MULTI FACTOR AUTHENTICATION ACCESS CONTROL FOR STUDENT AND STAFF BASED ON RFID, BARCODE AND GIS

BY

Simukali Moono Consuela

A Dissertation submitted to the University of Zambia in partial fulfilment of the requirements of the degree in Masters of Engineering in ICT Security

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DECLARATION

I, **Consuela Moono Simukali,** the undersigned, declare that this has not previously been submitted in candidature for any degree. The dissertation is the result of my own work and investigations, except where otherwise stated. Other sources are acknowledged by given explicit references. A complete list of references is appended.

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CERTIFICATE OF APPROVAL

This dissertation by **Consuela Moono Simukali** has been approved as fulfilling the requirements for the award of the degree of **Masters of Engineering in ICT Security** by the University of Zambia.

Examiner 1……………………………......……….... Signature: ………………………Date………

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ABSTRACT

University of Zambia like most Public Universities and Higher Learning Institutions in Zambia have a challenge preventing unauthorized access into their campus environment. There is no automatic identification of all who enter or exit the campus facilities. No audit trail or record is kept for visitors who enter the campus. This makes it a challenge to protect the organisations' assets such as information, personal property, staff and students. Members of Staff, Students and Visitors of the University have lost and continue to lose belongings such as laptops and cars. This study proposes an Access Control and Visitor Real Time Tracking System to improve the level of security on the campus. A baseline study was conducted to measure the level of security at the University using questionnaires that were designed based on ISO 27002 Standard for Physical and Environmental Security. The results of this baseline study show that the University's security is porous. The findings also revealed that more than ninety percent of the respondents were victims of theft or have known of a victim of theft whilst on campus. Data was collected from 200 students, 120 members of staff ten of which are from the University of Zambia's (UNZA) security office. Based on the results from the baseline study a model Access Control and Real Time Tracking system was to designed to control all who enter and exit the campus. The designed model was based on RFID, Biometrics, Barcode and GIS. The RFID, Biometrics, and Barcode Technologies are designed as an identification and authentication mechanism of people entering and exiting the campus. The study focused on developing a real time visitor tracking system using GIS and GPS Results from the real time tracking system show that a visitor's movement and geographical location was known. A record of past visits could also be reviewed. This research is expected to allow the University have control of who accesses the University premises and ensure visitors are recorded and access only facilities they are allowed to.

Keywords: *Security and Access Control, Authentication, RFID, ISO 27002, GIS*

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ACRONYMS

UNZA	University of Zambia
Wi-Fi	Wireless Fidelity
2D	Two Dimension
ISO/IEC	International Organization for Standardization/ International Electrotechnical Commission
MFA	Multifactor Authentication
ATM	Automated Teller Machine
PIN	Personal Identification Number
QR	Quick Response Code
PDF	Portable Data Files
GIS	Geographical Information System
GPS	Global Positioning System
GPRS	General Packet Radio Service
RFID	Radio Frequency Identification
EPC	Electronic Product Code
CIA	Confidentiality Integrity Availability
GSM	Global System for Mobile communication
GPRS	General Radio Packet Service
ERD	Entity Relationship Diagram
OO	Object Oriented
OOP	Object Oriented Programming
OOSD	Object Oriented Software Development
OOSDM	Object Oriented System Development Methodology

CHAPTER 1: INTRODUCTION

This chapter introduces the research study. In this chapter, the following are covered Motivation for the study, Significance of study, Problem Statement, Aim, Objectives and Research Questions. Finally, the organization of the thesis, contributions to the research study and summary of this chapter are also presented.

1.1 Background to the study

Physical access control involves the process of knowing who should be granted access, when access should be granted and why access should be granted to any environment such as a University. Physical access control systems play an important and central role in the protection of critical infrastructure and assets of any University. A University has assets such students, stuff, equipment and information that need protecting. Physical access control is a vital element in protecting and securing environments and critical infrastructure such as airports, train or bus stations, energy generation plants and military infrastructures [1]. Physical access control enhances physical security. Apart from protecting infrastructure, physical security is fundamental in protecting information systems and services. Physical security is used to protect an organization's premises, sites, facilities, building, people, information and other assets [2]. Physical security and access control is an important part of protecting the confidentiality; integrity and availability of resources, therefore it is important that security controls put in place effectively secure critical resources and infrastructure.

Most Public Universities in Zambia rely on using security guards to secure their institutions. In most cases the security systems and functions are outsourced to external contractors and security firms. In several situations these systems have not been effective considering the number of reported thefts and uncontrolled student unrest [3]. For facilities such as hostels and offices mechanical locks, steel keys and grill gates have been as a sole access control mechanism. Mechanical locks always have some vulnerabilities that have some inherent risks. Techniques such as 3D printing make it easier, more effective and cheaper to exploit mechanical locks [4].

As students and staff acquire more property, theft in campus becomes more apparent and theft techniques become more sophisticated [5]. There are several short comings in the approaches to physical access control in public institutions in Zambia. In most cases anybody can access the campus or student hostels without any form of identification or minimum set of privileges to access of resources such as lecture rooms. The other short coming is that in most cases the ability to monitor and audit staff, student or visitor access to physical resources is non-existence. In recent years, there has been significant interest from researchers and the industry into the use of security technologies [6] [7] [8]. Several security technologies have been used to control access to facilities, buildings and campus environment. Use of RFID proximity cards as a sole access control is common security practice but also has some vulnerability such as man in the middle and relay attack [4]. Latest practice of biometric controls also has shown to be lacking [9]. Each of these access control systems have advantages and disadvantages. Knowing their flaws and creating a combined multifactor access control is effective in minimizing physical security risks. Multifactor authentication requires that more than one principal of authentication is used by using a combination of validating a user with two types of authentication such as using something a user has and something you are. Multifactor authentication adds an extra layer of protection [10]. Given the threats that come with lack of appropriate physical security and access control into public Universities, a multifactor authentication access control for student and staff using RFID, biometrics has been designed and a Visitor real time tracking based on GIS has been designed and developed.

1.2 Related Work

This section surveys previous work in Access Control system and people location and tracking. Several work has been done in Access control through people identification by use of Barcode or RFID identification and Biometrics. The study also surveyed related works that achieved works through Multifactor authentication which authentication that requires more than one form or factor to authenticate. Related work in people location and movement were also surveyed.

Peter et al in [95] developed an RFID based access control security system with GSM technology to be an addition to already existing security personnel. This system mainly achieves by the use of a Radio Frequency Identification (RFID) system but lacks prevention of illegal use of card by unauthourised card user. Therefore, would not prevent security threats associated with a stolen card.

Umar et al. in [97]proposed an RFID and biometrics based security and access control system. This is the design of an RFID-based security and access control system for use in youth hostels at

Punjab University. The system combines RFID technology and biometrics to perform the required task. Although the developed system is useful for reducing threats to the safety of hostels, the response time of the system can be further improved by using dedicated processors that are dedicated to the task as is proposed in this study.

In [108] personnel location tracking is achieved through use of Near field Communication (NFC). Near Field Communication (NFC) is an automatic identification method that remotely stores and retrieves data using devices called NFC tags or transponders. The main goal of the system is to give employees a real-time location in the company's business premises. In addition to the location, the employee's physical location, the system also captures the date and time the employee accessed the system. However, the system is very expensive to implement and may not be suitable for government organizations. Therefore, this study proposes a much cheaper real time tracking and movement locator.

1.3 Problem Statement

The University of Zambia has limited control of who accesses the University campus, offices and student hostels and this has posed to be a threat to the protection of UNZA's assets namely students, staff and information. The University of Zambia's security is porous.

Student and staff have lost and continue to lose personal belongings from offices, hostels and cars whilst parked in the campus car parks. Common belongings that are mostly lost include media such as mobile phones, laptops, IPads and personal belongings such as clothes have been stolen while on the clothes line. Handbags have also been commonly stolen from offices.

UNZA's access control measures are limited. The access control measures that have been put in place do not conform to any standard. There are no written down procedures of how the access into the university should be controlled. There are no specific identification measures put in place to identify students or staff from visitors. Visitors, students and staff can access the University campus freely and at any time. The University has employed security personnel and also contracted a Security Firm but these personnel put together is not sufficient especially in time of student unrest.

UNZA experiences student unrest regularly. Controlling these riots has been a big challenge and has sometimes led to serious injuries and death. There are no security measures to quarantine students in the hostels so that students do not run to places such as Road Side to break public property such as cars.

UNZA has no procedure written down to record visitors if any procedures, most personnel concerned are not aware of such procedures. Visitor date and time of visit to the UNZAs' facilities are not recorded. There is no audit trail to show visitors whereabouts while on campus nor a record to show they visited the intended place.

1.4 Aim

The main aim of this study was to design and develop a Multifactor Student and Staff access control system to improve security at UNZA and keep an audit trail of all visitors that come to UNZA.

1.5 Objectives

This research was guided by the following objectives,

1. Carry out a baseline study to establish the level of Security at the University of Zambia student hostel and staff offices.
2. Design a security model based on Radio Frequency Identification, Biometrics, barcode and GIS technology to address challenges in objective (i).
3. Build a prototype based on the model in objective (ii)

1.6 Research Questions

This research was guided by the following research questions,

1. What is the level of security in the Student hostels and Staff Offices based on ISO 27002?
2. What security model based on Multifactor Authentication can be used to address challenges in (2)?
3. Is it possible to build a prototype based on the model in (2) to address challenges in (1)?

1.7 Motivation and Significance of the Study

Physical security and access control are vital and play a central role in protecting any organization assets such as information, people, equipment and infrastructure. Implementing an extra layer of security through the use of multifactor authentication of users and control who enter and how they enter can greatly improve security in any organization. The findings of this research were published in International Journal of Advanced Computer Science and Applications (*IJACSA)* [1]

1.8 Scope

The research investigated the level of security at the University of Zambia based on ISO 27002; Physical and Environment Security model. Multifactor Authentication based on RFID and Biometrics authentication and real time visitor tracking based on GIS was designed and developed in this research. A detailed literature review of GIS, RFID, Biometrics and Barcode technologies in authentication and access control was conducted to determine the most effective and appropriate method to implement the system. Site visits were also conducted. The outcomes of this research were analysed from survey conducted with students, staff and security personnel at the University of Zambia and a prototype designed.

1.9 Research Contributions

This research was focused on multifactor authentication access control of students and staff into the University of Zambia Campus, student hostels, offices and Visitor real time tracking. The major contribution in this research was the baseline study on measuring the level of security at the University of Zambia. The level of security was measured against the ISO 270002 Physical and Environmental Security Model.

10.0 Organization of the Dissertation

This research is divided into five chapters.

Chapter 1 is the introduction to the research and gives an overview of the work. The Aim, Significance of Study and Problem Statement are presented. This chapter concludes with presenting the thesis outline.

[1] Simukali C. M., & Phiri, J. (2018). Multifactor Authentication for Student and Staff Control. International Journal of Advanced Computer Science and Applications, *IJACSA*, issue 1, Vol 10.

Chapter 2 discusses more in detail the literature reviewed on RFID, biometric, barcode and GIS. Related works regarding multifactor authentication and access control is presented.

Chapter 3 outlines the research methodology. The methods used to conduct the baseline study and to design and develop the prototype are presented.

Chapter 4 gives the research findings of the baseline study and system design and implementation.

Finally, chapter 5 presents the discussion and conclusion.

11.0 Summary

In this chapter, an introduction of the work in this thesis was given. A review of the area being studied and current information surrounding access control was presented. The current methods being used at the institution were also evaluated. The chapter closed with an outline of the thesis.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature reviewed and works related to this research study are reviewed. An extensive review of technologies that are related to the access control, identification and real time tracking are reviewed. These include Barcode Technologies, Radio Frequency Identification (RFID), Biometrics, GIS and GPS. The chapter also reviews Physical Security and multifactor authentication as factors that are applied in access control. Also, a brief review of International Organisation Standards (ISO) and how they relate to security are included in this chapter.

2.2 Physical Security and Access Control

Physical security is fundamental in protecting information systems and services. Physical security is used to protect a company's premises, sites, facilities, buildings, people, information, and other assets [1]. It is an important part of protecting the confidentiality, integrity and availability of resources. It is vital to develop physical security in a way that can effectively secure critical resources, infrastructure and systems. The 'CIA triad' consists of confidentiality, integrity and availability. Security controls are designed to protect these aspects of information systems. Properly designed and maintained access controls are the cornerstone of securing and controlling organizations assets. They control how resources are accessed, and reduce the risk of unauthorized modification or disclosure [2].

2.2.1 Physical Controls

Facilities require physical access controls that control, monitor and manage access. Different levels of access control are required to limit the areas that users must enter, depending on how they are identified. There are many mechanisms for controlling and isolating access permissions. These mechanisms should prevent and detect unauthorized access.

2.2.1.1 Perimeter Security

Mantraps, doors, fences and turnstiles are used outside the facility to provide additional security before entering the building. Fences clearly distinguish the boundaries between protected areas and public areas. The materials used to make fences vary in type and thickness. The protected facilities determine the necessary security levels of the fences. Types of fences include electric wires, barbed wire, thermal, motion or laser detection, concrete and floor-painted strips [11].

Doors or gates are entrances and exits through a fence. To be effectively deterrent, barriers must provide the same level of protection as fences. Otherwise, attackers have the opportunity to bypass the fence and use the gate as a point of attack. The door construction should consist of hardened hinges, locking mechanisms and locking devices. The number of doors must be limited to consolidate the resources required for backup. Dogs or surveillance cameras have to be used to watch the doors that may have no guards.

Turnstiles are a kind of door through which a person can enter. They must offer the same protection as the fence to which they are connected. Turnstiles work by turning as a revolving door in one direction and a person can simultaneously exit or enter the building [2].

Mantraps are small parts that prevent people from entering. Only one person can participate in the Mantrap design at a time. The idea is to block the person attempting to access them by locking them in until the proof of identity is confirmed. If the person has permission to enter, the inner door opens to allow access. This is a security surveillance measure that delays the access of unauthorized persons to the facility until the arrival of security forces or the police.

2.2.1.2 Badge

A proof of identity is required to verify that a person is an employee or a visitor. These cards come in the form of name badges, name badges and identity cards. ID cards can also be chip cards that are integrated into access control systems. Images, RFID tags, tapes, computer chips, and employee information are often included to assist employees with security testing.

2.2.1.3 Motion Detector

Motion detectors offer different technology options as needed. They are used as intrusion detectors and work together with alarm systems. Infrared motion detectors observe changes in the infrared light patterns. Heat-based motion detectors detect changes in heat levels. Wave pattern motion detectors use ultrasonic or microwave control changes in the reflected patterns. Capacity motion detectors monitor changes in electrical or magnetic fields. Photoelectric motion detectors look for changes in light and are used in dimly lit rooms. Passive motion detectors hear unusual noises.

2.2.1.4 Intrusion alarm

The alarms monitor various sensors and detectors. These devices are door and window contacts, window break detectors, motion detectors, water sensors, etc. Changes in the status of the devices trigger the alarm. In hardwired systems, alarms detect that the device status changes by creating a short circuit. The types of alerts are deterrent, repulsive and notifications.

Deterrence alarms attempt to prevent attackers from gaining access to key resources by closing doors and activating locks.

Rejecting alarms use sirens and bright lights to force attackers to leave the site.

Notification alerts send alerts via modems

2.2.2 Technical controls

Technical controls focus primarily on access control as it is one of the most vulnerable security domains [12]. Smart cards are a technical control that provides physical access to a building or secure room, as well as a secure connection to corporate networks and computers. In the event of an overlap, multiple layers of defense are required to protect attackers with direct access to corporate resources. Burglar alarm systems are essential technical controls as they detect intrusion. Detection is important because the security event is notified. By knowing the event, the organization can respond to the incident and narrow it down. Audit trails and access logs must be continuously monitored. They allow the organization to identify where and how often violations occur. This information helps the security team reduce vulnerabilities.

2.2.2.1 Smart Card

Token cards include chips and integrated circuits that are embedded in the cards that process the data. Microchips and integrated circuits allow the chip card to be authenticated according to two factors. This authentication check prevents hackers or unauthorized employees from accessing rooms where they are not authorized. Employee information is stored on-chip for easy identification and authentication. Two-factor authentication protects computers, servers and data centers from unauthorized persons. The evaluation is not granted with the possession of the card alone. To unlock the card, you must enter a biometric form (whatever you are) or a PIN or password (something you know) to authenticate the user.

There are two types of access to the chip card: contact and contactless. Contact smart cards have a contact on the front of the card for data transfer. When the card is inserted, the device's fingers connect to the contact points of the chip. The connection to the chip provides power and allows communication with the host device. Contactless smart cards use an antenna that communicates with electromagnetic waves. The electromagnetic signal feeds the chip card and communicates with the card readers.

Access token cards are considered insensitive to manipulation methods. These cards are not foolproof though. Security offers the complexity of the smart token. The smart token reads the card only after entering the correct PIN. Encryption methods prevent attackers from capturing data in the microchips. Smart cards also have the option to delete the data stored there. The card detects fake.

The cost is a disadvantage of smart card technology. Creating smart cards and buying card readers is expensive. Smart cards are essentially small computers and carry the same risk. As technology advances, storage capacity and the ability to separate "critical security computations" [13] into smart cards becomes more and more important. Smart cards can store keys used with encryption systems, which contributes to security. Due to the autonomous circuits and memory, the card can use encryption algorithms. Encryption algorithms provide secure permissions that can be applied across the enterprise.

2.2.2.2 Proximity reader and RFID

Access control systems use proximity readers to scan cards and determine if they are authourised to enter the facility or zone. Access control systems evaluate the permissions stored in the chip, which are sent via the radio identification RFID. This technology uses transmitters (for sending) and answering machines (for receiving).

Physical access control uses the use of proximity readers and access control cards with passive tags. The passive tags are powered by the proximity readers via an electromagnetic field generated by the card reader. When you drag a card, a signal is sent to the reader. The door will be unlocked once the signal has been received and verified.

Active tags contain batteries for the self-sufficiency of the RFID tag. Active tags have an integrated power source that allows them to transmit signals further than passive tags. However, their costs are considerably higher and their life is limited due to the life of the battery. These are generally used to track items of great value. Readers can track movements and find items when connected to the network and recognition system. When an asset is removed from specific areas, the organization may ask the access control system to trigger an alert.

2.2.2.3 Intrusion Detection, Guards and CCTV

If the device is moved without authorization, Intrusion Detection Systems (IDS) can monitor and notify unauthorized entries. SDIs are security-relevant because systems can send a warning when a specific event occurs or at an unusual time an access attempt was made.

Protectors are an important part of an intrusion detection system because they are more adaptable than other security aspects. Security officers can be stationed in one location or on patrol to patrol the campus.

2.3 International information security standards.

International standards and guidelines are available to help and support organisations with management of Information Security, by established rules and regulations. The Table 1 shows some international Security Standards established between the period 2001-2013. Moore [15] observes that without standards that provide objective criteria for organsational security choices, the people

Table 1: International Security Standards, Years 2001 – 2013 [15]

Standard	Description
ISO 27001 2013	The objective of the standard itself is to provide requirements for establishing, implementing, maintaining and continuously improving an Information Security Management System
ISO 27002 2013	The standard established guidelines and general principles for initiating, implementing, maintaining, and improving information security management within an organization. The standard is also intended to provide a guide for the development of organizational security standards and effective security management practices and to help build confidence in inter-organizational activities.
ISO 27003	The purpose of this development standard is to provide help and guidance in implementing an Information Security Management System
ISO 27004	It is intended to help an organization establish the effectiveness of its Information Security Management System implementation process
ISO 27006	Its formal title is Information technology - Security techniques. Requirements for bodies providing audit and certification of information security management systems and it consists of 10 chapters and four Annexes.
PCI/DSS Payment Card Industry	Payment Card Industry Data Security Standard - This standard is used to the security of clients personal information on online card transaction industry
ITIL or ISO/IEC 2000 series	Information technology Infrastructure Library - Dwells on the service processes of IT and considers the central role of the user.
BS7799	British Standards Institute - Is a standard that was written and maintained by the British Standards Institute, and they provide comprehensive information on the standard as well as where to obtain it from. In addition, Guidelines for Information Security Risk Management. It supports ISO 270010 (2013) standard and covers the main aspects for risk assessment.
BSI IT	Baseline Protection Manual - Aims to achieve a security level for IT systems and industry that is responsible and acceptable to satisfy normal protection requirements.

responsible with making these choices can make them based on undeserved aspects that might include lack of knowledge, supposed constraints, inappropriate confidence and personal motivations.

2.3.1 Physical and Environmental Security

Based on the ISO 27002 (2013) standard, the objective of the Physical and Environmental Security is to avoid unapproved access, loss and conflicts to organisation facilities and secure areas.

Critical or sensitive business assets and information processing must be in protected areas, secured by a clear security limit with appropriate security barriers and entry controls. The safeguard delivered must be matching with the acknowledged risks. Additional procedures in order to adopt secure physical security can be implemented [14]

2.3.2 Role of ISO 27002 Standard

The ISO/IEC 27002 Code of Practice for Information Security Management establishes guidelines and general principles for organizations to initiate, implement, maintain, and improve information security management. The objectives that are outlined provide general guidance on the commonly accepted goals of information security management. ISO/IEC 27002 contains best practices of control objectives and controls in the following areas of information security management [15]:

i. Information security policy;
ii. Organizational security;
iii. Asset classification and control;
iv. Physical and environmental security;
v. Communication and operation management;
vi. Aspects of business continuity management;
vii. Compliance with the legal requirements;
viii. Internal information security.

2.4 Multifactor Authentication

Digitalisation decisively penetrates all the sides of the modern society today. The continuous growth of digitally based systems such as in online payments, communications, access right management etc. has also brought with it an ascent in security concerns [14]. One of the key enablers to maintain these systems secure is authentication. Authentication is the process of identifying an individual by using a factor such as something they know (password), something they have (Identification card), something they are (biometrics) and so on. Authentication merely ensures that the individual is who he or she claims to be. In [16], authentication is a process where a "user identifies himself by sending *x* to the system; the system authenticates his identity by computing a result F (x) and checking that it equals the stored value *y*". This definition has not changed significantly over time despite the fact that a simple password is no longer the only factor for validating the user from the information technology perspective [17]. Authentication by one factor such as use of a password only or ID card only is the weakest level of authentication because by either sharing the password or using a stolen ID card can compromise a transaction. Further, it was realised that authentication with just a single factor is not reliable to provide adequate protection due to a number of security threats [18]. Multifactor authentication (MFA) is a security system in which more than one form of authentication is implemented to verify the legitimacy of a transaction. MFA has several categories for defining factors of authentication and these are knowledge factor (ID/Password, PIN, Challenge-Response), Possession factor (Security Token, Smart Card, Smart Phone, ID OTP Token), Inherence factor (retina scans, iris scan, fingerprint scans, voice recognition, hand geometry, earlobe geometry), Location factor (GPS) and time factor [19].The goal of MFA is to make a layered hindrance and make it more difficult for an unapproved individual to get to a focus, for instance, a physical zone, figuring contraption, framework or database. In case one part is exchanged off or broken, the attacker still has no short of what one more impediment to break before viably breaking into the target. The multifactor method demands various reactions to test request and recoups 'such as something you have' or 'something you are' [20]. In the Figure 1 below a sample process of two stage Multifactor Authentication is shown.

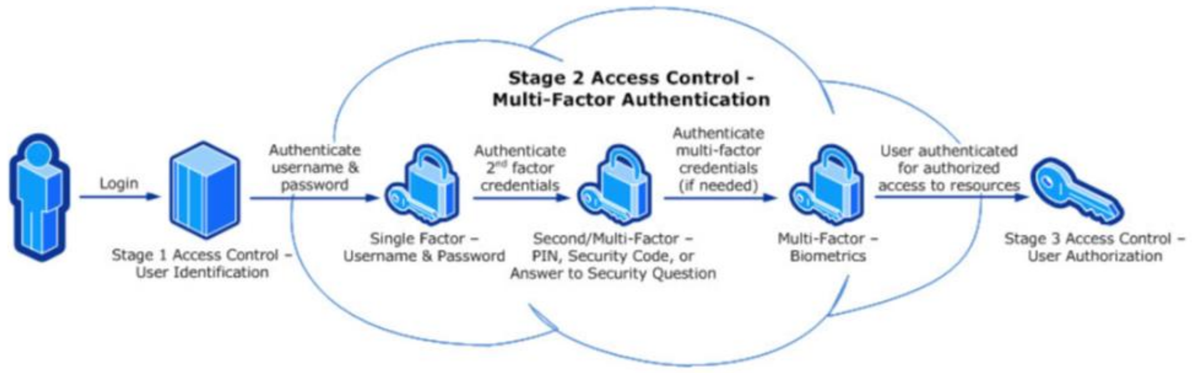

Stage 2 Access Control -
Multi-Factor Authentication
Login
Authenticate username & password
Authenticate 2nd factor credentials
Authenticate multi-factor credentials (if needed)
User authenticated for authorized access to resources
Stage 1 Access Control - User Identification
Single Factor - Username & Password
Second/Multi-Factor - PIN, Security Code, or Answer to Security Question
Multi-Factor - Biometrics
Stage 3 Access Control - User Authorization

Figure 1: Multifactor Authentication System [19]

2.4.1 The Five Different Authentication Factors

2.4.1.1 Knowledge factors: something only the user knows

2.4.1.1.1 Password

A password is a secret word or string of characters that is used for user authentication. It is the most commonly used authentication mechanism in two factor authentication.

2.4.1.1.2 Pin

A Personal Identification Number PIN typically used in ATMs as basically a secret numeric password. ATM card do not contain a PIN or magnetic Stripe therefore the PIN is not typically considered as something that a user has.

2.4.1.1.3 Pattern

Pattern is usually in the form of a sequence of cells in an array that is used for authenticating the users. An example is the pattern used in android devices at login.

2.4.1.2 Possession factors: something only the user has.

2.4.1.2.1 Token with a display (disconnected tokens):

Token are available which display a changing passcode on a Liquid Crystal Display (LCD) or e-ink display, this must be typed in at an authentication screen, therefore avoiding the need for an electronic connection. A number is derived from the sequence of numbers that are shared secret by a cryptographic process. This process makes it infeasible to work out the secret from the sequence of numbers.

2.4.1.2.2 Magnetic Strip Cards

Magnetic stripe cards examples being Credit cards, Debit cards, ATM cards, Loyalty cards, Gift cards, etc. are easily cloned and so are being or have been replaced in various regions by smart cards, particularly in banking.

2.4.1.2.3 Smart Cards

Smart cards are usually the same size as a credit card and in some cases are used to perform several functions of a proximity card physical access device, network authentication or Identification badge. Users can be authenticated into a facility such as a building via proximity detection and then insert the card into their PC to produce network logon credentials.

2.4.1.2.4 Wireless

Available in this category are RFID-based tokens, Bluetooth-based tokens and Contactless smart cards which are a wireless version of the traditional smartcard.

2.4.1.2.5 USB Tokens

A Universal Serial Board (USB) port is standard equipment to most modern computers. USB tokens generally have a large storage capacity for logon credentials as well as for data storage. However, they may be relatively costly to deploy and support. They are also prone to theft and fraud for example nothing can stop a stored secret X.509 certificate stored on the USB Token from being copied.

2.4.1.2.6 Mobile phones

There are available Two factor authentication tools that transforms the PC user's mobile phone into a token device using SMS messaging, an interactive telephone call, or via downloadable application to a Smart phone.

2.4.1.3 Inherence factors: something only the user is.

This is achieved through Biometrics technology; a living persons' identification can be automatically verified or recognized based on a physiological or behavioral characteristic.

2.4.1.3.1 Types of Biometrics

There are available various biometric methods that have been introduced and the following are what has gained acceptance;

2.4.1.3.2 Typing patterns.

These are similar to signature dynamics but extended to the keyboard, recognizing not just a password that is typed in but the intervals between characters and the overall speeds and pattern.

2.4.1.3.3 Eye scans.

This can involve two parts of the eye the retina or iris. This technologies hardware is expensive and specialized, and using it is slow and inconvenient and may make users uneasy.

2.4.1.3.4 Fingerprint recognition.

Fingerprints are unique to every individual. They are also readily accessible and require little physical space either for the reading hardware or the stored data.

2.4.1.3.5 Ear biometrics.

This will be the most important biometrics identification factor in the near future because of qualities such as the fact the seven features on human ear that recognition is based on remain permanent over the course of the human life and are unique. Additionally, the acquisition of ear images does not necessarily require person's cooperation though considered to be non-intrusive by most people. Because of these qualities, the interest in ear recognition systems has grown significantly in recent years.

2.4.1.3.6 Hand or Palm geometry.

This factor involves reading the individual entire hand instead of just fingerprints. The reading devices depend on measuring the length and angles of individual fingers. Although more user-friendly than retinal scans it is quite a cumbersome technology.

2.4.1.3.7 Voice recognition.

Requires that the individual is recognized by matching the individual’s speech to a stored voice pattern and not necessarily understanding what is being said [21]. The concept of voice recognition is shown in the Figure 2 below.

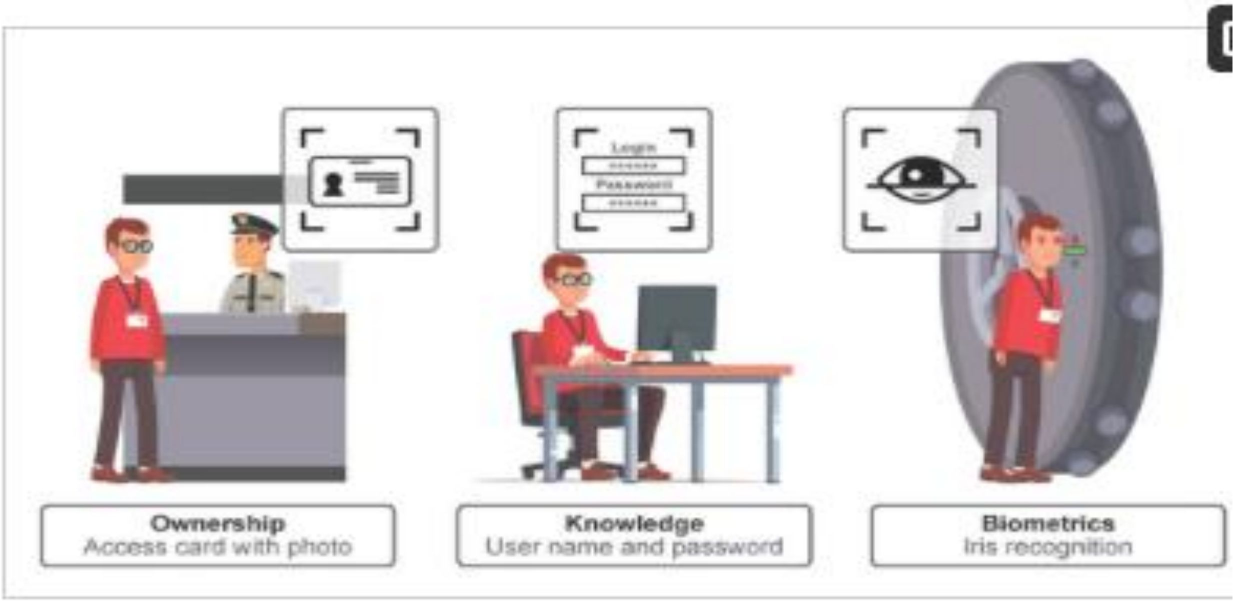


Figure 2: Conceptual Authentication examples [21]

2.4.1.3.8 Facial recognition.

Uses distinctive facial features such as upper outlines of eye sockets, areas around cheekbones, the sides of the mouth and the location of the nose and eyes. Most technologies avoid areas of the face near the hairline because hairstyles change and can affect the recognition.

2.4.1.4 Fingerprint or Face Detection have some disadvantages like:

- Quality of the fingerprint scan may be affected by an individual's age, or how much grease is on the fingers. Other factors such as their occupation or lifestyle may affect the fingerprint.

- Elastic distortion of the skin of the finger due to touch sensing methods and potential problems with cleanliness of the sensor and public hygiene.
- In some cases, where people have no fingers or maybe without a full set, these people cannot be fingerprinted.

2.5 Barcodes

Barcodes are part of every product that we buy and has become the ubiquitous standard for identifying and tracking product. Barcodes have been used as automate-identification systems using the two dimensional system of barcoding which allows barcodes to hold more data.

Barcoding dates back to 1950's when Bernard silver and Norman woodland patented printing patterns called the bulls-eye printing pattern. By the 1959 an automatic car identification system was developed by David Collins which became the first commercial use of a linear barcode [21].

IBM also developed the uniform grocery product code (UPC) in 1973. This was adopted by the national association of good chains.

A barcode is a machine readable representation of information in a visual format. A barcode comprises of a series of parallel, adjacent bars and spaces. Different alphanumeric symbols, numbers, characters, colon and others can be used to represent information.

Barcode have in recent past used in many areas such as market production, electronic devices or people identification cards.

