Using AJAX to build an on-line QTI based assessment system

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Abstract: - Assessment plays an important role in the distance-learning research. Generally, the process of instruction completed with the assessment that be used to evaluate learners' learning efficiency, skill and knowledge. With the evaluation of assessment results, instructor can judge learners' learning efficiency and ability; students also can find out whether they acquire the learning material completely or partially. AJAX is novel technology using in rich-client web application recently, it uses an asynchronous communication way and provides a better using experience to users. Thus, we propose an on-line adaptive testing system which provides the QTI standardized item and adaptive assessment mechanism. The system integrates the Question and Test Interoperability (QTI) Version 2.0 proposed by IMS Global Learning Consortium and Item Response Theory (IRT). The purpose of this research is to construct an adaptive, reusable and sharable assessment system.

Key-Words: - Computerized Adaptive Testing (CAT), Item Response Theory (IRT), IMS Question and Test Interoperability (QTI), AJAX.

1   Introduction

Assessment is one of the distance learning research issues; it plays a very important role in this field. Generally, most instructional process completed with the assessment to estimate the learners' learning efficiency, skill and knowledge. According to the assessment results, instructors could judge the students' ability and students also could know that they have understood the knowledge completely or not. In intelligent tutoring system, assessment is even more important. It provides tailored learning contents based on cognitive analysis, students' ability and study status to individual students.

From the year of 2004, with the rising force of Web 2.0 to nowadays, websites trend to work as social or group software where people can work together, share the knowledge. And rich-client applications using FLASH or AJAX techniques are popular and catch the people attention. We proposed an adaptive testing system using AJAX to provide a rich-client application to construct and manage the Human Machine Interface (HMI), and communicate with server side. In order to achieve the knowledge share during the learning phase, we also proposed the database of answers. The instructors in this virtual society also can provide different opinions with different solving skill but with the same answer to all the items in item-bank. The learners can reference all the provided answers to choose their acceptable problem solving skill and learn something usefully. Regarding to someone's impression, when testing by the traditional Paper-and-Pencil method, the learners begin to focus on passing the tests rather than real studying [1]. In other words, learner tries to memorize the questions sequence and answers in the assessment. Thus we can't really measure students' learning efficiency, and system can't provide real tailored and individual assessment items to each learner. We try to propose a computerized testing system based on Item Response Theory (IRT) and IMS Question and Test Interoperability specification (QTI). Our system provides the tailored assessment item more effetely and follows the international standard to interchange between other compliant assessment systems.

The other parts in this paper are organized as follows. Section 2 discusses the related work of testing theory, on-line testing system, and self-assessment tools. The main theoretical basis - item response theory, and technical standard - IMS QTI and AJAX are described in Section 3. Section 4 shows the adaptive on-line testing system. Finally, the conclusion and our future works are presented in section 5.

2   Related work

Psychometrics is kind of study concerned with the theory and technique of psychological measurement, which includes the measurement of knowledge, abilities, attitudes, and personality traits, such as psychological testing and assessment [2]. The field is primarily concerned with the study of differences

between individuals, quantitative psychology and mental test theories. It involves two major research tasks, namely:

(I) the construction of instruments and procedures for measurement;

(II) the development and refinement of theoretical approaches to measurement [3].

Mental test theories tell experimenters how to perform particular comparisons between specific theories, or between specific classes of theory. There two classes in mental test theories:

(I) Classical test theory based on true score model [4];

(II) Modern test theory based on item response theory [5].

Traditional paper-and-pencil method is kind of classical test theory, and there are many computerized testing systems follow the classical test theory. Gwo-Jen Hwang provides a test-sheet-generating algorithm for multiple assessment requirements [6], and Gwo-Jen Hwang, Peng-Yeng Yin, Gwo-Haur Hwang and Ying Chan proposes a approach for composing test sheets from large item banks to meet multiple assessment criteria [7], although Dr. Hwang's research provide a novel and heuristic approach to improve the efficiency of composing near optimal test sheets from very large item banks to meet multiple assessment criteria, and have outstanding accomplishments, but it still lacks for the issue of providing adaptive test items to individual student.

