**PROJECT ON**

**QR-CODE: A SMART MEANS FOR TRACKING AND SECURITY AND SECURITY**

**SUBMITTED BY**

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**February 2023.**

# CERTIFICATION

I hereby certify that the content of this report was carried out by OGHENETEGA POWELL IGHO of the department of Information Technology, School of Computing, Federal University of Technology, Akure. Nigeria.

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Prof. (Mrs) O.K Boyinbode Date

Supervisor

# DEDICATION

This project work is dedicated to God, for wisdom and the strength and grace given to start and complete this project. I also dedicate this project to my family and relatives who have contributed to the success of this project.

**ACKNOWLEDGEMENT**

I would like to express my profound gratitude to all those who have contributed to the successful completion of this research project. First and foremost, I want to acknowledge the Almighty God, who has been my rock and my strength throughout this journey.

I am immensely grateful to my project supervisor, Prof. (Mrs) O.K Boyinbode, for her exceptional guidance, invaluable support, and unwavering commitment to ensuring that this research project was a success.

My heartfelt appreciation goes to my parents, Mr and Mrs Adu, whose unwavering love, support, and financial assistance made this research project a reality and my guardians here in Akure Mr. and Mrs. Blackwell for their love and support.

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**ABSTRACT**

Misplacement and theft of small devices and products are common challenges that have been difficult to address due to the lack of an effective monitoring system. Smart product tracking using QR code is an innovative solution for managing and tracking valuable products. The system uses a QR code that carries information about the product, allowing users to easily access information by scanning the code with their smartphones. This system is designed to be easily accessible and affordable for a wide range of users, with a focus on minimizing the use of cutting-edge technologies. The system also aims to bridge the gap between business-to-business and business-to-consumer structures in e-commerce by involving manufacturers in product tracking with the permission of the user. This paper presents a comprehensive analysis of the system's architecture, its features, and its limitations, and suggests recommendations for improving its functionality and usability. The paper concludes by recommending the need to improve the system's security and privacy features to prevent infringement of user information and real-time location, and also calls for the development of structured terms and conditions for manufacturers to provide tracking information to users.

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# CHAPTER ONE

# INTRODUCTION AND BACKGROUND STUDY

# 1.0 INTRODUCTION

# The ability to track an item, its whereabouts and ownership history, is crucial in today's business world. Traditional item tracking systems, however, often fail to track products once they are dropped off at single-point delivery locations. To overcome this limitation, this research proposes the use of Quick Response (QR) code technology. QR codes are matrix barcodes that can store more data than traditional codes, and can be scanned quickly using smartphones. They have many applications, from document management to item tracking, and are increasingly popular due to their versatility. By using QR codes, businesses can communicate with customers directly, and users can access information quickly and easily. Despite recent breakthroughs in computing and geolocation, however, no system has yet been implemented that effectively tackles the challenge of missing or stolen products, while remaining cost-effective and easy to use. This research seeks to bridge that gap by proposing a system for smart item tracking using QR codes.

# 1.1 MOTIVATION

QR code has been massively adopted in today’s business world due to the seamless integration of internet and e-commerce in daily living people, as per projections, mobile commerce sales are expected to reach $3.56 trillion in 2021. Therefore, ecommerce store proprietors can no longer disregard the significance of having a mobile-friendly online store if they want to entice customers and expand their business (Lin, 2023). This has allowed the easy penetration and usage of QR code with many various applications that has bridged the gap between business to consumer interaction, this could also be used an effective solution for item tracking that involves both parties.

A statistical examination of larceny-theft in Nigeria would reveal that the numbers would be substantially higher than the 4.61 million documented incidents of larceny-theft that were reported in the United States in 2020. The unlawful taking, carrying, leading, or riding away of something from the possession or constructive possession of another is referred to as larceny in the FBI's Uniform Crime Reporting (UCR) Program.

# 1.2 AIM

The aim of this research is to develop a system using QR code technology that will allow products that are vulnerable to theft, like laptops, mobile phones, electronic devices, and other hand-held gadgets, to be smartly tracked and reflect the condition of the item or product as a means of security against such kinds of theft.

# 1.3 SCOPE OF THE STUDY

This research is restricted to gathering and storing user information, changing and updating product status, and intelligently tracking the position of the product using QR code geolocation technology due to the serious security and item monitoring between persons concerned.

# 1.4 OBJECTIVES

The objective of this project is to develop a web based smart tracking system with the use of QR code that is readily accessible to individuals and with involvement of the manufacturer.

# 1.5 CONTRIBUTION TO KNOWLEDGE

At the conclusion of this study, a web-based smart security system would be created that would expand the uses of QR code technology to monitor an item and their condition as they interact with people, therefore reducing the security risk associated with larceny theft.

# CHAPTER TWO

# LITERATURE REVIEW

# 2.0 INTRODUCTION

Advanced sensors are being developed quickly, and their widespread use is laying the groundwork for new paradigms to address problems with important tasks like locating, tracking, and smart sensing in difficult situations with little a priori knowledge (Tiancheng Li et all, 2021). Yet there still pose a great challenge for tracking an item as soon as it leaves the supply chain to the hands of the final consumer. Due to the fact that most traditional package tracking systems are concerned primarily with item identification and as a result, do not explicitly define any connection to product tracking systems, most packages are not tracked after being dropped off at a centralized mail services center with single-point delivery (AHM Shamsuzzoha and Petri T Helo, 2011). With respect to tracking and tracing system, Jansen divides the supply chain logistics parties into two groups: suppliers and industrial customers and end-customers. End customers place requirements on the supply chain as "business-to-consumer" requirements, whereas suppliers and industrial customers impose requirements as "business-to-business" requirements with regard to monitoring and tracing. (AHM Shamsuzzoha and Petri T Helo, 2011).

The focus of this research is centered on the development of a tracking system for business-to-consumer requirement of the supply chain.

Through the years, there have been several tracking systems developed through GPS, RFID, GTIN, Barcode, however, most of this tracking systems has been able to effectively manage tracking products within the business-to-business requirement, but pose a challenge to be used to develop a tracking system within the business-to-consumer requirement. The majority of the tracking and tracing systems now in use rely on unique tracking numbers created by the operating systems of the various organizations and are built on an information architecture, where the tracking data is centralized with the tracking service provider. Existing tracking systems are unable to determine, for instance, when a package is open or its contents are missing or stolen, what is contained inside. (AHM Shamsuzzoha and Petri T Helo, 2011). The basic methods provided for customer to access the tracking information are less desirable, an example of such is, tracing shipment through manual query such as using a website or a phone call or an email, or by integrating a tracking system with the product which will ultimately increase the cost of transportation of the product, and not suitable to implement outside the supply chain where the product is outside the bounds of the company’s tracking boundary.

# 2.1 TRACKING SYSTEMS: APPLICATION AND LIMITATIONS

There are a number of tracking systems based on technologies like GPS, GTIN, RFID, and barcodes, but none of them have been able to successfully address the issue of supply chain item tracking, and their operational models are not suitable for creating a tracking system suitable for tracking specific products.

# 2.1.1 RFID TRACKING SYSTEM

RFID (Radio Frequency IDentification) is a wireless communication technology used to capture data, which may be linked to different identification attributes (serial number, position, colour, date of purchase, etc.) of entities carrying RFID labels (tags). The interchange of electromagnetic waves between RFID tags and RFID readers provides the basis for data collection. When compared to barcodes and other Auto-ID technologies, this Automatic Identification and Data Capture (Auto-ID) technology can provide more precise labeling. (Chetouane, 2015).

RFID integration to any process is usually achieved according to three facets: Context, Capture and Control.

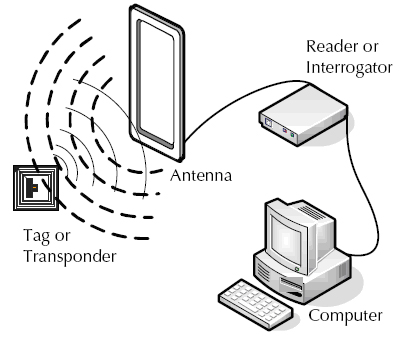
**Context Facets:** The environment is the focus of the context aspect of RFID technology. By examining the operational environments in which RFID tags will be used, one must investigate the evolution environment of the process exposed to RFID integration. It is necessary to analyze the information to be gathered from the process, as well as the communication restrictions/barriers caused by the process environment (interference, reflection, and other communication obstacles).

**Capture Facet:** The selection of RFID hardware (tags and readers) is dealt with in the capture facet to enable proper data gathering from the investigated process and environment. For effective data collection and dependable RFID interrogation zone design, a few parameters still need to be modified, including operating frequencies, RFID tags reading range, RFID antenna positions, power control, information privacy and security concerns.

**Control Facet:** The control facet primarily deals with the implementation of business intelligence rules and real-time control of RFID systems (through middleware links to other corporate applications, EPC databases, and graphical user interfaces) (information processing, system response to RFID tag triggered events, control rules, algorithms). Typically, the limitations imposed by the context and capture facets serve as the basis for developing an RFID middleware. A basic RFID system is generally made of the following components:

* RFID tags fixed to entities with unique electronic product code (EPC) per entity (wireless RFID network)
* Networked RFID readers, and real time databases
* RFID antennas for information exchange between the tags wireless network and middleware/control platforms.

From the concept drawn by Shi Yong-Dong is that the purpose of RFID’s application is to facilitate the communication between suppliers and customers. Tracking is the most common use of RFID in logistics. Automatic product, container, vehicle, and employee identification is essential to

contemporary logistics management. In the company's MIS and ERP systems, some information must be transferred and reflected in real time. Since RFID can fully perform these tasks, it can be used in all aspects of logistic management. (Shi Yong-Dong et al, 2009).

## Fig. 2.0. Architecture of RFID system

# 2.1.1.1 APPLICATION OF RFID

The logistics chain's business linkages and processes include purchase, stock, packaging, handling, transportation, delivery, processing, distribution, sales, and service. They are constrained by one another and complement one another. Corporations must comprehend and manage the directions and changes in the commercial flow, logistics, information flow, and cash flow in all linkages of logistics properly and in real time. Companies can only optimize the potential economic and social advantages if the 4 segments' flow and each process are synchronized with one another. All sectors are, however, loose and in motion since the real things are moving. When a result, information frequently changes as an item moves across time and space. It has an impact on information sharing and accessibility. Fortunately, RFID is a logistics management technology that can address issues with data input/output, process control, and tracking, as well as lower error rates. Numerous aspects of logistics, such as the retail, stock, delivery, and distribution processes, depend greatly on RFID. (Shi Yong-Dong et al, 2009).

**The Application Of RFID In The Containers' Tracking And Management:**

The way that an RFID recognition system is used in container management is by attaching or mounting tags to containers or plates and using hanging read-write equipment, read-write equipment mounted on forklifts, or handheld read-write equipment to read the tags' dynamic information. The read data may be sent to a database or monitor. A container RFID identification system can concurrently identify 80 plastic containers and 40 plates. The crucial connection in the transit and use of containers is monitoring management, which guards against theft, loss, and damage to the containers and boosts turnover to encourage usage efficiency. Container tracking is necessary for the container transport firm to reach the aforementioned objective.

RFID (Radio Frequency Identification) technology provides a swift and dependable approach to monitor the stock levels of products. If coupled with a warehouse management system (WMS), the integration provides instantaneous and current information regarding inventory levels, and automated reordering can even be set up. Hence, RFID systems are an efficient way to track product inventory and manage the stock levels of your business. (Advance Mobile Group, 2022).

The supply chain industry has an increasing demand for transparency and visibility. Customers now desire to have information about the origin of their products and even want to track shipments from the warehouse. To provide a seamless customer experience and address bottlenecks in the supply chain, retailers and distribution centers require increased visibility as well. RFID technology provides a solution by offering real-time data on the location of items, which helps improve the overall transparency and visibility of the supply chain. (Advance Mobile Group, 2022).

**The Application Of RFID In Tracking The Fruit And Other Kinds Of Food**

RFID may be used to trace the fresh fruit supply chain from the point of origin to the end consumers, ensuring the fruit's nutritional value and freshness. Attach the tags to the fruit crates using tape or adhesive until the fruits are accounted for. Read-write equipment can detect tags, and the data is transferred in real-time to a database or monitor. Future refrigerators in homes will be able to read the RFID tags on frozen food, remind you to get fresh milk, toss out any food that is over its expiration date, cut down on the consumption of high-cholesterol foods, and more.