The lines on the barcodes represent the product referencing number. These are different types of barcodes with the barcode symbol defining the technical details of a particular type of barcode. The barcode types can be classified into four categories which are numeric-only barcode, alpha-numeric barcode, 2D barcode and industry standard for barcode and labels. There are three basic types of bar code readers namely fixed, portable batch and portable RF [22]

Barcodes are categorized into two: one dimensional (1D) barcode and the two dimensional (2D) barcode.

2.5.1 One Dimensional (1D) Barcode.

One dimensional barcodes have a linear representation of data and its represented systematically by varying sizes of spaces (width) in between the parallel lines in the barcodes, examples of linear barcodes include Universal product code UPC and International Article Number (also known as European Article Number or **EAN**) codes.

a) Universal Product Code (UPC)

This is the most used barcode worldwide. It labels and scans customer products at the checkout points. The UPC has two variations: UPC-A which encodes 12 numeric digits and the UPC-E which encodes 6 numeric digits.

In the UPC code the first 6 to 9 digits are referred to as the "company prefix". These digits are assigned by GIS US formerly known as the Uniform code council. This company prefix number does not change on the company product range. The next range of digits known as Product numbers uniquely identify individual items of a company. While the company prefix is assigned by GIS, the product number are assigned arbitrarily by each particular company. The twelfth character or number used is called "check digit" and is calculated based on first 11 digits of the UPC code [23]. Figure 3 below shows an example of UPC Barcode.

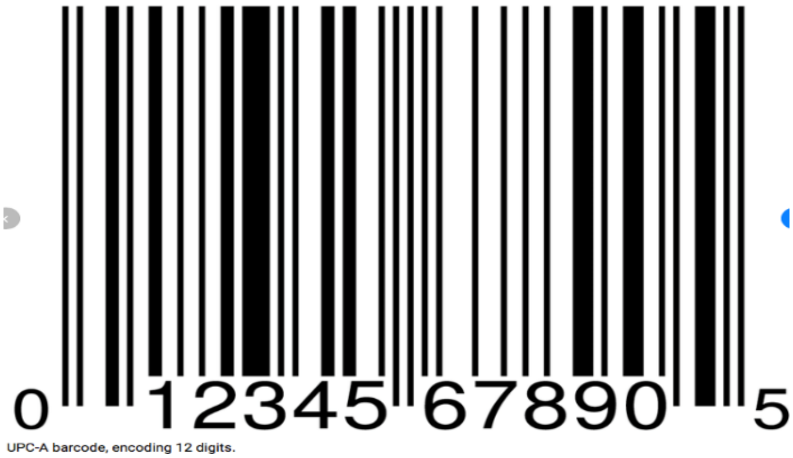


Figure 3: UPC Barcode [23]

b) EAN code

The EAN codes are basically used in Europe to label and scan products at the point of sale. They are numeric only barcode used for identification of retail products, the EAN codes are not so different from UPC except for the geographical application. There are two types of the EAN code: EAN-13 and EAN -8. The EAN- 8 uses 8 digits and is mostly used in situations where space is limited.

The EAN-13 as in Figure 4 is mostly used as default form factor and like the code is written it has 13 digits [24].

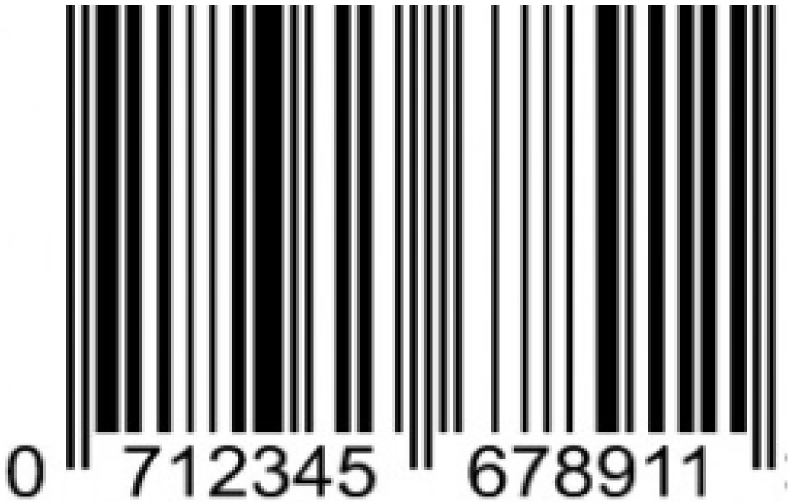


Figure 4:: EAN -13 barcode image [24]

Examples of one dimensional codes

c) CODE 39

The code 39 is sometimes referred to as 3 of 9 is mostly used in industry to label goods. The major industries being automotive and department of defense of the United States of America. This code gets its namely from the limitation of it only been able to encode 39 characters. Never versions are now able to encode up to 43 [25]. Figure 5 shows an example of Code 39.

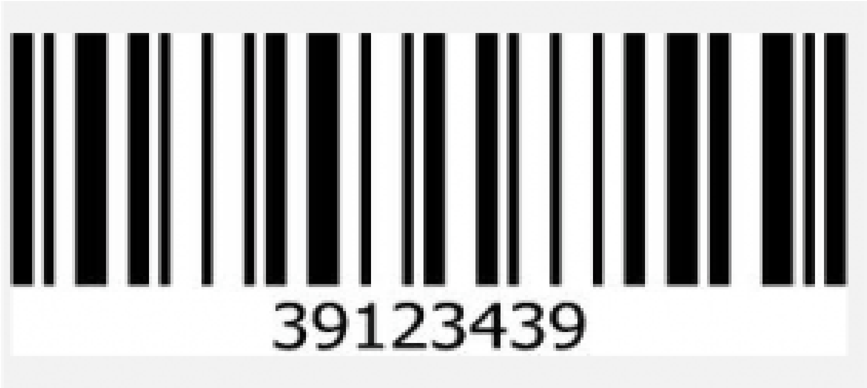


Figure 5: Code 39 image [25]

d) Code 128

This code is commonly used in the logistics and transportation industry for ordering and distributing. Product Code 128 supports any character of the ASCII 128-character set and is therefore able to store diverse information. Figure 6 shows an example of Code 128.

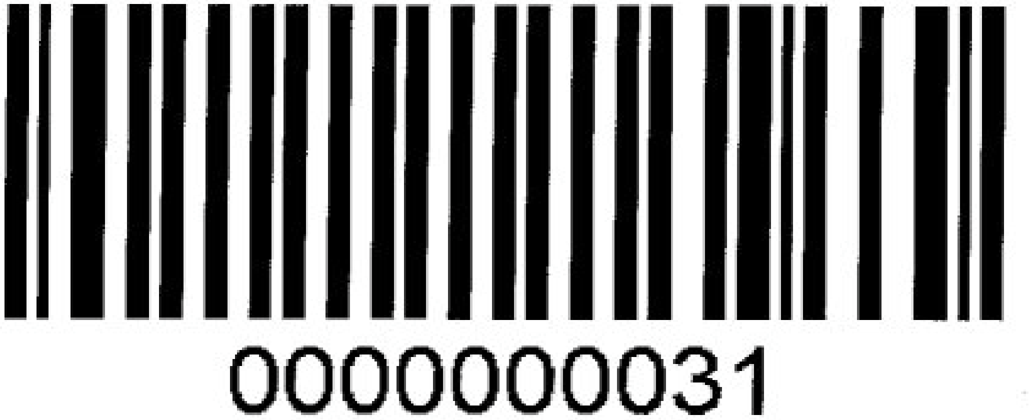


Figure 6: Code 128 image [26]

There are several other one dimensional codes available such as code 93 which has a full support of ASCII, with additional security within the barcode itself and its labels 25% shorter than code

39% [26]. Another type is the CODA BAR, which has an advantage of ease of print. The Coda bar is a discrete self-checking symbol and is capable of encoding up to 16 different character [27].

2.5.2 Two-Dimensional (2D) Barcode

These barcodes represent information using two-dimensional symbols and shapes. They are capable of storing more data per unit are [28]. The most commonly used two-dimensional barcode today are QR code and PDF 417.

a) Quick Response code (QR CODE)

Developed by Deusa-wave a Toyota subsidiary, this code is widely used in japan for tracking inventory [29].

QR codes can't be read by a laser scanner, they are able to support four different modes of data that is numeric, alphanumeric, byte/binary and kunyI. The Figure 7 below shows the different types of QR code. This code is mainly used in the advertisement, marketing and business card industry, it has a flexible size with a high tolerance to fault. QR code can also be read very fast and comes in different versions as depicted in Figure 7 below.

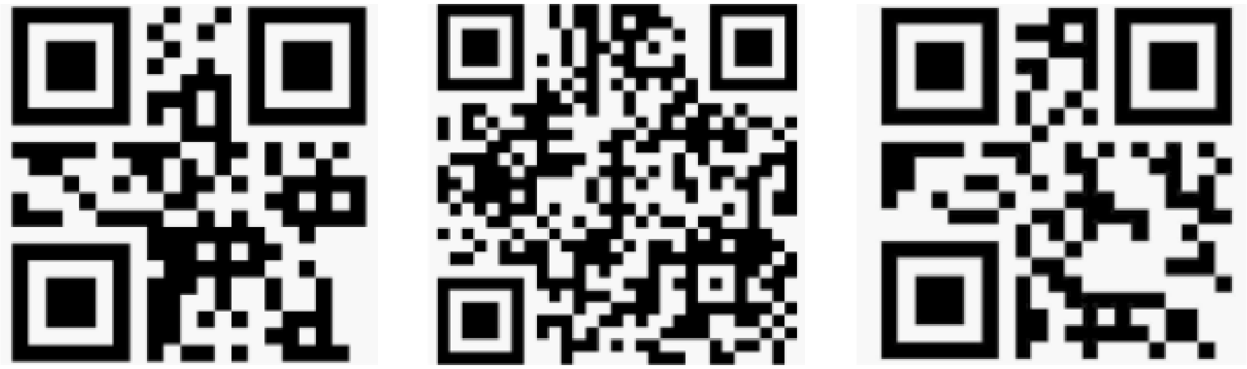


Figure 7: QR code versions image [29]

The QR code has two types that are in use today: static and dynamic QR code.

b) Static QR code

is the most commonly used to disseminate information to the public. It’s especially used in adverting and marketing. It’s possible to track information about the number of times a static QR code has been scammed as well as the associated action taken with each scan. Information such as the operating system of the device that scanned the code can also be traced.

c) Dynamic QR code

Also referred to as unique code has more added functionalities than the static code such as ability to track specific information examples include scanners names, email address and the number of times that code may have been scanned. Their typical use is in retail, entertainment and adverting.

Figure 7 retail [28]

d) Portable Data Files (PDF) 417 CODES

This code is made up of 17 modules of 4 bars and spaces, that’s what 417 represents in the code, these codes require a large storage machine-readable data capacity of over 1.1 kilo bytes. The huge capacity storage is required for data such as photographs, finger prints, signatures, texts, numbers and graphics. modified handheld lasers or lines CCD scanners can be used to read the ADF 417 code. The Figure 8 depicts a symbol of PDF.

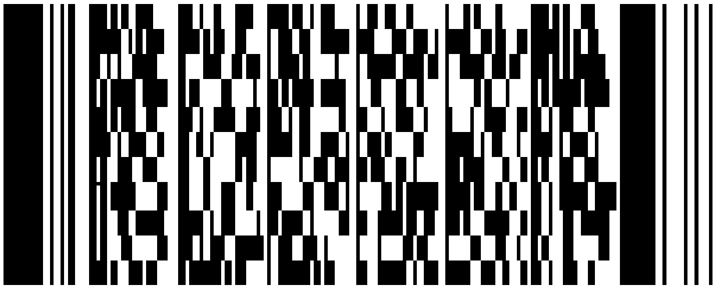


Figure 8: Symbols of PDF 417 image [28]

A PDF 417 code can contain anything from 3 to 90 rows with each comprising of the following components;

- Leading quiet zone
- Start pattern
- Left row indicator
- Right row indicator symbol character
- Stop pattern
- Trailing quiet zone

Figure 8 above shows PDF 147 used in logistics industry

2.5.3 Barcode Readers

Barcode reader has four types of technology in use today. The four categories of the bar code readers are pen type, laser scanners, Charge Coupled Device readers and camera based readers.

a) Pen Type Readers

A pen type reader as the name suggests has a photo diode and light service the readers. To read a barcode, the pen type reader is steadily dragged across the entire barcode strips. The measurement is determined by the intensity of the light across the bars. The intensity of the light is measured by the photo diode as its reflected back by the light source. The waveform voltage generated from the photo diode and reflected by the light source is used to measure the width of the bars and spaces in the barcode. The disk shades absorb the light while the white spaces reflect the light. The waveform voltage generated by the photo diode is has exact duplicate of the bar and space pattern in the barcode [30]. Figure 9 below shows an example of a Pen like reader.

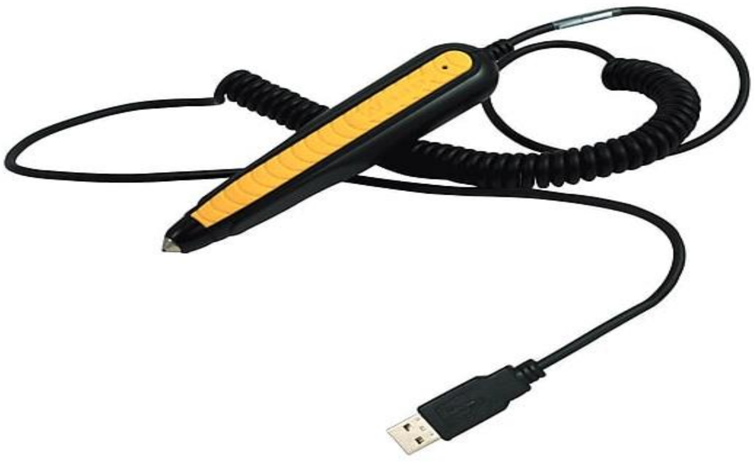


Figure 9: Pen like reader [29]

b) Laser Scanners

The lasers scanners have a photo diode to measure the light intensity and a laser beam as a source of light. To scan the barcode, two methods are used, either reciprocating mirror or a notating prism.

The laser beam is scanned back and forth across the bar code to take a measurement. The photo diode is designed to detect the only specific frequency to which the reader is turned. Different laser scanners have different resolutions [31]. Figure 10 below shows a type of Laser scanner image.

Figure 10: Laser scanner image [30]

c) Charge Couple Device (CCD)

Charge Couple Device has a head which is designed with hundreds of tiny sensors lined up in an array of rows. Each sensor operates like a photo diode to measure the intensity of light. When the reader is placed over the barcode, the many sensor light generate a voltage pattern identical to the barcode lines and spaces. Unlike the pen type and laser scanner, the Charge Coupled Device measures reflected light of a specific frequency from the scanner itself.

d) Camera Based

Camera based reader has a video camera with hundreds of rows of sensors arranged in a two dimensional array. An example of a Camera based image reader is shown in Figure 11 below.

A digital image of the barcode is captured where a sophisticated digital image processing technique the barcode is decoded [32].

Figure 11: Camera based image scanner [31]

2.5.4 Structure of Barcode

A barcode is structured in such a way that it is split into four sections with each section having its own function as shown in Figure 12.

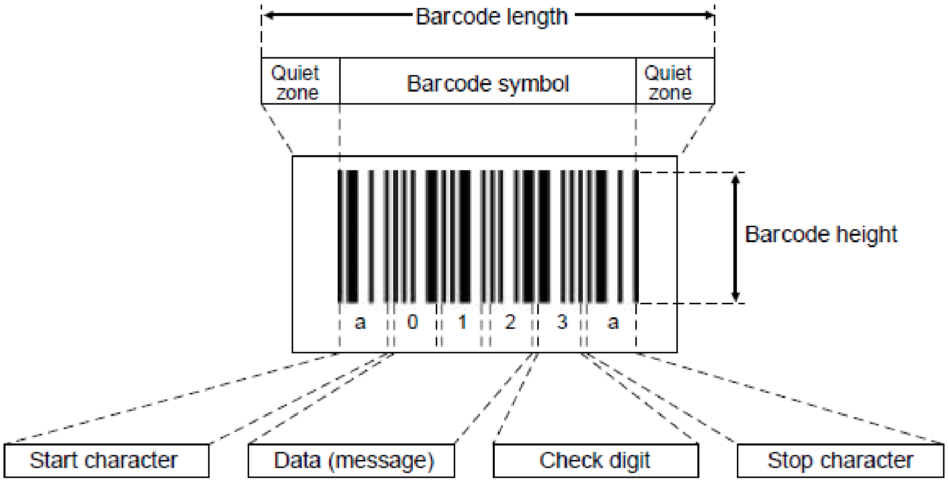


Figure 12: Image of Barcode [32]

Sections of the barcode include:

a) Quiet zone

This is the minimum space required for a barcode to be scanned or read. The minimum space needs to be ten times the width of the narrowest element.

The minimum space always precedes the start character symbol in the barcode. The quiet zone has to be clear of any print and should be the same color and shade as the background of the symbol of the barcode.

b) Start code

The start code is characterized by special characters and marks at the beginning of the of the barcode. The special characters signify the start of data to a scanner or reader.

c) Check Digit

Always present in the barcode, the check digit is used to verify the accuracy of the elements found in a barcode. It is in an extra digit added at the end of a barcode and that's what the scanner uses to ensure that data read is accurate. The check digit is not transmitted to the host as part of data [33].

d) Stop code

The stop code indicates the end point of the barcode. The character in the stop code are not transmitted to the host [33]

2.6 Biometrics

The biometric data may be captured by a physiological feature or a behavioral trait. A physiological trait is a relatively stable human physical trait. An example of a physiological feature is a fingerprint, an iris-retina pattern, or a geometric pattern in the hand. Physiological measurements are static and cannot be changed. This type of measurement is invariable and irreversible or permanent, except in cases of deformities caused by significant external stresses such as physical illness or injury [34]. A behavioral trait, on the other hand, tries to resemble the psychological constitution of a human being. This is influenced, among other things, by the height and gender of a person. Behavioral traits can be identified, among other things, in activities such as language, typing speed, and the pressure exerted on the paper during writing. Four methods of biometric authentication systems were investigated based on physiological and behavioral characteristics. These were examined with regard to the basic functions, advantages and disadvantages of the implementation.

2.6.1 Fingerprint Authentication

Fingerprints are composed of rib patterns on a person's fingers. These peak models can uniquely identify and identify individuals. Fingerprints are characterized by arches, loops and towers. A single fingerprint has at least one of these key features. The small details captured by these fingerprint features are called minutiae. Figures 13 and 14 show a fingerprint pattern and its fingerprint features. The authentication process is an automated method for checking the correspondence between different human fingerprints [35].

Figure 13: Fingerprint image sample [34]

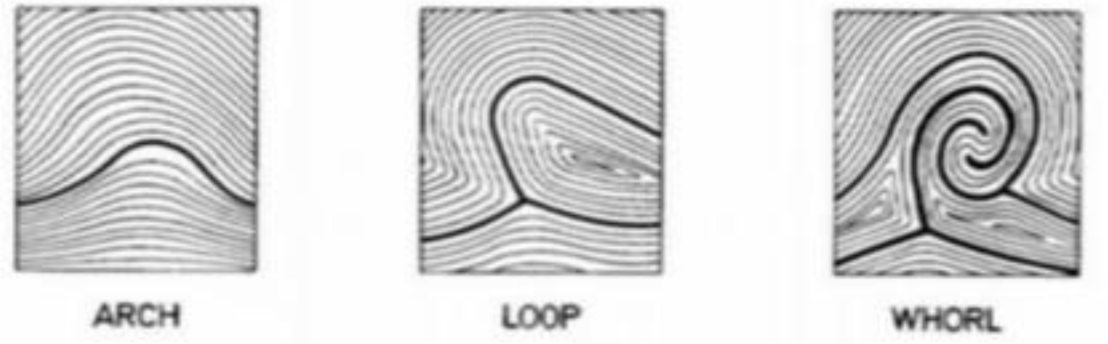


Figure 14: Fingerprint features and cannot be forged [35]

a) Advantages

Some of the advantages of Finger Print authentication include

(i) Individualistic features ensure the authentication of the subject.

(ii) Systems are relatively cheap to buy and install

(iii) After use, the user no longer needs to access that password storage because fingerprint authentication guarantees access

(iv) A fingerprint identification point cannot be forged

(v) Different even in identical twins

(vi) Very specific with unique structure throughout the life of the subject.

(vii) The wearing of glasses or contact lenses does NOT function as a method of contraception with technological precision.

(viii) High accuracy and high processing speed [34] [36].

b) Disadvantages

Some Disadvantages include

(i) Injury or eye disease can render can render this biometric system ineffective

(ii) Injury or eye disease can render this biometric system ineffective.

(iii) Intrusive technology that may not be well received by many people.

(iv) Lighting may affect the accuracy of the reader.

(v) Quite expensive to acquire compared to other biometric systems.

2.6.2 Voice Authentication

This technology allows the conversion of voices or sounds of a human voice into an electrical signal that can be encoded. The speech recognition software is designed to identify a person via their unique voiceprint. Voice prints are generated from the physical characteristics of an individual's throat associated with his mouth. Research has shown that there are no two identical voices. Voice biometrics therefore offers a rare opportunity to use one's voice to authenticate or identify people [36]. An example of a voice pattern is shown in Figure 15 below.

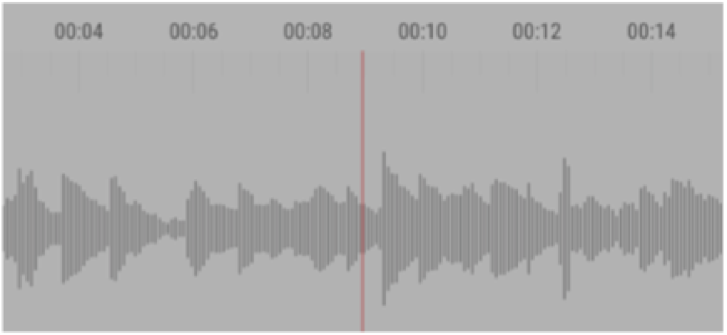


Figure 15: Showing a voice pattern [36]

a) Advantages

Some advantages of Voice Authentication

(i) No need for training, users can simply speak in the biometric voice reader

(ii) Voice communication is a natural activity for human beings

(iii) Voice communications eliminate the need to learn Keyboard operations (and thus helps to narrow the gap between valid people and those with limited abilities in hand-motion activities, such as writing). By eliminating learning, the voice eliminates the need to learn

(iv) This eliminates the need to be precise in written declarations as is the case for password authentication.

(v) Since the voice is used, the speed of operation is improved. People usually speaker faster than they are able to write [36].

b) Disadvantages

Some disadvantages of Voice Authentication

(i) The catch limit is reduced to an individual finger with additional limitation of the capture reduced to a section or part of that finger only and not to the whole finger.

(ii) Susceptible of FAR (false acceptance error) while a wrong subject is registered access is allowed.

(iii) Injuries to the hands (including the fingers), chemical work and work (such as brick-laying or metal) have intrapersonal variations that make reading and capture difficult fingerprints.

(iv) Washing with soap or dipping a finger in the water for about 30 minutes serves as a means of contraception for fingerprint readers, which may prevent readers from capturing or recording fingerprint until that the finger returns to its original position, the original form in which it was found during capture or inscription [37].

2.6.3 Retina Authentication

This is one of two forms of ocular biometrics; the other being the recognition of the iris. This form of biometrics is one of the most secure authentication systems in the world. The installed technology requires that the fingerprint of a retina pattern is taken and stored. The authentication process involves assessing the retina of a subject with a stored version (recorded impression) of that subject's retina. Retinal recognition has a low acceptance error (FAR) and a low rejection rate [38].

c) Disadvantages

Some disadvantages of Voice Authentication include:

(i) Impulse noise can affect the accuracy of the voice report and render the system ineffective.
(ii) The proximity of the microphone must be accurate for the system to work properly.
(iii) A prerecorded sound may bypass this system
(iv) A person may speak different languages which may affect the accuracy of the device if that person uses a different language or dialect.
(v) Some words have a homonym feature, which can affect the accuracy of the device.
(vi) The learning curve of the system can be long because it is formed by voice.
(vii) Most voice-activated biometric data are expensive.

2.6.4 Face Authentication

Facial biometrics is divided into two aspects, facial recognition and recognition programs. Face recognition extracts a face from a given image, while face recognition compares a captured face to registered faces to match the face. The whole process is executed by a series of complex algorithms. One of the options of facial recognition is to select the characteristics of a face and to match them to a face. Facial features or the dataset are normally stored in a database. In ideal situations, this database must be encrypted to obtain sufficient security [39].

(a) Advantages

Some advantages of face authentication include

(i) Non-intrusive technology and can be realized sneaking without the subject knowing is revealed, therefore ideal for investigation purposes.
(ii) Some algorithms can be adjusted to analyse a large scale of a population and this technology is therefore ideal in overcrowded environments**.**

(iii) Ideal for tracking people and reporting incidents

(iv) User friendly because there is no need for complex training for topics to grasp.

(v) Can be developed and run from a basic camera without having to buy other tools. This proves to be one of the major benefits and reduces the cost of this technology exponentially.

(vi) Some pre-trained and easy-to-install facial calibration tools are available. This further reduces installation costs.

(vii) Biometric face algorithms have a person inside calculation of the variation capable of detecting aging and basic facial deformity and reducing a face to a known variable [40].

(b) Disadvantages

(i) Some algorithms may not work correctly on black

2.6.5 Quick Response Code

QR code is a machine readable imprint consisting of a set of black and white squares that normally incorporate certain information into the print. The QR codes were developed by a Japanese company called Denso Wave for the purpose of monitoring manufacturing processes. However, QR codes can authenticate and identify an entity. In this way, QR codes can be used as an additional security feature, especially when connecting to networks. Networks can be designed to read QR codes, verify data, and offer or deny access to an entity. Because QR code information is not human readable, it is a basic form of information hidden from view (encryption). This hidden information can then be transmitted. When used with geolocation, QR codes can be used to determine the location status of an entity [41].

2.7 RFID identification

RFID is an automated technology that uses wireless technology to uniquely identify and track tagged objects as a unique serial number [42] [43] [44]. The identification and tracking of objects takes place without human intervention [45]. RFID technology collects data about an object without having to touch or display the data carrier. This is done by inductive coupling or electromagnetic waves [46]. Ruiz-Garcia and Lunadei [47] point out that RFID technology is well-suited to collecting multiple data on people, animals and objects in order to track and count them in the different environment.

RFID is one of a broad category of technologies known as Auto-ID technologies [44]. According to Wyld and Budden [48], automatic identification technologies provide fast and reliable object identification and tracking capabilities. Automatic identification systems associate an identifier with a physical object through means that can be read automatically. The Auto-ID can be displayed optically, electromagnetically or even chemically [49]. Other technologies classified as Auto-ID include barcodes, magnetic connections, Optical Character Recognition, speech recognition, touch memory, smart cards, and biometrics.

Both barcodes and RFID technology are used to facilitate process automation through unique identification, but barcodes require line of sight to identify objects [50]. Table 2 shows the differences between barcodes and RFID technologies.

According to Weis [49], the first application of RFID systems during the Second World War was applied to the "Identify Friend or Foe" (IFF) systems of the British Royal Air Force. IFF allowed radar operators and pilots to automatically distinguish user-friendly aircraft from enemies using high-frequency signals. IFF systems have helped prevent "friendly fire" incidents and intercept enemy aircraft [49].

An RFID system uses small integrated circuit chips or transponders, called tags, attached to physical objects. These tags contain credentials and transmit them to an RFID reader, a device that is capable of communicating sequentially with computers [51]. RFID tags do not require a line of sight for the reader. RFID tags can be embedded in an object or placed in the packaging [52]. A typical RFID system includes four basic components, including RFID tags, readers, antennas, and a central node computer system that can accommodate the database server and middleware [42], [53], [54]. Figure 16 shows the basic components of an RFID system.

Table 2: Barcode vs RFID [50]

Barcode Technology	**RFID Technology**
Barcode needs line of site to read	RFID tags can be read or updated without line of sight
Barcode can only be read individually	Multiple RFID tags can be read simultaneously
Barcodes cannot be read if they become dirty or damaged	RFID tags are able to cope with harsh and dirty environments
Barcodes must be visible to be logged	RFID tags are ultra-thin and can be printed on a label, and they can read even when concealed within an item
Barcode can only identify the type of item	RFID tag can identify a specific item

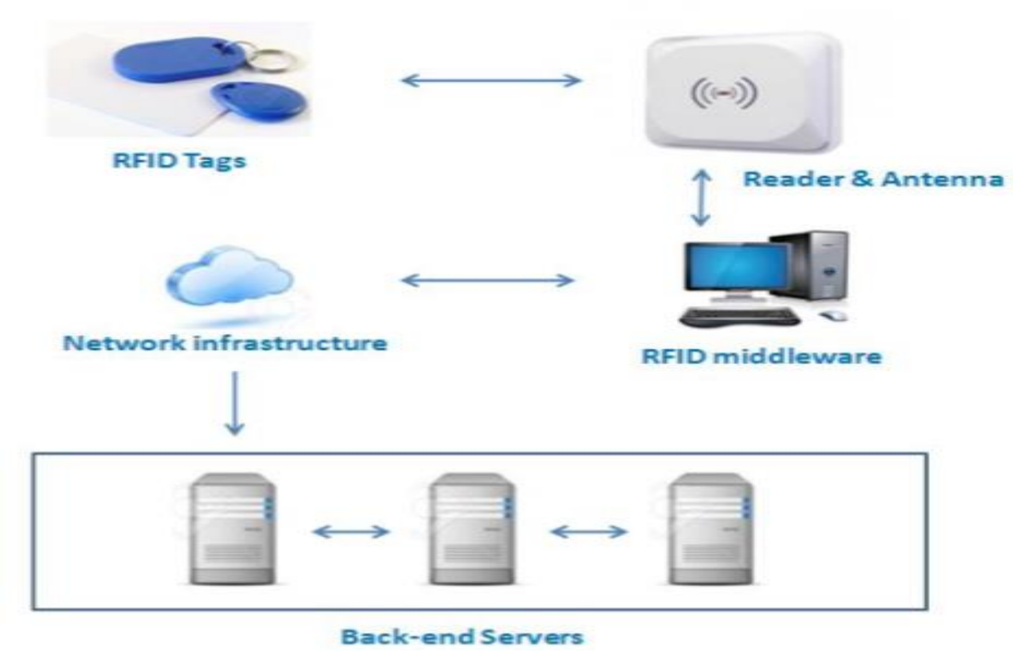


Figure 16: Basic components of RFID system [41]

2.7.1 RFID Tags

The label or RFID transponder is the data carrier which, with the aid of a microchip and an antenna integrated therein, transmits information to the RFID reader (transceiver) within a given range, [46] [55] [[56] [57]. A microchip in the tag stores a unique serial number or other information depending on the type of tag memory that can only be read, read-write or write once (26). The integrated circuit (IC) chip contains an electronic product code or EPC (Electronic Product Code) unique. The antenna, which is attached to the chip in the label, transfers data from the chip to the reader. A larger antenna shows a longer reading range [55] [56] [57].

The label is attached or identified in an object identified, such as a product, [57] box or a pallet. The labels can be scanned by mobile or stationary readers with radio waves. [57] The RFID tag sends information to a host computer to host the database via the RFID reader [55] [56] [57]. Labels can vary depending on the amount of information they may contain, their life expectancy, their capacity for recycling, the method of attachment, ease of use and costs. [54] Figure 17 shows the internal structure of an RFID tag.

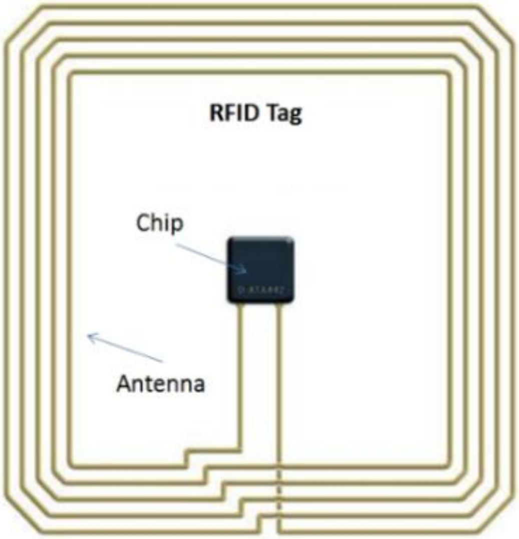


Figure 17: RFID tag image

RFID tags have three classifications, these include, active, passive and semi passive *[58] [55]*. Table 3 highlights the comparisons of features among active, semi-passive and passive tag.

Table 3:Active vs Passive vs Semi-passive [59]

Feature	**Passive**	**Active**	**Semi Passive**
Read Range	Short (Up to 10cm)	Long (Up to 100m)	Long (Up to 100m)
Battery	No	Yes	Yes. Where the battery powers the chip.
Life Validity	Up to 20 years	Between 5 and 10 years	Up to 10 years
Storage	128 bytes read/write	128 kilo bytes read/write	128 kilo bytes read/write
Cost	Cheap	Very Expensive	Expensive
Application	Attendance Management System	Proximity Access Control Card	Identification badge

Tag features also differ according to the frequency bands in which the tag is designed to operate. Four frequency bands are used in tag design utilized [59]:

(i) Low Frequency - LF 125 - 135 KHz;

(ii) High Frequency - HF 13.56 MHz;

(iii) Ultra-High Frequency - UHF 860-960 MHz;

(iv) Microwave Frequency - 2.45 - 5.8 GHz.