In Modern test theory, item response theory always comes with Computerized Adaptive Testing (CAT). Adaptive testing is used in computer administrated tests to dynamically estimate the examinee level, such as Graduate Record Examination (GRE) and the Test of English as a Foreign Language (TOEFL) [8]. However, this kind of technique is appropriate for testing, not for assessing student's needs. Focusing on getting higher grades if the examinees answer the harder item, it still has some differences between adaptive testing we followed. It works when there is a need to determine a student's level of knowledge, but not measuring the student's knowledge in every concept or level in the course. In the other point of view, some researchers focus on initializing the model of students, using machine learning technique to classify students with similarity between them [9]. Educational applications can offer individualized support to students with these characteristics. Distance learning related research always focus on learning problems, like SCORM-based learning management system [10] [11]. Our final goal is to build a adaptive learning environment, not only provide a SCORM-based learning content, but also propose a standardized adaptive testing environment based on QTI and item response theory to make the learning process more efficacious.

3…Theoretical Basis
3.1 Item Response Theory (IRT)

Item Response Theory is a branch of modern test theory, a family of mathematical expressions of what happens when an examinee meets an item. It is based on two essential postulates: 1. The performance of an examinee on a test item can be explained by a set of latent traits called abilities. 2. The relationship between examinees' item performance and the set of abilities underlying item performance can be represented by a monotonically increasing function called an item characteristic function or item characteristic curve (ICC).

The ICC represents the conditional probabilities of the successful answer to the item by a student with a certain latent trait measured in the domain of real numbers. The ICC must be previously known for each item and is expressed by means of a probabilistic function. In our system, the latent trait is the knowledge level. The ICC parameters must be assigned previously by innstructor faithfully or should be taken form the performances of students that have taken a test with these items no adaptively.

3.2 IMS Question and Test Interoperability (QTI)

IMS Question and Test Interoperability specification is proposed by the IMS/GLC which stands for Instructional Management Systems/Global Learning Consortium, Inc. IMS develops and promotes the adoption of open technical specifications for interoperable learning technology. Several IMS specifications have become worldwide standards for delivering learning products and services, like ADL SCORM CAM (Content Aggregation Model) referred to IMS Content Packaging, and ADL SCORM Sequencing and Navigation Model also referred to IMS SSS (Simple Sequencing Specification). Our mission is to build an item bank to provide a source for testing system. We choice the IMS Question and Test Interoperability (QTI) to describe the testing items in item bank. IMS QTI model provides assessments composed from sections, composed from items. Our system supports the creation of the libraries of items and sections that can be used by reference. There are almost twenty item types defined by the IMS QTI Specification: True/False (or Single choice); Multiple choice; Order;

Associate (pair); Match (directed pair); Gap Match; Inline choice; Text entry; Extend text; Hot text. Some item types associated with graphic presentation, such as: Hot spot; Select point; Graphic order; Graphic associate; Graphic gap match; Position object. And other advanced multimedia support: Slider; Drawing; Upload. QTI describes items' data model with XML. It is an ideal way to exchange data between any kind of development platforms and operating systems, and truly achieve the platform and operating system independent.

3.3 Asynchronous JavaScript and XML (AJAX)

When Google announced Gmail and Google Maps, started to develop applications with AJAX, AJAX earned some attention in the public. AJAX is the shorthand for Asynchronous JavaScript and XML. That is a web development technique for creating interactive web applications. AJAX use JavaScript to construct the XmlHttpRequest object to communicate with server components asynchronously and update the source of HTML page based on the resulting XML/Text response dynamically. Web communication based on AJAX is different from traditional web communication model. In traditional web communication model, the client sends the request to web server, and the server returns the response to browser one by one. On the other hand, AJAX-based Web applications make web pages more responsive by exchanging small amounts of data with the server behind the scenes, so that the entire web page does not have to be reloaded in each time when the user makes a change. In our proposed system, we use AJAX to provide a rich-client application; the detail will be discussed in the following section.

