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A Generic Certificate Verification System for Nigerian Universities

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Abstract- The certificate issued by educational institutions is one of the most important documents for a graduate. It is a proof of the graduate's qualification and can be used anywhere. However, due to advances in printing and photocopying technologies, fake certificates can be created easily and the quality of a fake certificate can now be as good as the original. Certificates issued by many institutions have been forged and these forgeries are difficult to detect. Moreover, many factors have led to reduced operational efficiency in student services in many institutions. One of the most significant factors is the verification process for educational certificates and related documents. Certificate verification is necessary to ensure that the holder of the certificate is genuine and that the certificate itself comes from a real source. However, the verification of certificates is a challenge for the verifier (the prospective employer who wants to verify the certificate). To address this issue, a Certificate Verification System for Institutions (CVSI) using the Top-Down Design approach with iterative model is proposed. The system uses a NoSQL database (MongoDB) for certificate storage and Hypertext Preprocessor (PHP) for the front-end design. The university, the graduate and the verifier are the three parties involved in the proposed solution to accomplish accurate certificate verification. Several benefits can be obtained by using the proposed model. These benefits include; improved work processes, ease of use and maintenance by the University for the Verification Process as well as longtime of operation due to the use of MongoDB (a NoSQL database) which supports even horizontal scaling.
Keywords- Certificate, Verification, System, Database, NoSQL, MongoDB, PHP and CVSI.

I. INTRODUCTION

Institutions issue certificates to those who have completed the requirements for graduation. However, due to the presence of advanced and cheap scanning and printing technologies, the forgery of certificates has increased, which threatens the integrity of both the certificate holder and the university that has issued the certificate [1].
Therefore, document validation and verification has become an important task. It is the process of ensuring that the graduation certificate presented by a prospective employee is genuine and that the holder is the rightful owner. Moreover, a graduation certificate has to be verified to ensure that its content is true and also to ensure that the issued certificate comes from a real source [2]. According to [3] verification is the process of establishing the truth, accuracy, or validity of something such as the verification of official documents.
A certificate verification system as in this project is an application program used to verify that someone or something rightly and legally belongs to an organization or an individual or both. It is a computerized means of verifying someone's claim of certificate- ship from an institution. Online Certificate Verification system improves the speed, quality of service of certificate authentication, globalization of markets, and cuts down cost [4]. Educational establishments try to combat fraud and forgery in several ways, however, most of the methods are time-consuming because they are manual, partly automated or involve human to human interaction [2].

Hence, this research attempts to design a web-based system to verify graduation certificates and preserve the confidentiality of the information in them. The system is designed for employers or recruiters, organizations, graduates and institutions.

Verification of certificates is a major concern in organizations, academic institutions, recruiters and employers. Employers have been experiencing high alarming rate of fake certificates [3]. Certificate verification is inescapable in institutions as students are issued admissions and grants because of the certificate they presented and staffs are employed and positioned based on the qualifications they provide. Thus, invalid certificates have become greater than valid certificates [5]. Again, inadequate certificate verification techniques and access to original certificates and poor methods of keeping certificate records, further compounds the problem. Therefore, certificate verification has become an important task. However, this study "A certificate verification system for institutions" can be used to tackle the above challenge.

The aim of this study is to develop an online certificate verification system that easily confirm the authenticity of a certificate by employers or recruiters with the objectives: to provide a database where an institution can keep certificate records of its graduates, to provide a durable system that can withstand long period of time operation, to develop a flexible system that can be adjusted based on changing requirements and to develop a system that can improve operational efficiency

There are several units in Institutions, but this study focuses on certificate verification. The system will handle queries like; Registration, View of all students' certificates records, and printing of certificates so verified. It is a case of Benue State University Makurdi (BSUM).

This study is limited to information gathered from the review of literature and the proposed system is designed on the NET framework.

The significance of this study was to help certificate owners, employers or recruiters, institutions and anyone who wants to verify the authenticity of a certificate from the school. Furthermore, the proposed system permits certificate owners to promptly print their original certificates any time. Hence, solves the issue of certificate loss or damage due to fire. Finally, the system will bring and maintain the reputation of institutions that may adopt its usage.

