*International Journal of Engineering Science Invention (IJESI)*
*ISSN (Online): 2319-6734, ISSN (Print): 2319-6726*
*www.ijesi.org ||Volume 9 Issue 4 Series III || Apr.2020 || PP 01-13*

# An Improved Adaptive Simulation Modelling of a Card-Based Centralized Locking System for Nigerian Banks' Staff using Digital Twin Paradigm

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***ABSTRACT:****The major challenging factor for programmers and Software Developersis the problem of poor simulation and modelling technique. The problem has resulted in the development of faulty software and application programs due to lack of adaptive simulation skillsthatutilizes digital twinparadigm. Adaptive Simulation provides adaptive algorithmsthat can automate the whole process of running flow simulations. In thiswork, an Improved Adaptive Simulation of a Central Locking System for Banks' Staff wasdeveloped. The Structured System Analysis and Design Methodologywasadopted in thisapproach. The system wasimplementedwithHypertext Pre-processor and MySQL Database as backend. The parameters for ourresult performance achieved an overall performance rate of 95% whencomparedwith the mostrecent Pervasive Computing System for Central LockingSystems. The parameters for the comparisonincluded Time Complexity (TC), Life-Cycle Assessment (LCA), Benchmarking (B), Multi-CriteriaDecisionMaking (MCDM), Risk Assessment (RA), CostBenefitAnalysis (CBA) and Speed (S) presented as TC, LCA, B, MCDM, RA, CBA, S = 16, 20, 14, 12, 8, 10 and 15 as comparedwith the existing system parameters values of 15, 18, 14, 10, 7, 12 and 17 respectively. Furthermore, the obtainedresultscontributed a Card-Based Technique for security checks in banksthatwillalso enable staffs of the bank to boycott previoussecurity checks thatinvolvesmanualprocedures. The security information obtainedfrom the staff willbeembeddedinto the card to enable validaccess at any time. In addition, thisworkcouldbebeneficial to the bankingsector, to staff of the bankand to relevant securityagencies in Nigeria.*

***KEYWORDS****-Adaptive Simulation, Card-based, Central Locking, Digital Twin Paradigm, Modelling*

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Date of Submission: 16-04-2020 Date of Acceptance: 01-05-2020

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## I. INTRODUCTION

The major challenging factor for programmers and Software Developers is the problem of poor simulation and modelling technique. The problem has resulted in the development of faulty software and application programs due to lack of adaptive simulation skills that utilizes digital twin paradigm. Adaptive Simulation provides adaptive algorithms that can automate the whole process of running flow simulations; their innovations are a spin-off from world-leading research conducted over the last decade by a team of researchers at the KTH Royal Institute of Technology in Stockholm, Sweden. According to Umut et al [1], "the integration of haptic, the sense of touch, in human computer interaction has increased the immersion effect of virtual environments". Haptic has been used to serve different aims such as guidance, visualization, and realism in various computer applications. Considering the growing use of haptics in medical applications, such as in virtual simulations for training and rehearsal purposes, the degree of realism has become a crucial issue.

Achieving a compromise between realism and stability has always been a major challenge in haptic, especially for deformable objects. High refresh rates (1 kHz) are necessary to achieve a stable and continuous force feedback, while solution of the physical models with desired resolutions comes with a heavy computational burden. Adaptive multi-resolution techniques have been among the most popular methods proposed to achieve desired refresh rates with required resolution. A major problem with this approach, however, has been a lack of focus on the reduced realism due to the error introduced by adaptive simulation and the lack of standard error metrics. In the case where a single ordinary differential equation is considered, the time-step is crucially important to achieve acceptable accuracy. In the case of a large number of differential equations, however, keeping the time-step just under the stability limit provides sufficient accuracy. The reason for this is the fact that a stiff system of differential equations covers a wide spectrum of natural frequencies. The stability limit is evaluated with respect to the highest frequency of the system. Therefore, for a time-step which is close to the critical stability time-step limit, the response of the model for the highest frequencies will not

have high accuracy. Fortunately, the structural response of the objects is dominated by much lower frequencies which are sufficiently more accurate for the chosen time-step.

1.1 AIM AND OBJECTIVES

The aim of this study is to develop a Card-based security system. The specific objectives are to:

i) design a Card-based security Model using Adaptive Simulation Approach and Digital Twin Paradigm
ii) implement the proposed system with Hypertext Pre-processor and MySQL database as backend
iii) compare our results with the existing card-based security systems

## II. RELATED WORKS

Aurelien et al [2] looked at adaptive simulation of hybrid stochastic and deterministic model for Biochemical Systems, in which in the past years it has become evident that stochastic effects in regulatory networks play an important role, leading to an increasing in stochastic modelling attempts. In contrast, metabolic networks involving large numbers of molecules are most often modelled deterministically. Going towards the integration of different model systems, gen-regulatory networks become part of a larger model system including signalling pathways and metabolic networks. Thus, the question arises of how to efficiently and accurately simulate such coupled or hybrid systems.

Cheng et al [3] looked at an improved scale-adaptive simulation model for massively separated flows. The work proposed a new hybrid modelling method termed improved scale-adaptive simulation (ISAS) through the introduction of von Karman operator into the dissipation term of the turbulence scale equation, proper derivation as well as constant calibration of which is presented, and the typical circular cylinder flow at Re = 3900 is selected for validation. As expected, the proposed approach with the concept of scale-adaptive appears more efficient than the original method in obtaining a convergent resolution, meanwhile, comparable with capturing the fine-scale unsteadiness. Furthermore, the grid sensitivity issue is encouragingly remedied benefiting from the local-adjusted limiter.

