**ABSTRACT**

The traditional username and passwords approach used in most authentication system is susceptible to sniffing and may be insecurely stored. Some persons tend to use strong passwords but it becomes difficult to remember several strong password for different accounts. As a result, this project work proposes the development of a novel multifactor authentication system for secure and efficient access control which will have a good balance of security and convenience. It combines Personal Identification Number (PIN), One-Time-Password (OTP) and Quick Response (QR) to achieve optimal Security in authentication system. A cryptographic hash function is used in generating the OTP and it is delivered to the user through Short Message Service (SMS). After the design and implementation, the system proved to be an efficient system that adds another security layer in authentication systems. It was developed as an android application using Java programming Language while the development followed the waterfall model which breaks down the development process into processes that are followed sequentially.

**MATERIALS AND METHODS**

**3.1 Materials**

For the development of the mobile-based secure access control system using multifactor authentication techniques, we have several options and choices in terms of mobile and web development tools, platforms and technology, the materials selected for this project work are listed and described in this section.

1. **Operating System**
   * 1. Android Operating System
     2. Windows Operating System
2. **Integrated Development Environment (IDE) and Text Editor**
   * 1. Android Studio (Version 2.3)
     2. Sublime Text
3. **Programming Languages**
   * 1. JavaScript
     2. JSON
     3. CSS
     4. HTML
     5. BOOTSTRAP
4. **Server-side Integration** 
   * 1. Apache HTTP Server
     2. MySQL Database
     3. NODE JS
     4. TWILO (SMS GATEWAY)
     5. GOOGLE AUTHENITACTOR
     6. RECAPTCHA
     7. ...................
5. **Development and Testing Device**
   * 1. Laptop
     2. Smartphone
6. **Android Operating System:** This is an Operating system (OS) developed by Google for mobile phones. It is based on a modified version of the Linux Kernel and other open source software and is designed mostly for touch screen mobile devices such as smart phones and tablets. In addition, Google has built Android Auto for cars, Android TV for televisions and Wear OS for wrist watches, each with a specialized Graphical User interface (GUT). This operating system was initially developed by Android Inc, which Google bought in 2005. The operating system was unveiled in 2007, with the first commercial Android device launched in September 2008. It has since gone through multiple major releases, with the current version bbeing 9, Pie, released in August 2018. Google release the first Android Q beta on all Pixel phones on March 13, 2019. The core Android source code is known as Android Open Source Project (AOSP) and is primarily licensed under the Apache License.
7. **Windows Operating System:** This is a group of several graphical operating system families, all of which are developed and sold by Microsoft Corporation. Active Windows families include Windows NT and Windows Embedded; these may encompass subfamilies such as Windows Embedded Compact of Windows Server. Encompass subfamilies such as Windows Embedded Compact or Server. Defunct Windows families include Windows 9x, Windows Mobile and Windows phone. The android application was developed on a personal computer running on Windows 8.1 operating system.
8. **Android Studio:** This is the official Integrated Development Environment (IDE) for the android operating system. The IDE is built on JetBrains Intellij IDEA software and designed precisely for android application development. Android studio has replaced the Eclipse Android Development Tools (ADT) as the primary IDE for native Android application development. Some features of this IDE include the following amongst other:
9. Android-specific refactoring and quick fixes
10. Gradle-based build support
11. A rich layout editor that allows users to drag-and-drop UI components.
12. Android Virtual Device (Emulator) or run and debug applications in the IDE
13. **Sublime-Text:** This is used for entering and editing the PHP program source code, this text editor was selected. Sublime text is a proprietary cross-platform text editor. It natively supports many programming languages and markup languages, and its functionally can be extended by users with plugins, typically community-built and maintained under free-software licenses.

XML; is an abbreviation for Extensible Markup Language, which is a mark-up language that defines a set of rules for encoding documents in a format that is both human readable and machine-readable. It’s design goal put emphasis on simplicity, generality and usability across the internet. XML is a textual data format that has strong support for different human languages via Unicode. Though, the design of the mark-up language focuses on documents, XML is widely used for the representation of arbitrary data structures such as those used in web services. In the system implementation, XML is used to design the graphical user interface (GUI) of the android application.

