Securing Computer Based Testing (CBT) System for Tertiary Institutions in Nigeria

ABSTRACT

This research, securing computer based testing (CBT), systems for tertiary institutions provides an improved means for protecting examination question against unauthorized access. The research focuses on developing an independent and secure computer base testing system with an improved level of integrity, authenticity and confidentiality of exam questions. The methodology employed for the research design include studying writing materials on security aspect of CBT such articles and lecture notes as well as physically inspecting how the CBT system works with a view to finding leakages and vulnerabilities. Modeling tools such as UML use cases, Flowchart and entity relationship (E-R) diagrams were used to model the design. The overall design was implemented using HTML, PHP, MySQL and JavaScript platforms in order to actualize the objectives of the design. The system was tested locally using WAMP and found to be effective in reducing the problem of authenticity (especially with the Fingerprint Mechanism embedded) confidentiality and integrity of exam questions.

Keywords: *Vulnerabilities, unauthorized, fingerprint, secure.*

1.0 INTRODUCTION

Computer-based testing (CBT) is the application and use of electronic system in place of manual paper-and-pen method for any assessment related activity. Computer based testing system enables educational institutions and other organizations that need some kind of assessment to conduct and schedule surveys, quizzes, tests and exams to be administered through a computer system and responses/results are electronically recorded and assessed. The target is to make examination or assessment process fair, faster and reliable [1] The Paper based testing (PPT) method is characterized by massive leakages, impersonation, and demand for gratification by teachers, invigilators etc. hence, the need for computer-based testing. However, the non-existence of a known standard or framework for the design, implementation and deployment of the software for administering the examinations(CBT) makes some of the challenges associated with the manual examination process to persist [2] In Nigeria, most of the universities conducting computer based examinations 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 porous, defective software.

The present problems associated with tertiary institutions in the conduct of electronic examination and registration for testing the ability of their candidates are lack of resumption capability when power, network and or physical computer's components experience failure [3]; poor integrity of examination results due to examination questions passing through so many hands, especially when a private individual is involved [1]. Questions to be uploaded into the server are scripts which makes the whole process very tasking and a measure of errors are unavoidably introduced into the questions. [4][5] point out that most researchers in this field agree on the basis that some aspects of complex achievement are difficult to quantify using objective type questions. All questions type in Microsoft word are being converted into a format that is acceptable to the software [4]. Choice randomization distribution within each question must be performed to ensure security, robustness against cheat attempts during examination process and impersonation in the examination hall, as well as conspiracy and collaboration of security agents and officials to compromise the integrity of the examination [3];[6]. Unscrupulous practices by some administrators in the manipulation of exam scores of the students and inability of the system to keep track of user activities are other possible loopholes that can undermine the integrity of the exam.

To reduce drastically the ills and drawbacks of the manual paper and pen method of testing, and what has also become of the CBT systems, there is need to develop independent and more secure systems i.e. systems that do not in any way require the input of a vendor in the administration of the entire exam process. This will increase the integrity and confidentiality of the exam, and guarantee security of the entire system to an appreciable extent.
This research therefore, focuses on building security solutions into the CBT system, revolving around certain parameters as Confidentiality, which means all questions/exam resources must be kept private and away from unauthorized third parties; Authenticity, which means the candidate taking the test/exam is the real, right and genuine person who is supposed to write the exam and not an impostor; and Integrity, which means no part or section of the exam questions or even the entire content is tampered with, distorted, altered or corrupted in any way, thus ensuring that the questions are exactly as set by the course lecturer or examiner.

2.0 REVIEW OF LITERATURE

2.1 Cryptography in Computer Based Testing Systems.

[1] Proposed a novel approach that enhances the security of online exams by introducing the idea of group cryptography with an e-monitoring scheme. Also, they proposed a cryptographic scheme that should be executed at every stage of the exam in order to get the maximum security. Their system is based on different cryptographic protocols offering high level of security during the entire exam. The authors identified different stages of exam where cryptography should be employed, for example, setting up an exam, beginning, holding and submitting, grading, obtaining, and revising the exams.

There is a growing body of research centered on developing better ways of managing e-exam systems, and some of these researches focus on various sections of the system.

[7] looked at an e-learning web based system that could simply offer and grade mathematical questions with infinite level of patience. Therefore, it requires the capability for input and output of mathematical formulas, the dynamic generation of plots and the generation of random expressions and numbers. [8] presents an applied Generic Software of multiple kinds of e-exam package; this package of e-exam is directed to Hearing Impaired (HI) persons. Therefore, the exam material of this package is translated into language of HI persons like sign language and finger spelling. The idea of the Generic software is to present an empty template to the teacher who would like to develop the required e-exam for the needful topic (mathematics, language, science, etc) and desired exam kinds ranging from multiple choices, matching between words, fill in blanks, etc.

Web-based Examination System is an effective solution for mass education evaluation [9]. He developed a novel online examination system based on a Browser/Server framework which carries out the examination and auto-grading for objective type questions and operating questions, such as programming, operating Microsoft Windows, editing Microsoft Word, Excel and PowerPoint, etc. It has been successfully applied to the distance evaluation of basic operating skills of computer science, such as the course of computer skills in Universities and nationwide examination for the high school graduates in Zhejiang Province, China. Another paper [10] presents a web-based educational assessment system by applying Bloom's taxonomy to evaluate student learning outcomes and teacher instructional practices in real time. The system performance is rather encouraging with experimentation in science and mathematics courses of two local high schools.