Jinjiang et al [4] looked at digital twin for rotating machinery fault diagnosis in Smart Manufacturing. According to the work, Digital Twin has gained increasing attention as it offers an enabling tool to realize digitally-driven, cloud-enabled manufacturing. Given the nonlinear dynamics and uncertainty involved during the process of machinery degradation, proper design and adaptability of a Digital Twin model remain a challenge.

According to Victor et al, [5], Smart cards are used in information technologies as portable integrated devices with data storage and data processing capabilities. As in other fields, smart card use in health systems became popular due to their increased capacity and performance. Their efficient use with easy and fast data access facilities leads to implementation particularly widespread in security systems.

Nsebehe [6] suggested that memory cards contain eeprom and rom memory, as well as some address and security logic. In the simplest designs, logic exists to prevent writing and erasing of the data. More complex designs allow for memory read access to be restricted. Since they cannot directly manipulate data they are dependent on the card reader (also known as the card-accepting device) for their processing and are suitable for uses where the card performs a fixed operation.

Ginola [7] looked at automated access in financial institutions. According to the study, Integrated Circuit Cards have conventionally come to be known as "Smart cards". A smart card is a card that is embedded with either a microprocessor and a memory chip or only a memory chip with non-programmable logic.

Uchendu [8] researched on the need to implement real-time card-based systems for large industrial environment. The study further illustrated that Smart cards, unlike magnetic stripe cards, can carry all necessary functions and information on the card. Therefore, they do not require access to remote databases at the time of the transaction. Smart cards are passive devices which mean that to function. A smart card needs to be inserted into a reader connected to a computer, or an integrated smart terminal.

Makinwa [9] researched on an enhanced model for automated security for industrial organizations. According to the study, devices are usually known as CAD (Card Acceptance Device), and come in much kind of shapes: readers integrated into a vending machine, handheld battery-operated readers with a small LCD screen, readers integrated into a GSM mobile phone, or attached to a personal computer by a variety of interfaces.

Ayodele [10] looked at card-based central locking systems: a modified survey. The study illustrated that since data cannot be retrieved directly via the CAD (Card Acceptance Device), smart cards have been proposed as portable and secure data storage devices. In addition, their computing capabilities (especially if integrated by the cryptographic co-processor) make them especially suitable as private key storage devices for asymmetric algorithms, since in this way private keys can be generated and stored on board the card, and never leave it. Encryption and decryption of data are performed on request by the card chipset itself

## III. MATERIALS AND METHODS

### 3.1 METHODOLOGY

The Methodology for the Proposed System Design is Structured System Analysis and Design Methodology (SSADM). Structured Systems Analysis and Design Methodology is a systems approach to the analysis and design of information systems.

### 3.2ANALYSIS OF THE EXISTING SYSTEM

Over the years, various control systems have been designed to prevent access to unauthorized user (figure1). However, the existing system of locks for banks is not card-based. Furthermore, the existing lock methods have proven to be a bit unsatisfactory in one way or the other. Though, some have advantages outweighing the disadvantages while others have much more disadvantages. Due to the fact that live and property may be at stake, it is important to always have a reliable lock system, putting into consideration the high rate of crime and insecurity. Most door lock systems also require carrying external lock devices which complete the system; this may include keys, cards, remote controls, etc. On losing any of these devices, one may need to change the lock system in order to apply precaution(s) in case they have fallen into wrong hands. Also, due to the rapid growth in computer, gsm control system and technology advancement in general, it may be seen worthwhile to move with the recent trends either privately-in our homes or in our establishments. The existing system also provided automatic doors used mat actuator as the access control mechanism. Over the years, modifications have been made to improve this door. A safe and deadlock free locking policy is introduced, called pre-analysis locking. A transaction system with no lock and unlock operations in the transactions is first being analyzed by the pre-analysis locking algorithm. Then, the result of this analysis is used to insert lock and unlock operations into the transactions with the goal of achieving a degree of concurrency as high as possible. However, pre-analysis locking is merely a heuristic operating in polynomial time; therefore, it is not guaranteed to perform optimally in all cases. Electronic locking systems are rather new products in the physical access control market. In contrast to mechanical locking systems, they provide several convenient features such as more flexible access rights management, the possibility to revoke physical keys and the claim that electronic keys cannot be cloned as easily as their mechanical counterparts. While for some electronic locks, mechanical flaws have been found, only a few publications analyzed the cryptographic security of electronic locking systems.

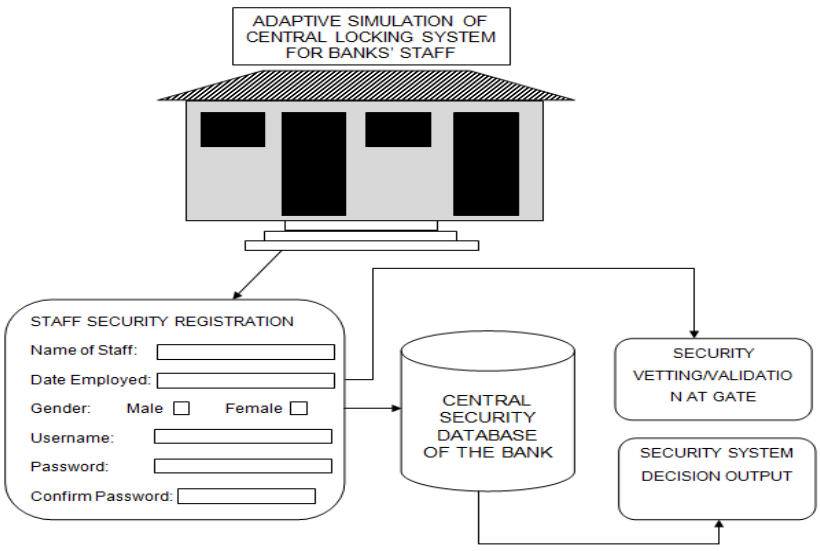


**Fig. 1:** Adaptive Simulation of Central Locking System for Banks' Staff (Existing System)
(**Source:** [3])

Locks might be the most frequently used symbol icon when it comes to explaining IT security and cryptography. While mechanical locks have evolved for more than two millenniums, digital access control systems have only been increasing their market share in the last decades. Such systems allow greater flexibility when it comes to managing access control for a large number of users for a facility and easy revocation of lost keys. They also provide the user with the advantage that only one single token is needed for accessing many different locks. Furthermore, electronic locking system manufacturers claim that it is difficult to copy or clone keys, or in other words, forge the authenticity of key owners. In general, the authenticity of a person or object can be ensured by the means of knowledge, ownership or inherent properties. In the case of almost all