1. **Java:** This is the programming language chosen for implementing the business logic of the android application of this project work. It is a general-purpose programming language which is concurrent, object-oriented and specifically designed to have as few implementation dependencies as possible. It is intended to let software developers ‘ write once, run anywhere’ meaning that complied java code can run on all platforms that support Java without the need for recompilation. Java applications are typically compiled to byte code that can run on any Java virtual machine (JVM) regardless of computer architecture. Java is one of the most popular programming languages in use, particularly for client-server web applications, with a reported 9 million developers. Java was originally developers.

Java was originally developed by James Gosling at Sun Microsystems (which has since been acquired by Oracle Corporation) and released in 1995 as a core component of Sun Microsystems’ Java platform. The language derives much of its syntax from C and ++, but it has fewer low-level facilities than either of them.

1. **PHP:** This is a server-side scripting language designed primarily for web development and also used as a general-purpose programming language. In this project work, this programming language was selected for developing the web Application Programming Interface (API) which enables the android application to communicate with the database. Is interpreter, powered by the Zend Engine, is a free software and the language is widely ported and can be deployed on most web servers on almost every operating system and platform, free of charge.
2. **JSON:** This is an abbreviation for JavaScript Object Notation, an open-standard file format which utilizes human-readable text to transmit data objects consisting of attributes-values pars, array data types or other serializable value. It has become a very common data format used for asynchronous client-server communication. It has replaced the widely known Extensible Markup Language (XML) in some AJAX-style systems. In this project work, reponses from the server are presented or returned to the client in JSON format which is the parsed and used appropriately.
3. **Apache HTTP Server: This**  is the world most used web server software and to available for a variety of operating systems like the Microsoft Windows. It is free and open source cross-platform web server software, released under the terms of Apache License 2.0. apache is developed and maintained by an open community or developers under the auspices of the Apache Software Foundation. This is the web server selected for hosting the web files (API) developed in this project work.
4. **MySQ:** This is an open source relational database management systems. Its name is a combination of ‘My’ the name of the co-founder Michael Widenius’s daughter and ‘SQL’ the abbreviation for Structured Query Language. MySQL is written in C and C ++; its SQL parser is written in yacc, but it utilizes a home-brewed lexical analyzer.

This relational database management system works on many operating system platforms such as Linux, Solaris macOS, windows and FreeBSD. The software System developed in this project work uses MySQL for the purpose of data and information storage.

SMS Gateway: this is a system that allows computer system to send and receive Short Message Service (SMS) transmissions to and from a teleconmmunication link.

This project work uses an SMS gateway to transfer cryptographically generated tokens needed for the multifactor authentication mechanism.

Laptop: This is the development machine used during report compilation and software system implementation. Also called a notebook computer, it is a small, portable personal computer with a ‘clamshell’ form factor, having, typically, a thin LCD or LED computer screen mounted on the inside of the upper lid of the clamshell and an alphanumeric keyboard on the inside of the lower lid. Some testing was also done on this machine.

1. **Smartphone:** This is a category of mobile phones and multi-purpose mobile computing devices which are distinguished from feature phones by their robust hardware capabilities and extensive mobile operation systems that enables wider software, internet and multimedia functionality, alongside core phone function such as voice calls and text messaging. The smarphone used in testing the android application is an infinix product which is an android powered mobile device.

**3.2 Methods**

Software development methods involve the process of dividing software development work into different phases to improve design and project management.

This is also known as a software development life cycle. The methodology may include the pre-definition of specific deliverables and artifacts that are created and completed by a project team to develop or maintain an application. Most modern development, spiral development, rapid application development, and extreme programming. The method used in this project work in the waterfall development model.

**3.2.1 The Waterfall Development Method**

The waterfall development model is a sequential development approach in which design, development, and implementation are conducted in a sequential manner through the following phases: requirements gathering and analysis, design, implementation, testing(validation) integration and maintenance. This model was chosen for this project work because it is a structured approach; a progressively linear model that follows discrete, easily understandable and explainable phases. The model provides milestones throughout the development cycle. The phases involved in this development method are depicted in figure 3.1: