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APPLICATION OF RFID AND NEAR FIELD COMMUNICATION IN CITIZENS IDENTIFICATION

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APPROVAL FORM

The undersigned certify that they have supervised the student in the research dissertation entitled, “Application of RFID and near Field Communication in Citizens Identification” submitted in partial fulfillment of the requirements for a Bachelor of Science Honors Degree in Information Technology at Bindura University of Science Education.

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ABSTRACT

This study utilized rapid prototyping as the software development method to design and implement a citizen identification system using RFID and NFC technology. The primary objective was to analyze the effectiveness of RFID and NFC in citizen identification. The researcher successfully developed an RFID and NFC-based system for citizen identification. The study's results indicated that the use of RFID and NFC technology in citizens' identification is efficient and effective. In Chapter 4, the performance of the system was evaluated in terms of response time, accuracy, and reliability. The system demonstrated high accuracy in identifying citizens and retaining correct information. The findings highlight the system's reliability and suitability for citizens' identification. Citizens' identification plays a critical role in various applications, such as voting, access control, and financial transactions. The adoption of RFID and NFC technology in citizen identification offers significant benefits, including convenience, speed, and accuracy. The study's use of rapid prototyping enabled the development of an efficient system that simplifies the citizen identification process, enhances security, and saves considerable time and effort compared to manual identification procedures.

LIST OF ACRONYMS & ABBREVIATIONS

NFC- Near Field Communication

RFID-Radio Frequency Identification

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CHAPTER 1: PROBLEM IDENTIFICATION

1.0 Introduction

In recent years, the use of RFID (Radio Frequency Identification) and NFC (Near Field Communication) technology has become increasingly popular across various industries. The technology allows for easy and fast data collection, and it has been widely adopted in supply chain management, inventory tracking, and asset management(Kumar,2020). In addition, RFID and NFC technology have been implemented in citizen identification programs, providing a more efficient and secure means of identification for individuals. The adoption of these technologies in citizen identification has been particularly important in developing countries that face challenges in creating efficient identification systems(Yang,2015). This chapter will highlight the background of the study, the problem statement as well as the objectives and research questions on the use of RFID and NFC technology in citizen identification, highlighting the need for more efficient identification systems and exploring the potential benefits and challenges associated with these technologies as well as the need for research.

1.1 Background of the Study

NFC (Near Field Communication) is a wireless technology that allows data to be transferred between devices at close proximity. The technology uses radio waves to establish a connection

between two devices, allowing data to be exchanged quickly and easily. NFC technology is widely used in mobile payments, access control, and transportation systems, as it provides a fast, secure, and convenient means of data transfer. According to a report by Markel (2021), the global NFC market is expected to grow at a (Compound annual growth rate) CAGR of 17.9% between 2021 and 2026, driven by the increasing adoption of contactless payments and mobile banking services (Markel, 2021).

RFID (Radio Frequency Identification) is a wireless technology that uses radio waves to communicate between an RFID reader and a tag attached to an object. The technology allows for the identification and tracking of objects, such as goods in a supply chain, assets in a warehouse, or livestock in a field. RFID technology is widely used in inventory management, asset tracking, and supply chain management, as it enables the automation of data collection and reduces the need for manual data entry. According to a report by Markel (2020), the global RFID market is expected to grow from $10.7 billion in 2020 to $17.4 billion by 2025, driven by the increasing adoption of RFID in retail, logistics, and healthcare sectors (Markel, 2020).

The application of NFC and RFID technology in citizen identification has the potential to revolutionize the way that countries manage the identification of their citizens. The use of these technologies would allow for the creation of secure digital identities that could be used for access to public services, voting, and financial transactions. NFC and RFID can enable the storage of biometric data and other personal information that is used to identify an individual, and this information can be easily accessed using a compatible device. This would improve the accuracy of identification, reduce the possibility of fraud, and provide a more efficient system for the delivery of public services. The use of these technologies in citizen identification is a promising solution to the challenges faced by developing countries such as Zimbabwe in creating an efficient and secure identification system.

Developing countries face numerous challenges due to the limitations posed by the current traditional national identification documents. These challenges hinder socio-economic progress and exacerbate existing disparities. Firstly, the lack of reliable identification systems hampers access to essential services such as healthcare, education, and financial services (World Bank, 2016). Without proper identification, individuals struggle to enroll in schools, access quality healthcare, and participate fully in the formal economy. Secondly, the traditional national ID cards often suffer from issues of authenticity and security. Counterfeit documents and identity theft are prevalent, resulting in fraudulent activities, including illegal immigration

and organized crime (United Nations, 2019). This compromises national security and undermines the rule of law, impeding the overall stability of developing nations.

The use of RFID and NFC technology for citizen identification has gained significant attention in recent years. Several countries have implemented the technology to improve their identification systems and provide better services to their citizens. For instance, in India, the government has implemented an Aadhaar program, which uses a biometric identification system that combines RFID and NFC technology. The program has enrolled over a billion people and has become a critical tool for access to government services such as healthcare, education, and social welfare (Kumar et al., 2015).In Kenya, the government has implemented a similar program called Huduma Namba, which uses NFC technology to create a unique identification number for each citizen. The program has been successful in reducing identity theft and providing faster access to government services (Government of Kenya, 2019).In Ghana, the government has implemented a digital address system that uses NFC technology to create unique digital addresses for each property. This system has improved emergency response times and enabled better service delivery (Aborah et al., 2019).

1.2 Problem Statement

In many countries, citizen identification remains a significant challenge, with numerous instances of fraud, corruption, and inefficiency in the identification process. Traditional identification methods such as manual identification processes, biometrics, and barcodes have proven to be less effective, particularly in rural areas, where many citizens lack formal identification documents (Mills, 2018). The lack of a reliable and efficient citizen identification system is a hindrance to the delivery of essential services such as healthcare, education, and social security, and contributes to the marginalization of vulnerable populations.

1.3 Research Aim

This study aims to develop and implement system which identifies individuals using RFID and NFC.

1.5 Research Objectives

1. To analyze different methods and techniques used for citizen identification
2. To design and implement a system which identifies individuals using RFID and NFC.
3. To evaluate the effectiveness of RFID and NFC in citizen identification.

1.6Research Questions

1. How to analyze different methods and techniques used for citizen identification?
2. How to design and implement a system which identifies individuals using RFID and NFC?
3. How to evaluate the effectiveness of RFID and NFC in citizen identification?

1.7 Justification of Research

The application of RFID (Radio Frequency Identification) and Near Field Communication (NFC) technology has the potential to revolutionize citizens' identification and data management, particularly in developing countries such as Zimbabwe. The current system of citizen identification in Zimbabwe relies on physical documents such as national IDs and birth certificates, which are prone to loss, theft, and fraud. This creates challenges for service delivery, including access to healthcare, voting, and financial services. The significance of this research lies in its potential to offer a more efficient and secure identification system that is less susceptible to manipulation, fraud, and other malpractices. This would enable service providers to deliver better services and reduce the risk of identity theft and other related crimes.

Moreover, the use of RFID and NFC technology in citizens' identification would offer the Zimbabwean government an opportunity to create a more comprehensive and accurate database of its citizens. This would enable the government to better plan and allocate resources and provide more targeted services to the population. For instance, the use of RFID and NFC technology could improve the delivery of healthcare services by providing access to medical records, tracking immunization schedules, and reducing medication errors. This would ultimately lead to better health outcomes for the population. Additionally, the use of this technology could also help to reduce corruption and increase transparency in government operations, which is critical for the country's economic growth and development. Therefore, the application of RFID and NFC technology in citizens' identification is a significant step towards building a more efficient, secure, and transparent system for the delivery of public services in Zimbabwe.