II. RELATED WORKS

Several approaches have been made to verify certificates and clear the issue of certificate forgery, however, certificate verification method still prevalent today is a manual process, whereby, whoever wants to verify a certificate trips to the institution or send a written request.

In light of the above, Srushti et al. [6] presented a certificate generation system to ensure an efficient certificate management using huge data and to provide mark sheets for credit-based grading system (CBGS) in a very user-friendly manner. In this system, the admin enters the marks of each student. That information will be stored in internal collection information database, percentage and grade is calculated manually. The system embedded the digital form in mark sheet using encrypted QR code, so that any unauthorized user cannot retrieve any information. However, the system is partly automated made it inefficient.

Hampo [7] in his work adopted the Structured System Analysis and Design Methodology (SSADM) which emphasizes on completing a phase of the software development before proceeding to the next phase and also being able to go back to the other phases in a purely sequential manner. The model used for this project is the Rapid Application Development (RAD) model proposed by International Business Machine (IBM) in 1980 and introduced to software community by James Martins through his book Rapid Application Development. Unfortunately, it was not a web-based application but a desktop application software which made the system less valuable as compared to web applications.

[2] Incorporated cryptography approach and cloud-based model to enhance the verification mechanism and thereby reduce the incidence of certificate forgeries and ensure that the security, validity and confidentiality of graduation certificates would be improved. By using the Cloud-based model, some of the factors that result in reduced operational efficiency in student services at universities can be addressed and this should have a positive impact on the quality of services provided by universities. However, since cloud infrastructures are owned and managed by service providers, the cost of implementation is also high. Thus, most institutions could not afford its implementation.

Yusuf, Boukar and Shamiluulu [5] research work enabled an end-user to define certificate template and template format without the requisite of XML knowledge by clicking few buttons and typing from the system GUI,

verifying the certificate and generating one or more certificate(s) simultaneously. In the system, students' details are imported into the system using an excel file, thus, making the system partly automated and inefficient.

Singhal and Pavithr [8] to prevent the circulation of fake degree certificates adopted the use of the QR Code and Smart Phone Application. A QR Code contains a digital signature over the data such as degree holder's name, enrollment number, roll number, total marks obtained etc. which will be signed by university authorities. To verify the digital signature a person needs to use a specific smartphone application which will scan the QR Code and authenticate the certificate. The system was able to combat certificate fraud by embedding the QR Code on the degree certificate and by introducing the smartphone application which will read the digital data from the QR Code. It enables the verification of the certificate without depending on the certificate issuing institution. This did not only improve the authenticity mechanism of a certificate at a much faster rate than manual verification but also prevents the creation of fake certificates through cost-effective.

Musee [3] in his study Employed Agile Methodology approach and Unified Process modelling to develop a cloud-based prototype which is used as SaaS to provide certificate verification. The prototype allowed users to request to get the academic certificates verified by filling the name of institution, course name, year of graduation and the verification code. All these processes were carried out in private cloud and accessible online.

The main disadvantage of the system is the use of Relational Database Management System (RDBMS) which does not support horizontal scaling that is partitioning or sharding.

Boukar, Yusuf and Muslu [9] adopted the use of Java DataBase Connectivity (JDBC) and MySQL connector jar file hence designed a web-based approach proposed to replace the traditional (manual) verification process by retrieving certificate data from institutions in JSON format and archiving them in a database from which verification can be made eliminating security threats and human error. An SQL query was executed to retrieve relevant information from the database. Results are parsed and presented in a JSON format using the GSON jar file and JSON library functions. However, the use of NoSQL features in MySQL became the major deficiency of their system as it slows down the system operation.