mechanical locks, the ownership of a key can be tracked down to the knowledge of its shape that can be observed and cloned easily. Some attacks even focus on reconstructing mechanical keys from newspaper or television images. This is not possible for electronic access tokens such as smartcards or electronic transponders: even though they are supposed to contain secret keys, cryptographic algorithms and protocols shall ensure their secrecy. However, the exact functionality of electronic locks is often not documented in contrast to mechanical locks with public technical principles. This violates Kirchhoff's principle and makes it difficult for third parties to independently evaluate the security of electronic locking systems.

3.2 Explanation of the Existing System Components

The following components of the Existing System are:

i) The Building Icon:

This component serves as the bank's building and welcome screen to the user in order to enable full understanding of the system.

ii) The Staff Security Registration Platform:

This component enables the staff to input vital information in order to be allocated a unique username and corresponding password.

iii) The Central Security Database:

This component contains the organized collection of staff information which would be used for security vetting/access validation.

iv) Security Validation at gate:

This component enables the staff to assemble at the security checkpoint of the bank in order to commence the security check / access validation.

v) Security System Decision Output:

This component displays the resulting output from the security check / access validation of the staffs

3.4 Disadvantages of the Existing System

The following disadvantages of the Existing System are:

i) The existing system does not consistently take care of home security due to non-card basedImplementation. This is as a result of the unavailability of an improved adaptive simulation system that uses digital twin paradigm.

ii) The existing system cannot be interfaced to global system of mobilizations. In addition, there was a need to automate home so that user can take advantage of the technological advancement in gsm technology and computer control system. It is also interesting to know that commonly used devices like a telephone land line or the Global System of Mobile communication (gsm) can possess features which can be used domestically by individuals or industries to operate appliances like; door, electric bulb, television, refrigerator, air condition, robotic arm, etc.

3.5 Analysis of the Proposed System

The proposed system for a card-based security system is a micro-controller chip that will secure doors in Guaranty Trust Bank (see figure 2). A microcontroller is a computer-on-a chip. It can also be described as a single chip computer. The 8952 is a low power, high performance CMOS 8-bit microcontroller with 8kbytes of flash programmable and erasable read only memory EPROM. It is compatible with the industry standard 8051 and 8052 instruction set and pin-out. By combining an industry standard 8-bit CPU with ROM on a monolithic chip, the 8952 is a powerful micro-computer which provides a highly flexible and cost effective solution to many embedded control applications. The Parallel Port is the most commonly used port for interfacing homemade projects. The port is composed of 4 control lines, 5 status lines and 8 data lines. It's found commonly at the back of the PC as a D-Type25 Pin female connector. This will be a serial RS-232 port and thus, is a totally incompatible port. Visual basic 6.0 cannot access the computer parallel port directly unlike serial port. Some DLL (Dynamic Link Libraries) that was built in embedded C must have been deployed in the system32 (the system registry) first. And a module that can reference to this DLL must have been declared in the program. This module contains some functions like VB-in and VB-out, which VB 6.0 uses to read from and write to the port respectively. They are often used to connect devices or receive large amount of data. They transfer 8 bits (one byte) of a time using a cable with 8 data line-they're also known as DB 25 since they have 25 female pin connector. The lines in DB 25 connector are divided into; Data line (data bus) = 8 lines, Control lines = 4 lines, and Status line = 5 lines.