**Warehouse Management**

RFID can efficiently manage the information regarding the movement of shipments. As a result, it can improve the capacity for processing freight and the store of information. The warehouse door has technology for reading and writing on it. Every cargo unit is equipped with RFID tags, and the warehouse's main computer stores all of the information from the tags. "The read-write equipment can identify and communicate to the central computer which trailer is operating and which cargo is being moved when the merchandise is taken out of the warehouse or transported. The management center may monitor the volume of items entering and exiting storage, identify cargo, and determine the locations to track the products by doing this. Tracking the cargo is a crucial piece of technology in logistics management. In the sphere of logistics management abroad, RFID is highly common.

The distribution center of goods primarily consists of a warehouse, which is responsible for gathering and distributing information and maintaining a record of the goods. The warehouse is an essential part of logistics and is integrated into various logistics activities such as procurement, production, transportation, and processing. The accuracy and efficiency of storage are crucial to enhance the efficiency of the entire logistics supply chain. To achieve this, sensor technology is used to monitor temperature, humidity, and whether the container door has been opened or hit, while RFID technology is used to track the movement of goods and provide real-time information about their location, reducing the risk of inventory loss. RFID technology has been successfully implemented in high-profit or expensive goods stores. (Haoyuan et al, 2017)

# 2.1.1.2 LIMITATION OF RFID

The article RFID technology principles, advantage, limitations and its application describe some limitation of RFID technology that prevent this technology to include individual ownership in the supply chain. Listed below are some of the limitation.

**Convinence**: Furthermore, RFID technology requires specialized equipment to read the tags, which can be a barrier to adoption for consumers. Not all smartphones or devices have built-in RFID readers, so consumers would need to purchase separate equipment to access the information on the tags. This added cost and inconvenience could discourage some consumers from engaging with RFID technology.

**Standardization:** The features of the application and the context of usage decide the right tag, but the lack of standards still gives a lot of latitude in terms of the communication protocols chosen as well as the format and quantity of data included in the tag. Companies that want to share their application with others after moving beyond closed-loop solutions may run into problems because the standards that cooperating partners must follow for communication protocols, signal modulation types, data transmission rates, data encoding and frames, and collision handling algorithms must all be agreed upon.

**Cost**

The price of tags varies according on the type. RFID Systems in the Manufacturing Supply Chain, ARC's 2003 study The economic usage of tags would still need a maximum of 25 cents per tag for high-end items and 5 cents for typical item-level tagging, even after accounting for the accompanying 5–35% drop in labor costs and zero tag information generating expenses. Even more prohibitive are the costs of active or semi-passive tags (at least $1 per tag), which limit their economic use to scanning expensive products at a distance.

# 2.1.2 Global Trade Item Numbers (GTINs)

TIN (Global Trade Item Number) is a unique identification number used to identify trade items, such as products, services, or packages. It is a globally recognized standard managed by GS1, a non-profit organization that develops and maintains global standards for business communication.

The GTIN is a standard used for identifying trade items globally, providing a unique identifier for each item. These identifiers can be 8, 12, 13, or 14 digits long, and data structures require fields capable of storing up to 14 digits. Any software processing GTINs should be designed to accommodate 14 digits. Trade items refer to any product or service that requires predefined information retrieval and can be priced, ordered, or invoiced at any point within the supply chain. This includes individual items, as well as any of their various packaging configurations.

The GTIN is usually a 14-digit number that is encoded into a barcode or RFID tag and can be scanned by point-of-sale systems or other scanning devices. The first part of the number identifies the GS1 country code, the next part identifies the manufacturer, and the final part identifies the product.

The most commonly used types of GTINs are:

1. GTIN-13: This is a 13-digit number used for most retail products sold internationally. It is also known as an EAN-13 (European Article Number).
2. GTIN-14: This is a 14-digit number used to identify individual units of products that are packaged together, such as a case of 12 cans of soda. It is also known as an ITF-14 (Interleaved Two of Five).
3. GTIN-8: This is an 8-digit number used for small products or those that have limited space for a barcode. It is also known as an EAN-8.

While GTINs are a widely accepted standard for identifying trade items, there are some limitations to their use. Some of the limitations of GTINs are:

1. Limited product information: GTINs do not provide detailed information about a product, such as its specifications, ingredients, or country of origin. Additional product information may need to be provided separately.
2. Limited use for non-retail items: GTINs are primarily designed for use with retail products, and may not be appropriate for non-retail items, such as equipment, machinery, or services.
3. Limited ability to identify individual items: GTINs are designed to identify a particular product, but do not provide information about the individual item. This can be a limitation in situations where individual items need to be tracked, such as in the case of pharmaceuticals or medical devices.
4. Complexity: The process of obtaining and managing GTINs can be complex, especially for small businesses or those that sell products in multiple countries. This can be a barrier to entry for some businesses.
5. Cost: There is a cost associated with obtaining and using GTINs, which can be a limitation for small businesses or those with limited resources.

# 2.1.3 QR-CODE

QR codes are becoming increasingly popular among younger generations due to their simplicity compared to traditional user IDs and passwords. There are many advantages to using QR codes, such as their ability to store large amounts of data, quick scanning, the ability to be read from any angle, small size, error correction capabilities, support for multiple languages, and resistance to damage. Many businesses that are new to the online market are adopting QR codes as an alternative to traditional login methods. (Chinmay Jathar et all, 2019).

QR codes are used in a variety of ways. For example, they are used in advertising campaigns to provide more information about a product or service, or in event tickets to provide access to event information or to streamline check-in processes. They are also used in inventory management to track products, in shipping labels for better tracking of packages, and in mobile payments for secure and convenient transactions.

QR codes have many advantages over traditional barcodes. They can store much more data, are easily scanned by smartphones, and are more versatile in terms of their usage. They are also more secure than traditional barcodes since they are encrypted, making it more difficult for counterfeiters to replicate them. Despite their advantages, QR codes also have some limitations. One limitation is that they require a smartphone or QR code reader to be scanned, which may not always be available. Additionally, they can be difficult to scan if they are damaged, poorly printed, or poorly lit. Finally, there is a risk of fraud if QR codes are used for sensitive information like payment details, as hackers may be able to create fake QR codes and steal data.

A dynamic 2-dimensional machine-readable matricial bar code is essentially what a QR code is. Denso Wave, a Japanese corporation, created the QR code in 1944 with the intention of creating a quick and accurate inventory checks. (Md Shamim Hossain, et al, 2018). The black and white pieces on a Go board served as inspiration for the early design of the QRcode. Its function was to replace several bar codes on each box, each of which had to be scanned separately, in order to track automated parts made by Denso.

QR codes are structured in a specific way to allow for the storage of data in both horizontal and vertical directions. The code consists of a square grid of black and white modules, arranged in a specific pattern that allows for the code to be read and interpreted by scanning devices. QR codes can range in size from small codes that can be printed on a business card to large codes that can be placed on billboards or buildings.

The data encoded within a QR code can vary depending on its intended use. Common types of data that can be stored in a QR code include URLs, contact information, product information, event details, and payment information. The data is encoded using specific rules and algorithms that allow it to be read and interpreted by scanning devices.

Scanning devices, such as smartphones or QR code readers, are used to read and interpret QR codes. The device uses a camera to scan the code, and then uses software to interpret the data that is encoded within the code. The software may take different actions depending on the type of data encoded within the code, such as opening a website, adding a contact to an address book, or initiating a payment.

**The QRcode Structure.**

The international journal of application or innovation in engineering and management published a journal a review on Qrcode analysis by Chinmay Jathar, Swapnil Gurav and Krantee Jamdaade describe the structure of the QRCode. The QRcode is divided into 8 sections described below

**Finder Pattern (1):** Three similar structures make up the finder pattern, which is present in all save the bottom right corner of the QR Code. The foundation of each design is a 3x3 matrix of black modules that are surrounding by white modules that are then encircled by black modules. The Finder Patterns enable the decoder software to recognize the QR Code and ascertain its precise orientation.

**Separators (2):** The white separators, which are one pixel wide and help to distinguish the Finder Patterns from the real data, improve pattern identification.

**Timing Pattern (3)**: By switching between black and white modules in the Timing Pattern, the decoder software may identify the width of a single module.

**Alignment Patterns (4**): Alignment Patterns aid in compensating the decoder program for light image distortion. There are no alignment patterns in version 1 QR codes. Alignment Patterns are added in greater numbers as code size grows.

**Format Information (5)**: The QR code error correction rate and the chosen masking model are stored in the 15 bits of the formation information section, which is located next to the separators.

**Data (6):** Data is transformed into an 8-bit bit stream and then stored in an information segment (known as codewords).

**Error Correction (7):** The error correction section stores error correction codes in 8 bit long code words, much like the data section does.

**Remainder Bits (8):** If the data and error-correction bits cannot be divided into 8-bit codewords without leaving a remnant, this section is empty.

## Fig 2.1. Structure of QR Code

Security is a key issue with the use of QR codes. Because QR codes are printed in two dimensions on paper or a screen, they are quite susceptible to several kinds of cyber-attacks. To prevent this, one must confirm the source of a certain QR code and fully comprehend the data nature of that specific QR code. There are several QR code assaults and countermeasures. The safety Due to the widespread use of QR codes, serious problems with data loss and data manipulation have arisen. To address the information security and safety issues with QR codes, Xiaohe Cao suggested a visual cryptography-based secure QR code method. The QR code is divided into two shareable images that will be sent separately. The pseudo-random matrix served as the foundation for the creation of the two shared images; hence, the pixels in the two shared images are decided by the values of the pseudo-random matrix. Only by stacking the two shared photos can the information be revived. The results of the simulation show that it is possible to effectively mask and restore the QR code's image. (Chinmay Jathar, et al, 2019).

In many research works of recent, has dealt with the use of QR code in security related services and has been utilized by many applications. The QRcode is appropriate for protecting data privacy and may be a useful tool when utilizing encryption techniques to do so. (Abbas M. Al-Ghaili, et al, 2020). Authentication is a major aspect in application using QR code in specialized manners.

# Area of application of QR code

QR codes are widely used in the manufacturing industry for various purposes such as marking products, managing ticketing processes, and keeping track of inventory. They are also helpful in enabling mobile ticketing, promoting events, and boosting tourism through location-based services. By scanning QR codes, users can quickly access relevant information about a product, service, or event, which enhances the overall customer experience. Moreover, QR codes are durable and can withstand harsh conditions, making them ideal for use in manufacturing and other industries where products need to be tracked and identified throughout the supply chain.. It is frequently used in government offices to distribute instructions and varied information, support document and permission applications, and streamline everyday office tasks. In social media platforms like WeChat, Facebook, and Snapchat, QR codes are also employed as application tools. (Md Shamim Hossain, et al, 2018).

QR codes are making lives easy for merchants and businesses In small and medium-sized enterprises (SMEs), a QR code is generated by the merchant for each vendor to denote the location of the cash register and other relevant information. To initiate payment, the customer scans the QR code associated with the vendor. The vendor then sends the receipt to the customer's smartphone from the cash register, after which the customer confirms the payment. Once the customer scans the QR code, they are directed to a payment portal where they can select their payment method and complete the transaction. The payment portal may be hosted by a third-party payment provider or may be integrated directly into the merchant's mobile app. The payment provider or merchant will then receive the payment information and process the payment.

The stored information inside a QR code can be encoded as a URL, which can be easily read by the cameras of mobile devices and redirect users to specific websites where users can communicate with vendors or service providers, this according to (Albăstroiu and Felea, 2015) One of the technologies that will have a huge influence on consumer product choice and shopping experience is QR codes.

Several studies have explored the use of QR codes as a medium for communication. In the article "QR code Usage for Marketing Activities of Logistics Companies," it was observed that QR codes allow users to switch between social media alternatives. Consequently, QR codes have been employed as a cross-media marketing technique rather regularly. (Berk Kucukaltan, Deniz Herand, 2014). QR codes can be included in print or digital advertisements, providing users with a way to easily access additional information about a product or service. For example, a QR code on a billboard or a magazine ad could link to a website or video showcasing a product.

QR code has been shown to have various technology impact aside from bsuiness to Business (B2B), all of these are described in the related works below, this provided the motivation for this project as a combination of certain features addressed by those studies, as well as their limitations.

