Computer-Based Test: Security and Result Integrity

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Abstract—**the gradual acceptance of Computer-Based Test (CBT) or Electronic Examination (e-Exam) as an ideal means of examining not only students but also prospective job seekers in Nigeria is a welcome development. However, the non existence of a global standard or framework for the design, implementation and deployment of the software for administering the examinations made some of the challenges associated with the manual examination process persistent. In this paper the researcher examines some of the challenges of some existing Computer-Based Test systems and the test processes with security and result integrity as the objects of enthusiasm. The analysis of some of these systems and the evaluation of their challenges and security lapses led to the development of a new Computer-based test system. The new system was designed using unified modeling language (UML) and implemented with HTML, PHP & MySQL as a web-based application which may be deployed either on internet or intranet.**

Keywords-Computer-based Test (CBT), e-Exam, Security, Result integrity, Unified Modeling Language (UML)

I. INTRODUCTION

Computer-based testing is the use of information technology for any assessment related activity. It allows educators and trainers to author and schedule surveys, quizzes, tests and exams to be administered through the computer system and responses are electronically recorded and assessed. The intent is to make examination or assessment process fair, faster and reliable. Computerized testing methods were first introduced over 60 years ago. [1] Computerized testing has since then evolved into what it is today as a result of the technological advancements. Paper based exam are characterized by massive leakages, impersonations, demand for gratification by teachers, bribery etc. hence, the need for computer-based testing. However, the non existence of a global standard or framework for the design, implementation and deployment of the software for administering the examinations made some of the challenges associated with the manual examination process persistent. Although, the International Test Commission adopted and published guidelines for Computer-based and Internet delivered testing, [2] most institutions deploying this technology and the software developers are not aware of this guidelines and as a result cannot take informed decisions about design, implementation and deployment. In Nigeria most of the universities conducting electronic examination rely solely on the software vendor for the administration of the exams. A few that have managed to domesticate the conduct of the exam are either poorly managed or use defective software. As the Unified Tertiary Examination (UTME) in the country gears towards computer-based examination [3] there is a need to develop an independent system i.e. a system that does not in any way require the input of the vendor in the administration of the exams. This will increase the integrity of the exam and security of the entire system will be guaranteed.

A. Aim

The aim of this research is to develop a secured Computer-based test system with high result integrity.

B. Objectives

- Review of related literature.
- Define user requirements for the system.
- Develop a use case for the system using Unified Modeling Language.
- Implement the model using HTML, PHP and MySQL.
- Test for correctness, completeness and consistency in accordance with the aim of the research.

C. Significance of Study

It is imperative to point out the challenges of electronic examination and also develop a working prototype that could serve as a standard as universities/institutions [3] across the country are embracing computer based test. This study

outlined the associated security challenges of computer based testing and implemented practical solutions available.

II. REVIEW OF RELATED LITERATURE

A. *Existing System*

In Nigeria paper based testing is still very predominant though some universities have started embracing Computer-based testing technology. The CBT applications used by the few institutions using this technology administer mainly multiple choice questions (MCQs). There is growing interest and increasing practical experience in the use of computers to deliver objective tests. Objective testing is often taken to imply the use of multiple choice questions (MCQs). However, objective tests can incorporate a wide range of question styles in addition to standard multiple choice questions; for example multiple response, word entry, number entry, gap-fill and free-format where student entry is compared to a correct solution using a keyword search. Objective tests and MCQs in particular, are generally considered to be an efficient method of testing factual knowledge, enabling a wide syllabus to be examined in a relatively short time. It is, however, important for academic staff to be aware of the limitations of objective tests (especially MCQs), particularly in their inability to indicate higher level and process skills. Objective tests can be used for both formative and summative assessments, and a variety of scoring systems can be applied, tailored to the importance of discouraging students from guessing answers.[4] The existing approach to the design and implementation of a computer-based test or an online examination system entails mainly multiple choice questions, randomized questions, a question at a time or all question at a time, password required for access to test etc. and security features such as password encryption in some cases, no backtracking, right click disabled to prevent saving or printing of page as observed in the implementation of [5]. According to [6] secure testing is made possible by the following two conditions. (1) A robust Learning Management System (LMS) that can allow instructors to create and host all the test questions is required. Features such as randomization, one question at a time, specific testing time setting, automatic self-grading, and re-grading are also necessary. (2) The test questions need to be administered in a secure browser where opening new windows, minimizing windows, right clicking, or printing will be prevented.