[11] proposed a web based online examination system that carries out the examination and auto-grading for students' exams. The system facilitates conducting exams, collection of answers, auto marking the submissions and

production of reports for the test. It supports many kinds of questions. It was used via Internet and is therefore suitable for both local and remote examination. The system could help lecturers, instructors, teachers and others who are willing to create new exams or edit existing ones as well as students participating in the exams. The system was built using various open source technologies AJAX, PHP, HTML and MYSQL database. An auto-grading module was generalized and used to enable different exam and question types. The system was tested in the Mansoura university quality assurance center. The test proved the validity of using this kind of web based systems for evaluating students in institutions with high rate of students.

An online website for tutoring and e-examination of economics as a course aimed to present a novel software tool that can be used for online examination and tutorial application of the syllabus of economics as a course [12]. Also, among the main interests of the paper is to produce a software through it there is assurance that students have studied all the concepts of economics. So, the proposed software is structured in two major modules: The first one was an online website to review and make self-test for all the materials of the economics course. The second part is an online examination using a large database and databank of questions through which the level of students can be evaluated immediately and some statistical evaluations obtained. The developed software offers the following features:

1) Instructors could add any further questions to maximize, expand the size of the bank of questions.
2) Different examinations for each student with randomly selected questions from the pool of questions can be done.
3) Different reports for the instructors, students, classes etc. can be sorted and obtained.
4) Several students can take the exams simultaneously without any problem inside and outside their campus. The proposed software has been designed to work base on the client server architecture.

[13] described a cryptographic scheme that possesses security requirements, such that authenticity, anonymity, secrecy, robustness, correctness without the existence of a Trusted Third Party. The authors of the paper proposed a protocol that provides students a receipt, a proof of a successful submission, and it is based on the existence of anonymous return channels. [14] proposed a model for e-Examination in Nigeria where all applicants are subjected to online entrance examination as a way of curbing the irregularities as proposed by the Joint Admissions Matriculation Board (JAMB). This model was designed and tested in Covenant University, one of the private universities in Nigeria. Their findings

revealed that the system has the potentials to eliminate some of the problems that are associated with the traditional methods of examination such as impersonation and other forms of examination malpractices. [14] seeks to solve a part of that problem by designing and developing a web application where tests in multiple choice formats will be taken on an online platform and graded immediately. The web application relies solely on Microsoft developed technologies. It runs on the Microsoft.net framework, uses the ASP.NET web server, C# as the intermediate language, ADO.NET to interact with the relational database and Microsoft SQL server as the relational database.

A web-based online examination system that is not limited by time and place was developed by [5] to enable students to arrange their time for examination in accordance with the progress of their lessons. The system had simple fraud protection function by employing a random generation in the order of questions in each student's test, making cheating extremely difficult. The questions could also be in diagram form, animations and other multimedia forms other than textual test questions, therefore making the test questions more diverse. Teachers can make statistical analysis aimed at making any given test to determine the average mark scored by students and this can be used as a reference material for teaching remediation. The design was broadly structured into three aspects: the student aspect, the teacher aspect and others (includes administrator, production group and comments). Implementation was done using Windows 2000 as the operating system. ASP (Active Server Pages) was used to provide a dynamic web page while the functions required by the online examination system were appropriately processed through the VB (Visual Basic) Script in ASP. The system also used the IIS technology (Internet information Server) to construct an ASP platform while Microsoft Access served as the database. The database was accessed using ODBC. Users can arrange their examination time in accordance with the progress of their lessons. Candidates who took the test can check the test solutions immediately after the test, thus making students know their mistakes and work to effect corrections. With the rise in cybercrimes, the security enhancement of the online examination system should be looked into in order to ensure that the questions for students' assessment are not tampered with or leaked prior to formal examination date.

[5] proposed an online examination system called System of Intelligent Evaluation using Tests for Teleeducation (SIETTE). SIETTE is a web-based environment to generate and construct adaptive tests. It can be used for instructional objectives, via combining adaptive student self-assessment test questions with hints and feedback. The proposed software has been designed to work based on the client-server

architecture. SIETTE supports secure login and portability features. On the other hand, the other features: resumption capability, multi-instructor, random question selection, random questions distribution and random choices distribution are missing. [5] proposed a web-based Test, Examination and Assessment System (WETAS). WETAS is a web-based system designed for integration into existing Learning Management Systems (LMS); this system provides an examination environment and assignments as well to facilitate database supported e-Learning Test, suitable for the pre- and posttests of Reusable Learning Objects (RLO) as well as the remote lab entry test.

3.0 Methodology

3.1 Materials and methods- no uniform font

The software methodology adopted for this research is the unified software development process. This is because the unified process is component based, which means the software is built is made up of software components interconnected via well defined interfaces and the use of system design tools like the UML use case as a visual language allows for modeling the different interacting processes, application and systems in order to expressly and clearly come up with robust system architecture

Interviews were administered to twenty-five (25) departmental and faculty exam officers and ICT staff as well. Moreover observation of how CBT exams are conducted in the university was carried out in order to elicit information needed for the development of a better system.

In addition, about twenty (20) journal articles relating to Computer Based Testing (CBT) were consulted and reviewed.

In a bid to actualize the overall aim of this research, securing CBT was developed with tools such as Hyper-Text Markup Language (HTML5) Cascading Style Sheet (CSS3) and JavaScript for the front-end interface while the back-end functionalities are powered by HyperText Preprocessor (PHP 5.5), Server site scripting Language and MySQL running on a web server. The local testing was done using WAMP (Windows Apache MySQL and PHP).