# 2.4 Related Works

Adeniyi et al, 2020, presented a paper on the application of smartphone QR code scanner as a means of authenticating student identity card. During registration, the system gathers the essential student information. It then creates and encrypts a QR code using the student's unique value, which is subsequently inserted in the student ID card. It directs to a webpage before authenticating the distinct and encrypted value stored on the student ID when scanned by the camera of a smartphone. The research's goal was accomplished by showing that any smartphone with a built-in QR code scanner can quickly and automatically collect precise encrypted data throughout the authentication procedure. This restriction makes the formal ID ineffective and raises the cost of creating ID cards for students. The information can only be altered by the system administrator, and a new QR code is created once the information is edited.

In a study titled "Using QR Code for Contact Tracing Framework for Sustainable Containment of COVID-19," Lorraine et al. This contact tracing methodology uses two key concepts. The first is the usage of public health authority-issued QR health codes, which are symptom-based. Instead of retrieving user location information, the codes support two colors to distinguish users' health condition. A green code indicates that the person has passed the health verification test since a polymerase chain reaction (PCR) test record indicates that they do not have COVID-19 infection. An orange designation, on the other hand, denotes either a COVID-19 infection or a high probability of infection. Officially, the QR codes are recognized as digital health status certificates for people. By using QR scanners, the data contained in the codes is automatically read and evaluated. The design's fundamental goals are to improve data reliability, quicken processing, and minimize mistakes brought on by manual labor. According to Lorraine et al, 2020, the synthesis of important features—including contract tracing, exposure risk self-triage, self-update of health status, medical appointments, contact-free psychiatric counseling, and QR codes for other family members—is the second crucial idea. Additionally, the platform may effectively combine prescription and health insurance services, lowering user expenses and operational delays. Since the initial instance, the study's framework has been used across Fujian province, home to more than 40 million people. Of the 363 recorded cumulative cases, 99.4% of patients have recovered, the death rate was 0.3%, and 0.3% of patients are still alive. They said that the use of the symptom-based QR strategy makes it possible to allocate the limited health care resources as efficiently as possible and that it may be applied as a normal surveillance tool in the post-pandemic era to help people recover quickly from the shock of the epidemic.

The primary worry that turned out to be a limitation of the contact tracing framework was that acceptance of this approach could be compromised in an economic environment where the general population is highly sensitive to maintaining privacy. This will lead to close observation of the effects of containment. Another worry was how to prevent malicious or authorized use of the QR data.

QR code technology has practical application in solving congestion and cutomer orders in a resturant by a paper published by (kartik and karekar, 2019), Resturant automation system using QR code. The Major Objective is to assist restaurants in resolving these issues by putting into place a low-cost strategy to boost patron and employee happiness. The concept is to use QRCODE technology to create a menu. With a specially created QRCODE reader App, QRCODE tags will be attached to the restaurant menu. Customers may read it by hovering over the QRCODE reader. Since QRCODE are so discrete (nearly the size of a sticker! ), restaurants may maintain their present menu layout and design while using the new technology with little effort. The automation system opens the online application using QR codes. Angular is used to create the web application, which also uses Node.js, Express.js, and a Mongo DB database. All of the restaurant's tables have different QR codes. The web application may be launched by the user by scanning the QR code with their smartphone. As soon as the code is scanned, the program is launched and the table number is registered.

Prof. Rama Chandra Rao et al, in a paper, Smart Car Parking Using Qrcode, provided a means to to provide accurate information about nearby parking spaces for the driver and to book a slot using smartphone, tablet or Pc’s using QRcode, which is used as a mode of authentication. The proposed system aims to overcome the challenges of conventional car parking systems, such as difficulty in finding parking spots and inefficient use of space. The system uses QR codes to enable users to easily find available parking spots and to navigate to their designated parking spots. The paper describes the architecture of the system, including the hardware and software components, and discusses the implementation of the system. The authors also evaluate the performance of the system, including its accuracy and efficiency, and present the results of their experiments. Overall, the paper presents a novel approach to car parking management using QR codes and demonstrates the potential for using this technology to improve efficiency and convenience in parking systems.

In a paper QRCode DOOR Project: Access Control Application using QR Code Image presented by Luiz Antonio Pereira et al, 2020, The study introduces a new method for access control that involves using a smartphone as a key. The approach uses two types of cryptography to generate a QR code image that, combined with a webcam and an electric lock, enables access control. The paper provides an overview of the access device's architecture, the process of creating a QR code image using encrypted user data, and the encryption process. The paper also outlines the development of the QR code reading device using a Raspberry Pi 2 microprocessor. In the paper, The challenge highlighted is related to managing physical access. One of the main issues faced by organizations is the administration of access keys. Traditional physical access control systems rely on keys, which can be easily lost, misplaced, or stolen. If a key is lost or stolen, it may compromise the security of the facility, as unauthorized individuals may gain access. Similarly, employees may lend their keys to others, which can also lead to security issues. Furthermore, traditional physical access control systems lack the flexibility to enforce access rules, such as scheduling access at specific times, limiting access to certain areas or sub-locations within a facility, or limiting the number of people who can access a particular area at a given time. Without such granular access control, there is a risk of unauthorized access to sensitive areas, which can result in theft, vandalism, or other security breaches.

In summary, the challenges with managing physical access using traditional key-based systems include the potential for lost or stolen keys, lack of flexibility in enforcing access rules, and the risk of unauthorized access to sensitive areas. These challenges can be mitigated with modern access control solutions that offer more granular control and management capabilities.

The aim and objective of the paper was to establish the necessary components and their interactions for proper system functioning. The validation and access liberation process identified at least five components: an access key, a sensor, a client, authentication service, and a physical access device. The access key is created by the user's smartphone, which generates the QR Code using the aforementioned process. The sensor is a WebCam installed at the door and positioned within the user's arm's reach. Any physical limitations of the user, such as height, wheelchair, or crutches, must be taken into consideration for proper QR Code reading. The client is responsible for establishing and maintaining a connection between the sensor, the authentication service, and the door lock activation. The authentication service module contains all the access rules and responds to clients with either allowed or denied access.

Qrcode was used in the development of an identity based information management system for monitoring hostel residents in a paper presented by Onyekachi, 2021, in the research paper, an information system was developed for managing the identity of residents of students hostels with the purpose of monitoring movements into and out of their various hostels. The study identified the various user and system requirements, specified the system design and implemented the system. This allows for real time monitoring of student movement in and out of the hostel especially with events of accounting for the number of students present in the hoste during head count. The methodology used in this study has limitations with regards to the interaction between students and authorities. The process involves individual students being scanned by the authorities using a mobile phone, which is not fully automated and can be burdensome.

Karia et al (2019) conducted a study on the potential uses of quick response (QR) codes in healthcare education. The authors identified four key areas where QR codes could be beneficial in healthcare education: increasing participant engagement, facilitating just-in-time (JIT) learning, assisting with administrative tasks in training, and simulation training. The study also noted areas where QR codes may not be suitable, such as in plastic surgeon training. The authors found that QR codes could improve the training experience by enhancing feedback methods and recording procedures in a log book. However, the study is limited by a lack of methodology that could be applied to a larger number of institutions and broader fields of study beyond healthcare.

In recent years, QR codes have been created with a variety of use cases in mind, including identification, security, transportation, tracking, and commerce. Similar use cases and applications exist for other technologies, such as RFID, particularly in e-commerce and the supply chain. This study aims to expand the use of QR codes for individual smart tracking of product and also in e-commerce by extending the supply chain to include business-2-consumers. In this way, the supply chain doesn't end at the retailer and the company can continue to track the product as a service rendered to the people who are in possession of their products as a means of offer additional security features, Additionally, it aims to enhance the integration of QR code technology with other technologies, allowing it to interact and have a dynamic influence on systems like GPS, databases, and maps rather than merely being used in isolation.

# CHAPTER THREE

# SYSTEM DESIGN AND IMPLEMENTATION

# 3.0 INTRODUCTION

In order to bridge the smart tracking gap between business-to-business transactions and business-to-consumer interactions, the objective of this article is to create a smart monitoring system that is commonly and readily available to practically all classes of people through the use of smart mobile phones. The system overview, the system architecture, the data flow diagram, the numerous software tools, and the methodology used for the study are all presented in this chapter.

For the smart tracking system case study, we have chosen to integrate the QR code system into student ID cards. The main objective of this integration is to track the status of the ID cards in case they are misplaced. By integrating the QR code system into the student ID cards, the system will be able to monitor the state of the ID cards. When the ID card is scanned, the QR code will provide the location of the card. This will allow for efficient tracking of the student ID cards and provide information to anyone who scans the card about the status of the card. This integration will improve the tracking of the ID cards, ensuring their security and making it easier to locate them if misplaced.

# 3.1 SYSTEM OVERVIEW

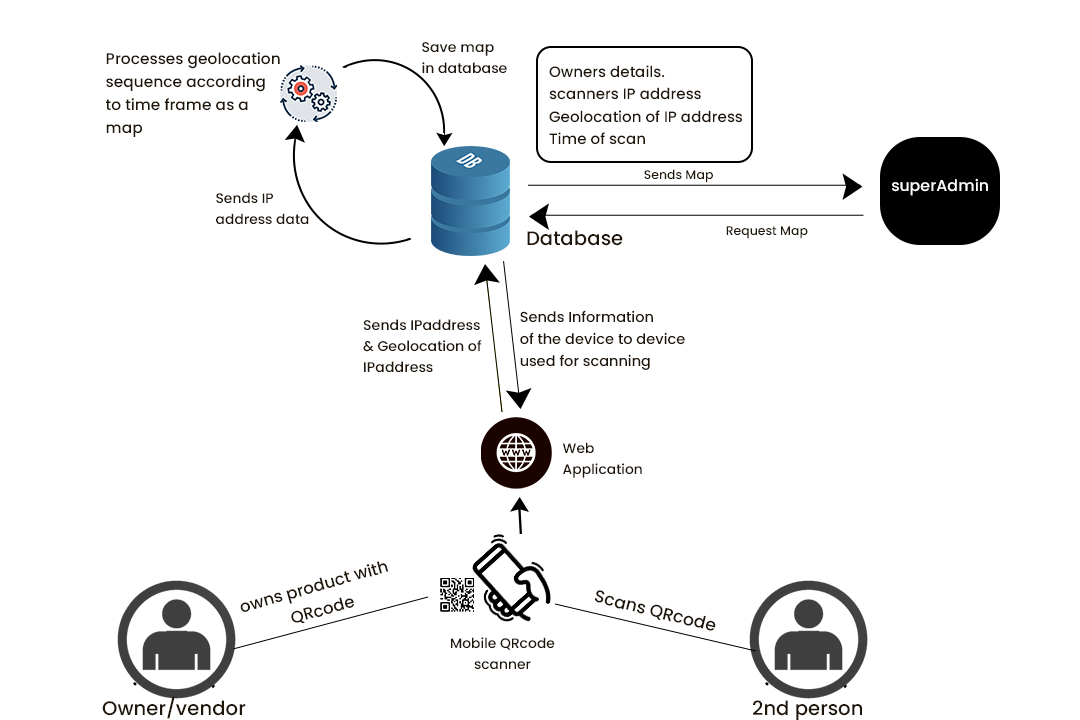
The smart tracking system consists of three main parts: a mobile application that operates on a phone, a processing engine that converts recorded location data into map patterns, and database integration. The system is web-based, providing a universal point of entry for any device, regardless of its operating system. The only requirement is that these devices include a QR code scanner that allows instant access to the web browser.

# 3.2 SYSTEM ARCHITECTURE

# 3.2.1 MOBILE QRCODE PRODUCT SCANNER ARCHITECTURE

Client-server architecture is used in the Smart Mobile QRcode scanner. As can be seen from the interaction between these elements of the system, the architecture is divided into 3 entities;

* The QRcode
* The Web application
* The database



## Fig. 3.0. The Architecture of the Mobile QR code Scanner

* **The QR code**: The QR code is attached to the device or product so it can be scanned by mobile QR code scanners, in an Ideal situation where QR code is generated by the manufacturer, the or code is embedded in the item. At the point of student ID card creation by the educational institution, a unique QR code is integrated into the card, containing the specific information of the student. This means that the QR code will contain details such as the student's name, identification number, and other relevant data. The integration of the QR code into the student ID card ensures that each student is uniquely identified and that the student's information can be easily retrieved through the scanning of the QR code. By embedding the QR code into the student ID card, the educational institution is taking a proactive measure to ensure that each student's identification details are secure and easily accessible. The QR code contains a link that redirects to the web application, that contains the;
* The Item Name
* The serial number of the card
* The date of creation
* The name of the Student
* The image of the Student
* The status of the IDcard

In the course of this research, we will generate the QR code through a QR code generator, that contains the information listed above, which will be returned from the database and displayed on the web application, so that the state of the device and device information can be read by anyone you scans the QR code.