Tint and Win [10] to control fake certificates, considered the combination of Elliptic Curve Digital Signature Algorithm (ECDSA) and Secure Hash Algorithm-1 (SHA-1) algorithm which provides strong cryptographic strength and optimizes the computational speed as well as space. In this process, the input message from the user is hashed into a message digest. This digest code is encrypted into signature value using the ECDSA algorithm. The signature value is converted into barcode. The user input message and barcode are combined into electronic certificate. If a user is a new user, he/she must register first. This user needs to input his/her information and generate public/private key pair. This user information and private key will be used to create an electronic certificate. The system, however, lacked the certification authority (CA) between user and server for a trusted third-party system and to get a more secure client-server authentication system.

Warasart & Kuacharoen [1] in their paper, implemented a paper-based document authentication in which a document can be verified with the use of a digital signature and QR code. This enables the verification of the documents without depending on any special institute such as the forensic science centre or accessing the database. The verification process can be done automatically if the Optical character recognition or optical character reader (OCR) is accurate. Otherwise, human inspection is required. The inspector can see the differences between the printed message and the message in the QR code. This semi-automated process is the major drawback of their system.

Nwachukwu & Igbajar [4] considered the adoption of Top-Down structure (a modular approach) with Iterative model and designed an online certificate verification system that can be implemented as a standalone application or embedded in a school official website depending on how the institution decides to use it.

The system was based on an RDBMS for certificate storage though can automate the process of certificate creation and management but lacked partition tolerance i.e. horizontal scalability, Flexibility and above all Efficiency when data became very large.

A. The Existing System

The existing system is a Web-Based Certificate Verification System that can be implemented as a standalone app or embedded in a school official website depending on how the institution decides to use it. The software components of the graphical user interface (GUI) screens serve as the front-end written with PHP and JavaScript. The database implemented was MySQL which served as the back end for storage purpose. In the system, a prospective user would register and having his/her unique username and password to access the portal any time to verify his/her Certificate. The person is expected to provide a password known only to him during registration. The username and password would then be entered into the system to give access to the user into the verification

system. If any of the data is wrong, the user would be denied access. The user can view the certificate using the certificate number, but cannot make changes to the certificate [4].

Verification process: all that is required of the verifier is to log onto the verification link given, which is a link to the institution portal and enter the certificate number of the certificate he/she wants to verify, then the original copy of the certificate will be displayed on the screen. You compare the certificate you have at hand with the one on screen if there is any difference between the two certificates then the certificate is invalid. But if a certificate number (or code) entered is invalid the following message will appear "Invalid certificate number", the details of the person you are searching is not in the system, "it is either you missed typed the certificate number, or the owner did not pass through this institution, Verify and try again, please if the problem persists contact the school". The certificates and its details must conform to the certificate number.

Their system has taken the challenge of building an online certificate verification system using MySQL (an RDBMS) for certificate storage that was able to perform the following basic tasks:

i. The system automated the manual process of certificate verification

ii. Stored the certificate details of all graduates of any institution that adopt the use of the system.

Figure 2.3 the schematic view of the existing system [4].

B. Database design of the existing system

The system was implemented using My Structured Query Language MYSQL (an RDBMS) server. In the MySQL database environment, tables have dictionary items for each field that define the source of the data, all stored in a logical table. This additional information can provide insight into relationships between fields and tables thus:

Entities: The database comprised of major entities, namely, User Registration, User_Log_Book, Certificate details, the user Registration entity or table gives information about registered users. It contains fields or attributes like the username and password (in hashed format) Name, Address and others. The user_Log_Book keeps records on the date and time the registered user logs in to use the system. It has attributes as username, Date, Time and. The certificate image and Certificate detail contain information about students who owns the certificate that is being verified.

Queries: The system used various queries to maintain system data. Some of these include; Retrieve_User_Record (which retrieves the details of a registered user from the user_Registration table), Update_User_Record (which updates the records of a user), Certificate image (which displays a copy of the original certificate that was awarded to the student at their time of graduation, and log in Status_of_users (which displays the list of users who have already registered in the system and may have had some interactions with the system.

