Abstract—The online course registration system is the central part of the educational administration system, which consists of registration guidance, registration controlling, undergraduate course registration, graduate course registration, retaking and retesting, dropping the course in the middle phase and information exchange, etc. The new course registration system at Tsinghua University was put into use in April 2009. By registering the course voluntarily, the new system improved registration mechanism, implemented course registration of common course for undergraduate and graduate students, and also supported the teaching activities across spring, summer and fall semesters. This article introduces the design and implementation of the new online course registration system, including registration mechanism, technical architecture, and system design, etc.

Keyword-registration mechanism; registering courses voluntarily

I. PREFACE

Tsinghua University offers more than 3,000 curriculums per semester, and online course registration seven times. More than 500,000 students will register courses via those registration activities, which have become an important part of academic administration. All students have to register courses via the online registration system opened in 1998. To be an exception, some compulsory courses are offered to the freshman in the entrance according to their classification. The registration will be carried out by two kinds of drawing lots, real time (undergraduate students) and system automatic (graduate students).

Early 2006, we started a special project in the 2nd phase of “985” named by “the modernization of technical platform supporting education”. To emphasize the student-oriented concept, improve the efficiency and quality of course registration, and fully meet registration requirements, we used a totally new registration mechanism in the implementation of this new online course registration system, which supports classification education training for undergraduate students, common course registration of both undergraduate and graduate students, and teaching activities across semesters. We reconstructed the online course registration system by introducing new registration mechanism, system architecture and design method to ensure the system more flexible and adaptable to support all kinds of students and online courses.

The system was put into use in April 2009. After two years’ usage, with the high attention of high level management teams, all academies and departments, proactive cooperation of all teachers and students, the system now has reached domestic advanced level through continuous improvement. It solved perfectly the problems like fake registration numbers, course chose by system is not the real one wanted, and unfair registration etc. It will introduce system design and implementation from 3 aspects: registration mechanism, system architecture and design method.

II. REGISTRATION MECHANISM

The online course registration system is the central part of the educational administration system. We did research on registration mechanism before system design. Based on the analysis on some existing registration mechanism, we proposed three operative registration methods: point assignment, willingness and drawing lots. After collecting feedback and comments from all teachers and students, we decided to use the method of willingness.

Concerning the real situation and previous problems in the method of drawing lots, we optimized and adjusted the existing drawing lots method by using multi-level, multi-classification and multi-willingness. The students’ willingness is considered when deciding the registration priority. It means the registration willingness will influence the rate of drawing lots to solve the problem mentioned above like fake registration numbers to meet students’ requirement maximally.

After finalized registration mechanism, we separated the registration process into 3 phases which are same to previous ones: registration, adjustment and dropping. Detailed description could be found below:

A. In the registration phase

we used the willingness method. Three willing levels are designed for compulsory courses for undergraduate students, restriction courses, optional courses and physical courses, with exceptional high priority for optional courses. For graduate students, three willing levels are also designed for
degree courses, non-degree courses and physical courses with exceptional high priority for degree courses and non-degree courses. For the overloaded courses, the system itself will draw lots randomly in the background according to the students’ current training plan and willing level.

B. In the adjustment phase
the students can register via first-come-first-serve if the capacity of the courses allows.

C. In the dropping phase
the students could do nothing but drop courses.

III. TECHNICAL ARCHITECTURE
The online registration system is a periodic heavy load system especial in the registration phase: too many online users and concurrent operations, which are relatively minor in other phases. So it’s very important to choose appropriate system architecture.

A. User model
First of all, we analyzed the current system users. Registration activities involve all undergraduate students, graduate students, most of teachers, graduate schools, academic affairs office, and all related education administrators. Considering the large number of system users and wide coverage, the users are separated into three categories:

- Student: It refers to the undergraduate and graduate students who will inquire online courses and complete registration steps to generate personal registration table.
- Teacher: It refers to the users who will deliver courses, and check the status of online course registration.
- Administrator: It refers to the users who will control registration process, adjust detailed information of online courses according to the real-time registration status, and complete administration tasks in the background including drawing lots, willingness release, etc.

B. Technical architecture
There’re tens of thousands people involved in registration activities as the major part. System administrators are relatively stable while administration operations are complicated. Based on the analysis of user category and activities, the system design is using the integration of C/S architecture based on Citrix and B/S architecture based on J2EE, which is also integrated together with authorization system and official portal of Tsinghua University.

- C/S: C/S architecture is used to implement administration functionalities. Developing environment is PowerBuild 10.2. The B/S access method is implemented in C/S system by applying Citrix technology. In this way, the system implements seamless integration and roaming access between C/S and B/S, which solves the problem that it’s not convenient for application access and update.
- B/S: B/S architecture is used to implement all kinds of functionalities for the students and teachers by using JAVA. The framework is based on Spring and Hibernate. It uses MVC structure which separates view, business and model.

- Authorization: It’s integrated into authorization system directly which ensures all kinds of users can access the online course registration system via portal, and doesn’t require the 2nd account and password.
- View: Through the two channels of teaching and teaching management, the system integrates all functionalities related to course registration via direct integration with portal. The students and teachers can take required actions via registration item listed in the channel of teaching. The administrators can run operation according to their role assignment after entering the channel of teaching management.