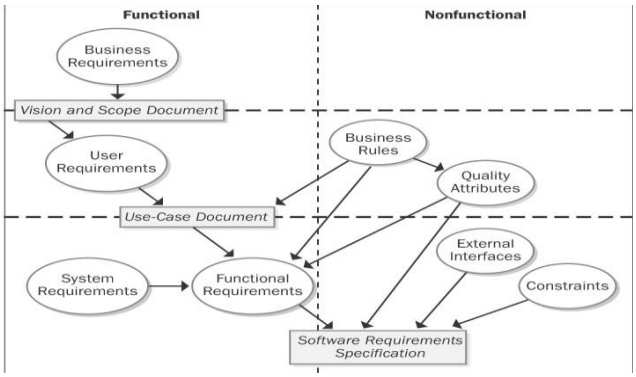
In the analysis of [7] on enhanced approach for secure online exam process. The researcher identified challenges associated with online examination and the comparative study shows that cryptography supports enhanced security control for the online exam process, as well as authentication and integrity. The focus should not be on security breaches that may be perpetrated by skilled personnel. According to [8] extended testing window, reuse of items-exposure rate, testing environment-CBT lab etc are factors that could affect testing integrity. “Processes and policies must be tailored to the types of risks or threats to test integrity that are anticipated based on the intended use, stakes and consequences for school, students and educators.”[8]

B. *Proposed System*

Universal design of assessment generally means an approach that involves developing assessments for the widest range of students from the beginning while maintaining the validity of results from the assessment. Universal design also sometimes refers to multiple means of representation, action/expression, and engagement. [9] One thing is clear from the CBT research: There is no single CBT model that is ideal for all educational tests. Rather, all models have their strengths and weaknesses, and some are better suited to the characteristics of a particular testing program than others. Recent research has also shown the advantages and limitations of particular CBT models. The argument of this research is that the development approach of a CBT system determines its level of security and result integrity. The development approach for the proposed system is cognizance of the fact that user can compromise security consciously or unconsciously and their act may affect the integrity of the test result. Hence, the proposed system integrated features that may improve security and result integrity. The features are outlined in Table 1 below.

III. METHODOLOGY

The software development approach that has been



employed for this research is the Unified Software Development Process or in short, the Unified Process. The Unified Process is component-based, which means that the software being built is made up of software components interconnected via well-defined interfaces. Besides that, the Unified Process uses Unified Modeling Language (UML) in preparation of blueprints for the software.

A. *System Analysis*

This section will outline the user and system requirements for the proposed computer-based test system. The user requirements highlighted in the table below are products of the researcher’s extensive analysis of some electronic examination

systems and views of the users of these systems about things they wish were included in the system.

Table 1 below shows the user inputs categorized based on the components of software requirements see figure. 1.

Table 1 DEFINING USER INPUT

User Requirements	Categories
The system should save time and efforts	Business Requirements
The system should be able to accommodate at least five question patterns that can be administered individually or collectively in a given test session. e.g. Objective, Multiple Choice, True or False, Contextual/Fill in the gap etc.	Solution Ideas
Questions should be randomized and fetched from a large pool for reduced exposure rate even when reused.	Functional Requirements
The system should allow individual upload of questions one after another or in batches using a CSV file.	Use case
The system should allow registration of actors (student, lecturer and administrators).	Use Case
The system should be user-friendly, reliable and prevent unauthorized access.	Quality Attributes
Lecturers should have managerial access only to courses allocated to them.	Functional Requirements
Administrator should have control over active exams or test.	Use Case
The system should allow inclusion of multi-media; picture or images to any of the question types	Solution ideas
The system should be scalable and support newer technologies.	Quality Attributes
The test should be automatically marked and immediately the test/exam is concluded, the result/score is made available.	Functional Requirements
The software should implement very high security features to prevent any form of malpractices or illegal use.	Business Rules
Students' should be authenticated before they can take test/exam on the CBT system.	Functional Requirements
Lecturer should be able to set number of question to be answered and the time for each exam.	Use Case

Figure 1. Components of software requirements

B. Use Case

According to [10] use case is a single, discrete, complete, meaningful, and well-defined task of interest to an external user in some specific role or roles in relationship to a system, comprising the user intentions and system responsibilities in the course of accomplishing that task, described in abstract, technology-free, implementation independent terms using the language of the application domain and of external users in role.

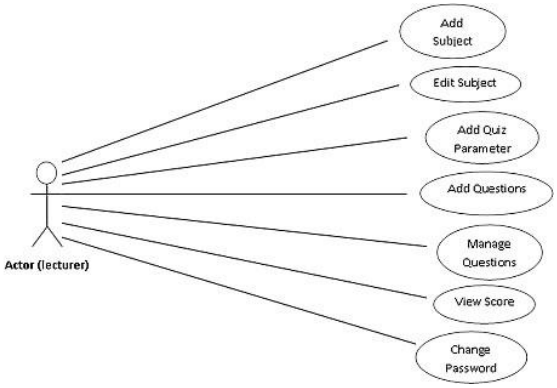


Figure 2. Lecturer use case

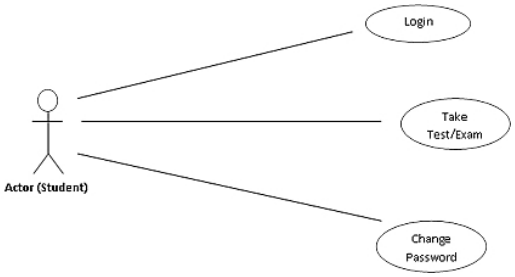


Figure 3. Student use case

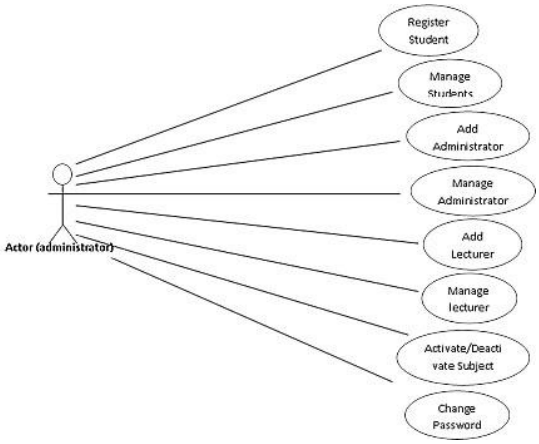


Figure 4. Administrator use case

The figures 2, 3 and 4 above show the use case for the system. There are three users/actors; lecturer, administrator and student.

C. Entity Relationship Diagram

The entity relationship diagram in Figure 5 shows the simplified view of the database schema and its cardinalities.