Entity-relationship diagram: The entity-relationship diagram of the online certificate verification system is an important synergy. The entity-relationship diagram is as follows:

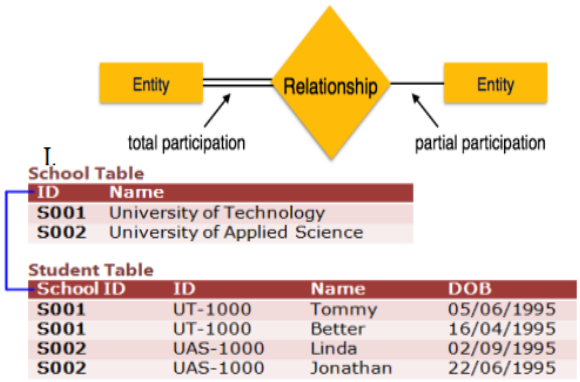

Figure 2.4: Entity Relationship Diagram of the existing system [4].

C. Advantages of the existing system

1. The system minimized paperwork for certificate storage.
2. It also resolved the risk of tripping to and fro an institution just to verify a certificate.
3. The system also saves time than the manual process.

D. Disadvantages of the existing system

1. The system was effective but not efficient enough as data increased in the database (MySQL) used, whose query time is affected by the number of rows and columns.
2. Lack of flexibility of MySQL database is also another drawback to the system since

   SQL enforces a fixed schema, thus, modifications in the database due to future demands is a challenge.
3. Lack of horizontal scaling of MySQL database which is used also limits the storage capacity of the system since SQL does not support scaling-down that is partitioning or sharding.
4. The system cannot also withstand a long time operation (durability) due to continuous increase in data size which slows down the operations of the system, may lead to system total break-down with time.
5. Weak security check as users were allowed to select user role at the point of registration.

III. THE PROPOSED MODEL

In this study, we present a model for Certificate Verification System for Institutions (CVSI). This work was proposed to overcome the above drawbacks of the existing system. The proposed system, however, adopted the use of a NoSQL database (precisely MongoDB) for storing certificate details. The choice of MongoDB which is a document-oriented NoSQL database is considered here due to its Flexibility, Scalability, and partition tolerance all of which makes it Efficient even when data becomes very large as a result of the indexing capability of MongoDB.
The verification process is same as in the existing system, however, the implementation using a NoSQL database is a unique and key feature of the proposed model to improve on the established pitfalls found in the existing system.

A. Database modeling for the proposed system

The design and implementation of the systems database is done using a NoSQL database called MongoDB. It uses Java-Script Object Notation (JSON) to represent a schema-less arrangement. This database consists of collections which host a group of MongoDB documents with different fields as sampled below:

Admin_collection (stores login details of the administrative user of the system) {
"_id": ObjectId("5cb0998403ee2c07d4003fa3"),

"name": " Kenneth Dekera Kwaghtyo",
"email": "dekerakenneth2014@gmail.com",
"phone": "08168211908",
"address": "Logo",
"password": "2010400056",
"role": "admin"
"profile img": "1555079020.jpg",
"date_added": "19-04-12 02:58:28 pm"
}

Users_collection (stores graduate's details)
{
"_id": ObjectId("5cb09a1703ee2c07d4003fa4"),
"name": "Kwaghtyo Dekera Kenneth",
"email": "kennethdekera@yahoo.com",
"phone": "08121000440",
"address": "Lessel",
"password": "2010400056",
"role": "student"
"profile img": "1553179021.jpg",
"date_added": "19-04-12 03:00:55 pm"
}

B. Improvements on the Existing System

The major enhancement factor of the proposed certificate verification system is the use of the features of NoSQL database system precisely MongoDB (a document-oriented NoSQL database) as highlighted below.

i. Efficiency: The verification was done in a more efficient manner using MongoDB indexing functionality which supports the efficient resolution of queries. Without indexes, MongoDB must scan every document of a collection to select those documents that match the query statement. This scan is highly inefficient and require the mongod (MongoDB server) to process a large volume of data. If an appropriate index exists for a query, MongoDB uses the index to limit the number of documents it must inspect.

ii. Flexibility: An interesting benefit of the document-oriented database is that they don't enforce a fixed schema. This makes them much more flexible than traditional database tables. That is, with the use of schema-less feature of MongoDB, one can modify a document without affecting other documents in a collection based on future demands thus, flexibility is enhanced.

iii. Durability: When designing a database we ensure that the data we want to be stored gets stored and can stand the test of time. Data durability is a key factor in applications. In addition to many of the performance considerations that MongoDB has improved upon in recent versions, data durability is another improvement to the existing system as MongoDB supports scaling down (partitioning or sharding).

iv. Use of NoSQL: NoSQL stands for (Not-only SQL). It is a non-relational database (no tables) and a flexible database used for big-data and real-time web applications. NoSQL is more flexible than SQL databases. Hence the researcher considered it more suitable for this project to enhance certificate verification.