Tags operating at Ultra High Frequency (UHF) have longer reading ranges than tags operating at other frequencies. [54]. Table 4 shows the tag frequencies, advantages and disadvantages.

2.7.2 RFID Reader

The second component in an RFID system is the reader. It consists of an antenna, a decoder and a transceiver. The reader is also known as a transceiver. This means that it’s a combination of a transmitter and a receiver. The readers’ role is to query a tag and receive data from it [60]. A reader uses its built-in antenna to communicate with the tag. When a reader broadcasts its radio waves, all the tags chosen to respond to that frequency and within the range of the reader will respond. A reader is able to communicate with tags without a direct line of sight depending on the radio frequency and type of tag used. Readers are able to process several items at once, this allows for increased read and processing times [57]. Readers convert radio waves from tags into a form that can be passed to middleware. Readers accomplish two tasks, these include, receiving commands from the application software and communicating with tags [58].

Readers fall into two categories. These are the active and the passive readers. Active readers have the ability to detect an active tag at a few meters to the line of sight. The passive reader on other hand, can only detect passive tags at a few centimeters away from itself [61]. Readers contain built-in anti-collision schemes. A single reader can operate on multiple frequencies. Readers can be used as standalone electronic devices or can be integrated with other devices.

A Reader consists of components such as power for running a reader, a communication interface, a micro-processor, channels, a controller, a receiver, a transmitter and memory built into it [62]. A reader can be fixed in a suitable place or hand-held. A hand-held reader is a small, mobile, lightweight device that is used to receive information from the tag as one moves along. A fixed reader is installed on a stationary point. It can be secured on a wall or a ceiling to read movement, location, or internal data of objects in the area as shown in Figure 18 [62] [63] [64].

2.7.3 RFID Antennas

Qian [53] describes an antenna as a device which has the ability to convert electromagnetic waves received to a current signal and vice versa. The antenna generates radio signals to activate the tag and read/write data to it [42]. An antenna amplifies the signal emitted by the reader to the tag. Equally, it is used to amplify the signal which is returned to the reader by the tag, thus increasing the tag's reading range [43]. The antenna controls the RFID systems' data acquisitions and communications. The electromagnetic field generated by an antenna can exist persistently when multiple tags are expected to be read continually. Antennas can be built into a doorframe to receive tag data from objects being passing through the door [42]. The longer the antenna, the longer the capturing range is [45]. An illustration of an RFID antenna is shown in Figure 18.

Table 4: Tag frequencies, advantages and disadvantages [30] [31]

Tag Frequency Type	Read Range	Advantages	Disadvantages
Low Frequency tags (LF)	LF 125 to 135 KHz have a very short read range up to 40 cm with low- read speed	Least affected by their surroundings. Least affected by the presence of water.	Can't read tags large number of tags (lower read speeds) and at distances of more than half a meter. Larger tags (may not fit on small objects)
High Frequency tags (HF)	HF 13.553 to 13.567 MHz have a short to medium read range – 30cm to 1m with medium-read speed	Cost less than most LF. Can read tags over a larger distance than LF.	Shorter tag read range than UHF and Microwave. Not best for reading many tags at the same time, but better than LF.
Ultra-High Frequency tags (UHF)	UHF 860 to 960 MHz have a medium read range -60cm to 6m with high-read speed. The tag costs are high.	Generally, cost higher than LF or HF. Identify objects fast because of fast read speed. Have good range.	There can be more RF transmission complications
Microwave frequency tags (MF)	MF have a medium read range -60cm to 15m with high read speed. Microwave tags are very expensive	Identify objects fastest because of fastest read speed. Excellent for reading many tags at the same time.	Cost more than LF. Doesn't work well through water or objects with water in them

.

Figure 18: Antenna [42]

2.8 Central Node Computer System (Database Server/ Middleware) rewrite

The middleware and the database server form the core of a complete RFID system [42] [45] [65]. The data transferred between the tag and the reader is only useful for a commercial application if the large amounts of information are integrated into a larger system [66]. The middleware at the central node manages this data embedding. The middleware manages the information exchange between the readers and the main database server [67]. The middleware between readers and applications includes two interfaces, the application interface and the reader interface, to communicate with the environment [68]. Drives are usually connected to a main database via middleware. The middleware cleans up the data obtained from the communication by eliminating erroneous readings. It also performs the aggregation and filtering of the data. By monitoring multiple drives, the middleware can also detect the movement of labels as they move from one reader's reading range to another [66].

In addition to middleware, the servers on which the databases are hosted are essential components of a complete RFID system. Computer database servers provide storage, management, and read and write control of radio frequency tag data. They deliver the data received from the reader to the software application [53].

I) Other RFID Attributes

a) Electronic Product Code

The Electronic Product Code (EPC) is the code that is used for automatic and unique identification of objects such as parts, products, pallets, locations and so on. It is a standard product coding structure for item management applications [68]. EPC is the - 16 - standard designed to allocate a unique identifier to each object. EPC comprises four sequences of binary digits, these include [69]:

(i) an eight-bit header,

(ii) the EPC manager (28 bits),

(iii) the product type (24 bits) and,

(iv) Serial number of the product (36 bits).

The EPC global Inc. oversees the development of the EPC Standard [69]. An example of an EPC code is shown as an image in Figure 19. The development of the Electronic Product Codes (EPC) was initiated by the auto ID center in 1999 [70].

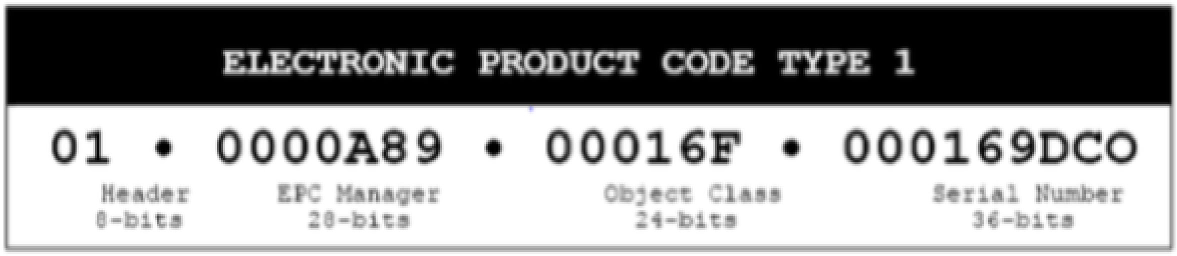


Figure 19: EPC example image [70]

II) RFID Limitations

a) RFID Standards

MuzaffarIqbal and Singh [45] indicate that standards for radio interface protocols (radio frequency, data signal strength, communication protocols, for example), tag encoding format (writing and blocking data) are essential. , Encryption) and information about the service infrastructure (e.g. data structure for supply chain applications). Information coding models and information processing software vary from provider to provider. When switching systems from one provider to another, all items must be redrawn or the software changed. Therefore, it is important to develop common RFID standards that should be accepted by all [42]. Scattered standards leave much freedom in the communication protocols, formats and choice of information store. Current standards focus on radio interface protocols, data content and application of technology. According to Samadi [70], the International Organization for Standardization (ISO) has created some standards necessary for RFID technology. Some of the basic standards established by ISO include [70]:

(i) ISO 11784 for the monitoring of RFID cattle.
(ii) ISO 11785 for the interface protocol.
(iii) ISO 14443 for the use of smart cards in payment transactions and
(iv) ISO 15693 for neighbourhood maps.

Standardisation is a crucial factor that must not be ignored in RFID technology

(b)Costs

The cost is another major obstacle to the introduction of RFID [42] [52] [71]. The drives, antennas and tags used in this technology require large sums of money. Additional system costs include attaching labels to items, buying and installing drives, implementing system application solutions, redesigning work processes, and training and education personnel [42], [71]. In [72] the author indicates that the cost of a fully functional RFID system can range from $ 20,000 to $ 1 million, depending on the size of the application and the application. Recovery times are usually too long [73].

Depending on the type of system and uses, the initial installation and operating costs may be too high [71]. In [56] points out that the initial implementation of an RFID system is very expensive, but the benefits in most cases outweigh the original costs. The cost is another major obstacle to the introduction of RFID [42] [52] [71]. The drives, antennas and tags used in this technology require large sums of money. Additional system costs include attaching labels to items, buying and installing drives, implementing system application solutions, redesigning work processes, and training and education personnel [42] [71]. The author in [72] indicates that the cost of a fully functional RFID system can range from $ 20,000 to $ 1 million, depending on the size of the application. Recovery times are usually too long [74]. Depending on the type of system and uses, the initial installation and operating costs may be too high [71]. Hashemipour [74] and Sharma et al. [56] point out that the initial implementation of an RFID system is very expensive, but the benefits in most cases outweigh the original costs.

2.9 Data Security and Confidentiality

Kuar et al. [44] argued that, depending on the scope and, in some cases, the law, it may be indispensable to prevent unauthorized persons from reading or writing data stored or transmitted there from labels. Therefore, encryption (data encryption) must be ensured at all interfaces where data can be intercepted or transmitted. This can be done both on the medium itself and on the communication reader of tags or reader host.

2.9.1 Deployment of RFID Tags and Readers

a) Deployment of Tags

Dolgui and Proth [69] suggest that tags can be deployed by introducing them at the object level, i.e. each object is tagged. Consequently, each object is tracked to ensure that any element that disappears from the system is recognized immediately [69]. Ruiz-Garcia and Lunadei [52] also suggest that labels can also be inserted into an object or placed in the packaging.

b) Deployment of Readers

RFID reader can be deployed in two ways namely fixed or hand-held. The RFID reader can be fixed in an adequate place or hand-held [62] [63] [75]. A hand-held reader is a lightweight device that can be carried around [62] [63] [75]. A fixed reader is installed on a stationary point, for example, on a wall or a ceiling. [62] [63] [75]. Antennas can be built into a doorframe to receive tag data from objects being passing through the door [42].

c) RFID and Cloud Computing

Data collected by RFID readers can be processed and stored either on local servers or in servers hosted in the cloud [76]. Cloud Computing is a computing paradigm where real-time scalable resources such as files, data, programs, and hardware can be shared with users over the Internet [76]. Cloud computing should be the solution that solves the problem of processing large amounts of data [77]. Using cloud computing significantly reduces the cost of deploying software and data storage solutions. Cloud solutions have desirable features such as high scalability, agility, high availability and reliability, and multi-sharing [77]. Clouds offer a variety of service models, including: software, platform, platform and infrastructure as a service [77]. In the IaaS service model (Infrastructure as a Service), vendors offer physical or virtual machines that can meet customer requirements for implementing software solutions [77]. The PaaS service model (Platform as a Service) already has software applications such as an operating system, programming language or web server installed [77]. PaaS facilitates the implementation and testing of software solutions and provides the resources needed to run applications. Finally, the SaaS service model (Software as a Service) is described as a pay-per-view service, where vendors offer their customers a fully configured hardware and software solution [77]. The advantage of SaaS is that customers do not have to worry about maintenance, hardware or software [77]. Figure 20 shows an example of a cloud configuration.

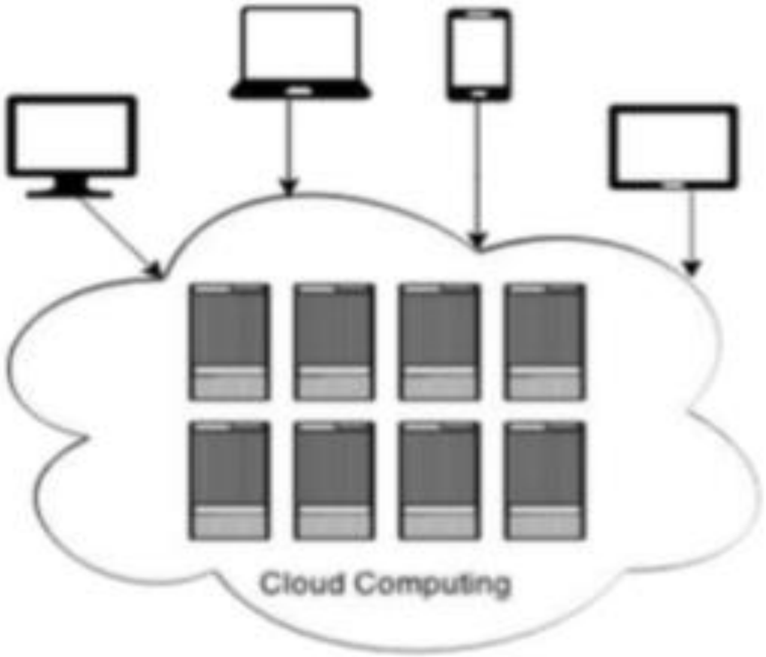


Figure 20: Cloud configuration [77]

2.10 Review of Software Development Methods

A software development methodology (SDM) is a process sequence that leads to the development of an application [78]. It is a set of modeling conventions, including a modeling language and a process [79]. The modeling language helps to model the different aspects of the system, and the process determines the activities to be carried out for the development of the system [80]. , Software processes are a series of related activities that lead to the manufacture of software products [81]. In a software process, user requirements are translated into software requirements.

The requirements are then translated into designs, the designs are implemented, and the implementation is tested. Software processes can overlap or iteratively execute [78]. An SDM can be classified into two classes, a conventional SDM and an object-oriented SDM (OOSDM).

2.10.1 Traditional methodology and object-oriented methodology

Traditional approaches to system development consider software as a set of programs or functions and isolated data. Algorithms and data structures form a program. A structured method based on the waterfall model [82] [83] [84] is an example of a traditional approach to system development. The Cascade Model takes a very formal approach to the phases and activities of the System Development Life Cycle (SDLC). The activities of one phase must be completed before you can move on to another phase. An iteration is not allowed model [82] [83] [84]. The SDLC OO approach, on the other hand, pursues an iterative and incremental approach to system development. In OO, the SDLC is visualized as a series of increments or phases. Everyone from SDLC phases are interactively visited until the developer is satisfied with model [83] [84] [85]. The main difference between traditional system development methods and OOSDMs depends on their main purpose. The traditional approach focuses on the functions of the system. The OOSD approach focuses on the object that combines data and functionality model [82] [83] [84]. The development phases of a system, ie planning-analysis-design-implementation, do not change. The only change, however, is the way they are performed. The structured approach focuses on understanding a problem using a model called the Data Flow Diagram (DFD). Consequently, all system components are derived from DFD model [82] [83] [84] On the contrary, the OO approach uses use cases. There are many models that need to be dealt with in the OO approach, and there are no clear steps so that the design of system components logically follows from a single model [82] [83] [84].

2.11 Methodology for Object-Oriented System Development

An object-oriented system development methodology (OOSDM) can be defined as a system of principles and procedures applied to the development of object-oriented software (OOSD) [85]. OOSD provides a way to develop software by creating standalone modules or objects that are easy to replace, modify, and reuse. Object Orientation (OO) is a means of visualizing and modeling the world or system as a set of interacting and correlating objects [86]. An object can be a physical or immaterial physical entity. Examples of objects are an agency, a job, a place, or a person [86].

2.11.1 Advantages of Developing Object-Oriented Systems

The advantages of an OOSD approach to system development as opposed to a traditional approach are [83] [84]:

(a) The orientation object (OO) offers a higher level of abstraction at the object level. Objects encapsulate data and functions and thus their higher level of abstraction. Development can be continued at the object level, ignoring the rest of the system for as long as necessary. This facilitates the design, coding, testing and maintenance of the system.

(b) OO ensures a seamless transition between the different phases of software development. OO uses the same language to talk about analysis, design, programming, and database design. This transparent approach significantly reduces complexity and redundancy. This allows a clearer and more robust system development. On the other hand, traditional approaches to system development require different styles and methods for each stage of the development process.

c) OO promotes reusability. Objects are reusable because they are modeled directly from a real problem domain. Each object stands alone or in a circle of other objects.

2.11.2 Uniform Modeling Language

The modeling language used in an object-oriented SDM is the Unified Modeling Language (UML). UML is a set of diagram techniques [84]. UML uses graphical notation to express the design of software developments [80]. Examples of design artifacts include requirements, architecture, design, source code, test cases, prototypes, etc. [86] [87]. The modeling provides a representation or simplification of reality. It provides a plan of the system. UML supports independent specifications for specific programming languages, technologies and development processes [86] [87]. The underlying assumption of UML is that no diagram can capture all the different elements of a system [80]. UML consists of three basic elements, namely elements, relationships, and charts. The elements are the main components of the model, while the relationships link them. Finally, diagrams provide mechanisms for grouping collections of elements and relationships. Examples of elements in UML include [86] [87]:

a) Structure: is the static part of the model, which is a conceptual element. Examples of structural elements are classes, use cases, collaboration and components.
b) Behavior: represents behavior in time and space. Interaction and state describe behavioral elements.

The UML is characterized by nine main diagrams. A diagram is a graphical representation of a group of elements and relationships in which node elements and edge relationships are. The nine main diagrams are: class, object, use case, order, collaboration, status table, activity, component, and deployment [86], [87].

2.11.3 Object-oriented system development: A case-based approach

A use case is an interaction between a user and a system that captures the goals and needs of the user [81], [87]. The main advantage of a case-based OOSD approach is that all design decisions can be tracked directly according to user needs [88]. OOSDMs consist of an object-oriented system development cycle (OOSDLC). The OOSDLC file contains three macro processes, namely Object Oriented Analysis (OOA), Object Oriented Design (OOD), and Object Oriented Implementation (OOI). The OOSDLC macro processes can be broken down into the following phases [86] [87] [89]:

a) Object-oriented analysis (OOA phase): The requirements of the users are modeled, what the future system has to do. OOA helps to understand the needs of the company and to process the requirements. OOA focuses on developing an object-oriented model of the problem domain. OOA answers the question of what the system should do. The result of this phase is a conceptual model consisting of two results, namely requirement models and object models.

b) Object-Oriented Design (OOD Phase): OOD provides the ability to develop object-oriented software / system models to implement the OOA-determined requirements. The result of OOD is a plan that shows how the system meets the requirements analysis model requirements. OOD answers the question of how the system will do this.

2.11.3.1 Object-oriented Languages

The OOP languages include Java, Cis-C (C #), and C-Plus Plus (C ++). Java is a portable OOP language introduced by Sun Microsystems [90] [91]. C # is a C ++ and C ++ based OOP language and was developed specifically for the Microsoft .NET platform. Microsoft's .NET platform provides developers with the capabilities they need to build and run computer applications that run on computers on the Internet. C ++ is an extension of the language "C". C ++ offers functions for OOP. C ++ was developed by Bjarne Stroustrup at Bell Laboratories [91].

The use of The use of an OOP language offers some advantages over a non-OOP language such as [90]:

a) Improved productivity in software development: OOP has a modular structure; i.e. it allows the separation of tasks in the development of object-based programs. It is extensible because objects with new attributes and behavior can be extended. In OOP, objects can be reused in and between applications. Because of these three factors - scalability, scalability, and reusability - object-oriented programming improves the productivity of software development over traditional procedural programming techniques.

b) Software Maintenance Function: For the above reasons, maintaining object-oriented software is easier. Due to the modular nature of the system, part of the system can be updated in the event of problems without requiring extensive changes.

c) Faster development: Reusability allows for faster development. OOP languages come with extensive object libraries. Code developed during the projects can also be reused in future projects.

d) Reduced development costs: Reusing software reduces development costs. Typically, object-oriented analysis and design (OOAD) requires more effort, which reduces the overall cost of development.

e) Better Software: The faster development of software and its development costs reduce the time and resources required for software verification. OOP tends to lead to better software.

2.12 Geographical Information Systems (GIS) and Geographical Positioning Systems(GPS)

For centuries, geographic information in the form of paper maps has been a driving force for the progress of our society. Just a few decades ago, the manipulation, synthesis and presentation of geographic information on paper maps was limited to tasks that were limited to manual and non-interactive processes. The exponential improvement in the performance of computer technologies and the increasing demand for interactive manipulation and analysis of geographic information have led to a need for Geographic Information systems (GIS)

2.12.1 What is Geographical Information Systems (GIS)

Geographical Information Systems (GIS) can generally be described as purpose computer-based technologies basically used for handling geographical data in digital form in order to capture, store, manipulate, analyse and visualize information, where part of the information is sets of spatial or geo-referenced data [95]. Geographic Information Systems are a special class of information systems that keep track of not only events, activities and things, but also of where these events, activities, and things happen or exist. In essence, GIS are spatial databases of digital maps which store information on various phenomena and their locations. Figure 21 depicts a basic GIS system.

GIS have been used in a multitude of applications as ‘scientific tools in natural resource management (forestry, agriculture, conservation), cave and karst research, visitor management, environmental management, health and environmental health research, mining and petroleum research, hazards management and Earth science, among others [96].

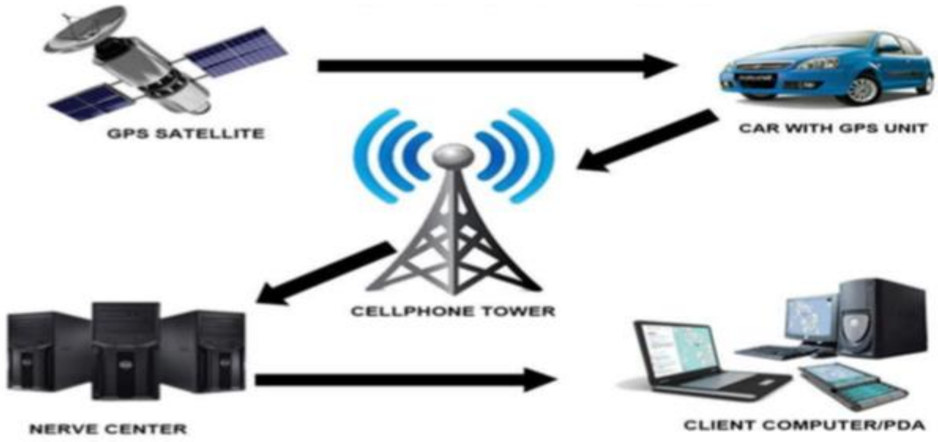


Figure 21: Basic GPS system [93]

2.12.1.1 Basic GIS Concept

Certain characteristics of geographic information which are peculiar to it impose requirements on the design of the architecture of a GIS. The first point of view that can be used to discover these requirements consists of an analysis of the functionality that must be provided by any GIS application. This functionality can be classified as follows [97].

(i) Data input and verification.

This concerns all aspects of capturing geographic data, verifying their correctness and converting them to a common digital form.

(ii) Data storage and management.

It covers the structure and organization of geographic information both in terms of the way in which it is perceived by the user (i.e. Conceptual model) and the way in which it is handled in the computer (i.e., logical model and physical model).

(iii) Data transformation and analysis.

This functionality consists of the processes of editing the information to keep it up to date or to remove errors. Data analysis is one of the main tasks of GIS, and concerns the application of analysis methods to the information to achieve answers to the questions asked to the GIS.

Data output and presentation.

The functionality of producing maps and map-based material is a highly distinctive feature of GIS compared with a general-purpose information system. Together with the analysis techniques, this is the aspect that differs the most from traditional information systems.

2.12.1.2 GIS as a decision making tool

GIS has a wide range of areas where it can be applied. Some examples include urban planning, forestry, climate science, military use, emergency management, public health, epidemiology, location tracking etc.

GIS can use spatially referenced data, make detailed location based analysis, and keep track of events on an area over extended period of time to see how things are changing with time. A university may require to make complex decisions about its environment but sometimes decisions are made with incomplete information. GIS enables to build a model that helps to make decisions easier in a complex environment. Visually depicted data is far easier to understand than just the raw data itself. In addition to that, GIS makes the interaction between various factors that the data represents to be easily recognized. For example, in University Access Control one might need to know the number of people accessing the university premise, their exact location, the number of the undeserved people and the accessibility to the existing facilities. The acquired data on its own might not be easy to understand or make sense at all to take a comprehensive action. Especially, in the case of spatially referenced data such as location, it is virtually impossible to conceive without the help of a map. Therefore, maps are a key in turning raw data and experience into usable information.

A large amount of different data becomes more conceivable and easier to understand when processed into required information.

Geographical Information Systems (GIS) have been integrated with other technologies to build systems such as fleet tracking system. An example is GIS, GPS, GPRS and Web – based Framework for Fleet Tracking [102]. Real time location information of the fleet is collected via GPS. This information is transferred continuously through the General Packet Radio Service (GPRS) to a central database. The users are able to view the current location of each of the vehicles in the fleet via a web-based GIS application.

Visitor location can be tracked in any University Via GPS and viewed and displayed via GIS through a server.

2.12.2 Global Positioning System (GPS)

GPS is a modern technology [92]. The importance of GPS in our daily lives is undeniable. This is because GPS applications are growing rapidly in today's dynamic world. The main objective is to facilitate the execution of tasks and to solve many of humanity's problems. It's very important in health, crime, transportation and communications, and its applications have been expanded [92]. The Global Positioning System (GPS) is a space navigation system that provides location and time information in all weather conditions, whether it is on or near Earth, where four or more are more than four GPS satellites in sight [92]. The Global Positioning System (GPS) shows you where you are on Earth. A related study [92] notes that this is a navigation technology that provides accurate locations and information. GPS is a space satellite system that allows you to contact any GPS compatible receiver. GPS (Global Positioning System) technology is an essential tool for the management of agricultural and natural resources. [92] adds that the Global Positioning System (GPS) is a system of Navigation system based on a network of 24 satellites in orbit. The system provides vital information to military, civil and commercial users worldwide and is freely accessible to anyone with a GPS receiver. GPS works in all weather conditions around the world. The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information anywhere, regardless of weather conditions, on or near Earth, where there is an unobstructed line gives. With four or more GPS satellites, GPS satellites rotate around the earth twice a day in a specific orbit. These satellites send information about the signals to earth. This signal information is received by the GPS receiver to measure the correct position of the user.

The GPS receiver compares the time at which a satellite transmits the signal with the time at which the signal is received. The calculated time difference allows us to determine the distance of the satellite. By measuring the distance of some additional satellites, the position of the user can be checked and displayed on the electronics board of the device. GPS is a satellite and ground based radio navigation and location system that allows the user to determine very precise positions on the earth's surface. Remote Sensing: Remote sensing technologies are used to collect information from the Earth's surface from a remote platform, usually a satellite or air sensor. Most remote sensing data used for mapping and spatial analysis are collected as reflected electromagnetic radiation and converted into a digital image that can be superimposed on other spatial data.

According to [93], GPS technology and its application can be designed using all three GPS components. Its three components are: The Room Segment: which consists satellites and transmitted signals. THE CONTROL SEGMENT: consists of ground stations (worldwide), which ensure the proper functioning of the satellites. THE USER SEGMENT: consists of receivers which you can hold by hand or get into your car.

2.12.3 Various Navigation Systems

Currently, navigation systems are available and people use them to track each object. GNSS (Global Navigation Satellite System) includes three main satellite navigation systems. These are GPS (Global Positioning System), GLONASS and Galileo. Other navigation systems include GPS NAVSTAR navigation timing and Satellite Telemetry, the world's most fully functional US navigation system in the world, the BEIDOU regional system of the People's Republic of China, which is currently limited to Asia and the US. West Pacific, the global system of COMPASS People's Republic of China, is expected to be operational by 2020 [92], IRNSS - Indian regional navigation satellite system, India's regional navigation system covering India and India the north of the Indian Ocean. QZSS - Japanese regional system for Asia and Oceania [92].

Table 5 shows the three main GNSS technologies from which it can be seen that GLONASS and Galileo provide more precise location than GPS but they are costly. GPS (Global Positioning System) is highly available GNSS technology.

Table 5: Shows the three main GNSS technologies [93].

Parameter	**GPS**	**GLONASS**	**Galileo**
Satellites per complete constellation	32(Block III)	24	27+3 spares
Orbital Planes	6	3	3
Plane Inclination	55 deg.	64.8 deg.	56 deg.
Radius of Orbit	26650 km	14100 km	23222 km
Period of required cycle	12 hrs.	11 hrs. 15 min	11 hrs. 15 min
Civil Data Rate of Satellite	50 bps, up to 100 sps	50 bps	50 bps, up to 100 sps
Accuracy	5-20 m	50 -70m	Claimed 1 m
Operation Bands of Satellite	L1,L2,L5	L1,L2,L3,L5	E1,E5,E6

2.13 Related Works

2.13.1 Access Control through People Identification

Manual registration and identification of students in classroom attendance causes time wasting and is prone to personal errors [51]acknowledges that automated identification systems eliminate or reduces time wasted during manual recording of Students attendance by lecturers. Research has shown that using RFID based automated systems [93] [94] to identify and track student attendance in a classroom has advantages such as all student attendance information will be stored in a database. This information cannot be manipulated and can be there used for future reference.

In this paper the author noted that in today's world, technology is fast growing therefore it has become necessary that there is transformation in every field to make productive use of technology. In [95] a Student Authentication and Verification System using Barcode Scanner is designed. The is used to reduce paper work and minimize the work pressure of the library staff and central computer center management experienced when using the traditional keyboard data entry to identify students as they access the services of the library and central computer centre at the college. Figure 22 depicts an image of the Student Authentication and Verification System using Barcode scanner. Barcode technology was used to replace for the traditional keyboard data entry. In this system a web based application is used which integrates all the services of the library and central computer center of the college to access the library and central computer center in most advanced way. "Student Authentication and Verification System using Barcode Scanner" allows the students to obtain access to the facilities of the college such as library and Central Computer Centre more easily but only to those with authorized ID cards. All information about the students, the various users and transactions of the library and Central Computer Centre are stored in the database.

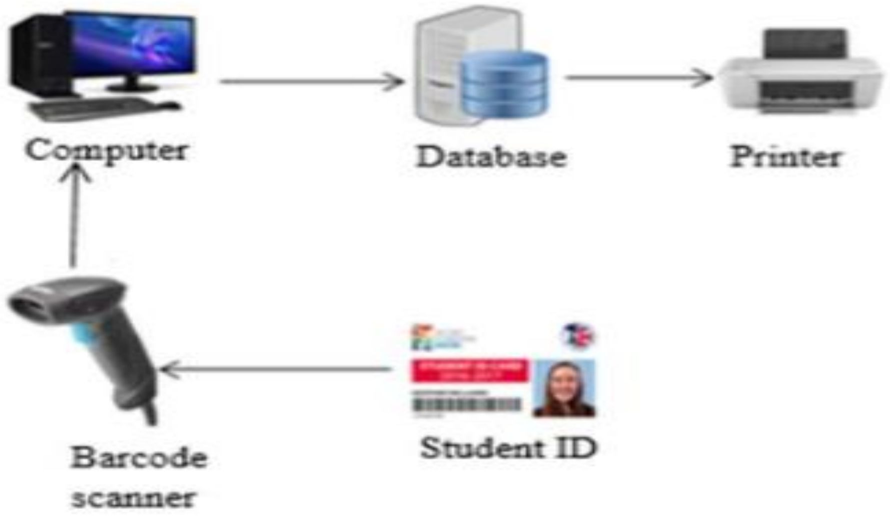


Figure 22: Student Authentication and Verification System using Barcode Scanner [95]

Peter et al in [95] developed an RFID based access control security system with GSM technology to be an addition to already existing security personnel. This system mainly achieves by the use of a Radio Frequency Identification (RFID) system with an operating frequency of 125 kHz, programmed with a microcontroller programmed to send control signals, a DC motor, a relay, a buzzer, a liquid crystal display (LCD) and a GSM / GPRS Modem. The users' unique information by scanned by RFID reader and confirms compliance with the information stored in the microcontroller. The microcontroller is then prompted to enable the DC motor via the L293D driver to display and enable "USER NUMBER and CARD NUMBER". The GSM / GPRS modem sends a SMS alert "Permitted authorized RFID card, the user may enter a user number" to the security personnel. Otherwise, the DC motor is off, the LCD displays "READ RFID CARD NOT VALID", the buzzer stays on for about 5 seconds and the GSM / GPRS modem is enabled to send "An unauthorized RFID card is being used on the security system "on security personnel. The electronic circuit was implemented, the microcontroller codes were written in assembler, using the integrated development environment KEIL Micro vision 4 developed and compiled and programmed into the hex files microcontroller with a universal programmer. The hardware simulation was performed with VSM (Proteus Virtual System Modeling) Version 8.0.

This system (illustrated in Figure 23) proves to have lower maintenance costs and is more efficient than a keys system but lacks prevention of illegal use of card by unauthourised card user. Therefore, would not prevent security threats associated with a stolen card.