* **The Web Application**

Software or a program that can be accessed using any web browser is known as a web application. HTML, CSS, and Javascript, which are supported by most major browsers, are often used to develop it's frontend. A programming stack like LAMP, MEAN, or another one might be used at the backend (Martin, 2022). To enable the collaboration of numerous applications, web application architecture describes the interactions between applications, middleware systems, and databases (Stringfellow, 2017).

The smart QR code web application architecture comprises of two main components namely:

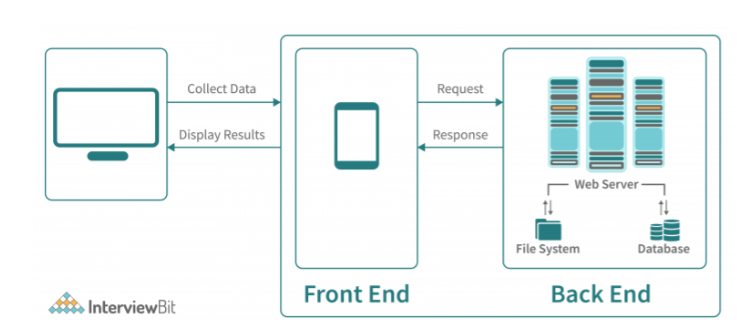
* The web browser
* The web server

The web browser serves as the interface through which the system communicates with the application. It interacts with users, collects input, manages display logic, and controls user interactions with the program. As can be seen in the fig 3.0 above, it acts as a middleman between all of the system's processes and its users. This is regarded as the front end of the application.

The web server, also called the backend or server-side component, is one of the most important parts of the web architecture. It manages all operations for the program, processes user requests, and controls the business logic. It can handle requests from multiple clients, such as web browsers or mobile apps. The server is responsible for receiving requests, processing them and returning the appropriate response.

For example, the smart QR code scanner, uses Firebase as its web server, Firebase can be used to handle several key components of the web architecture, including:

* Firebase can be used to create a web server that can handle and manage requests from a variety of clients. This means that the QR code scanner can use Firebase to receive and process requests from the frontend, such as the web browser, and provide the appropriate data in response.
* Hosting and CDN: Firebase also provides hosting and CDN service, which means the QR code scanner web application can be deployed and served to users from Firebase servers.



## Fig. 3.1 Web Architecture

* **The database**

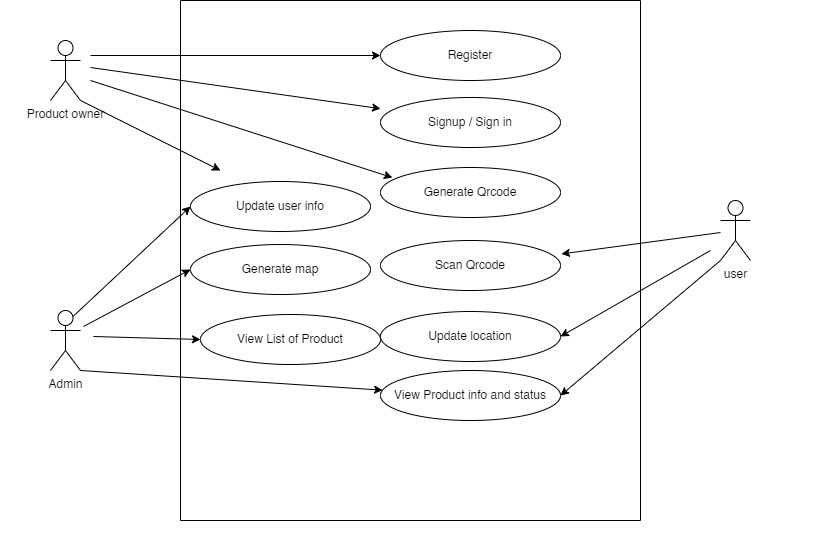
The data needed by the program is provided by the database server, which is responsible for managing and maintaining all data related tasks. The database server stores and retrieves data from a database, which is a structured collection of data, typically stored in a non-relational format. Database servers are responsible for maintaining the integrity and consistency of the data, as well as providing efficient access to the data.

In a multi-tiered design, the database server may also handle business logic using stored procedures. Stored procedures are pre-written pieces of code that are stored in the database and can be executed by the server. In the smart QR code scanner application, the database server can be responsible for storing and retrieving the data related to the QR codes, such as the scanned code, the date and time of the scan and the user who scanned it. Additionally, the database server can use stored procedures to validate the QR code before storing it or to calculate statistics related to the scans. Overall, the database server is a critical component of the web architecture that ensures the efficient storage, retrieval and manipulation of data, and enables the smooth functioning of the web application.

Firebase is useful for the QR code scanner by providing a reliable and scalable web server, real-time database, authentication, user management, and hosting services. This can help to simplify the development process and minimize the complexity of the application, allowing developers to focus on building the core functionality of the QR code scanner.

# 3.2.2 UML diagram of the smart QR code tracking system

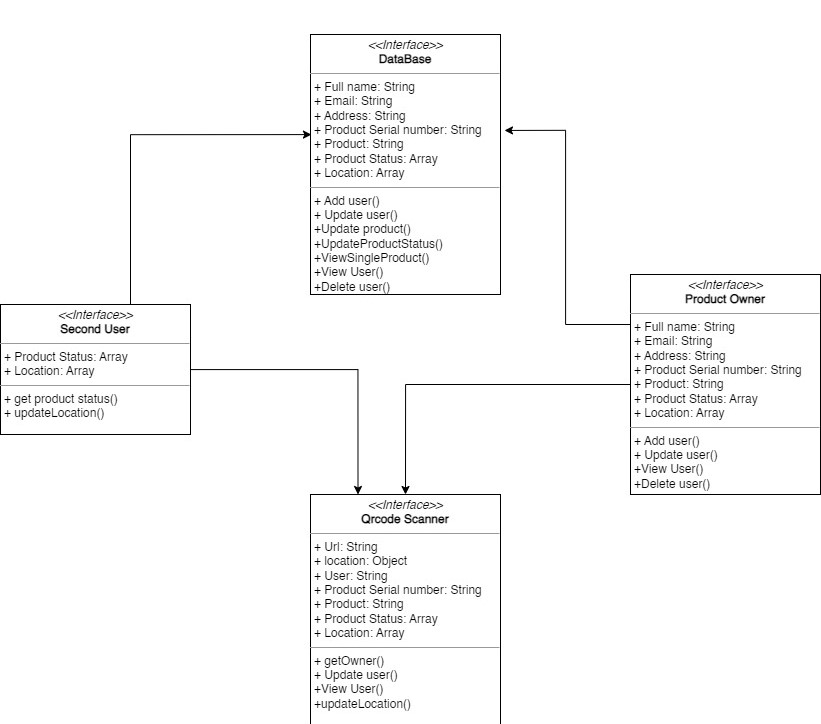
# 3.2.2.1 Use case Diagram of the smart QR code tracking system

The diagram below shows a use case diagram that consist of three actors of the system

## Fig 3.2 Use case diagram for the smart QR code tracking system

The use case diagram depicts three main actors: the product owner, the user, and the administrator. The product owner is responsible for creating a QR code during product registration, which contains a link to the product details page. The user scans the QR code to access the product details. The administrator is responsible for managing the QR codes and tracking data. The product owner can view relevant information such as location history associated with the scanned QR code. Meanwhile, the administrator has the authority to add or remove QR codes, and view or export tracking data. This smart QR code tracking system allows for efficient tracking and management of products, providing useful information to both the product owner and administrator

# 3.2.2.2 Class Diagram of the smart QR code tracking system



## Fig.3.3 The class diagram of the smart Qrcode tracking system

the class diagram shows the interactions between the actors in the smart QR code tracking system, including how the product owner registers the product and generates a QR code, how the user scans the QR code to view the product details, and how the database stores and retrieves the product information.

* The product owner (Student): This actor is responsible for registering the product and generating a QR code that carries a link to the product details. In the class diagram, the product owner is represented by the class "ProductOwner" which has two methods: "registerProduct" and "generateQRCodeLink". The "registerProduct" method takes in the product details and saves it to the database. The "generateQRCodeLink" method generates a unique QR code link for the product that can be printed on the product.
* The user: This actor scans the QR code to view the product details. In the class diagram, the user is represented by the class "User" which has one method: "scanQRCode". The "scanQRCode" method takes in the QR code and retrieves the product details from the database.
* The database: This actor stores all the input leaves and retrieves data when requested by the product owner or user. In the class diagram, the database is represented by the class "Database" which has two methods: "saveProductDetails" and "getProductDetails". The "saveProductDetails" method takes in the product details and saves it to the database. The "getProductDetails" method takes in the QR code and retrieves the product details from the database.

# 3.2.2.3 Activity diagram of the smart QR code tracking system

The activity diagram illustrates the flow of actions and events in the Smart QR Code Tracking System, highlighting the interactions between the actors (Product Owner, User) and the system (QR code generator, database).

## Fig. 3.4 Activity diagram of the smart QRcode Tracking Technology

# 3.3 SYSTEM METHODOLOGY

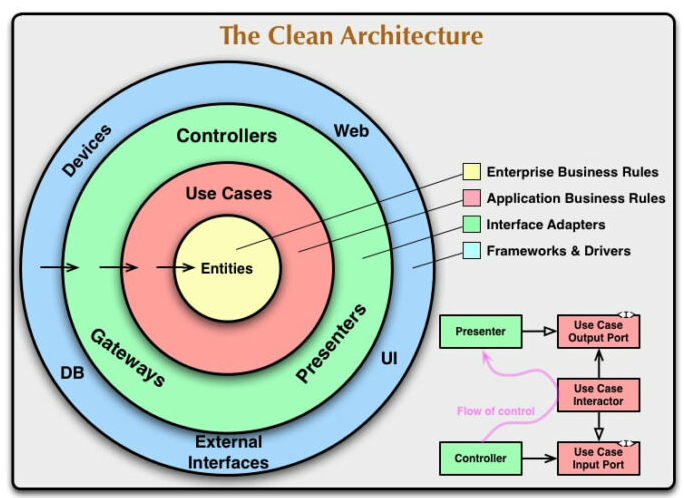
This project was developed using two software methodologies, one for the overall product production and the other for the system design. The two methodology are listed below;

* The Agile development model
* The CLEAN architecture model

# 3.3.1 The CLEAN Architecture Model

Clean Architecture is a type of layered architecture, where the central layer is the domain (entities) layer, surrounded by the application layer (use cases). The outermost layer consists of ports and adapters, which serve as intermediaries between the application and external systems, such as the web, database, and user interface, through the use of controllers, repositories, and presenters.

This architecture is focused on the domain, putting the domain model at the center of the application. The domain model encompasses both behavior and data, but does not specify how it interacts with the database. The persistence and presentation of the domain model are considered to be secondary details, located at the periphery of the architecture. (Ostrenko, 2021). By utilizing Clean Architecture, you can create applications with minimal coupling and that are insulated from technical implementation details such as databases and frameworks. This results in applications that are easy to maintain and adapt to change, and are also highly testable. (Allies, 2021)



## Fig. 3.5 Clean architecture figure

The CLEAN architecture model is used in structuring our React app project folders, a ReactJs folder structure that makes use the CLEAN architecture may have the structure as shown below.

# 3.3.2 The Agile Development Methodology

Agile development methodology is a flexible, iterative approach to software development that values customer collaboration, adaptive planning, and delivering working software frequently. It prioritizes rapid, iterative prototyping and delivery, and encourages active collaboration between developers, customers, and stakeholders. In the development of the project the agile methodology principle of continous iteration was used factoring the timeline for which the project was to be planned to be implemented.

The Agile development methodology can be highly beneficial for the development of a smart QR code tracking system. This methodology emphasizes the importance of customer collaboration, flexible planning, and delivering working software frequently, which are all critical components of a successful tracking system.

The use of sprints and user stories in Agile methodology can help to ensure that the development of the QR code tracking system is focused and well-organized. The team can plan and develop specific features within each sprint, and user stories can help to define the requirements and goals of the system from the customer's perspective.