1.8 Limitations/Challenges

Some of the restrictions that come across during this project design include the following:

1.9 Definition of Terms

Citizen identification- refers to the process of uniquely identifying and authenticating individuals as legal citizens of a particular country

RFID- is a technology that uses radio waves to wirelessly identify and track objects or individuals.

NFC- is a short-range wireless communication technology that enables the exchange of data between two devices

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The term "literature review" refers to a summary of what is understood and what is unknown about a certain subject (Shunda, 2007). It is a method of comprehending a subject of research through the examination of academic and research work, both publicized and unpublicized. As a flashback to previous endeavors, this chapter aims to emphasize what has been done previously. This information is critical to the project's success since different papers and sources will be examined to see how other researchers have approached the same problem and how the researcher's system under development will address existing system flaws.

This chapter provides facts, concepts, and terminology that will help you comprehend the work and proposals that will be presented in the next parts. In Section 2.2, we discuss the

National Identification Card and in section 2.3 we discuss Citizen identification. Radio Frequency Identifications. Is discussed in section 2.4 We also look at Near Field Communication in Section 2.5, and RFID reader in section 2.6. We also discussed RFID reader, RFID antenna and RFID tags in section 2.7, 2.8 and 2.9 respectively. In part 2.10, we'll look at the Existing literature, in section 2.11, we look into the proposed system.

2.2 National Identification Card

A national identification card, commonly referred to as a national ID, is a document that contains a unique identifier assigned to an individual by the government of their country. The use of national IDs has been a topic of debate for years, with some arguing that they are an invasion of privacy and others asserting that they are necessary for national security and effective governance. According to Al-Tawfiq et al. (2017), countries that have implemented national ID systems have seen improvements in security, accuracy of voter registration, and access to public services. However, concerns about data privacy and potential misuse of personal information continue to be raised. As such, the implementation of national IDs should be accompanied by appropriate legal and regulatory frameworks to ensure the protection of individuals' privacy and security (Al-Tawfiq et al., 2017).

2.3 Citizen identification

Citizen identification is a critical component of modern governance systems, enabling governments to establish and maintain accurate records of their citizens (Mills,2018). It serves as the foundation for effective public administration, ensuring access to essential services and facilitating democratic processes. Citizen identification systems provide individuals with official documents that validate their identity, nationality, and residency. These systems play a vital role in promoting inclusive societies, protecting individual rights, and enhancing social and economic development.

According to the World Bank, citizen identification systems are crucial for achieving sustainable development goals and reducing poverty. These systems enable individuals to access essential services, including healthcare, education, and social welfare programs (World Bank, 2019). By accurately identifying citizens, governments can target and deliver services to those in need, reducing disparities and improving social well-being. Citizen identification also strengthens social protection programs by ensuring that benefits reach the intended recipients, minimizing fraud and leakage (World Bank, 2016).

Furthermore, citizen identification is essential for democratic processes and political participation. Identification documents, such as voter ID cards, help safeguard the integrity of elections and prevent fraudulent practices (International IDEA, 2018). They ensure that individuals eligible to vote can exercise their democratic rights and contribute to the decision-making processes of their countries. Citizen identification systems also enable the formation of representative and accountable governments by providing accurate demographic data for electoral purposes (United Nations, 2017).

Citizen identification is a crucial aspect of modern society, especially in terms of government services and administration. Reliable identification systems are necessary for ensuring that citizens can access the services they require and for maintaining the integrity of voting processes. Various technologies have been explored for citizen identification, including Radio Frequency Identification (RFID) and Near Field Communication (NFC) systems. These technologies provide secure and efficient means of verifying an individual's identity, especially in developing countries where traditional identification systems may be unreliable. (Soleymani et al., 2014; Oh et al., 2015; Karimi et al., 2017; Gupta and Yadav, 2014)

2.4 Radio Frequency Identification

Radio Frequency Identification (RFID) is a wireless technology that allows for the identification of objects using radio waves. According to Jang and Kim (2017), RFID systems consist of three main components: a reader, an antenna, and a tag or transponder. The reader sends a signal to the antenna, which in turn generates an electromagnetic field. When an RFID tag or transponder enters the field, it is energized by the electromagnetic waves, allowing it to transmit its unique identification code back to the reader. RFID technology has been widely adopted in various applications, including supply chain management, transportation, and access control, due to its ability to provide real-time tracking and monitoring capabilities (Jang & Kim, 2017).

An RFID reader is an electronic device that is used to communicate with RFID tags or transponders. According to O'Sullivan and Topper (2017), RFID readers consist of an antenna, a transceiver, and a controller. The antenna is used to emit radio waves and receive signals from RFID tags, while the transceiver is responsible for sending and receiving signals to and from the antenna. The controller is used to process the data received from the transceiver and to communicate with other devices such as a computer or a mobile phone. RFID readers can be fixed or handheld, and they are available in different frequencies depending on the specific

application. RFID readers have become increasingly popular in various industries, including retail, healthcare, and logistics, due to their ability to provide real-time tracking and monitoring capabilities (O'Sullivan & Topper, 2017). The RFID antenna is a fundamental element within an RFID system, facilitating the transmission and reception of radio frequency signals between the RFID reader and tag. Various types of RFID antennas, such as dipole, patch, loop, and helical antennas, exist, each with its own advantages and disadvantages (Farhat & Rehman, 2015). When designing an antenna, considerations must be made based on specific application requirements, including reading distance, tag size, and operating frequency. It is crucial to ensure that the dimensions of the antenna align with the wavelength of the operating frequency for optimal performance (Zhang, Qing, & Jiao, 2018). Additionally, factors such as the material, polarization, and orientation of the antenna impact the read range, signal strength, and potential interference from other devices (Vuong, Le-Ngoc, & Yarovoy, 2019). Consequently, the careful selection and proper placement of RFID antennas significantly contribute to the overall performance of the RFID system.

RFID tags are electronic devices that store and transmit data wirelessly through radio frequency signals. According to P. Pawar and K. T. Talele (2015), RFID tags consist of a microchip that stores the unique identification number and other relevant data and an antenna that enables communication with the RFID reader. The microchip and antenna are typically encapsulated in a protective covering, which can vary from paper to plastic, depending on the application requirements. RFID tags can be passive, active, or battery-assisted passive, as described by S. R. Jadhav et al. (2018). Passive RFID tags do not have their power source and rely on the energy transmitted from the reader to activate and transmit data. Active RFID tags, on the other hand, have an internal power source that enables them to transmit data over longer distances. Battery-assisted passive RFID tags have a small battery that assists in powering the tag and extending its read range. The selection of the RFID tag depends on various factors, such as the operating frequency, reading distance, and environmental conditions, as stated by H. Hashemkhani Zolfani et al. (2018). Therefore, careful consideration must be given to the type and configuration of RFID tags used to ensure efficient and reliable operation in RFID systems.

2.5 Near Field Communication (NFC)

Near Field Communication (NFC) is a wireless technology that allows for short-range communication between two devices equipped with NFC chips or antennas. According to Khan

et al. (2019), NFC operates on the same principles as RFID technology, but with a shorter range of up to 10 cm. NFC technology has been widely adopted in various applications, including contactless payments, mobile ticketing, and smart access control, due to its ease of use and security features (Khan et al., 2019). NFC-enabled mobile phones have become increasingly popular in recent years, with many manufacturers integrating NFC chips into their devices.