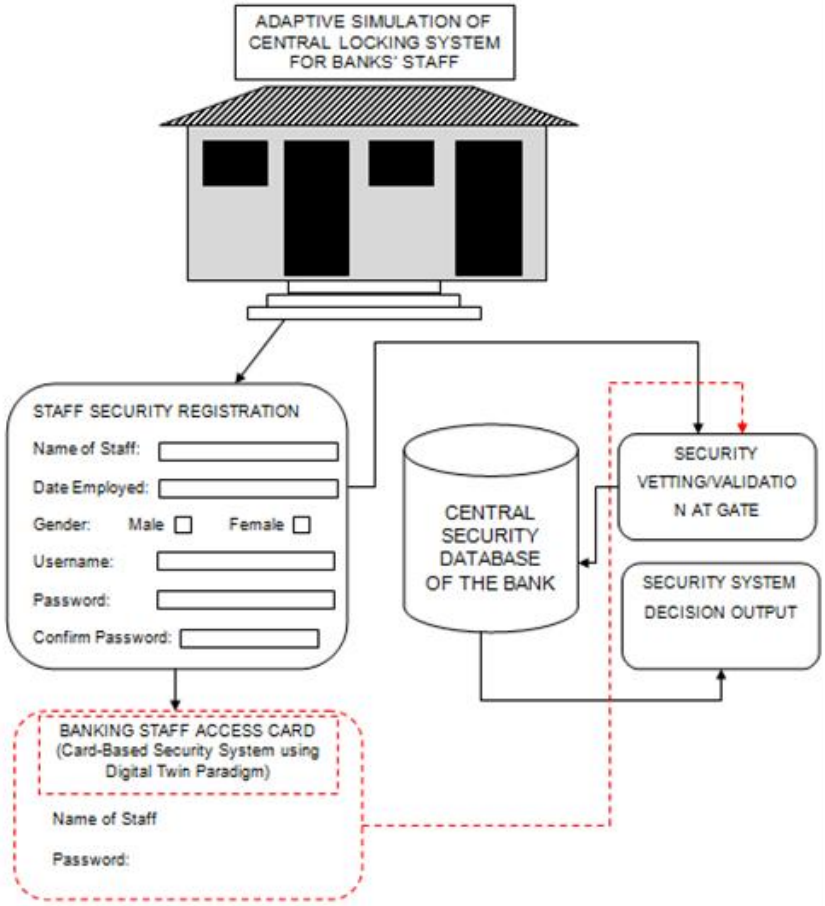


**Fig. 2**: Proposed System: Adaptive Simulation of a Central Locking System for Banks' Staff

3.6 Explanation of the Proposed System Components
The following components of the Proposed System are:

i) Card-Based System:
This particular simulated component will enable the staffs of the bank to boycott previous security check. The security information obtained from the staff will be embedded in the card to enable valid access at anytime.

3.7 Advantages of the Proposed System
The following advantages of the Proposed System are:

i) The proposed system is card-based was developed using digital twin paradigm and can be interfaced to a mobile phone in order to enhance portability among users.
ii) The proposed card-based system is implemented with Hypertext Preprocessor (PHP), Visual Basics and MySQL as Database. This has made the system to have a good graphical user interface, good sensors that respond rapidly to the card usage, and an efficient information storage platform.

3.8 Existing System Algorithm

STEP ONE:
START
STEP TWO:
DECLARE VARIABLES
SSR, NOS, DE, G, UN, PW, CPW, CSD, SVV, SSDO
WHERE SSR IS STAFF SECURITY REGISTRATION,

NOS IS NAME OF STAFF, DE IS DATE EMPLOYED,
G IS GENDER, UN IS USERNAME, PW IS PASSWORD
CPW IS CONFIRMED PASSWORD, CSD IS CENTRAL
SECURITY DATABASE, SVV IS SECURITY VETTING
AND VALIDATION AT GATE, SSDO IS SECURITY
SYSTEM DECISION OUTPUT

STEP THREE:
INITIATE SSR
STEP FOUR:
SSR = NOS + DE + G + UN + PW + CPW
STEP FIVE:
POST SSR TO CSD
STEP SIX:
CSD = 0 +SSR
STEP SEVEN:
INITIATE SVV
STEP EIGHT:
SVV = CSD
STEP NINE:
INITIATE SSDO
STEP TEN:
SSDO = 0 + SVV
STEP TEN:
STOP

3.9 Proposed System Algorithm

STEP ONE:
START
STEP TWO:
DECLARE VARIABLES
SSR, NOS, DE, G, UN, PW, CPW, CSD, SVV, SSDO, BSAC
WHERE SSR IS STAFF SECURITY REGISTRATION,
NOS IS NAME OF STAFF, DE IS DATE EMPLOYED,
G IS GENDER, UN IS USERNAME, PW IS PASSWORD
CPW IS CONFIRMED PASSWORD, CSD IS CENTRAL
SECURITY DATABASE, SVV IS SECURITY VETTING
VALIDATION AT GATE, SSDO IS SECURITY
SYSTEM DECISION OUTPUT AND BSAC IS BANKING
STAFF ACCESS CARD

STEP THREE:
INITIATE SSR
STEP FOUR:
SSR = NOS + DE + G + UN + PW + CPW
STEP FIVE:
POST SSR TO BSAC
STEP SIX:
BSAC = 0 +SSR
STEP SEVEN:
POST BSAC TO CSD
STEP EIGHT:
CSD = 0 + BSAC
STEP NINE:
INITIATE SVV
STEP TEN:
SVV = GET BSAC FROM CSD
STEP ELEVEN:
INITIATE SSDO
STEP TWELVE:

SSDO = 0 + SVV
STEP THIRTEEN:
STORE OUTPUT
STEP FORTEEN:
STOP

## IV. RESULTS AND DISCUSSION

4.1 Choice and Justification of Programming Language used

We implemented the Proposed System design with PHP, JavaScript Programming Language, Hypertext Markup Language, Cascading Style Sheet and MySQL Relational Database Management System. JavaScript is a server-side scripting language that is used for making web pages interactive. It is supported by all major web browsers. This is a programming language that is used by web developers for the creation of contents that communicate with databases. Secondly, PHP can be used for the development of web-based applications, system function performance; HTML is an acronym for Hypertext Markup Language and is used for structuring web pages. It consists of tags and is also supported by all major web browsers. Cascading Style Sheet (CSS) is a web development content that is used for styling and beautifying web pages. MySQL is the world's most popular open source database. With its proven performance, reliability and ease-of-use, MySQL has become the leading database choice for web-based applications, used by high profile web properties including Facebook, Twitter, YouTube, Yahoo and many more. Oracle drives MySQL innovation, delivering new capabilities to power next generation web, cloud, mobile and embedded applications.

4.2 Discussion of Results

Figure 3 shows the home page of Improved Adaptive Simulation of Central Locking System for Banks' Staff. The home page presents the user with the following options which includes Staff Security registration and Security Vetting. The registration link enables the staff to input registration details in order to be allocated a security access card by the bank. Secondly, the proposed system result also shows the process where internet computing can affect everything, and can be accessed from anywhere through any object (e.g. Smartcards). A user interacts with the computer which can exist in many different forms including laptop computers, tablets and terminals in everyday objects such as refrigerator or a pair of glasses. The staff of the bank is allocated a smart card that will enable him or her to gain access to any specific area in the bank. Secondly, the system is an embedded one located at each door of the bank which prompts the staff to input some vital information before slotting in the card in order to gain access.