3.2 Design of the new system.

The new system is a 3-tier architecture and comprises of the presentation tier, the logic tier and the database tier. The presentation tier interfaces between the user and the system, the logic tier serves as the middleware that is responsible for processing user requests, while the database tier serves as a repository to the pool of examination questions.

The development approach for the new system is in view of the numerous challenges associated with existing CBT systems, as it pertains to authenticity, confidentiality and integrity of the system. Hence, the new system is embedded with additional features and functionalities to improve on the existing system security. The features of the new system are outlined hereunder:

1. In addition to the regular authentication methods (username and password), Biometric fingerprint authentication mechanism is embedded into the system.
2. Examination questions are encrypted in the database to prevent tampering, illegal and malicious access, and other negative tendencies that will undermine the integrity and confidentiality of the exam questions.

One of the major features of the new system is the encryption of the exam questions being sent into the database, depending on the cryptographic algorithm type adopted. The proposed cryptographic scheme will enable questions being sent to the database to be encrypted. Questions will be decrypted only during examinations, when they will be sent to, and accessed only by authentic students during examination.

3.2.1 The Proposed Biometric Fingerprint System.

The next cardinal feature of the new system is the introduction of a biometric fingerprint authentication system embedded into it. The fingerprint system will help check for impersonation among all the actors relating with different system functionalities.

The user is enrolled into the system using his/her fingerprint, which is stored as a template on the database. When a user attempts to enter the examination platform, a biometric program will pop up for the user to put his finger on the scanner for verification/authentication and the main features of the finger scanned are then extracted and converted into a digital representation. This file is then compared with the templates on the database. If a match is found, the user is granted access to the examination platform, otherwise access is denied.

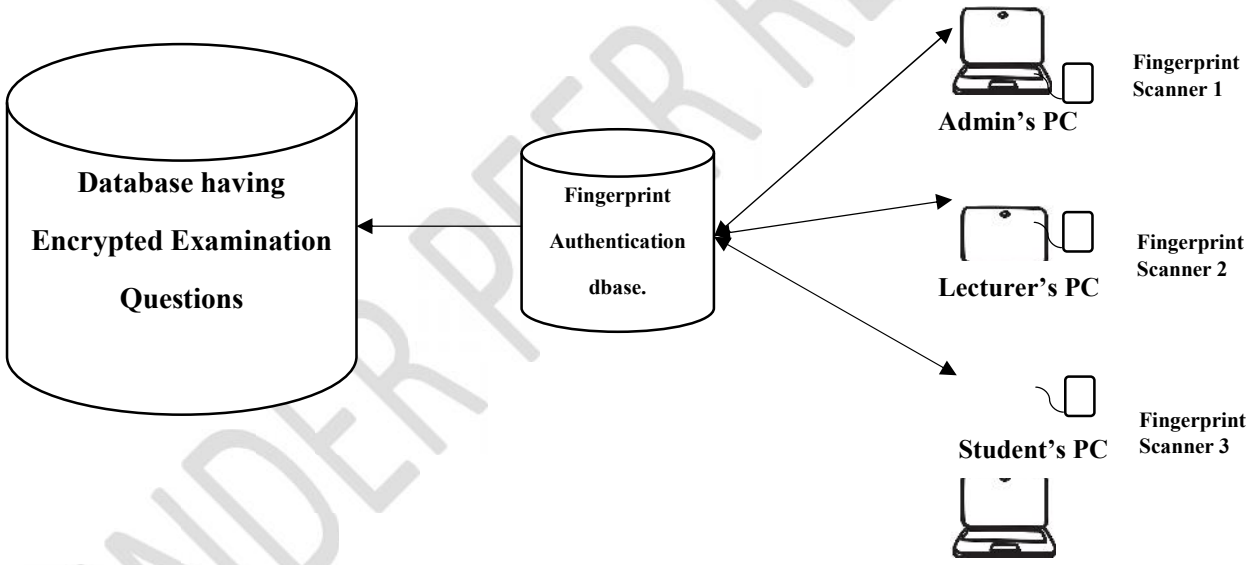


Fig 1: Conceptual design of the Proposed Biometric System for the CBT system.

3.2.2 System Model/Architecture.

The system basically involves three actors which include the ADMINISTRATOR, the LECTURER and the STUDENT. The following are some of the activities of these actors as well as the functions of the system that meets the requirements of the new system:

1. Students should be authenticated using the biometric fingerprint system, before they can access questions and take tests/exam on the CBT system.
2. The administrator should have control over the entire system as well as active exams or test.
3. Lecturers should have access only to courses allocated to them.
4. The system should allow registration of the various users (students, lecturers and administrators).
5. The test should be automatically marked and immediately the test/exam is over, the result should be made available.