IV. METHODOLOGY

Software methodology is the set of rules and practices used to create computer software. It consists of a software development model used together with at least a technique. Thus, METHODOLOGY = SOFTWARE MODEL + TECHNIQUE(S) [7].

The methodology to be adopted for this project is the Top-Down Design approach with iterative model.

According to Nath [11], Top-Down Design approach (also known as stepwise design, deductive reasoning or used as a synonym of analysis or decomposition) is essentially the breaking down of a system to gain insight into its compositional sub-systems. In a top-down approach, an overview of the system is formulated without specifying any details. Each subsystem is then refined in yet greater detail, sometimes in many additional subsystem levels, until the entire specification is reduced to base elements. Once these base elements are recognized then we can

build them as program modules that can be put together, making an entire system from these individual components. Top-down approach starts with the big picture then breaks down into smaller segments.

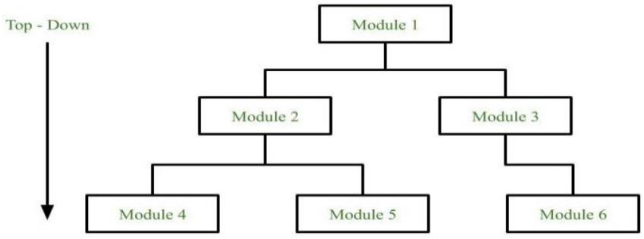

Figure 4.1The Top-Down Structure [12].

That is, Top-Down Design approach is based on the use of modules in which the program is further split into small modules so that it is easy to trace a particular segment of code in the software program. Each module is based on its functions and procedures.

The top-down approach emerged in the 1970s when IBM researchers Harlan Mills and Niklaus Wirth developed the top-down approach for software development. Mills created a concept of structured programming that aided in the increased quality and decreased time dedicated to creating a computer program. Again, Wirth developed a programming language 'Pascal' that relied on the Top-Down approach [13].

According to Abolaji [14], the Merits of top-down programming include:

1. Fewer operational errors.
2. Less time consuming (each programmer is only concerned in a part of the big project).
3. Very optimized way of processing (each programmer has to apply their knowledge and experience to their parts (modules), so the project will become an optimized one).
4. Easy to maintain (if an error occurs in the output, it is easy to identify the errors generated from which module of the entire program).

Iterative Model: [4] considered the adoption of the Iterative (Incremental) model in which a software is broken into smaller modules and each goes through the requirements, design, testing and implementation phases as shown in the following figure;

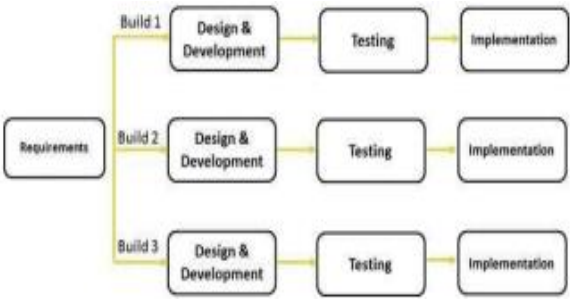

Figure 4.2 Typical Iterative model diagram [4].

Nwachukwu & Igbajar [4] said this model is often used in the following scenarios:

1. Requirements of the complete system are clearly defined and understood.
2. Major requirements must be defined, although some may evolve with time.
3. There is a time for the market constraint.
4. A new technology is being used and is being learnt by the development team

5. The needed skill set are not available and are planned to be used on a contract basis for specific iterations.

6. There are some high-risk features and goals which may change in the future.

A. Proposed process for certificate verification

To enhance the general process of certificate verification, three parties should be involved in the process to complete certificate verification. It is proposed that the university issues a secret number to each graduate to ensure confidentiality. This number is given to the graduate at the point of receiving his/her certificate.

