ANALYSIS, DESIGN AND IMPLEMENTATION

OF

WEB BASED EXAMINATION SYSTEM (WBES)

By

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A thesis submitted to the faculty of Computer Science Department Military College of Signals, National University of Sciences and Technology, Rawalpindi in partial fulfillment of the requirements for the degree of MS in Computer Sciences

April 2006

ABSTRACT

Web Based Testing System (WBTS) is gaining popularity all around the world due to its diversified application and dynamic nature. Still there is a valid requirement of research in many areas for implementing a WBTS. While almost all commercial testing systems provide the ability to build multiple choice questions (MCQ), very few of them implement hot spot or selection/association type questions. Each of the question categories evaluates different types of knowledge. This obviously imposes the requirement of a testing system that provides the widest range of question types available since different learning outcomes assessed within different courses.

Current status of the existing WBTS like Blackboard, WebCT, Castle, WebMCQ and CQuest Net is analyzed and a customized solution for different tests to be conducted at different campuses of NUST is developed. The solution inherits all the functionalities of existing WBTS and adds novel methodologies by implementing question types such as multiple choice, multiple response, true/false, selection/association, visual identification/ hot spot and short answer. It promises to unravel the problem of assessment and automated examination management, by utilizing latest tools and methods.

An application, Web Based Examination System (WBES) is developed after applying all the concepts presently under discussion by researchers and carefully analyzing potentials, benefits, and limitations of implementing Web-based assessment in education and training. System has a user friendly interface for online developing, administering and delivery of assessments tests. Unit testing and system performance testing ensures its reliability and consistency.

ACKNOWLEDGEMENTS

First of all I would like to thank Almighty Allah for His help and blessings which let me complete my thesis. I would like to express my gratitude to all those who gave me the possibility to complete my thesis.

I would like to express my special thanks to my supervisor Air Commodore (R) Waqqar Sami Khan for his valuable help and cooperation throughout the thesis completion period and to my committee members, Lt Col Naveed Sarfaraz Khattak, Maj Muhammad Faisal Amjad and Asst Prof Arif Raza for their valuable guidance and advice which help me a lot for completing this task.

I would like to give my special thanks to my parents, my wife and my children whose patient love enabled me to complete my thesis.

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Chapter 1

Introduction

1.1 Introduction

Testing and evaluation plays an important role in present instructional system. Students often seem too anxious and feel unknown fear for the exam. On the other hand teachers spend a major portion of their professional time to prepare, grade and analyze exam. In order to transform this powerful educational tool into more meaningful form, the tests should be designed and implemented in a way that these can be used as a proper instrument for evaluation of student understanding of subject matter. In addition to that, these can also be used as a motivation force for students self evaluation. Appropriately designed tests could reinforce learning by providing a clear indication of strengths and weaknesses of student in particular area of subject. This will definitely provide a better ground for students in defining future learning objectives and concepts which require their concentration. Traditional summative assessment technique is not very helpful in fulfilling this goal. There is a need of more interactive and formative assessment methods to provide students a better feedback of their progress. The advent of computer provides a better ground for developing an interactive assessment system, in which the assessment process can be as often as desired and taking corrective actions becomes easy. New technology to use computer in assessment is a relatively new venture in which both teachers and researchers are exploring the effects and impacts of test authorizing software on educational environment [1].

Computer-assisted assessment (CAA) refers to the use of computers in assessment. The term encompasses the use of computers to design, deliver, mark and

analyze assignments or examinations. CAA is often referred to as Computer-Based Assessment (CBA) [2].

Although Web Based Testing started in the form of multiple choice questions stored in the database on the internet with secured access, but at present attempts are on the way to use a wide variety of test questions in online assessments [3]. These include: Checklists, Calculation Questions, Classification Questions, Interpretive Exercises, Multiple Choice Questions, Multiple Answer Questions, Locate Answer Questions, True-False Questions, Masked Answer Completion Questions, Numeric Answer Completion Questions, Drop-Down Completion Questions, Extended Response Essay Questions, Restricted Response Essay Questions, Matching Questions, Drag and Drop Questions, Likert Scale Questions, Rank Order/Sequencing Questions, Quick Reaction Questions, Reconstitute Sentence Questions, Crossword Puzzle Questions, Multi-part Questions [3].

Today's available tools include user-friendly advances in computer technology, including advanced programming architecture and web-based delivery tools that offer instructors a high degree of customization and individualization in test preparation and management. However, computer aided testing/ assessment, while introduced for fixed-item testing in traditional applications, has not been exploited as an enabler of new assessment methods employing feedback, peer review, creation of student ownership of learning and computer adaptive testing (CAT) capabilities for wide spread educational use [1].

Current studies indicate that computerized testing offers numerous advantages for test administrators in terms of consistency, flexibility of test management, self-pacing, security and adaptability [1].

New studies and research shed new light on numerous claims [1]. Interactive technology combined with clear measurable learning objectives, frequent feedback, and other key factors, increased student time on task, increased student motivation and in turn, increased student achievement [1].

1.2 Web-Based Testing

Generally speaking, a computer-based test is taken at a computer. An online test is a type of computer-based test. Questions or test items are viewed on a computer monitor and answered using a keyboard and mouse instead of pencil and paper. A web-based test is a computer-based test delivered via Internet. The test is located as a website on the tester's server where it can be accessed by the test-taker's computer, the client. The client's browser software (Netscape Navigator, MS Internet Explorer) displays the test, the test-taker completes it and—if so desired—sends his/ her answers back to the server, from which the tester can download and score them.

1.3 Web-Based Testing Merits

Computer/ web based testing have several merits over traditional paper and pencil tests. Examination of variety of areas broadens the test scope. Frequent assessments helps monitoring of student progress and taking corrective actions in learning process. Variety of question types can be constructed using graphics and multimedia. Automated scoring saves teachers time and gives prompt feedback. More students can be tested in less time. Reports and analysis of student performance can be obtained in number of formats. Automated result storage and quick availability of result can be possible. Self assessment using mock up tests enable students monitor their progress and prepare for final assessment. Automated testing helps student to learn computer skills. Learning can be enhanced with the utilization of formative methods. Clues can be provided to students and marking can be done accordingly. Testing can be

designed to gauge student ability by utilizing adaptive testing. Instant feedback is provided to students at completion of test and saved for future reference [2].

1.4 Limitations of Web-Based Testing

Computer technology is evolving with time and the limitations in the technology are taken care of. For future evolvement of CBT/ WBT, problems with human factor are more concerning than technological shortcomings. Students are very comfortable with the technology and adapt to its usage very rapidly. However, the technology is not perfectly reliable and this leads to insecurity for both the student and the instructor. Instructors seek technology that enhances learning. This enhancement is most useful if it comes with modest increases in time and effort and with technology that is user-friendly. Computerized classrooms in which each student has a computer with access to all necessary software are required.

Unfortunately, computers occasionally fail and all networks have downtime. Further, computer programs occasionally lockup and many have errors that can produce spurious results. Loss of files during an exam can be stressful and claims of computer difficulties can be used to cover a lack of preparation. Course policies, such as replacement of an exam score with the final exam score and/ or giving exams when additional time can be granted to reproduce any lost work, are necessary. These policies alleviate some anxiety in students. Effectively, there is no partial credit (part scores for matching and multiple guess types of questions are awarded) for machine graded problems. Essay questions may be posed but require manual grading off-line [4].

Designing of proper objective tests is very time consuming and requires substantial experience. Testing of higher order skills is not easy. Improper designed objective tests can cause misunderstanding. Implementation of CAA is costly and

time-consuming. Good system maintenance is required to avoid downtime during examinations. Students' liberty of scanning questions to choose which to answer as in pencil and paper test cannot be attained. In order to take test students require the know how of computer and its usage. Assessors and invigilators need training in assessment design, IT skills and examinations management. A high level of organization is required across all parties involved in assessment. Overuse may promote surface learning. Large bank of questions required to prevent banding and hence loss of discrimination. [2]

1.5 Literature Review

Web based testing is relatively new technique for conducting student evaluation. All over the world teachers and researchers are exploring different aspects of WBT. Before this technology can be used for masses, there are many issues which are required to be addressed and settled [1].

Indirect measures of knowledge and learning based on observations of what a person says and does are used. Based on these observations judgments about the level of a person's knowledge or progress in learning are made. This process is formally known as "assessment and evaluation". Traditional assessment is seen by many educators as inadequate in that a small amount of data is used to describe and summarize a person's total learning and knowledge. There is now a movement in education towards "authentic assessment", an effort to have a more holistic approach to assessment and evaluation. Authentic assessment is a move away from traditional multiple-choice, standardized achievement tests to the inclusion of direct observations of learner performance on meaningful tasks that are relevant to the learner [3].

As well, assessment often needs to go beyond the simple reporting of numbers to the identification of various educational, psychological, sociological and neuro-

physiological constructs. Assessment constructs include such ideas as IQ, personality traits, medical and psychological diagnoses, performance levels, and attainment of specific competencies. These constructs are often identified by specific answers, or a particular combination of answers, to test questions or performance indicators [3].

Online examination can be used for three purposes self evaluation, teacher feedback and automated testing. First type can be used by students to evaluate their knowledge and understanding, second type provides teachers a feedback about students' knowledge and the teachers can adapt the content of the course according to results. The third type is used for student evaluation as a part of exam [5].

Assessment can be formative or summative. Summative assessment is assessment in which the testing of the ability to reproduce information – or "how much we know" is measured. This is the traditional view of assessment in schools, where the ability to recall "facts" is of paramount importance [3].

Formative assessment provides feedback to teachers and student so that they can carry out adjustment in teaching and learning process. There are number of areas, where assessment is difficult using traditional methods, like assessment of practical work by running it. Computer-based simulation provides solution for this problem. When testing a skill, i.e. Word, Excel, Access or PowerPoint, students perform better when using the assessment software over the traditional multiple-choice, true/false exam. Formative assessment provides a feel of involvement to student in learning process, to evaluate their progress and to practice for summative assessment.

Three factors that can cause problem in formative assessment implementation are time to construct the assessments and support materials; the availability of easy to use software tools; and support by the institution [6].

Software tools that have a steep ‘learning curve’ or are difficult to use can be seen as contributing to the construction time factor. Similarly, software that generates materials that cannot easily be re-used in alternative ways increases the time to produce interrelated materials and revised versions of a project. Commercial software provided by an institution may not be readily available to staff due to cost or licensing arrangements. The institution may provide support for the delivery of assessments but this may be directed at summative rather than formative assessments. Software that is complex to use requires support for its implementation. An institution may not provide support or support may not be readily available [6].

To date there is still a notable lack of a definitive tool for CAA that meets all of the technical requirements, has sufficient developer backing, and is intuitive, powerful, and usable enough to gain widespread acceptance [7]. Convenient and interactive teaching tools, such as electronic whiteboards, test-taking applications and note-taking tools running on an IT infrastructure, can provide for real time exchange of information between instructors and students [8].

There are two types of presentation of items in a test, first is linear and the other is adaptive. In linear testing, order of the presentation of items is constant. In adaptive testing, process of testing continues according to examinee’s performance. Computers permit adaptive testing to be conducted in a rapid and sophisticated manner. Item response theory (IRT) to estimate examinee proficiency is used in current CAT. The duration of test may be pre estimated or vary along with examinee response. In later type of CAT the test ends when examinee reaches at pre defined competency level [9].

In recent time most of the CAT systems use multiple choice questions also termed as selected response items. These are most suitable type for computer

administrated tests and also cost effected in large scale testing. Many large-scale testing programs that traditionally have relied on selected-response items are now exploring the use of items that require examinees to generate their own answers—these are called constructed response items. Computers can accommodate a wide variety of such items. For example, students may be asked to move or organize objects on the screen (e.g., on a history test, put events in the order in which they occurred). Other tests may involve students using the computer to prepare essay answers or other products. Some constructed-response items may be machine scored, particularly if the responses are brief and straightforward (e.g., a numerical response to a math problem). Researchers are exploring the use of computerized essay scoring, and it is likely that future generations of examinees will take tests that involve automatic scoring of extended responses. Currently, however, most constructed responses must be scored by trained readers [9].

It has been experienced that question items construction requires much greater efforts and time in CAT as compared to paper-based assessments. Unfortunately, the increase in construction time can be greater than the reduction in grading time. With the current technology, it is extremely difficult to develop large, multi-step problems requiring problem analysis and solution synthesis skills without leading the student to the answer [4].

CAT does not allow partial credits and this feature also not liked by a number of students. The insecurity associated with working in a virtual environment also creates negative perspectives in student [4].

The major problem of many existing computerized training systems is “reusability”. Most of them store questions in a proprietary format with different storage set ups, such as relational databases, object-oriented databases or even flat

files. Unlike text or image editors, training systems do not have any agreed format, and thus there are difficulties to transfer data from one system to another. Therefore, a standard format for communication among different training systems is necessary [10].

The recent approach of the Quality Assurance Agency to improve quality in higher education has been to focus on learning outcomes and their assessment, on the specification of standards and on the role of external examiners to assure these standards. Where institutional learning and teaching strategies focus on assessment they are nearly always about aligning learning outcomes with assessment and about specifying assessment criteria. All of this focus, of the media, of quality assurance and of institutions, is on assessment as measurement [11].

Number of projects is in a way for standardization of CAA and to resolve the main technological issues. The CAA Centre, funded by the higher education funding councils of England, Wales and Northern Ireland under phase three of the Teaching and Learning Technology Program (TLTP3) project on the implementation and evaluation of CAA. The Center aimed to assist staff in higher education with the development and implementation of CAA. Ultimately the Center will act as a focus for CAA in higher education. The Center already offers the services listed in Table 1-1 [12].

Council of the International Test Commission formally adopted the guidelines at its July 2005 meeting in Granada, Spain. The aim is to produce a set of internationally developed and recognized guidelines that highlight good practice issues in computer-based and Internet-delivered testing and to raise awareness among all stakeholders in the testing process of what constitutes good practice [13].

Table 1-1: Services Offered by CAA Center

1.	Up to date knowledge of CAA activities
2.	Strategic advice on the implementation of CAA
3.	Guidance on the evaluation of both cost and learning effectiveness of CAA
4.	Consultancy on the implementation and evaluation of CAA
5.	Generic and subject-specific workshops
6.	Models for the implementation of CAA
7.	Staff development and training materials

1.6 Objective of Thesis

With the application of emerging technologies, computers have become standard and pervasive tools that significantly changed the ways in which tests and assessments are developed and administered. They offer alternative option of creating, storing, accessing, and distributing the shared distance-learning environment. Assessment is a systematic method of obtaining evidence from tests, examination for specific purpose. In order to deploy a Computer/ Web Based Testing System in an institute, there is a need of software that suits the requirements of the institute. To fulfill these requirements the institute either has to purchase off the shelf available systems or develop it on its own. Off the shelf available systems have disadvantage that it may not meet the exact requirements of the institute, so it has to be got tailored according to organization requirements which is a costly option. The other option that organization develops its own software is a viable solution.

The theme of this project is to conceive, design and implement a system for developing, administering and delivery of assessments tests via web, in which items reside on a server packaged with some technology tools, which can be easily adopted in NUST.

An application, Web Based Examination System (WBES) is developed to prove the concepts presented in this thesis. It provides a user-friendly interface and an easy navigation tool to test takers for moving back and forth through test sheet easily. It allows them to change answers, fill in unanswered questions or simply review their own responses. It allows test maker to create exams quickly and easily. It allows test administrator to electronically distribute exams to computer-assisted testing centers and save test results to the system's databank for future needs. The system provides an extremely high level of exam security by verifying test-taker's identification, test-version control based on the dimensions of time and location, real-time test generation by randomly selecting a specified number of questions from the items bank, and randomly ordering the chosen questions and automated scoring. The multiple-choice options (A, B, C, D) are also randomly ordered. Exam items accommodates varied formats including, multiple-choices, true/false, fill in the blanks. Teachers have the facility to insert questions into the system databank online. It records and time-stamps the student's answer for every test item visited, in sequence, during the test session in order to automatically recover from catastrophes such as power failures or machine crashes.

1.7 Organization of Thesis

This thesis is organized into six chapters. The first chapter provides the introduction and overview of literature on the Computer/ Web based Assessment. The second chapter discusses the question item types and formats used in the WBES. The third chapter provides an introduction to the architecture of WBES and describes the tools and techniques used for each phase of the project. The fifth chapter gives the explanation of the requirements analysis phase, designing phase and implementation phase of WBES. The sixth chapter covers testing phase. The last chapter gives the

conclusion of the overall discussion in a brief manner. It involves applications of the system in different areas. It also gives some recommendations for improvement of system's features in future. The last section contains the appendices.

1.8 Conclusion

Computer based assessment provides a lot of incentives for educational institution. In order to provide their students a better interactive environment, institutions have to shift on CAA. There is also a requirement of research on the limitations of CAA, so that a more reliable infrastructure can be built for WBT.

Chapter 2

WBES Question Item Formats

2.1 Introduction

Modern computer software tools allow the use of advanced question formats. A brief description of these questions types is presented in this chapter. These question types have been identified in the present research work. These are the outcome of an extensive study of the present CBTS and the formal paper based tests.

2.2 Question Types

Effectiveness of educational institution depends on the evaluation process they adopt. The evaluation process has number of purposes which focuses on the achievement of student. It helps teachers to determine the ability of student; shows student progress; creates better leaning experience; evaluate quality of educational program; points out the strengths of students and programs; and identify the areas of difficulty. Consequently, tests are highly stressful and anxiety-producing events for most people. Because of this, students should never be measured on the basis of one test alone and test constructors must be careful to develop quality tests [14].

Keeping in view the importance of test, the test constructor needs to consider all the elements that create any impact to reliability and validity on the examination. He should be very clear about the objectives of the test and what abilities of the student he has to test. Next, he has to be very certain that how much emphasis he has to give on each objective and its associated test item. Now he should know that at how much level of learning, he wants student to perform for each objective. Finally, he has to choose that how many and what type of questions should be included in a test. To adequately sample the objectives and the content, he needs to consider what

type question is best suited to address the required level of learning. He must also consider the amount of training emphasis and time (value) given to each objective. Increasing the number of questions increases the probability that he will be able to adequately assess what the student knows and can do [14].

There are two broader types of questions, subjective and objective. Subjective questions can also be termed as open-ended questions since in these questions student has to formulate his own answer. This type includes sentence completion, short answer and essay type questions. The other type of questions are objective questions which can also be termed as limited-choice questions, which includes multiple-choice, true/false and matching type questions in which student has to choose answer. The decision of using either type of items depends on circumstances and goal of the test [15].

The most common types of questions are multiple choice, multiple response, true/false, selection/association, short answer, visual identification/hot spot and essay. Each of the question categories may be used to evaluate different types of knowledge. Therefore, the selection of a Test Management System (TMS) may be driven by the ability to be assessed, according to the class of questions made available. Many universities are adopting the same tool for all courses in order to reduce costs and to allow students to interact in the same way throughout their evaluation process. This obviously imposes the requirement of selecting a TMS that provides the widest range of question types available since different learning outcomes may be assessed within different courses. While almost all commercial TMS provide the ability to build multiple choice questions (MCQ), very few of them implement Hot Spot or Selection/Association type questions. An even smaller subset of TMS claims to implement Essay type questions. Although there are some research efforts on the

automatic scoring of essay type questions, mainly in the area of natural language understanding, the assessment of this class of questions relies on the manual intervention of the teacher for the commercial products on the market [15].

2.3 Multiple Choice Questions (MCQ)

This class of questions is organized into three parts: a stem, a key and some distracters. The problem part is known as stem. Suggested solutions may include words, numbers, symbols or phrases are called alternatives, choices or options. The student is asked to read the stem and to select the alternative that is believed to be correct. The correct alternative which must be one, and only one, is simply called the key, whilst the remaining choices are called distracters, since their intended function is to divert students from the correct one [16].

MCQs are most often used and most versatile type of questions. They are used to test student's ability to recall facts, understanding and ability to apply learning. Unfortunately, well designed MCQs are difficult and time consuming to construct, especially in which alternatives are well constructed and open to misinterpretations. Normally, four to five choices are an optimum size of alternatives for MCQs [15].

Each class of available questions may support different scoring schemes. The simplest way to assign a score to a MCQ is to mark 1 for the correct answer and 0 for the other options, but that option allows students to make blind guesses or random responses. Other option is to go for negative marking, assigns 1 for the correct response, 0 for no response and -1 for an incorrect response, or any other combination [16].

An additional piece of information that is presented to the student after posing a question and before he answers it is termed as hint. Hints may provide an explanation of the stem, clues for rejecting one or more answers, indications on how

to proceed, etc. Hints can be invoked in two different ways: a) active, in which the examinee asks for the hint by clicking a button or b) passive, in which the hint is triggered as a consequence of his/her behavior while answering the question that indicates that the student has reached an impasse (for example, too much time waiting). If student uses the hint option then fraction of his marks may be deducted from his score [17].

