Intelligent Question Bank and Examination System

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Abstract: - Question bank can be described as the databank that keeps all the examination questions whether pre-existing or created by user while web based examination system is an online assessment tool that used to evaluate students' performance. In this paper, we develop and implement an online Intelligent Question Bank and Examination System (IQBAES), which make use of open source technology. This paper is concerned with the design and implementation of the IQBAES that incorporate questions with varying complexity and serves as the assessment tool to track student understanding of the classroom material.

Key-Words: - Question Bank, Online Examination, Intelligent Assessment System.

1 Introduction

Nowadays, Internet-based education is growing in number and in quality. We expect many kinds of merits of IT-based education. It enables us to let learners more eager to study the subject, to easily share the world-wide instructive resources, to give students distance learning and conduct online examination at anywhere in the world. Online examinations have become a cost-effective and popular means of assessing student knowledge. However, it is difficult to make a fair online evaluation of how well the students understanding. There are several disturbances for realizing fair grading such as mere duplication of answers between the students or illegally pretending to be other persons to answer the exam.

An online question bank and examination system is a relatively new and rapidly expanding system. Although it is an effective solution for mass education evaluation, the fairness of the evaluation is still a big concern. Most of the present systems were designed to grade students based on how well they have done on their examination. These systems were designed with the concept of traditional paper based examination in mind. There is a need to use a range of different assessment methods, in order to prevent assessment being biased against students that have particular problems with one particular method.

Another drawback of present systems is that there is no flexibility and there are very limited options for the examination questions. Most of the systems were designed to deliver and mark multiple-choice questions. These systems will not precise enough to represent the knowledge of individual users and to select problem to extend the user's current level of understanding. On top of that, the definition of the level of difficulty for examination question often creates an argument. We do not have a clear mechanism to define the level of difficulty for each question. Hence, there is a need to come out with a system that can base on question difficulty assessment algorithm to determine the level of difficulty for each question.

In this paper, we present an online Intelligent Question Bank and Examination System which carries out the examination and auto-grading. The main idea of this system is to provide a system that will enable lecturers to author and store a bank of examination questions. The system will then assemble the questions from various topics with different level of complexity and assigned to students as per level. For this purpose, functional concept graph will be used to define the level of difficulty. After the examination has been assembled, student can then access the system and take part in the exam. Upon examination completed, the system able to grade student based on the questions with varying complexity. With this features, the system has provided a fair assessment method for the students.

The remainder of this paper is structured as follows: Section 2 provides an overview of the related work. Section 3 presents the system architecture. Section 4 discuss about the system implementation while section 5 describes the system evaluation of the IQBAES. Finally, the conclusion is reported in Section 6.

2 Related Work

An examination system in Malaysia consists of four main stages shown in Fig. 1 [1]. The first stage is the registration of students for an examination. This stage involves obtaining relevant particulars of each student and entering the data in a form of register. The second stage involves organizing the examination process. This includes setting the questions, preparing the marking scheme, scheduling the examination as well as marking the examination scripts. The third stage is the recording of marks in marks sheets, processing the results, including calculating grades, averages and class positioning. The final stage of the examination system is the presentation of the results in a readable form.

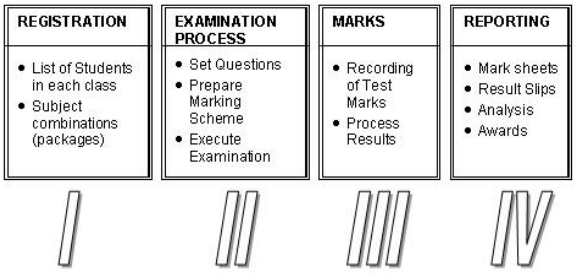

Fig. 1 Stages in the Examination System

In this section, a brief literature review is done on the existing question bank and examination system. Some of the examples like MIND, ExamManager, Web-based Adaptive Testing, SIETTE and Architecture Tutor. The review seeks to discover how the existing systems perform their tasks, their strengths and weaknesses.