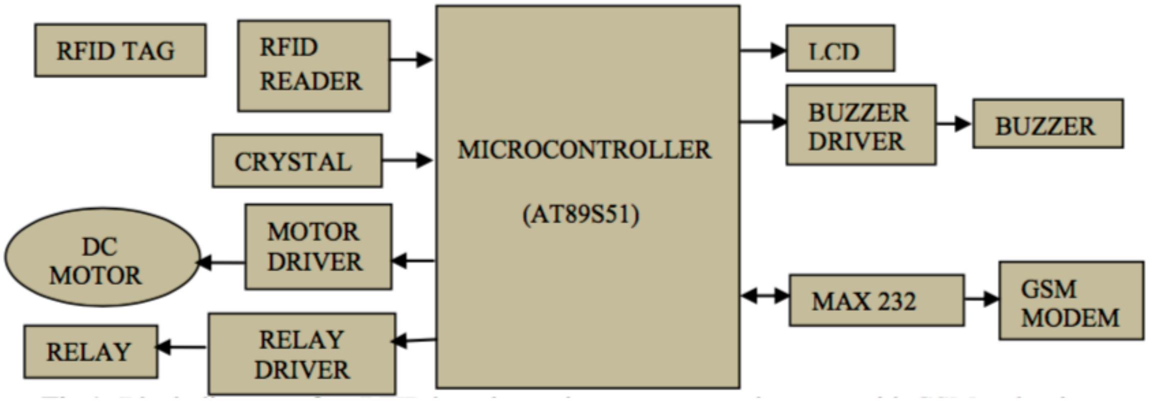


Figure 23: Block diagram of an RFID based security access control system with GSM technology [96]

In [96] an RFID-based automatic access control system with Arduino is developed. The system combines RFID and Arduino technology to accomplish the required task of controlling access in a secure environment in a cheaper, effective and reliable way. Figure shows the hardware connections of an RFID- based automatic access control system with Arduino. When the RFID reader installed at the entrance detects an RFID tag, the system records the user's unique identifier (UID) and compares it with the stored UID for a match. If the detected UID user matches one of the stored UIDs, access is granted. Otherwise access is denied. This work presents an automatic access control system by use Radio Frequency Identification (RFID) with Arduino technology to distinguish authorized users from unauthorized users. The RFID reader reads the RFID tags sent to the user and assigns them to the UID stored in the microcontroller. In the case of a successful match, the microcontroller grants or denies access if no match is found. Such a system shown in Figure 24 can be installed at the entrance of a secure environment to prevent unauthorized access to the environment. Figure 25 shows a block diagram of an Automatic Access Control prototype using Arduino and RFID System.

Another layer of security was not added in this system to cater for unauthourised RFID card use. There is no way of confirming if the person using the RFID card is really the authentic owner or the card is stolen.

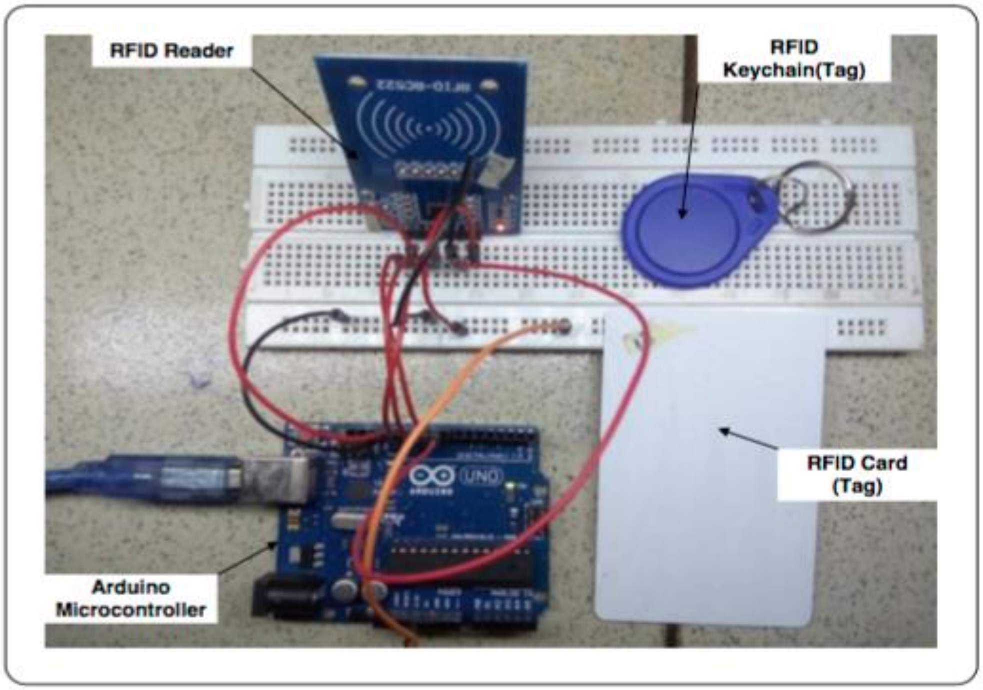


Figure 24: Automatic Access Control prototype using Arduino and RFID [97].

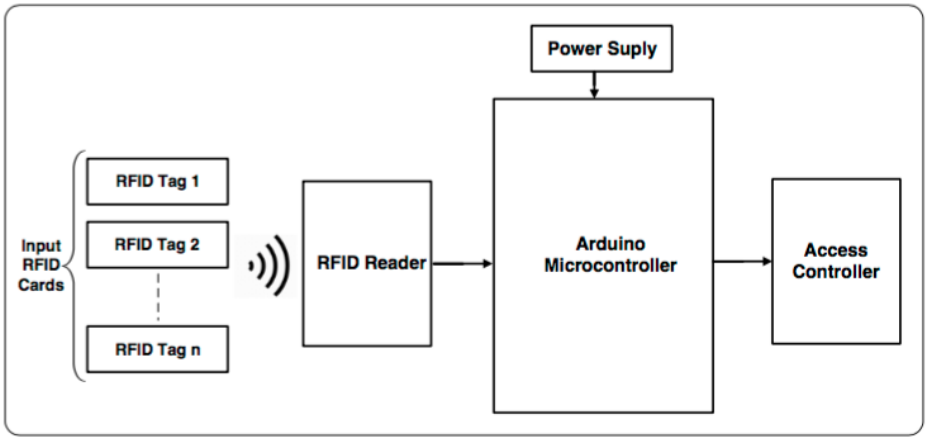


Figure 25: Automatic Access Control prototype using Arduino and RFID System Block [97].

2.13.2 Access Control through Multifactor Authentication

Umar et al. in [97]proposed an RFID and biometrics based security and access control system. This is the design of an RFID-based security and access control system for use in youth hostels at Punjab University. The system combines RFID technology and biometrics to perform the required task. When the RFID reader installed at the entrance to the host detects the UID of the tag, the system records the user's image and analyzes the database for consistency. If both the UID of the card and the captured image match a registered user is granted entry. Otherwise, access is denied and the system activates the alarm to alert unauthourised users to security. The advantage of the system is that it successfully performs security and control tasks by processing information from sub-controllers, e.g. Input monitoring controllers, output monitoring controllers, and confusion monitoring controllers installed on the front door, the exit door, and the mess door, respectively. Although the developed system is useful for reducing threats to the safety of hostels, the response time of the system can be further improved.

Response time can be improved by using dedicated processors instead of computer systems that can process images in real time. Figure 26 shows system Operation of the RFID and Biometrics based security system.

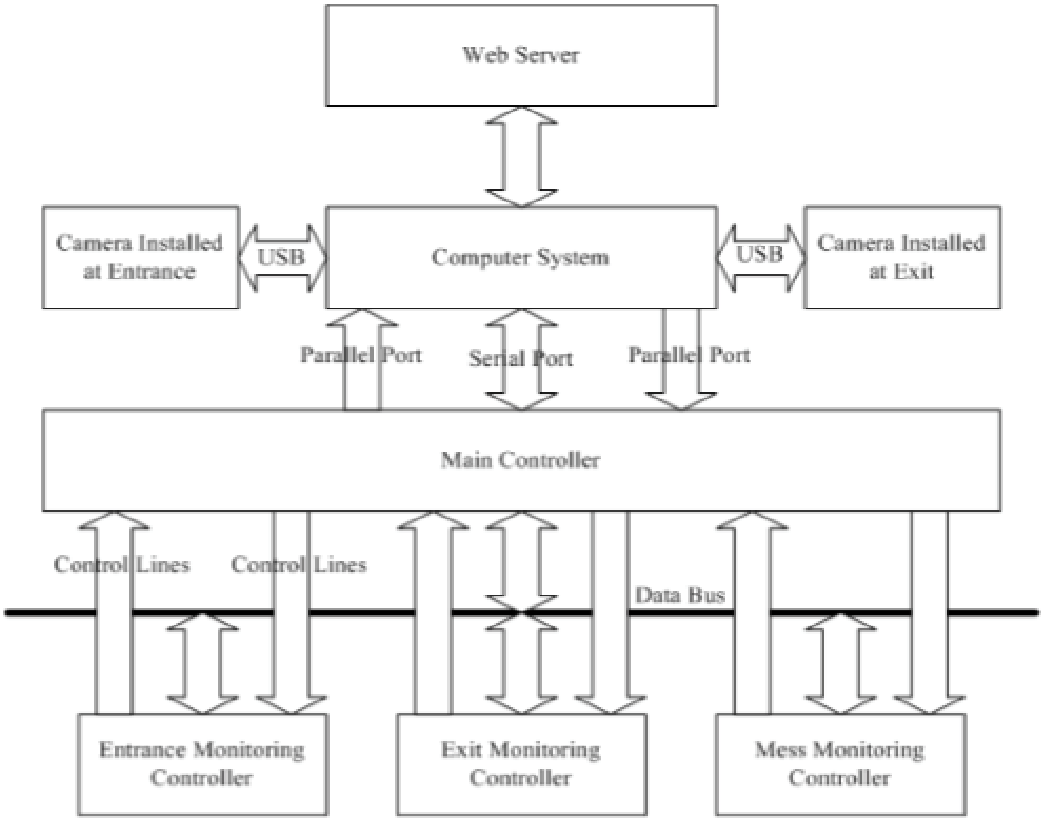


Figure 26: Block diagram showing system Operation [98]

The RFID and biometrics security and access control system has two phases: the registration phase during which ten images of the user of the hostel are captured and an RFID tag issued. The ten images are used to form a feedback neural network with a back propagation learning algorithm, and the convergent outputs are stored according to a particular user. The recognition phase takes place when the point of desire to enter the hostel. At this point, a user receives the RFID user number, the user's image is captured and transmitted to the neural network for detection. If a match is found, the user is granted access. The authenticity of the user is checked in three places: entrance of the hostel, exit of the hostel and entrance of the Mess.

The input and output modules use RFID technology and face recognition for identification, while the mess module uses RFID technology with a password to grant authorization. These modules communicate with the computer system via a master controller. The main controller transmits the module information to the computer system. After processing these interrupts, the computer system sends commands to the modules via the main controller. Data exchange between the main controller and the computer system is via a serial interface, while control lines and parallel interface data are used for handshaking.

In order to respect the limited resources and capabilities inside the tag for performing complex operations. M.E. Beqqal et al. in [98] proposes a solution that combines smart card biometrics solutions. with Furthermore, even if the smart card is falsified or the person ask for authentication with a borrowed RFID tag, the verification based on multi-level of security will deny his access to the secured room. The RFID card is used because it is a fast automatic technique of identification and is combine with the biometric fingerprint to check true identity of the person aiming to access a secure area. Figure 27 illustrates a solution that combines smart card and biometrics authentication.

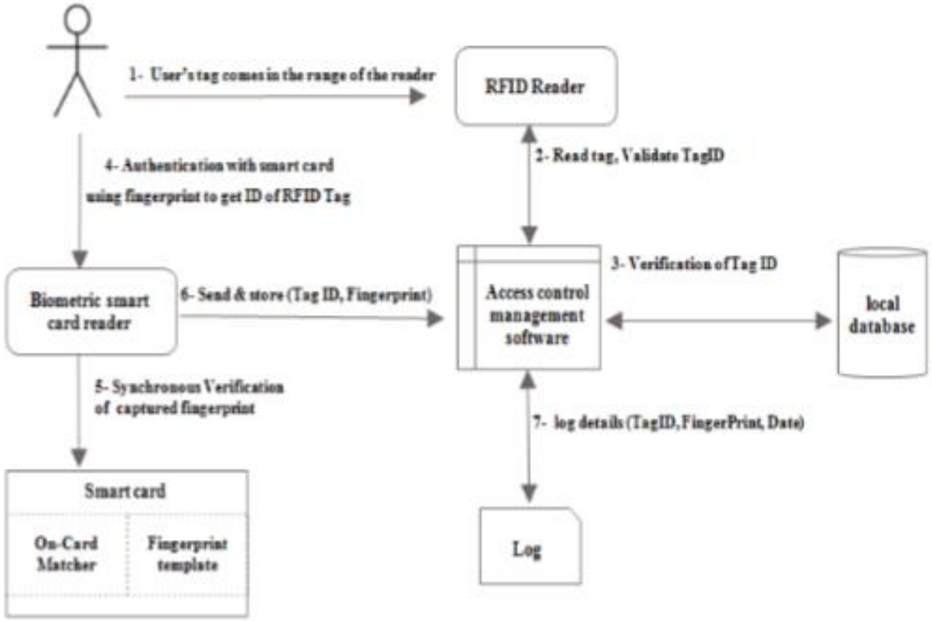

1- User's tag comes in the range of the reader
RFID Reader
2- Read tag, Validate TagID
4- Authentication with smart card
using fingerprint to get ID of RFID Tag
3- Verification of Tag ID
Biometric smart card reader
6- Send & store (Tag ID, Fingerprint)
Access control management software
local database
5- Synchronous Verification of captured fingerprint
7- log details (TagID, FingerPrint, Date)
Smart card
On-Card Matcher
Fingerprint template
Log

Figure 27: Sequence of actions during the authentication process [99]

Radio Frequency Identification (RFID) technology uses electromagnetic fields to transmit data to automatically detect and track labels or object labels [99].

The author notes that it offers opportunities for designing and implementing relatively inexpensive systems, especially for security aspects. In this system a digital access control system is proposed, that can be used in a secure area where only individuals with authenticated authentication information can enter. The system was implemented in the server room of an educational institution in Bangladesh to test its efficiency and spending. The implemented system includes a digital door lock that can be unlocked in real-time to provide secure access indicating activation, authentication, and user verification before the RFID card is brought closer to the reader. To ensure and maintain the overall integrity of the system is connected to a central client-server subsystem. The visitor registration status based on the key identity information is logged and managed by the associated subsystem. The systems rightfully generate a report for all visits but lacks the facility to authenticate the card holder.

Filipe [100] notes that researchers have utilized RFID technology in developing access control system. The author has developed an RFID based monitoring and access control system consisting of RFID terminal, camera, server and an alert device. Upon detecting an RFID tag, the terminal captures a photo and transmits the data including the TAG's UID and photo to the server through TCP/IP connection. The database server is searched for this particular query and sends the results back to the terminal to allow or deny the access. Illicit acts such as a person trying to enter when the door is open without completion of authentication process causes the web application to turn on the alert device using web services. The performance of the system is tested by installing RFID kits with antennas covering a range of 10cm and satisfactory results are obtained.

Xiang-Lei Meng [101] has developed an RFID based embedded security authentication system with novel face recognition structure. The system comprises of two phases first phase is the registration in which ten pictures of user face with different emotions are collected and eigen information is obtained with an extraction algorithm. The information form the registration phase along with a UID is written on RFID tag. In recognition phase, a camera tracks the face and an extraction algorithm returns Eigen information of the face in the picture. This information is then matched with the information already stored on the tag for authentication. The entire processing of this system is on the embedded ARM11 processor. Instead of a computer terminal/server a S3C6410 is used which has resulted in faster response time, about 57ms with an authentication accuracy up to 86.5%. The performance of the system is compared with the existing database systems and is found to have far better response time with the same authentication accuracy.

In [102] Dong-Liang Wu has experimented and implemented a system that can improve the security of RFID access control. The system is based on RFID in conjunction with face recognition and based on neural network. The system recognizes the face of person holding RFID card and denies the access if person is found to be unauthorized. Radial basis function neural network (RBFNN) has been used for learning the face of authorized persons. For extracting the features from the image, Principal component analysis (PCA) has been used and linear discriminant analysis (LDA) has been used for refining these features. The network is trained with localized generalization error model (L-GEM) for enhancing its generalization capabilities.

According to [103] RFID has become a reliable solution for automatically identifying and tracking labels associated with real objects. The author notes that it can be used to integrate physical and digital worlds. In this RFID-based security in an intelligent building is examined. In the Smart Building case study, people (physical objects) carry RFID tags that help them to participate in the calculations. The tag reader checks the information of the tag which is worn by the person. The systems involve a two-stage authentication process which aims to protect the smart building from unauthorized access using RFID-based mechanisms. Two algorithms have been proposed for this purpose. The first ACTIA algorithm performs the verification of the non-collision RFID tag information, while the second IMA algorithm uses the biometric metric known as the face-image match. If authentication fails with ACTIA, image matching is not required because it can be concluded that unauthorized persons are trying to compromise security. The DAISY descriptor, is used by the IMA algorithm which is more accurate compared to SIFT and SURF. The performance of the three algorithms is evaluated in terms of average accuracy, average execution time, accuracy, and retrieval. The results revealed through standard AT & T image data experiments showed that the proposed biometric authentication based on Radio Frequency Identification (RFID) methodology is effective in protecting the smart building with secure access control. Fully automatic trust management in critical RFID applications is yet to be implemented. Figure 28 shows a security solution that can be used in a smart building and Figure 29 shows the flow chart of how the system achieves its function.

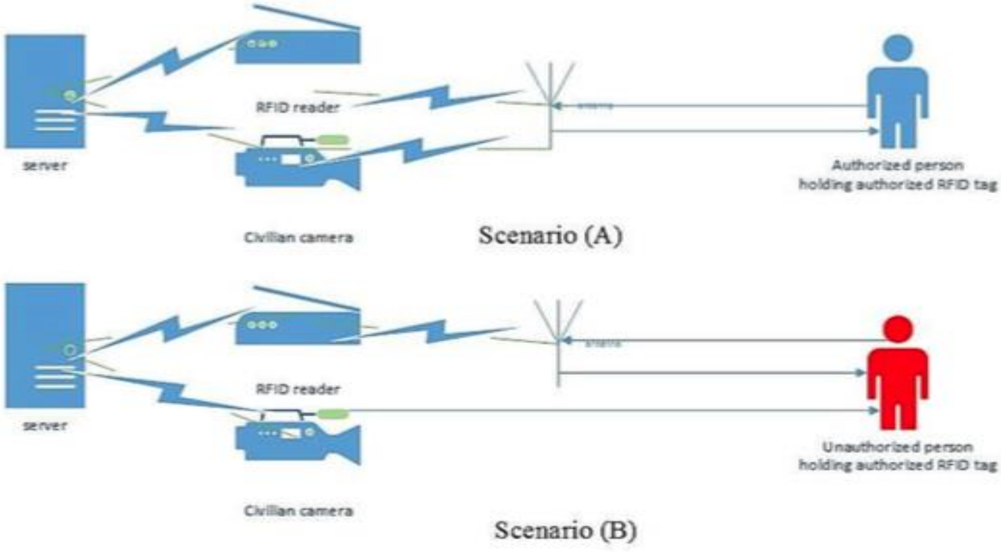


Figure 28: Broad overview of the proposed system [103]

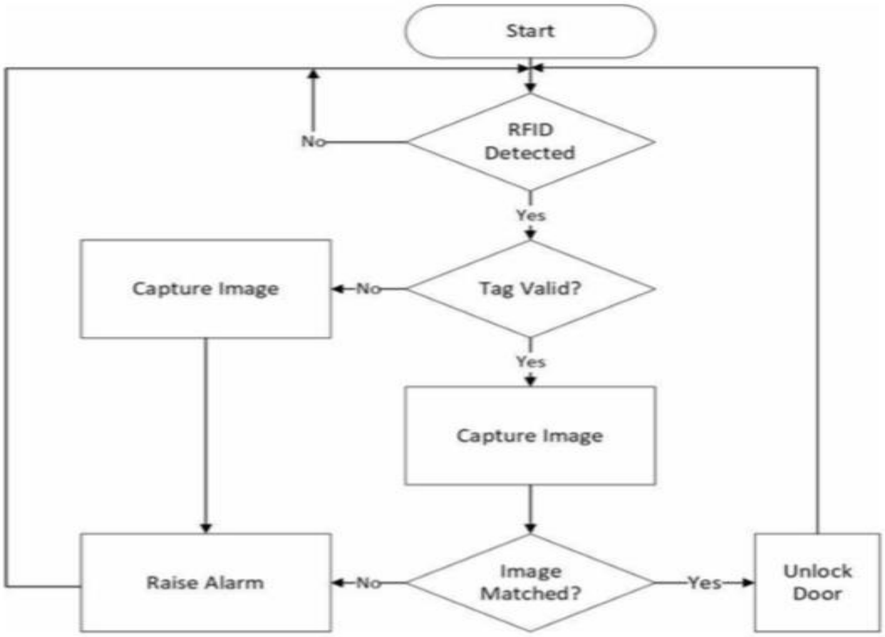


Figure 29: RFID based two-fold authentication [103]

2.13.4 Location Tracking

In [104] a Tracking methods generally based on a moving object’s distance, direction, or both is developed. The tracking system which is based on ZigBee wireless communication as shown in Figure 30 helps to identify the visitor's location, path check and estimated time of arrival.

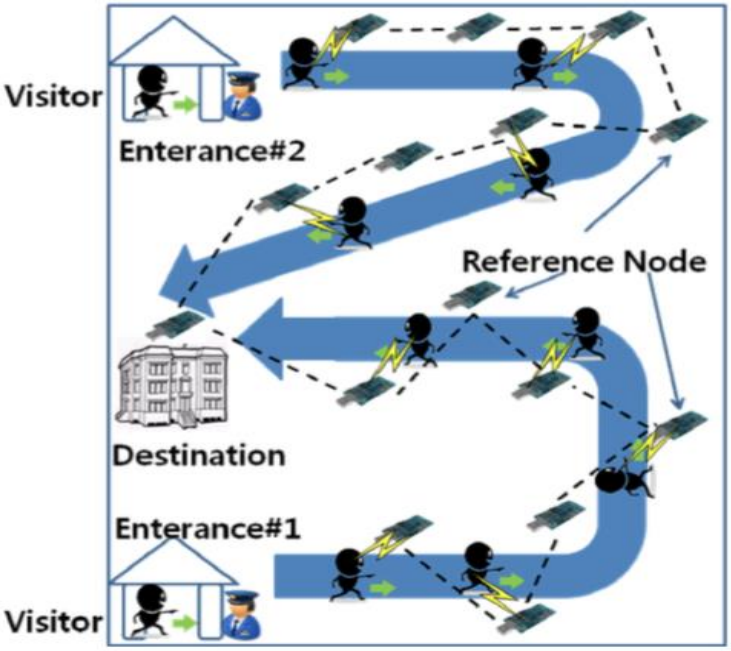


Figure 30: systems structure Tracking using wireless communication [101]

A visitor who wants to visit the university campus or the factory site receives a transmitter. This transmitter is a node that can communicate wirelessly. A node assigned to a visitor is previously assigned a unique identifier. When a visitor arrives at the entrance (it can be greater than or equal to two), he receives a node that can identify the visitors and move them to the destination. In the destination path, the reference node is installed at regular intervals based on the ZigBee communication area. When visitors access the first reference node installed in the migration path, a visitor node communicates with the first reference node and acts as a member or child node. At that time, the visitor information system checks the location of the visitors with information about the location of the first reference node and calculates the estimated time of arrival. Then the visitors move on the defined path to the next place. If the RSSI value of the second reference node is greater than that of the first one, the visitor node is replaced by a child node of the second reference node. The visitor information system displays information about visitor movements and the estimated time of arrival has changed. Finally, as visitors approach the final reference node of the destination, the parent-child relationship changes according to the strength of the signal in the RSSI values and indicates the estimated time of arrival based on the average distance traveled. to the buildings. The location and the path of the visitor are monitored, but real-time physical site capture is active.

In [105]a new upcoming model of real time location system (RTLS) to focus and track the exact location of real time objects in vicinity is proposed. Overcoming the limitations of size, power, attenuation of GPS & DGPS system, the active RFID tags can be easily affixed with objects. The TIA approach of distance calculation will minimize the errors occurred in RSSI method. Geographically fixed matrix of RFID readers at 50 m to 1 km apart, will monitor, track, and calculate the exact position of tagged-object by communicating with the tag and other co-readers. One 48 MHz PLL enabled 8-bit CPU in RFID reader is enough to calculate the TIA with an accuracy of 3.3 m distance. One active tag with 100 mAh cell can respond many thousands of times using IEEE802.15.4 standard which makes it globally acceptable. DSSS and GFSK used in the tag for more reliable data communication. One central server is enough to store, filter, and handle the calculated data flowing from the matrix net of RFID readers.

In [106] the author notes that apart from the importance of tracking the target in wireless sensor networks in an area of application, communication consumption and the lowest energy source must also be considered. The author also further notes that wireless sensor networks are more focused on tracking individual targets for quantitative monitoring methodology. In this study a new method based on quantitative multi-target tracking is introduced. To meet the demand for wireless sensor networks, nodes must first save power and reduce power consumption. A new combination of common probability data using the Innovation Mark (SOI-JPDA) is applied. This algorithm allows for minimal power consumption, and the performance and complexity are very close to the data association algorithm. normal ordinary probability. An SOI-JPDA based multi-target distributed tracking algorithm in wireless sensor networks is proposed. The results of the simulation show that this algorithm can successfully track multiple targets with minimal power consumption in wireless sensor networks.

A system that uses an Android to track and monitor incoming calls, outgoing calls, SMS and the location of employees on the premises is developed [107]. The system consists of three main applications: Employee App, Central Server and Manager App. The Employee App runs continuously on Android phones from company employees. The manager application provides employee details via e-mail to the manager. The database is stored on the central server and is only accessible to the manager. In this system, the system closely monitors the history of incoming calls, outgoing calls, web browser history, web browser history, data usage, and list of unauthorized calls. and employee location that determines employee behavior. in society. The system uses JSP for server-side implementation. Mysql is the database used because it is open source and easy to use. Apache Tom-Cat and Xampp and Android Studio are used to design the system. The connection to the database is established, and the information is displayed to the manager in the form of JSP and HTML web pages. Wi-Fi and 2G are the technologies used, but their speed is limited and makes it difficult to control employees when they are away from the premises. The main idea of this system is to monitor the use of the company's phones. Therefore, the location and use of the phone cannot be monitored if employees are not at hand.

In [108] personnel location tracking is achieved through use of Near field Communication (NFC). Near Field Communication (NFC) is an automatic identification method that remotely stores and retrieves data using devices called NFC tags or transponders. NFC is therefore a wireless identification. Normally, the NFC system consists of two main parts: NFC reader and NFC tag. Each employee receives a Smart ID with integrated NFC tag. NFC readers are in some parts of the organization to read the labels and find the employees. The main goal of the system is to give employees a real-time location in the company's business premises. In addition to the location, the employee's physical location, the system also captures the date and time the employee accessed the system. The employee wears a label recognized by the NFC reader and activates the employee card. The NFC reader reads employee information from the NFC tag, displays it on the host computer, and records that employee's location. The system database automatically updates the employee's location and the supervisor or supervisor can see the employee's location. Data Collection / Pre-Survey All NFC system data is collected as appropriate hardware and software for this system. SQL Server 2008 and Microsoft C Sharp are used for this NFC system. However, the system is very expensive to implement and may not be suitable for government organizations. The following diagram, Figure 31 shows the proposed NFC-based monitoring system.

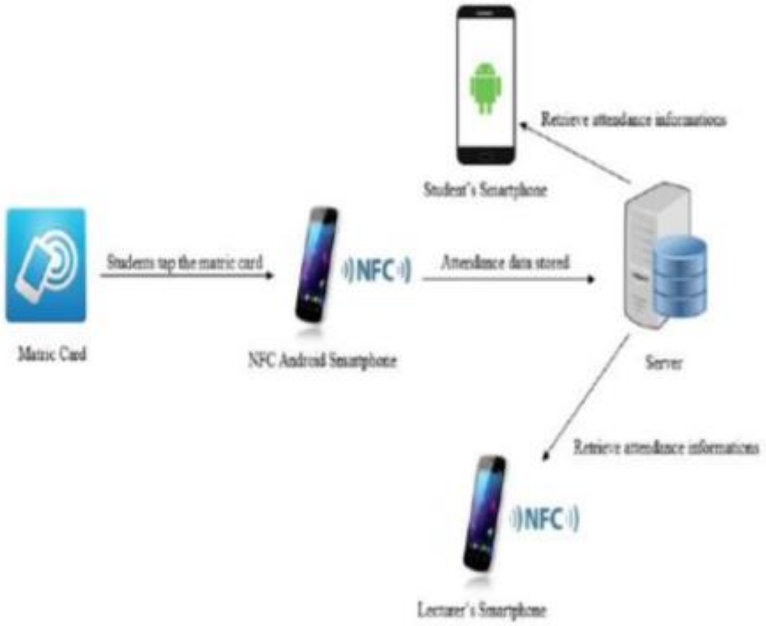


Figure 31: NFC based personnel location tracking [105]

In proposed system [109] an employee's office cell phone usage and location of employee while at work is tracked. The overall behavior of the employee is also tracked, using K-means algorithm. The system uses a Telephony manager to store subscriber id, SIM serial no, etc. All the details like call log, SMS history, Data usage history, web browsing history, location are tracked and recorded. Location of employee is traced by using Global Positioning System. GPS and can also give location of employee at outside the corporate area. The features of this system as shown in Figure 32 are record of incoming and outgoing calls. text and multimedia Messages, browser history, data usage, current location of employee, alerts to Managers, unauthorized call list and behavior of Employee

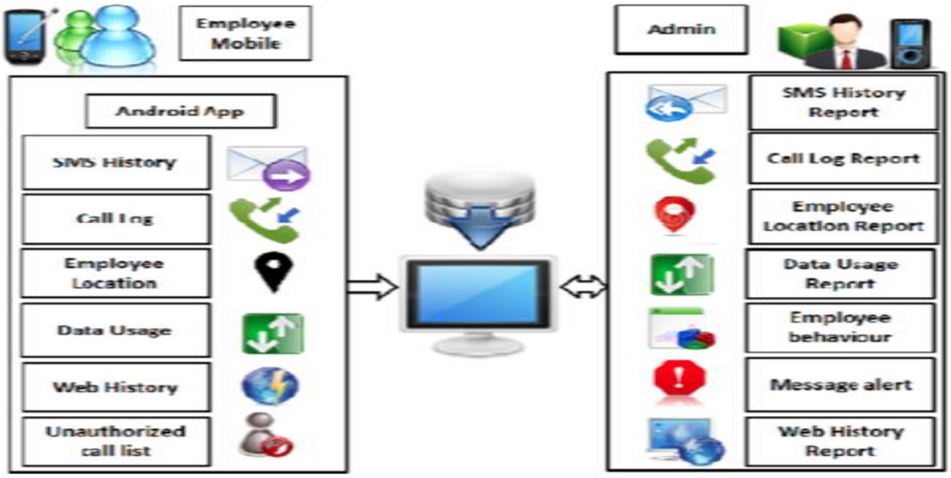


Figure 32: Proposed system architecture [19]

In this study depicted in Figure 32, the author acknowledges that RFID technology meets identification and tracking needs in healthcare environments with the potential to accelerate and increase process flows. As a result, high expectations have been expressed regarding this integration, but hospitals and medical centers interested in introducing RFID require prior knowledge of the use of RFID capabilities, actual expectations and challenges. Electricity. In [110], a laboratory-tested solution in two specific care scenarios is proposed. On the one hand, the case of a medical device monitoring system for healthcare facilities, which enables both real-time localization and theft prevention is proposed. Aspects such as possible EMI interference, choice of technology and management of RFID data from the hospital information system are analyzed. In this case, laboratory reliability testing of the system based on passive UHF RFID will be provided. On the other hand, a patient treatment and control solution in a hospital based on passive RFID-HF with the result of a fully functional demonstrator is analysed. The prototype reduces the RFID functionality to provide a backup data source from the patient wristband. In addition, it provides an offline workflow to increase application security in the event of a network outage, thereby improving patient safety. Considerations of the experiences and challenges encountered are outlined.

2.14 Summary

In this chapter detailed overview of the background theory identification technologies such as Biometrics, Barcode and RFID and some examples of related works to use of these identification technologies have been given. Applications of multifactor authentication by combining biometrics and RFID are many and in various systems of access control and identification. They have been commonly used in various organization such as education, healthcare, supply chain for tracking, monitoring and identification. Tracking of object or personnel has also been successfully implemented by use of GPS.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter presents the research design, the material and methods used to conduct research. The proposed business process to control access by identification and multifactor authentication to control access into the university is outlined. The Chapter also defines the methodology used to design and develop the prototypes for access control and people real time tracking.

3.1.1 System Design Methodology

A mixed method approach was used in this study; qualitative and quantitative. For quantitative data, three questionnaires were designed based on ISO 27002 standard with focus on Physical and Environmental Security, best practice and guidelines. Questionnaires were distributed to 150 students, 120 members of staff (Academicians and Support Staff) and 10 Security personnel. The study focused on four controls of the ISO 27002 Physical and Environmental Security controls.