In WBES interface, a student enters into the after login session. The test starts. Suppose he/she selects a question type (e.g. MCQs) from the Interface. A list of MCQs is displayed in front of the student and he starts checking the corresponding answer using the Interface. He/she can change the option selected anytime before finishing the time of the question. This option may be either wrong or right. There will be a predefined grading scheme for this type of question. An example of MCQ is presented in Figure 2-1.

What is the result of the expression: 1/8 + 1/4?

A. 3/4 C. 3/8

B. 2/4 D. 2/8

Possible hints may be:

Hint 1 1/4 can be also represented as 2/8

Hint 2 First, find equivalent fractions so they have the same denominator.

Hint 3 Once, fractions have the same denominator, sum up numerators [17].

Figure 2-1: MSQ Type Question Example

2.4 Multiple Selection Questions (MSQ)

Multiple selection questions or multiple response questions (MRQ) are a variation of multiple choice in which the student is allowed to choose more than one choice [18]. MSQ can be chosen so that the answer choices are presented in random order.

Presenting the answer items in random order helps to eliminate order effect. Order effect is the bias that is introduced as a result of the fixed ordering of questions or response choices. In other words, order effect can occur if the same response choices are always presented in the same order [19].

The popularity of MSQ comes from its ability to capture as many of the possible pre-formatted answers to a question as possible. Its use is convenient for surveys [20].

WBES specifies different grading criteria for this kind of questions. For example, the question is graded fully correct if the student chooses all the correct responses (no incorrect responses). Students receive partial credit on multiple selection questions based on the number of correct selections and non-selections they submit.

In WBES interface, a student enters after login session. The test starts. Suppose he/she selects a question (e.g. MSQs) from the interface. A list of MSQs is displayed in front of the student and he starts checking the corresponding answers using the interface. He/she can change the option selected before finishing the time of the question. An example of MSQ is presented in Figure 2-2.

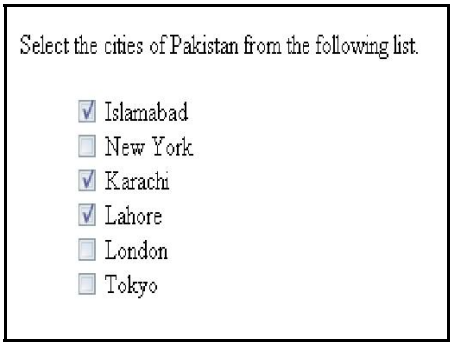

Figure 2-2: MSQ Type Question Example

2.5 Ordering Questions (OQ)

Ordering or Ranking type of question provides student with a list of steps, which he/she can rearrange into the appropriate order. These types of questions require the student to relate items in a column to one another and can be used to test the knowledge of sequences, order of events, and level of gradation [18]. In WBES students will be prompted with multiple fields of questions, which are to be rearranged. When the information is presented to the student, the answers are randomized in these fields.

In WBES interface, a student enters after the login session. The test starts. Suppose he/she selects a question (e.g. Ordering Questions) from the Interface. A list of Ordering Questions is displayed in front of student and he starts ordering the questions by selecting the appropriate answer. He/she can change the option selected before finishing the time of the question. Example of ordering questions is given in Figure 2-3.

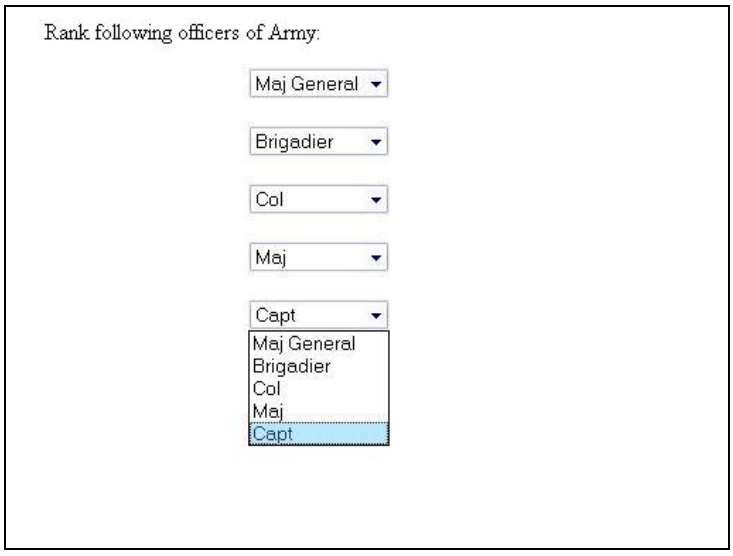

Figure 2-3: Ordering Questions Type Question Example

2.6 Fill in the Blanks (FIB)

In fill in the blank or completion items type of questions, the reader is given an incomplete statement or a phrase. WBES would mark incomplete portion with a long or small dashed line (e.g. using the text area). Completion items are especially useful in assessing mastery of factual information when a specific word or phrase is important to know. They are used for judge application, synthesis, analysis, and evaluation levels. They are easy to construct, good for "who," what," where," "when" content, minimizes guessing and encourages more intensive study-student must know the answer vs. recognizing the answer. They preclude the kind of guessing that is possible on limited-choice items since they require a definite response rather than simple recognition of the correct answer. Because only a short answer is required, their use on a test can enable a wide sampling of content [15].

Completion items, however, tend to test only repetitive responses, and they may encourage a fragmented study style since memorization of bits and pieces of information can result in higher test scores. They are more difficult to score than forced-choice items, and scoring often must be done by the test writer since more than one answer may have to be considered correct [15].

A student enters into the test environment of WBES after login session. The test starts. Suppose he/she selects a question (e.g. Fill in Blanks) from the Interface. A list of Fill in Blanks is displayed in front of the student and he starts entering text (answer) into the text areas using the system Interface. He/she can change the text entered anytime before finishing the time of this question type. Example of fill in the blanks is as follows.

SSL stands for _____.

2.7 True/False (TF)

A true-false question is a specialized form of the multiple-choice format in which there are only two possible alternatives. These questions can be used when the test-designer wishes to measure a student's ability to identify whether statements of fact are accurate or not. True-false questions offer lecturers a very efficient method of testing a wide range of material in a short period of time. They can also be combined within a multiple-choice to create the more complex assertion-reason item [18].

Such questions, however, have certain disadvantages. They are quite difficult to construct flawlessly—the statements have to be defensibly true or absolutely false. Teachers must be taught thoroughly how to construct these question types. When a student answers a "false" question correctly, only that can be concluded that the student knew the statement was false, not that he or she knew the correct fact [21]. A student has a 1 in 2 chance of guessing the correct answer of a question. The format does not discriminate among students of different abilities as well as other question types [18].

A student enters into the test environment of WBES after login session. Suppose he/she selects a question (e.g. True/False) from the interface. A list of True/False displays is displayed in front of the student and he starts checking either of two options using the system interface. He/she can change the two options anytime before finishing the time of this question type. Example of True/False is as follows.

Fast Ethernet has transmission speed of 10Mbps. [T/F]

2.8 Short Matching Pairs Questions (SMPQ)

Matching questions are really a variation of the multiple choice format. MCQs which share the same answer choices can be grouped into a matching item. Matching items

require students to match a series of stems or premises to a response or principle. They consist of a set of directions, a column of statements and a column of responses.

Matching questions are particularly good at assessing a student's understanding of relationships. They can test recall by requiring a student to match, definitions to terms; historical events to dates; achievements to people; statements to postulates and descriptions to principles. They can also assess a student's ability to apply knowledge by requiring a test-taker to match, examples to terms; functions to parts; classifications to structures; applications to postulates and problems to principles [18].

Matching items are generally quite brief and are especially suitable for who, what, when, and where questions. They can, however, be used to have students discriminate among, and to apply concepts. They permit efficient use of space when there are a number of similar types of information to be tested. They are easy to score accurately and quickly [15].

Among the drawbacks of matching items are that they are difficult to use to measure learning beyond recognition of basic factual knowledge, and they are usually poor for diagnosing student strengths and weaknesses. Matching items are appropriate in only a limited number of situations, and they are difficult to construct since parallel information is required [15]. Short matching item questions requires matching of small pair of words or symbols.

A student enters into the test environment of WBES after login session. Suppose he/she selects a question (e.g. Short Matching Pairs Questions) from the Interface. A table of two columns is displayed in front of the student. The Student is asked to match the first column with the corresponding item in the second column. He/she reads the instructions before solving this kind of question carefully. He starts

selecting the matching answer before the corresponding first column item. He/she can change the selected answer anytime before finishing the time of this question type. Examples of paper based version and computer based version of SMPQ are given in Figure 2-4 and Figure 2-5.

*p	Not Equal To
==	Equals To
||	Pointer
!=	OR

Figure 2-4: Paper Based Version of SMPQ

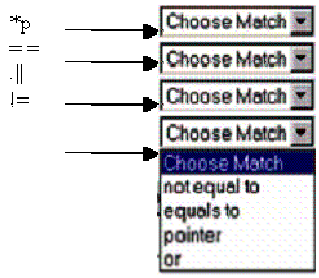

Figure 2-5: Computer Based Version of SMPQ

2.9 Long Matching Pairs Questions (LMPQ)

Long matching pairs questions is an extension of short matching pairs questions. In this type of question usually a sentence is matched with other sentence or word or symbol. Examples of paper based version and computer based version of LMPQ are given in Figure 2-6 and Figure 2-7.

Flash Plug-in	a. allows you to see graphics in almost any format.
Authoware Plug-in	b. allows you to view documents with .pdf extensions
Quick Time Plug-in	c. allows you to listen to music and watch videos.
Adobe Acrobat Reader	d. allows you to create interactive web exercises.

Figure 2-6: Paper Based Version of LMPQ

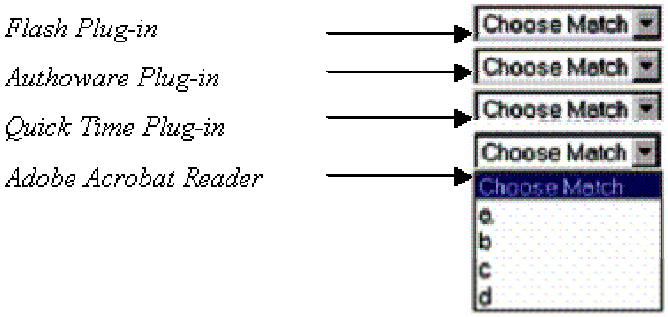

Figure 2-7: Computer Based Version of LMPQ

2.10 Pointing Answers to Questions Using Images (PAUI)

These questions are also termed as Hot Spot Questions. In these types of questions, the Students have to point on one or several areas on the image to give the specific answer. For hotspot questions it is also possible to associate different scores to different areas of the image containing the information to be identified [16]. Example of pointing answers to questions using images is given in Figure 2-8.

A student enters into the test environment of WBES after login session. Suppose he/she selects a question (e.g. Pointing Questions) from the Interface. A graphical image and associated text is displayed in front of the student and he points to a specific area of the image according to the question. When the student clicks on one image, he/she cannot move back to that image again. Rather he moves towards the next image question part.

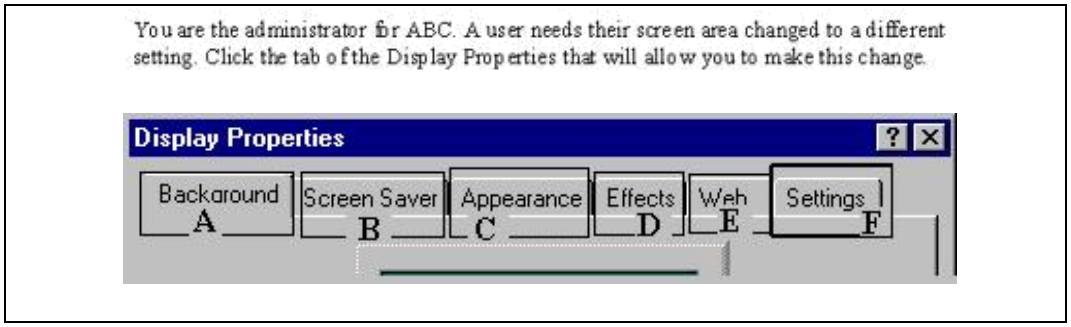

Figure 2-8: Pointing Answers to Questions Using Images (PAUI)

2.11 Short Answer Questions (SAQ)

Short-answer items, those limited to fewer than five full sentences, are interchangeable with completion items. A possible advantage of this question type is that the student must supply the correct answer rather than identify or choose it. The likelihood that the candidate will guess the correct answer is lower than that of a multiple choice question. However, the short answer response questions can be difficult to phrase in such a way that only a single correct answer is possible. Additionally, if you are marking the assessments with computers, spelling errors may disadvantage students who know the right answer. However, with some software, the test designer can identify numerous permutations of the correct answer for which the student will be awarded full marks. For example if "United States" were the correct response to a short answer question, the author of the test could designate full marks to be awarded for all of the following: "United States", "US", "USA" and "United States of America" [18].

Short Answer Questions impose certain problems when considering their implementation details. In order to add such type of questions, WBES has to produce a list of all possible answers from the single correct answer entered by the teacher. Then teacher would validate correct version of answers. It increases the complexity. In some cases presence of keywords can be checked. But in worst cases the sequence of key words matters and may change or invert the overall meanings as well as implications of the statement(s). The Students have to give one to two lines short answer for the given question. Examples of short answer questions are given in Figure 2-9 and Figure 2-10.

In example 2 shown in Figure 2-10, the keywords sequence matters. None of the other sequences is correct except {12345} and {1235}. The presence of keywords 1,2,3 and 5 are mandatory. If we automate the answers, the systems will generate

number of other sequences which are not correct. The other option is that the teacher enters all the correct sequences and system will just compare the answer with these sequences. This option will create extra amount of work for the teacher.

Question: What is a Web Application?

Correct Answer entered by Teacher:

A web application uses a web site as the front end to a more typical application.

Possible Answers Generated by System

Keywords: 1. web application 2. web site 3. front end 4. typical application.

A web application uses a web site as the front end to a more typical application. {1234}

web application uses web site as front end to typical application. {1234}

Typical application using web site as front end is called a web application. {4231}

Typical application is a web application if it uses web site as front end. {4123}

Typical application is a web application if it implements front end as a web site. {4132}

If one implements front end of a typical application as a web site then it is a web application. {3421}

If one implements a typical application with front end as a web site then it is a web application. {4321}

Figure 2-9: Example 1 of Short Answer Questions

Question: Write the SQL statement for retrieving all data in Authors Table in Publications (Pubs) database?

Correct Answer entered by the Teacher:

SELECT * FROM Pubs. Authors

Possible Answers Generated by WBES:

Keywords: 1. SELECT 2. * 3. FROM 4. Pubs 5. Authors

SELECT * FROM Pubs.Authors {12345}

SELECT * FROM Authors {1235}

Figure 2-10: Example 2 of Short Answer Questions

2.12 Questions with Audio Narration

The test taker would listen to the recorded audio narration. After completion of the audio narration, a question statement would be posed in audio form. In front of the listener several possible answer options would be displayed. The Student selects one of these, the one on which he trusts. Complex graphics and interactive features may reduce software running speed or increase download time. Items should be designed to fit the test purpose and objectives of assessment, and advanced multimedia features should be used only where justified by validity.

2.13 Questions with Audio Narration and an Illustration

The test taker would be presented a graphical illustration with or without textual description. An audio is narrated to explain the complete scenario. After completion of the audio narration a question statement may be narrated in audio form or it could be displayed in textual form depending on the choice of the designer of the question.

2.14 Conclusion

In this chapter an over view of different question types is presented. Today's students are more informed and demanding. They need the application and practicing of

interactive learning and assessment, the learning and assessment that can be helpful for them to assess their strengths and weaknesses. The types of questions discussed in this chapter and the amount of research undergoing on the psychological and institutional learning aspects of each question type gives us enough ground to use these questions for assessment of group of students and then compare the results of the outcome with the traditional assessment methods. New assessment methods and question items are need of the time.

Chapter 3

WBES Architecture

3.1 Introduction

In this chapter the architecture of WBES is described. This includes the technology used, users' description and features of the systems.

A 3-Tier Web Application uses the client/server computing model. With three tiers or parts, each part can be developed concurrently by different team of programmers coding in different languages from the other tier developers. Because the programming for a tier can be changed or relocated without affecting the other tiers, the 3-tier model makes it easier for an enterprise or software packager to continually evolve an application as new needs and opportunities arise. Existing applications or critical parts can be permanently or temporarily retained and encapsulated within the new tier of which it becomes a component [5].

An overview of tools which are used for various phases of whole system development process is presented in this chapter. These phases include analysis, design and implementation phase. Tools to create this product are software packages including Microsoft .NET Framework, that allows one to develop interactive applications with a variety of static and dynamic content. SQL Server 2000 is a database tool for storing and retrieving the information. The product uses IIS server as a web server for providing the services to the web application. Microsoft Internet Explorer™ 6 is used as web browsers to test the system.

3.2 WBES Architecture

WBES is based on the Three-Tier architecture [22]. Front end (Presentation Layer) is for user's interaction with the system. On client side this system gives a user-friendly

interface and an easy navigation tool for the test takers for moving back and forth through the Test Sheet easily. Client fulfills the requests of individual users. More than one user on different client machines can access WBES simultaneously. There is a huge database management system for data management capabilities. It comprises the Data Layer. On the server side, the system runs the Application Tier. It provides capabilities to retrieve and store tests and results from the back end database. Server will provide instructional and communicational information and services as well as it coordinate all essential features of the system.

3.3 User Characteristics of WBES

There are three categories of users accessing this system (Students, Teachers and Administrator). These users are differentiated on the basis of education level and technical expertise.

Students can take tests using the system interface. Students may be of different levels (e.g. graduate or post graduate level). To use this system, students must know how to use computer and how to navigate through browser.

Teachers can create exams quickly and easily using the system interface. They will have a facility to insert questions and their answers into the system database through an easy to use interface. So they must have an educational experience and also some computer related knowledge.

Administrator can distribute the exams to the testing centers and manage the results. He will manage and administrate the overall system. So he/ she must have sufficient knowledge about the computer hardware and software. Further he must have privileges to be able to use the system.

3.4 Main Features of WBES

The WBES has user-friendly graphical interface. All the logic and programming is hidden from the user. This system is easy to use and easy to understand. The system is basically divided into three major modules; Admin Section, Student Section and Teacher Section. Only an authenticated user of that particular module accesses each module. Each module provides following features to users. (Administrator, Teacher, Student)

System provides an easy to use interface to teachers for developing test items. Teachers can add and remove the items from the database. Similarly teachers can modify existing items.

Administrator can set the accounts for teachers and students. Administrator can manage different types of questions using administration section. Finally administrator can add or remove exam/test settings.

WBES provides an interface for users (students, teachers, and administrator) for authentication. User enters his User ID and password before entering into the particular section. This functionality enhances system security feature.

When student enters into system Interface and selects a particular category of test, there is an algorithm that will be operating in the web server. The algorithm selects different questions from database randomly. Then it will order questions randomly. This feature is used for preventing from cheating. Every student will get a unique paper at delivery stage of test.

There are different difficulty levels of questions for different categories of students. Teachers will go into the development section. They can add questions with additional information pointing out their different difficulty levels. Corresponding difficulty levels would be cross verified by others.

WBES provides an automatic facility to control specific version of test. When a test is conducted at a specific location, WBES would identify exact version of that test by storing the information about location and specific time of the test.

WBES has inherited basic question types already used in CBTS and introduces new and innovative styles of questions. Some of these are quite appealing ones for future assessment developers as well as these will enrich experience to students. The numerous formats inherited and newly discovered are accommodated in WBES in the varied forms.

Administrator can set a timing limit of exam by entering time in hours by using administration section. When student starts specific question, timer will be running. Timing for exam is controlled dynamically on runtime by the system.

WBES would display results immediately to students. In addition a final printed Test Report would be sent to them both by post mail and/or by electronic means like email. Immediate Test Report will contain information about all questions showing correct answer, respondent answer, and a percentage score or grade at the end. There would be different grading scheme for each type of question type evaluated by the teacher, which will be discussed later.

System would store all the results of students into the System Databank permanently for future needs. The system would also provide a capability for students to search their results/reports by entering test information through their interface.

3.5 Techniques and Tools Used in WBES

Analysis of major requirements of the system is done using the techniques of unified modeling language. Identification of actors, use cases and finally development of interaction diagrams are completed using the UML modeling. Whole process of UML

modeling is done using the Rational Rose 2000. It provides an easy to use interface for creating use case diagrams and interaction diagrams.

Design phase of project starts by identification of classes. System's design phase is divided into two types design levels. Abstract level defines the classes. Message passing between the classes is shown at this level. Attributes and functions definition is modeled in detailed design level. Interaction and relationship among various classes is shown at this stage which provides a lot of help in the implementation phase. Rational Rose 2000 provides an easy to use interface for development of class diagrams. This tool provides an easy pick and drop facility for creating the relationships among the classes.