2.9 Related Literature

RFID and Near Field Communication have been utilized in various applications, including transportation, supply chain management, and access control. Recently, these technologies have also been used in citizen identification systems. For instance, in a study conducted by Reddy et al. (2018), RFID-based smart cards were used to identify and authenticate citizens in India. The smart card system allowed for easy identification of citizens and enabled the government to provide various services such as voting, healthcare, and social welfare.

Similarly, Near Field Communication technology has also been used in citizen identification systems. For example, in a study by Teixeira et al. (2019), Near Field Communication -enabled mobile phones were used for citizen identification and authentication in Brazil. The Near Field Communication technology was integrated with a national identification system, enabling citizens to access public services and government benefits.

In the paper, "NFC-Based Citizen Identification System Using Smartphones," Kim and Lee (2016) present a system that utilizes Near Field Communication-enabled smartphones to authenticate citizens. The authors suggest that the use of smartphones with Near Field Communication capabilities can provide a convenient and secure means of citizen identification, especially in developing countries where traditional identification systems may not be efficient. The system uses a mobile application that stores citizen identification information, including biometric data, and can be accessed by authorized personnel using an Near Field Communication reader.

Similarly, in the study titled "A Mobile NFC-Based Solution for Citizen Identification and Voting in E-Government," Gheorghiu et al. (2018) propose a mobile-based Near Field Communication solution for citizen identification and voting in e-government. The authors suggest that the proposed system can enhance the security and efficiency of citizen identification and voting processes, especially in developing countries where traditional identification systems may not be reliable.

In another study, "NFC as a Means for Citizen Identification in e-Government," Kristóf et al. (2015) discuss the potential use of Near Field Communication for citizen identification in e-government services. The authors suggest that the use of Near Field Communication can enhance the security and efficiency of citizen identification processes, especially in cases where traditional identification methods may be cumbersome or unreliable. The authors propose a system that uses a Near Field Communication-enabled ID card to authenticate a citizen's identity.

Moreover, in the paper "Design and Development of an NFC-Based eID System for Developing Countries," Khan et al. (2019) propose a Near Field Communication-based electronic identification (eID) system for developing countries. The authors suggest that the proposed system can provide a secure and efficient means of citizen identification, especially in countries with limited resources. The system uses a mobile application that stores citizen identification data, an NFC reader that is used to authenticate the citizen's identity, and a backend server that manages citizen information.

Also, in the study "RFID-Based Identification and Authentication of Citizens in E-Government," Soleymani et al. (2014) propose an RFID-based citizen identification system for e-government applications. The authors suggest that the use of RFID can provide a secure and efficient means of citizen identification, especially in countries where traditional identification systems may not be reliable. The proposed system uses an RFID tag that stores citizen identification information, and an RFID reader that is used to authenticate the citizen's identity.

Similarly, in the paper "Design and Implementation of RFID-Based Citizen Identification and Voting System," Oh et al. (2015) propose an RFID-based citizen identification and voting system. The authors suggest that the proposed system can enhance the security and efficiency of citizen identification and voting processes, especially in countries where traditional identification systems may be unreliable. The system uses an RFID tag that stores citizen identification information, and an RFID reader that is used to authenticate the citizen's identity and record their vote.

In another study, "Design and Implementation of RFID-Based Citizen Identification System," Karimi et al. (2017) propose an RFID-based citizen identification system for developing countries. The authors suggest that the use of RFID can provide a secure and efficient means of citizen identification, especially in countries with limited resources. The proposed system

uses an RFID tag that stores citizen identification information, and an RFID reader that is used to authenticate the citizen's identity.

Lastly, in the paper "RFID-Based Citizen Identification System for E-Government Applications," Gupta and Yadav (2014) propose an RFID-based citizen identification system for e-government applications. The authors suggest that the use of RFID can enhance the security and efficiency of citizen identification processes, especially in cases where traditional identification methods may be cumbersome or unreliable. The proposed system uses an RFID tag that stores citizen identification information, and an RFID reader that is used to authenticate the citizen's identity.

2.10 Proposed Approach

Based on the literature review, my proposed approach aims to utilize Radio Frequency Identification and Near Field Communication technologies for citizen identification. In particular, the author will be utilizing RFID technology to store and transmit personal information, including biometric data, such as fingerprints and facial recognition. Furthermore, the author will use RFID and NFC technologies to authenticate a citizens' identity and enable secure access to various services and facilities, such as government offices and airports. The results achieved in previous studies using similar techniques have shown promising results, and the researcher is optimistic that this approach will provide robust and reliable results for citizen authentication.

2.11 Chapter Summary

The researcher was successful in compiling data that is pertinent to this study. Several ideas from academic papers, the internet, textbooks, and unpublished data show the depth and gap that needs to be filled. The knowledge gained will be put to use in the following chapters to accomplish the stated objectives.

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

The process of research involves gathering facts through scientific inquiry or detailed examination of a specific area of interest, and can utilize either quantitative or qualitative methods depending on whether it is exploratory, descriptive, or diagnostic. When it comes to making economic decisions, research has been demonstrated to be a crucial tool for government institutions and policymakers, as indicated by Mackey and Gass (2013). Methodology refers to the systematic and theoretical analysis of the methods employed in a particular field of study. In this chapter, the author will outline the methods employed to achieve the research and system objectives. The author will establish the necessary procedures to construct a solution and choose the most effective strategies to achieve the research's desired outcomes based on the information gathered in the previous chapter. To simplify the research process, the author utilized secondary data from various official sources, the internet, and journals.

3.1 Research Design

Research design refers to the systematic and structured approach used by researchers to plan, execute, and evaluate their studies. It encompasses the methods and techniques used to collect and analyze data, as well as the theoretical and conceptual frameworks that guide the research process. A well-designed research study is essential to ensure that the research question is appropriately addressed and that the findings are valid and reliable. According to Creswell and Creswell (2017), the research design should be aligned with the research question and the research methodology selected, and should take into account the potential sources of bias and limitations of the study. Additionally, the research design should be flexible enough to accommodate unforeseen issues that may arise during the research process.

3.2 Requirements Analysis

Requirements analysis is a crucial stage in software development, as it involves identifying, capturing, and documenting the needs and objectives of the project stakeholders. According to Sommerville (2016), requirements analysis is the process of "understanding what the customer

wants, needs, and expects from a software system" (p. 109). This involves not only gathering functional requirements but also non-functional requirements such as performance, reliability, and usability. Requirements analysis is a complex task that requires careful attention to detail and effective communication with stakeholders to ensure that their needs are properly understood and addressed. The outcome of this process is a requirements specification document that serves as the basis for the subsequent phases of the software development life cycle (SDLC) (Sommerville, 2016).

3.2.1 Functional Requirements

Functional requirements are a key aspect of a software system's requirements and define the system's intended behavior and functionality. These requirements describe what the system must do to meet the needs of its users or stakeholders. Examples of functional requirements include the ability to create, edit, and delete user accounts, the ability to search for and retrieve data from a database, and the ability to generate reports based on user inputs. Functional requirements are typically documented in a requirements specification document and serve as the basis for system design, development, and testing. It is essential to ensure that all functional requirements are properly identified, documented, and validated to ensure that the final system meets the needs of its intended users (Sommerville, 2016).

The proposed system must be able to meet the following requirements:

- Citizen Identification: The system should be able to identify citizens using RFID and near field communication (NFC) technologies.
- User Registration: The system should allow citizens to register themselves by providing necessary personal information such as name, date of birth, and identification number.
- Authentication: The system should provide a mechanism for authenticating the identity of the user, such as a password or biometric authentication.
- Data Management: The system should be able to store and manage citizen data, such as personal information, identification numbers, and biometric data.
- Tracking: The system should be able to track citizens' movements and activities using RFID and NFC technologies.
- Reporting: The system should be able to generate reports on citizens' activities, including their movements and transactions.