MIND has developed an Online Evaluation System as a product for online examination and opinion polls, with key features like question bank, time control and security. The value added features provided by MIND include questions with varying complexity from a question bank. Further more, stopwatch is displayed so that the user can manage the time during the examination. However, the grading was solely based on traditional marking strategy. Grading will not base on the level of difficulty and student will be graded base on how well they have performed in the exam in terms of the number of the correct answers.

ExamManager is a web-based exam assessment system. It allows the users to create multiple types of questions. User can add pictures, case studies, and explanations to the questions. Besides, ExamManager also provide a study tool for the user. When reviewing a quiz, the student will get immediate feedback on whether the selected answer is correct. An explanation page can be linked to the question, providing students with study references. ExamManager provide more flexibility to its users by providing the study tool. However, the questions are not properly categorized into various level of difficulty. Students will be graded base on how many questions they have answered correctly.

Web-base Adaptive Testing is an online assessment system that can generate questions adaptively. The students will be given a pre test with different difficulty levels. The scores obtained from this pre-test will be used as the starting estimated ability value. This ability level is computed based on the following equations. The question level is from one to ten.

NewValue = OldValue + OldValue * (level of Question / 10) (1)

NewValue = OldValue + OldValue * (5 - level of Question / 10) (2)

The first equation is for correctly answered questions and the second equation is for wrongly answered questions. When the student starts the quiz, the OldValue is the value scored by the student during pre-test. After that, this value will be updated based on the student's response for every question. The quiz grading is in the boundary 0 to 1. Finally, at the end of the quiz, a report will be displayed. The report will include the result as well as all the topics that the students need to revise.

SIETTE is a web-based adaptive testing system implements computerized adaptive test (CAT). These tests are tailor-made, theory-based tests, where questions shown to students, finalization of the test and student knowledge estimation are accomplished adaptively [2]. SIETTE works as a student knowledge diagnosis tool. The components of the SIETTE system are:

- Question Knowledge Base - A database of questions related to a test. All these questions are calibrated with some parameters. All the contents are structured in subjects. Each subject comprises a set of topics. Each topic can be decomposed into a set of subtopics following aggregation relations.
- Test Edition Module - The tool used to define the tests and the structure of the subject domain: topics, questions, relationships between them, and relative weights of topics in the test.
- Student Model – It consists of a vector of K probabilities (p_0, p_1, ..., p_{K-1}), where p_i represents the probability that the student has reached certain knowledge level i about the domain,

where 0 is the lowest level and K-1 is the expert level.

- Test Generator – It is responsible for selecting the questions that will be posed to each student. It will use different algorithms such as Bayesian procedure, difficulty-based procedure and random procedure for questions selection.

The Architecture Tutor is an intelligent tutor system for computer architecture developed at Azusa Pacific University. This system applies functional concept graph as an assessment approach in the system. Specifically, its approach is for course subjects that are based on well-formulated concept hierarchies and applicable for tutoring subject in science and engineering. In the functional conceptual graph, a set of nodes are being defined. These nodes are corresponding to each question in the system with an associated value. Typically, if a node consists of a number of child nodes, this node will have a higher value than its child node. This system helps in assessing the student's understanding of a certain subject.

As a summary, it is concluded all the systems are well developed. Nevertheless, there is still a room to improve the functionality of these systems. It would be better to propose an approach that incorporates the question difficulty, question generator and the intelligent questioning system into a single package.