4   Proposed Web Adaptive On-Line Assessment System

4.1 Architecture

Figure 1 shows the architecture of our proposed system. The architecture includes four modules as follow:

- Authoring system: Item providers use authoring system to build up the item bank. In addition, every author in the virtual society can provide their opinion and answer to all items in item bank individually. So there are not only the items in the item bank, but also contain many problem solving skills with each item. So users can reference many solutions when they browse

the items in the item bank.
- Publishing system: Instructors or administrators can set up the test sheets for students via publishing system.
- Item bank system: Item bank system plays the role of repository, which contains the items and test sheets.
- Delivery engine: Delivery engine is what this paper focuses on. Users attend the examinations with delivery engine. The delivery engine plays the role as IMS QTI runtime environment.
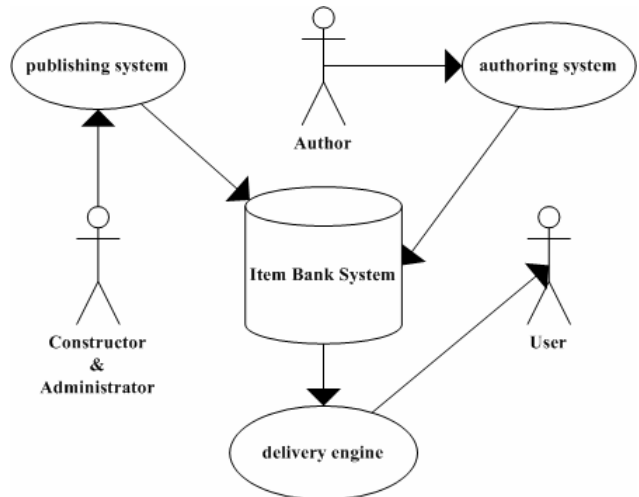

Figure 1 System Architecture

4.2 AJAX based communication model

We propose an AJAX based on-line testing system, using basic HTML, Cascading Style Sheets (CSS), DHTML and JavaScript providing interactive and exquisite user interface. In the Figure 2 shows the AJAX based communication model in our proposed system. There are three states, including Examinee initial phase, Attend examination phase and Terminational phase.

In Attend examination phase, the communication model turns into asynchronous way. The first step is getting the assessment profile file which is called imsmanifest.xml. We can get some useful information about the assessment that examinee selected, such as assessment title and description. When user pushes the button to enter the assessment, the AJAX engine communicates the server asynchronously again. The AJAX engine requires the Web Service to get the first item from item bank system randomly, after examinee answer the question and push the next button. According to the response answer of user, the Web Service returns the lower difficulty than previous item, if previous item has wrong answer. If previous item gets the right answer, the Web Service returns the higher difficulty than the

previous one. This activity repeats until the difficulty stable, and then the state will turn into Terminational phase.