The overview of the current business processes was learnt through on-site walk-throughs and random interviews with students, security personnel and members of staff. The site walk through was done by entering the University Perimeter as a motorist and as pedestrian. Entering and checking access control available to facilities such offices, hostels and lecture rooms was also done to understand the current business process.

Object-Oriented Systems Development Methodology (OOSDM) was used to analyse, design and develop the software prototype system. Some of the diagrammatic representations that are used in Unified Modeling Language were used to visualise how the system would operate from different perspectives. Object-Oriented System Development Life Cycle (OOSDLC) was used for the systems development in this research study.

The third research question was achieved through an experiment and tests with the prototype. The experiment was done to validate the model by actually testing a person’s location in real time. The testing was done to have a deeper understanding of how visitors’ location in real time can be tracked to allow visitors to be identified and only allow them to access areas they are allowed to.

3.1.2 Sampling

The research population was purposely sampled using the homogenous purposive sampling because the researcher's focus was on specific population characteristics that would adequately answer the research questions which are related to their environment. Data was collected from answered questionnaires. The researcher also took time to visit sites and access the university using different modes as pedestrian or motorist over a period of one month. Random interviews were also done with different people found on campus. Interviews were also conducted from the testers of the prototype to get reviews of the working model.

3.1.3 Data Processing and Analysis

A computer based software called IBM Statistical Package for Social Science [SPSS] was used to process and analyze the data collected from the questionnaires. The data from the questionnaires was presented in the form of charts and narrations. The study also validated results from the prototype by allow it to be tested by independent testers.

3.1.4 Ethnical Consideration

All the respondents to the questionnaires were assured of confidentiality as no identity was required to be revealed as they answered the questionnaire.

3.1.5 Limitations of the Baseline Study

The study faced a lot of apathy from the respondents. It was not easy to collect the questionnaires back on time causing delays in data processing and analysis.

3.1.6 Presentation of Findings

The analyzed data was summarized and presented in the form of pie charts, figures and tables.

3.1.7 Flow of the Methodology

The study followed steps as described in the flow chart Figure 33 below

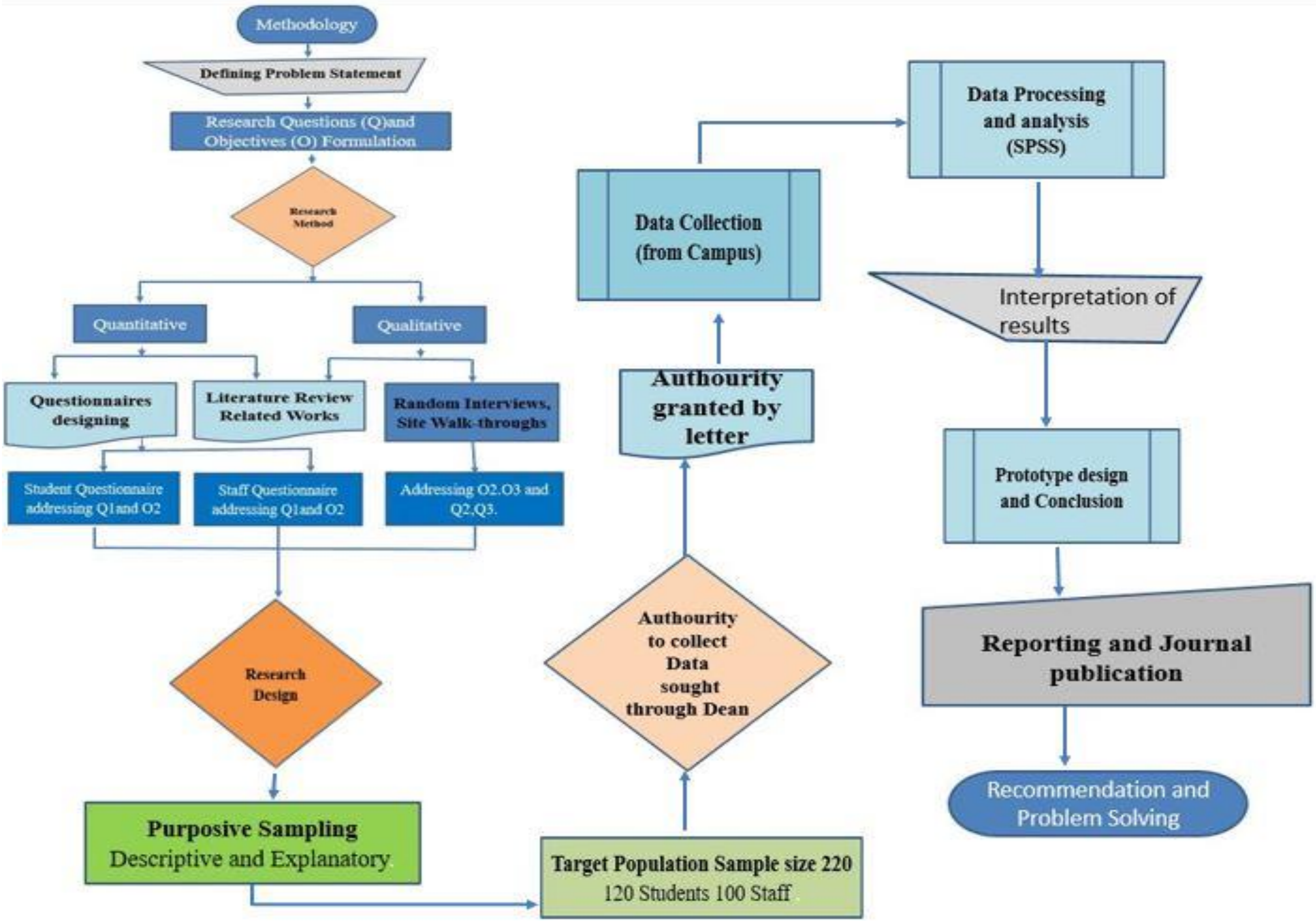

Methodology
Defining Problem Statement
Research Questions (Q)and Objectives (O) Formulation
Research Method
Quantitative
Qualitative
Questionnaires designing
Literature Review Related Works
Random Interviews, Site Walk-throughs
Student Questionnaire addressing Q1and O2
Staff Questionnaire addressing Q1and O2
Addressing O2.O3 and Q2,Q3.
Research Design
Purposive Sampling
Descriptive and Explanatory
Target Population Sample size 220
120 Students 100 Staff
Authourity to collect Data sought through Dean
Authourity granted by letter
Data Collection (from Campus)
Data Processing and analysis (SPSS)
Interpretation of results
Prototype design and Conclusion
Reporting and Journal publication
Recommendation and Problem Solving

Figure 33: Methodology Flow Chart

3.2 Baseline Study

3.2.1 Level of Security at UNZA

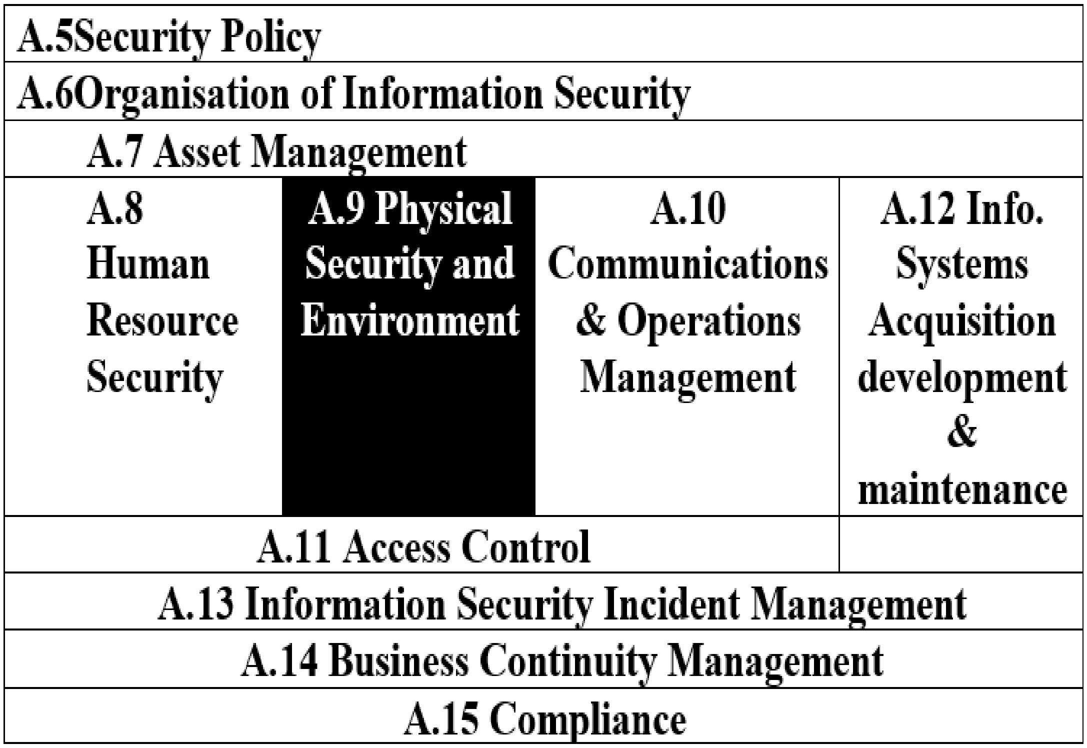
To measure the level of security at the University of Zambia data was collected through three questionnaires that were developed based on the ISO 27002 Physical and Environmental security model. Qualitative and secondary data from existing and reviewed literature supplied through journals, peer reviewed articles and other resources were used to specify the model requirements, design and development of the prototype. The questionnaires were developed with consideration from requirements of Physical and Environmental security as guided by ISO 27002 standards. The following are the best practice and guidelines from the Physical and Environmental:

(i) Secure Areas should have measures implemented that prevent unauthorized physical access, damage or interference to the organization's premises and infrastructure by using controls that are appropriate to the identified risks and the value of the assets to be protected.

(ii) Physical security perimeter should be used to protect areas that contain information and assets important to the organisation such as the people. Entry into the physical perimeter should be controlled by use of walls, controlled entry doors/gates, manned reception desks and other measures can be used. Additional physical barriers where appropriate to prevent unauthourised access and physical contamination should also be used. The measures put in place should be designed in such a way that sufficient redundancy such as single point of failure are taken care of to ensure security is not compromised. Use of appropriate intrusion detection such as video and surveillance can enhance physical security. The walls should be built of an appropriate strength, the windows protected with bars while the doors should be protected will grill gates.

(iii) Physical entry control should be controlled in such a way that appropriate entry controls are implemented to ensure that only authorized personnel are allowed access. Appropriate controls would include such as authentication mechanisms, recording of date/time of entry and exit, and/or video recording of activities in the entry/exit area, as appropriate; identification should be visible, appropriate authorization and monitoring procedures and regular review of all these implemented mechanisms. Authentication mechanisms that can be are for example a keycard or PIN. It should be a requirement for authourised persons to wear visible identification and if any are not abiding they should be reported. Access rights should also be denied were appropriate.

(iv) Secure offices, rooms and facilities should have their own appropriate physical security designed and implemented commensurate with the identified risks and value of the assets in each setting. Secure offices, rooms and facilities should where appropriate should unobtrusive or hidden controls and facilities especially for highly sensitive assets. Information about the location of sensitive facilities should be very restrictive. Measures that balance relevant health, safety and related regulations and standards should also be appropriately implemented. The Figure 34 below shows the ISO 27002 format and structure.



A.5Security Policy

A.6Organisation of Information Security

A.7 Asset Management

A.8 Human Resource Security

A.9 Physical Security and Environment

A.10 Communications & Operations Management

A.12 Info. Systems Acquisition development & maintenance

A.11 Access Control

A.13 Information Security Incident Management

A.14 Business Continuity Management

A.15 Compliance

Figure 334: ISO 27002 Structure and Format.

3.2.2 Current Business Process

Qualitative data was generated from research paper reviews especially peer reviewed journal articles and site walk through such as visiting the student hostels, offices, lecture rooms and entering the campus using different entrances as a motorist and other times as a pedestrian. Random interviews were also conducted with visitors, students and members of staff. The members of staff include both academic staff and support staff.

(i) Student Scenario: the current student business process was reviewed. Students were interviewed and observed for the process of how they access the student rooms from the moment they enter through the campus perimeter. The current process is such that when a student arrives at the campus, they go through the perimeter gate without any form of identification. To go to a students' room a student goes through the hostels' perimeter gate without any need to show identification. The students also enter through the Hostel building entrance without any form of security check and then finally enter their room by unlocking the door with a steel key. Figure 35 shows the current student business process.

(ii) Staff scenario: the staff 's current process was also observed. A staff who is a motorist was observed through the current business process. A member of staff drives through the university gate without the need to show identification. Random requests for identification by security guards are done but on an irregular basis. The Staff goes through main office building without identification into his office controlled access by steel key. Figure 36 shows the current staff business process.

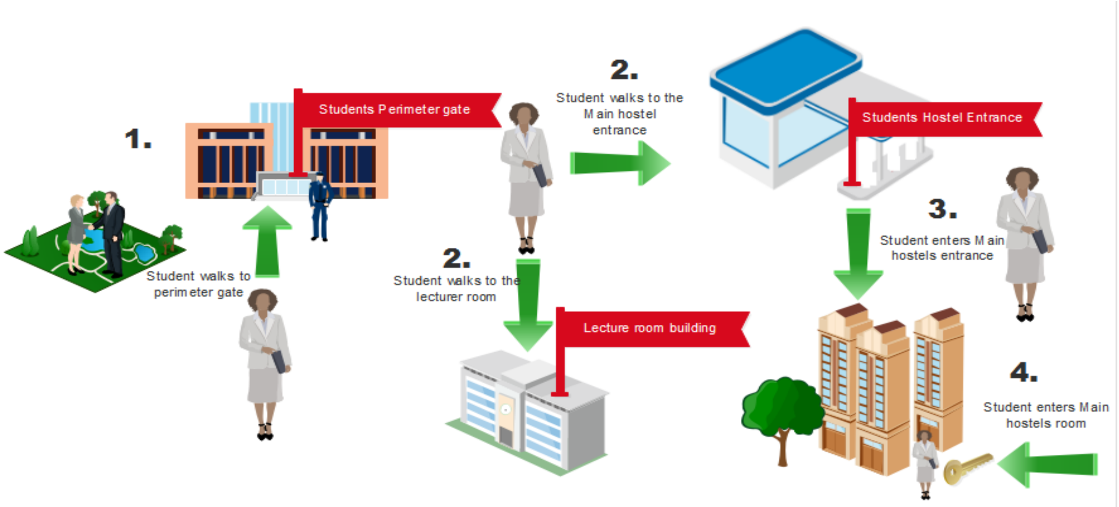

1.
Students Perimeter gate
Student walks to perimeter gate
2.
Student walks to the Main hostel entrance
Students Hostel Entrance
2.
Student walks to the lecturer room
Lecture room building
3.
Student enters Main hostels entrance
4.
Student enters Main hostels room

Figure 35: Current Business Process of Student access into UNZA

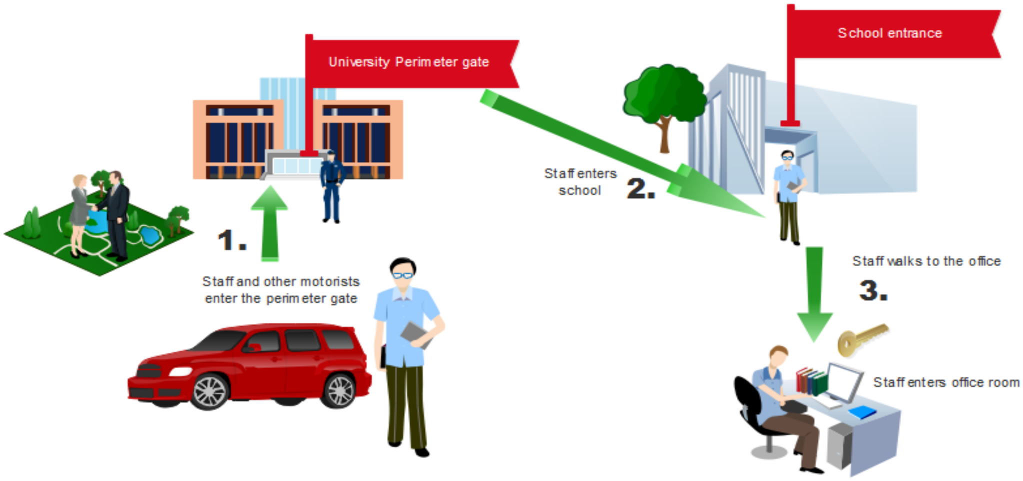

University Perimeter gate
1.
Staff and other motorists enter the perimeter gate
Staff enters school
2.
School entrance
Staff walks to the office
3.
Staff enters office room

Figure 36: Current Business Process of Staff access into UNZA

3.2.3 Student and Staff access of Library and Examination Room

To enter secure areas such as Library or Examination rooms students or staff need to provide identification. Every registered student and member of staff have been provided with an Identification card which is based on barcode technologies. The ID card is used as identification when entering the Library or Examination room. The same ID that has a barcode is used to borrow books. The barcode is tied to staff Man number and students number. An algorithm was created to ties the barcode to an RFID unique number that is provided in the RFID identification card. The RFID tag is tied to the staff or student's biometric that is the fingerprint.

3.3 System Automation

3.3.1 Multifactor Authentication Proposed Access Control System for Student and Staff

The purpose of this research is to measure the level of security and then propose a model to automatically identify all people that enter the campus thereby improving the security of the University. The proposed model is designed with the following functionalities;

Student and Staff access control by automatic identification and authentication when entering or exiting campus, student hostels or offices. This is achieved by use of RFID and Fingerprint Scan.

Control of access of visitors into campus. The proposed model will track visitors' movement in real time and keep an audit trail of all the places that are visited while on campus.

a) System Automation

The results of the base line study and current business process were used to design a model to control access into the University of Zambia. The study designs a model based on RFID and Biometric authentication and access control with the inclusion of a visitor real time tracking while on campus. For Student and Staff access control into Campus facilities and secure areas the study adopted the models by [97] BIO and RFID that use RFID and Biometric to control access into hostels. In this model Farooq uses a computer as the control and main processor but this study proposes use of an Arduino. This literature is presented in the Literature review section. For the visitor tracking in real time while on campus the study adopted the models in [95] [109] that uses GIS, GPS and GPRS/GSM as well as google maps. The study as depicted in Figure 37, however includes cloud storage to the said models and bring in web based live tracking to enhance the functionality.

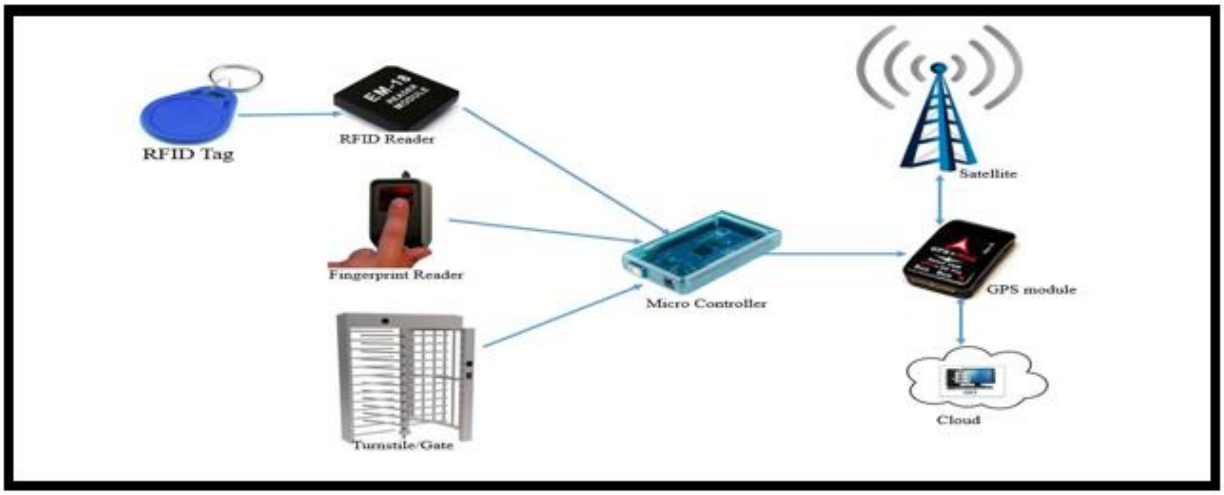


Figure 37: Proposed Access Control Business Model

3.4. Visitor Tracking

In the study the visitors’ RFID access card shall have a tracking module containing GPS attached to it. This device will be used to transmit data directly to the tracking Server and database in the cloud. The tracking device will work in such a way that it will continuously request data to the GPS satellite for its location information. The GPS satellite will provide the location information to the tracking device attached to the visitor’s RFID card. The location information will be sent to the tracking and record database server housed at Centre of Information and communication Technologies (CICT) through the wireless network already installed at the campus. We will use google maps for displaying the visitors’ coordinates on the map and Arduino UNO R3 microcontroller as the hardware interface. GIS is used to analyse the data collected and the data used appropriately.

The RFID module provided to the visitor shall be used to gain access into all facilities such as offices or hostels that have been authourised. A record of date, time and door or turnstile accessed shall be kept once the card is swiped and access is granted. A record of the visitors’ exit time and date shall also be recorded.

3.4.1 Materials and Methods

The function of this study is to automatically control access into the university, track visitors' movement and therefore improve the security of the university. A prototype to track visitors' movements and keep an audit trail of the places visited while on campus has been developed. In this section the hardware components are discussed in detail.

3.4.1.1 Materials and Hardware used

Visitor tracking using GPS include

1. Arduino UNO (Microcontroller)
2. GPS Module
3. GPS Antenna
4. Battery

a) Arduino Uno R3 (Microcontroller)

Arduino is an open-source venture that is used for building computerized gadgets and intelligent items that can detect and control physical gadgets shown in Figure 38. Arduino Uno R3 is the microcontroller is used in this prototype. Arduino Uno as shown in Figure 38 is based on the microcontroller ATmega328A board. This board has 32KB RAM of which 0.5 KB is occupied by the boot loader. The ATmega328A board also has 2KB SRAM and 1KB of read and write EEPROM. The microcontroller has 20 digital input output pins that Six pins for PWM outputs, six analog inputs, a USB connection, a power jack, a reset button and an in-circuit programming (ICSP) header. It connects to an external source using a Vin input as voltage. The USB uses a 5 volts as input voltage while the Vin input can use a DC power source in the 7 – 12V range. The Arduino Microcontroller use a maximum current of 50mA. The Arduino's Uno R3 clock speed is at 16Mhz which makes it perform faster the earlier versions. The clock will operate continuously no matter the code that is being processed. Therefore, the code does not affect the clocks speed. Its only come to a stop when its set to sleep mode while the other components will continue to draw current from the board. The Arduino software supports 12c for library and SPI library for SPI communication.

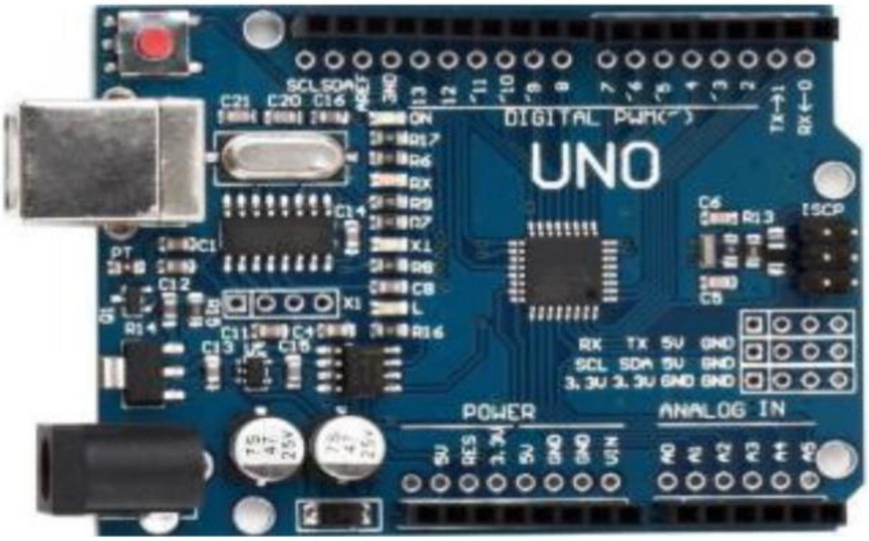


Figure 38: Arduino Uno r3

b) **GPS Antenna:**

This GPS antenna draws about 10mA and will gave us an additional 28 dB of gain. It’s got a 5-meter-long cable so it will easily reach wherever it is needed to. The antenna is magnetic so it will stick to the top of a car or truck or any other steel structure. Figure 39 shows a typical GPS Antenna. Its operating frequency range is 1575.42±1.023 MHz and voltage range is 2.5V- 5.5V and corresponding current

Figure 39: GPS Antenna

range is 6.6 mA - 16.6 mA [9]. GPS signals are extremely weak and present unique demands on the antenna so the choice of antenna plays an important role in GPS performance. A GPS unit needs to have a clear, unobstructed sky view, to best receive the microwave signals that allow it to communicate with satellites. GPS Down/Up converter used for very long cable runs. This GPS antenna was used to the GPS signal, converts it to a lower frequency which is then sent down the cable.

c) Battery

The alkaline 9v energizer battery which sits in the battery pack was used to power up the sim808 GPS module when transit is initiated from one location to another. This power is needed to ensure the GPS module can operate as it relies on power. Figure 40 shows a battery back that can be used with a GPS module.

Figure 40: Battery

3.5 System Requirements Specifications

In the system requirements specification phase of the research study, Object-Oriented Analysis (OOA) was used. System Requirements are descriptions of what the system should do, the services provided by that system and the constraints on its operation. Requirements reflect user needs for a system that serve a certain purpose. A requirement may also be described as a high-level abstract statement of a service that a system should provide or a constraint on the system [111]. Software system requirements can be categorized into functional and non-functional requirements. Sommerville [111], describes functional requirements as statements of services the system should provide and non-functional requirements as constraints on the services or function offered by the system

The System Requirements Specification section, therefore, provides a complete description of all the functionalities and specifications for the multifactor authentication visitor monitoring proposed module.

Functional Requirements

The functional requirements required for application processes are shown in Table 6.

Table 6: Details the functional requirements required for application processes.

FR1	The device shall have a GPS module
FR2	The device shall have a GPS antenna
FR3	The device shall have a GPRS module
FR4	The device shall have a microcontroller Arduino Uno that shall supply the GPS module with commands for monitoring. The visitor id shall also be supplied by the commands in the microcontroller.
FR5	The device shall have a battery to power up the GPS module
FR6	The device shall also have a USB cable and power bank to power the microcontroller.
FR7	The device through the GPS module and antenna shall receive coordinates from the satellite as the visitor is moving.
FR8	The cloud application shall have google earth maps that will be responsible for displaying the coordinates
FR9	For visitors driving, the GPS monitoring device shall be fitted in the vehicle upon carrying out registration and surety of national registration cards and drivers license at the main security entrance at the main security entrance.
FR10	For walking visitors the GPS monitoring module shall be given to them upon carrying out registration and surety of national registration cards at the main security entrance.

FR11	User admin with the relevant access rights shall have the ability to access the visitor monitoring dashboard.
FR12	User admin with the relevant access rights shall have the ability to monitor the visitors in real time using google maps.
FR13	User admin with the relevant access rights shall have the ability to save the visitor movements and view them later as visitor history.
FR14	User admin with the relevant access rights shall have the ability to change the password for security reasons.

Nonfunctional Requirements

The performance, serviceability and security requirements of the system are shown in Table 7.

Table 7: Shows the performance, serviceability and security requirements the system

NFR1	The hardware part of the system shall be able to perform indefinitely without complete loss of service, except in the event of total failure of primary and backup power.
NFR2	System failure shall not compromise data integrity.
NRF3	All system processing and interconnect hardware shall be readily accessible for maintenance, repair, replacement and/or reconfiguration
NRF4	The software application module shall be debug gable
NRF5	All users using the system shall login using some form of unique identification (e.g., username or employee number and password)
NRF6	All login attempts shall be done in a secure manner. (e.g., encrypted passwords)
NRF7	The hardware devices shall not cause harm

NRF8	The visitor tracking once started shall not delay in signaling the web application of the visitors under tracking

3.5.1 System Modeling and Design

To design the system models for the Multifactor Authentication visitor monitoring module, Object-Oriented Design (OOD) was used.

3.5.1.1 Interaction Models – Use Cases

Use case modeling is used to model interactions between a system and external actor's which may include users and other systems [111]. Also adds that in their simplest form, a use case identifies the actors involved in an interaction and names the type of interaction. This is then supplemented by additional information describing the interaction with the system [111]. Actors are a representation of the roles that people, other systems or devices take on when communicating with particular Use Cases in the system. Table 8 Shows the actors and description of each actor in the visitor monitoring module, while Figure 41 represents a used case diagram of the visitor monitoring module.

Table 8: Visitor monitoring actor description

Walking Visitor	This is a visitor upon authorization at the security check point who enters the university premises and either walks to the hostels or respective schools.
Driving Visitor	This is a visitor upon authorization at the security check point who enters the university premises and either drives to the hostels or respective schools.
Monitoring Dashboard	This is the dashboard of the system in the cloud that is used to monitor the visitor movements using google maps.

Satellite Station	The satellite provides location coordinates to the GPS module.
GPS System	The GPS module visitor locations from the satellite in form of coordinates.

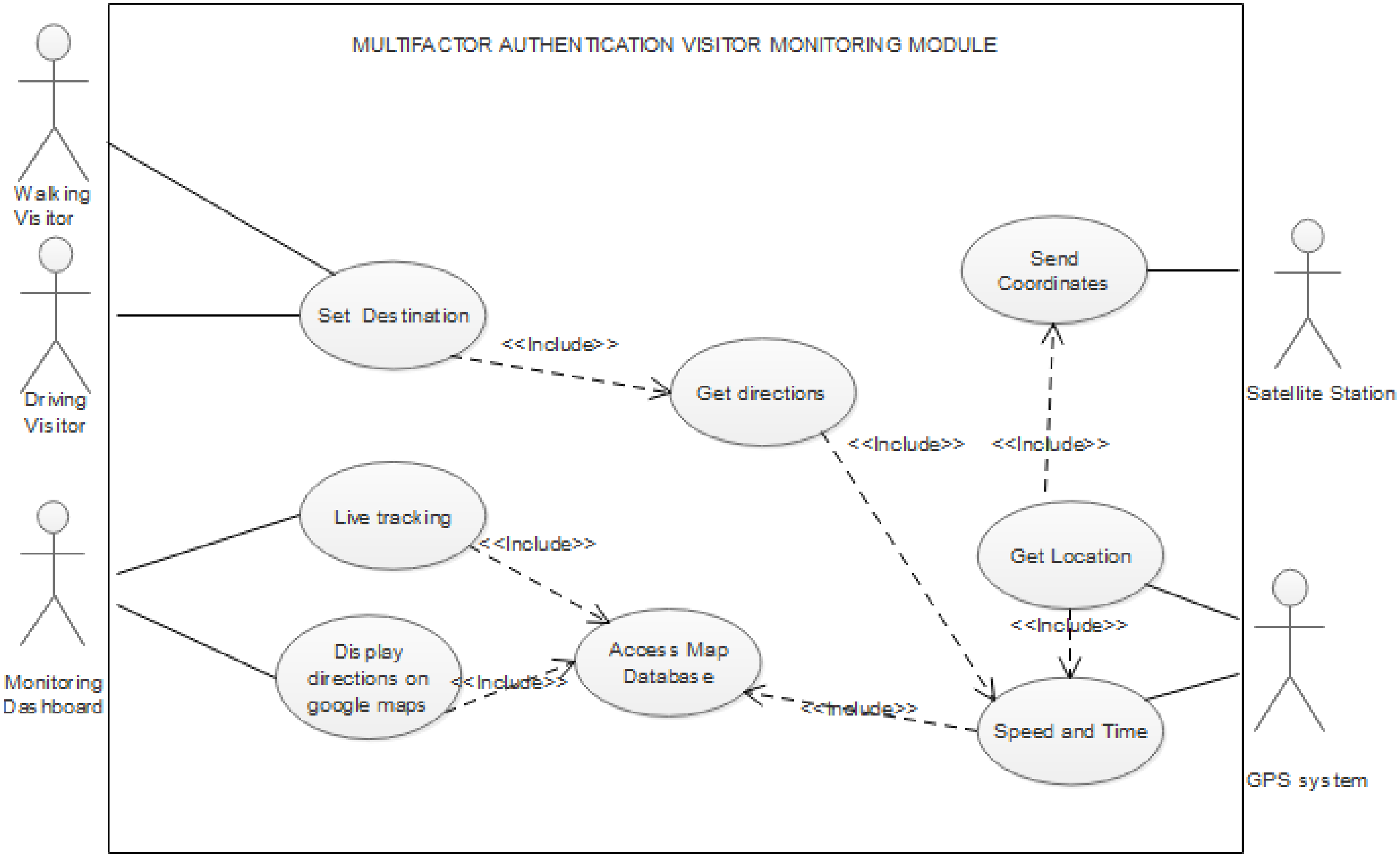


Figure 41: Visitor Monitoring Use Case diagram

Visitor monitoring Use Case is described in the Table 6.