The focus on continuous improvement in Agile methodology can help to ensure that the QR code tracking system is constantly evolving and improving based on customer feedback and changing requirements. This can be particularly important in a rapidly changing environment where the requirements of the tracking system may change frequently.

The emphasis on working software in Agile methodology is also particularly relevant to the development of a QR code tracking system. By delivering working software as soon as possible, the customer and stakeholders can provide valuable feedback and test the system early in the development process. This can help to identify any issues and improve the quality of the final product.

## Fig. 3.6 The Agile development methodology

Finally, the collaborative approach of Agile methodology can help to ensure that the QR code tracking system is developed with the needs of the customer and stakeholders in mind. This can help to ensure that the system meets the requirements of the customer and is well-suited for the environment in which it will be used. the Agile development methodology can provide a flexible and customer-focused approach to the development of a smart QR code tracking system, helping to ensure that the system is well-organized, constantly evolving, and meets the needs of the customer and stakeholders.

# 3.4 tools and Libraries Used

* React Js
* Firebase auth library
* React Qrcode Generator library
* React Geolocation library
* Formik library
* Firebase Firestore

**React Js**

ReactJS is a JavaScript library for building user interfaces. React is based on the concept of components, which are self-contained, reusable pieces of UI that manage their own state and render their own output. ReactJS was used for the implementation of the QRcode smart tracking system was used to build the user interface for displaying tracking information, such as the location and status of assets, in a clear and intuitive way. React components can be used to display this information in charts, tables, or other types of visualizations, making it easy for users to understand and interact with the tracking data.

**Firebase authentication Library**

Firebase Auth is a library from Firebase that provides authentication and authorization services for applications. It offers an all-in-one solution for managing user authentication and authorization by providing pre-constructed tools and services that can be integrated seamlessly into applications. The authentication methods offered by Firebase Auth include email/password, phone number, as well as popular third-party identity providers like Google, Facebook, and Apple. For a smart QR code tracking system, Firebase Auth can play a crucial role in ensuring the security of the tracking information by authenticating the users who need to access it. The email and password authentication feature of Firebase Auth can be used for user registration and login in the application, making it a convenient and reliable option for securing user access.

**React Qrcode Generator library**

React QR Code Generator is a library for generating QR codes in React applications. It provides an easy-to-use API for creating and displaying QR codes within a React project. The library allows developers to quickly and efficiently generate QR codes for various purposes, such as for encoding contact information, URLs, and other types of data. One of the key advantages of using React QR Code Generator is that it is designed specifically for React projects, making it a well-integrated and seamless solution for generating QR codes in React apps. Additionally, the library is highly customizable, allowing developers to specify the size, color, and error correction level of the QR codes generated.

In the context of a smart QR code tracking system, the React QR Code Generator library can be used to generate unique QR codes for each tracking item. The QR codes can be displayed in the user interface and scanned by the system to track the location and status of the items. By using the React QR Code Generator library, the QR codes generated are optimized for use in the React-based tracking system, providing a seamless and efficient solution for tracking items.

**React Geolocation library**

The React Geolocation library is a library for accessing the device's geolocation data in React applications. It provides an easy-to-use API for accessing the device's current location, which can be useful for various purposes, such as for tracking the location of users or items. In the context of a smart QR code tracking system, the React Geolocation library can be used to track the location of the items being tracked by the system. By using the library, the system can access the location data from the device and use it to update the location of the items in real-time.

This library can also be used to determine the location of the user who is scanning the QR code. The location data can then be used to validate the authenticity of the scan and ensure that the tracking information is accurate and up-to-date. By utilizing the React Geolocation library, the smart QR code tracking system can provide a more robust and reliable solution for tracking items and ensuring that the tracking information is accurate and up-to-date.

**Formik library**

Formik is a popular library in React that helps simplify and streamline the process of handling forms in applications. It provides a comprehensive set of tools for managing form state, validating user input, and submitting data to a server. With Formik, developers can easily create complex forms with multiple fields and validate user input in real-time.

Formik provides a number of helpful features that make it easier to work with forms. For example, it automatically keeps track of the form's state, so developers don't need to manually manage the state of each field. It also integrates well with other libraries and frameworks, such as Yup, which is a popular library for validating user input. Additionally, Formik provides a simple API for submitting form data to a server, which can greatly simplify the process of working with forms in React.

In the context of a smart QR code tracking system, Formik can be used to create forms for collecting information from users, such as information about the items being tracked or the location of the item. By using Formik, the system can ensure that the user input is validated in real-time and that the information being collected is accurate and complete. Additionally, Formik can be used to submit the information to the server for storage and processing, making it easier to manage and track the information over time.

**Firebase Firestore**

Firebase Firestore is a NoSQL cloud-based document database provided by Google as a part of the Firebase platform. It is designed to store and manage large amounts of data and is highly scalable and flexible. Firestore stores data in documents that are organized into collections, and provides a powerful querying system to retrieve data from these collections.

One of the key benefits of Firestore is its ability to synchronize data in real-time between the client

and server. This means that any changes made to the data on the client side are automatically updated on the server side, and vice versa. This feature is particularly useful in applications where multiple users may be accessing the same data simultaneously, such as in a smart QR code tracking system.

In a smart QR code tracking system, Firestore can be used to store and manage the data associated with each QR code, such as the item being tracked, its location, and other relevant information. By using Firestore, the system can ensure that the data is stored securely and is accessible from anywhere at any time. Additionally, the real-time synchronization feature of Firestore can be used to ensure that all users of the system have access to the most up-to-date information at all times.

Firestore also provides a range of other features that make it useful for developing a smart QR code tracking system. For example, it supports offline data persistence, which means that data can be stored locally on the client device and synced with the server when an internet connection is available. This can be particularly useful in scenarios where the system is used in locations with limited internet connectivity.

Furthermore, Firestore provides powerful querying capabilities that can be used to filter and sort data, and to perform complex queries. This can be useful in a smart QR code tracking system for generating reports, tracking trends, and analyzing data to make informed decisions. Overall, Firestore is a powerful and flexible database solution that can be used to build robust and scalable smart QR code tracking systems.

# CHAPTER FOUR

# 4.0 IMPLEMENTATION AND RESULT

# 4.1 INTRODUCTION

This research is built on the aim and objectives stated in chapter one of this paper which is, to develop a system using QR code technology that will allow products that are vulnerable to theft, like laptops, mobile phones, electronic devices, and other hand-held gadgets, to be smartly tracked and reflect the condition of the item or product as a means of security against such kinds of theft. The process of creating the system will be explained in this section, including the steps involved in generating a tracking tag in the form of a QR code. The section will also cover how the tracking tag is used for tracking a product, the technologies employed in the system, and the user experience.

# 4.1.1 THE MINIMUM HARDWARE REQUIREMENT OF THE SYSTEM

The minimum requirement required to create a protype of the smart QR code system is listed below

1. **A database server**: The database server used in the implemtation of this project is a NoSQL database, which is the firebase firestore.
2. **A backend server**: This is responsible for handling requests from the client (mobile app or web application), processing data, and interfacing with the database in the case of this project it is the firebase server under the firebase base as a service tier.
3. **A client-side application**: This is a web application that interacts with the backend server and displays the tracking data to the end-user.
4. **QR code scanning functionality**: This can be implemented using a third-party library or an SDK.
5. **Geolocation functionality**: This can be implemented using a geolocation library or an SDK.
6. **User authentication functionality**: This can be implemented using a user authentication library or an SDK, such as Firebase Auth.

# 4.2 APPROACH

The approach taken to develop the smart QR code tracking system is the web based which would require a camera (either built-in to a mobile device or connected to a computer), as well as an internet connection (either via cellular data or Wi-Fi). The web-based approach would also require a device with a web browser.

The system is built as a web application that can be accessed via a browser on a mobile device or desktop computer. Users would be able to scan QR codes using their device's camera or by uploading an image of the code, and could track their items using the web app's interface. he web app approach has several advantages, including the fact that it is accessible from any device with an internet connection, including desktops, laptops, tablets, and smartphones. It also allows for easier updates and maintenance, as changes can be made to the system without requiring users to download and install new software.

Taking this approach into consideration, the system was built as follows;

1. **The development of a website:** The website through which users interact with the smart QRcode tracking system (Front-end) is built using ReactJs.
2. **The Backend application:** This is responsible for handling user requests, processing data, and providing responses. The backend can be implemented using a server-side language in the case of this project, Firebase service was used for its implementation all interation with the backend application and server was through firebase api calls implemented using Javascript programming language.

One of the key considerations when using the web app approach is ensuring that the application is responsive and optimized for different devices and screen sizes. This involves using responsive design techniques and ensuring that the user interface is designed to be intuitive and user-friendly. It's also important to consider security concerns, such as implementing proper authentication and access control measures to protect user data and prevent unauthorized access.

# 4.2.1 FIREBASE CONFIGURATION TO ENABLE API CALLS TO AND FROM THE FIREBASE SERVER

The Firebase configuration is important to import to a React app to enable communication with the Firebase server. This is because the Firebase configuration contains important information needed to establish a connection between the app and the Firebase server.

The configuration information includes the Firebase project credentials, such as the project ID, API key, and other authentication details that are necessary to authenticate the app with the Firebase server. Without this information, the app would not be able to interact with the Firebase server. By importing the Firebase configuration into the React app, the app is able to use the Firebase SDK and its various services, such as Firebase Authentication, Firestore, and Cloud Functions, to add functionality to the app. This makes it possible to leverage Firebase's powerful tools and services to create high-quality, scalable apps quickly and efficiently.

// Import the functions you need from the SDKs you need

import { initializeApp } from "firebase/app";

import { getAuth } from "firebase/auth";

import { getFirestore, collection } from 'firebase/firestore'

// TODO: Add SDKs for Firebase products that you want to use

// https://firebase.google.com/docs/web/setup#available-libraries

// Your web app's Firebase configuration

const firebaseConfig = {

apiKey: "AIzaSyAJVTBuCutDf3X6\_AtwZvpa4mJLvbtFxT8",

authDomain: "qrcode-9a2ac.firebaseapp.com",

projectId: "qrcode-9a2ac",

storageBucket: "qrcode-9a2ac.appspot.com",

messagingSenderId: "859403005026",

appId: "1:859403005026:web:29494af7278b98e6e6f53b",

};

// Initialize Firebase

const app = initializeApp(firebaseConfig);

// Initialize Firebase Authentication and get a reference to the service

export const auth = getAuth(app);

export const db = getFirestore(app)

// initialize collectionRef

export const CollectionRef = collection(db, 'projectList')

# 4.2.2 THE CODE IMPLEMETATION TO GENERATE QRCODE

import React, { useState } from "react";

import { QRCodeCanvas } from "qrcode.react";

import QrScanner from "qr-scanner";

import GeoLocation from "../../infrastructure/GeoLocation";

const Qrcode = () => {

const [inputValue, setInputValue] = useState("");

const [result, setResult] = useState("");

const downloadQRcode = (e) => {

e.preventDefault();

let canvas = document.querySelector("canvas");

let image = canvas.toDataURL( "image/png");

let anchor = document.createElement("a");

anchor.href = image;

anchor.download = `qr-code.png`;

document.body.appendChild(anchor);

anchor.click();

document.body.removeChild(anchor);

setInputValue("");

};

const readCode = (e) => {

const file = e.target.files[0];

if (!file) {

return;

}

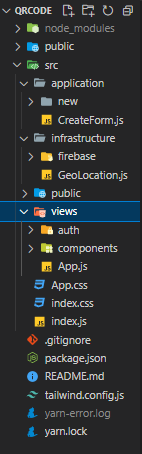
QrScanner.scanImage(file, {

returnDetailedScanResult: true,

}) .then((result) => setResult(result.data)).catch((e) => console.log(e));};

# 4.2.3 IMPLEMENTATION OF THE CLEAN ARCHITECTURE ON FOLDER STRUCTURE OF THE APPLICATION

As discussed in chapter 3, the clean architecture is an architectural pattern for building software systems that emphasizes separation of concerns and modularity. It aims to create software that is easy to maintain, test and develop. The folder structure used in the project is as shown below;