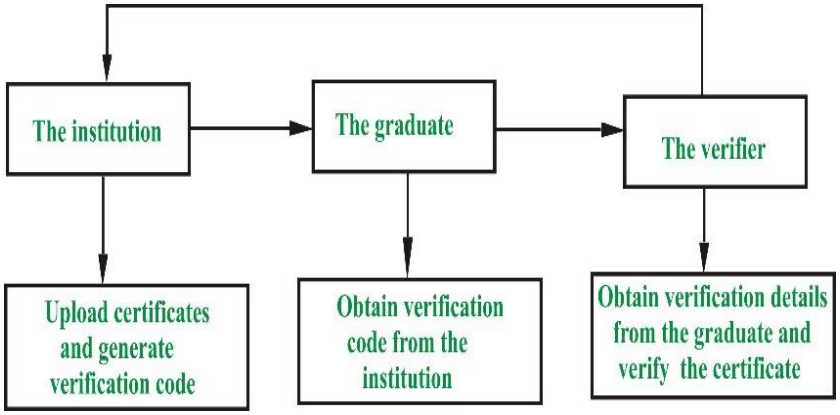

Figure 4.3 Proposed process for certificate verification

B. System Algorithm

This shows how the proposed system will work. Sequences of steps for implementation of the system are as follows:

1. Start

2. Register

3. Login

4 If username and password valid goto 5 else goto 2

5 If admin then goto 6 else goto 8

6. Register and Upload certificate

7. Modify records

8. Verify certificate

9. Print result

10. End.

C. System Flow Chart

All the components of the program (such as different subprogram/modules designed separately) were integrated to become a single program and then test run. The figure below gives the overall flowchart of the proposed system.

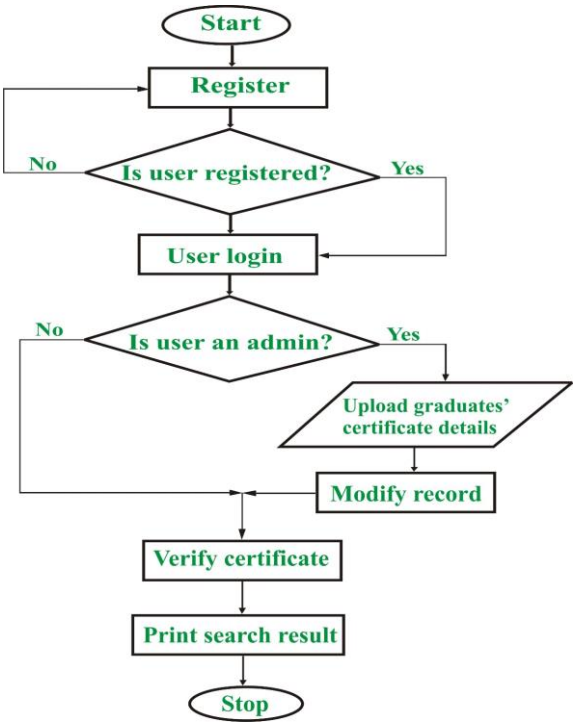

Figure 4.4 the proposed system flow chart.

D. Use case

Use case diagram which is a graphical representation of the system's functionality by the different users is also applied to describe this automated system. The use case diagram consists of actors, use cases and arrows for events flow. The actors as concerned in this verification system are Admin (Administrator), graduates and the verifier. The use cases are registration, Login, Upload certificate, modify records, and add admin, verification, print, and logout menu. The modify menu consists of Edit and Delete of graduate information. The use case diagram of this automated system – certificate verification system; is as given below.