As WBES is 3-tier architecture, so for implementing three layers of the system, various techniques and tools are used. Markup language, scripting languages and programming languages are used for whole process of implementation. Whole system is developed using major tool, Microsoft .NET Framework, which provides a sophisticated interface for database connectivity.

The system is developed using the .NET Framework. It provides all the services for developing and managing various files. It provides a drag and drop facility for the developer for designing the web forms. The intelliSense facility of .NET presents statement completion for recognized objects, and automatically lists information such as function parameters in helpful ToolTips. On the whole, the different modules of the system are developed with the support of .Net interface in an efficient and well-organized way.

The implementation code of the system is written in VB.NET language. It provides a true object oriented programming environment to the programmer. The

codes behind files of the system are written in VB.NET. .Net Framework provides a method of linking the ASP.NET web controls with the VB.NET language.

Client side interface of WBES is developed using HTML which is embedded in the .Net Framework. .NET Framework provides an HTML editor for creating any html files.

.NET framework provides a general CSS class for project to format the overall files. The WBES uses the CSS class.

All the web forms use the facility of HTML Server Controls and Web Controls. The Data Grid, a rich ASP.NET Web Control, is used for displaying the information retrieved from the database, e.g. the question items are displayed using the Data Grid.

Sometimes some requests to the server are not required. So to prevent from sending the requests again and again, the WBES uses JavaScript on client side. It provides a better performance in speed. .NET framework provides a facility for embedding the JavaScript in ASP.NET applications. So there is no problem for controlling client side and server side processing using this platform.

IIS (Internet Information Server) is installed on computer system. All the ASP.NET pages of WBES are accessed through the ASP.NET services provided by ASP.NET run time engine.

Most of the data access in WBES is done by using the data reader because it provides a live connection to that datasource. The fast forward-only and read-only nature of datareader makes it better than the dataset. However, sometimes dataset is used in WBES for handling large amount of data accessed by a number of students during the exam session. Furthermore, ADO.NET objects provide an easy method for manipulating SQL statements and stored procedures.

SQL queries are not used mostly because of slow processing and less efficiency. Because the queries are sent from the client side to the server over the network, it adds up a lot of network traffic, which can cause congestion. SQL queries are not pre-compiled. This deficiency of queries shows less performance as compared with the stored procedures. To relieve congestion and keep low traffic on network, there is a need to lessen code that is sent from client machine to database server. For this purpose, code is stored on server, by turning SQL query into the stored procedure.

Microsoft SQL Server 2000 is used as a database server for WBES. SQL Server 2000 works with Microsoft Windows® 2000 Server and Microsoft Windows NT® Server security and encryption facilities to implement secure data storage.

3.6 Conclusion

WBES is an object oriented system, based on Three-Tier Architecture. Latest techniques and tools are used to develop this system. This assures the quality and reliability of the system, which can be comparable to any of the other Test Management System. Object oriented design and Three-Tier Architecture assure that the system will be flexible enough to cater for the future changes.

Chapter 4

WBES Design and Implementation

4.1 Introduction

WBES is designed on object oriented basis. Whole project is completed in different phases of software development starting with the requirement analysis and ending at the testing phase. This chapter and next chapter give detailed information about the phases of the system. This chapter presents overview to the requirement analysis phase, design phase and implementation.

4.2 Requirements Analysis Phase

Requirement analysis is an essential step before starting design phase, as it is basic key in understanding details of the proposed system. Main objective of requirement analysis is to clearly identify requirements of the proposed system. Requirements of the system are posted in a document known as SRS.

4.2.1 Actors

Analysis phase starts with identification of major users of system which are called actors of the system. An actor is anyone or anything that interacts with system being built. Actors are outside system scope. WBES has three actors named as Administrator, Teacher and Student.

4.2.2 Use Case Diagram

A use case diagram shows interaction between actors and use cases. It is used for communication purposes. Use case diagram of WBES is divided into different levels, which are encapsulated into use case packages. Use case packages used for the analysis of the system are shown in Figure 4-1. Details of each use case package are described in preceding section.

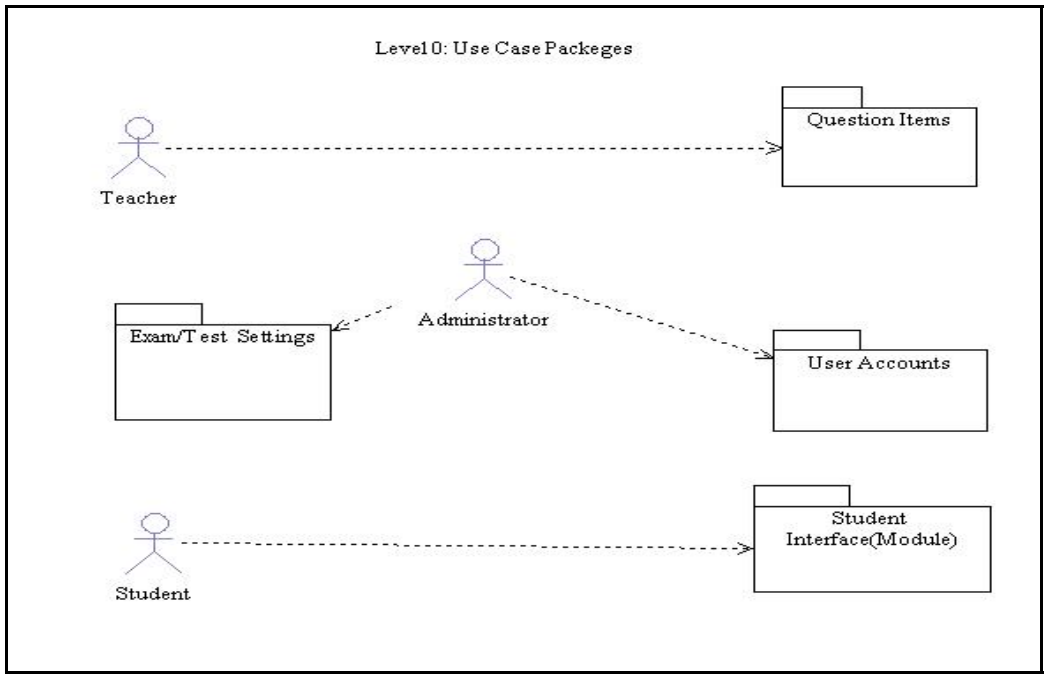

Figure 4-1: Use Case Packages

4.2.3 Use Case Diagram: Question Items

Teacher can add, modify and delete question items by interacting with this use case package. Before doing this, a teacher must be authenticated. Use case diagram for Question Items use case package is shown in Figure 4-2.

4.2.4 Use Case Diagram: Exam/Test Settings

Administrator can add, modify and delete exam settings. These settings are used to generate a unique test for students. Use case diagram for Exam/Test Settings use case package is shown in Figure 4-3.

This use case diagram provides the facility for administrator to add new exam settings into the database. An administrator can also delete the existing exam/test information from the database. Similarly administrator can modify the existing exam/test information.

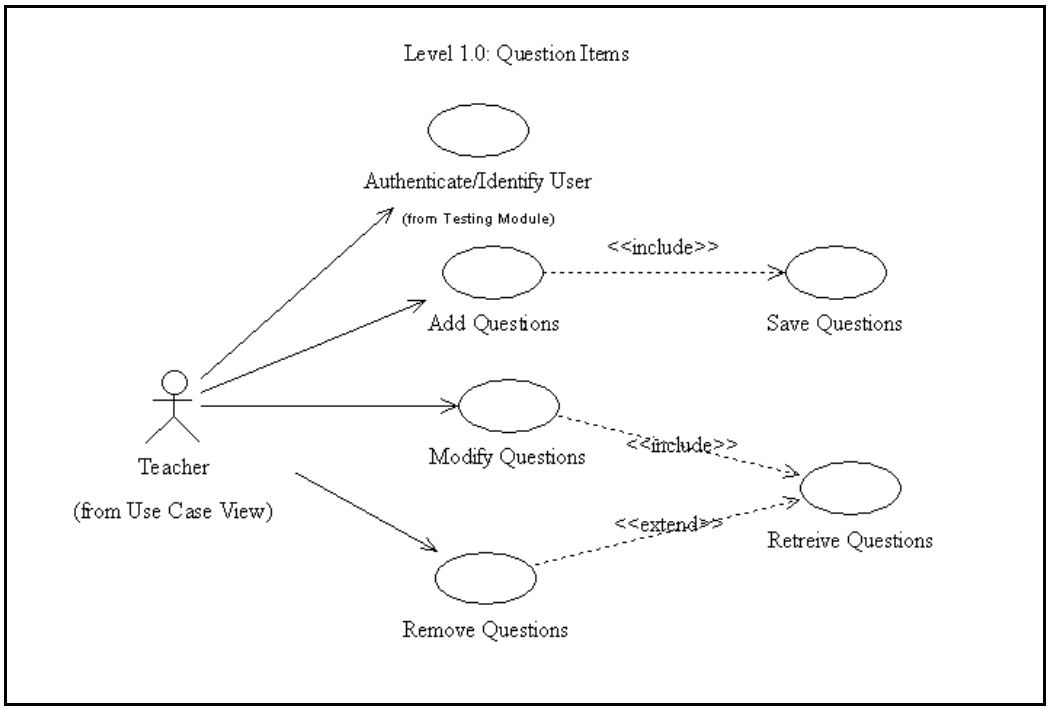

Figure 4-2: Use Case Diagram for Question Items

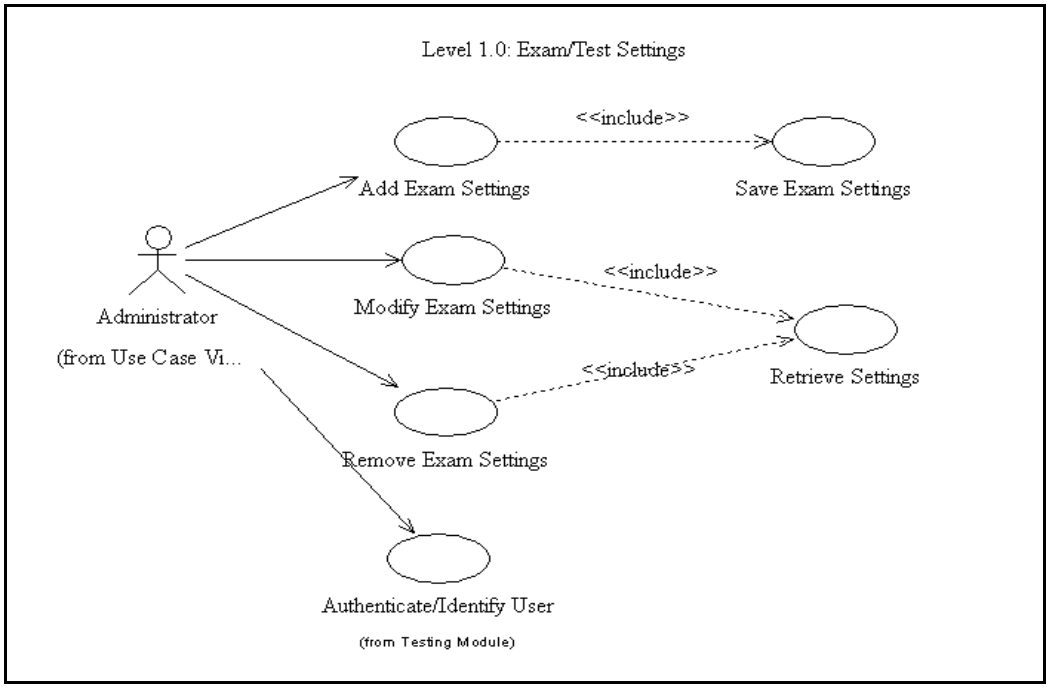

Figure 4-3: Use Case Diagram for Exam/Test Settings

4.2.5 Use Case Diagram: User Accounts

An administrator can set accounts for users of system by interaction with this use case package. The use case diagram for User Accounts use case package is shown in Figure 4-4.

This use case diagram provides facility for administrator to add new user accounts into the database. An administrator can also delete existing account information from database. Similarly administrator can modify existing user account by interacting with a use case.

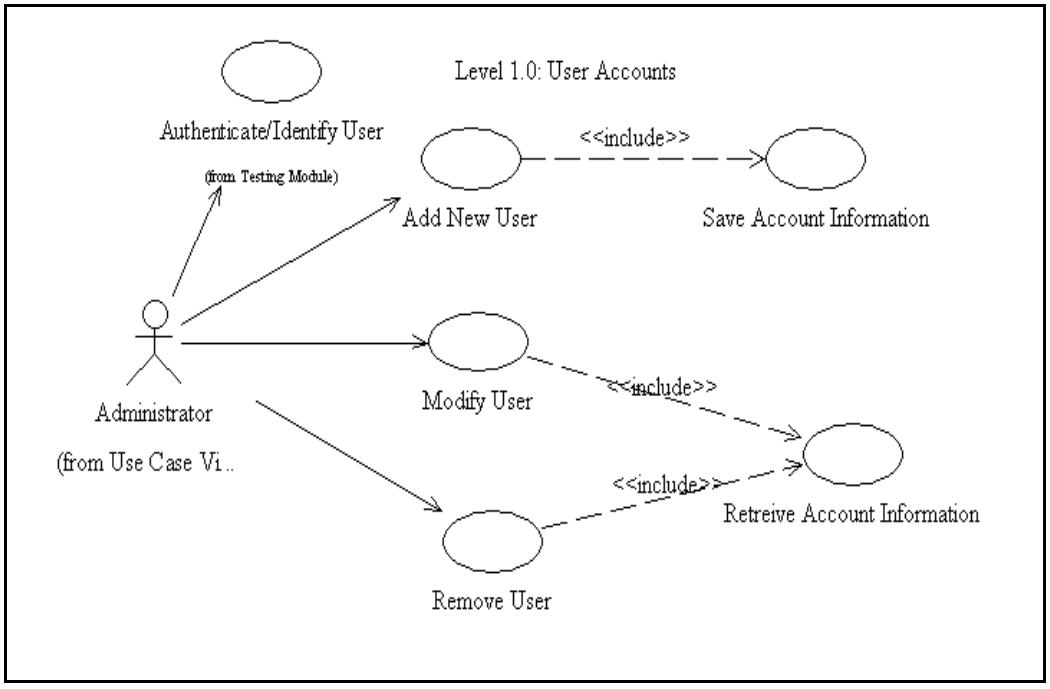

Figure 4-4: Use Case Diagram for User Accounts

4.2.6 Use Case Diagram: Student Module

Students can take tests by the interaction with this module. Student Module consists of two use case packages, Testing Module and Student Reports. Use case diagram of Testing Module is shown in Figure 4-5.

Use case diagram of Testing Module provides facility for student to take the test. System automatically generates a unique paper for students. The most important functionality that is shown in this use case diagram is automatic scoring of tests during the exam/test session. Results are automatically saved into the database.

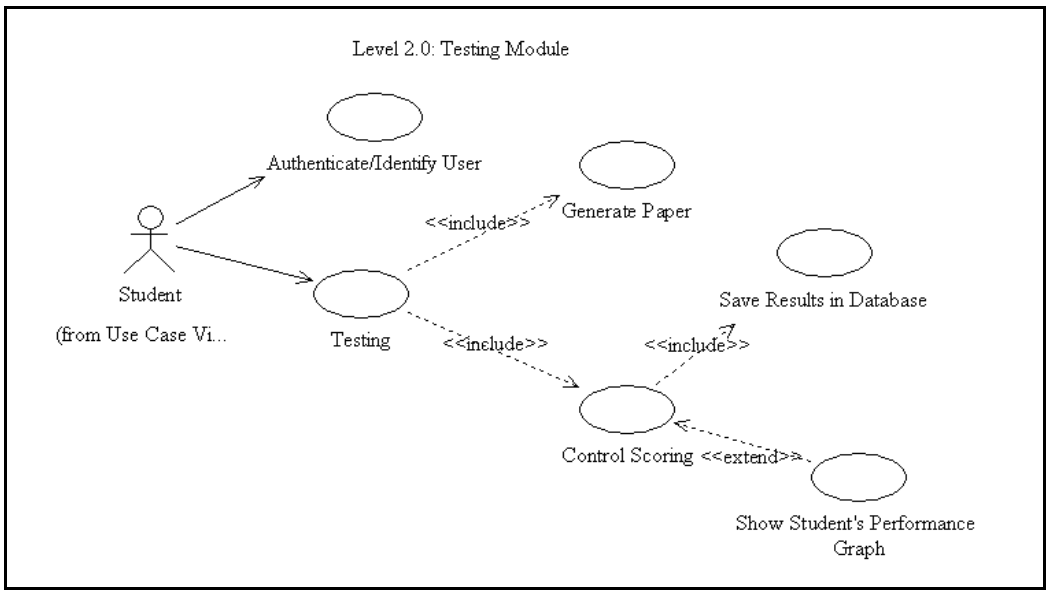

Figure 4-5: Use Case Diagram for Testing Module

4.2.7 Interaction Diagrams

Interaction diagrams show relationship among objects, which are identified, in use case diagrams. Each use case has one or more than one sequence diagrams. Messages are shown on the sequence diagrams. There are a number of sequence diagrams in WBES, which are developed using Rational Rose. Details of some important ones are described in following section.

4.2.7.1 Sequence Diagram: Add Multiple Choice Questions

Suppose a teacher wants to add the MCQ into the database. He can add the question items by entering into his/her development section. System provides an easy to use interface for entering question items into database. Interaction diagram is show in Figure 4-6.

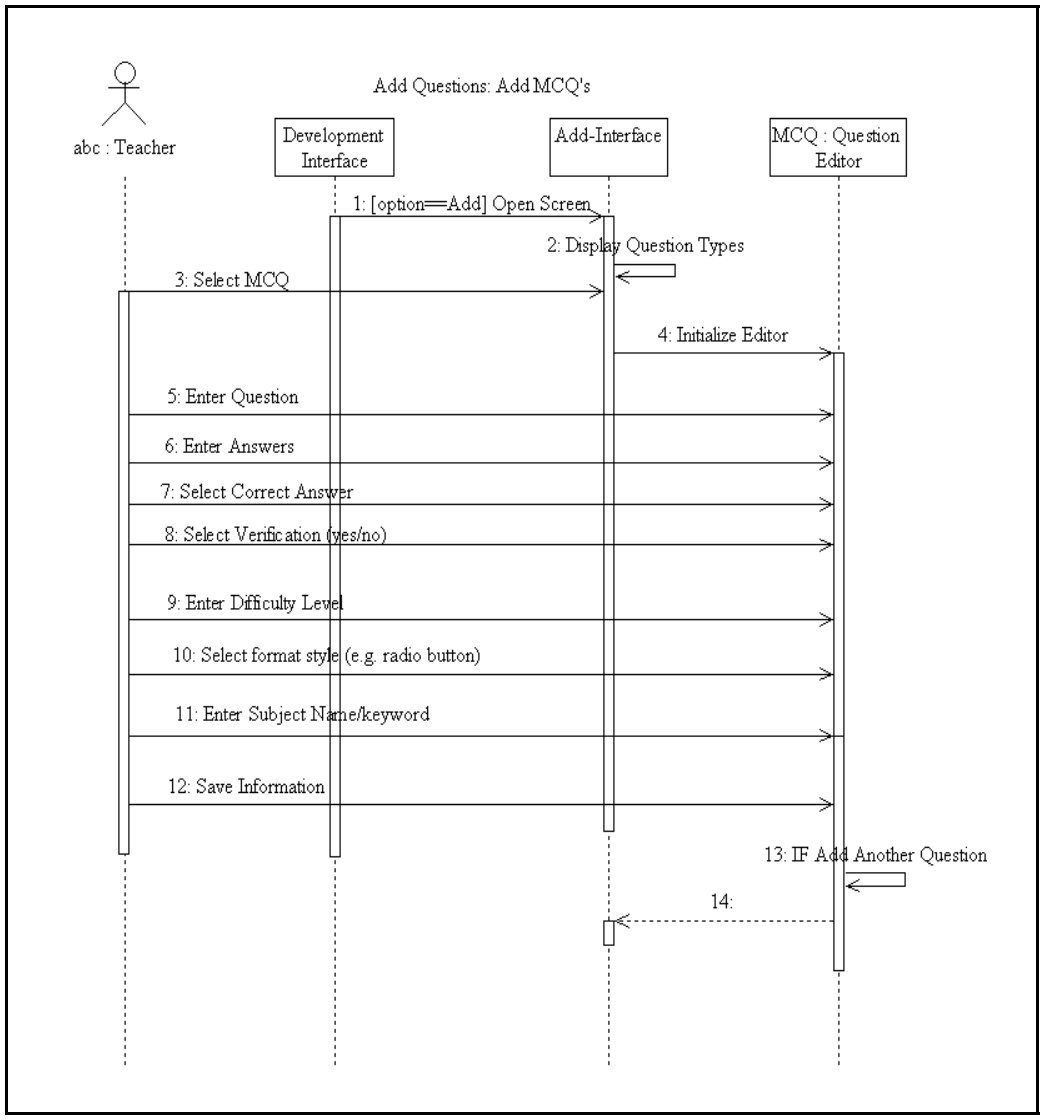

Figure 4-6: Sequence Diagram for Add Multiple Choice Questions

4.2.7.2 Sequence Diagram: Add User Accounts

Suppose an administrator wants to add new user account in database. He can add information of the new user by using the administration section interface. System provides an easy to use interface for entering the question items into the database. The interaction diagram is show in Figure 4-7.