In the final state, we back to the traditional communication model. We use JavaScript to count out the final assessment result and submit the result to the Web Service. The Web Service will update the Student Profile in database and terminate the assessment.
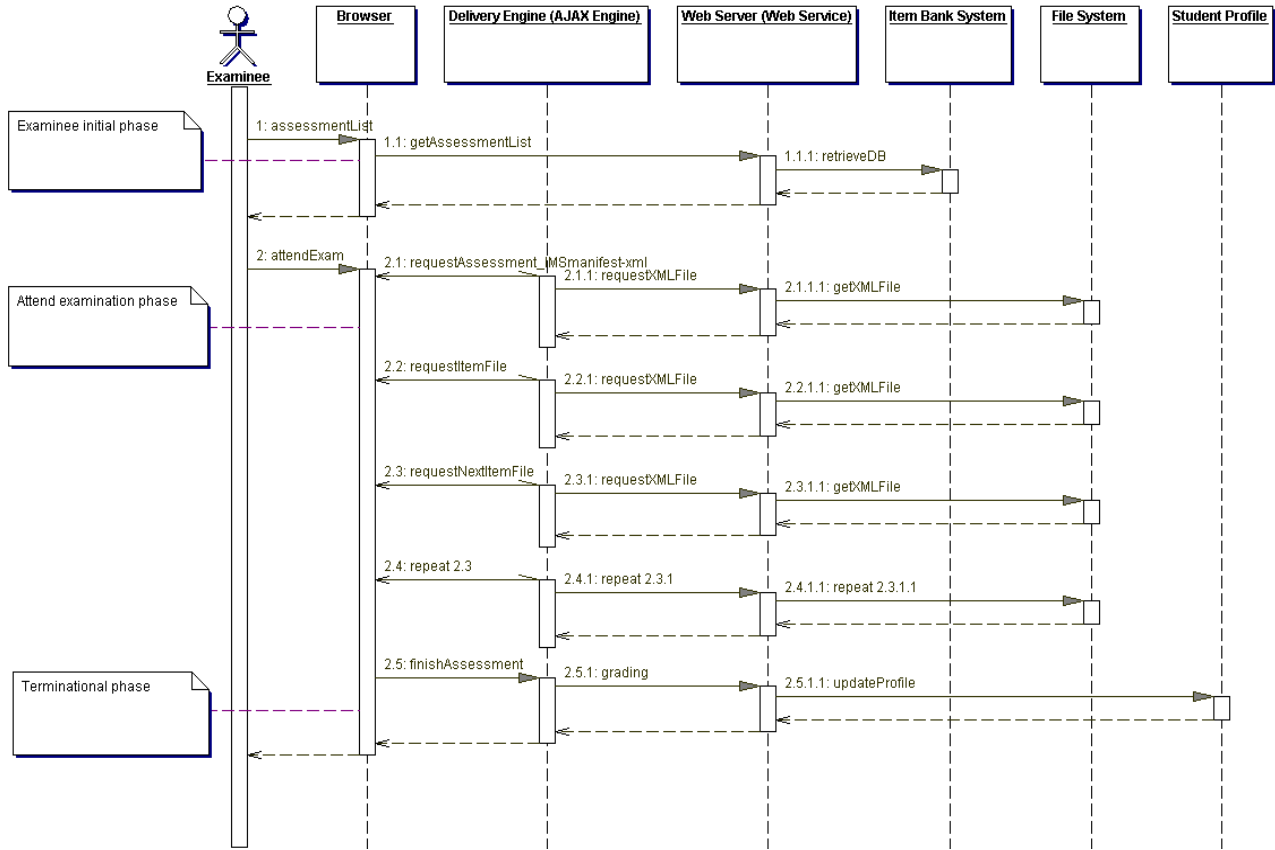

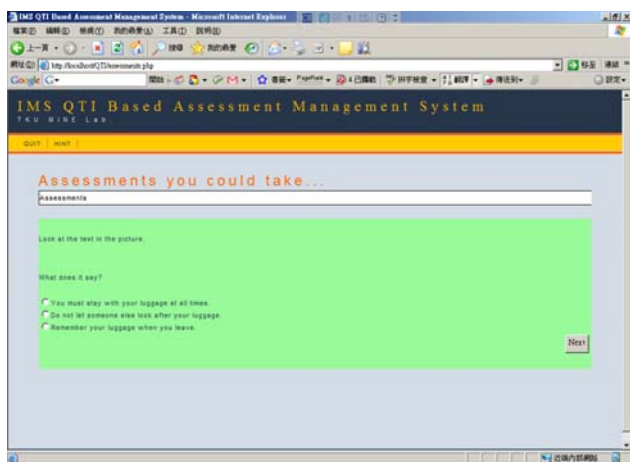Figure 2 AJAX based delivery engine communication sequence

4.3 The prototype

Figure 3 Prototype

The Figure 3 shows the screen shot of our prototype. Although the IMS QTI specification provides almost 20 types of question, we just implemented single choice and multiple choices in prototype stage. In the future we will carry out more types of question in order to achieve the goal of establishing diversified test content. When user login the system, user can find the assessment menu. After selecting assessment they want to attend, the system automatically direct to the test content as shown as figure 2. One item is drawn from the item bank and assigned with an assumed difficulty. Once the learner replies the answer, the assessment system automatically adjusts itself. By continuing the process of replying and adjustment, the assessment system is able to measure the student's learning performance with item response theory.