## Fig 4.1 Clean Architecture Folder structure

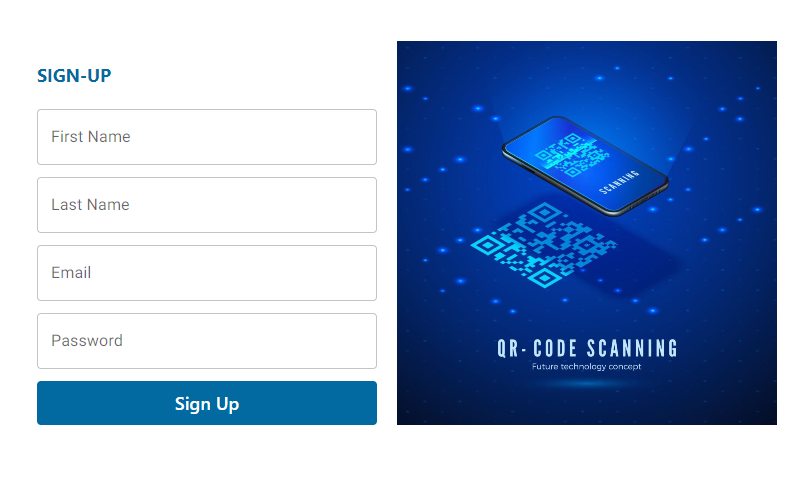
# 4.3 APPLICATION USER INTERFACE

# 4.3.1 CARD TO BE SCANNED



## Fig 4.2 IDcard that carries QRcode

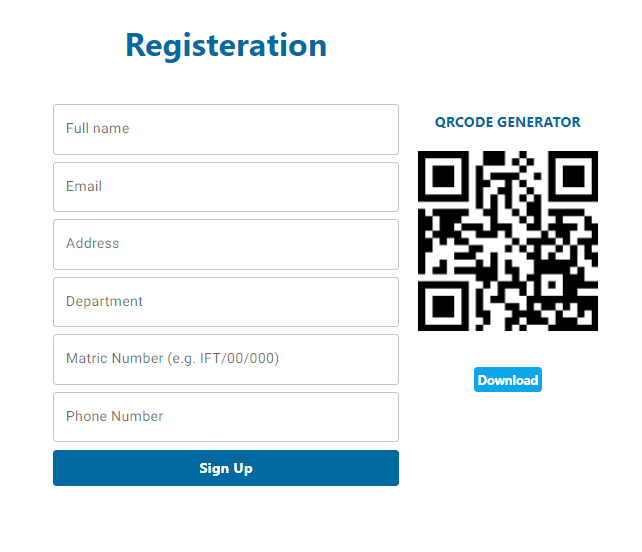
# 4.3.1 THE SIGNUP PAGE

****

## Fig. 4.3 The Sign up page

The system will require an individual to signup so that their details can be in the database

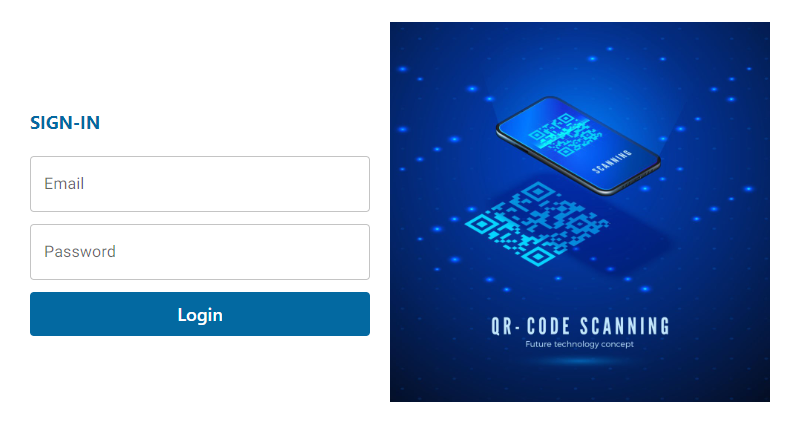
# 4.3.2 THE REGISTRATION PAGE

****

## Fig. 4.4 The Registeration Page

The user will register on the application so that QR code will carry the detail that is reflected on the QR code, once the QR code is scanned, there it will redirect the user to the page that shows the details of the registered user

# 4.3.3 THE SIGNIN PAGE



## Fig. 4.5 The Signin page

# 4.3.3 USER INFO AFTER CARD IS SCANNED

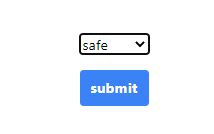
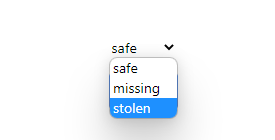
# 

## Fig. 4.6 Users Info when QRcode is scanned

A user who scans the QR code will be redirected to a web url that would display the info of the user as well as the state of the users card, the location of the scanned user will be updated in the database as shown below

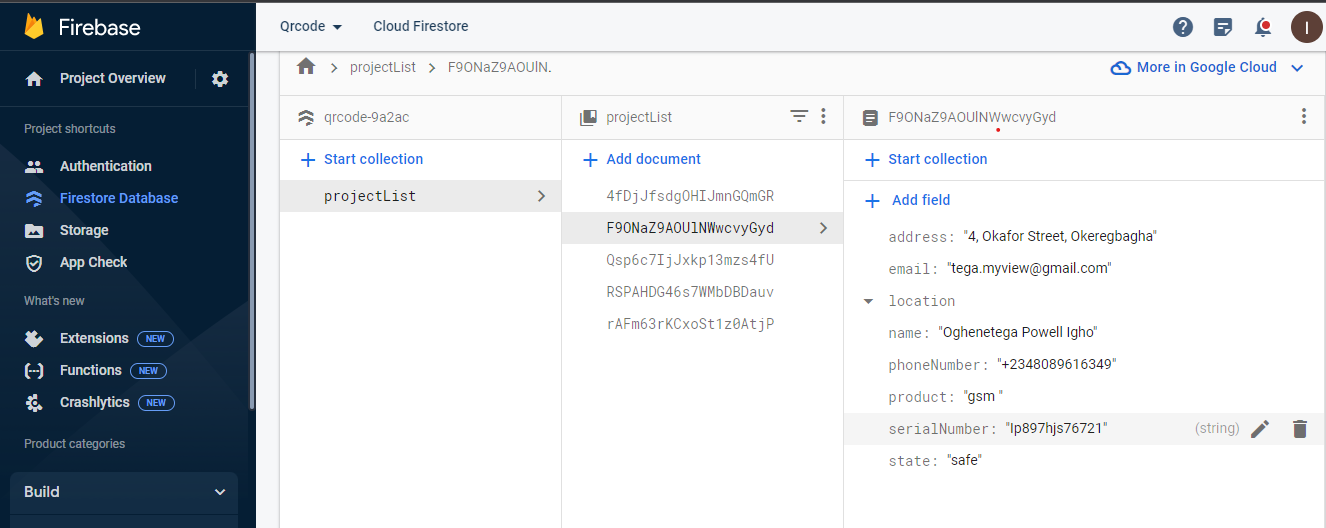
# 4.3.3 UPDATE CARD STATE INFORMATION

Only registered users has the authority to update the sate of the card from either missing, to stolen or to safe. When ever an arbitrary user scans the QR code in the card they see the information details of the card as well as the state of the card as shown in fig 4.5.



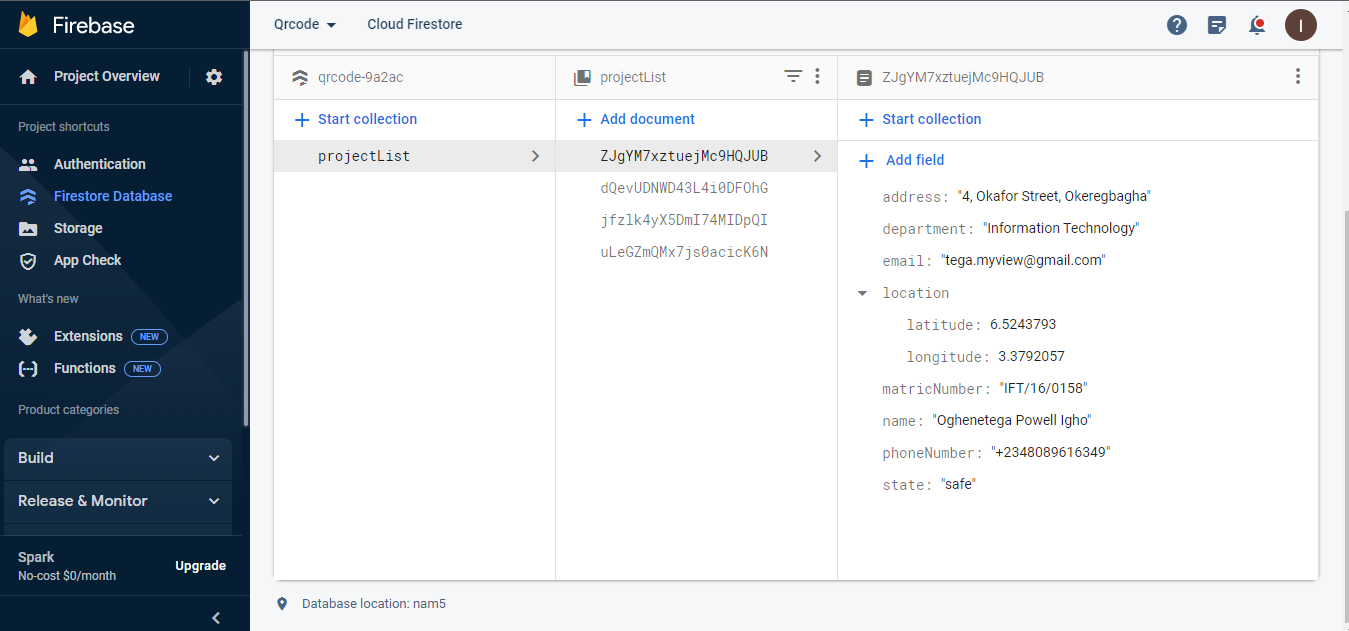
## Fig 4.7. How the state of the card is changed by the user

# 4.3.3 DATABASE RECORD BEFORE SCAN



## Fig. 4.8. Databaase record of registered user before QRcode is scanned

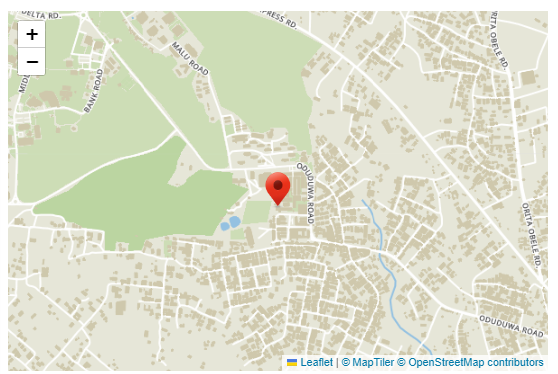
# 4.3.3 DATABASE RECORD AFTER SCAN



## Fig. 4.9. Databaase record of registered user after QRcode is scanned

After the Qr code is scanned by another user, the location is updated in the database the user can now get the location of where the card was last scanned to keep track of the card. This will enable the user to constantly track the location of the card every time it is scanned

# 4.3.3 MAP VIEW OF LOCATION STORED IN THE DATABASE

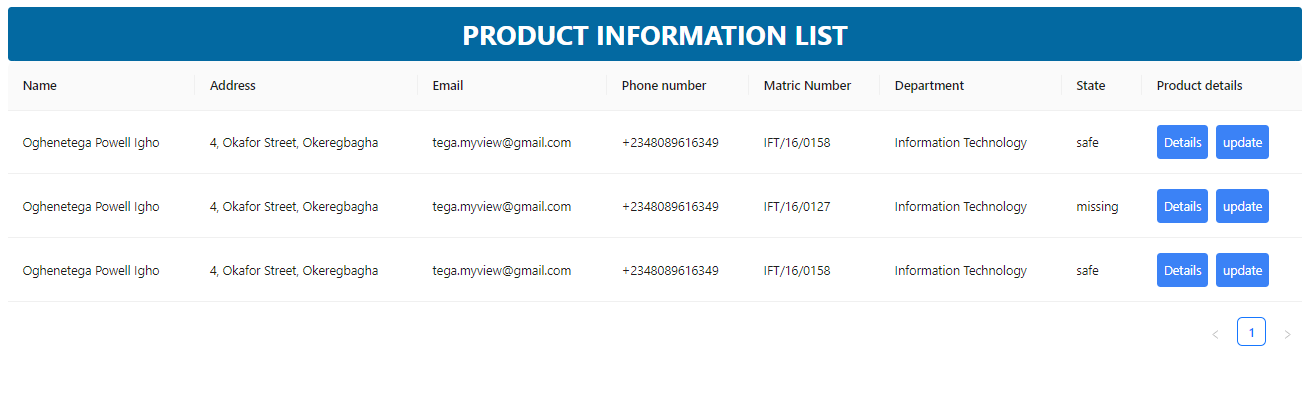
****

## Fig. 5.0. Map view of the location of the user that scanned the Qrcode

The application has the functionality to retrieve location data from a database. The database store location data in a format in latitude and longitude format not easily readable to humans, such as coordinates or latitude and longitude values.