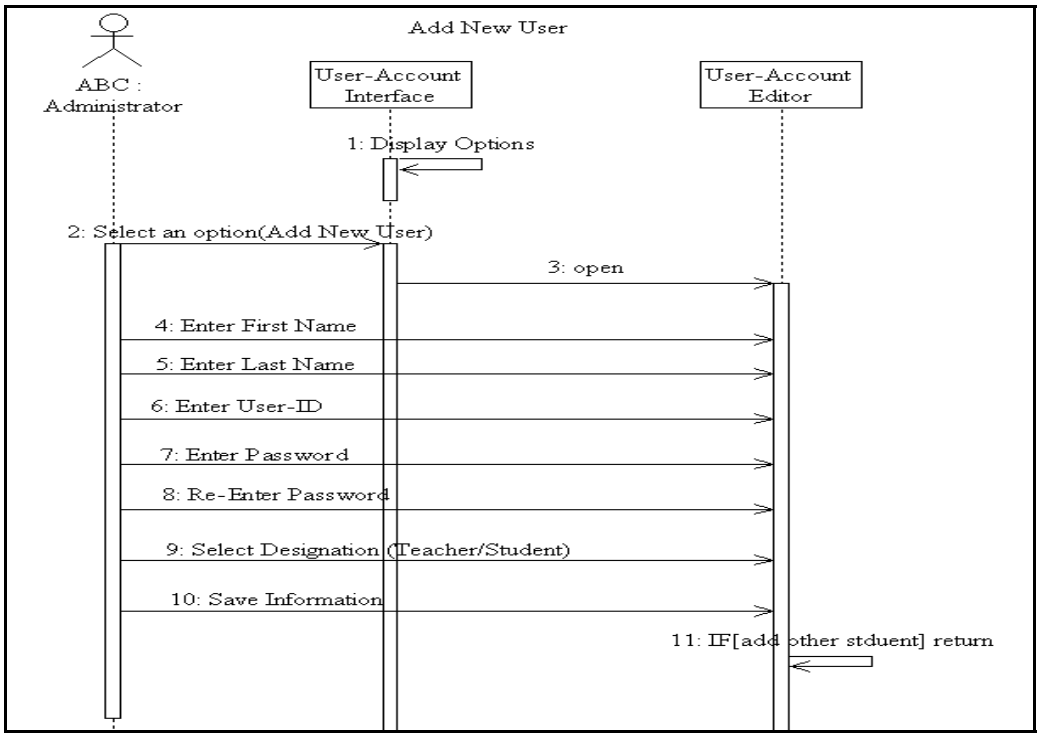

Figure 4-7: Sequence Diagram for Add User Accounts

4.2.7.3 Generate Unique Paper

This is the most important sequence diagram for the use case "Generate Paper". There is an algorithm, which generates a unique paper for each student. Sequence diagram identifies objects, which are involved in development of this functionality. Random generator picks question items randomly and displays them to students. The diagram is shown in Figure 4-8.

4.2.7.4 Control Scoring

This is another important functionality of the system. System automatically checks paper of students during the exam/test session. There are different criteria for checking various types of questions. Sequence diagram of this functionality is shown in Figure 4-9.

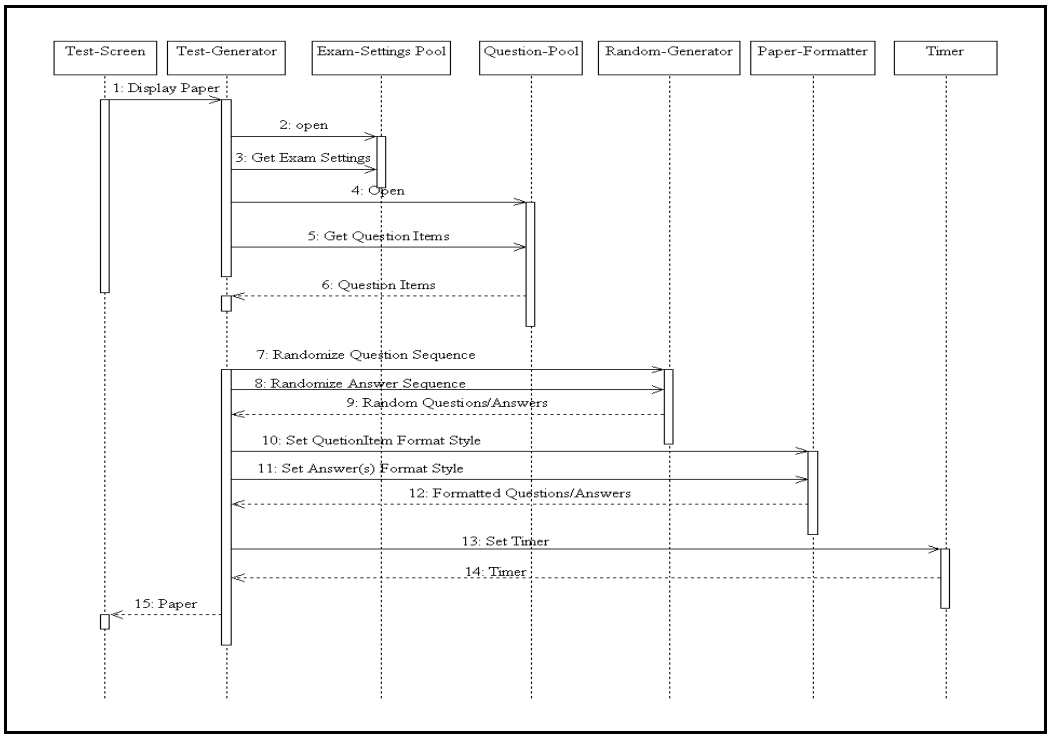

Figure 4-8: Sequence Diagram for Generate Unique Paper

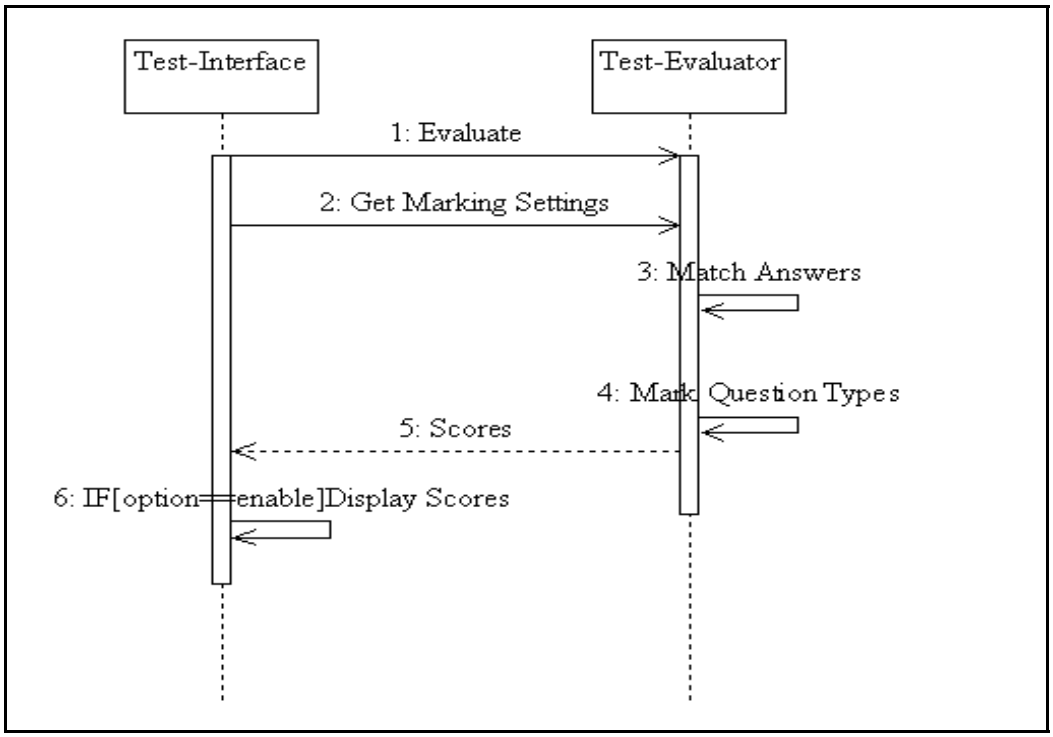

Figure 4-9: Sequence Diagram for Use Case: Control Scoring

4.2.7.5 Control Format of Question Types

When test/exam is delivered, there is a controller that formats all the question types on demand. There is a different format style for each type of question. For example, Multiple Choice Questions have options, which are displayed using the radio buttons. Similarly, for ordering questions, system will show a drop down list to the students for selecting a particular order. Sequence diagram of this functionality is shown in Figure 4-10.

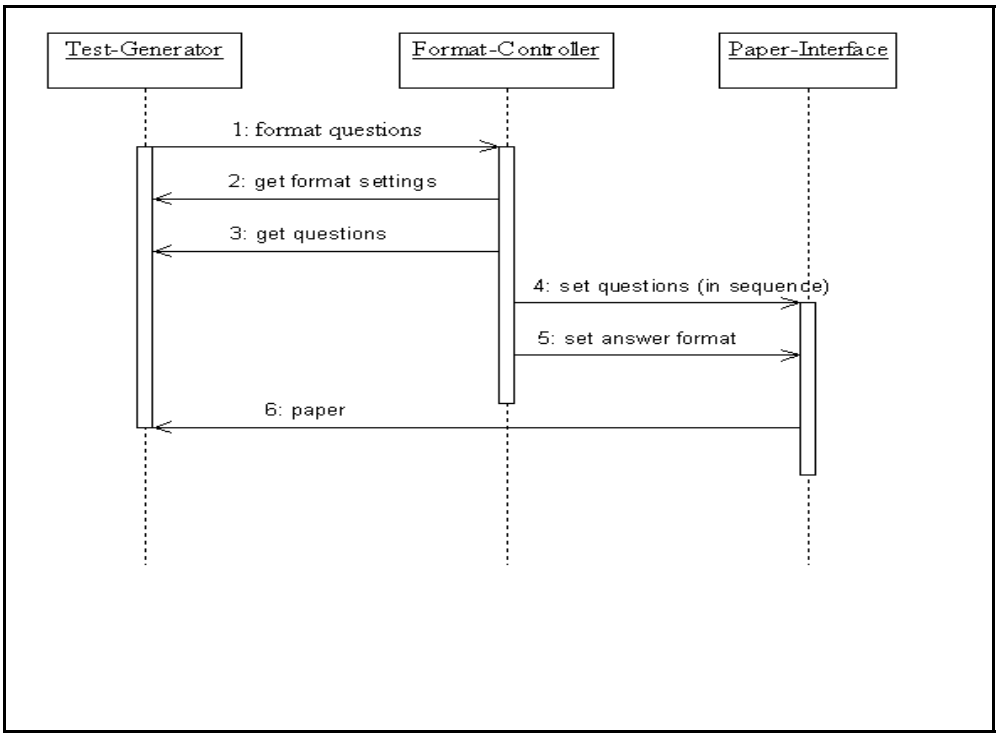

Figure 4-10: Sequence Diagram for Use Case: Control Format of Question Type

4.2.7.6 Authenticate Users

This is a basic functionality for accessing different sections of system. There is login functionality for the users, who enters their ID's and passwords before entering into their respective section. Sequence diagram is shown in Figure 4-11.

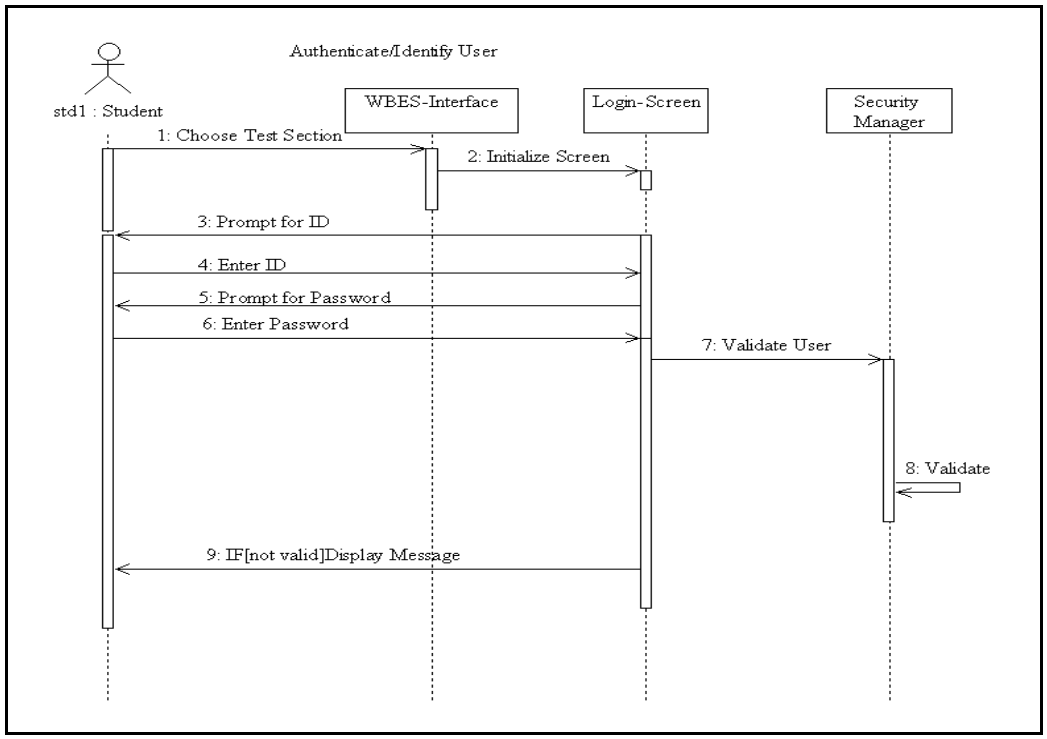

Figure 4-11: Sequence Diagram for Use Case: Authenticate Users

4.3 Design Phase of WBES

Design phase of system is divided into two parts. First one is abstract design level, in which different classes are identified as objects in the sequence diagrams. The specific names are assigned to the different classes. The detailed design of the system involves the relationships among the various classes. This section provides an overview to design phase of the system.

4.3.1 Classes

Class diagram is a combination of classes which are identified in sequence diagrams. A class has three parts, its name, attributes and functions. Description of some important classes is follows and UML diagrams for these classes are shown in Appendix A.

4.3.1.1 Class: Authenticate Users

This class has the responsibility of validating user. When user tries to enter in any of the three sections i.e., Administration section, Teacher section and Student section of WBES, he is prompted for his identity. When he supplies his user name and password this class verifies his credentials with the help of security manager. If his both identities are fulfilled, then he will be allowed to enter in his authorized section. Otherwise a message will be displayed for invalid user name and/or password by the system. He will be prompted for two more times and if he does not supply correct user name and/or password then the system will intimate the system administrator that some unknown person is trying to enter in the system.

4.3.1.2 Class: Add User Account

It controls all operations for adding the user account information into the database. The System Administrator is authorized to add new user and this functionality is only available to the person who login as an administrator. During this process the administrator can enter the user personal information, his security status and set user name and password for him. System administrator can also modify or delete the User Account information.

4.3.1.3 Class Diagram: Add Question Items

This class provides an interface for adding the question items into the database. Teacher can add new questions. He has to enter question type, subject name, question text, answer choices, correct answer, difficulty level, format style and verification either this question is ready to be included into test. Teacher can also modify and delete any question.

4.3.1.4 Add Exam Settings

This class provides an interface for adding new Test/Exam settings into database. Administrator has to enter examination title, instructions and maximum time for the

Exam. He also has to identify number of question items, question types, maximum marks, difficulty level, marking criteria and randomization to be done or not.

4.3.1.5 Class Diagram: Save Question Items.

All the logic for saving the question items into the database is controlled by this class. The information enters by administrator is saved in the database by this class. It means that database interface is handled by this class.

4.3.1.6 Class Diagram: Control Scoring

All the logic for the evaluation of the various parts of the test is encapsulated by using this class. The class accepts input of student ID, exam ID, score and performance graph to be shown to the student after exam or not. Its methods are evaluate paper, match answers, mark question types, get score, show graph and save result. The scoring is done according to question type and as per predetermined marking system which is required to be given by test administrator.

4.3.1.7 Class Diagram: Test Generator

All the logic for generating a unique paper with all formatted question types is controlled by using this class. It accepts exam settings, and then retrieves question items, get these formatted according to settings. The class diagram is shown in Figure 4-12.

4.4 Database Designing

Information used in WBES needs to be stored into the database permanently. This information contains Student accounts (IDs and passwords), Teacher accounts (IDs and passwords), Question Types, Question Items of different question types and Student's Results.

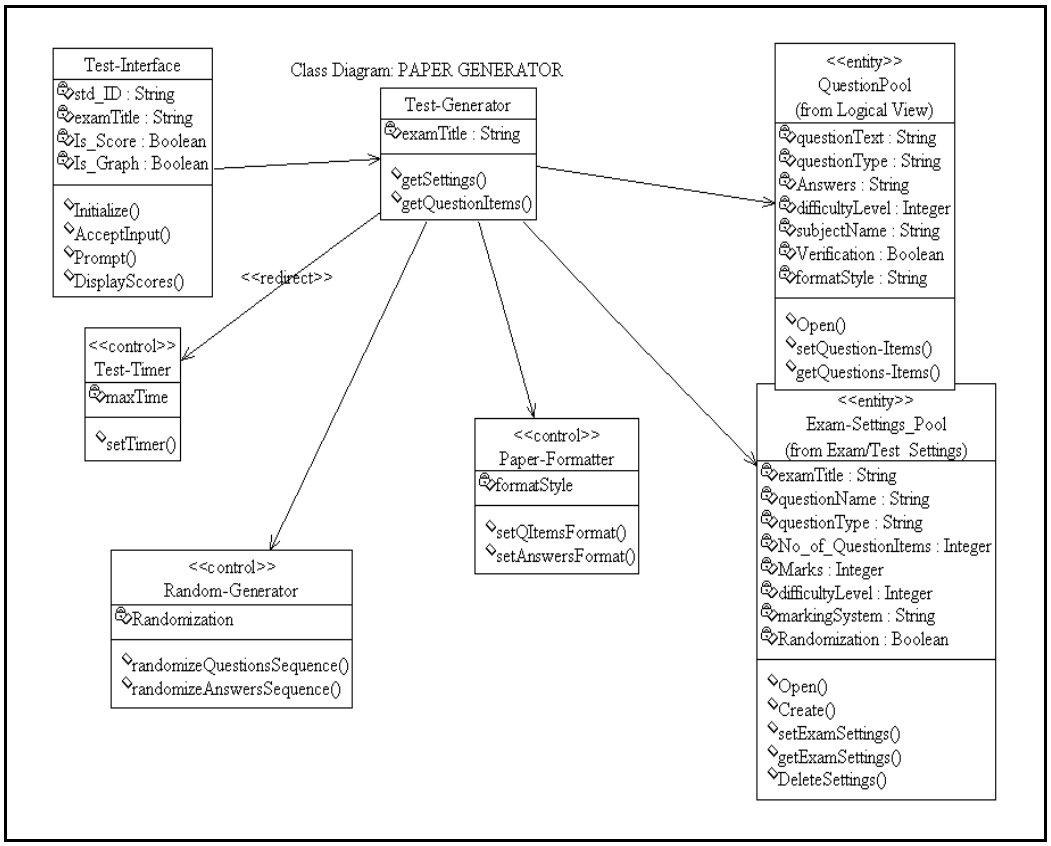

Figure 4-12: Class Diagram-Unique Paper Generation

An E-R model consists of entities. An entity is any object that exists and is distinguishable from other objects. Entities are described by their attributes and these are connected by relationships. E-R model also allows expressing constraints or restrictions on the entities or relationships. E-R diagrams contain symbols for entities, attributes and relationships.

An E-R Model (E-R Diagram) can be created for providing a graphical method for depicting the logical structure of the database. In WBES, E-R diagrams are developed for different modules in which the information is stored or retrieved.

4.4.1 User Account Information

To store the account information of a student or a teacher, two tables are used in the database. Each of these tables is known as an entity set. The E-R diagram for this module is shown in Figure 4-13.