We can see the http communication logs in Figure 4. After client request the assessment.php file, the communication model turns into asynchronous model as red-marked in figure 4. When user selects the assessment, the AJAX engine only requests the imsmanifest.xml asynchronously. When user attends the first item, the client requests the first choice.xml asynchronously also.
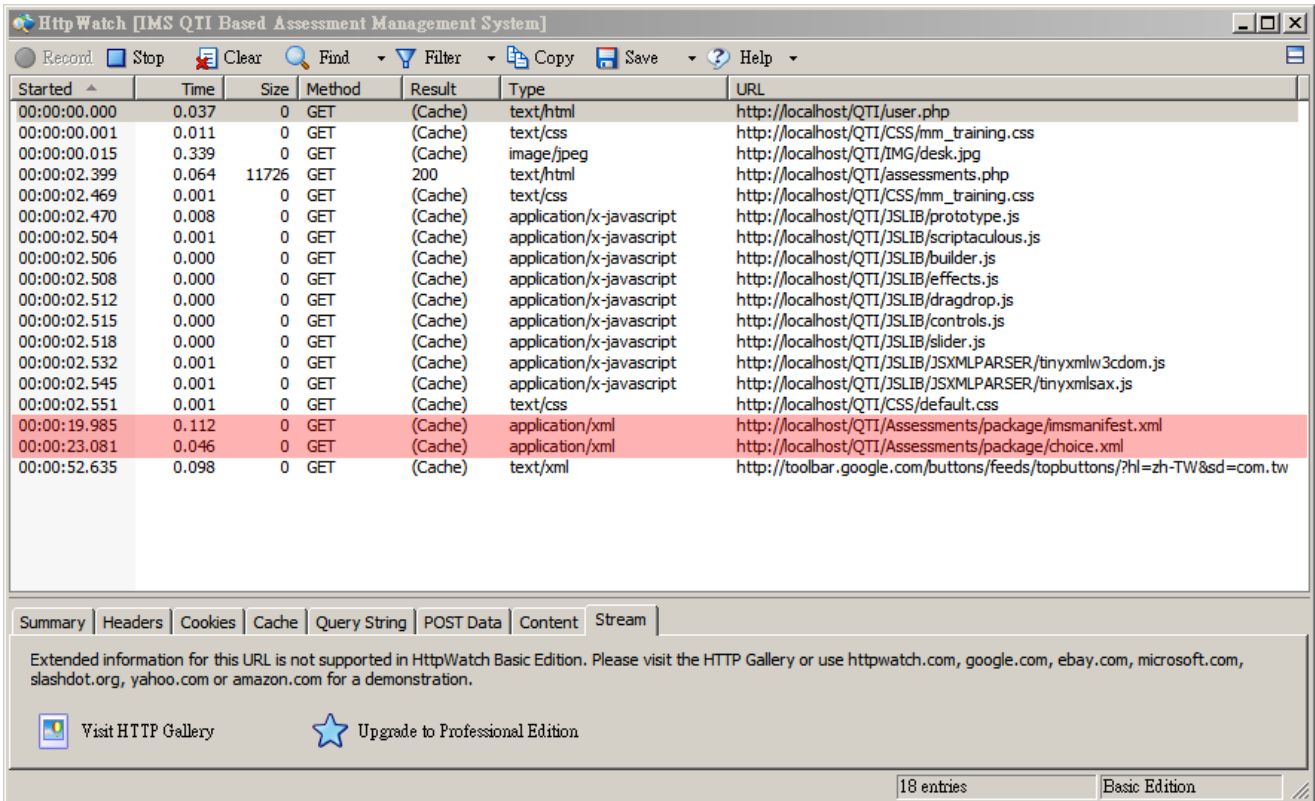
Figure 4 Http communication logs

5   Conclusion and Future Work

The current trend in the development of e-learning system is building a standardized environment which ensures teaching and testing content that can be reused and shared among different compliant systems. Our system adapts the specification of IMS QTI to create a standardized e-learning environment. Moreover, a successful e-learning system should be suitable for every learner who has different learning ability. Based on the item response theory, our system is adaptive to learners with different learning ability. Building a detailed and abundant item bank and providing diversified question types are still an ongoing process. We use AJAX in our system to provide a rich-client application with interactive and exquisite user interface. Users can use this on-line assessment system to attend the examinations and browse the item bank to reference the solutions from author society. So user can really learn something after using this system.

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