To make the location data more human-readable and understandable, the application uses a map library. Using the map library, the application generates a visual map that displays the location of the misplaced or stolen card. This map shows a geographical area, such as a city or a specific location on a street. The registered user of the application can then use this visual map to ascertain the location of the card. This is be useful for retrieving a lost or stolen card, as the user can see where the card is located and navigate to that location.

# 4.3.3 BUSINESS INVOLVEMENT IN USER TRACKING

****

## Fig. 5.1. Record of all registered users

In the application, there is an admin who represents the business. This admin has the authority to access all the records of registered users. These records likely include information about each user, such as their name, contact information, matriculation number and department of the user. Additionally, the records includes information about the state of each user's card. The state of the card refers to whether it is safe, missing, or stolen. This information is updated by the user themselves. For example, if a user misplaces their card, they can update their card's state to "missing" in the application.

The admin can then view the state of each card in the records and determine the status of the card. This can be useful for the admin to keep track of the status of each card and take action if necessary. For example, if a large number of cards are reported as stolen, the admin may need to investigate and take measures to prevent future thefts.

Overall, the ability for the admin to view all the records and the state of each card can provide better management and oversight of the application and the business it represents. The admin can also view the location of the card anytime it is scanned by an arbitrary user in order to get the location of the card as shown below.

****

## Fig. 5.2. Registered user information and the card current location

In the application, both the admin and the registered user have the ability to click on the details as shown in fig 5.0. When they do so, they will be able to view more information about the card and its current status. This can be useful for identifying the owner of the card or for determining what steps need to be taken to retrieve it.

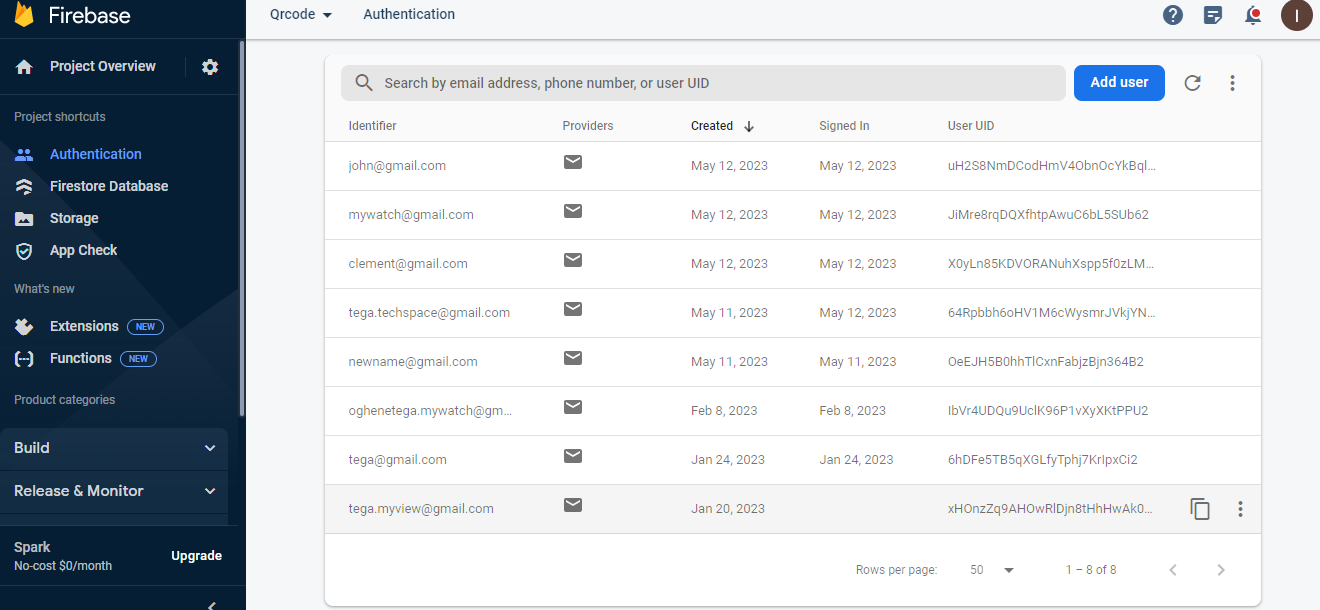
By viewing the last scanned location of the card, the admin can get a better understanding of where the card might be located. This can be useful for taking action to retrieve the card, such as notifying close by authorities to that location to search for it.

Overall, the ability to view details about the card and its last scanned location can be extremely helpful in retrieving lost or stolen cards. It provides the admin and the registered user with valuable information that they can use to take action and recover the card.

# 4.3 EVALUATION

The objective of this project as stated in chapter 1 is to develop a web based tracking system with the use of QR code that is readily accessible to individuals and with involvement of the manufacturer. The application has been able to achieve its objectives by meeting objective requirement as listed below

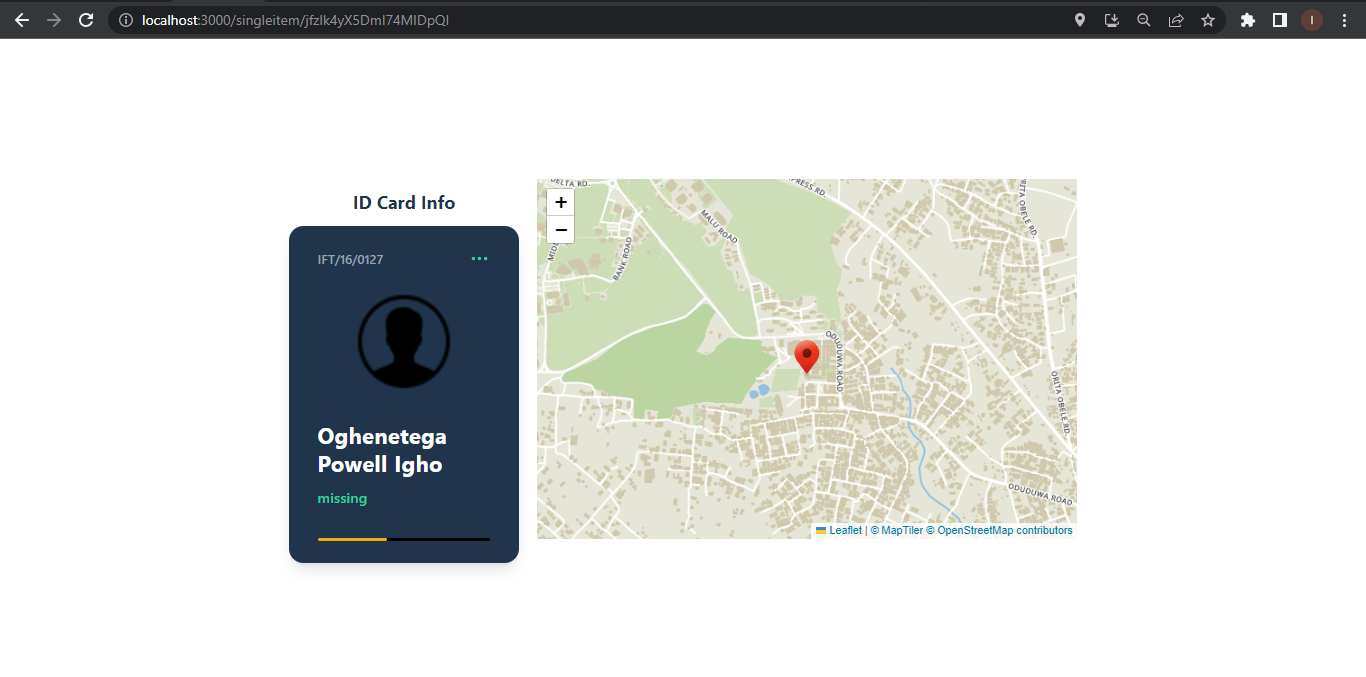
**Identifying users with an ID card:** The application provided a means where users signup and register in order to generate a unique QR code that contains their details and state of the ID card. The users must sign in with a unique email. This could be implemented in institutions where students have to register to get ID cards and will have a means of tracking the card. Below is how the database stores signed up user



## Fig 5.3. Database record of signed in users

**Accessibility:** The QR code is easily accessible by anybody without login or sign up, as soon as the QR code is scanned, its redirects the users scanning the QR code to a web page that displays the information of the users as well as the state of the card. Also with the users’ consent, the application retrieves the location of the user scanning the QR code.

**Data Accuracy:** The application through several test has been able to get the accurate location of where the QR code was scanned by any arbitrary user. Fig show an accurate representation of the location between Oduduwa road and malu road where the qrcode was scanned. This also based on the coverage of that area by the mapping library used in the application which could be a limitation of the application.

****

## Fig 5.3. Map showing accurate location between Malu road and Oduduwa road FUTA

**Manufacturers’ Involvement:** The manufacturer (The school that issues the card) has an admin that can view all the registered users and well as the state of the card and also, have access to the location information of the card. The admin can then view the state of each card in the records and determine the status of the card. This can be useful for the admin to keep track of the status of each card and take action if necessary.

**Cost Efficiency:** There is no cost incurred in generating the QR code and scanning the Code. All that is needed is a smartphone that has a camera. Most smartphone camera has an integrated QR code scanner that can be used to scan the QR code of the card.

### TABLE 1.0 METRICS USED IN EVALUATION APPLICATION OBJECTIVE

|  |  |  |  |
| --- | --- | --- | --- |
| **METRICS** | **LOW** | **MEDIUM** | **HIGH** |
| User Accessibility |  |  |  |
| Data Accuracy |  |  |  |
| Response Time |  |  |  |
| Manufacturers’ Involvement |  |  |  |
| Cost Efficiency |  |  |  |
| Users Identification |  |  |  |

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATION

# 5.0 CONCLUSION

The smart QR code tracking system offers a reliable and efficient way to track and manage valuable products such as laptops, mobile phones, and other electronic devices. The system allows product owners to generate a unique QR code for each product, which can be scanned by users to access product information and track its location. This not only helps to prevent theft of valuable products, but also provides a seamless way for users to access information about the product.

Furthermore, the smart QR code tracking system can bridge the gap between business to business and business to consumer structure of ecommerce. By providing a service that connects the user to the manufacturer, the system can facilitate communication and transactions between the two parties. This can help to improve customer satisfaction and loyalty, as users can easily access information about the product and the manufacturer can better understand customer needs and preferences.

Overall, the implementation of a smart QR code tracking system can provide a range of benefits for both product owners and users, including improved security, efficiency, and communication.

# 5.1 RECOMMENDATIONS

In order to improve the effectiveness and efficiency of the QR code smart tracking system, certain limitations and challenges must be addressed. One major limitation of the system is its access to users' data and location information. To protect the privacy of users and prevent unauthorized access, it is recommended that the system be isolated from the rest of the internet through means such as a virtual private network (VPN).

Another area for improvement is in the interaction and service provision between manufacturers and users. While the system aims to bridge the gap between consumers and manufacturers, it does not currently have structured terms and conditions outlining how tracking information will be provided and under what conditions such services will be offered. Establishing clear guidelines will enhance the user experience and provide a better understanding of how the system works.

The scope of this research is limited to the method of generating QR code for individual items, so they can be tracked. This research good be extended to include governmental parastatals in creating laws that could help create laws that guide users in purchasing an item, or purchase of used items using the QR code to validate the owner and state of device before purchase.

Overall, these recommendations can help to make the system more effective and efficient in providing a reliable and secure way to track and manage valuable products. Future systems should take note of these limitations and challenges, and work to address them in order to provide a better user experience and ensure privacy and security.