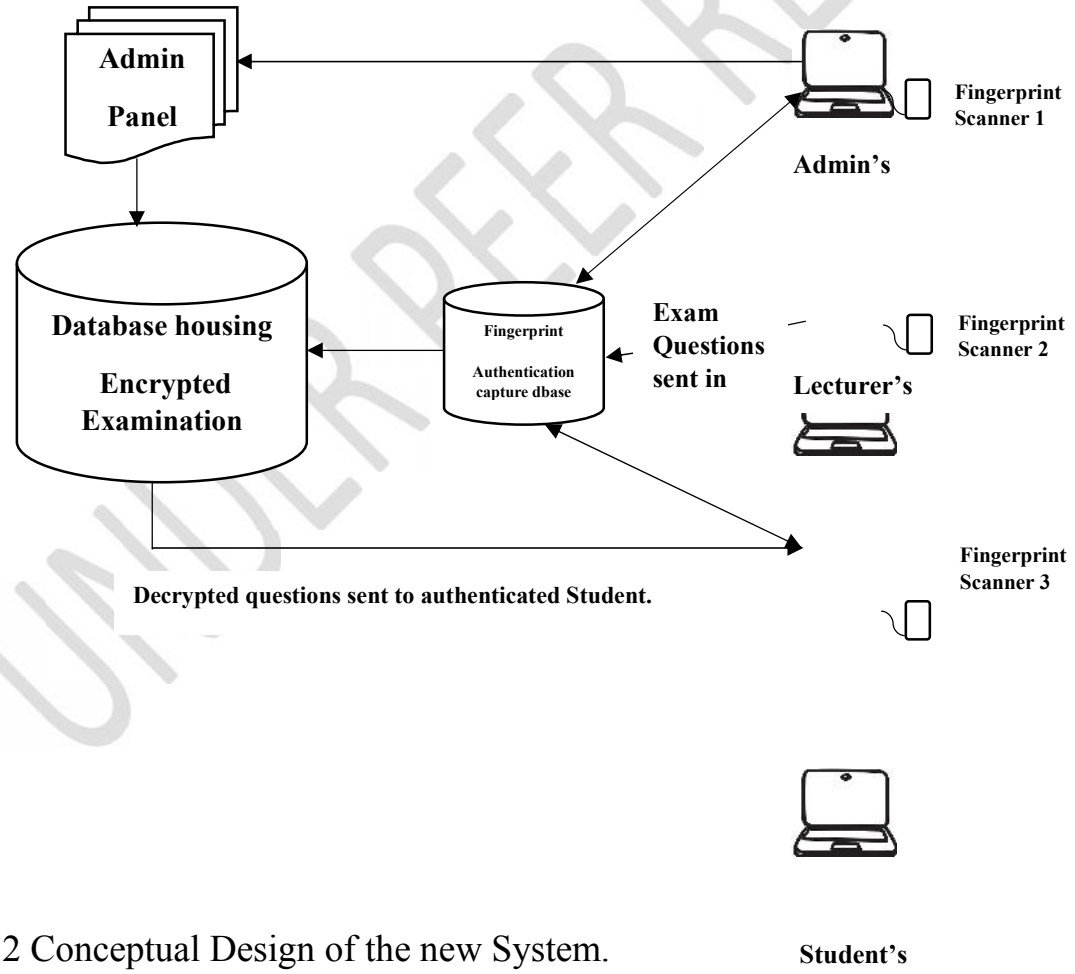


Fig. 2 Conceptual Design of the new System.

3.2.3 System Requirements.

3.2.3.1 Functional requirements:

The functional requirements of this system are presented in scenarios that depict an operational system from the level of its end users. They include:

The system should allow registration of the various actors (STUDENT, LECTURER AND ADMINISTRATORS).

i. Students should be authenticated using biometric fingerprint before they can be granted access to take test/exam on the CBT system.
ii. The test should be automatically marked and immediately the test/exam is concluded, the result/score made available.
iii. Questions should be encrypted while sending into the database and decrypted only during exams to be accessed only by genuine and authentic students.

3.2.3.2 Non-functional requirements.

Non-functional requirements address aspects of the system other than the specific functions it performs. These aspects include system performance, costs, and such general system characteristics as reliability, security, and portability. The non-functional requirements also address aspects of the system development process and operational personnel. It includes the following:

i. The system should be user-friendly, reliable and prevent unauthorized access.
ii. The system should provide attractive graphical interface environment for the user.
iii. The system should be scalable and supportive to newer technologies over time.

3.2.4 Software Requirements:

The software tools required include:

i. HTML5,
ii. Php5.5
iii. CSS3,
iv. JavaScript
v. MySQL.

vi. Brackets(text editor)
vii. Apache Server(WAMP or XAMPP)

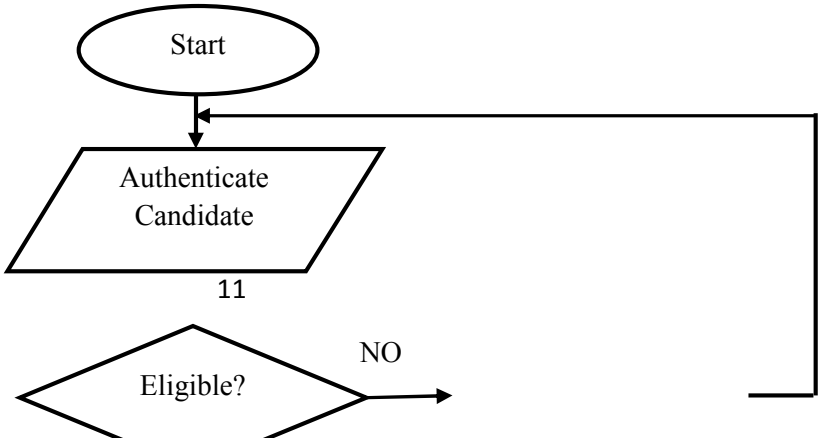
3.2.5 Hardware Requirements:

The hardware tools required include:

- Computer System (Laptop or Desktop)
- 1Gb RAM(at least)
- 50Gb Hard disk(at least).

3.2.6 System Flowchart

The diagram below depicts the flowchart for the Secure CBT system.



ACCESS DENIED

YES

Figure 3: Flowchart for the Secure CBT system.