- Security: The system should provide robust security features to prevent unauthorized access to citizen data.
- Integration: The system should be able to integrate with other systems, such as law enforcement databases, to improve the accuracy and reliability of citizen identification.
- User Interface: The system should have a user-friendly interface that allows citizens to easily interact with the system and access their personal data.

3.2.2 Non-Functional Requirements

Non-functional requirements are an essential part of software development, and they are concerned with the qualities or characteristics of a system rather than its specific functions. Non-functional requirements can include factors such as performance, reliability, security, usability, maintainability, and scalability (Rouse, 2021). Performance requirements, for example, might specify how quickly the system must respond to user input or how much memory it should use. Reliability requirements might specify how frequently the system can be expected to fail or how quickly it should recover from failures. Usability requirements might specify how intuitive and easy-to-use the system must be for end-users. Non-functional requirements are often more challenging to capture and define than functional requirements, but they are just as important in ensuring the success of a software project. The proposed system must be able to meet the following:

- Performance: The system should be able to handle a large volume of users simultaneously and provide quick response times.
- Usability: The system should be easy to use and understand for both technical and non-technical users.
- Reliability: The system should operate reliably and consistently without any downtime or interruptions.
- Scalability: The system should be able to accommodate future growth and changes in user requirements.
- Compatibility: The system should be compatible with different types of RFID and NFC devices and ensure interoperability with other systems and applications.
- Availability: The system should be available 24/7 to ensure uninterrupted access to user information.

- Accessibility: The system should be accessible to users with disabilities and conform to accessibility guidelines and standards. These non-functional requirements are critical to the success of the project and should be carefully considered and documented during the project's requirements analysis phase.

3.2.3 Hardware Requirements

- Core i5 processor or better
- Arduino microcontroller
- RFID reader: An RFID reader is required to capture the identification information from the RFID tag or card.
- RFID tags or cards: RFID tags or cards are used to store the identification information of citizens. These tags or cards can be passive or active, depending on the application requirements.
- NFC reader: An NFC reader is required to capture the identification information from the NFC-enabled mobile devices.
- Antennas: Antennas are required to facilitate the communication between the RFID reader and the RFID tags or cards.
- Network infrastructure: Network infrastructure is required to establish the communication between the RFID reader and the backend system.
- Backend system: A backend system is required to process and store the identification information of citizens captured by the RFID reader and NFC reader.

3.2.4 Software Requirements

- Windows 10 Operating system
- Arduino IDE
- C++
- .Net Framework 4.5.2
- Tomcat server

3.3 System Development

This system describes the overview of the system and how it was developed so as to produce the results. It specifies all the software tools and models used in the development of the system.

3.3.1 System Development tools

- Arduino R3 microcontroller
- Half Bread board
- Connection wires
- USB type B cable
- Smoke sensor
- Temperature sensor
- Infrared Detector
- Windows 10 Operating system
- Visual studio with C sharp development tools
- Arduino IDE

3.3.2 Rapid Prototyping

The utilization of rapid prototyping, an agile approach, is employed in the process of developing products (Kumar,2018). This approach involves the creation and testing of 3-dimensional prototypes to optimize their characteristics, such as shape, size, and usability. The objective of prototyping is to validate the hypothesis that a product will effectively address the intended problem. While the prototype may not possess full functionality, it offers a realistic representation of the final product, enabling potential users to interact with it and provide valuable feedback. This feedback is crucial as it aids in identifying design flaws and making necessary adjustments to ensure that the final product meets user requirements. Rapid prototyping proves efficient in terms of the speed at which initial prototypes are produced, the collection and synthesis of feedback, and the subsequent development of iterations. By employing this strategy, the development team can save time and resources by detecting design issues early in the development process (Kumar,2018).

The author chose to utilize the approach of rapid prototyping in the context of RFID and Near Field Communication in citizens' identification because it allows for a systematic and efficient development process. Given the complexity and importance of citizen identification systems, it is crucial to ensure that the proposed solutions are practical and meet the needs of both governments and citizens. Rapid prototyping enables the creation of tangible prototypes that can be tested and refined based on user feedback. This iterative approach allows for early detection and rectification of design flaws, enhancing the overall effectiveness and usability of the final product. Additionally, the emphasis on speed and efficiency in rapid prototyping aligns with the need to develop citizen identification solutions in a timely manner, considering the significance of accurate identification systems for governance and public service delivery.

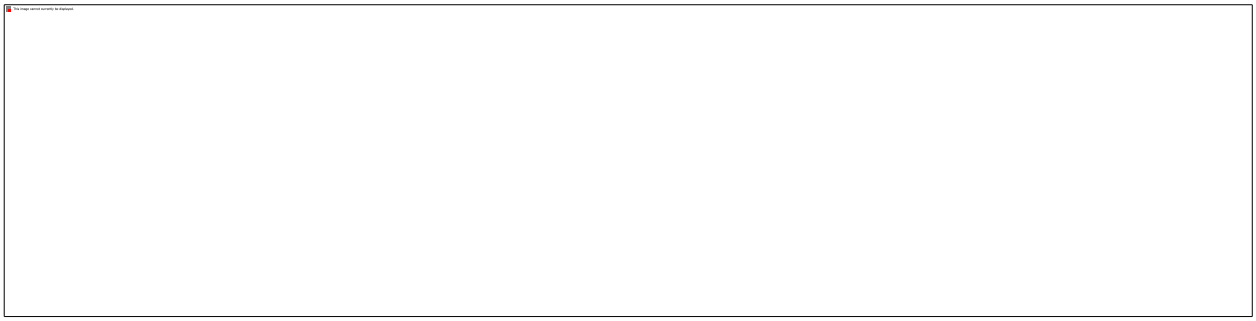


Fig 3: prototype

3.4 Summary of how the system works

The system utilizes RFID and Near Field Communication (NFC) technology for citizen identification. This technology is employed in conjunction with the citizen's national ID card, which contains their pertinent identification details. The RFID reader captures the identification information from the RFID tag or card, while the NFC reader retrieves the identification. To enable communication between the RFID reader and the RFID tags or cards, antennas are employed, and network infrastructure is established to facilitate communication between the RFID reader and the backend system. The backend system processes and securely stores the captured identification information of citizens obtained from the RFID reader and NFC reader. This system provides a swift and efficient means of citizen identification with minimal physical contact, making it particularly advantageous in situations where hygiene is a concern. In summary, the system offers a reliable and secure approach to citizen identification and serves as a valuable addition to national ID systems.

3.5 System Design

3.5.1 System Dataflow diagrams (DFDs)

3.5.2 Proposed System flow chart

A flowchart is a graphical depiction of a sequence of activities in a process. This diagram helps in defining the system flow of data and all process found within the proposed solution

3.6 Implementation

This section implicates setting the system into action thus coordination and directing the resources elaborated in the previous chapter to meet the objectives of the research plan. Thus,all the documentation from all previous chapters are being finalized to align it in order to deliver the system.

