Bank Management System [J]. JOURNAL OF GUANGXI ADMINISTRATIVE CADRE INSTITUTE OF POLITICS AND LAW, 2006(4):119-121.
- [3] Wu Shuixiu, Zheng Qingpeng, Wang Mingwen, Ding Shuliang. Intelligent Papers Generation and Adaptive Examination System [J]. COMPUTER AND MODERNIZATION, 2008; (1):172-175.
- [4] Hong wei-en. JVJA 2 Object-Oriented Programming. China Railway Press, 2002.8.
- [5] Cui Hongbin, Wang Aimin. J2EE Web Services. Tsinghua University Press, 2005.4.
- [6] Ma Handa. Design Technique of User Environment in Teaching Network [J]. LABORATORY RESEARCH AND EXPLORATION. 2006, 19(4):155-158.