Furthermore, the welcome screen was designed with Hypertext Preprocessor, and styled with Cascading Style Sheet. It also contains a hyperlink that allows the staff to navigate to the next phase of the system by clicking on the link. Having navigated to the next phase of the system, the staff is mandated to select a specific door of access. From figure 4, the program of the system is of two types; the assembly language program and the visual basic program. The onboard the system is used to store all the assembly language code that control the activities of the system. The program of the system was written in assembly language and was programmed with (Top universal programmer).The interfacing of the system was achieved with a computer set running on visual basic. To control access, a door must be modified in some manner to provide signals to the system to let it know whether or not the door is to be open or close, prohibiting passage of unauthorized persons. Simple access control is frequently used by corporate organizations and firms to limit access to their facilities, eliminating the need for a guard as well as the cost and headache associated with key control. In addition, the staff has to click on the door of access. The door buttons in the system are labeled, and the label corresponds with the door label.

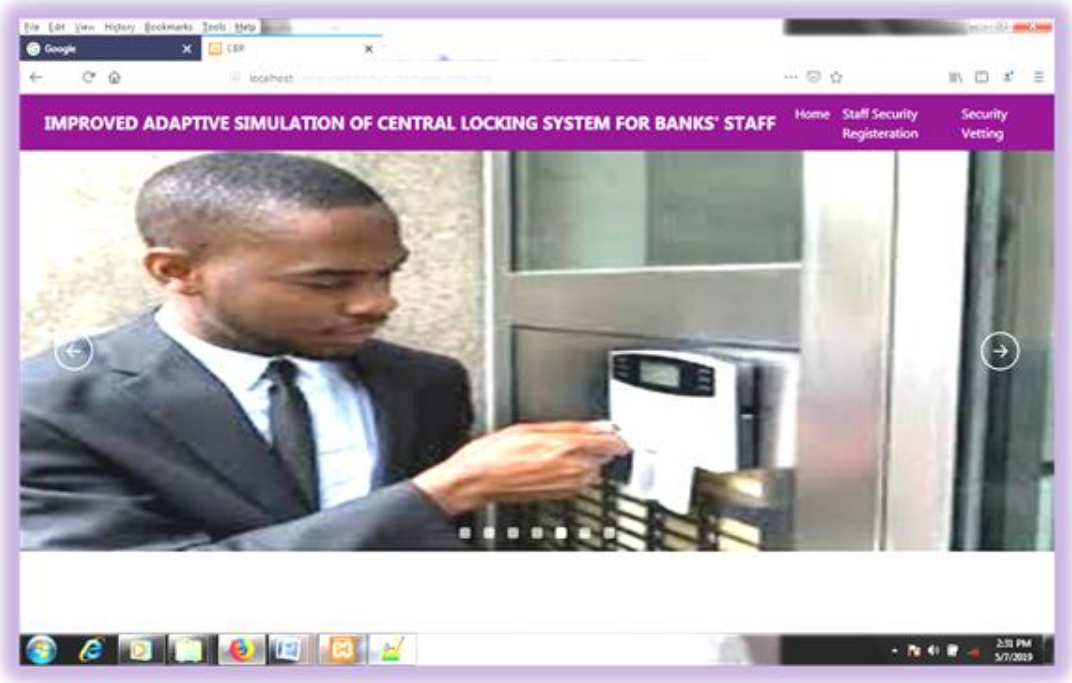


**Fig. 3:** Adaptive Simulation System: Home Page

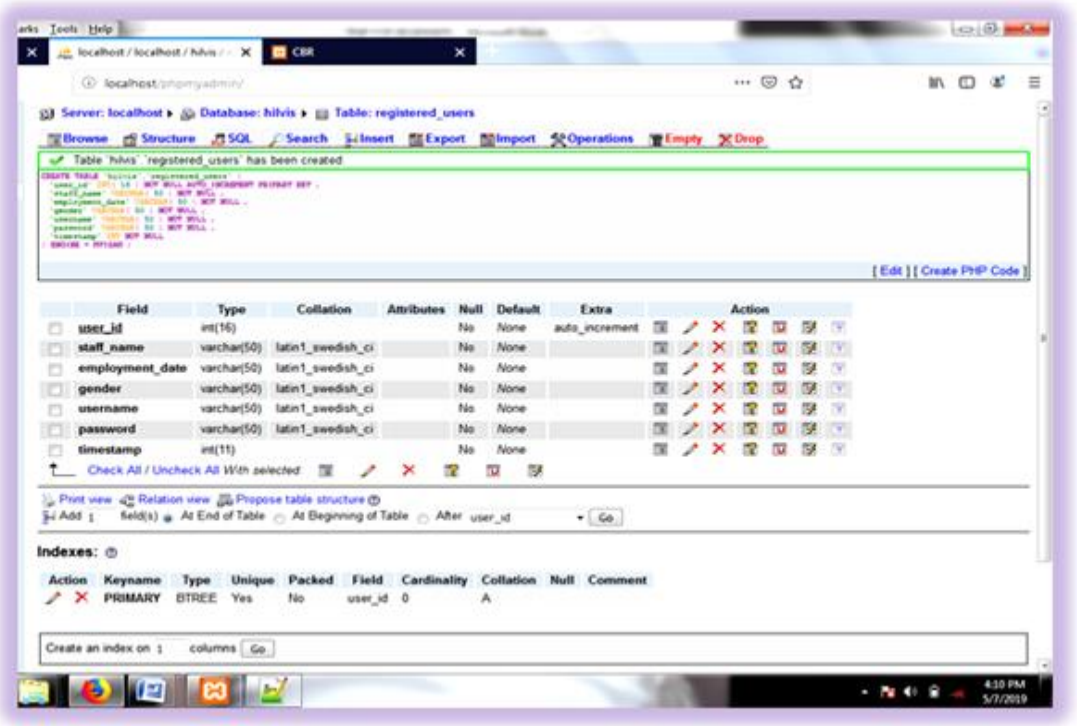


**Fig. 4:** Adaptive Simulation System: Central Security Database Creation

The staff must also be ready to input the allocated code of the card. The buttons were designed with Visual Basics 6.0 through the use of forms and buttons. Visual Basic Form is the container for all the controls that make up the user interface. Every window you see in a running visual basic application is a form, thus the terms form and window describe the same entity. Visual Studio creates a default form for you when you create a Windows Forms Application. An important part of Visual Basic is the ability to create Windows Forms applications that run locally on users' computers. From our results, provision was made for extreme cases were the device may have malfunctioned and no longer responds to the assigned codes. In such condition, an emergency open button is used which can be only accessed by the administrator. In the test carried out, the