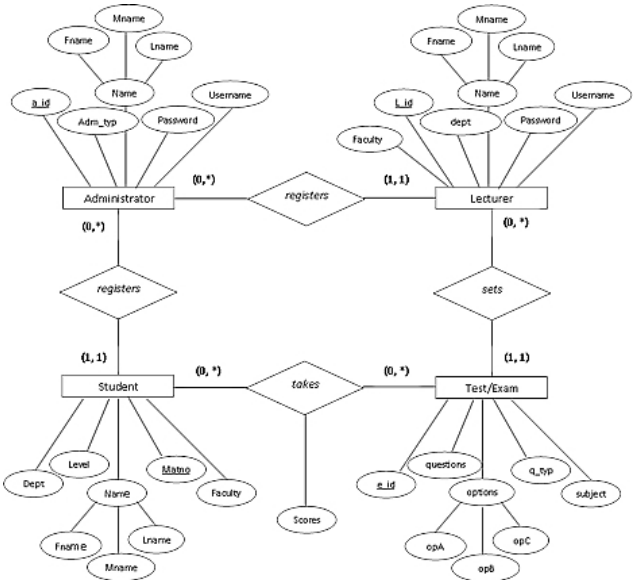


Figure 5. Entity relationship diagram

IV. IMPLEMENTATION

The implementation is done using HTML, PHP and MySQL as the database. PHP is a server side scripting language that is proficient in the development of dynamic web application. The choice of PHP as programming language is informed by the ease of deployment that characterizes applications developed with PHP. It connects effortlessly with MySQL which is a very portable relational database management system (RDBMS). The implemented system is a 2 – tier approach i.e. client/server architecture. The client (workstations on the network) request web interface from the server (which holds the logic and processes of the system) through which operations can be performed.

A. Database Design

The database is made up of about 16 tables. Some of the tables are admin_record, login, questions, student_records, choices, results, question_backup, auth_question etc. The schema of few of the tables is shown below:

Table 2 LOGIN TABLE SCHEMA

Field	Type	Null	Key	Default	Extra
Id	Int<3>	No	Pri	NULL	auto-increment
username	Varchar<15>	No		NULL	
password	Varchar<25>	No		NULL	
Access_level	Int<1>	No		NULL	
Access_type	Char<12>	No		NULL	

Table 3 QUESTION TABLE SCHEMA

Field	Type	Null	Key	Default	Extra
qId	Int<9>	No	Pri	NULL	auto-increment
qimg	Varchar<25>	No		NULL	
opA	text	Yes		NULL	
opB	text	Yes		NULL	
opC	text	Yes		NULL	
opD	text	Yes		NULL	
ans	text	Yes		NULL	
qtype	Int<1>	No		NULL	

Table 4 LOGIN TABLE SCHEMA

Field	Type	Null	Key	Default	Extra
Id	Int<9>	No	Pri	NULL	auto-increment
Matric_no	Varchar<11>	No		NULL	
Subject_id	Int<3>	No		NULL	
Score	Int<2>	Yes		NULL	
session	Varchar<9>	No		NULL	
Timestamp	Varchar<35>	No		NULL	

B. Security and Result Integrity Features Integrated

The developed system is implemented such that a registered lecturer answers some security questions on first login and asked to update his/her authentication details. The information supplied is encrypted and as such protected from illegal access to the database. On click of "forgot password" you are required to provide the same answers you provided on first login, incorrect response makes the account inaccessible. A lecturer can administer/manage ONLY the courses allocated to such lecturer. Questions can be uploaded in batches in CSV format or individually and the upload may be done few minutes to the commencement of the test/exam by the lecturer and in his own office without his physical presence at the server room or test center if the application is deployed on the intranet. Results are displayed for each candidate at the end of the exam so the issue of manipulation of results is ruled out. Comprehensive result list can be printed or downloaded in softcopy in excel format immediately after the test/exam. Administrators cannot access the lecturer's panel and as a result cannot leak the questions. The questions are obfuscated (using an algorithm) on upload; this makes it unreadable even if anybody manages to gain access to the database. Questions are randomly fetched for

each student and displayed one per page. In the case of computer system failure, if a candidate decides to login the timer continues from where it was and the already answered questions remain intact. All authentications are logged automatically by the system for investigation of any illegal access. A candidate cannot have more than one active session running concurrently. The system has a very friendly graphical user interface for ease of use and few hours of training would be enough to master its use. It does not require any technical skill and as a result third party interference is extricated.