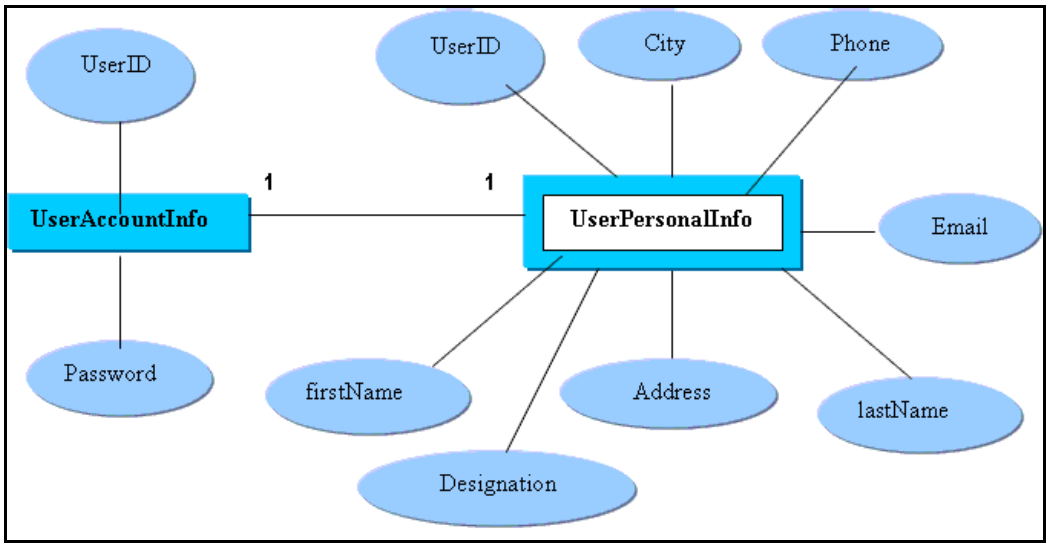

Figure 4-13: E-R Model for User Accounts Module

Rectangles show entity set and ellipses show attributes of an entity. There is a one-to-one relationship between two entities. Referential dependency exists between the two entities. It means that one entity (UserPersonalInfo) contains a foreign key, which is a primary key in other entity. Designation attributes helps in identifying a particular user (Student or Teacher). Equivalent E-R diagram drawn by SQL Server 2000 is shown in Figure 4-14.

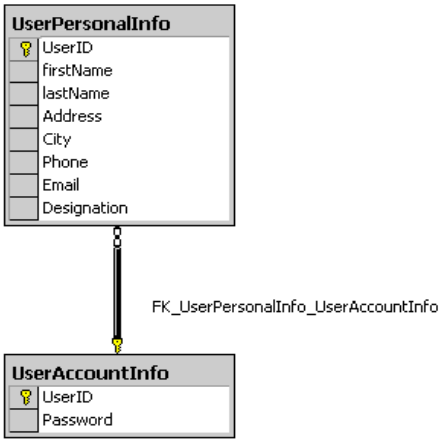

Figure 4-14: E-R Diagram in SQL Server 2000

4.4.2 Question Types

Administrator enters question types into database, which is supported by WBES. There is a table for storing question types with their abbreviation names. Graphical structure of table is shown in Figure 4-15.

Question type name is stored in first column, e.g. Multiple Choice Questions, Multiple Selection Questions etc. Short name of each question type is used as primary key for this table, e.g. MCQ (for multiple choice questions) and MSQ (for Multiple Selection Questions).

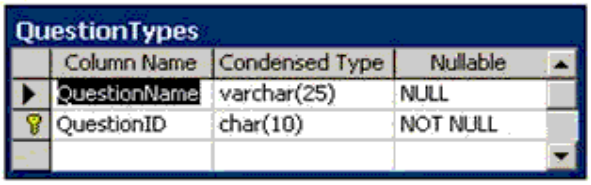

Figure 4-15: E-R Model-Question Types

4.4.3 Question Items

Teacher stores question items of different categories into database. There is a common table, which stores some common information for every type of question. Detailed information for every type of question is stored in separate tables. E-R diagram for this particular case is drawn in SQL Server 2000 as shown in Figure 4-16. There is a table for every type of question, which has a foreign key relationship with a common table.

Figure 4-16 illustrates that there is a relationship of generalization between the tables. The concept of generalization is to create a separate table, having the common attributes e.g. The higher level entity (commonT) has the common attributes (qID, qShort, Level, SubjName, SubjCode, format and techerID) of different specialized entities (e.g. MCQ, MSQ, FIB etc), and separate tables for each of specialized entities

with their own descriptive attributes and only primary key attributes of the higher level entity.

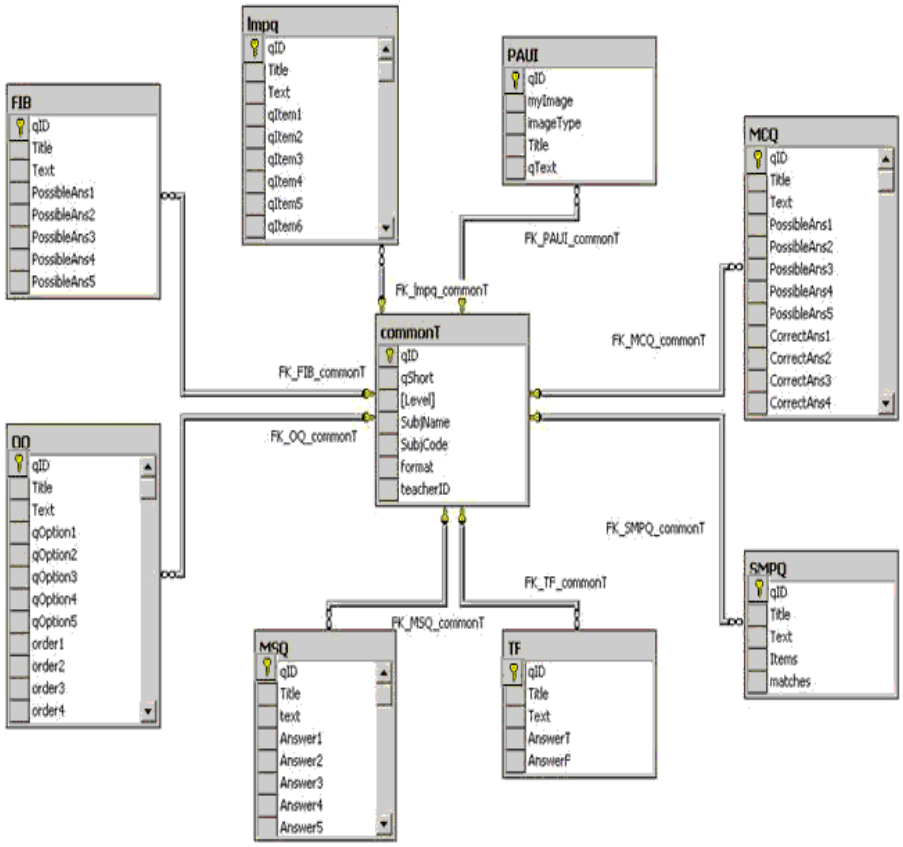

Figure 4-16: E-R Diagram for Question Items Module

4.4.4 Exam Settings

Administrator adds new exam/test settings into the database. Information required for this purpose is stored in the form of tables. There are two tables involved in this case, ExamSettings Table and Exams Table. ExamSettings table contains common information for each new exam/test. Primary key which is used in this table is examID. Exams Table is used to store further detailed information about the new exam/test. There is a foreign key relationship between these two tables. The E-R model for this module is shown in Figure 4-17.

The Figure 4-17 illustrates that there is a relationship of generalization between the tables. The concept of generalization is to create a separate table, having the common attributes e.g. Higher level entity (ExamSettings) has common attributes (examID, examTitle, examInstructions, maxTime), and separate tables for each of the specialized entities (e.g. Exams) with their own descriptive attributes and only primary key attributes of higher level entity.

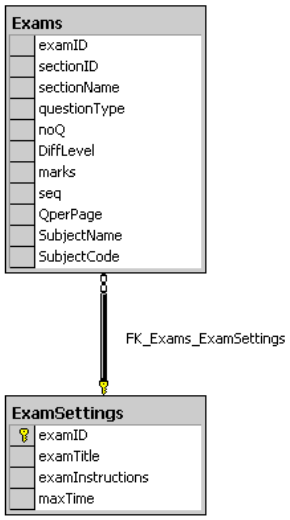

Figure 4-17: E-R Module for Exam Settings

4.5 WBES Implementation

When detailed design with database design of proposed system is available, implementation phase starts. In the implementation phase, design is converted into actual source code. This process is completed by using various programming languages and scripting languages. In case of WBES, VB.NET is used as a source language for writing code. .NET platform is used as a tool for writing the code. In this chapter, implementation of different modules of system is discussed. Screen shots of functionalities are displayed in Annexure B.

4.6 Database Connectivity

As mentioned earlier that this is the project of web technologies, so database connectivity with ASP.NET was the critical step. ADO.NET objects are used for connection establishment, data access and other operations on data source. In this section, an overview to the ADO.NET objects, which are used in the source code of project, is given.

ADO.NET objects are provided by using two methods. First method is provided by OLE DB Providers and second method is provided by standard SQL Server. Both methods work almost exactly same way; the only difference is that classes designed for SQL Server bypass the OLE DB layer, and provide better performance. In project implementation, the objects provided by OLE DB are used for the database operations.

Before accessing data from the data source, a connection is established with data source. An ADO.NET object, OleDbConnection, is used for this purpose. A connection string property of this object is specified [23]. Connection string is a series of distinct pieces of information, separated by semicolons.

After establishing connection, various operations are performed. Data is inserted, fetched, deleted or updated into database. ADO.NET provides a command object to execute a SQL Statement. This object represents a SQL Statement. Before executing command object, SQL statement is specified.

To retrieve information in a set of rows, DataReader is used. It is an ADO.NET object that quickly retrieves all information. It uses a live connection. After using DataReader, it must be closed. DataSet and DataAdapter are the core objects of ADO.NET. DataSet class stores disconnection information drawn from a database and allows a programmer to manipulate it as a single, neatly packaged object. DataAdapter is a bridge between command object and DataSet Object.

DataAdapter retrieves information from data source and fills DataSet with that information. DataSet is used in project in some cases where a large amount of information is used by a large number of users e.g. in case of unique paper generation, a dataset is created for test, which is accessed by the student.

In next section, important functionalities of WBES are described.

4.7 Add User Account

This is an important functionality. Administrator enters account information and personal information of a user (Student and Teacher) into the database. WBES provides a user friendly interface to the administrator.

Important point in this functionality is that password is stored in an encrypted form into database.

4.8 Remove User Account

Administrator selects an option Remove User Account from Admin Section. A new web form is displayed to administrator.

Administrator can remove existing user account information from database. Administrator selects a designation and selects a search option. When administrator clicks on Search Button, a Combo List and a detailed information chart about the user is displayed. Administrator selects a user from list box and presses delete button. All information of selected user is deleted from database.

4.9 Add Question Type

Administrator can add the question type into the database. These question types will be available to teachers at the development time. The WBES displays a List of supported question types. Administrator selects a question type from list and presses Save Button. When administrator presses save button, a static list of entering question

types will be displayed. Similarly, administrator can remove a question type from the database.

4.10 User Login

It is the most basic functionality for authentication of users. User enters user ID and the password to execute this functionality. User ID and password are matched with information placed in database. If the user ID and password are confirmed from the database, the system will allow user to enter in his requested section. Otherwise, a message will be displayed informing user that either his user ID and/or password are incorrect. User will be given two more chances for entering the correct user ID and password. If user enters incorrect information three times, the system will send message to administrator for an unauthorized person trying to enter in the system.

4.11 Question Items Addition and Modification

Teacher can add question items into test bank easily. WBES provides an easy to use interface to teachers for this purpose. Teacher selects an option Add Question Items from development section. System browses user to page. Teacher selects a question type from Combo list. System will open another page corresponding to selected question type. Teacher enters information of a question item into form and submits form. There are different editors for each type of question. Suppose teacher selects Multiple Choice Questions (MCS), then MCQ editor will be opened. Similarly teacher can enter other question types into their respective forms.

Teacher can also modify existing question items from database. Teacher must follow following steps before modifying existing question items.

When teacher clicks on an option Modify Question Items, a new web page will be opened with searching options. Teacher selects question type, difficulty level and subject name from Combo lists available. Question Items Viewer will be opened.

Teacher selects a particular question item and clicks on the “Details” Button to see the details of question item. Teacher can view 10 question items per page. Question editor will be opened again. All the fields in form are filled with existing information of that particular question item. Teacher can change required information and submits form.

4.12 Unique Paper Generation

Most important and difficult functionality of system is delivery of exam/test. The paper or test is unique for each student. It means that difficulty level of question types is same for each student but order of questions numbering is random. System informs student about latest exam that is going to be started on that day. Student selects a test. System browses student to login page. Student enters his ID and password. Instructions page of exam/test will be opened. Student starts test by clicking on button at the given time. Student reads exam instructions before starting exam. Exam title and student name are displayed in this interface. When student starts test, first section will be displayed to him. Student starts test and selects appropriate correct answers. After finishing this section, system will show next section to student. During this period, system evaluates all answers of first section attempted by the student.

4.13 Report Generation

At the end of the exam, system will show final report to the student. Report provides student total marks obtained, percentage and grade. When student clicks on button “Exam Details”, a new table will be displayed to student. This new table shows detailed information about sections (parts) of test.

4.14 Conclusion

This chapter describes requirement analysis and design phase of WBES. The complete picture of the system is depicted in this phase. Using UML diagrams, system’s functionality is described. Class diagrams, their relationships and ER

diagrams present foundation for the implementation. A brief preview of WBES implementation is then presented. The basic functionality of the system is described. The system interface is user friendly and any person who can operate computer can easily performed his desired task.

Chapter 5

System Testing

5.1 Introduction

This chapter explains testing process applied to proposed system and outcomes of this process. System testing is an essential step for development of a reliable and error-free system. Testing is process of executing a program with explicit intention of finding errors i.e., test cases are devised with this purpose in mind. A test case is a set of data items that system processes as normal input. A successful test is one that does find an error. There are two main parts covered in this chapter. First section of this chapter covers the introduction to the testing process. Second part covers the two types of testing, which are performed on WBES. Module testing involves the testing of few important system functionalities. System performance testing shows performance of the application on increasing load of users.

5.2 Testing

Testing is the process of exercising or evaluating a system or system component by manual or automated means to verify that it satisfies specified requirements or to identify differences between expected and actual results. Testing is exposure of a system to trial input to see whether it produces correct output [24].

5.2.1 Purpose of Testing

It reduces cost of developing the program. Minimal savings that might occur in early stages of development cycle by delaying testing efforts are almost certainly bound to increase development costs later. Common estimates indicate that a problem that goes undetected and unfixed until a program is actually in operation can be 40 – 100 times more expensive to resolve than resolving the problem early in the development cycle.

It ensures that application behaves exactly it is explained to user. For vast majority of programs, unpredictability is least desirable consequence of using an application. It reduces total cost of ownership. It develops customer loyalty and word-of-mouth market share. Finding success with a program that offers kind of quality that only thorough testing can provide is much easier than trying to build a customer base on buggy and defect-riddled code [24].

5.3 Testing Process

The Testing Process can obtain a valid value from the functional domain (or invalid one from outside the functional domain). Determine the expected behavior. Execute the program. Observe its behavior. Compare obtained and expected behavior. If the expected and the actual behavior agree, then the test case has succeeded, else the test case has uncovered an error.

5.4 Unit Testing

The primary goal of unit testing is to take the smallest piece of testable software in the application, isolate it from the remainder of the code, and determine whether it behaves exactly as it is expected. Each unit is tested separately before integrating them into modules to test the interfaces between modules. Unit testing has proven its value in that a large percentage of defects are identified during its use [25].

The most common approach to unit testing requires drivers and stubs to be written. The driver simulates a calling unit and the stub simulates a called unit. Even though the drivers and stubs cost time and money, unit testing provides some undeniable advantages. It allows for automation of the testing process, reduces difficulties of discovering errors contained in more complex pieces of the application, and test coverage is often enhanced because attention is given to each unit.

For example, there are two units and it is decided that there would be more cost effective to glue them together and initially test them as an integrated unit, an error could occur in a variety of places, error due to a defect in unit 1; error due to a defect in unit 2; error due to defects in both units; error due to a defect in the interface between the units or the error due to a defect in the test.

Finding the error (or errors) in the integrated module is much more complicated than first isolating the units, testing each, then integrating them and testing the whole.

5.5 Test Cases

Following are some important test cases, which were prepared for testing the system. Purpose of each test case, steps involved in performing each test case and some useful comments about each test case are given.

5.5.1 Test Case: For Login User

It is used to verify the login name and password of the user for the User Login Page. These steps are involved in the testing, enter the user name; enter the password; verifying user name and password from the database relation and entering user account main page.

If user name does not match with the name present in the database, there will be message displayed to the user, *"Invalid User Name! Try Again"*.

If password does not match with the password present in the database, there will be message displayed to the user, *"Invalid Password! Try Again"*.

5.5.2 Test Cases: Add User Account

There are few test cases for this functionality. A web form is displayed to the administrator. The administrator enters different input values into the text fields.

5.5.2.1 Test Case 1: User ID

This test case is used to verify the whether the user ID input is correct or incorrect.

Steps involved in the testing are to enter the User ID into the text field and system checks the User ID. If the User ID contains letters, numbers or underscore, it is valid otherwise the system will show an error message, "*User ID contains only letters, numbers or underscore"*.

5.5.2.2 Test Case 2: Password Length

It is used to check the password length. (It must be less or equal to the length of 15 characters). Steps involved in the testing are to enter the Password into the Password field and system checks the Password length. If the Password length exceeds the required limit, the system will show an error message, "*Password must be less than or equal to the length of 15 characters"*.

5.5.2.3 Test Case 3: Password Matching

It is used to match the passwords from two password fields. Steps involved in the testing are to enter the Password into the Password field, to enter the password into the Re-Type Password field and the system matches both passwords. If the first password does not match with the second password, the system will show an error message, "*Your Password does not match"*.

5.5.2.4 Test Case 4: Phone Format

It is used to check the format of user phone number. Steps involved in the testing are to enter the phone number; system checks the phone number against the given format (092-051-2290180). If the phone number does not match with the given phone format the system will show an error message, "*Invalid phone format"*.

5.5.2.5 Test Case 5: Email Format

It is used to check the format of user an Email address. Steps involved in the testing are to enter the Phone number and system checks the phone number against the given

format (emailID@domain.com). If the email address does not match with the given email format the system will show an error message, *"Invalid Email format"*.

5.5.2.6 Test Case 6: Blank Fields

It is used to check the blank fields of the form. There are two types of fields in the form. The administrator must fill the required fields. The optional fields are not necessary to fill. If the administrator leaves any required field blank, the system will show an error message to the administrator. Suppose the administrator leaves all the required fields blank, then the system response is shown in Figure 5-1.

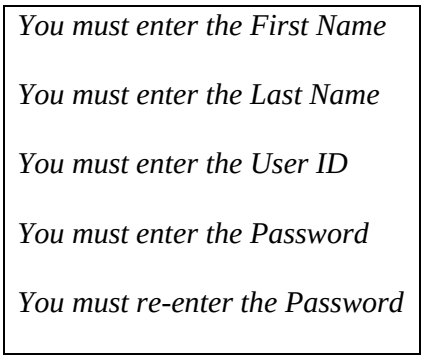

Figure 5-1: Systems Response for Blank Fields

5.5.3 Test Case: Search Users

It is used to check whether the user(s) exits in the database. Steps involved in the testing are administrator selects an option from the Combo list and presses the Search button; system searches the user(s) into the database against the selected option. If the system does not find any user(s) against the selected option, the system will show a message to the administrator, *"No User(s) Found"*.

5.5.4 Test Case: For Add Question Items

There are few test cases for this functionality. A web form is displayed to the teacher for entering the information about a specific question type.

5.5.4.1 Test Case 1: Range of Difficulty Level

It is used to check whether difficulty level in the range (1-3). Steps involved in the testing are, teacher enters the difficulty level into the given text field; system checks the range of the input difficulty level against the specified range. If the difficulty level does not in the specified range, the system will show an error message to the teacher, "*Difficulty Level is not in the range"*.

5.5.4.2 Test Case 2: Subject Code

It is use to check whether the subject code is correct or not. Steps involved in the testing are, teacher enters the subject code into the given text field; system checks the input subject code. If the subject code contains any value other than a letter, the system will show an error message to the teacher, "*Subject Code must be in letters (not in digit)"*.

5.5.4.3 Test Case 3: Select Coordinates of Image for PAUI

It is used to count the number of coordinates for a specific shape of the area on image. Steps involved in the testing are, system displays the image to the teacher; teacher selects a specific shape (Rectangle or Circle) for the area of correct answer; system counts the number coordinates selected by the teacher. Suppose the teacher selects the Rectangle Shape for the area. If the teacher selects more than two coordinates for a rectangular area, the system will show an error message to the teacher, "*Alert! You must select only 2 points for a rectangular shape. ! Select Again"*.