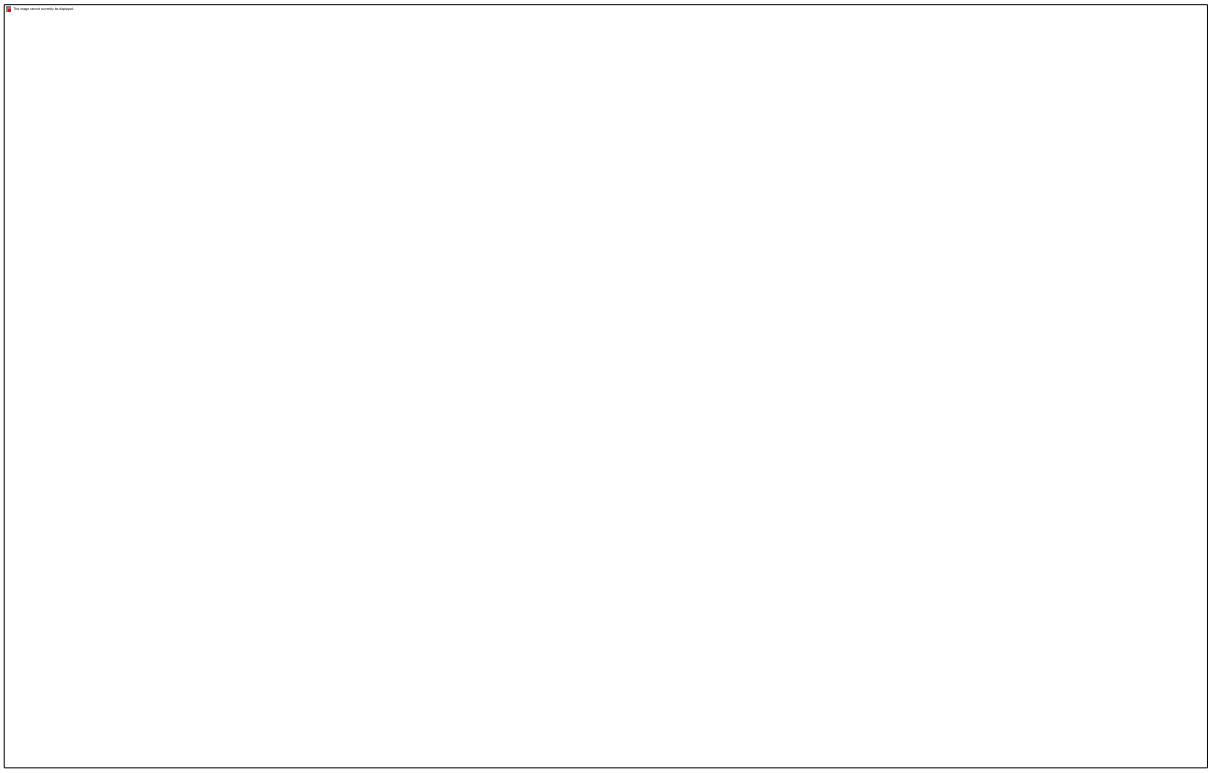


Figure 1 The above figure shows the details screen.

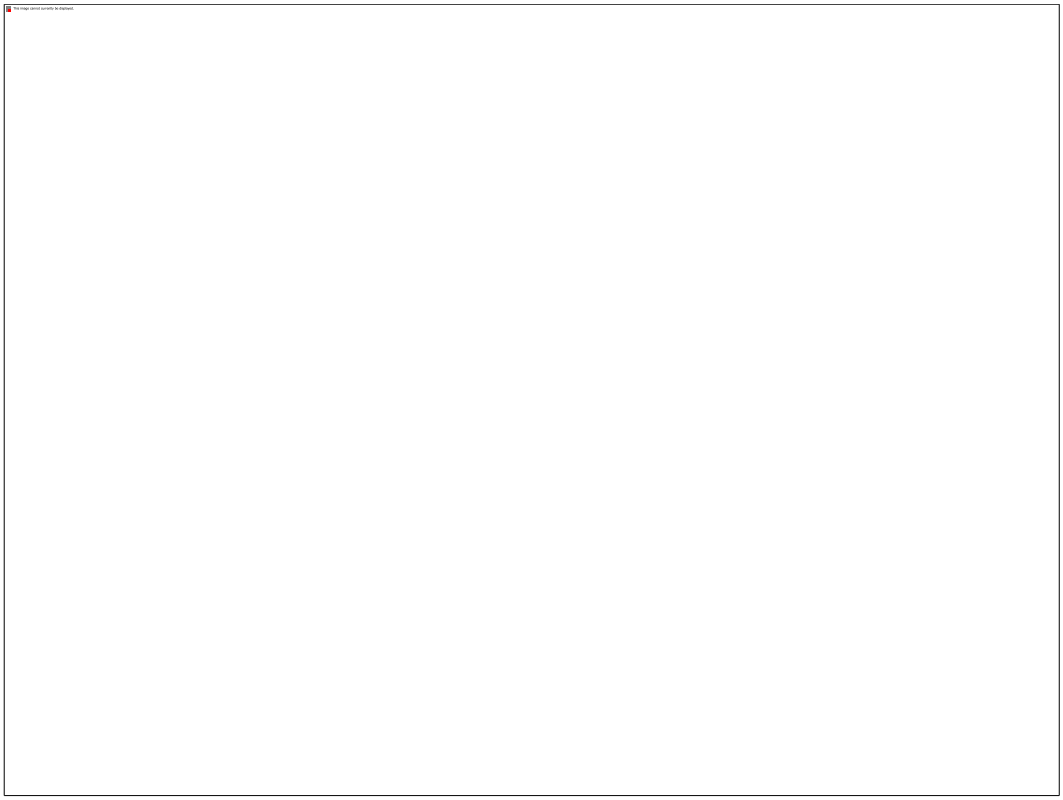
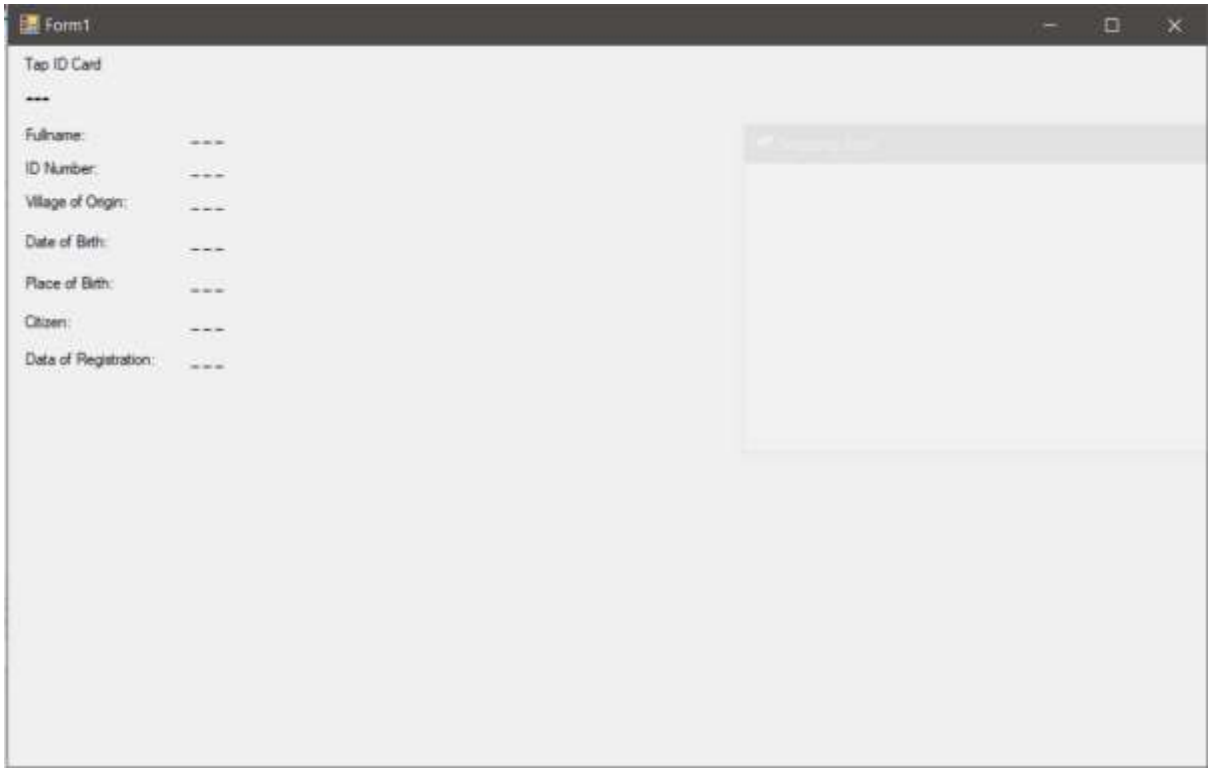
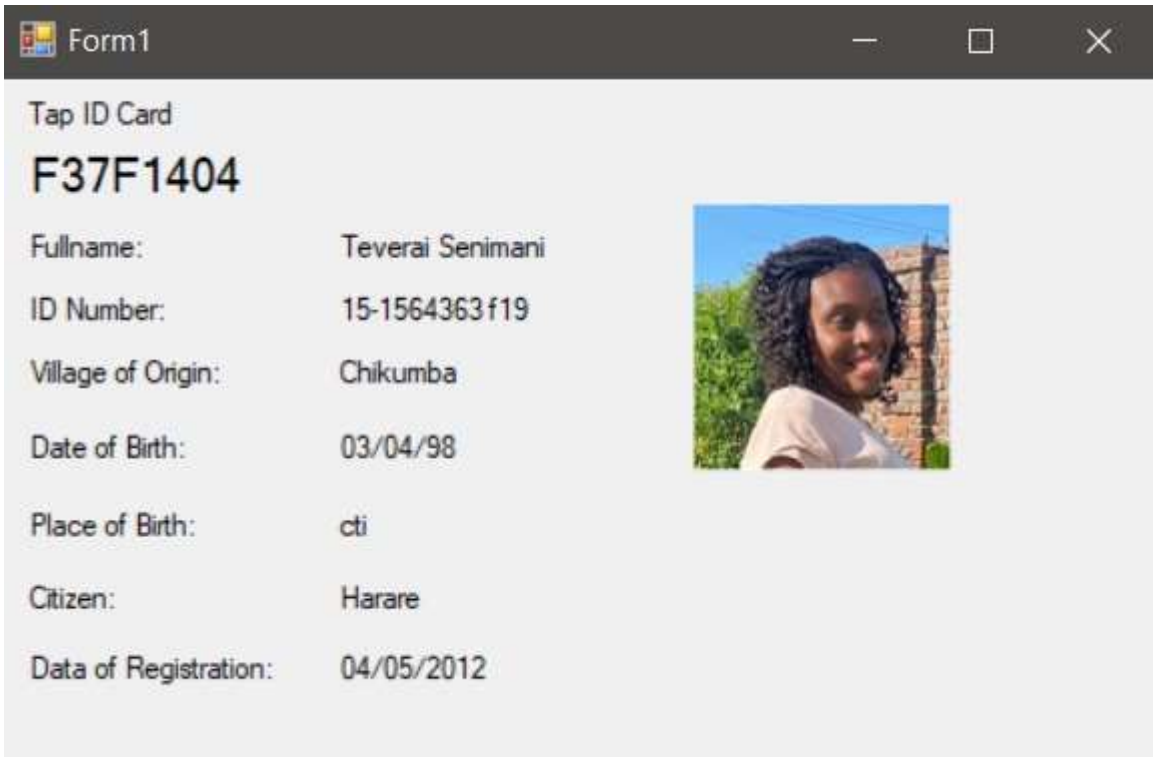