administrator accessed this form by entering correctly a restricted password. Once the Open button was clicked, the door automatically opens and closes back after ten seconds. Also, when a wrong code was entered by an intruder exceeding the no of error counts; alarm was triggered through the loud speaker made available in the system. Though the reliability of smartcard contacts has improved to very acceptable levels over the years, contacts are one of the most frequent failure points any Electro-mechanical system due to dirt, wear, etc. The contactless card solves this problem and also provides the issuer an interesting range of new possibilities during use. Cards need no longer be inserted into a reader, which could improve end user acceptance.

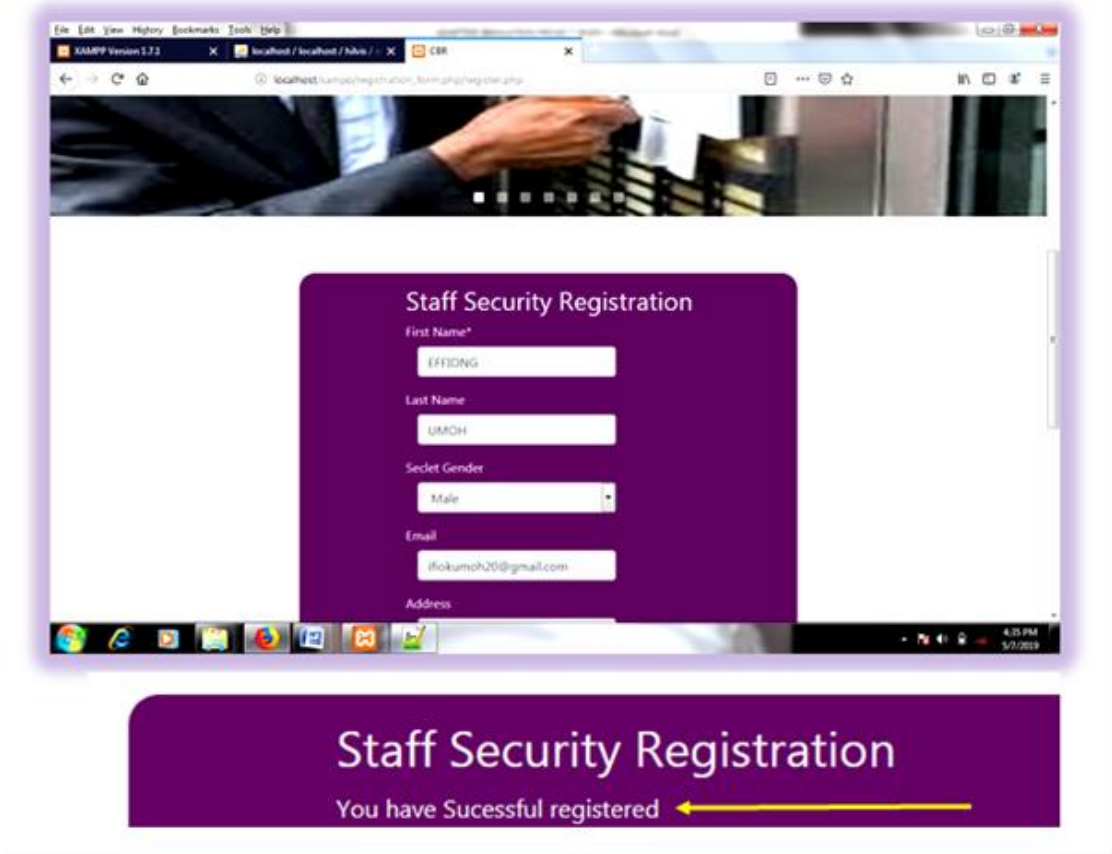


**Fig. 5:** Adaptive Simulation System: Staff Security Registration Form

No chip contacts are visible on the surface of the card so that card graphics can express more freedom. Still, despite these benefits, contactless cards have not yet seen wide acceptance. The cost is higher and not enough experience has been gained to make the technology reliable. Nevertheless, this elegant solution will likely have its day in the sun at some time in the future. Today, these cards have no processor in them (although this is coming in the near future). While the cards are comparable in price to chip cards, the card read and writes devices use non-standard protocols and are still very expensive. However such cards may find use in applications such as health care where large amounts of data must be stored. Memory functions such as reading, writing, and erasing can be linked to specific conditions, controlled by hardware and software. Embossing allows for textual information or designs on the card to be transferred to paper by using a simple and inexpensive device.