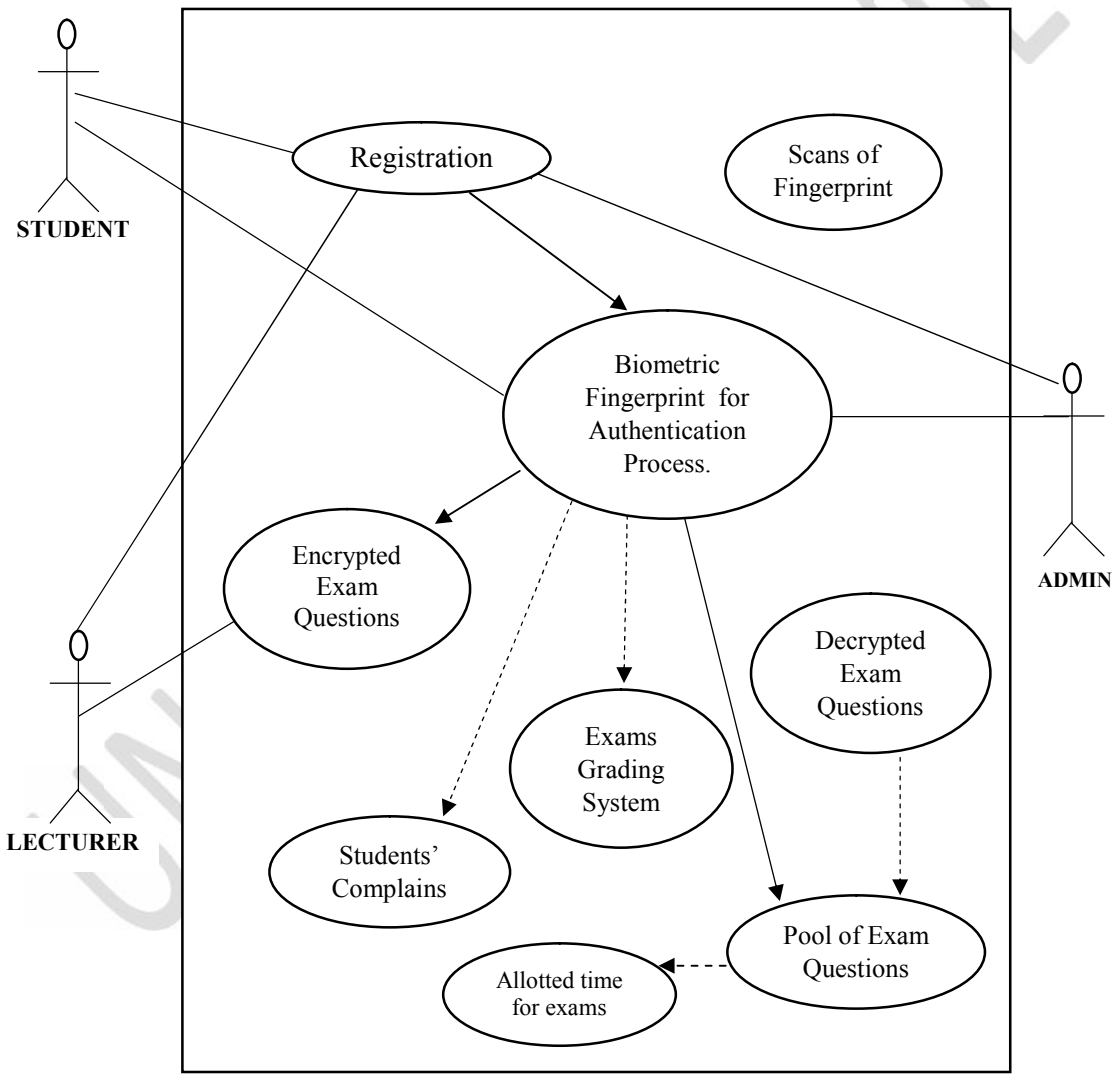


Fig 4: UML Activity diagram of the system -no uniform font

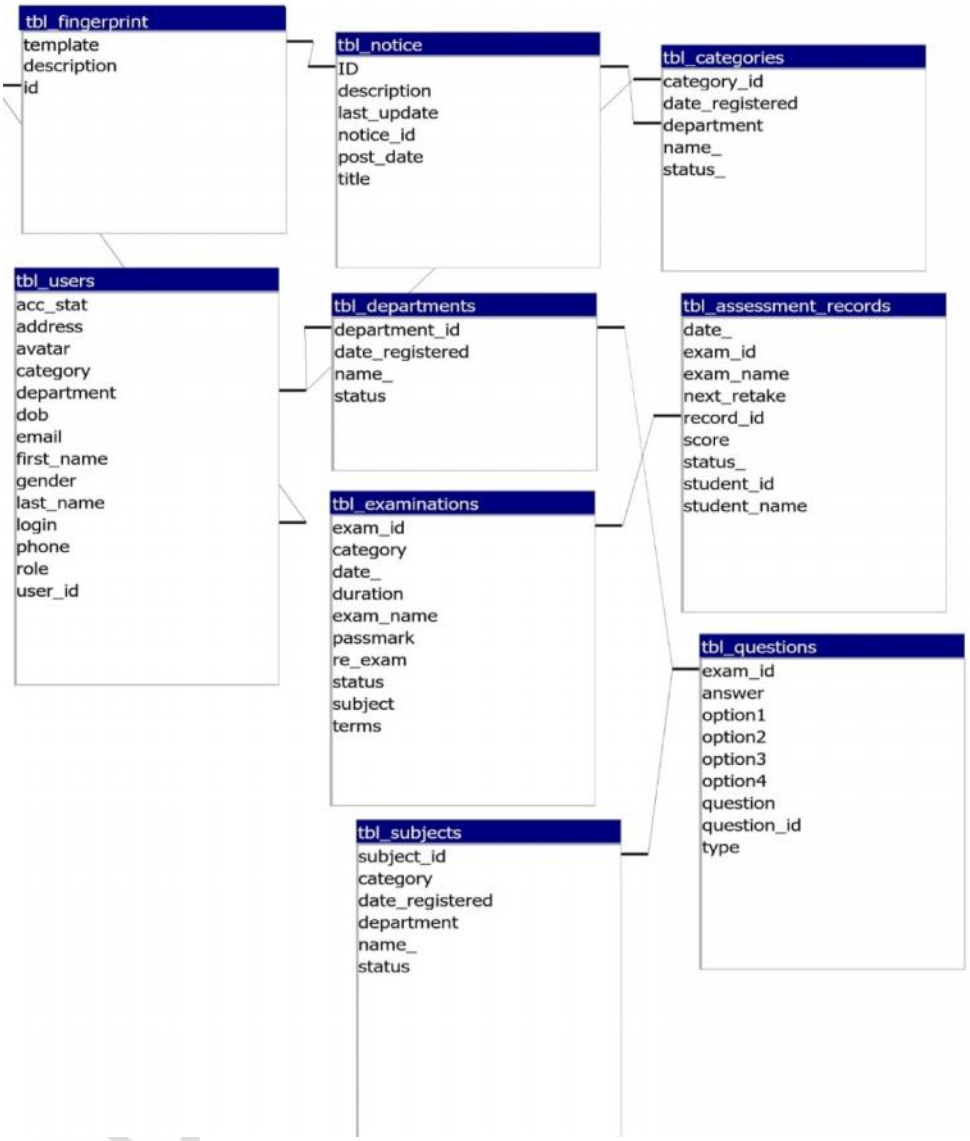


Fig. 5: Entity Relationship (E-R) Diagram for the system.

4.0 Results.

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