IV. SYSTEM DESIGN
A. External relationship
As the intermediate link in the teaching chain, course registration has relation to teaching planning, course arrangement, examination arrangement and scores management, which means course registration system has to cooperate with enrollment system, course system, teaching planning system, training system, examination arrangement system and scores management system. Based on the clarification of systems connections and relationship, the definition of system interface and message is described in the figure 1 below:

![Figure 1: Interfaces and messages between different systems](image)

It can be seen that enrollment system, course system, teaching planning system, training system, are superstratum systems which provide basic data for course registration system. Examination arrangement system and scores
management system are then substratum systems which will digest data provided by course registration system. The system interfaces are finalized:

- For superstratum systems, course registration system read all data initiatively. It will try to get a mass of basic data only once, and then save those data as the base for course registration. Later on, it will update accordingly if there’s any new information. For other kinds of data, it will read them on demand and won’t save them at all.
- For substratum systems, they can’t access registration data directly but only wait the data pushed out by course registration system to ensure registration date revised unconsciously.

B. Function structure

The course registration flow consists of data preparation, registration, adjustment, retaking and retesting, dropping in the middle phase which actually will be carried out by students, teachers and administrators. The system functionalities are designed based on the major flow and involved system users. Details could be found in figure 2:

![Figure 2: Structure of system functionalities](image)

The implementation of wishingness method is the key part including: priority determination and drawing lots calculation which can refer to my another paper: ‘Research and implementation of volunteer course selection algorithm’.

C. User interface

The business logic and function dependency in course registration system internal are very complicated. We need to hide the complicated business relation via kind of technology to ensure it’s easy to use for end users by using friendly user interface. We used the uniform design for style and color. The operation items are displayed on the top while the view items are under operations ones. The items are named briefly to represent the functionalities correctly with adding some User-friendly operation symbol. Two user interfaces are described detailed below:

- Registration UI: The registration UI interfaces are separated according to different kinds of courses. The registration UI interfaces for undergraduate students consists of four types of compulsory courses, restriction courses, optional courses and physical courses. The registration UI interfaces for graduate students are combined of three types of degree course, non-degree course and physical course. In the later adjustment phase, it adds a new UI interface for retesting and retaking. In this way, the system can work perfectly with each student’s teaching and training planning in corresponding systems and also can ensure registration work well. From the top to bottom of each UI interface, the areas in turn are query input, view of course available for registration and personal course. The initiative ratio of each area occupied is 20%, 40% and 40%. Because of limited length of query input, only the query used most often is displayed. Coming to the view area of personal course, only the information cared much are displayed in the first screen which aren’t decided randomly but after deep investigation. In the area of course registration, students can adjust willing levels via up/down arrow which not only save space but also make it much friendly to end users.

- Administration console: It is used for registration switch on/off and parameters adjustment and mainly used by administrators. Because the new online course registration system supports registration across semesters, administrators need control all three semesters’ course registration in the same time. In order to help administrators to know all ongoing course registration status well, the console is designed to display three semesters’ registration in the same time on the same page, which is separated into 3 same areas from left to right. Each area is separated into 3 minor areas as well from top to bottom, registration phase, registration controlling and registration parameters. In this way, administrators can control all three semesters’ course registration and compare the registration results.

D. Database design

- Design scheme: The real-time running tables are separated from the history backup tables, and meanwhile, lots of sub tables are integrated together. The real-time running tables save registration data by semesters and years. To be safe on data consistence and integrity, two master tables are used for course information and registration information, other additional information is saved independently after splitting. The history backup tables share the similar structure to the real-time running tables. The only difference is the new time stamp for registration phase in addition to the time stamp for semesters and
years. When one phase in one semester of one year is closed, the data in real-time running tables will be backup up to the history backup tables. For example, after the course registration for the fall semester of 2010–2011 was closed, a backup was executed. The data which has already back up cannot be revised in the front. In this way, the registration data in each semester then can be back up several times which helps to provide more information for later registration activities and optimization.

- Parameter design: Lots of pre-requisite and restriction conditions need to be determined in the system implementation, e.g. whether a student has school enrollment, whether a student meets the registration requirement, etc. These kind of pre-requisite and restriction conditions become blocking issues for smooth course registration and affect performance as well especial in peak time. We summarized all required pre-requisites and restrictions, some of which possible to use are designed as basic parameters, and saved by binary characters 0/1. Zero (0) means it doesn’t require a judgment while 1 requires. This kind of design helps to control system flexibly and improve system performance.

E. Performance optimization scheme

The online registration system is a periodic heavy load system especial in the registration phase. To avoid system bottleneck, we did research on performance optimization in the very beginning and introduced a lot of design methods. The operation performance is optimized by using data buffer on server side after each query. The efficiency of query is ensured by using corresponding index for physical tables which are transformed from complicated system views. The system load is minimized by fully using the calculation capability on client side.

In the same time, after analyzed previous registration problems and users’ activities, we also cared much on system maintenance and took a lot of actions for performance optimization to solve performance issues from all aspects. Some details are:

- Classical load balance, web server, application server and multi-level database design are chose for system architecture. System load is balanced well on different servers to solve single-point failure and too heavy load on single server.
- Systems run separately on different servers which ensure the normal use of not only course registration system but also others.
- Load balance and database servers are adjusted based on real-time monitor results.
- In the registration adjustment phase, to avoid bottleneck caused by too many students trying to access systems concurrently, entrance controlling is introduced to adjust users to enter system per time to control the number of active users.
- The operation times can be controlled as well to avoid malicious registration to protect system resource, e.g. if the registration times have reached maximal configured parameters(100 upper limit for registration submit, 200 upper limit for course query), it has to be re-logged to system for registration.

V. SUMMARY

The new online course registration system solves the unfair problem caused by drawing lots randomly and performance issues, implements common course registration for both undergraduate and graduate students, supports teaching activities across three semesters including fall, spring and summer. With the spread and realization of the concept for international education and the coverage of campus wireless network, the system will be continuously improved to support mobile, abroad students and international visiting students to ensure the teaching activities could be carried out more smoothly.

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