C. Algorithm for Obfuscations

```
function obfuscate_deObfuscate($Str_Message) {
        $Len_Str_Message = strlen($Str_Message);
        $Str_Encrypted_Message="";
        for ($Position = 0;$Position<$Len_Str_Message;$Position++){
                $Key_To_Use = (($Len_Str_Message+$Position)+1);
                $Key_To_Use = (255+$Key_To_Use) % 255;
                $Byte_To_Be_Encrypted = substr($Str_Message, $Position, 1);
                $Ascii_Num_Byte_To_Encrypt = ord($Byte_To_Be_Encrypted);
                $Xored_Byte = $Ascii_Num_Byte_To_Encrypt ^ $Key_To_Use;
                $Encrypted_Byte = chr($Xored_Byte);
                $Str_Encrypted_Message .= $Encrypted_Byte;
        }
        return $Str_Encrypted_Message;
}
```

D. Simulation and Result

The implementation was simulated on apache server localy hosted on a computer and tested for consistency and correctness. The screen shots in the figures below shows few interfaces from the system.

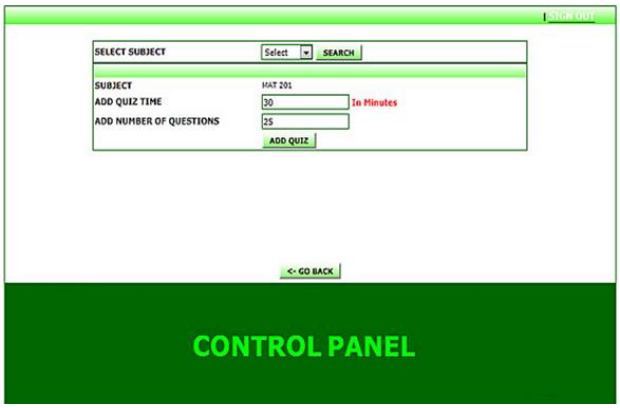


Figure 6. Screen shots for setting test/exam parameter

Figure 7. Shows question upload in batches in CSV

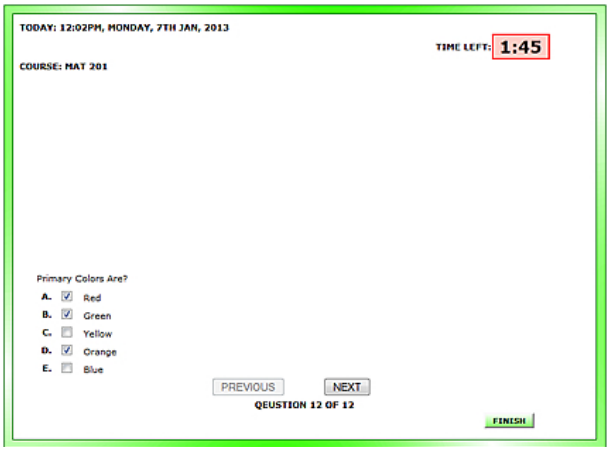


Figure 7. screen shot for test/exam

E. Discussion of Result

This implementation shows that a computer-based test system can be administered independently by interested institution without software vendor interference if properly designed. Extricating the involvement of third party would better improve testing integrity. The developed system may be improved by integrating biometric verification to prevent impersonation if verification of candidates manually proves inefficient. Different question type such as multiple choice, objective, fill in the gaps, true or false integrated into the system will not only improve the integrity of the exam it will also ensure different parts of the brain are tested. Encrypting all authentication details is also geared towards improving the security and result integrity. This application is currently evaluated and used for exams in Kwara State University, Nigeria.

CONCLUSION

In this paper, we developed a system that can be adapted for most types of computer based exams in any institution with reliable security and result integrity.

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