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# APPENDIX I

**QRCODE COMPONENT CODE SNIPPET**

import React, { useState } from "react";

import { QRCodeCanvas } from "qrcode.react";

import QrScanner from "qr-scanner";

import GeoLocation from "../../infrastructure/GeoLocation";

const Qrcode = ({getId}) => {

console.log(getId)

const urlall = window.location.href

const url = `${urlall.slice(0,-9)}/${getId}`

console.log(url)

const [inputValue, setInputValue] =

useState("");

const [result, setResult] =

useState("");

const downloadQRcode = (e) => {

e.preventDefault();

let canvas =

document.querySelector("canvas");

let image = canvas.toDataURL(

"image/png"

);

let anchor =

document.createElement("a");

anchor.href = image;

anchor.download = `qr-code.png`;

document.body.appendChild(anchor);

anchor.click();

document.body.removeChild(anchor);

setInputValue("");

};

const readCode = (e) => {

const file = e.target.files[0];

if (!file) {

return;

}

QrScanner.scanImage(file, {

returnDetailedScanResult: true,

})

.then((result) =>

setResult(result.data)

)

.catch((e) => console.log(e));

};

return (

<div>

<p className='text-center text-sky-700 font-bold text-small px-10 pt-10 mt-24'>

QRCODE GENERATOR

</p>

<div className='my-5 flex justify-center'>

<QRCodeCanvas

size={200}

value={url}

viewBox={`0 0 256 256`}

id='QRCode'

/>

</div>

<div className='my-10 justify-center flex'>

<form onSubmit={downloadQRcode}>

<button

type='submit'

value='Download'

className='bg-sky-500 text-sm font-bold text-white rounded px-1 hover:bg-sky-700 py-1'>

Download

</button>

</form>

</div>

</div>

);

};

export default Qrcode;

**MAPLEAF CODE SNIPPET**

import React, { useRef, useState, useEffect } from 'react'

import { MapContainer as LeafletMap, Marker, TileLayer} from 'react-leaflet'

import MapConfig from './MapConfig';

import "leaflet/dist/leaflet.css"

import L from 'leaflet';

const Maps=(props)=>{

console.log(props.lat, props.lng)

let lng = props.lng

let lat = props.lat

const loc = {lat, lng };

const[center, setCenter] = useState(loc);

const ZOOM\_LEVEL = 9

const mapRef = useRef()

const markerIcon = new L.Icon({

iconUrl: require("../../public/location.png"),

iconSize: [35, 45],

})

return (

<div className='leaflet-container'>

<LeafletMap

className='flex justify-center'

center={center}

zoom={ZOOM\_LEVEL}

ref={mapRef}>

<TileLayer

url={MapConfig.maptiler.url}

attribution={

MapConfig.maptiler

.attribution

}

/>

<Marker

position={[

lat,

lng,

]}

icon={markerIcon}

/>

</LeafletMap>

</div>

);

}

export default Maps;

**PERMISSIONS ROUTE CODE SNIPPET**

import React, { useContext } from 'react';

import { Navigate, Outlet } from 'react-router-dom';

import { useAuthState } from './firebaseConfig';

const PrivateRoutes = () => {

const { isAuthenticated } = useAuthState();

return isAuthenticated ? <Outlet /> : <Navigate to='/signin' replace />;

};

export default PrivateRoutes;

**APPLICATION ROUTE CODE SNIPPET**

import React from 'react';

import { Routes, Route } from 'react-router-dom';

import Qrcode from './components/Qrcode';

import Registeration from './components/Registeration';

import SignIn from './auth/SignIn';

import SignUp from './auth/SignUp';

import ProductInfoList from './components/ProductInfoList';

import UpdateProduct from './components/UpdateProduct';

import SingleItem from './components/SingleItem';

import SingleItemUser from './components/SingleItemUser';

import { AuthContextProvider, useAuthState } from '../infrastructure/firebase/firebaseConfig';

import PrivateRoutes from '../infrastructure/firebase/privateRoutes';

import Profile from './components/Profile';

function App() {

return (

<AuthContextProvider>

<div>

<Routes>

<Route path='/' element={<profile />} />

<Route path='/signin' element={<SignIn />} />

<Route path='/signup' element={<SignUp />} />

<Route path='/product-list' element={<ProductInfoList />} />

<Route element={<PrivateRoutes />}>

<Route path='/profile' element={<Profile/>}/>

<Route path='/register' element={<Registeration />} />

<Route path='/update/:id' element={<UpdateProduct />} />

<Route path='/singleitem/:id' element={<SingleItem />} />

</Route>

<Route path='/:id' element={<SingleItemUser />} />

</Routes>

</div>

</AuthContextProvider>

);

}

export default App;

**CARD INFORMATION AND MAP DISPLAY**

import React, { useState, useEffect, Fragment } from 'react';

import { db } from '../../infrastructure/firebase/firebaseConfig';

import { doc, addDoc, updateDoc, onSnapshot, collection, setDoc } from 'firebase/firestore';

import profile from '../../public/profile.png';

import { useParams } from 'react-router-dom';

const SingleItemUser = () => {

const { id } = useParams();

console.log(id);

const [isLoading, setLoading] = useState(false);

const [name, setName] = useState('');

const [matricNum, setMatricNum] = useState('');

const [product, setProduct] = useState('');

const [state, setState] = useState('');

const [location, setLocation] = useState([

{

latitude: '',

longitude: '',

},

]);

const docRef = doc(db, 'projectList', id);

useEffect(() => {

onSnapshot(docRef, (doc) => {

let data = doc.data();

console.log(data);

setName(data.name);

setState(data.state);

setMatricNum(data.matricNumber);

});

}, []);

useEffect(() => {

navigator.geolocation.getCurrentPosition((position) => {

setLocation({

latitude: position.coords.latitude,

longitude: position.coords.longitude,

});

});

}, []);

const submit = () => {

updateDoc(docRef, {

location: { ...location },

})

.then((response) => {

console.log(response);

})

.catch((error) => console.log(error));

};

submit();

return (

<Fragment>

<div>

<div className=' flex flex-col font-medium items-center justify-center h-screen'>

<p className='text-center text-[#20354b] font-bold text-xl px-10 py-3 pt-10 '>

ID Card Info

</p>

<section className='w-64 mx-auto bg-[#20354b] rounded-2xl px-8 py-6 shadow-lg'>

<div className='flex items-center justify-between'>

<span className='text-gray-400 text-sm'>{matricNum}</span>

<span className='text-emerald-400'> <svgxmlns='http://www.w3.org/2000/svg'

className='h-6 w-6'

fill='none'

viewBox='0 0 24 24'

stroke='currentColor'>

<path

stroke-linecap='round'

stroke-linejoin='round'

troke-width='2'

d='M5 12h.01M12 12h.01M19 12h.01M6 12a1 1 0 11-2 0 1 1 0 012 0zm7 0a1 1 0 11-2 0 1 1 0 012 0zm7 0a1 1 0 11-2 0 1 1 0 012 0z'/>

</svg>

</span>

</div>

<div className='mt-6 w-fit mx-auto'>

<img src={profile} className='rounded-full

w-28 ' alt='profile picture' srcset='' />

/div>

<div className='mt-8 '>

<h2 className='text-white

font-bold text-2xl tracking-wide'>{name}</h2>

</div>

<p className='text-emerald-400 font-semibold mt-2.5'>{state}</p>

<div className='h-1 w-full bg-black mt-8 rounded-full'>

<div className='h-1 rounded-full w-2/5 bg-yellow-500 '></div>

</div>

</section>

</div>

</div>

</Fragment>

);

};

export default SingleItemUser;

**CARD INFORMATION TABLE COMPONENT**

import React, { useState, useEffect, Fragment } from 'react';

import { collection, getDocs, onSnapshot } from 'firebase/firestore'

import { db } from '../../infrastructure/firebase/firebaseConfig';

import Table from './DataTable';

import { useNavigate } from 'react-router-dom';

import CircularProgress from '@mui/material/CircularProgress';

const ProductInfoList =()=>{

const [isLoading, setLoading] = useState(false)

const [infoList, setInfoList] = useState([])

useEffect(()=>{

prodInfoList()

},[])

const prodInfoList = ()=>{

const productCollectionRef = collection(db, 'projectList')

onSnapshot(productCollectionRef, (snapshot)=>{

setLoading(true)

let products =[]

let docId = []

let newProduct;

snapshot.docs.forEach((doc)=>{

docId.push({id:doc.id})

products.push({...doc.data()})

return(

newProduct = docId.map((id, index) => ({...id, ...products[index]})))

})

console.log(docId)

setInfoList(newProduct)

setLoading(false)

})

}

console.log(infoList)

const idList = []

infoList.map(id=>(

idList.push(id.id)

))

console.log(idList)

return(

<Fragment>

<div className='text-center font-bold mt-5 text-white bg-sky-700 rounded mx-10 py-3 text-3xl'>PRODUCT INFORMATION LIST</div>

<div className='mx-10'>

<Table key={infoList.id} data={infoList} />

</div>

</Fragment>

)

}

export default ProductInfoList;

**USER REGISTERATION PAGE CODE SNIPPET**

import React, { Fragment, useState } from 'react'

import {Outlet} from 'react-router-dom'

import { useFormik } from 'formik';

import { TextField } from '@mui/material';

import { useNavigate } from 'react-router-dom';

// import CreateForm from '../../application/CreateForm'

import { db } from '../../infrastructure/firebase/firebaseConfig';

import CircularProgress from '@mui/material/CircularProgress';

import { addDoc, collection } from 'firebase/firestore';

import Qrcode from './Qrcode';

const Registeration =()=>{

    // const createForm = CreateForm()

    const navigate = useNavigate();

    const [getId, setId] = useState("")

    const [isLoading, setLoading] = useState(false)

    const formik = useFormik({

        initialValues:{

            name: "",

            email: "",

            address:"",

            department:"",

            matricNumber:"",

            phoneNumber:"",

            location:[],

            state:"safe"

        },

        onSubmit:async (values)=> {

            console.log(values)

            setLoading(true)

            try{

                const collectionRef = collection(db, 'projectList')

                const data = await addDoc(collectionRef, values)

                const response = data

                setId(response.id)

            }catch(error){

                console.log(error)

            }

            setLoading(false)

            navigate('/signin');

        }

    }

    )

    return (

            <Fragment>

                <div className='md:flex justify-center'>

                    <div>

                        <div className='text-center my-10 font-bold text-4xl text-sky-700'>Registeration</div>

                        <div className='flex justify-center'>

                            <form onSubmit={formik.handleSubmit}>

                                <div className='form'>

                                    <TextField

                                        id='name'

                                        value={formik.values.name}

                                        label='Full name'

                                        variant='outlined'

                                        className='w-full'

                                        onBlur={formik.handleBlur}

                                        onChange={formik.handleChange}

                                    />

                                </div>

                                <div className='form'>

                                    <TextField

                                        id='email'

                                        value={formik.values.email}

                                        label='Email'

                                        variant='outlined'

                                        className='w-full'

                                        onBlur={formik.handleBlur}

                                        onChange={formik.handleChange}

                                    />

                                </div>

                                <div className='form'>

                                    <TextField

                                        id='address'

                                        value={formik.values.address}

                                        label='Address'

                                        variant='outlined'

                                        className='w-full'

                                        onBlur={formik.handleBlur}

                                        onChange={formik.handleChange}

                                    />

                                </div>

                                <div className='form'>

                                    <TextField

                                        id='department'

                                        value={formik.values.department}

                                        label='Department'

                                        variant='outlined'

                                        className='w-full'

                                        onBlur={formik.handleBlur}

                                        onChange={formik.handleChange}

                                    />

                                </div>

                                <div className='form'>

                                    <TextField

                                        id='matricNumber'

                                        value={formik.values.matricNumber}

                                        label='Matric Number (e.g. IFT/00/000)'

                                        variant='outlined'

                                        className='w-full'

                                        onBlur={formik.handleBlur}

                                        onChange={formik.handleChange}

                                    />

                                </div>

                                <div className='form'>

                                    <TextField

                                        id='phoneNumber'

                                        value={formik.values.phoneNumber}

                                        label='Phone Number'

                                        variant='outlined'

                                        className='w-full'

                                        onBlur={formik.handleBlur}

                                        onChange={formik.handleChange}

                                    />

                                </div>

                                <button

                                    type='submit'

                                    className='bg-sky-700 hover:bg-sky-900 w-full text-center text-white font-bold rounded py-2'>

                                    {isLoading ? <CircularProgress color='primary' size={20} /> : <p>Sign Up</p>}

                                </button>

                            </form>

                        </div>

                    </div>

                    <Qrcode getId={getId} />

                    <Outlet/>

                </div>

            </Fragment>

        );

}

export default Registeration;