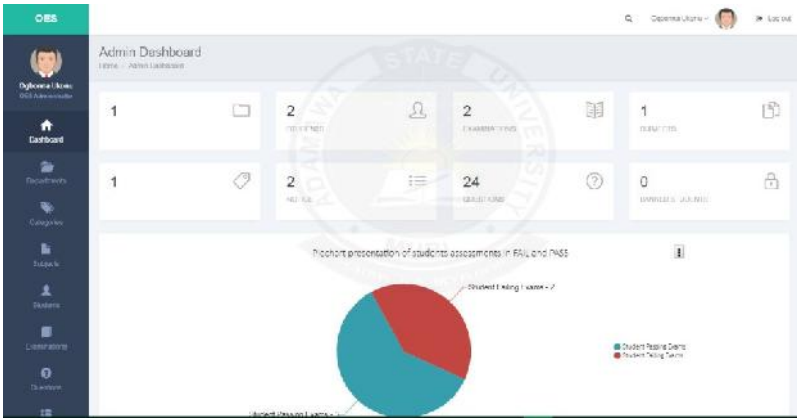


Fig.6: Administrator/Lecturer Login Interface.

Fig. 7: Administrator Dashboard.

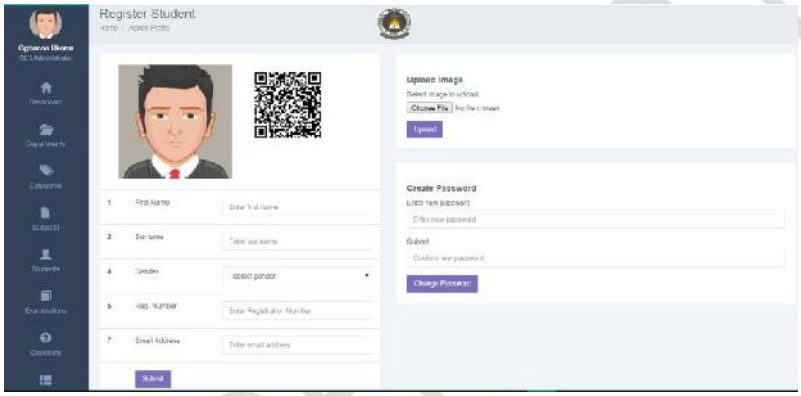


Fig. 9: Add question interface.

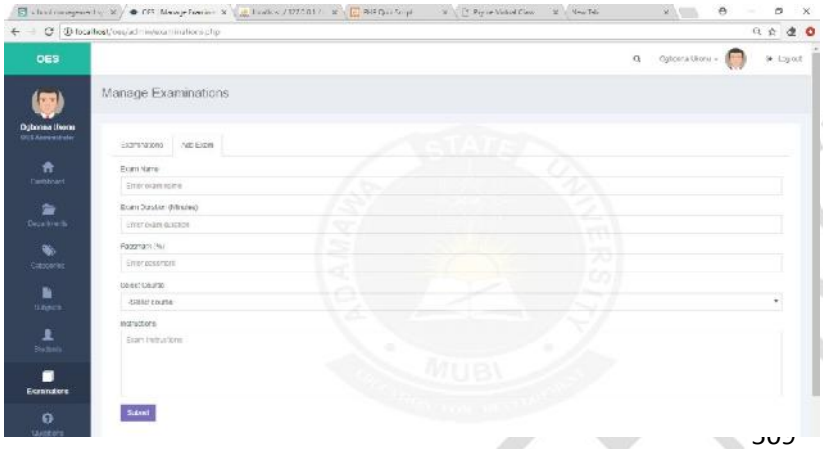


Fig.10: Create Exam Interface.