3 System Architecture

The IQBAES consists of 3 core components namely:

- Question difficulty assessment algorithm
- Automatic question generator
- Intelligent questioning system

3.1 Question Difficulty Assessment Algorithm

This component is developed based on the functional concept graph or Directed Acyclic Graph (DAG) [3]. By using the DAG, IQBAES defines the degree of difficulty as $D = w_1N + w_2P + w_3M$, where N is the number of conditions given in the questions, P is the number of downward edges in the paths traversed during question generation, and M is the number of upward edges traversed during question generation. Three weight factors w_1, w_2 and w_3 is used to balance between the path length and the number of conditions. Typically, $w_1<w_2<w_3$ because upward edges traversed represent more difficult concept association and downward edges, and the total number of edges, which corresponds to the number of problem solving steps involved, carries more information about the effort needed in problem solving. Fig. 2 below is one of the examples on how weight is assign to each of the questions in the question bank

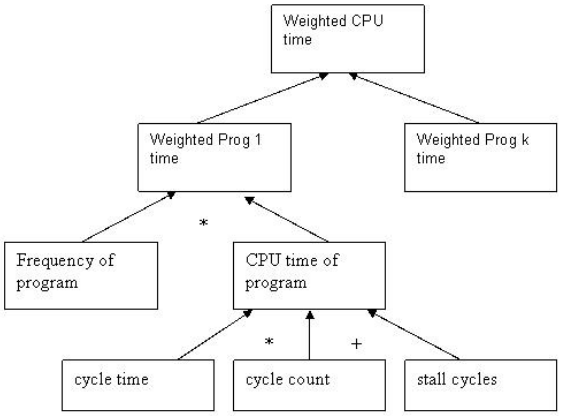

Fig. 2 Conceptual Graph

Weighted CPU time is defined as the sum of the weighted program time of the k programs. The weighted program time γ_i of program i is the CPU time of executing the program times the frequency of execution F_i of the program. The CPU time T_i is defined as the product of cycle time T_c and (cycle count + stall cycles). We denote cycle count by N_c and stall cycles by N_s. Assume that three programs, P_1, P_2, and P_3, under consideration. The total weighted CPU Time Φ is given. For program P_1, P_2 and P_3, the student is given N_{s1}, N_{c1}, N_{s2}, N_{c2}, N_{s3}, and N_{c3}. In addition, F_1 and F_2 are also given. The student is asked to find F_3. This question has 9 conditions. To compute F_3, one must know γ_3 and T_3. Since $\gamma_3=F_3*T_3$, $F_3=\gamma_3/T_3$. This requires one upward move to the node for γ_3. Now, γ_3 can be computed from Φ, γ_1 and γ_2 as $\gamma_3=\Phi-\gamma_1-\gamma_2$. This requires another upward move to the node for Φ. A total of two upward moves are needed. To compute each of T_1, T_2 and T_3, one must traverse three downward edges. To compute each of γ_1 and γ_2, two downward edges are traversed. From Φ to γ_1 and γ_2, two downward edges are also traversed. This results in a total of $(3\times3+2\times2+2)=15$ downward edges. We assign $w_1=1$, $w_2=5$ and $w_3=25$. The total complexity of the problem is thus $1\times9 + 5\times15 + 2\times25 = 134$.

3.2 Automatic Question Generator

This component generates the question based on the following algorithm [4]. An integer named credit is used to represent complexity. The larger the number, the more complex the question is. It uses a queue OPEN to store those nodes that are not yet expanded. A node is expanded if its descendants are generated. It is assumed that each node N_i stores an

estimated maximum difficulty D_i that is obtained by downward expanding the concept graph rooted at this node to the maximum. In addition, we assume that we have two basic types of nodes in a concept graph: the array nodes and the regular nodes. An array node may have several descendants of the same class and a result is computed from the descendent values. A regular node has descendants of different classes. The following is pseudocode:

```
1. Define Queue OPEN = new QueueList();
2. Select a node Nr from the entire concept graph and
mark it as closed.
3. If Dr < credit, then
     Traverse upward;
     credit = credit–w3;
     Push the parent of Nr to OPEN:
     OPEN.enqueue(parent of Nr);
   else
     Randomly decide traverse up or down to node N;
     Push the descendants of N to OPEN:
     OPEN.enqueue(descendants of N);
     credit = credit–w2* num_descendants;
     Dequeue a node N from OPEN and mark it as closed:
     OPEN.dequeue();
4. If D >= credit, then
     Select a random value in the interval specified in the
node for each node in
     OPEN queue;
     Finish question generation;
   else
     Randomly decide traverse up or down to node Nd;
     Push the descendants of Nd to OPEN:
     OPEN.enqueue(descendants of Nd);
     credit = credit-w2*num_descendants;
5. Go to step 3.
```