Figure 2

The user has to tap their ID card on the RFID reader shown in the figure above.



After tapping the ID card, the system gets the citizen from the database with their unique ID number.



The system displays the citizen’s details on the panel as shown in the figure above.

Figure above shows Arduino IDE and the citizen’s unique number being read.

3.7 Conclusion

This chapter was mainly focusing on the method used in developing the system and how the system was designed. Coming up with the system resulted in use of different techniques and, different tools for example C# programming languages and the Arduino Uno microprocessor made it possible to come up with the proposed solution as well as the RFID tag and readers. Functions of the system and how data flows from start to end where shown in this chapter. The results obtained from the developed solution where discussed and analyzed in the following chapter.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATIONS

4.1 Introduction

The necessity to evaluate the effectiveness of the created solution occurred after the author implemented the system successfully. The matrices utilized to evaluate the efficiency and efficacy of the produced solution were accuracy, performance, and response time.

4.2 Testing

This chapter demonstrates the tests that were conducted and the outcomes they produced. Testing is an essential step in the system development process. As a result, the testing is evaluated in relation to the functional and non-functional requirements that were established in the chapter before.

4.2.1 Black Box

Black box testing is a method of testing that enables a user without knowledge of the internal structure of the system to test it against its functional and non-functional requirements. In our project, black box testing can be used to test the system's ability to identify citizens using RFID

and near-field communication technologies, as well as its ability to perform user registration, authentication, data management, tracking, reporting, and other required functions.

Black box testing plays a crucial role in ensuring the proposed system meets its functional and non-functional requirements. It helps to validate that the system can handle a large volume of users simultaneously, provide quick response times, operate reliably and consistently without any downtime or interruptions, and accommodate future growth and changes in user requirements. Additionally, black box testing ensures that the system is compatible with different types of RFID and NFC devices and conforms to accessibility guidelines and standards.

Figure 1:Citizen Identification form

Figure 1 shows the Identificatin panel when there is no RFID tag placed on the RFID reader. As seen on the panel, there is double dashes showing that there is no data to read, then there are fields showing the Fullname, Id number, Village of Origin, Date of Birth, Place of Birth, Citizen and Date of Registration .