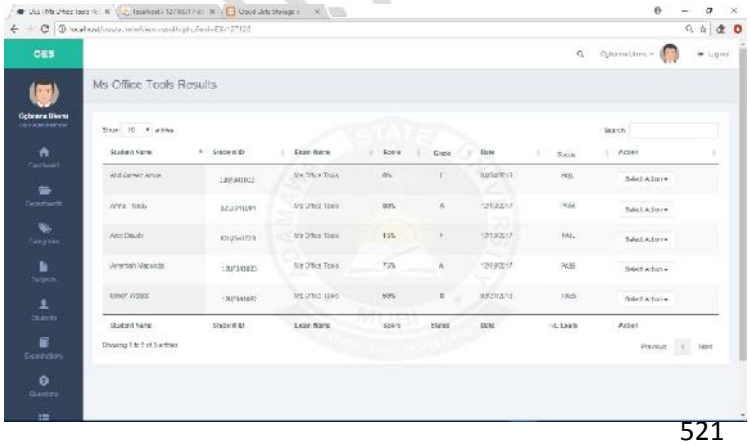


Fig.11: Interface showing result

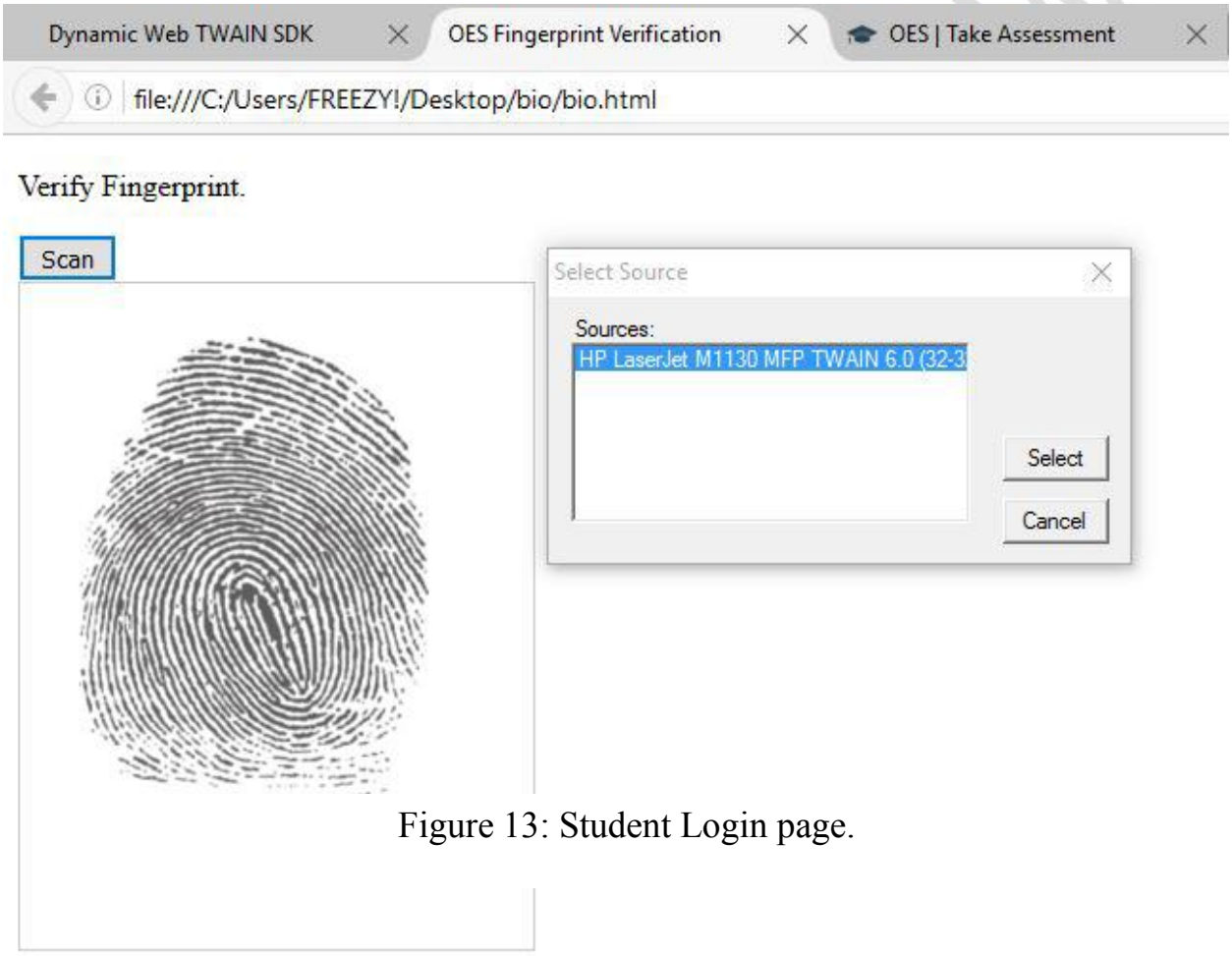


Figure 13: Student Login page.

Fig.12: Student Fingerprint Verification page.