5.5.5 Test Case: Unique Paper for Each Student

The system generates a unique a paper for each student. Suppose there are 10 students taking the exam/test of Computer Fundamentals on different client machines. When the students start the test, the system will display the same first section (question type) to the students but the question items order will be different for each student. This test works well on increasing the load of students from 10 to 50 or more.

5.6 Performance Testing

Performance testing is a process of measuring and understanding how the application responds under different user load conditions. Besides getting a qualitative analysis of application performance, it is also important to get quantitative measurements. These measurements help to analyze problem and even determine how to fix them properly.

During the performance testing process, it is important to monitor the application for certain errors or performance issues that may occur only under user loads. This helps to identify subtle bugs within the application that might not otherwise be detected until the application is deployed. Monitoring also helps to identify the effects of application changes during the process.

An important step in the performance testing process is identifying the targeted user load. Also, the load variance in the testing must be accounted for. Most applications do not have a constant load. In these cases, the performance test must simulate the peak user load rather than the average user load.

The performance of an ASP.NET application can be measured by its latency, throughput, and utilization metrics. All performance metrics (measures of performance) are based on system behavior over time.

Latency is the delay between the start and end of an operation (or between the request and the response). An application that exhibits a lower latency is always desired. In many Web performance tools, latency is represented by the metric Time to Last Byte (TTLB), which measures the delay between sending out a page request and receiving the last be of the page response. Another important metric is the Time to First Byte (TTFB), which measures the delay between sending a page request and receiving the first byte of the response. Both the size of the page response and the network latency affect TTFB.

Throughput, or capacity, measures the amount of work done per unit time, or the rate at which responses arrive. Throughput is the rate at which requests can be serviced. Throughput metrics can be measured in units of inverse time. In ASP.NET applications, throughput is the number of GET or POST requests per second, or simply the requests per second (RPS). Throughput is one of the more useful metrics, playing an important role in helping to identify performance bottlenecks.

Resource utilization, or simply utilization, is a measure of the percentage of available resources (system components, such as the CPU, memory, or data link) consumed by the application. Utilization is a percentile between 0 and 100 percent. When a system component reaches 100-percent utilization, it can no longer perform any additional tasks and will therefore become the performance bottleneck for the system. As a practical matter, latency increases rapidly as utilization approaches 100 percent so that many systems are designed to keep utilization below some threshold such as 70 percent or 80 percent. If a system component's utilization becomes the performance bottleneck, then an option to improving performance is to upgrade the system component to a higher capacity.

There are different tests for measuring the performance of a web application. Most basics tests use a dedicated server, a set of dedicated client machines that are interacting with the web server over a fast isolated network, and a load generating tool, that runs on the client machine. The load generating tool automatically requests the steady stream of pages, simulating a heavy load. There are different tools used for performance testing. The two most important tools are Application Center Test (It is included in Visual Studio .NET) and Web Service Applications Stress Tool (WAST). These tools generate the text summaries of the tests.

The load or stress test is the most common performance test because it is the most versatile. The load test measures the latency, throughput, and resource utilization at varying user loads. The goal of load testing is not only to gather metrics to describe the performance characteristics of the application but also to determine the limit of its performance. In essence, the goal is to crash the application by increasing the user load past performance degradation until the application begins to fail because of resource utilization or the occurrence of errors. Analyzing the results of the stress test will help to uncover bugs that would otherwise go undetected until the application was deployed. Because performance bugs are typically the result of design flaws, stress testing should begin early in the development phase on each area of the application.

Microsoft's stress testing tool is Application Center Test (ACT). ACT is included in the Visual Studio .NET Enterprise Developer and Architect Editions. ACT tests Web servers and analyzes performance and scalability problems with Web applications. ACT is a successor to the original Web Application Stress Tool (WAS), informally referred to as Homer. ACT supports many of the features left out of WAS by providing greater control in the test scripting interface and a more robust feature list.

5.6.1 Test 1: Interaction of Teachers with System

This test is used to determine the performance of the application, when a group of teachers interact with the application. This test is developed using the Application Center Test. The results are taken after getting 3 tests with the different number of browser connections.

The test is repeated for three times by changing the number of teachers from 5 to 15. At first time 5 teachers interact with the application. At the second time, 10

teachers interact with the application and similarly at the 3rd time 15 teachers interact with the applications. The General Report, which is generated using 3 tests by ACT, is shown in Table 5-1.

5.6.1.1 Description of Table

Table 7-1 provides some of the performance data of the test run, such as the requests per second that the Web server was able to handle, as well as the duration of the test and the total number of requests sent. Poorly formed URLs or invalid server names or port numbers can cause connection problems and other network errors. Under periods of intense load, the Web server will often begin to reject a portion of the new connections clients attempt to create. Under heavy loads, the Time to serve the Last Byte (TTLB) value will increase, often to the point where connection time-outs may occur for slower web applications.

Response codes should all be in the 200 range. Response codes in the 400 range indicate client errors, while numbers in the 500 range indicate server errors. 404 response codes could be due to missing content on the Web server or errors in the test requests.

Table 5-1: General Report of Teacher Test

Properties

	(1)	**(2)**	**(3)**
Test type:	Dynamic	Dynamic	Dynamic
Simultaneous browser connections:	15	10	5
Warm up time (secs):	0	0	0
Test duration:	00:00:02:00	00:00:02:00	00:00:02:00
Test iterations:	4,695	4,754	4,779
Detailed test results generated:	Yes	Yes	Yes

Summary

	(1)	(2)	(3)
Total number of requests:	4,321	4,635	4,708
Total number of connections:	4,434	4,752	4,779
Average requests per second:	36.01	38.62	39.23
Average time to first byte (msecs):	71.63	65.87	36.16
Average time to last byte (msecs):	71.84	66.03	36.33
Average time to last byte per iteration (msecs):	66.11	64.38	35.79
Number of unique requests made in test:	1	1	1
Number of unique response codes:	1	2	1

Errors Counts

	(1)	(2)	(3)
HTTP:	0	4	0
DNS:	0	0	0
Socket:	376	119	72

Additional Network Statistics

	(1)	(2)	(3)
Average bandwidth (bytes/sec):	127,280.16	136,614.94	138,693.43
Number of bytes sent (bytes):	5,266,346	5,650,416	5,740,808
Number of bytes received (bytes):	10,007,273	10,743,377	10,902,404
Average rate of sent bytes (bytes/sec):	43,886.22	47,086.80	47,840.07
Average rate of received bytes (bytes/sec):	83,393.94	89,528.14	90,853.37
Number of connection errors:	261	2	0
Number of send errors:	2	0	1
Number of receive errors:	113	117	71
Number of timeout errors:	0	0	0

Response Codes

	(1)	(2)	(3)
Response Code: 403 - The server understood the request, but is refusing to fulfill it.			
Count:	-	4	-
Percent (%):	-	0.09	-
Response Code: 200 - The request completed successfully.			
Count:	4,321	4,631	4,708
Percent (%):	100.00	99.91	100.00

5.6.2 Graphs

The ACT helps in generating the graphs for the tests. Here, few graphs are shown for the multiple reports generated for the test.

5.6.3 Graph1: Connections versus Requests per Second

This graph will be useful when trying to determine the maximum number of requests per second that the Web server can handle. When all test runs are completed, a graph is created with the number of simultaneous connections plotted on the horizontal axis, and Request per Seconds (RPS) on the vertical axis. Graph is shown in Figure 5-2.

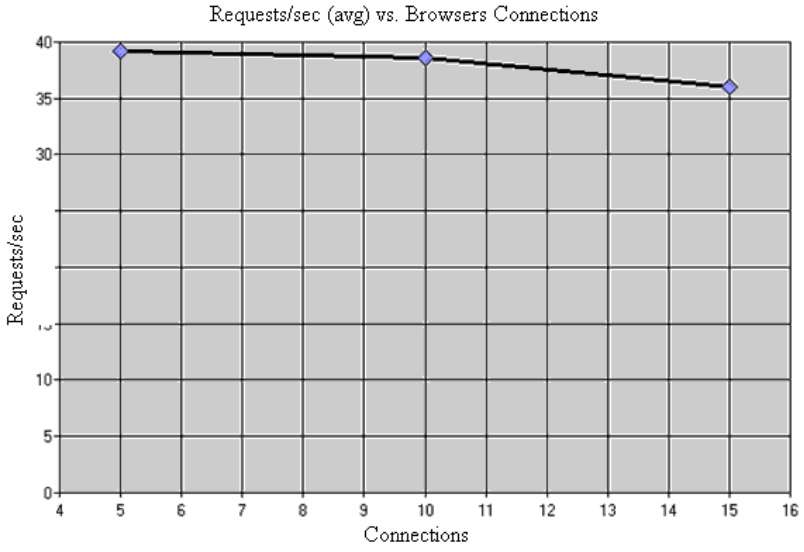

Figure 5-2: Graph b/w Connections and Request/secs

Many web applications will experience increased RPS values up to a certain point, and will then begin to show lower RPS values as the number of connections increases beyond the number that the web server is able to handle. From this, one will be able to determine the number of simultaneous browser connections that produces the optimum number of requests per second. As the number of simultaneous connections increases above this optimum value, one can expect the web site to process fewer requests per second.

5.6.4 Graph2: Connections versus Time to Serve the Last Byte (TTLB)

This graph is useful when trying to quantify how much the performance decreases when the number of simultaneous connections increases. The data for this graph is also created by running a series of tests using an increasing number of simultaneous connections for each test run. The graph is shown in Figure 5-3.

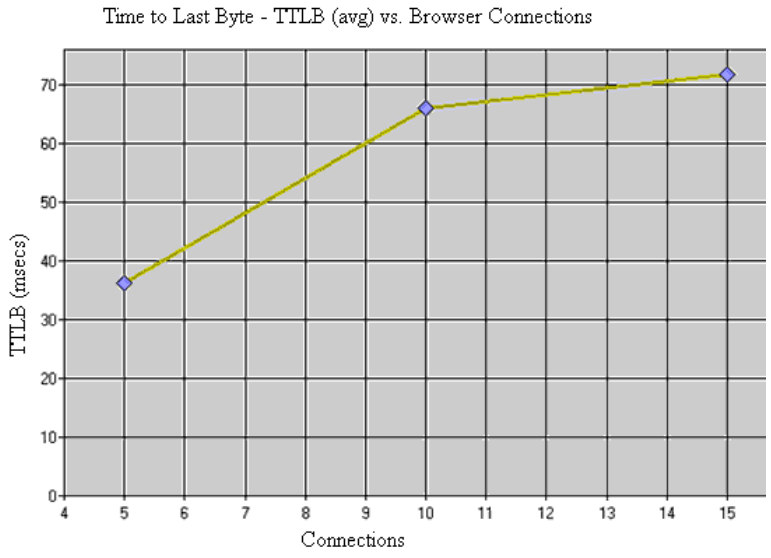

Figure 5-3: Graph of TTLB v/s Number of Connections

As the number of connections increases, the TTLB values will usually show a gradual increase. It means that as the number of teachers and simultaneous connections increases, the web server takes longer to complete each response.

The time to serve the last byte (TTLB) value for a page measures how long it takes for the last part of a Web server's response stream to reach the user's Web browser. As the TTLB increases, the site will seem slower and less responsive to users.

5.7 Interaction of Students with System

This test is the most important one. The system is tested by increasing the number of students which are ready to take the exam/test simultaneously. This test is completed by taking 3 reports. The first report is generated using 50 students. The second report is generated using 100 students and the third report is generated using 150 students. The general report of this test has the same format as discussed in the last test.

5.7.1 Graph1: Requests per Second versus Connections

Throughput tends to increase at a linear rate as the user load increases. However, at a certain user load, the maximum throughput for the system will be reached. Additional users on the system will decrease the number of requests serviced, resulting in a decreased throughput. An application must support the maximum number of users serviced while still providing adequate performance to meet the business requirements. The graph is shown in Figure 5-4.

Throughput metrics are highly dependent on the complexities of an application. A highly dynamic Web application would have different throughput metrics than a Web application serving static Hypertext Markup Language (HTML) pages. As such, comparing throughput metrics between different Web applications does not provide much information. However, comparing throughput metrics for the same

application will provide valuable information about how changes in the application have affected its performance.

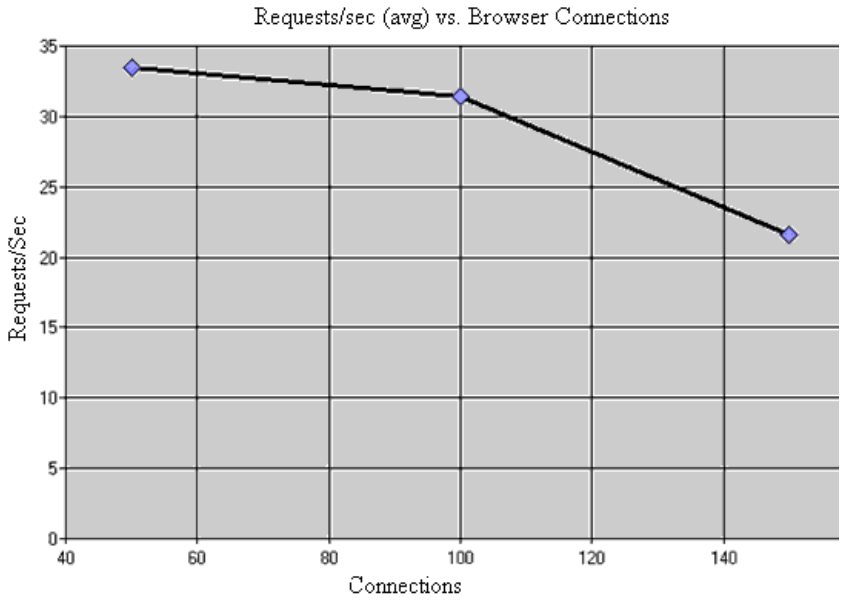

Figure 5-4: Requests per Second versus Connections

5.7.2 Graph2: Time to Last Byte versus Connections

In most applications, latency is linearly proportional to the user load within a range of user loads. In this range, as the user load increases, the latency will proportionally increase. This occurs when the application is in a steady-state, where performance techniques such as connection pooling and caching are in full swing with a set of multiple users. Typically, the sudden increase in latency is an indication of the system meeting a performance limit on one of its resources. Web servers commonly encounter this scenario when the number of requests exceeds the maximum number of concurrent sessions available. When this maximum is met, any additional requests will be placed in a queue and handled as sessions become available. The time spent in the queue contributes to the increase in latency. The graph is shown in Figure 5-5.

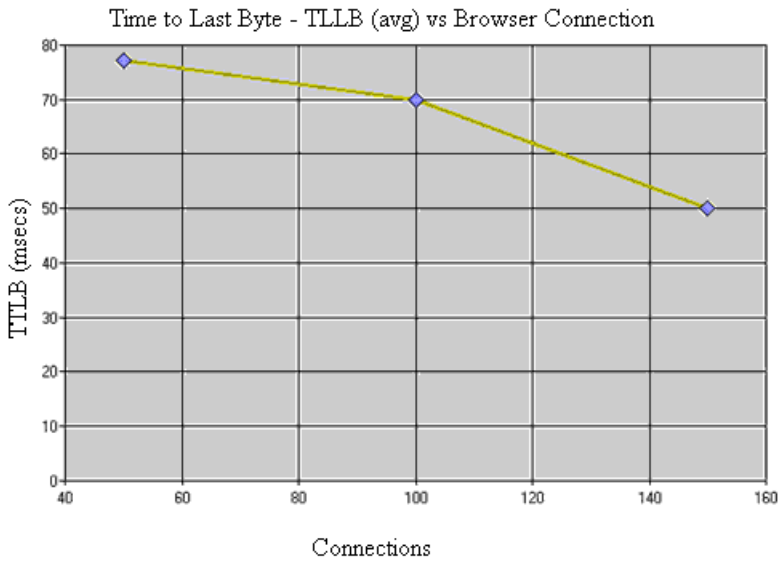

Figure 5-5: TTLB versus Connections

5.8 Conclusion

In this chapter different steps involved in testing of WBES are discussed. Module testing and performance testing of the application on increasing load of users is carried out. Performance testing is a necessary task to understand the limits of an application. Latency, throughput, and utilization help to quantify the performance of an application. Analysis of the metrics behind these concepts helps to draw conclusions about the software and hardware performance bottlenecks. The ACT tool provides a means to test, capture, and analyze performance metrics of an ASP.NET application. Its statistical and graphical features help summarize and organize the test run results.

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Chapter 6

Conclusion

6.1 Introduction

Latest concepts and studies undergoing in the field of evaluation and assessment are explored and then these are used to identify and select the question items to be implemented. Each of the question categories evaluates different types of knowledge. WBES is developed after carefully analyzing potentials, benefits, and limitations of implementing Web-based assessment in education and training. The system is designed and implemented in Object Oriented paradigm. The system Graphical user interface provides an easy way for users to interact with system. Authentication feature gives an efficient way for identification of users. System identifies question items, which are inserted by an individual teacher separately. Feature of unique paper generation is quite satisfactory in case of a large number of students. Every student gets a unique paper on demand. The automatic checking of different question types gives the accurate results in the end. The automatic generation of final report provides a better feedback to the students.

Aside from the features, which have been implemented, there are few features, which have not been implemented so far. Research on these features is required to be carried out in future projects in order to implement these features into the system.

6.2 Problems with Incomplete Features

There are few features, which have not implemented currently. In documentation, there are 12 question types, which were proposed to be developed in the system. But at this stage, there are 8 question types, which are available in the system. System provides an interface for teachers to insert questions using audio narrations (QWAN)

and questions using audio narration and illustrations (QWANI). But the system does not provide a way to display these types of questions at the delivery time to the students. Short answers questions are not difficult to implement for the teachers for inserting them into the database, but these impose certain problems when one considers their implementation details at the evaluation stage.

There may be another problem on the performance of the system. System has been tested on LAN or local PC with web server so far. When system is put into actual use, however, dozens of students will be accessing the system simultaneously, which may cause problems that have not been revealed thus far.

6.3 System Applications

Features of WBES like user accounts management, question items management, unique paper generation, automatic scoring and student reports enhance the applications of system. WBES provides a useful tool for the universities to conduct exams online due to vast availability of Internet these days. This system can be implanted in NUST, by creating a central database server and conducting exams at distant test centers. Virtual university (VU), a recent venture in the public sector, delivers the content via the television broadcast, and the reverse interaction is accomplished with the help of Internet. WBES will provide a good solution to develop an automated and highly organized examination management system for such an institution. Similarly, Allama Iqbal Open University (AIOU) has a large campus and a network of regional centers all over the country to provide the Distance Education Mode of instruction for skill oriented courses and programs. This system can be applied, in order to get fruitful results in the near future in the field of Distance Education.

WBES can also be used for general entry tests held by Medical Colleges or Engineering Universities. Finally, it can be used for general-purpose exams conducting in community colleges, trade schools, driving schools, computer skills training and certification companies.

6.4 Future Work

Number of follow-up projects can be undertaken. Before system is extended, however, more testing should be done. Testing which has done so far is exclusively on a single PC running the system, both locally and through a web server. So testing should be performed on a large scale. Since, system has not been tested with a huge question pool (e.g. with 1000 question items) in place. So, there will be a mechanism for a huge question pool management. In either case, performance should be tracked on the system once it contains thousands of questions in it.

As far as further additions to this project, there is much that can be done. A more advanced user interface can certainly improve the appearance and usability of the system. Another feature which would be an improvement to the system would be to have list of topics presented to user at the start of the test, where he or she can check off the topics they would like to be tested on.

Making additional types of questions (e.g. Short Answers, Questions using Audio Narration and Questions using audio narration and an illustration) available to the test system is a logical step in making the system more advanced. Implementation of evaluation of the short answers is more difficult. But there exists some useful research ideas for implementing this type of questions. One method can be made by producing a list of all possible answers from the single correct answer entered by the teacher. Then the teacher would validate the correct version of answers. Existing computer based testing systems do not check the short answers automatically rather

they provide a mechanism for sending an email to the concerned teachers automatically. So, there should be a complex algorithm for checking these types of questions in an efficient manner.

6.5 Conclusion

Web based testing and especially adaptive version of it, will soon be competing with and possibly replacing the paper-and pencil tests. A system in which adaptive assessments are delivered to students over internet has several advantages, including decreased testing time, enhanced security, novel item types, and rapid reporting. However, before this system can be put in place, a number of issues need to be considered, such as the psychometric quality of the measures, methods for maintaining item banks, infrastructure, human capital, costs, and comparability with paper-and-pencil measures across subject matter areas, and reporting strategies. Research is needed in all of these and other related areas to provide the foundation for a smooth and effective transition to web-based testing.