3.3 Intelligent Questioning System

This component is the core component in the overall questioning system. Key aspects of the question model include an intelligent questioning engine, a question or answer interface tool and a connection to a knowledge database to monitor student progress. The question model is a representation of the question database that is developed for each module in a course for a program of study. Each question is characterized by type (true false, multiple choice, numerical answers), weight, as determined by the difficulty level, and a knowledge key that defines the scope of the question and its coverage of the knowledge map. After each question is answered, the question management system then updates the student's progress through a knowledge map, again taking in into account the question characteristics.

Fig. 3 shows the Intelligent Questioning System concept. The Intelligent Questioning System is comprised of two basic components: the knowledge module and the question module [5]. The knowledge module presents the user with his or her current level in the system. The questioning module then identifies an appropriate set of questions within this level. A question is then randomly selected and presented to the user. When the user completes exam, the questioning module provides an assessment measure to the knowledge module. Fig. 4 shows the questioning module architecture. The knowledge module then updates the user's status in the system.

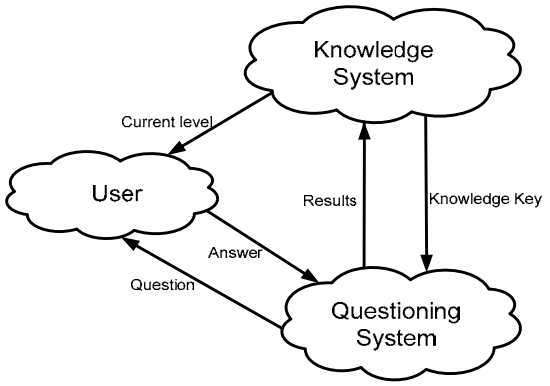

Fig. 3 Intelligent Questioning System Concept

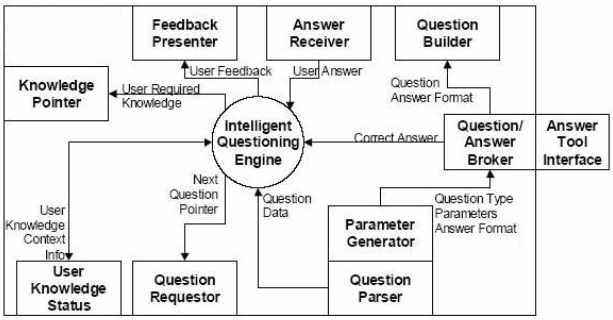

Fig. 4 Questioning Module Architecture

4 System Implementation

To implement this system, several databases are required. The question database contains the complete set of questions. The student system database encapsulates a model of the student's progress, maintaining information about which questions the student has attempted and the assessment measure for each question. The knowledge system database maintains the structure of knowledge flow.

The assessment system uses the weight of the question to provide the incremental score contributed by the answer to this question [6]. The

knowledge key information about each question is used by the adaptive questioning system, together with student input and the current state of knowledge, to determine which question to pose next. After each question is answered, the question management system updates the knowledge map.

Questions are grouped into a question set base on the level of difficulties. The questioning process involves: randomly selecting a question from the set, completing the question, gathering assessment information, and providing a measure of the degree of understanding back to the knowledge model for use in knowledge assessment. Besides selecting and asking a question, the question set also provides a mechanism to quantify degree of understanding. This is used to assist in assessing the student's level of competence in each topic.

IQBAES is developed using the open source technology. The technologies include java server pages (jsp), servlet, jdbc thin driver, jfreechart, ant, xml, log4j and hibernate. The system run on Tomcat 4.1 Application Server resides on a J2EE framework, which makes use of Model View Controller (MVC) design pattern. Fig. 5 shows the IQBAES framework.

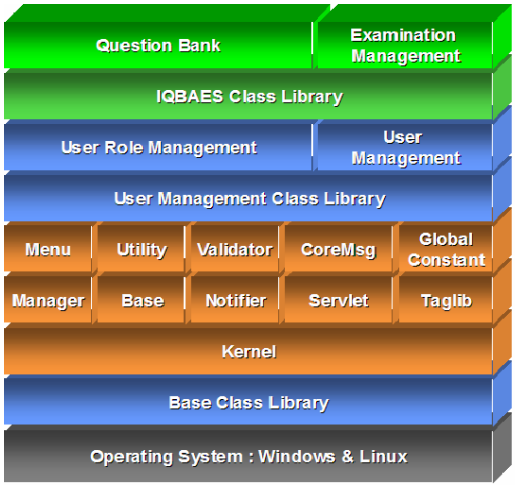

Fig. 5 IQBAES Framework

IQBAES framework is developed with the reuse and plug-in concept in mind. A few reusable generic components were identified and these components have been built into the kernel layer of this framework so that any vertical component build on top of IQBAES's base layer can utilize the component by calling its API. This framework will serve as the baseline for any application development to avoid reinventing the wheel of development for every new development work. Fig. 6 shows the implementations of IQBAES.

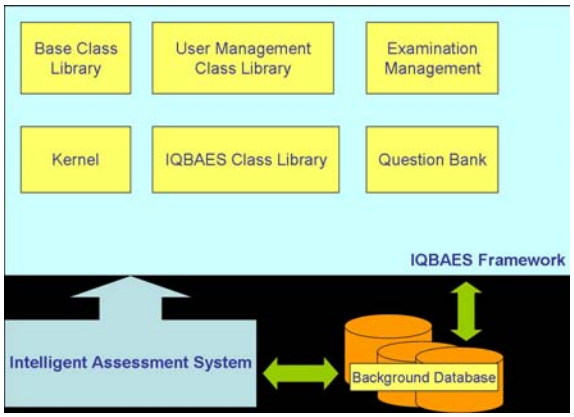

Fig. 6 Implementation of IQBAES

5 System Evaluation

IQBAES has been tested and evaluated by lecturers and students of one of the colleges in Malaysia, and it has been used fully to process the examination results. The evaluation process was carried out upon the development and testing of IQBAES completed.

A Questionnaire was given to those users directly involved in the system. The evaluation was performed using an examination for a course with large number of students. The students filled in the questionnaires directly after the grading was done for the exam. It is believed that this approach provides a measure of objectivity on the student side. Fig. 7 shows the result of the evaluation of the system. 78% of the users strongly agree that the system to be used as the assessment tool. The majority of students agreed that all phases of the exam process were part of the learning process. The students are happy to use IQBAES as compared to the traditional exam.

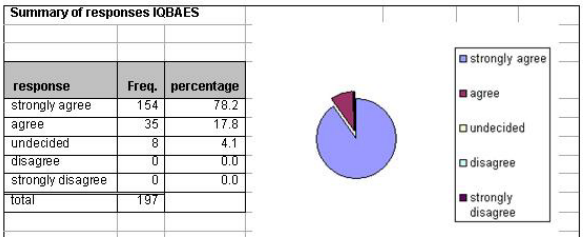

Fig. 7 System Evaluation of IQBAES

6 Conclusion

This paper describes a research focusing on web-based examination system and question bank. The work encompasses detailed investigation of the subject matter, development of a question bank and examination system, proposal of an enhanced question bank examination system, evaluation of

both existing and the proposed intelligent question bank and examination system through the developed system, and analysis of the results from the system. The IQBAES provides a mechanism for evaluating the question difficulty, an automatic question generator which automates the question generation process and intelligent questioning system to direct the learning process based on student's degree of understanding of individual concept. The entire development process provided insight to the detail working of the various open-source technologies and component of the java programming language.

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