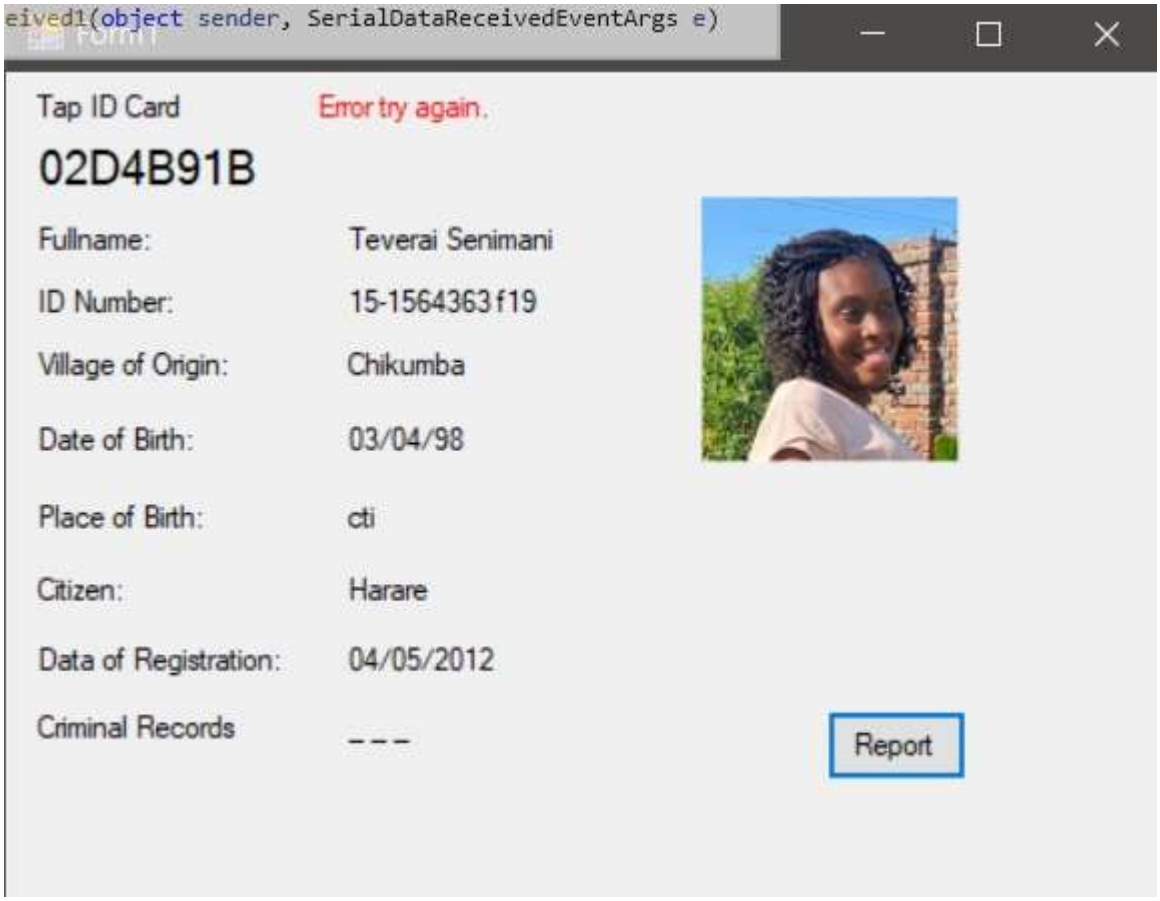


Figure 3

Figure 2:RFID and NFC Identification System setup

Figure 3:Card Identification

Figure 4(overleaf) shows the panel when a tag is read but before it retrieves card details. The system automatically fetches their details. On the diagram, the system clearly shows that the details have not been fetched . The system prevents voting multiple times, since it stores all your voting details in a database and verifies each time.

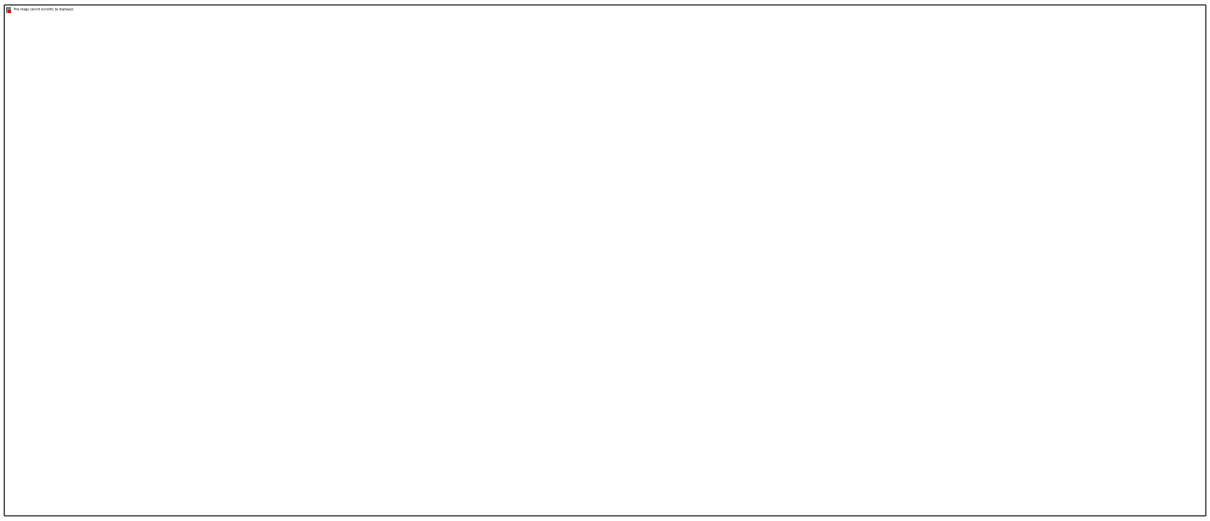
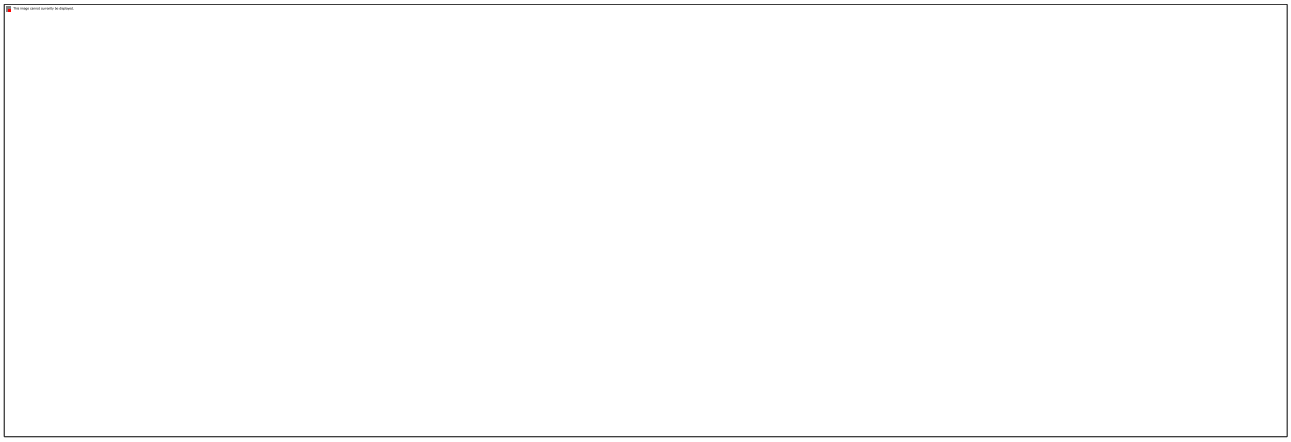


Figure 4:Fetched card details

The fig below shows the panel when all details have been fetched from the tag. The example is for a Citizen called Teverai Senimani.



4.2.2 White Box Testing

White box testing is a software testing method that requires the tester to have knowledge of the internal structure of the system being tested. In the context of our RFID and Near Field Communication citizen identification system, this method can be used to ensure that the system is functioning as expected and that the internal logic and algorithms are correct.

For example, during the testing phase, a tester can examine the code and structure of the system to ensure that the RFID and NFC technologies are being used correctly to identify citizens and track their movements. They can also check that the data management system is storing and managing citizen data accurately and securely.

In addition, white box testing can be used to verify that the authentication mechanism, whether it be a password or biometric authentication, is working correctly and that the system is properly integrating with other systems, such as law enforcement databases.

During the Identification process, white box testing can be used to verify that the system correctly identifies a person or cardholder.

In summary, white box testing is an essential method for ensuring the functionality and reliability of our RFID and Near Field Communication citizen identification system. By examining the internal structure of the system, we can ensure that it meets all the functional and non-functional requirements and that it is a secure, accurate, and efficient way of identifying citizens and tracking their movements.