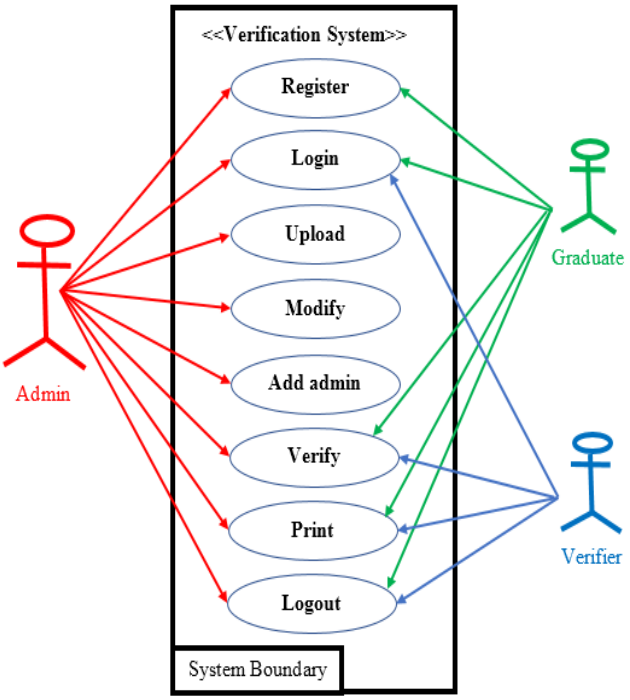

Figure 4.5 the proposed system use case diagram.

V. RESULTS AND ANALYSIS

The researcher used the following hardware and software requirements for experiments. The minimum hardware requirements include a desktop or laptop with Intel(R) Dual-Core CPU processor, 1.30 GHz speed, 2 GB RAM and a Hard Disk space of at least 30 GB.

The software requirements necessary for the system to be able to work with this model simulation include; Operating System (32-bit or 64-bit), Any Web Browser; Chrome, Firefox, UC-browser etc., XAMPP-win32-7.0.9-0-VC14-installer for (Apache Web-Server), Any Code Editor such as Macromedia Dreamweaver 8, Brackets or even Notepad++, Database Server (MongoDB) at least MongoDB-win32-x86_64-2008plus-SSL-4.0.2-signed, PHP-MongoDB Driver set up e.g. php_mongodb-1.5.0-7.0-ts-vc14-x86 that is compatible with your XAMPP version and Composer-Setup all installed.

An automated system may have a hundred program modules and a comprehensive database, all must be tested together to ensure harmony of operation. The purpose of system testing is to validate all software, input/output, databases and procedures as the case may be [7]. The result of the implementation and testing results are as follows:

5.1 The home page: This is the first interface encountered to access other features of this online certificate verification system. It comprises of a login and register menu to direct the user as appropriate as shown in fig. 5.1 below.

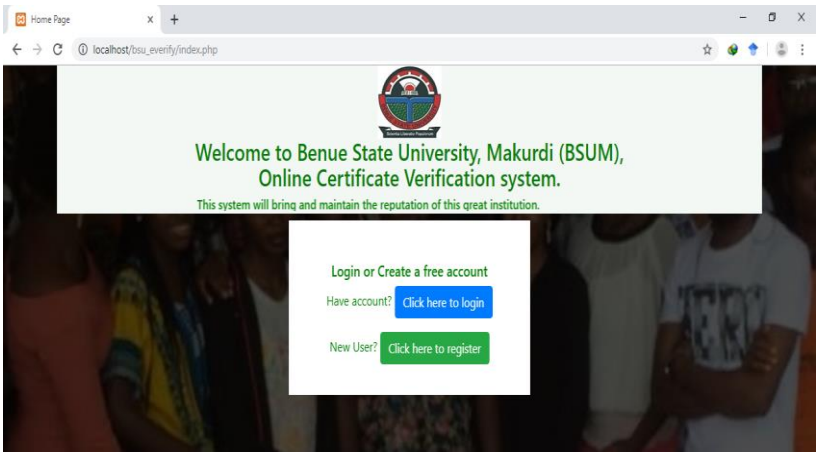

Figure 5.1 the Home or index page.