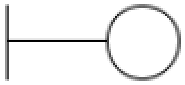
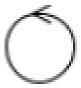
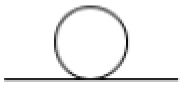
Table 9: Visitor monitoring Use Case description

Set destination	The visitors specify or indicate where they are going.
Live tracking	Live tracking gives us options to select the visitors with the GPS trackers and do live tracking on them.
Get directions	As the visitor is in transit, directions about its movement have to be tracked.
Display directions	The directions of the visitor under tracking are displayed on google earth maps via the webpage
Google maps	The google maps embedded in the web application are responsible for displaying the position of the visitors.
Access map database	The map database supplied by google maps through the google API
Send coordinates	The satellite supplies the GPS module with latitude and longitude of the current position of visitor under monitoring.
Get location	The get location is responsible via the GPS of collecting the coordinates from the satellite
Speed and time	The GPS module apart from getting the coordinates from the satellite also gives the speed and current time of the visitor under tracking

3.5.1.2 Interaction Models – Communication and sequence diagrams

Communication diagrams provide useful views of the internal details of the system. They explicitly show the interaction between objects [112]. Sequence diagrams on the other hand, are used to model the interactions between the actors and the objects in a system and the interactions between the objects themselves [111]. This section details the communication and sequence diagrams for each Use Case depicted in Figure 1. In the communication and sequence diagrams, three class stereotype symbols are depicted. A class stereotype represents particular kinds of classes that are encountered repeatedly during requirements modeling [112]. A class is a uniquely identified abstraction of a set of logically related instances that share similar characteristics [113]. Table 10 gives a description of each of the three symbols.

Table 10: Communication and sequence diagram symbols [112].

Symbol	Description
	Boundary Class Stereotype: Models the interaction between a system and its actors.
	Control Class Stereotype: Represents coordination, sequencing, transactions and control of other objects
	Entity Class Stereotype: Models information and associated behavior of some phenomenon or concept such as an individual, a real-life object or a real life-event.

3.5.1.3 Login

In Figure 42, the login user interface (UI) is started and then the control object is instantiated. The control object prompts the user for login credentials and authenticates the user upon supplying the correct login credentials. It then asks User entity object to get the user account from the database.

The control object finally asks the boundary object to display the home page to the user at the application interface.

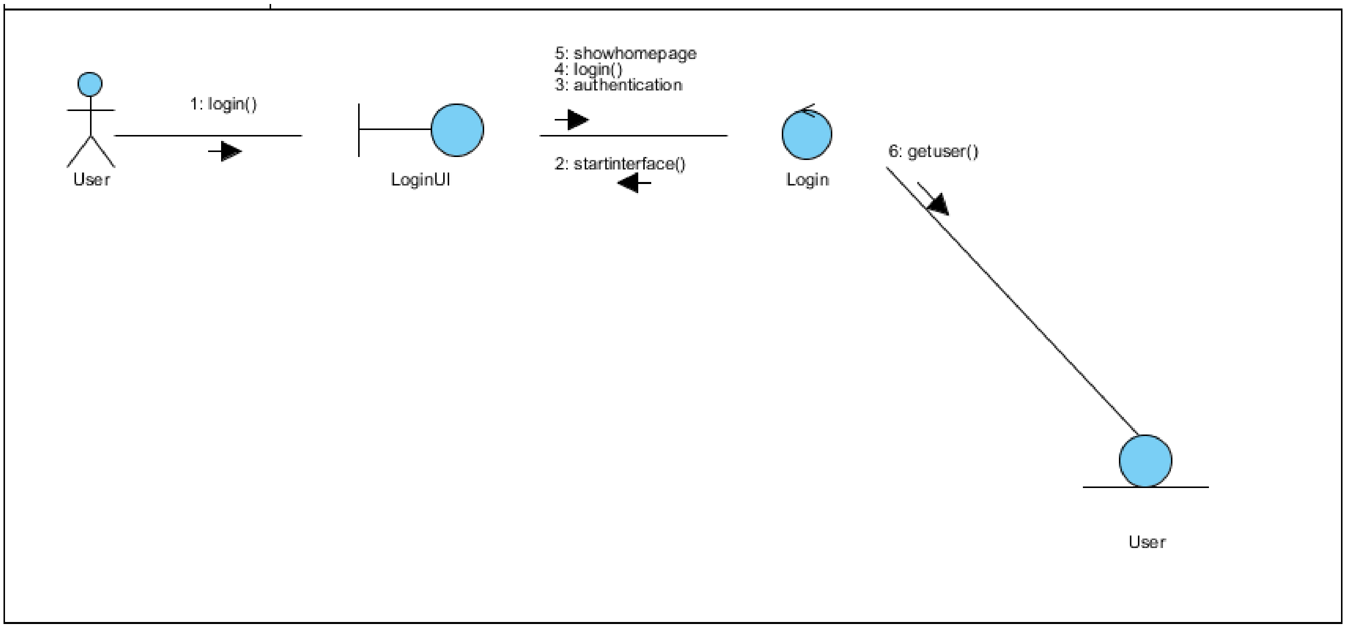


Figure 42: Login communication diagram

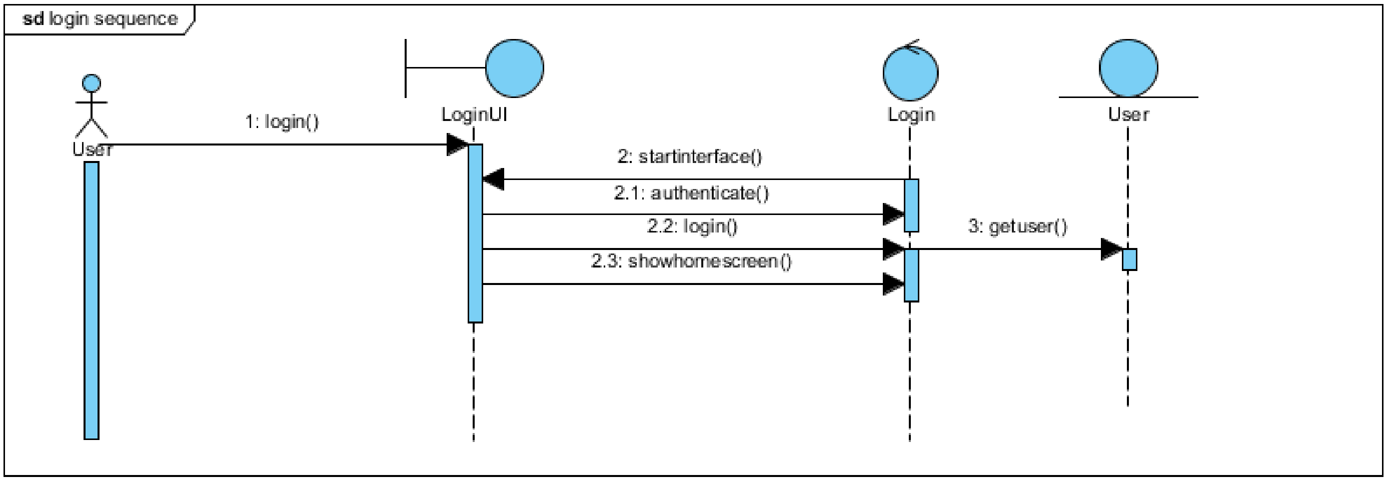


Figure 43: communication Diagram

The sequence diagram in Figure 42 is a synchronization of the communication diagram in Figure 43. The sequence of events for the Login Use Case are shown.

3.5.1.4 Get directions

In Figure 43, the direction object is initialized through the GPS module, the destination on the other hand is determined by the user. The control object prompts the satellite for GPS location coordinates. If the connection to the satellite is established, then the coordinates will be sent over to the GPS module that in turn provides the time and speed.

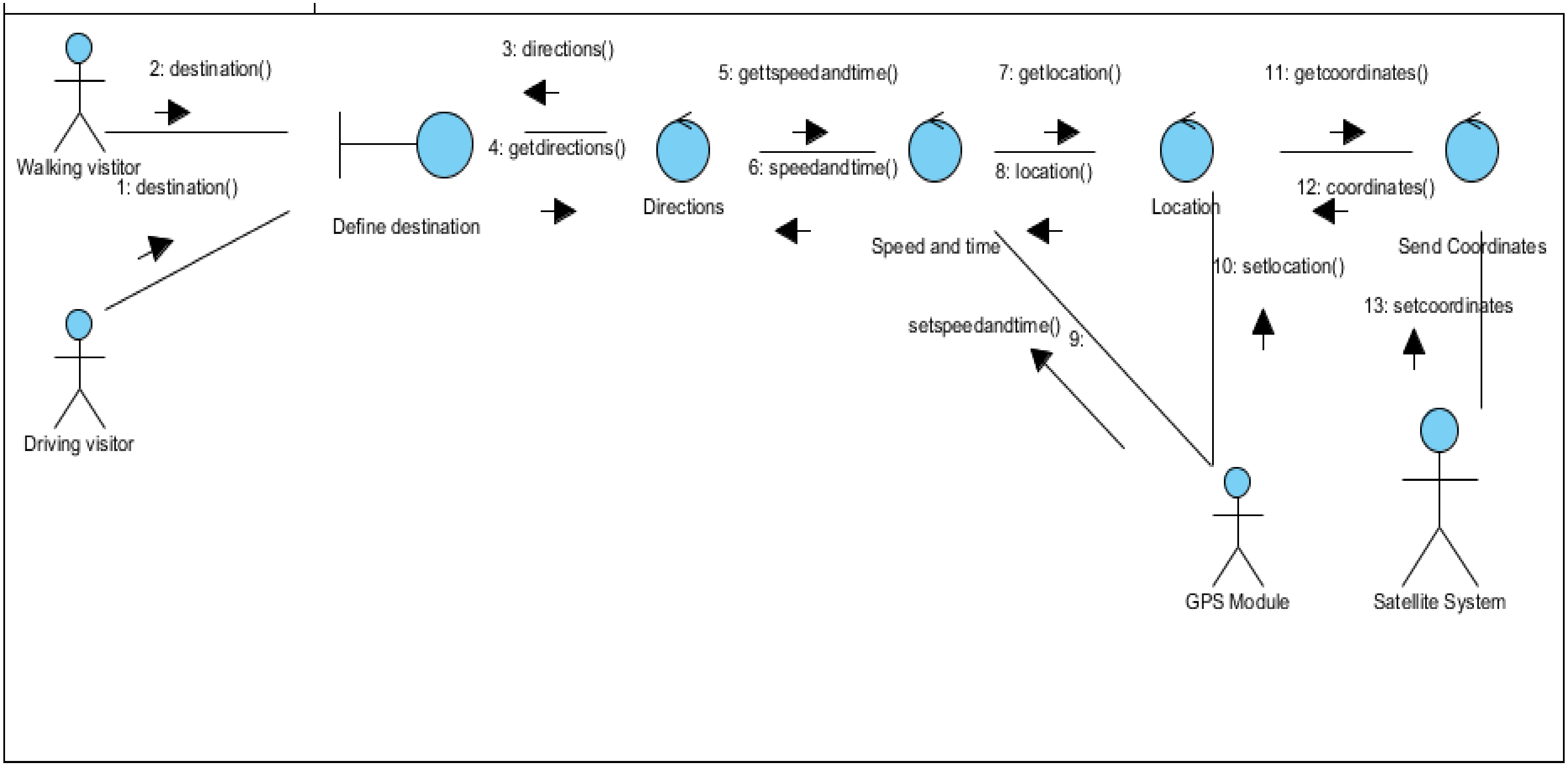


Figure 44: Get directions communication diagram

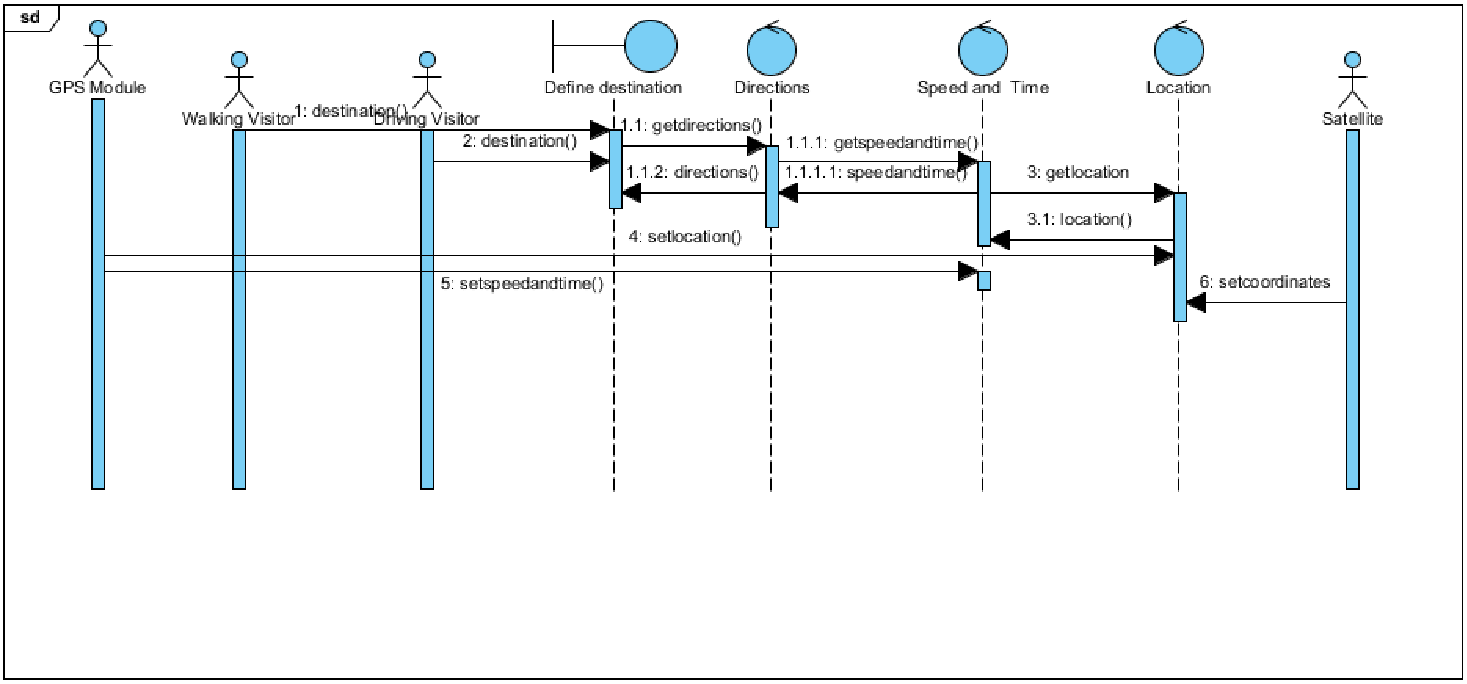


Figure 45: Get directions sequence diagram

The sequence diagram in Figure 44 is a synchronization of the communication diagram in Figure 45.

3.5.1.6 Monitoring dashboard

The monitoring dashboard communication Figure 46 shows how the interaction is done with various other objects and how monitoring is achieved both live and previous.

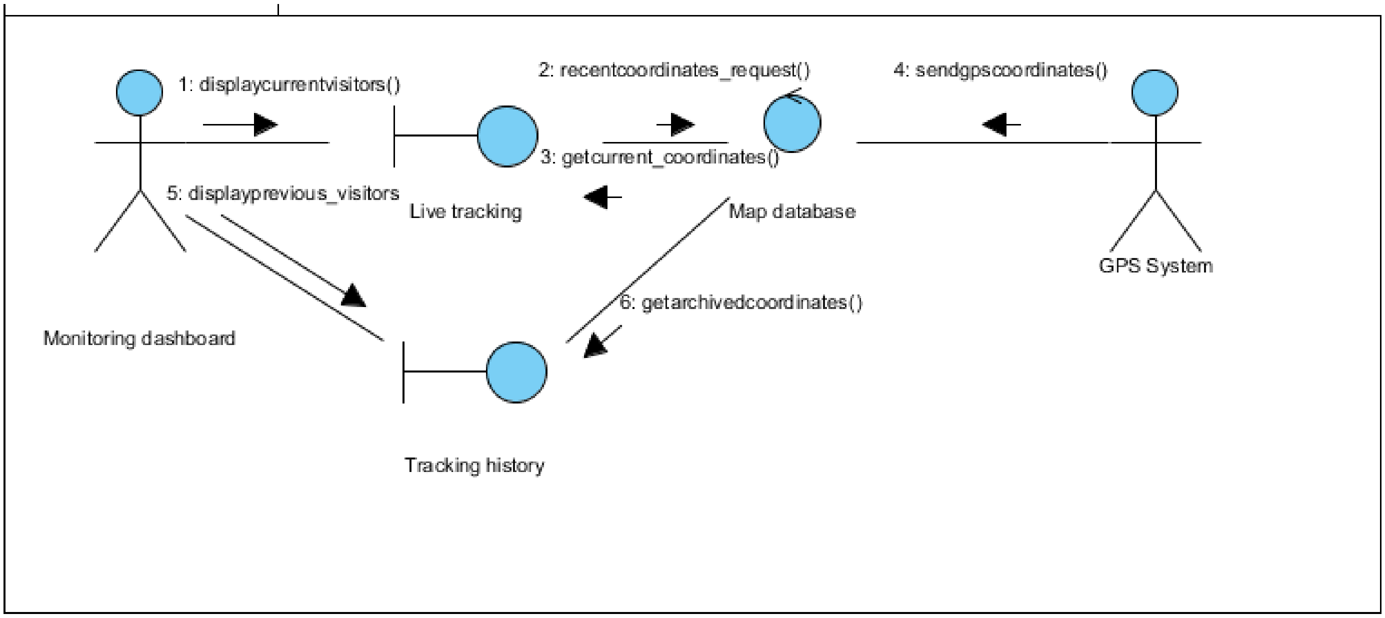

1: displaycurrentvisitors()
2: recentcoordinates_request()
4: sendgpscoordinates()
3: getcurrent_coordinates()
5: displayprevious_visitors
Live tracking
Map database
GPS System
6: getarchivedcoordinates()
Monitoring dashboard
Tracking history

Figure 46: Monitoring dashboard communication diagram

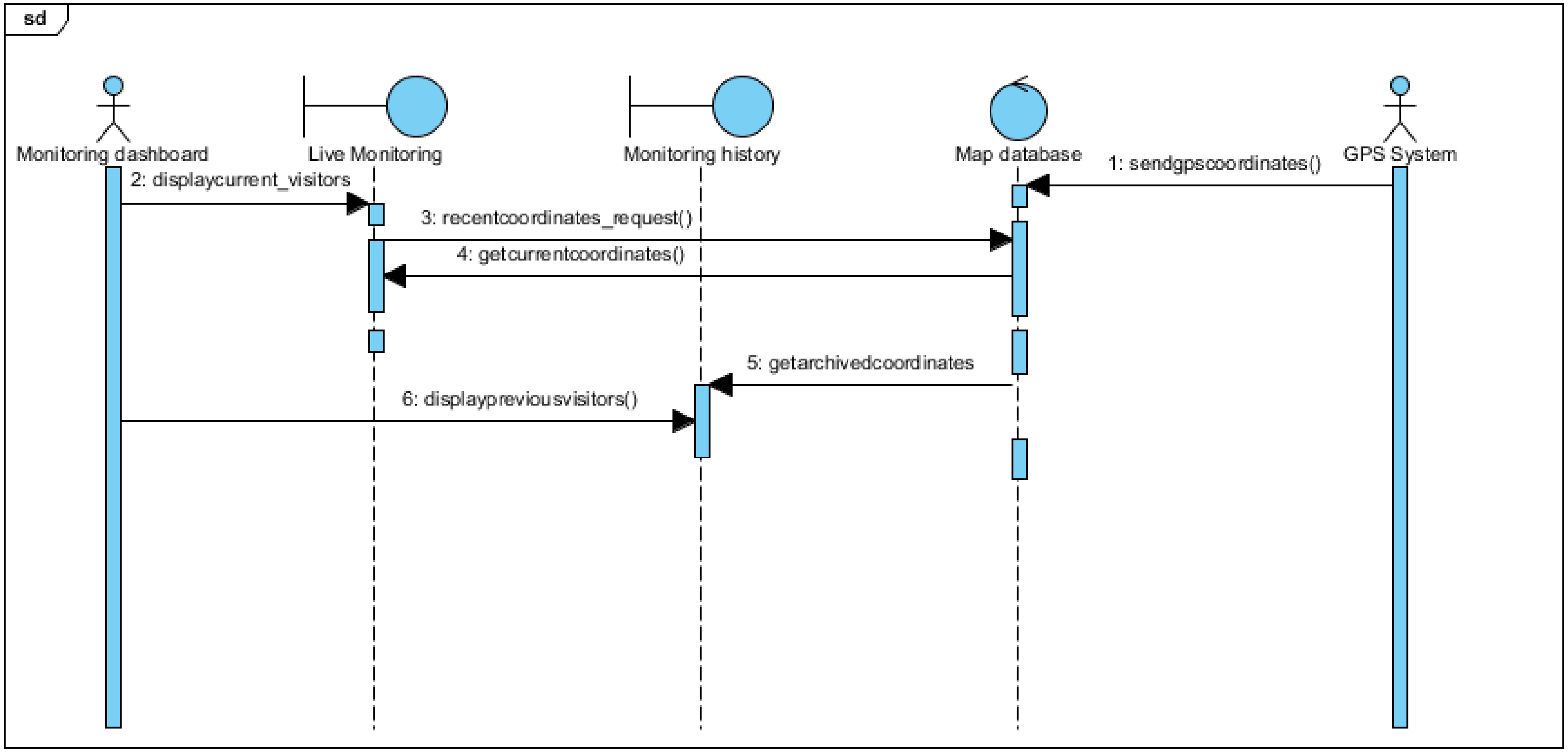

sd
Monitoring dashboard
Live Monitoring
Monitoring history
Map database
GPS System
1: sendgpscoordinates()
2: displaycurrent_visitors
3: recentcoordinates_request()
4: getcurrentcoordinates()
5: getarchivedcoordinates
6: displayprevioussvisitors()

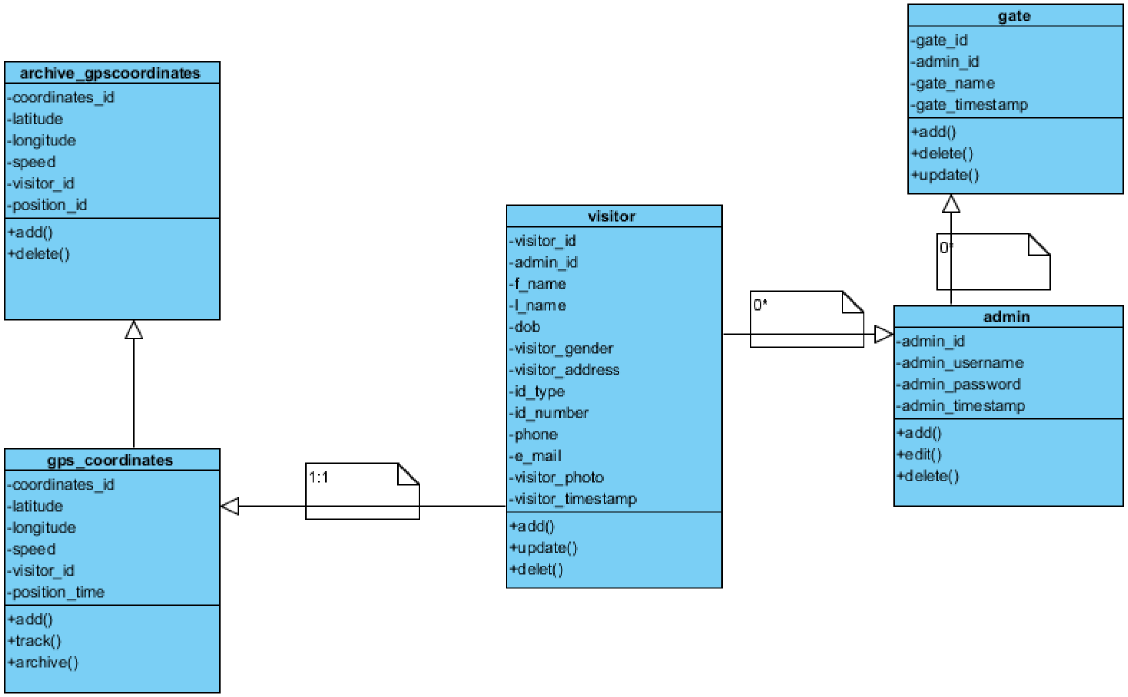
Figure 47: Monitoring dashboard sequence diagram

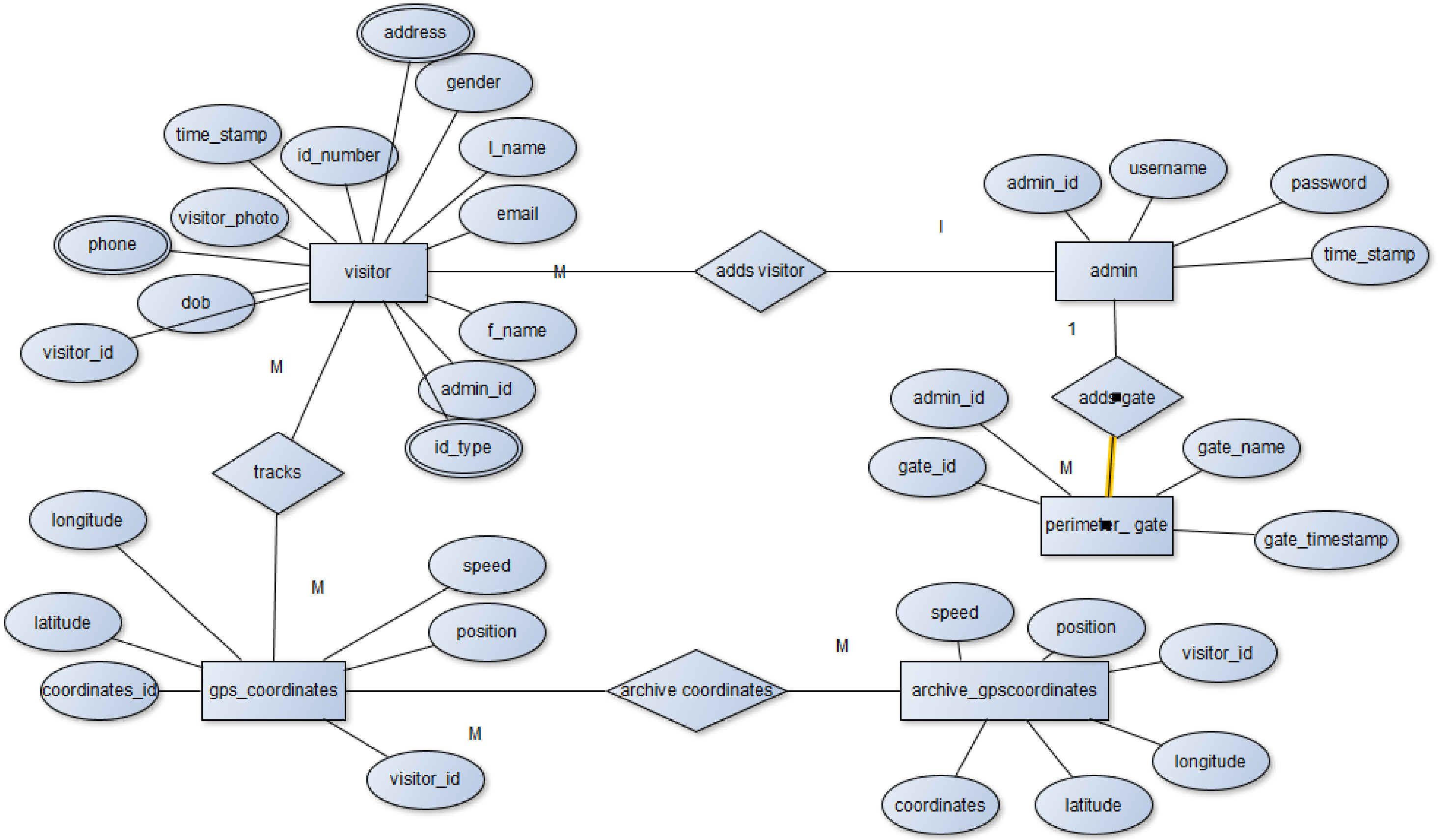
The sequence diagram in Figure 47 is a synchronization of the communication diagram in Figure 48, showing the sequence of events from one object to another.

3.5.1.7 Structural Models – Class Diagram

Class diagrams in an object-oriented system model are used to show the classes in a system and the associations between these classes. An object class can be a general definition of one kind of system object. An association is a link between classes that shows that there is a relationship between these classes. Objects represent something in the real world, such as a person, a transaction, and so on [111]. Figure below shows a class diagram model of the visitor monitoring module. The Figure 47 shows the objects that have been identified to constitute the system and the relationships between the objects.

Figure 48: Object that constitute system and their relationships




address
gender
time_stamp
id_number
l_name
email
visitor_photo
phone
visitor
dob
visitor_id
f_name
admin_id
id_type
M
M
adds visitor
I
admin_id
username
password
time_stamp
admin
1
adds gate
admin_id
gate_id
M
gate_name
perimeter_ gate
gate_timestamp
tracks
longitude
latitude
coordinates_id
gps_coordinates
M
speed
position
visitor_id
M
archive coordinates
M
speed
position
visitor_id
archive_gpscoordinates
longitude
coordinates
latitude

3.6 Summary

This chapter looked at the approach and methodology used to conduct and collect the baseline study, model design and prototype development. A mixed methods approach of qualitative and quantitative approached was used in this study. This chapter also looked at the functional specifications, system design and implementation and lastly the hardware, developmental tools and languages were also looked at.

CHAPTER 4: RESULTS

4.1 Introduction

In this chapter, we present the results that were derived from the baseline study as well as results from the implemented prototype. The results from the prototype are represented in screen shots taken from the software application. This section also illustrates how the hardware of the prototype is connected.

4.1.1 Baseline Line Study

This section presents results analysed from the baseline study which was conducted to measure the level of security at the University of Zambia. Questionnaires based on ISO 27002 standard guideline or Physical and Environmental security was distributed to measure this level of security. The results show that UNZA’s level of security needs improvement due to several factors. The survey reviews that the most commonly stolen property from students and staff is media such as laptops and mobile phones [3]. The results are presented in the form of tables and pie charts

4.1.1.1 Survey Results

Quantitative data was collected from three groups of respondents namely students, staff and from UNZA’s Security Personnel. Specifically designed questionnaires were distributed to 120 students, 100 staff and 10 security personnel.

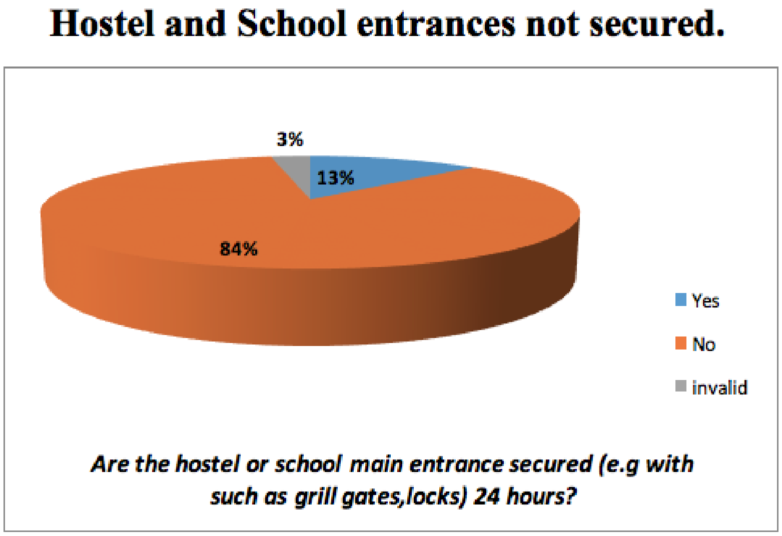
4.1.1.2. ISO Standards

This section is based on responses from questionnaires designed and distributed to Students and Staff. To measure the level of security at the University, questionnaires were designed based on ISO 27002, Environmental and Physical Security Annexure. Answered questionnaires were collected and analysed. The results are stated according to the findings and related to different sections of annexure number nine; Physical and Environmental Security of the ISO 27002 namely Secure Areas, Physical Security Perimeter, Physical Control and Secure offices, rooms and facilities.

1. Secure Areas

Secure Areas should have measures in place that stop unauthourised physical access, damage or interference to the organisations' premises and infrastructure by using controls that identify risks and the value of the assets to be protected. UNZA has facilities such hostels, offices, lecture theatres etc. that need to be protected from damage and unauthourised access. According to the survey most of these facilities can easily be accessed without authourisation. Some of these facilities do not have lockable grill gates and are open 24 hours. Vendors of all sorts of merchandise such as food, clothes and electronics can go through hostel and office gates without any need to request for authority to enter the premises.