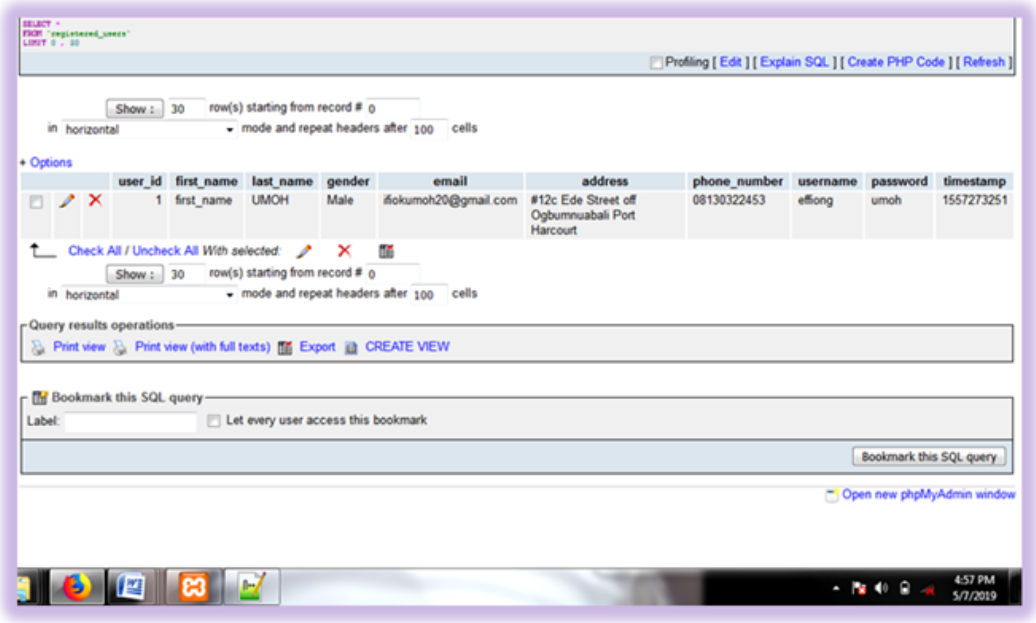


**Fig. 6:** Adaptive Simulation System: Database Confirmation of Registered Staffs

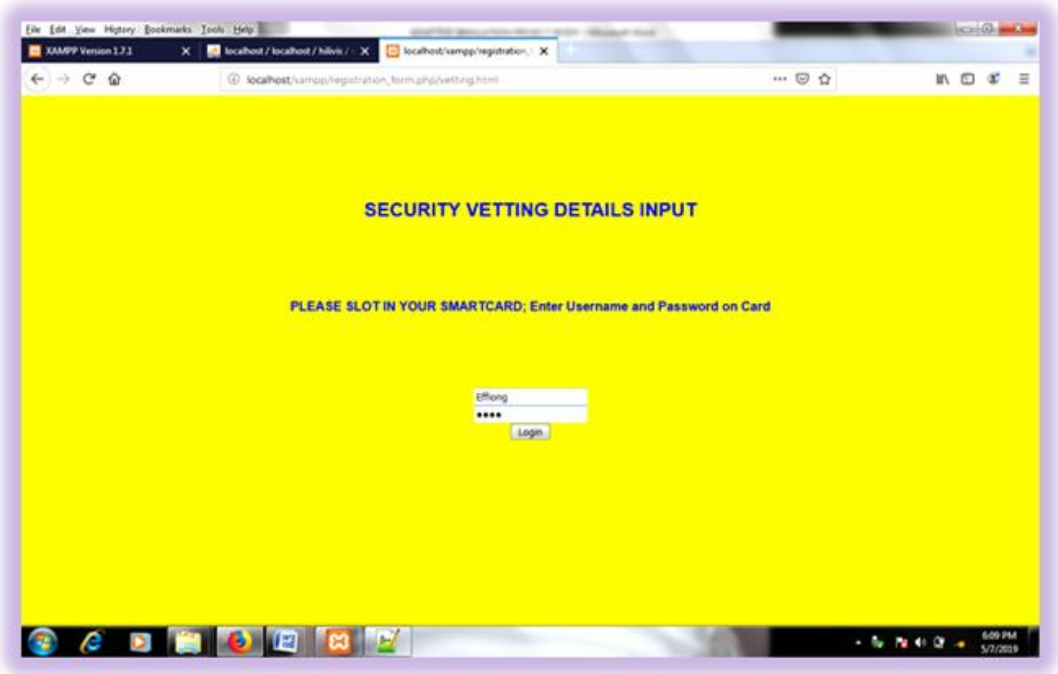


**Fig. 7:** Adaptive Simulation System: Security Vetting Details Input

The format specifies the embossed marks, covering their form, size, embossing height, and positioning. Transfer of information via embossing may seem primitive. A complete, high-level design methodology has been proposed for embedded information systems based on smart card devices. However, this methodology takes as granted that information stored on the card will be really securely stored, and access control will be correctly maintained. Making sense of the data, ability to curate data and perform data analytics at the edge (or mist rather than in the fog or cloud) is key to value. Delivering engines to the edge are crucial for analytics at the edge when latency is critical. The confluence of these and other factors may chart the future path for Digital Twins.