WBES presents a workable model for formative assessment. It provides overall solution to the examination system. It provides a user friendly platform of various question types to be used in assessments. The system is developed using latest analysis and design techniques. It is an object oriented design, which can be enhanced or extended in future according to requirement. It presents a concept of student evaluation by applying number of question types. All these question types measures different aspects of student knowledge and understanding. This type of interactive assessment is the demand of changing world.

Appendices

A. Class Diagrams of WBES

UML diagrams for some classes of WBES are shown in section.

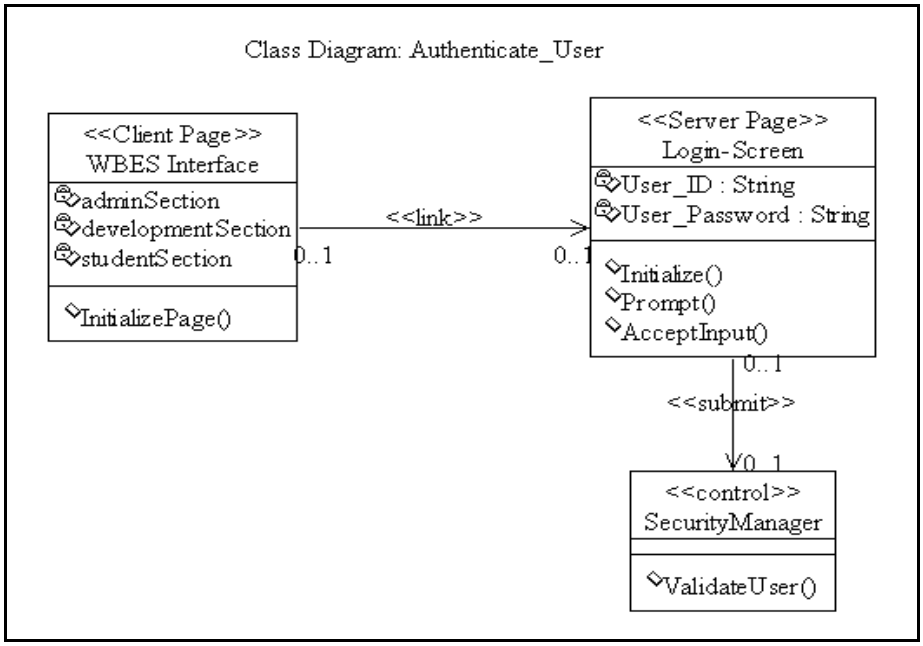

Figure A-1: Class Diagram: Authenticate User

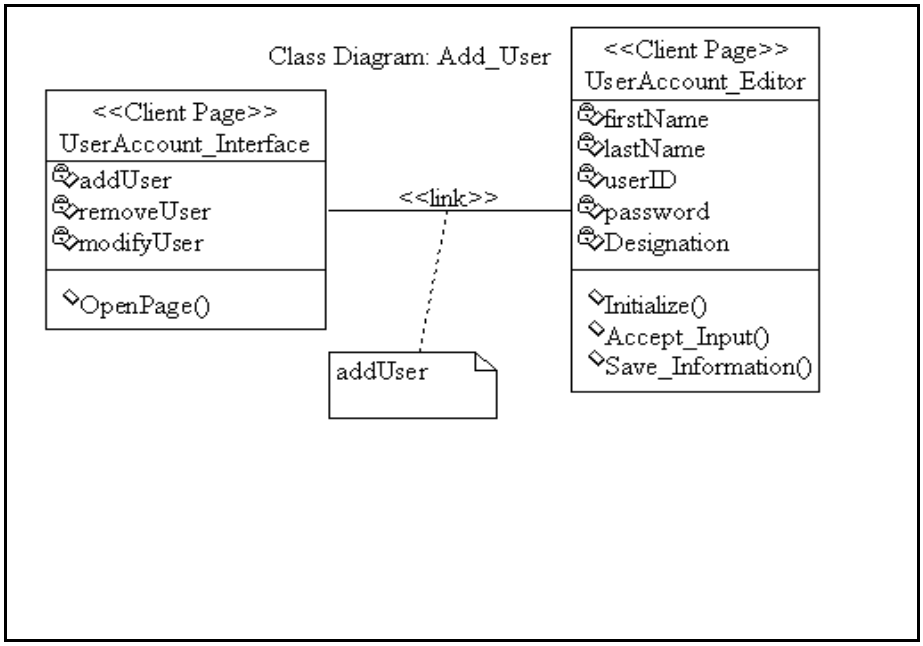

Figure A-2: Class Diagram: Add User

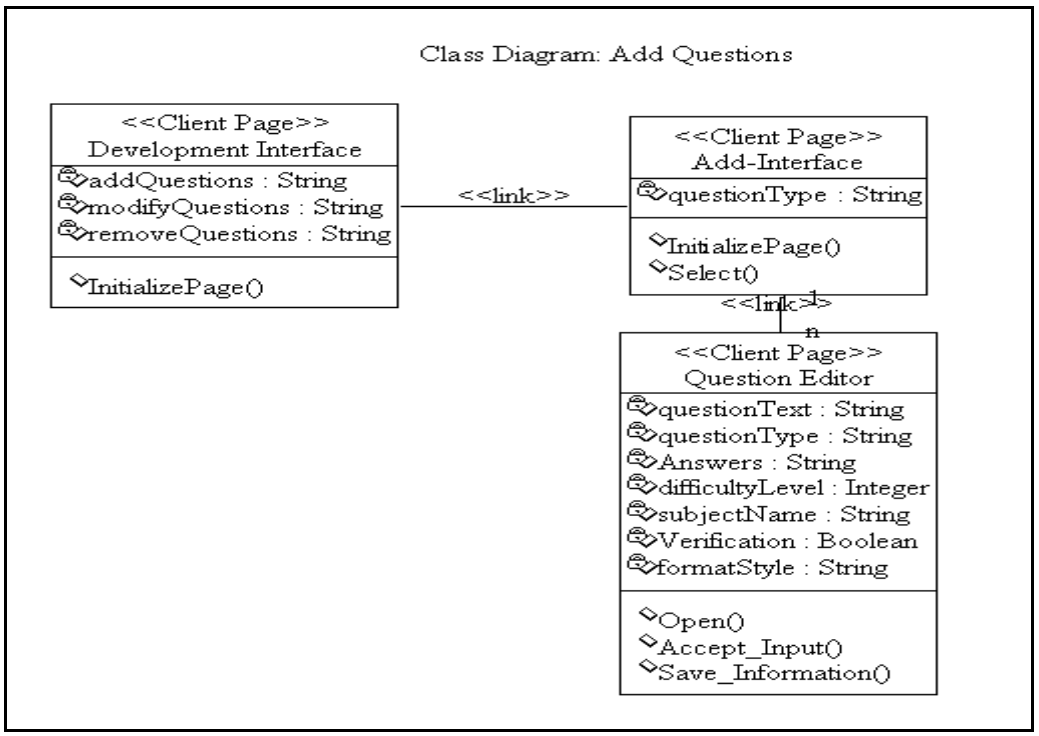

Figure A-3: Class Diagram: Add Questions

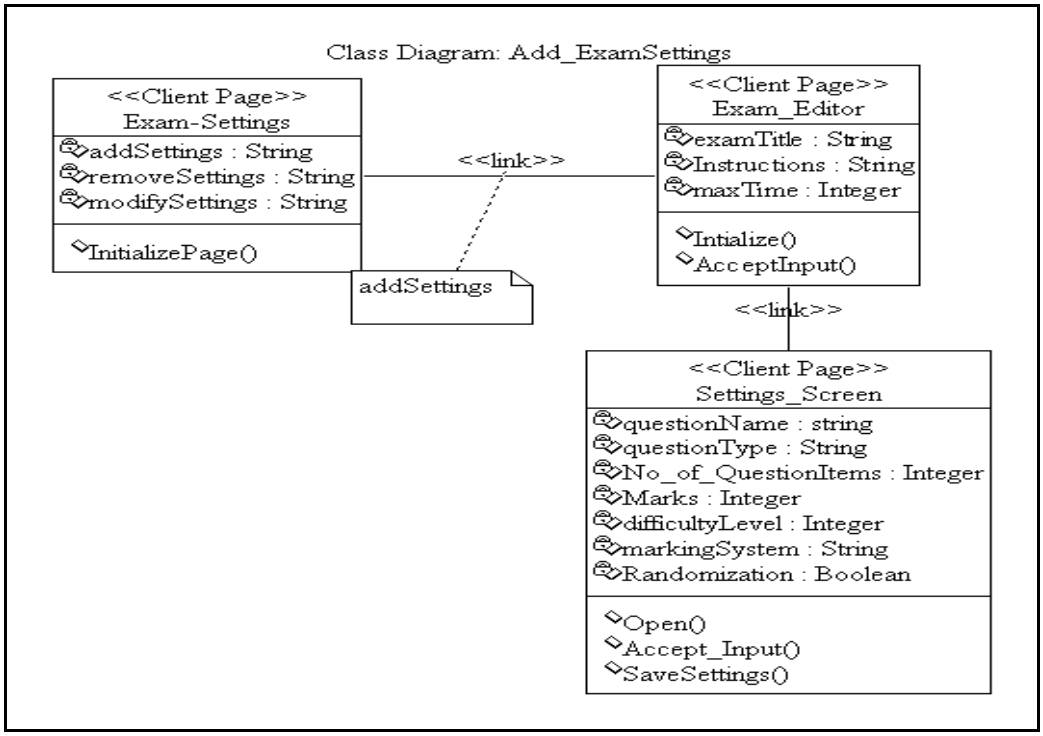

Figure A-4: Class Diagram: Add Exam Settings

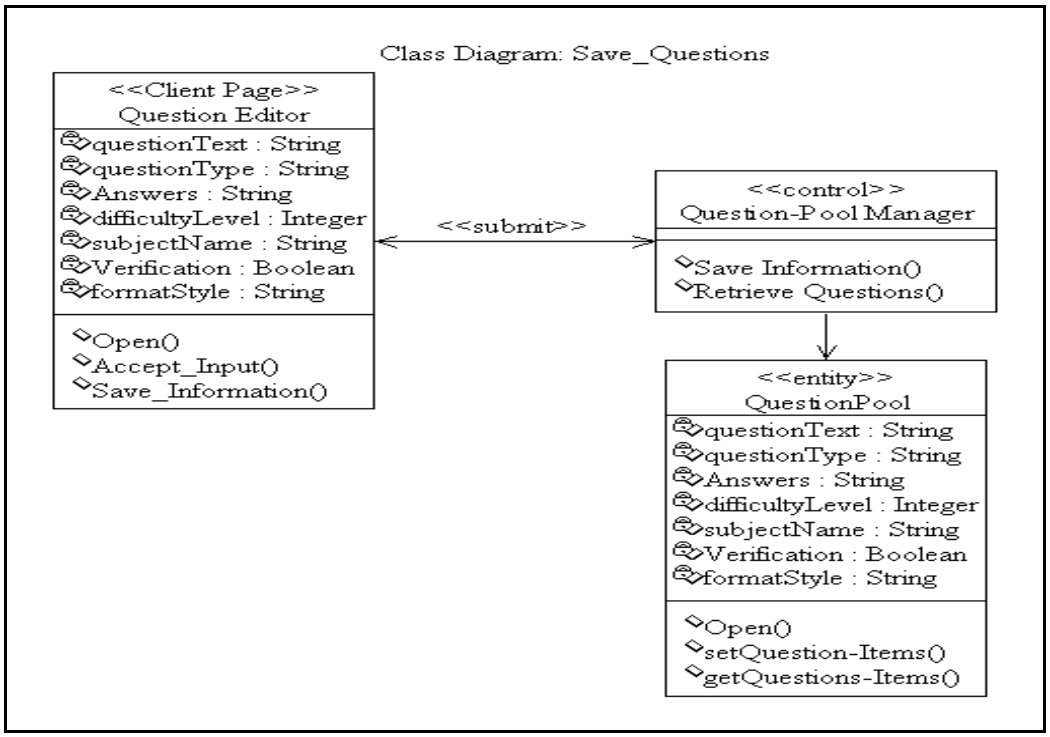

Figure A-5: Class Diagram: Save Questions

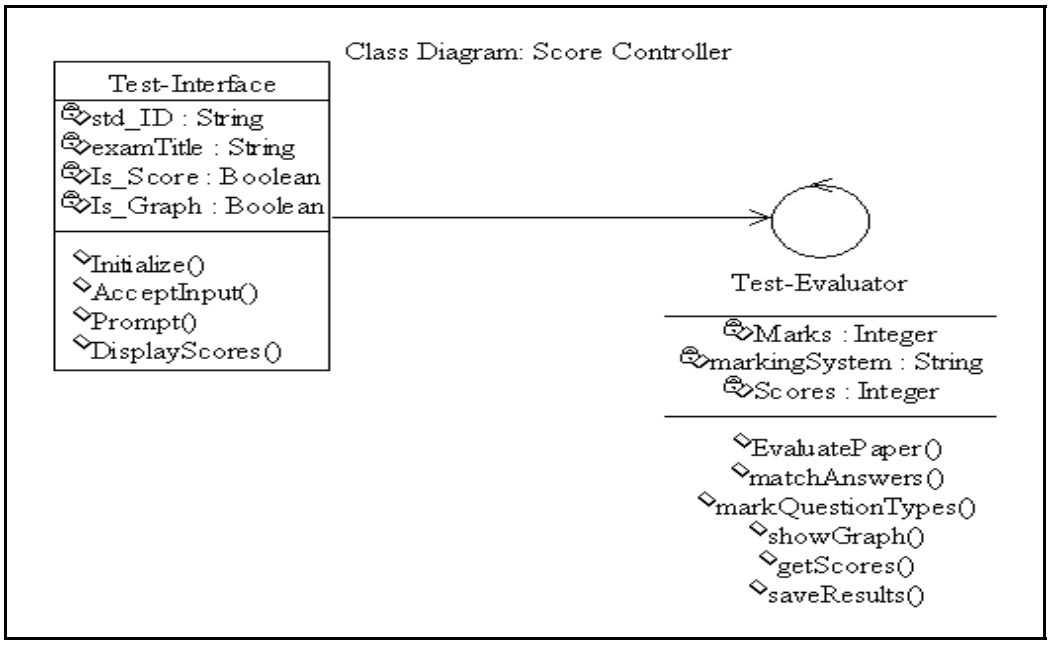

Figure A-6: Class Diagram: Score Controller

B. WBES Interfaces

In next section, screen shots of important functionalities of WBES are displayed.

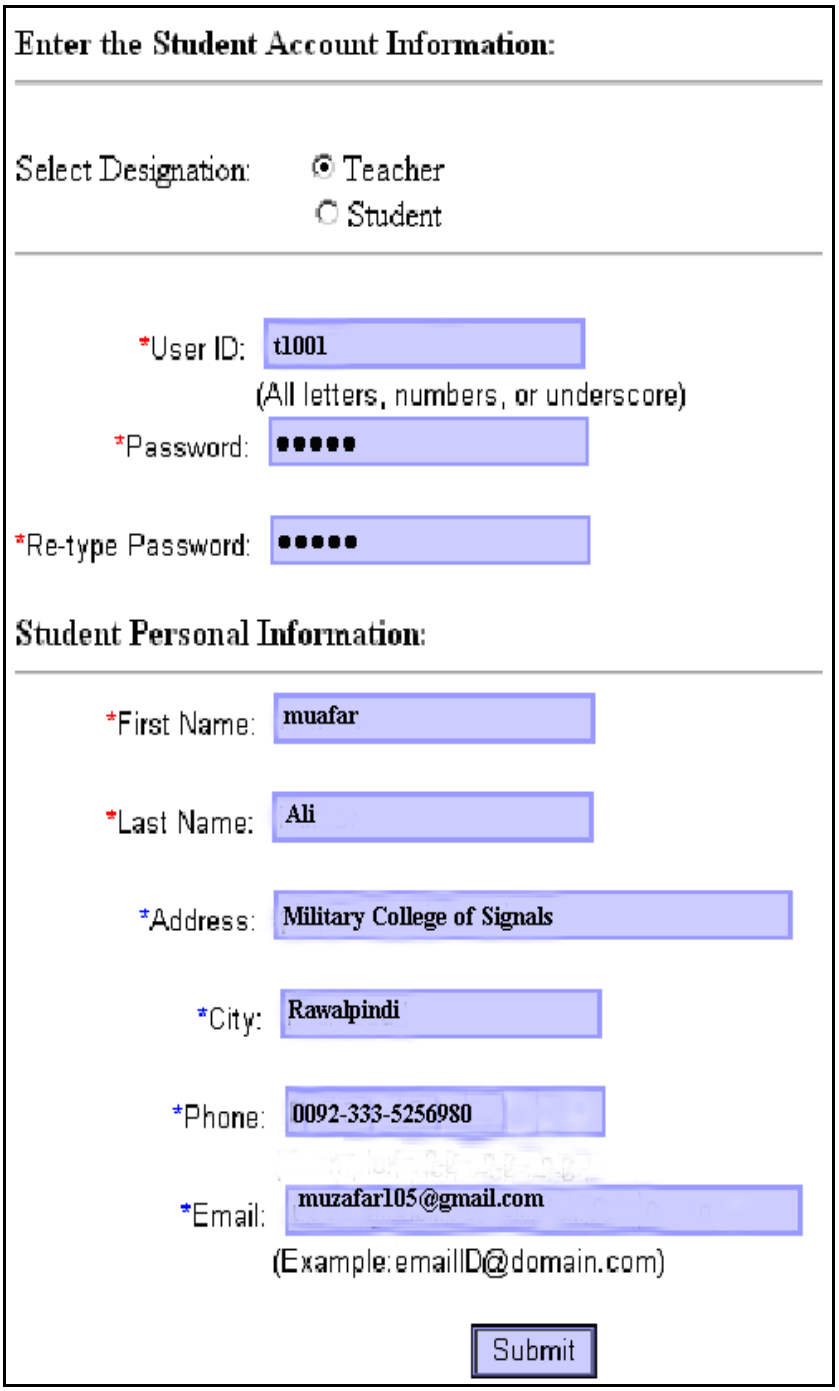

Figure B-7: Add User Account Interface

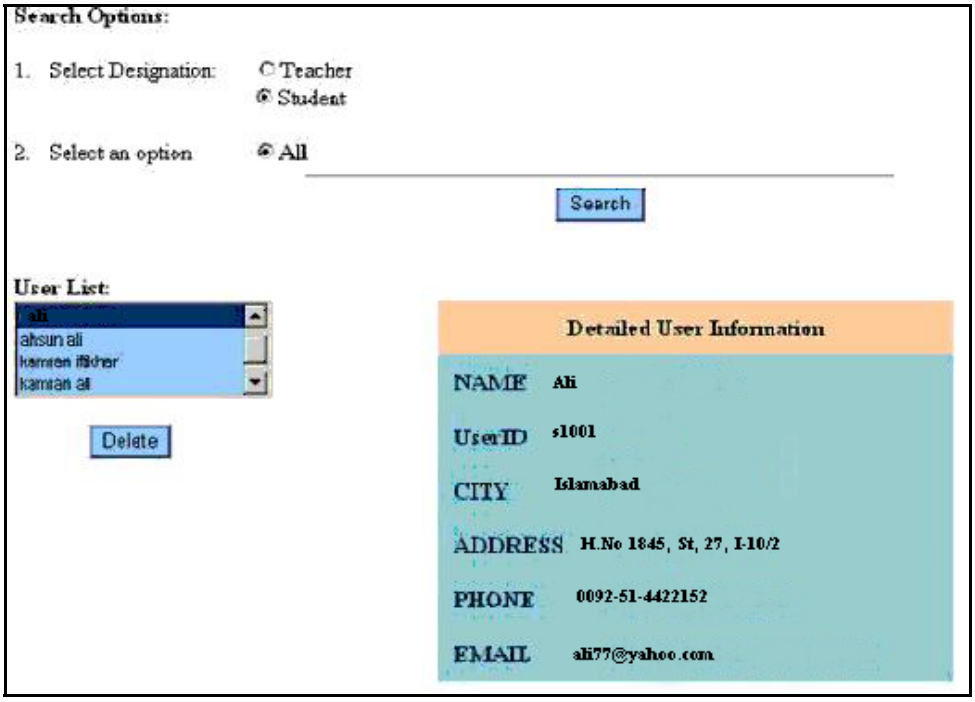

Figure B-8: User Account

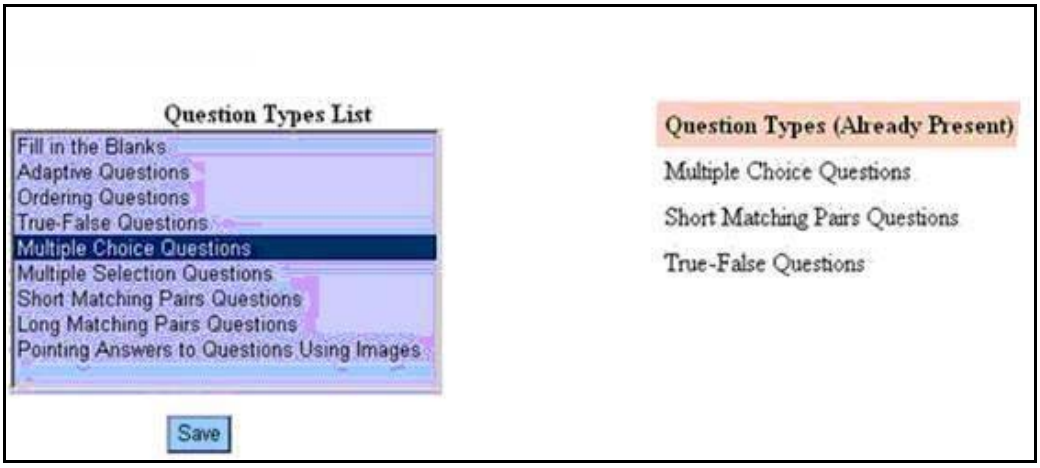

Figure B-9: Question Type

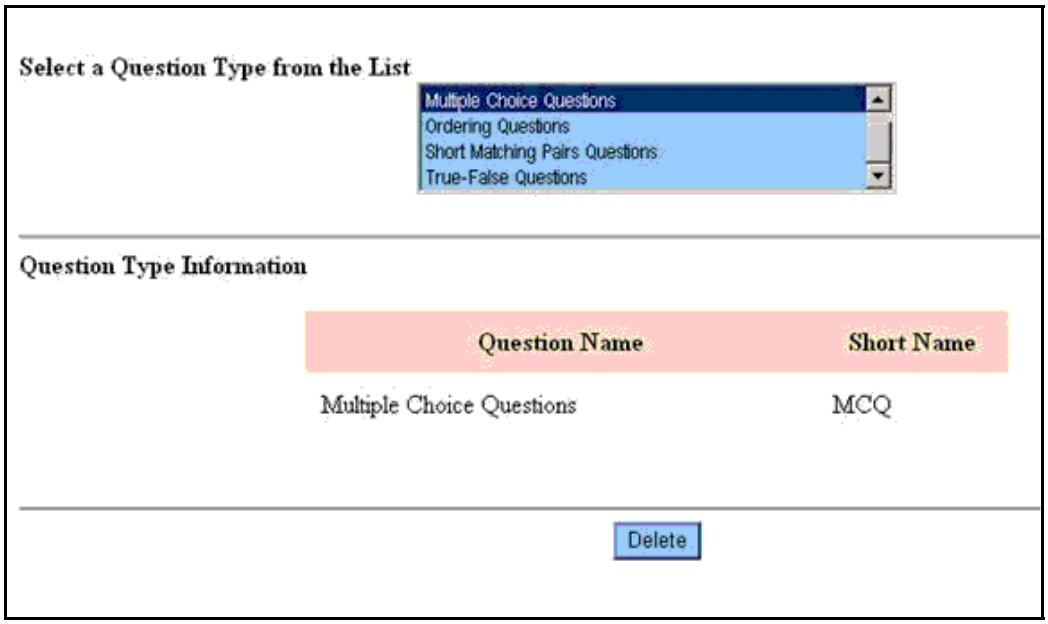

Figure B-10: Remove Question Type Interface

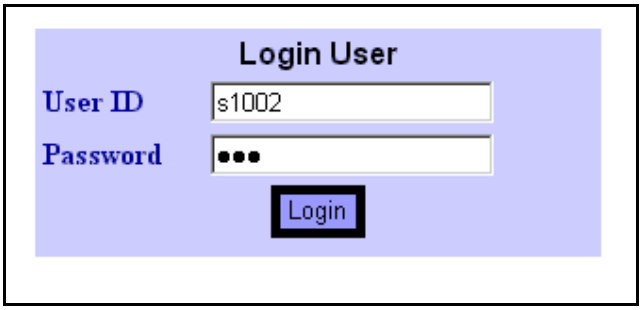

Figure B-11: Login User Interface

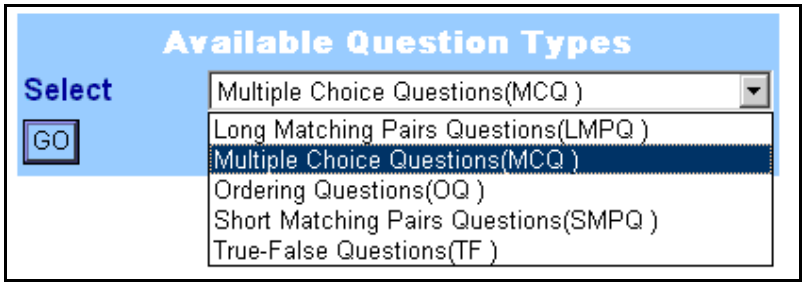

Figure B-12: Select Question Type Interface

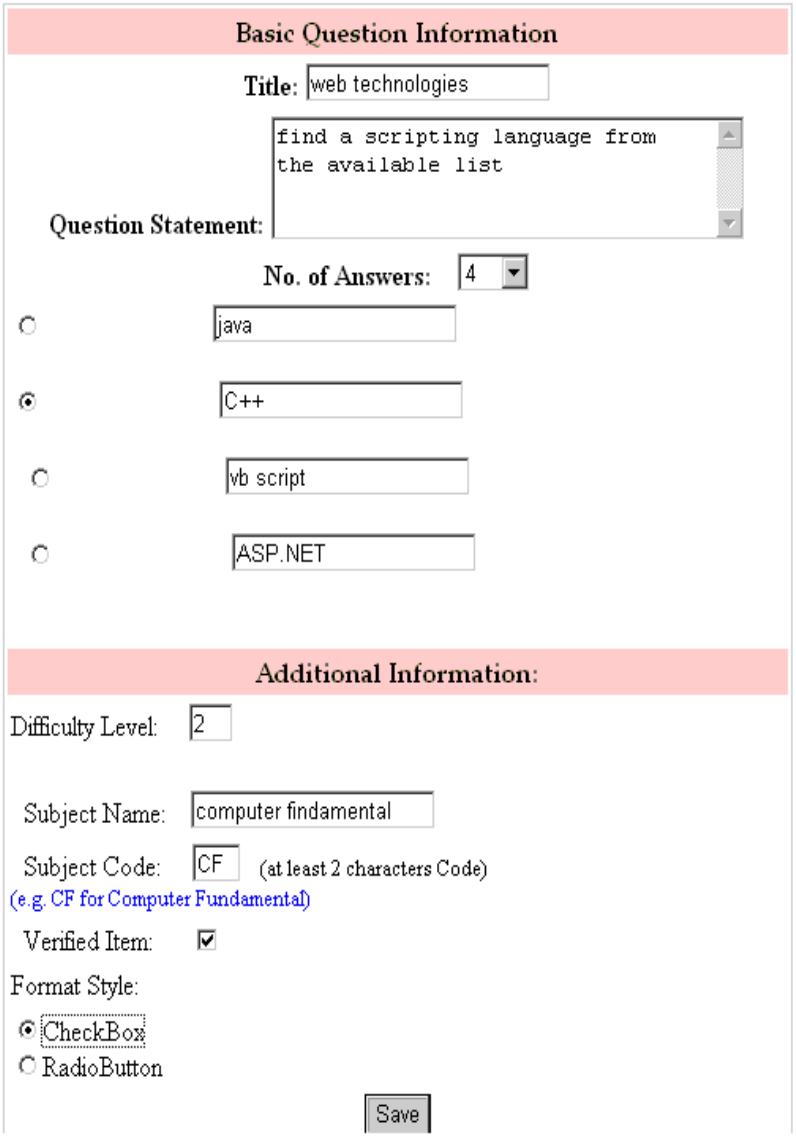

Figure B-13: MCQ Editor

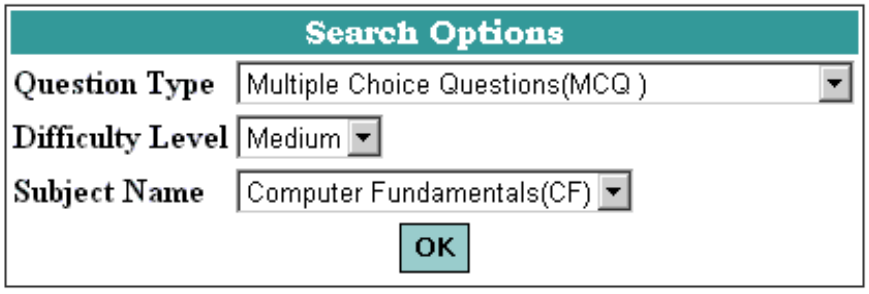

Figure B-14: Search Options

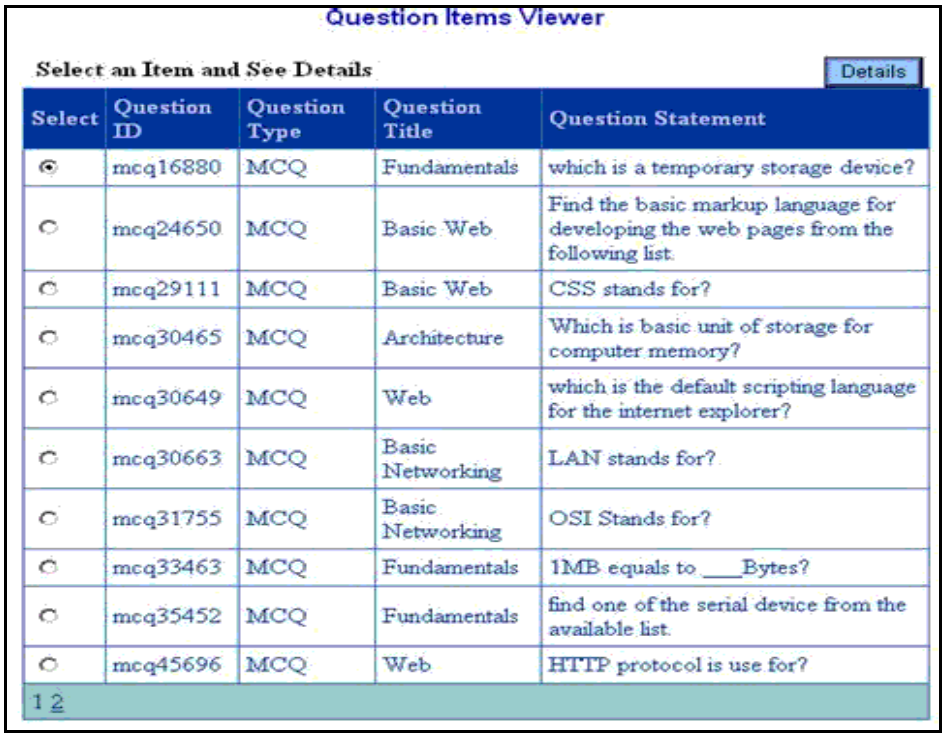

Figure B-15: Question Items Viewer

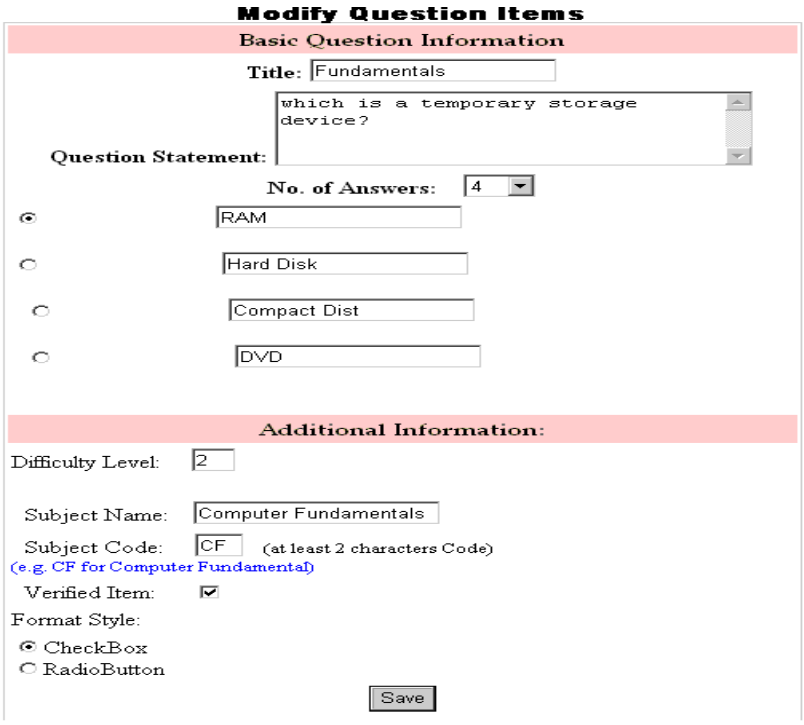

Figure B-16: MCQ Editor for modifying the question information

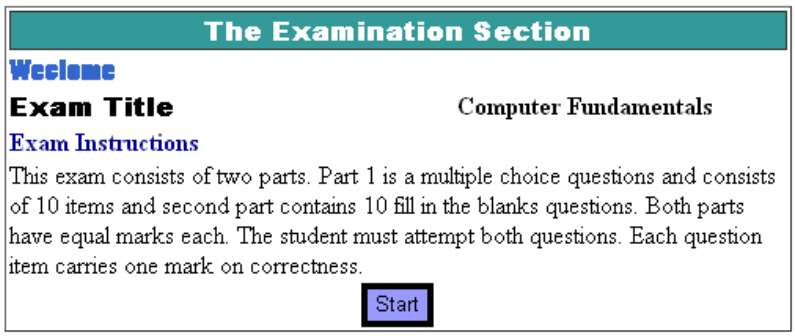

Figure B-17: Exam Instructions Interface

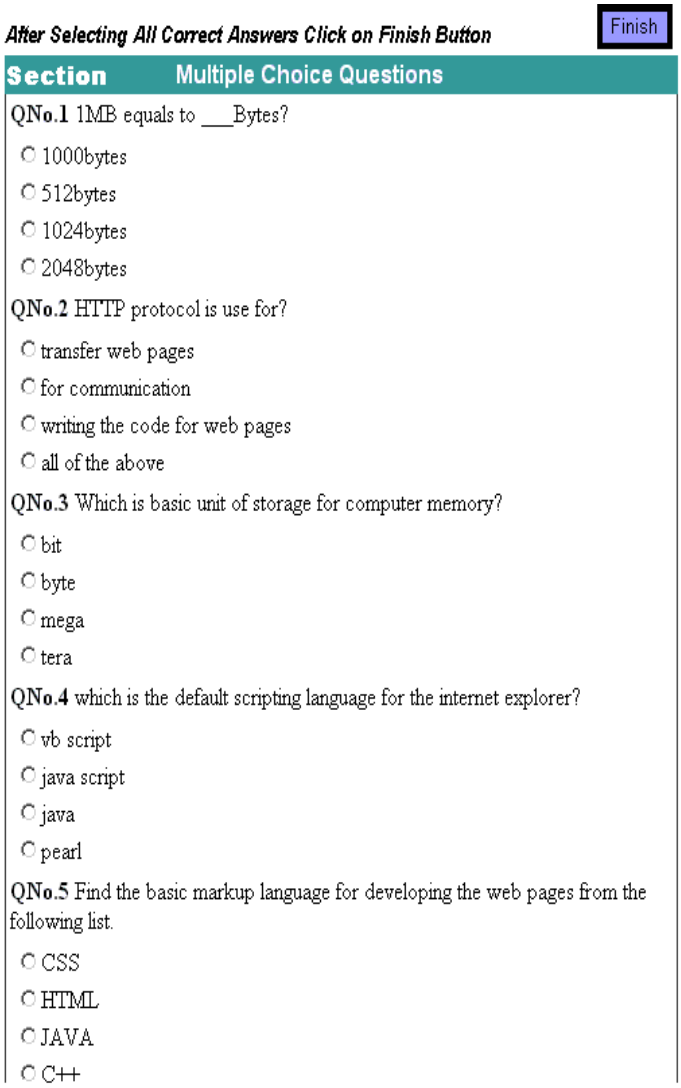

Figure B-18: Unique MCQ Paper

After Selecting All Correct Answers Click on Finish Button Finish

Section Multiple Choice Questions

QNo.1 IIS runs on the client machine.
- True
- False

QNo.2 RAM contains data permanently.
- True
- False

QNo.3 C++ is a case sesitive language
- True
- False

QNo.4 one character consumes 2 bytes of memory space
- True
- False

QNo.5 NTFS file system provides less protection than that of FAT system.
- True
- False

QNo.6 Java is a scripting language.
- True
- False

QNo.7 RAM bus speed is more than hard disk speed.
- True
- False

QNo.8 javascript is not a case sensitive language
- True
- False

QNo.9 Class is not a data type like other data types

Figure B-19: True False Unique Paper

Final Student Report

Student Name:	Kamran
Student ID:	s1002
Exam Title:	Computer Fundamentals
Total Marks	20
Obtained Marks:	15
Percentage(%):	75%
Grade:	A

Exam Details

Exam Details

Sections	Section Name	Marks	Obtained	Correct	Incorrect
1	Multiple Choice Questions	10	8	8	2
2	True False	10	7	7	3

Figure B-20: Student Final Report

C. Existing Computer-Based Testing Systems

Most of today's automated test systems are part of so called Computer-Based Testing Systems (CBTS). These systems provide the ease of presentation software coupled with branching and interactive capabilities, integrating text, sound, graphics, animation, and video with good performance [22]. The following section gives an overview to the existing computer based testing systems.

C.1 Blackboard

Blackboard is a course management system that contains many online tools such as discussion boards, chat rooms, online testing, survey tools, grade books, and content areas. Materials placed in Blackboard are password protected and available only to authorized users. Blackboard works well for web courses, hybrid courses, online communities, committees and collaborative projects, clubs/organizations and training.

C.1.1 Features

C.1.1.1 Kind of Assessment

Blackboard provides a number of different kinds of evaluation or assessment. There are two basic kinds: the Survey and the Quiz/Test.

Surveys record answers anonymously: they do not indicate which student answered. They are typically used for course evaluations and opinion polls. The Quiz/ Test format allows the instructor (1) to assign points to questions, (2) to have the questions graded, and (3) have the results for each student added into the grade book.

C.1.1.2 Assessment Pools

Assessment Pools are groups of questions that are stored for repeated use. Although a Pool is attached to a particular course/subject, Pools can be imported or exported to other courses. Following are the question types, which are used in Blackboard.

Multiple Choice Questions

Multiple Selection Questions

Fill In the Blanks

Short Answers Questions

C.1.1.3 Management of Grade Book

The Online Grade book posts the grades of all Blackboard assessments. All grades are automatically added to come up with a total. The Online Grade book can be used to post the grades in a timely manner and in a way that students can easily access. Student access is limited to the individual's own grades [26].

C.2 CASTLE

The CASTLE toolkit has been developed so that Tutors and Course managers can create on-line interactive assessments quickly and easily without any prior knowledge of HTML, cgi, or similar scripting languages. They are freely available to institutions and they are now part of the Talent project which aims to enhance teaching and learning through the use of web technology [27].

C.3 CQuest Net

CQuest Net delivers tests through the web browser. Developed for managed Intranet and Internet web servers, CQuest Net delivers tests which are generated using Microsoft Internet Explorer 5.x or higher and Netscape 6 or higher [28].

C.3.1 Features

Program-Generated HTML (No HTML or web programming knowledge required.)

Multiple Question Types

Multiple Selection Types

Multi-Media support with each question.

Immediate/Automatic scoring and recording

Display Correct Answer

C.4 WebCT

WebCT is a suite of educational tools that allows an instructor/designer to create a web-based interactive learning environment. The learning environment includes:

Educational tools to facilitate learning, communication, collaboration and evaluation of learning administrative tools for managing students and the course design tools for constructing the course (color schemes, page layout, etc). WebCT can be used to create entire on-line courses, or to enhance learning in classroom-based courses.

C.4.1 Grade Management

The course facilitator (and designated markers) can enter grades for each student. Grades are also automatically entered when on-line quizzes are marked.

C.4.2 Student Self-Evaluation

This tool allows the addition of automatically graded multiple-choice questions to any page of course content. Questions and answers can have multimedia content. When an answer is selected, WebCT displays an indication of whether the choice was correct, along with an explanation of why that choice was correct or incorrect [29].

C.5 WebMCQ

WebMCQ provides corporate trainers and educators with an easy-to-use system for presenting and managing questions on the World Wide Web [30].

The software provides clients, employees, and students with flexibility in terms of time and place, as they can log in to complete practice questions from home, school, university or work, confidence and ability to work independently and at their own pace when answering exams and quizzes increased motivation as they have the opportunity to receive and respond to individualized material presented in an interactive format.

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