In access control, it is important to that all entrances are secured with such as grill gates lock etc. the Figure 49 shows that most of the school and entrances are not secured.



Hostel and School entrances not secured.

Figure 49: Secure Entrance

The results review that 84% say that the hostel or school entrances are not secured while 13% reviews that they are secure. One way to ensure access to secure areas is controlled is by having lockable entrance doors or gates. If keys are used, they should be stored at a controlled place and copies of keys should be made only by authourised personnel whether the keys are being replaced. Some photos were taken at random to show uncontrolled access as in Figure 50.

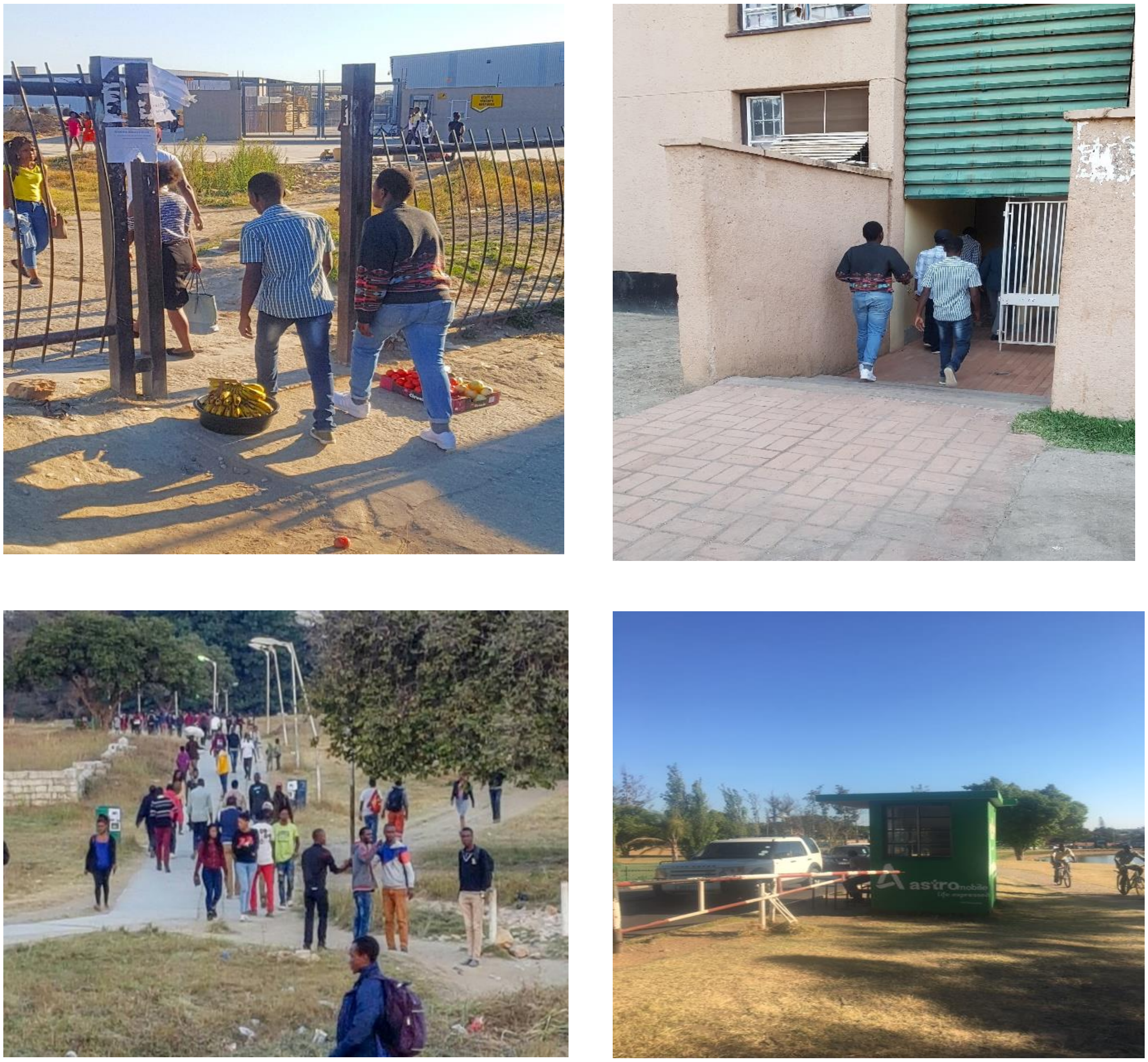


Figure 50: Events of uncontrolled Access into UNZA hostel or Premises

UNZA still uses steel keys which can easily be copied by unauthourised people making the offices and Hostel rooms vulnerable to damage or theft.

According to the survey most of the student rooms have more than one steel key that can be used to access the student' room. The Figure 51 below shows the number of keys that a student room has.

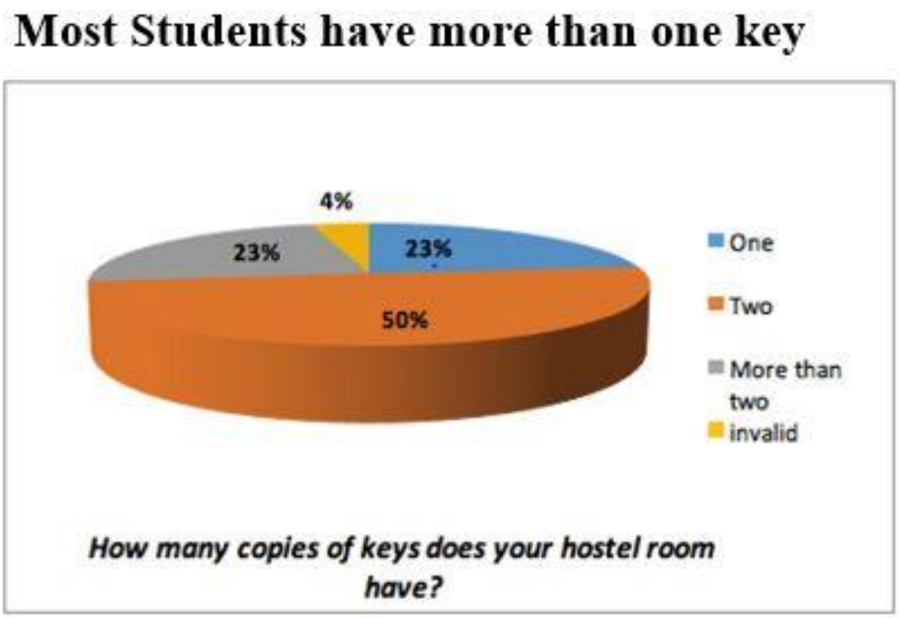


Figure 51: Number of keys per room

Theft cases have to be under control to achieve good access control. The results in Figure 52 below reveal that 87% of the respondents have been or known of a victim of theft while 11% have not been or known of any victim of theft.

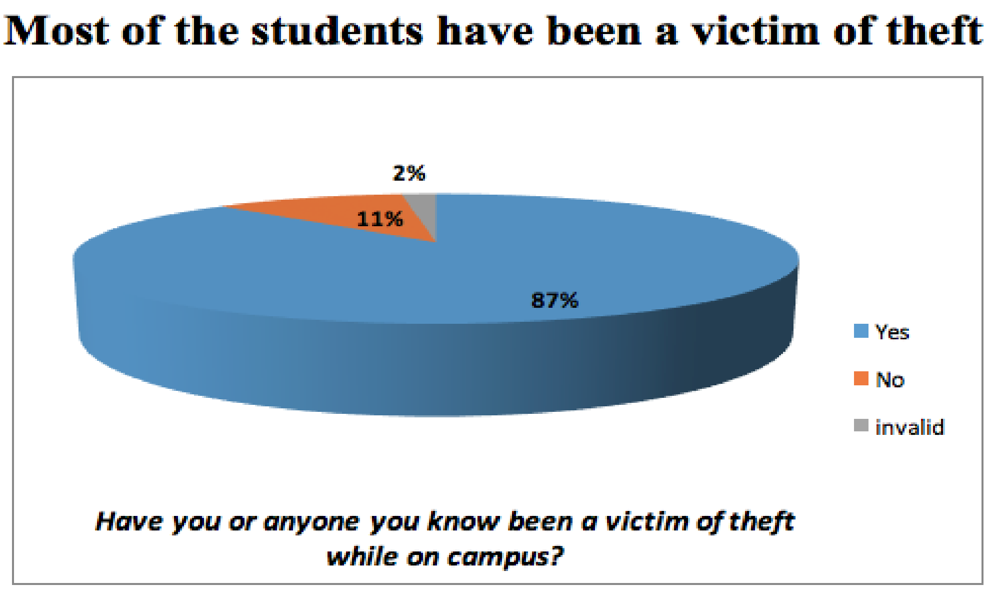


Figure 52: Theft Victims on Campus.

2. Physical Security Perimeter should be used to protect areas that contain assets such as information and people. Physical Perimeter should be defined in any institution. Fences or brick walls are some of the materials that perimeters can be made. Fences or Brick Walls can be used as physical barrier to unauthourised access. Entry into the physical perimeter should be controlled by use walls, controlled entry doors/gates, manned reception desks, other measures and should be built to a recommended strength. The physical barriers should completely cover the perimeter. The entrances in these perimeters should be secured with locks or manned by security such as Security Guards.

The survey reveals that the fence around the Campus defines the perimeter and is considered by most security personnel as a security barrier. The Figure 53 below shows the results of how the physical perimeter is viewed**.**

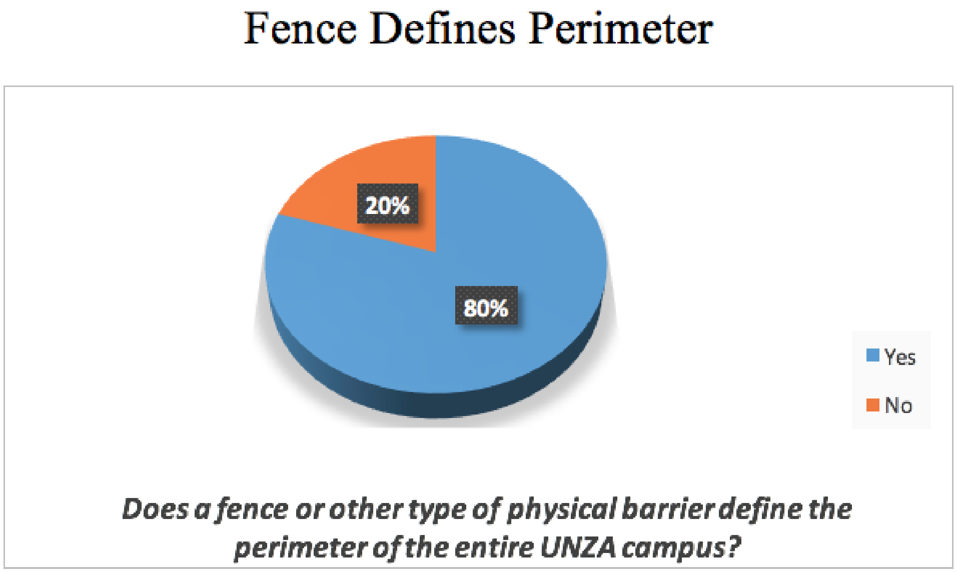


Figure 53: Perimeter Definition

While UNZA’s perimeter fence is viewed as a security barrier it does not fully cover the physical perimeter in order to provide necessary security.

To ensure total physical barrier, a fence must cover the perimeter totally. The survey results show that the 80% of the respondents say the fence covers the perimeter less than 50% while 20% said the fence covers the perimeter more than 50% as depicted in Figure 54.

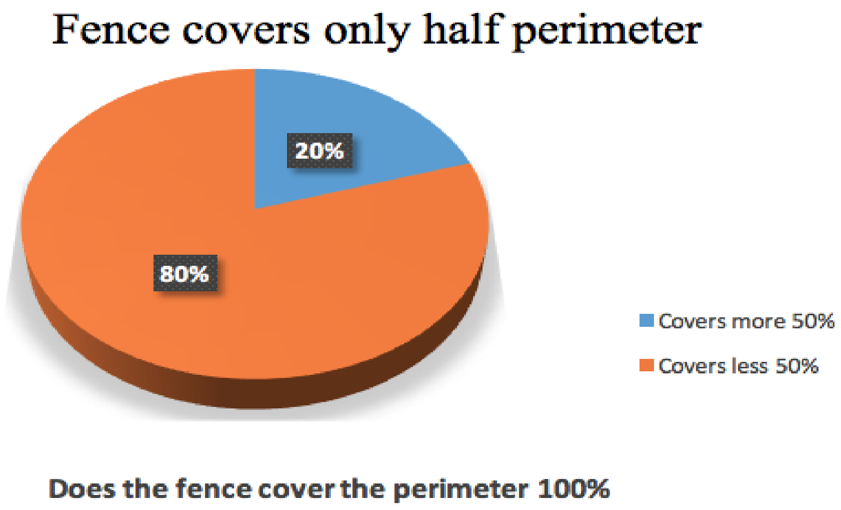


Figure 54: Perimeter Coverage

According to the survey as shown in Figure 55 the University has more than six entrance or exit points, this is according to 50% of the respondents, 30% indicated the university has four to six entrance or exit points while 20% shows that it has two to four entrance or exit points.

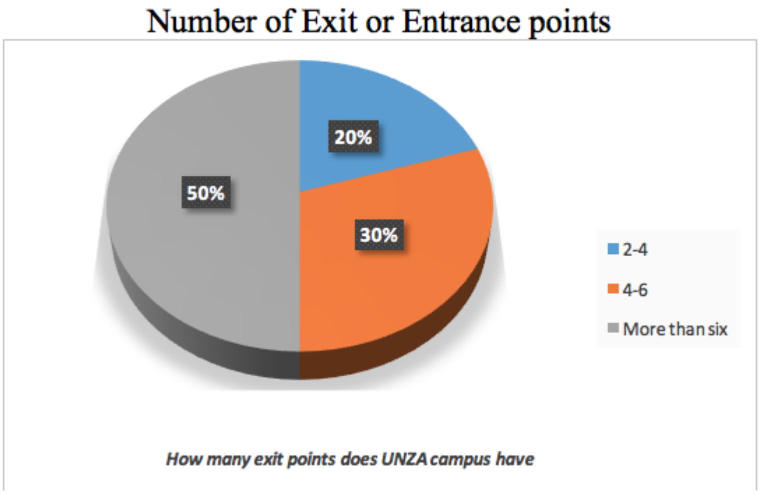


Figure 55: Existing Entrance Points

Physical Barriers have entrances that should be guarded or secured. The survey results indicate that 80% respondents as shown in Figure 56 indicated that only one to two of the entrances are secured while 20% shows that two to four of the entrances are secured.

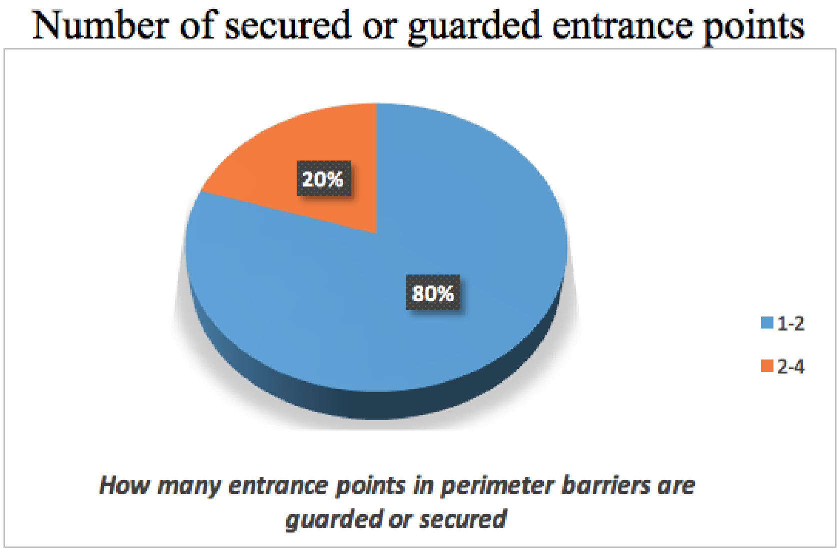


Figure 56: Guarded Entrances

3. **Physical entry control** should be controlled in such a way that appropriate entry controls are implemented to ensure that only authorized personnel are allowed access. The study reveals that UNZA has not fully employed authentication mechanisms such as automatic identification and authentication systems that can identify authourised entry into campus. Access control systems can be employed in several forms to deter, prevent, detect crime and these forms can be as one or a combination of CCTV, digital security locks. The survey shows that the access control systems have not be employed at UNZA.

From the Figure 57 shows that only 24% indicated that Access Control System have been employed while 76% revealed that Access Control Systems have not been employed.

Access Control Systems generally not employed

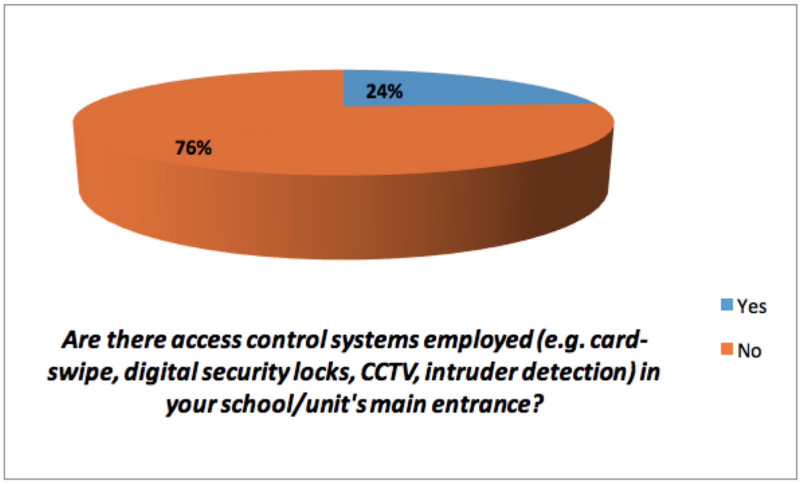


Figure 57: Employed Access Control Systems

The study reveals that Identification activities available include use of barcode based identification cards which can easily be used by unauthourised because the names and images are not very visible to distinctly identify the bearer.

Visitors and Contractors details are not recorded whenever they visit the University. There is no available appropriate identification such as badges for visitors and contractors. Date and time of entry activities for visitors or contractors therefore there is no audit trail kept of all visits whether personal or business.

Visitors and Contractors badges help identify them apart from employees. The figure below reveals the responses of whether there are any badges given to visitors or contractors as a form of identification. The Figure 58 reveals that 83% indicated that no badges are used to identify Visitors and Contractors while only 17% indicated that badges are available to identify visitors and contractors.

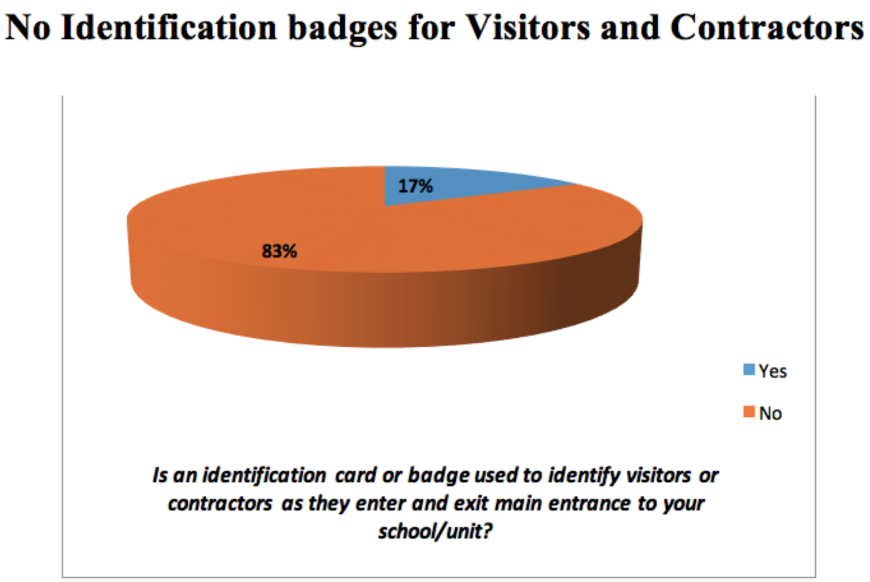


Figure 58: Visitor and contractor identification

It is important that visits in any institution are recorded as a measure of keeping an audit trail. The survey reveals that 94% indicated that visitors' details are not recorded while 6% reveals visitors being recorded, this is depicted in Figure 59.

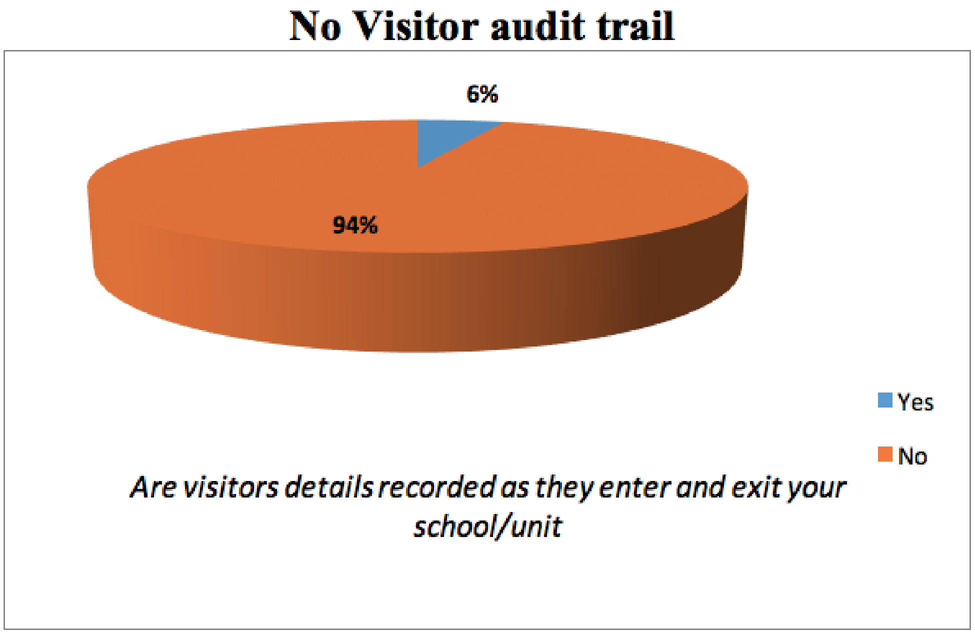


Figure 59: Visitors audit trail

4. **Secure offices, rooms and facilities should have their own appropriate** physical security designed and implemented commensurate with the identified risks and value of the assets in each setting. UNZA has not implemented controls that can help access to hostels and offices to be very restrictive. According to the study from the figure below reveals that 87% students believe Access Control systems would improve the security of the University, 9% believe that access control systems would not improve UNZA, while 1% believe implementing an access control system would me no difference to the level of security. Figure 60 shows these results in pie chart.

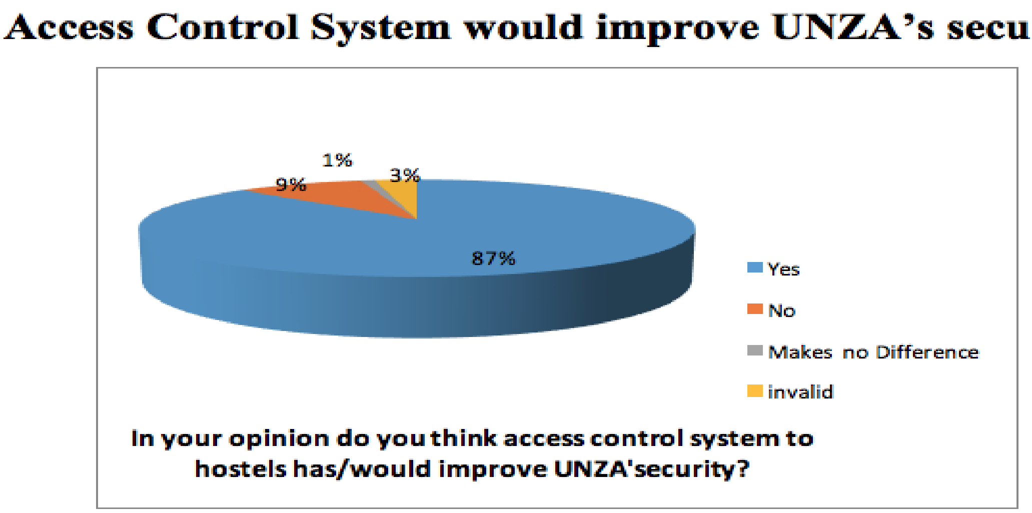


Figure 60: Access Control Systems

4.1.2 Visitor Tracking System Implementation and Testing

Visitor movements and physical location while on campus can be tracked in real time. All this information can be stored to a database. The history of the visitor's movements can be retrieved when necessary. In order to show proof of the concept a prototype was developed. The prototype was developed using an Arduino Uno R3 and SIM808 GPS module powered a 9V battery.

The current visitor business at UNZA was reviewed by using site walk-throughs, random interviews with people on campus at random and from questionnaire responses. The proposed model can be used to track visitor movements and location in real time. The screen shots from the firmware prototype's Graphical User Interface (GUI) are presented. The functionality of the prototype includes viewing the visitors' movement and location and also the history of the all visitors' movements while on campus. The prototype tracks both motorist and pedestrian visitors.

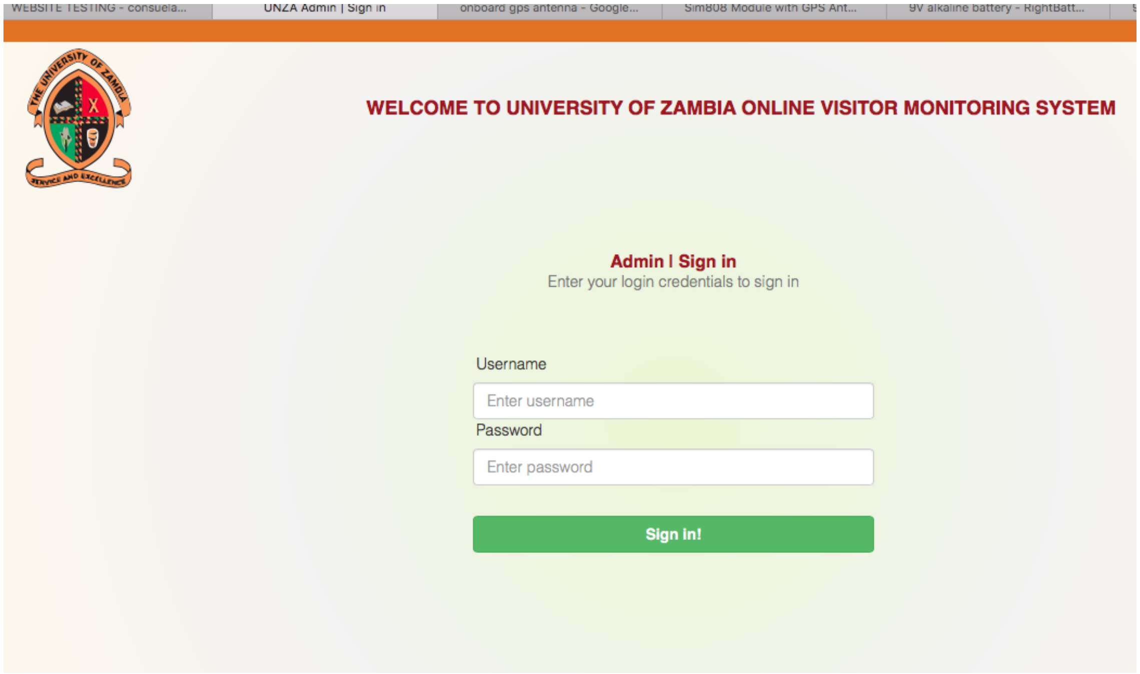
4.1.2.1 Current Visitor Business Process

The Current Visitor Business Process at UNZA is such that a visitor can basically move and enter most facilities without a need to identify himself. Access control is limited at UNZA and mostly to the Library and Administration. Identification of people entering the secure areas is through show of a barcode based ID. There is also no audit trail kept of visitors because no recording of such as date and time of visit are done.

4.1.2.2 Proposed Visitor Tracking Business process

An alternative business process to the current one is proposed. In the proposed, when a visitor arrives at UNZA, their details are recorded. The visitor is given an RFID access card to which a GPS is attached. The GPS continuously sends the visitors location and hence their movements.

To view the visitors' movements any User assigned with administrator privileges can log into the system. The Figure 61 below shows the login page of the systems developed in this study. While Figure 62 shows the applications' home page.

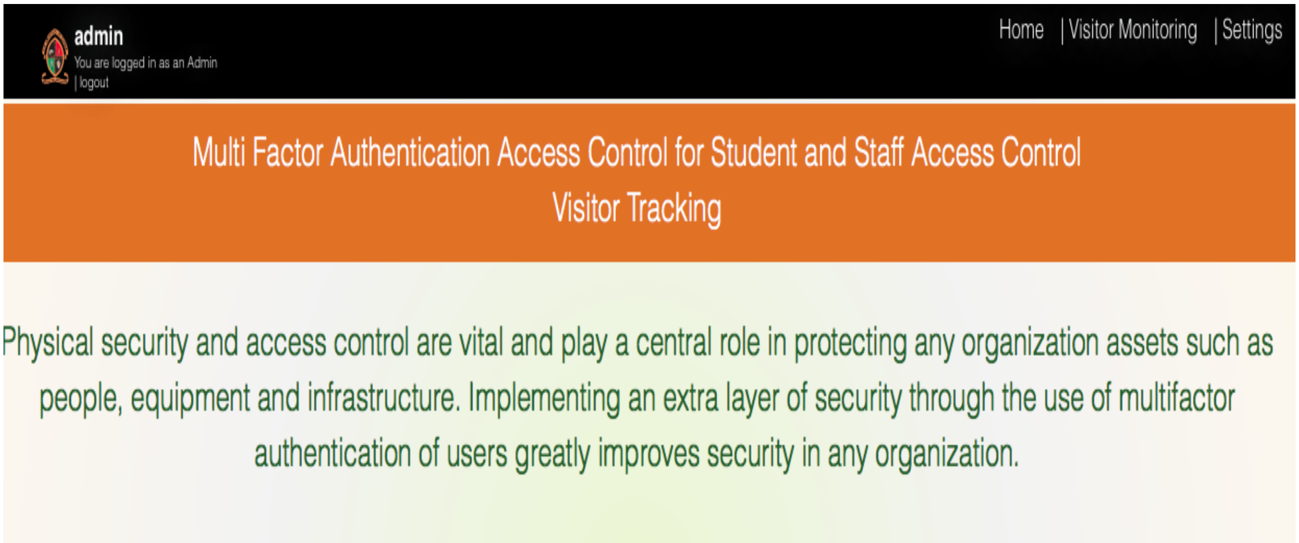

WEBSITE TESTING - consuela...
UNZA Admin | Sign in
onboard gps antenna - Google...
Sim808 Module with GPS Ant...
9V alkaline battery - RightBatt...
THE UNIVERSITY OF ZAMBIA
SERVICE AND EXCELLENCE

WELCOME TO UNIVERSITY OF ZAMBIA ONLINE VISITOR MONITORING SYSTEM

Admin | Sign in
Enter your login credentials to sign in

Username
Enter username
Password
Enter password
Sign in!

Figure 61: University Online Visitor Monitoring System Home Page



Multi Factor Authentication Access Control for Student and Staff Access Control
Visitor Tracking

Physical security and access control are vital and play a central role in protecting any organization assets such as people, equipment and infrastructure. Implementing an extra layer of security through the use of multifactor authentication of users greatly improves security in any organization.

Figure 62: Visitor tracking Home page

The software module consists three stages namely; the Perimeter Gates, Visitor Registration and Visitor Monitoring.