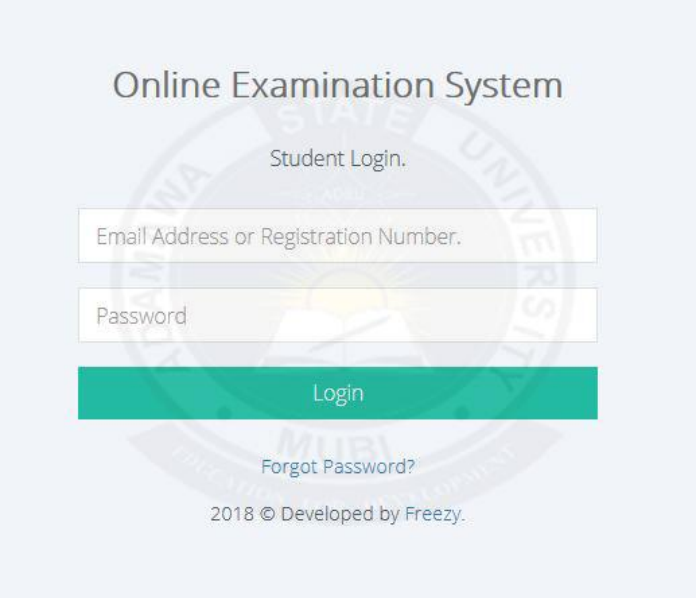


Fig. 13: Student login Form

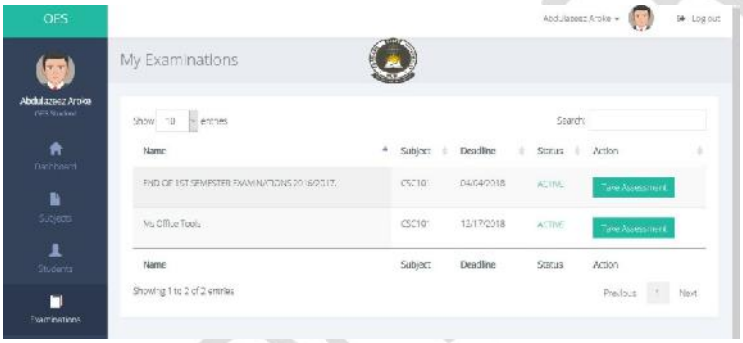


Fig. 14: Student home page.

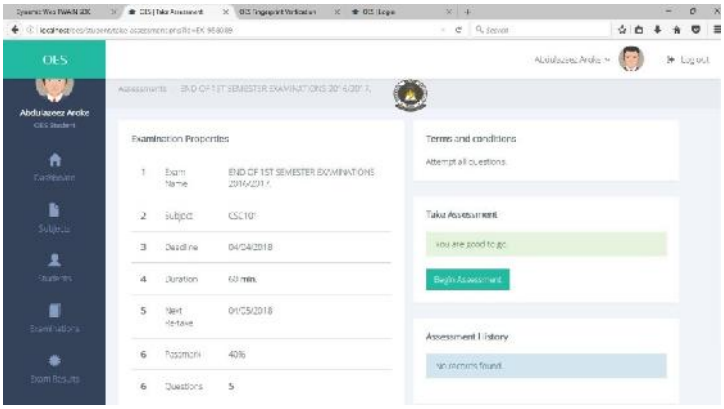


Fig.15: Examination Details page.

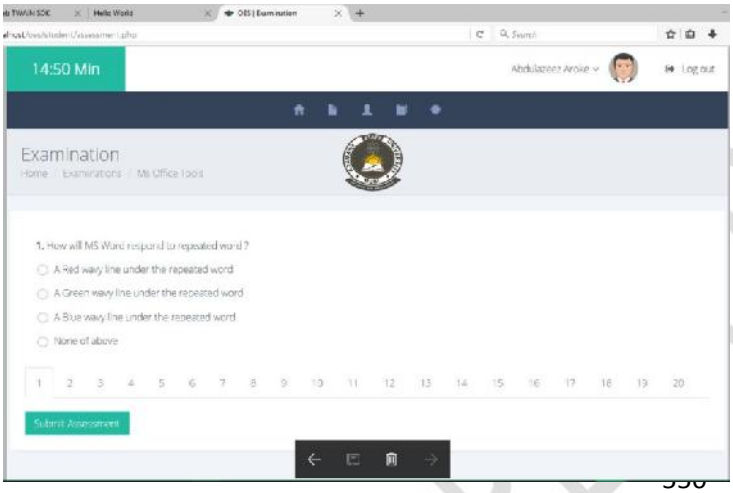


Fig. 16: Examination page.

Fig.17: Student's View

5.0 Conclusion

Security is an ongoing process where due care and diligence to protect online / Computer Based examinations need to be put in place. Inadequate security will make the system highly vulnerable to a lot of compromises and threats. Different information technologists have developed several tools, design phases and other techniques to help in the development of Secure computer based testing (CBT) systems, but most of them did not focus on biometrics for authentication and cryptography for encryption.

An improved, Secure and more robust CBT system has been developed and proposed in this research to meet varying institutional needs. The major strength of the developed system lies in its high scalability and flexibility, so that when fully implemented, the system will drastically reduce the problems of impersonation, exam questions leakages and especially, all security parameters defining the overall system performance in terms of efficiency and efficacy have been enhanced since the system includes biometric fingerprint authentication and data (questions) encryption and decryption mechanisms.

Furthermore, future researches may look at the financial implications associated with implementation of such solutions. Also, it might be necessary to authenticate students through hybridized biometric features like face and iris, considering parameters other than the ones raised in this research for better enhancements.

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