5.2 The verification request page: This is the module that handles certificate verification. The required field used as input in this form is the certificate verification number simply called "Cert _No or code". The researcher adopts the use of only one field here to reduce query time, thus improve the system's efficiency.

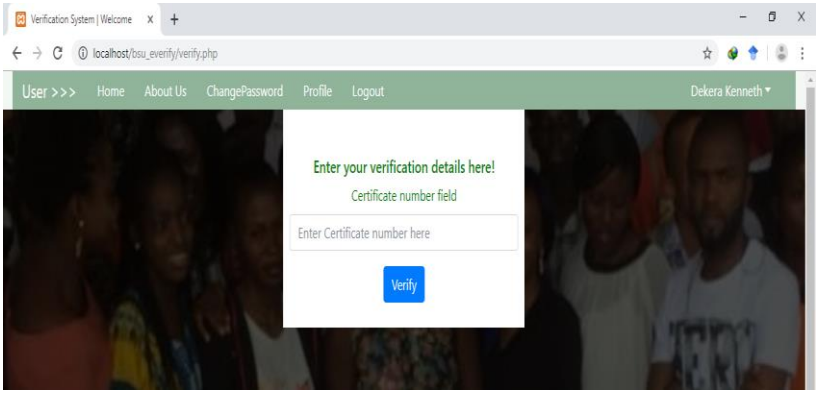

Figure 5.2 the verification request form interface.

5.3 The verification result page: This is the output form that displays the graduate certificate upon logging in and providing the correct certificate number (cert_No) issued to him or her by the institution. It has a print option should incase the verifier needs the hard copy.

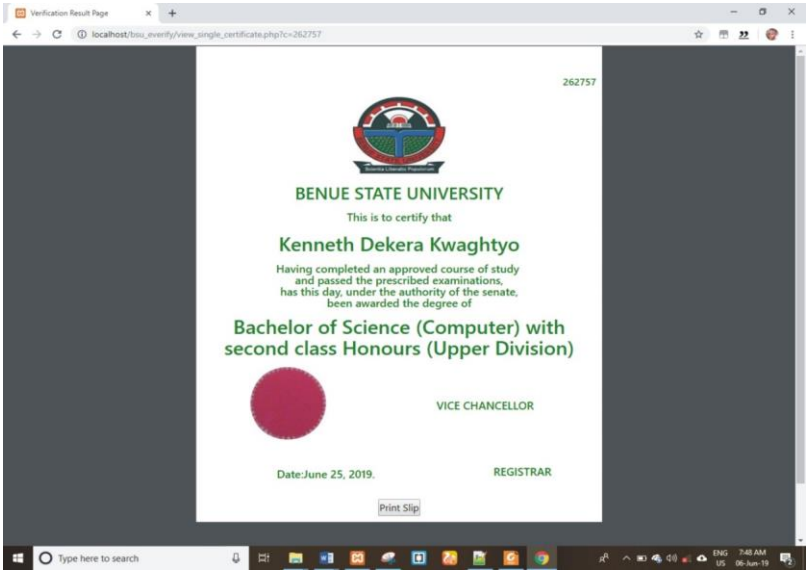

Figure 5.3 the verification result page interface.

VI. CONCLUSION AND RECOMMENDATION

This online certificate verification system averts fraud on academic certificates. It offers lesser cost involvement and convenience to both developers and users i.e. considerable ease to use by employers as they can get original certificate from school easily and more quickly than other conventional methods of verification such as manual method, QR code, Watermark, facial recognition, biometric technology which are more cost involving. The implementation of this web verification system using MongoDB (a NoSQL database server) shows a more effective way of building a certificate verification system that supports horizontal scaling (partitioning or sharding). The researcher, therefore, hope that when the system is implemented across various institutions of learning, the problems of having fake certificates will be greatly reduced if not completely wiped out.

A more elaborate and intensive research be fashioned out using a NoSQL database in the execution of a very complex application/process expected to surpass what is contained in this research work. Finally, verification systems security should be allowed to be scrutinized by experts in systems analysis and design, computer programming and computer system security. This would be the only way to ensure public confidence in such systems.

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