**Fig. 8:** Adaptive Simulation System: Security Vetting Validation (a)

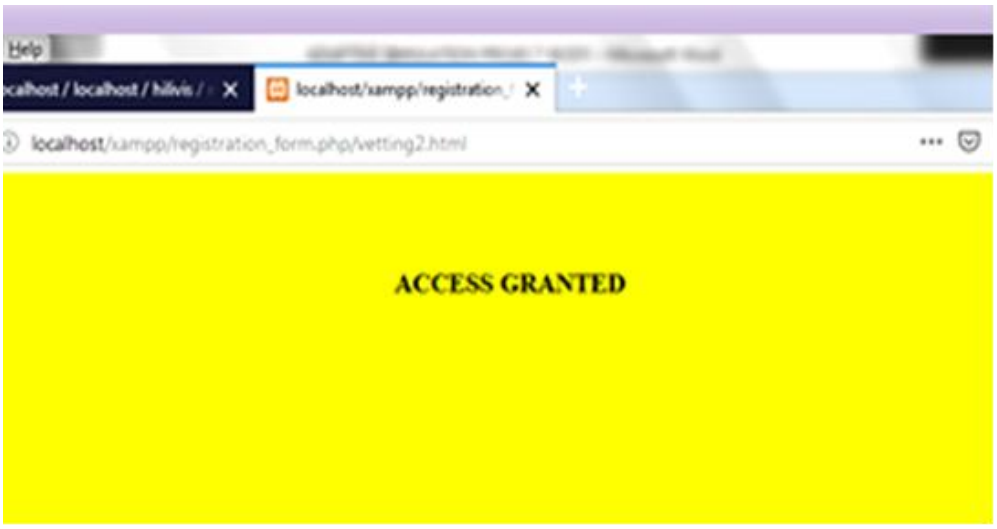


**Fig. 9:** Adaptive Simulation System: Security Vetting Validation (b)

**Table 1:** Cheng et al [3] Adaptive Simulation of Central Locking System for Banks' Staff N = 100
(where n is the overall total performance rate of the applied parameter)

| SN | PARAMETERS | ASSESSED PERFORMANCE RATE (%) |
|---|---|---|
| 1. | Time Complexity (TC) | 15 |
| 2. | Life-Cycle Assessment (LCA) | 18 |
| 3. | Benchmarking (B) | 14 |
| 4. | Multi-Criteria Decision-Making (MCDM) | 10 |
| 5. | Risk Assessment (RA) | 7 |
| 6. | Cost Benefit Analysis (CBA) | 12 |
| 7. | Speed | 17 |

**Assessed Parameters Summary:**

| | | |
|---|---|---|
| TC | = | 15 |
| LCA | = | 18 |
| B | = | 14 |
| MCDM | = | 10 |
| RA | = | 7 |
| CBA | = | 12 |
| S | = | 17 |
| TOTAL | = | 93% |

**Table 2:** Proposed: An Improved Adaptive Simulation of Central Locking System for Banks' Staff N = 100
(where n is the overall total performance rate of the applied parameter)

| SN | PARAMETERS | ASSESSED PERFORMANCE RATE (%) |
|---|---|---|
| 1. | Time Complexity (TC) | 16 |
| 2. | Life-Cycle Assessment (LCA) | 20 |
| 3. | Benchmarking (B) | 14 |
| 4. | Multi-Criteria Decision-Making (MCDM) | 12 |
| 5. | Risk Assessment (RA) | 8 |
| 6. | Cost Benefit Analysis (CBA) | 10 |
| 7. | Speed | 15 |

**Assessed Parameters Summary:**

TC = 16
LCA = 20
B = 14
MCDM = 12
RA = 8
CBA = 10
S = 15
**TOTAL = 95%**

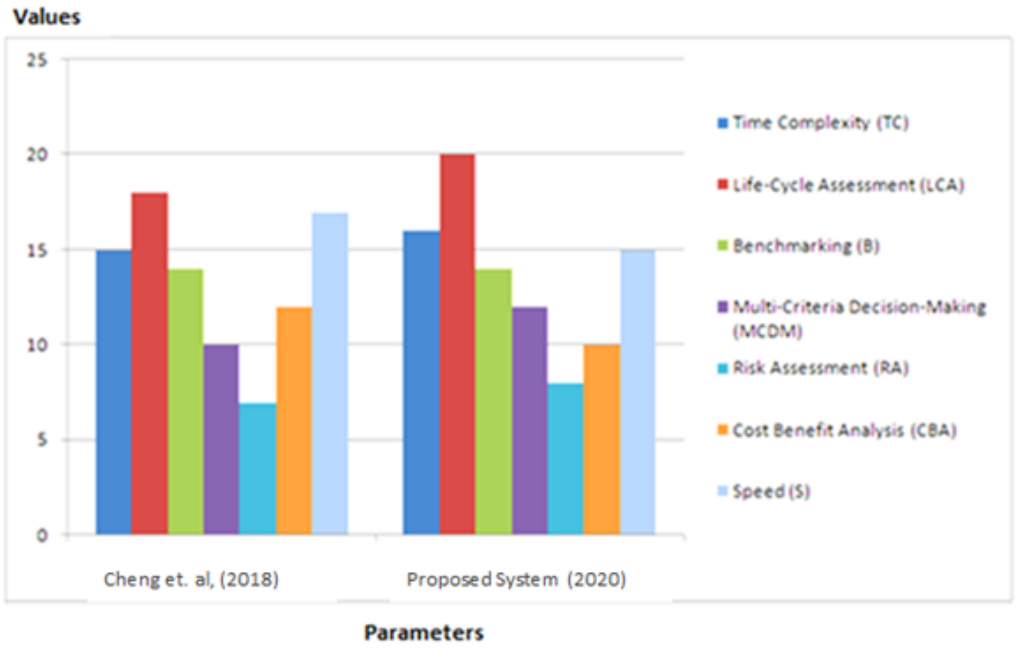


**Fig. 10:** Performance Evaluation Chart

## V. CONCLUSION

In this study, an improved adaptive simulation modeling of a centralized locking system using digital twin paradigm has been developed. A digital twin is a digital replica of a living or non-living physical entity. By bridging the physical and virtual world, data is transmitted seamlessly. A major challenging factor for programmers and Software Developers is the problem of poor simulation and modeling technique. The mentioned problem has resulted to the development of faulty software and application programs due to lack of adaptive simulation skills that utilizes digital twin paradigm. Many applications of computer graphics require the modeling of physical phenomena with high visual or numerical accuracy. Examples include the simulation of cloth, water, human tissue and engineering artifacts among many others. Typically the underlying formulations require the solution of partial differential equations. Such equations are also at the base of many geometric modeling and optimization problems.

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