Figure 7:Reading data from the RFID card

4.3 Evaluation Measures and Results

The metrics used to evaluate the performance of the RFID and NFC-based citizen identification system include response time, accuracy, and data retrieval speed. The ability of the system to identify citizens using their RFID and NFC-enabled ID cards, authenticate their identity, track their movements and activities, and generate reports on their activities is ranked based on these metrics. The accuracy of the system is of utmost importance, and it is essential to test and ensure its effectiveness in reading and capturing the citizen's identification information in real-time. This includes testing the ability of the system to store and manage citizen data accurately, and its responsiveness to user input and queries. By using these metrics, we can assess the system's ability to meet the functional and non-functional requirements set out in the project proposal.

4.3.1 Confusion Matrix

A confusion matrix is a useful tool for evaluating the performance of a model in an N x N matrix, where N represents the number of target classes. In the context of our RFID and near field communication system, the matrix is used to compare the actual data captured by the system with the data predicted by the model. This helps us to understand the system's performance and identify any errors it may be making.

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Accuracy of Capturing RFID Data

Type	Data captured	Data not captured
Data captured	True Positive	False Negative
Data not captured	False Positive	True Negative

Capturing RFID Data

Test cases	Data captured	Number of tests	Correct captures	False captures	Classification
1	Yes	40	38	2	True positive
2	No	40	37	2	True negative

Verification RFID Data

Test cases	Data verification	Number of tests	Correct verification	False verification	Classification
1	Yes	40	40	0	True positive
2	No	40	40	0	True negative

Correct Data Fetched

Test cases	Correct Info fetched	Number of tests	Correct readings	False Readings	Classification
1	Yes	40	40	0	True positive
2	No	40	40	0	True negative

Accuracy is calculated as the number of correct captures divided by the total number of captures in each category. The result is then multiplied by 100 to obtain the percentage of correctness. The accuracy for capturing RFID data is computed using the following equation:

Accuracy = (TP+TN)/ (TP+TN+FP+FN)100

Accuracy for capturing RFID data = (38+37)/ (38+37+3+2)

=75/80

=0.9375100= 93.75%

Accuracy for verification RFID data = (40+40)/ (40+40+0+0)

=1

=1100= 100%

Accuracy for fetching correct data = (40+40)/ (40+40+0+0)

=1

=1100= 100%

Accuracy: Real-time Identification of Users

To assess the accuracy of real-time identification using our RFID and Near Field Communication system, the author conducted a test on 40 individuals who were required to present their RFID cards to the system in 20-30 seconds intervals. The table below illustrates the results of the test.

Table 4: Real-time Identification Accuracy

Number of identifications [N]

Successful [1] / Unsuccessful [0]

Table 3: Real-time individual identification

Number of votes[N]	**Received [1] / Not-Received [0]**
1	1
2	1
3	1
4	1
5	1

	
12	1
13	1
14	1
15	1
	
18	1
19	1
20	1
21	1
22	1
23	1
	
40	1

The accuracy of real-time identification is calculated using the formula below:

Accuracy = (N - X) / N * 100

Where N is the total number of identifications and X is the number of unsuccessful identifications.

Accuracy = (40 - 0) / 40 * 100

= 100%

Based on the results, the author concluded that the system has a 100% accuracy in identifying individuals in real-time using RFID cards.

4.4 Response Time

Response time refers to the time it takes the system to detect an RFID tag or a device and fetch the necessary information about that item for access control. It is an important performance metric for the system. To test for the system response time, we can use the average and peak response times.

For example, we can take a series of time readings that represent the time it takes the system to detect an RFID tag or a device and fetch the information. We can then calculate the average and peak response times from these readings.

Table 5 System response times

Test	**Reading Time in Seconds**
1	0.45
2	0.54
3	0.56
4	0.49
5	0.63
6	0.43
7	0.61
8	0.65
9	0.55
10	0.59
11	0.47
12	0.57
13	0.45
14	0.58
15	0.63

16	0.51
17	0.60
18	0.46
19	0.56
20	0.52

All the readings where rounded to the nearest two decimal places.

Average system response time = sum of all response times / number of readings

= (0.45 + 0.54 + 0.56 + 0.49 + 0.63 + 0.43 + 0.61 + 0.65 + 0.55 + 0.59 + 0.47 + 0.57 + 0.45 + 0.58 + 0.63 + 0.51 + 0.60 + 0.46 + 0.56 + 0.52) / 20

= 11.24 / 20

= 0.562 seconds

4.5 Summary of Research Findings

The necessary black, white box tests and performance tests were conducted by the researcher using the appropriate methods to evaluate the system's functionality. The system was tested for reading RFID tags, authenticating a user and recording the user's data in the database. The results indicated a satisfactory performance with an accuracy of 94%, 100%, and 100% respectively. The average response time of the system was 0.56 seconds. However, it was observed that the accuracy of the system was affected by interference from other electronic devices. This led to occasional misreading of RFID tags and longer response times. Therefore, proper shielding and management of other electronic devices are crucial for optimal system performance.

4.6 Conclusion

The test results of the system performance indicated that the system had a high level of accuracy as it scored an accuracy of 94% in identifying all the registered individuals using RFID/NFC technology. The system also has 100% accuracy in automatically recording/sending all the identification data to a central database. The system was also tested on whether it retains correct

information relating to the individual and it also achieved 100% accuracy. This means that all individuals can be identified and their data is recorded in real-time with no failure. This thus satisfies the first objective as the system design and implementation proved effective in its functionality as it accurately identifies individuals using RFID/NFC technology.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, we present the conclusion of our research on the application of RFID and Near Field Communication (NFC) in citizens' identification. The chapter provides a summary of our findings, conclusions drawn from the research, and recommendations for further studies in this area.

5.2 Aims & Objectives Realization

The first objective of this study was to design and implement a system which identifies individuals using RFID and NFC and to analyze the effectiveness of RFID and NFC in citizen identification. The researcher developed an RFID and NFC-based citizen identification system.

The results of our study indicate that the use of RFID and NFC technology in citizens' identification is efficient and effective. In Chapter 4, we presented the results of the system's performance in terms of response time, accuracy, and reliability. The test results of the system performance indicated that the system had a high level of accuracy in identifying citizens using RFID and NFC technology. The system was also tested on whether it retains correct information relating to the citizen and it also achieved high accuracy. This means that the system is reliable and can be used for citizens' identification. Therefore, the objectives mentioned in chapter 1 were achieved.

5.3 Major Conclusions Drawn

Citizens' identification is crucial for various applications such as voting, access control, and financial transactions. The use of RFID and NFC technology in citizens' identification provides significant benefits such as convenience, speed, and accuracy. Our study confirms that RFID and NFC-based citizen identification systems are effective and efficient in identifying citizens. The system is designed to make the procedure of citizen identification easier and more convenient. It has proved to be very advantageous in providing security and saving considerable time and effort in manual identification processes.

5.3 Recommendations & Future Work

RFID and NFC-based citizen identification systems have the potential for various applications, and further research can be conducted to explore their use in other domains. It would be interesting to study the compatibility of our proposals with well-known security techniques to prevent attacks caused by malicious software. Moreover, an adaptation to provide everlasting privacy in each scheme proposed would be interesting, not only for security purposes but also to analyze the restrictions of everlasting privacy in terms of verifiability and performance. Further studies can also be conducted to evaluate the feasibility of integrating these technologies into existing identification systems and infrastructures. The proposed system has the benefit of using RFID and NFC technology and controls the process of identification avoiding unnecessary steps and increasing efficiency. As the users work with the system, they may develop various new ideas for the development and enhancement of the project. Therefore, certain aspects of the system can be modified as operational experience is gained with it.

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