4.1.2.3 Perimeter gates

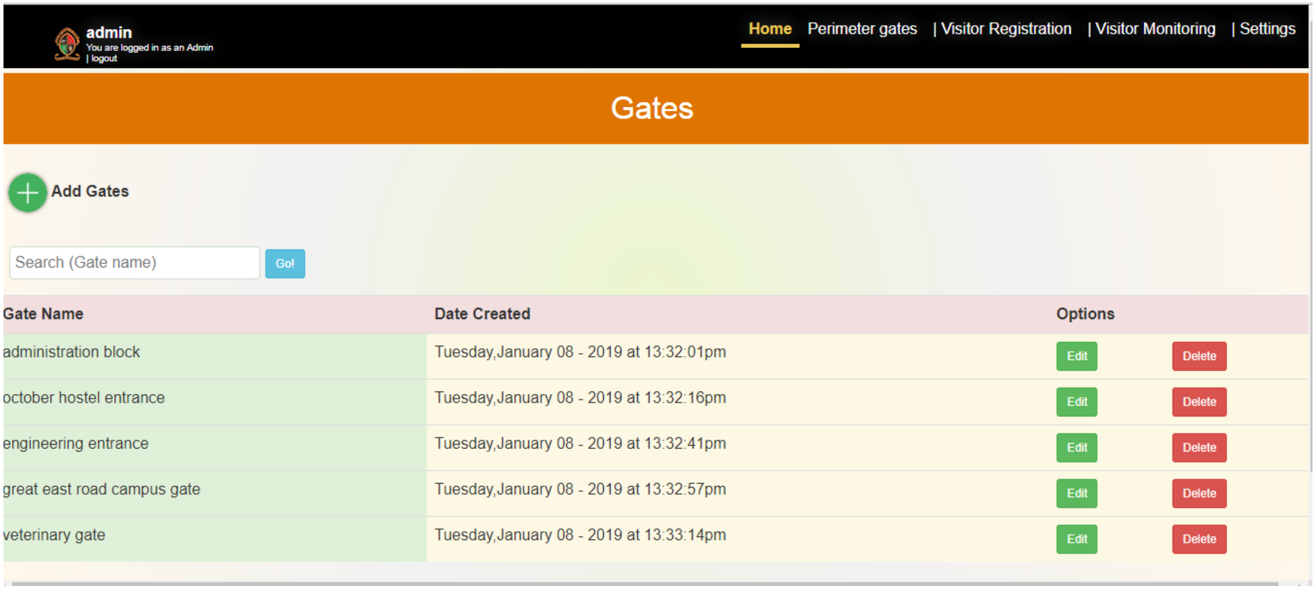
The system shows all the entry gates available. The visitor will enter campus through any one of the gates. It is at any of these that the visitors' details are recorded. A record of all the gates' activities are kept through this module. The systems have a capability to add more gates if necessary. A report of all the activities in terms of entry or exit can be printed or retrieved. Figure 63 shows the different perimeter gates and activities happening there. Figure 63 shows the gate addition and information module.

a) **Visitor registration**.

When a visitor arrives at any of the gates, they are given an access card to which a GPS module is attached. The visitors are registered and all their details recorded. Information recorded includes names, person to be visited, date and time of entry. Figure 64 shows the administrators login in screen were visitor information can be collected and stored.

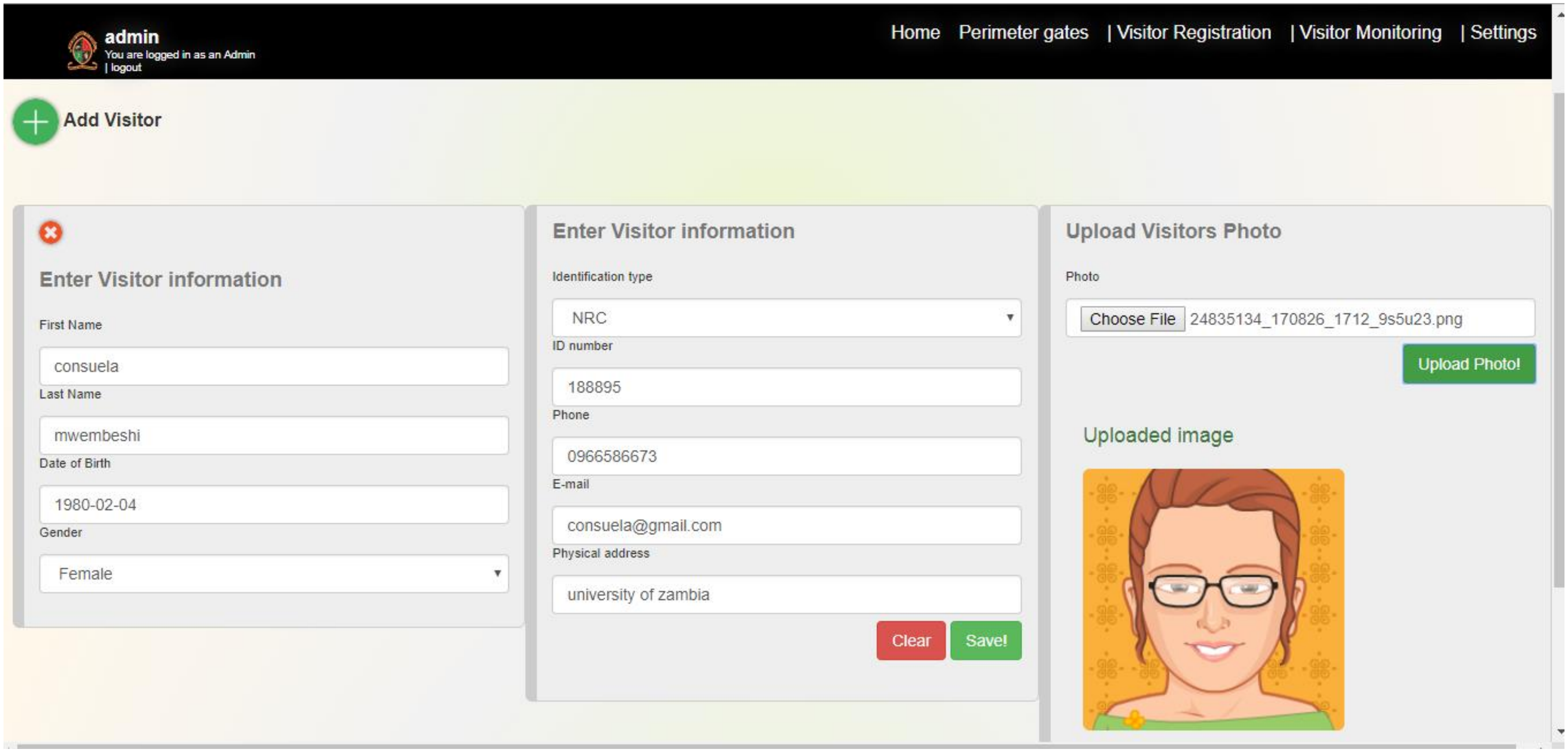
b) Visitor Monitoring

The visitor monitoring module monitors all the visitors' movements and physical locations in real time. When the visitors' position is located and the cursor is placed on the map, the systems reveals the date and time the visitor is at the particular location. This information can be stored in the data and can be reviewed when necessary as an audit trail.



Gate Name	Date Created	Options	
administration block	Tuesday,January 08 - 2019 at 13:32:01pm	Edit	Delete
october hostel entrance	Tuesday,January 08 - 2019 at 13:32:16pm	Edit	Delete
engineering entrance	Tuesday,January 08 - 2019 at 13:32:41pm	Edit	Delete
great east road campus gate	Tuesday,January 08 - 2019 at 13:32:57pm	Edit	Delete
veterinary gate	Tuesday,January 08 - 2019 at 13:33:14pm	Edit	Delete

Figure 63: Perimeter gate addition



Enter Visitor information

First Name: consuela

Last Name: mwembeshi

Date of Birth: 1980-02-04

Gender: Female

Enter Visitor information

Identification type: NRC

ID number: 188895

Phone: 0966586673

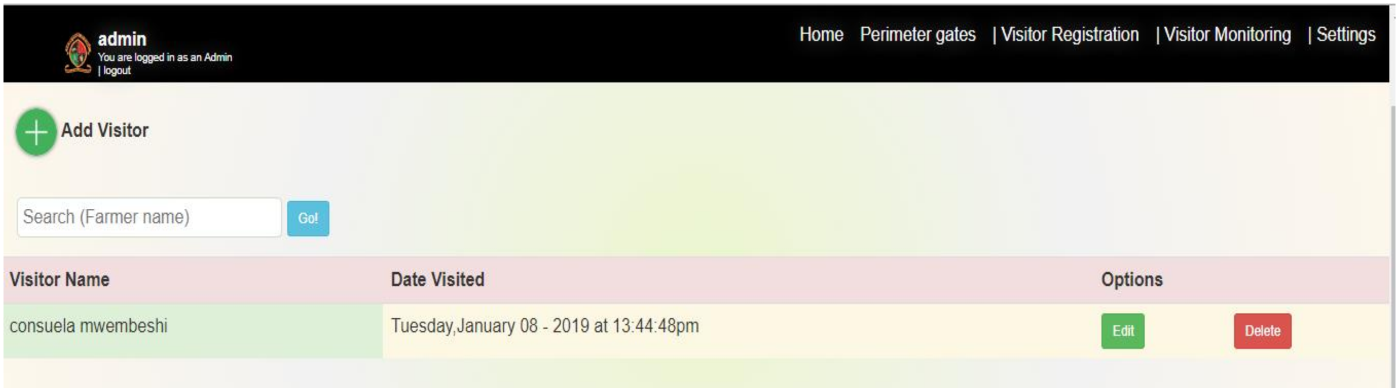
E-mail: consuela@gmail.com

Physical address: university of zambia

Upload Visitors Photo

Photo: Choose File 24835134_170826_1712_9s5u23.png

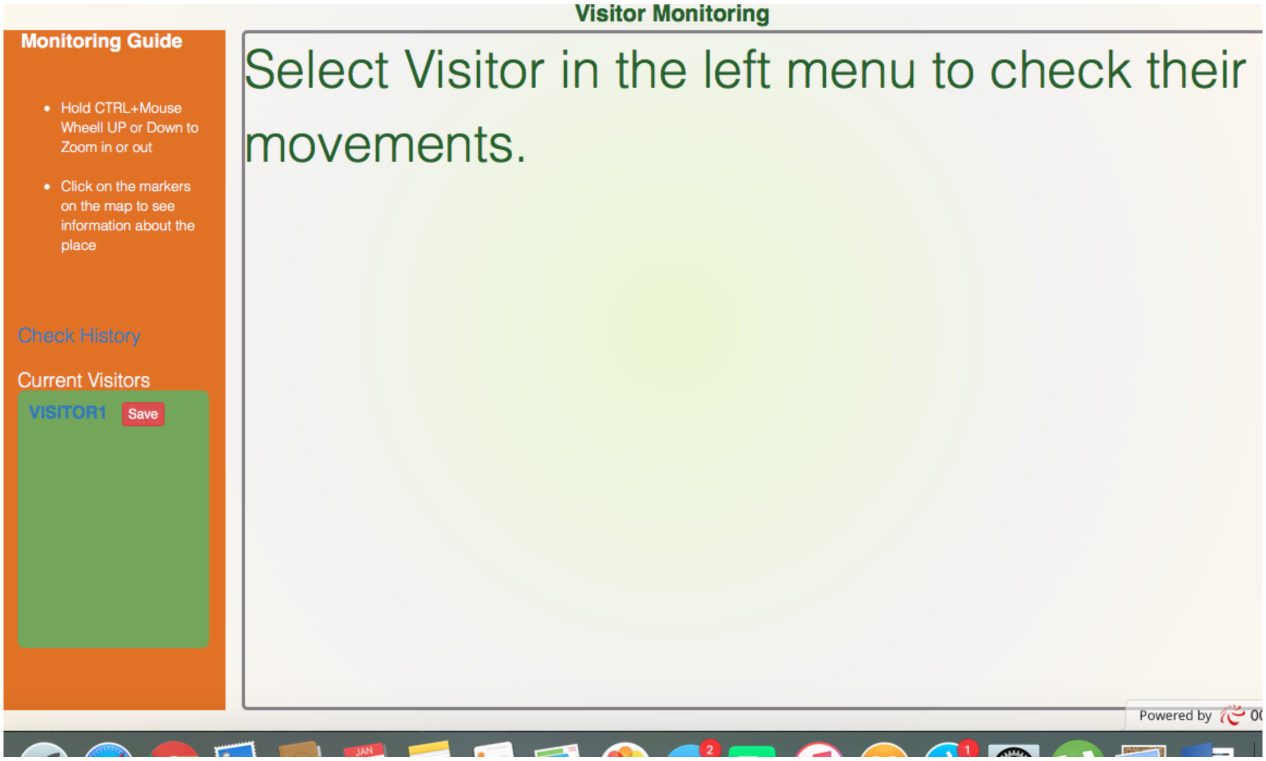
Figure 64: Addition of visitor information



Visitor Name	Date Visited	Options	
consuela mwembeshi	Tuesday,January 08 - 2019 at 13:44:48pm	Edit	Delete

Figure 65: Visitor added successfully

After the visitor has been added the system as depicted in Figure 65, the application is able to show the time, date, year and time of registration and the day the visitor visited. With this, a report and history of the visitor visits can be retrieved.


Visitor Monitoring

Monitoring Guide

- Hold CTRL+Mouse Wheell UP or Down to Zoom in or out
- Click on the markers on the map to see information about the place

Select Visitor in the left menu to check their movements.

Figure 66: Movements Check Option

The main function of the systems is to track visitor movements and track their physical location in real time. From visitor monitoring menu Figure 66 a visitors' movements and location can be traced.

4.1.3 System Hardware Setup.

The visitor tracking device consists of an Arduino Uno R3 module SIM808, which includes a GPS/GSM module with on board antenna, power pack and a USB cable. The heart of the tracking system is the Arduino Uno microcontroller. The geographical location of a visitor can be detected by a GPS receiver and this data is transmitted to the web server using GSM technology. This data is stored in a database. The SIM808 module is initialized to begin acquiring geographical location data through satellites. Using AT commands the deice which includes GPS and GSM modules is initialized. The GPS is turned on and put into reset mode. As soon as the module is ready to receive the coordinates of the satellite, the GPRS is then activated. The process includes the GPRS start, the definition of the service provider APN, initiates the start of the HTTP protocol and the definition of the protocol method (Get method). The device initialization process can take up to a minute to clear the position and calculate the exact position. If the network is unavailable, the acquired GPS coordinates and other data such as time and speed are buffered until the network is ready for use. Then, the stored coordinates are time stamped. An external power supply of 9V is used to ensure that the device is continuously powered during the process.

The GPS antenna and the GSM antenna are connected to the SIM808 module connector. The module and the Arduino have a common base. A program written in the C ++ programming language is loaded into the Arduino microcontroller using the Arduino IDE software.

4.1.3.1 Visitor Tracking

To monitor the motorist visitor, the device was placed on the vehicle's dash board. To monitor the movements of the pedestrian visitor, the module is carried round as the go around campus. The Arduino as connected to a USB power pack through the USB cable. The GPS/GSM module was powered using the energizer 9V battery. The GPS/GSM module was then connected to the Arduino module. The Figure 67 below shows the hardware connection of the device.

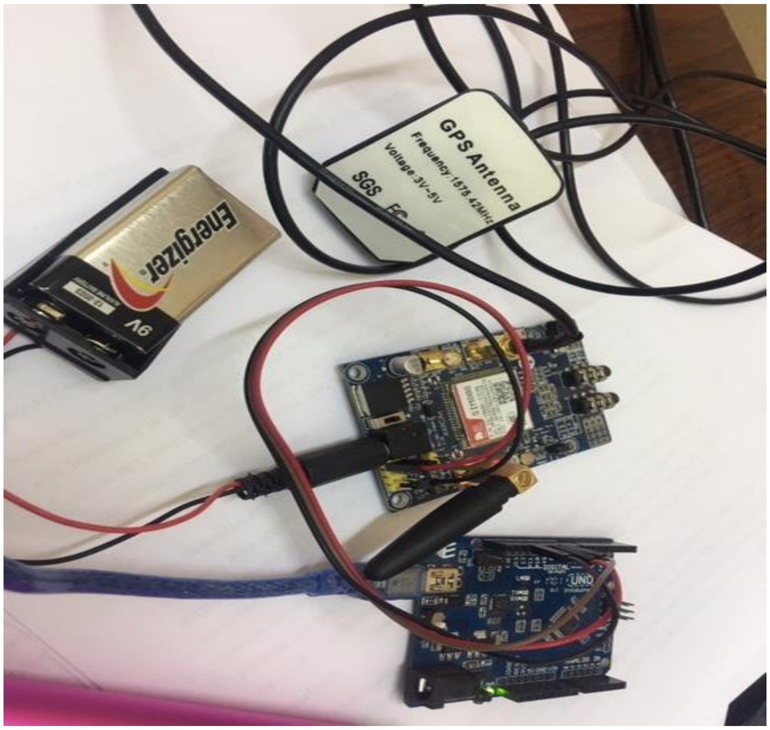


Figure 67: Hardware system set up image

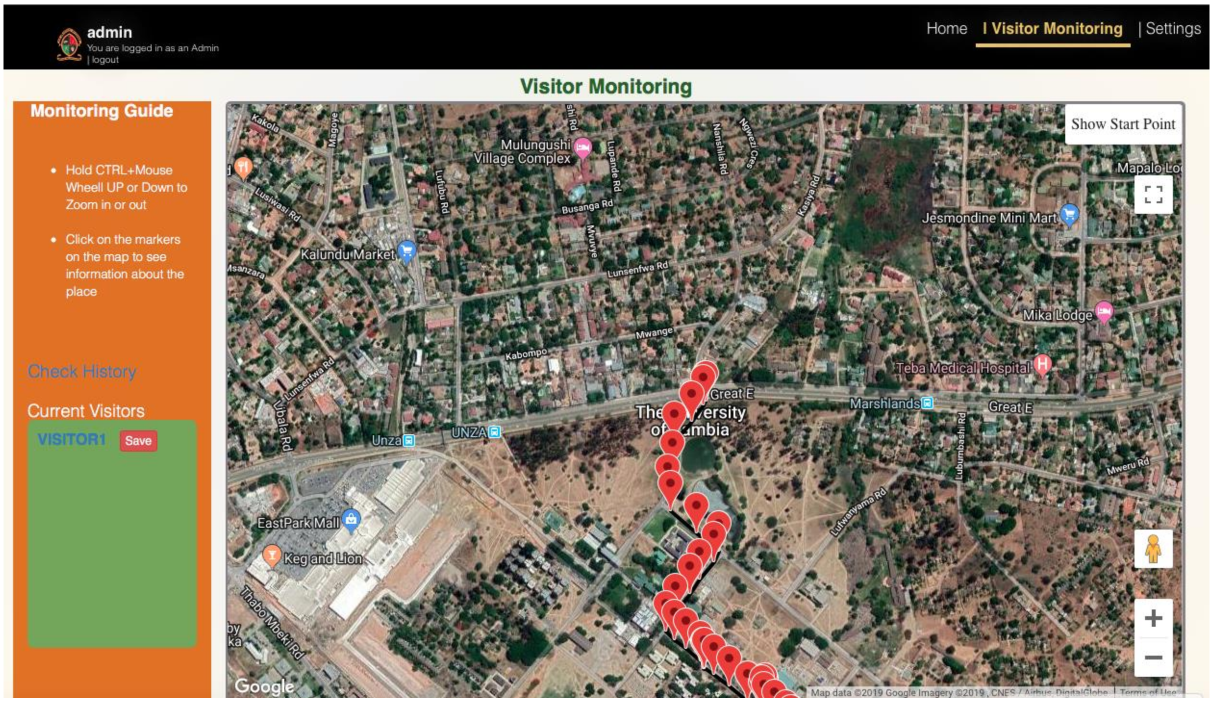
To monitor the visitor's position on the UNZA map, the study has developed a web application hosted on the remote cloud server. The web application was developed using PHP, HTML, Bootstrap and JavaScript. To save the received location data, a PHP file has been created, which is connected to the Arduino middleware. This PHP file receives the coordinates and sends them to the database for storage. Appendix 2, shows a snippet that shows the PHP code.

4.1.3.2 Tracking on Google Maps

The Google Maps API embeds map-based maps into the web application. The API automatically manages access to Google Maps servers. API calls are also used to add markers. The central location of the map is added with google. maps.LatLng (). Because the Maps API provides different types of map views, the study used Hybrid for this web application. To retrieve the data in Google Map, the getElementByID () method was used.

4.1.3.2 Real Time Tracking

When the vehicle to be tracked is chosen from vehicle list menu, then information about the visitor being tracked is displayed. The Figure 68 shows tracks of the motorist visitor.

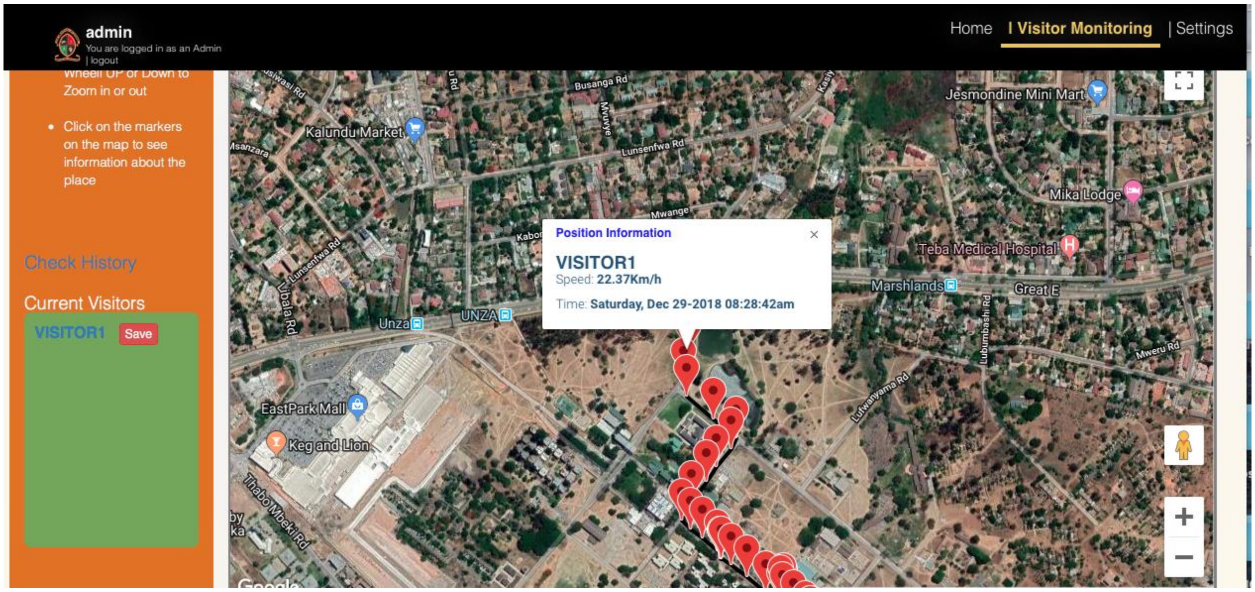


- Hold CTRL+Mouse Wheell UP or Down to Zoom in or out
- Click on the markers on the map to see information about the place

Figure 68: Visitor Tracking in Real Time.

4.1.4 Real Time Visitor Position Information

More information about the visitors' location and motorist can be retrieved using markers on the map. When a marker is clicked it pops up with information about the position as well their assigned ID. Some of the information displayed include date, time and speed**.** The system can also archive the tracking information for all the visitors and refer to the archived data later. Apart from real time tracking the system is able view positions in the past and all routes taken by the visitor. This can be viewed through the history page real time. The Figure 69 shows visitor archived information retrieved through the history tab.



You are logged in as an Admin | logout

Wheel UP or Down to Zoom in or out

- Click on the markers on the map to see information about the place

Position Information

VISITOR1

Speed: 22.37Km/h

Time: Saturday, Dec 29-2018 08:28:42am

Figure 69: Visitor information date and time.

4.2 Chapter Summary

This chapter shows the successful implementation of a visitor tracking system. The tracking has been achieved in real time. This also reviewed results from the baseline study.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Introduction

In this chapter, the main findings with regard the research questions are given in summary. General conclusions based on the findings of the study are also presented. Furthermore, limitations of this study are considered and recommendations are given.

5.2 Discussion

5.2.1 Baseline Study

A baseline study was conducted to measure the level of physical security at the University of Zambia. The study reveals that University of Zambia has limited or no control of who enters or visits campus. Analysis of the survey data identifies key points in the level of security and access control at the University of Zambia. It strongly shows that security at UNZA is porous. Access Control of who enters or exits the campus and what time is limited. The survey shows that the University Security Personnel are understaffed to man all the entry and exit points. The University does not have a system to automatically identify students, staff and visitors as is revealed from the baseline study conducted that more than 83% have no identification badges. This implies that anyone can access UNZA facilities such as offices and hostels without having the need to show identification. The survey shows that 84 % of office or hostels entrances are not secured by such as grill gates or automatic identification and access control system. Any institution that has no control of who accesses its premises is vulnerable to thefts and damage of property. The study revealed that University Staff and Students have been victims of theft or experienced a lot of thefts, the most common lost items being media such as laptop. The security department reports a total of 40 laptops belonging to staff, students and visitors stolen in the month of June alone.

According to the survey results the fence which is considered to be security perimeter only covers the University perimeter less than 50 % showing that unidentified people can enter, exit or trespass the campus premise without and need for permission. The results to the study also noted that about 83% show that there is no record kept of anyone who visits UNZA and at what time. Contractors deliver different supplies to the University but no audit record is kept of such visits. It is also not possible to ascertain whether the visitors only visited the intended and authourised place.

The baseline study conducted based on the ISO 27002 helped to measure the level of security at the campus. According to the survey the university does not have not have any written down procedures for security personnel to follow or reference to.

From the results as shown in results section 4.2, a prototype was designed and proposed to improve access control through automatic identification and authentication of all who enter campus. A prototype to track visitors' movements was also designed to ensure visitors can be tracked and an audit trail kept.

5.2.2 Security Model Design

Based on the results from the baseline study, a security model based on multifactor authentication access control was designed. This model based on RFID and Fingerprint was designed to improve security and control access to the university facilities. During registration a registered student and employed staff are registered into the system. The person's ID and finger print are matched in the system. The model also includes a module to monitor visitor physical location and movements in real time. The Visitor tracking module was designed, developed and implemented.

5.2.3 Visitor Tracking Module

The research implemented a visitor tracking module which gives required requests in real time. The visitor tracking device was designed, developed and validated through testing. Information such as date and time of entry and real time physical location and movements could be seen through the web application. This information is also stored on the cloud server. The tracking device which consists of GPS and GSM fetches the visitors' location and movements and then sends this information at regular intervals in this case was set to 4s intervals and is sent to the cloud server to ensure that the information is current. The system user or administrator can monitor the visitor's movements by logging into the systems' web application. The visitor information can be analysed through GIS.

The tracking device brings with it some benefits for UNZA. Since the visitor is notified or warned about the tracking, it works as a deterrent to visitors' who might want to visit unauthourised places. The devices keep a history of the past movements and locations, therefore it can also be used to keep a record and an audit trail of the visitor.

However, the tracking module has some limitations. For example, as was noticed during the testing phase, there was a skip in the visitor location results in places around campus where there are tall trees and buildings. The same was experienced during cloudy days, it was noticed that a multipath error was created leading to some errors in the results. The device had to be iniatialised several times in order to start reading again.

5.2.2 System Prototype Implementation

The study focused on developing the visitor tracking module, to which the basic functionalities were implemented on the basis of the use cases as indicated in the methodology Chapter 3 of the thesis document. To achieve this goal in this study, the proposed visitor tracking model was developed and a prototype system was implemented, demonstrating the concept of prototype operation. First, information was collected, analyzed and formulated as useful system requirements (methodology Chapter 3). The system requirements were derived from observing the current UNZA business process of Visitors hosting. The prototype of the system was developed in PHP and MySQL databases. The prototype has been successfully developed and shows how visitor movements can be tracked. The development tools used are available for free as they are all open source. The tools introduced in Chapter 4 were: Apache Web Server, MySQL, PHP, Bootstrap CSS, and JavaScript. The prototype demonstrates how data can be centrally managed and received in real time as they come from a variety of sources, most notably tracking people movements and physical locations. Cloud technologies like cloud storage and web application hosting making it possible for database storage. It can be concluded that cloud technologies are a better way to manage information from multiple sources. Storage in cloud databases also makes it possible to manage sensor data that is generated in large quantities, such as in people tracking. Based on the web application testing and validation, it has been experienced that the application provides easy and effective management and accessibility. The application was also reported as user friendly and easy to learn. The system also eliminates the need for paper records and accountability. All records are stored electronically in the cloud and are accessible to anyone with permission anywhere in the university.

5.3 Recommendations

The aim of the study was to design and develop a system to improve security at UNZA by controlling access and keeping an audit trail of visitors into the University. UNZA can greatly benefit in employing a visitor tracking system in so many ways. The study put forward the following recommendations:

(i) Visitor tracking at UNZA will allow to take control over who has access to UNZA premises and when.

(ii) The same visitor tracking system can be used for employee attendance tracking, giving an extensive overview of who is in, out or expected at the premises.

(iii) An audit trail date and time will be kept of all Visitors that come to the University.

(iv) Visitor tracking improves security; visitor control reduces the risk of theft taking place as where theft occurs it can help to identify the culprits.

(v) A Visitor tracking systems will allow authourised users of the systems to have full control over who has access to specific areas of the premises. Example would be during students' unrest; the students can be denied access out of the campus.

5.4 Conclusion:

In this thesis, the problem of limited control of access to the UNZA is addressed. The study designed a Multi Factor Authentication model for student and staff access control to UNZA based on RFID and Biometrics. One of the main contributions of this work is to improve identification and authentication of student and staff in comparison to what is currently being used which is identification with barcode based IDs. It is not easy to authenticate whether the person carrying the ID is actually the authourised owner. This work also measured the level of security at the University based ISO27002 physical and environmental security. According to the survey UNZA's security is porous. The institution can be accessed so easily by anyone, as has been revealed that only half the perimeter is fenced and not all entrances to hostels or offices are secured. No automated access control systems have been implemented.

The main focus of the thesis was to design and develop a prototype to monitor visitors' physical location and movements in real time. The prototype has been designed and developed and as seen from the testing and validation UNZA can greatly benefit from such an implementation.

5.5 Future Works

The student and staff access control will be developed and implemented to improve UNZAs' security. The Visitors module will be developed into a full-fledged system instead of just a prototype. Future implementations of the access control systems should include the use of a more intelligent and higher storage capacity micro controller such as Raspberry pi.

5.6 Chapter Summary

This chapter discussed the baseline study, system model design and visitor tracking. The study recommendations, conclusion and future works are also presented.

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APPENDICES

APENDIX A

A.1 Sample code

GPS C++ Code listing

```
#include <SoftwareSerial.h>

SoftwareSerial ss(10,11); //RX TX

#define GSM_PORT ss

#include "sim808.h"

#define JOURNEY "vr978rye7R"

void setup() {
  // setup code here, to run once:
  ss.begin(9600);
  Serial.begin(115200);
  Serial.println("Starting...");
  sim808_setup();
}

void sendPositionReport(unsigned long now) {

GSM_PORT.print("AT+HTTPPARA=\"URL\",\"unzavisitor.000webhostapp.com/gpsReceiver.php?");
  GSM_PORT.print("&vid=VISITOR1");
  GSM_PORT.print("&jn=");
  GSM_PORT.print(JOURNEY);
  GSM_PORT.print("&tm=");
  GSM_PORT.print( utc );
  GSM_PORT.print("&fx=");
  GSM_PORT.print(fixStatus);
  GSM_PORT.print("&lt=");
  GSM_PORT.print(lat);
 // Serial.print("Latitude=");
 // Serial.print(lat);
  GSM_PORT.print("&ln=");
  GSM_PORT.print(lon);
  GSM_PORT.print("&sv=");
  GSM_PORT.print(sats);
  GSM_PORT.print("&ha=");
  GSM_PORT.print(hdop);
  GSM_PORT.print("&gs=");
  GSM_PORT.print(sog);
  GSM_PORT.print("&hd=");
  GSM_PORT.print(cog);
  GSM_PORT.println("\"");

  flushGSM(now);

  delay(500);

  sendGSM("AT+HTTPACTION=0");
}

void loop() {

  unsigned long now = millis();

  boolean gotGPS = false;
  if ( actionState == AS_IDLE ) {
    if ( fixStatus > 0 && now > lastActionTime + 10000 ) {

      sendPositionReport(now);

      lastActionTime = now;
      httpResult = 0;
      actionState = AS_WAITING_FOR_RESPONSE;
    }
  }
  else {
    // waiting on response - abort if taking too long
    if ( now > lastActionTime + 15000 ) {
      actionState = AS_IDLE;
      parseState = PS_DETECT_MSG_TYPE;
      resetBuffer();
    }
  }

  sim808_loop();
}
```

PHP Web application code listing: Tracking page

```
<?php
	include('db_server.php');
	include('class_lib/class_lib_inc.php');
	if(!warehousesExist($conn) && !visitorsExist($conn)){
		header('location:manager_home.php'); die;
	}
	$trackingObj = new Visitor_Tracking($conn);
 ?>
```

```
<!--DOCTYPE html-->
<html lang="en">
<head>
  <meta charset="UTF-8"/>
  <meta name="viewport" content="width=device-width, initial-scale=1"/>
  <title>Admin | Maps |</title>
  <link rel="shortcut icon" href="images/logo.svg" type="image/x-icon">
  <link rel="stylesheet" href="js/bootstrap.min.css"/>
  <link rel="stylesheet" href="css/style.css"/>
  <link rel="stylesheet" href="css/typeheadAndMapStyles.css"/>
  <script src="js/jquery.min.js"></script>
  <script src="js/bootstrap.min.js"></script>
  <script src="js/myscript.js"></script>
  <script src="js/prefixfree.min.js"></script>
  <script src="managerWarehouse.js"></script>

  <?php include('mapsProcessorTracking.php') ?>

  <style type="text/css">
#addUserIcon:hover,#addUserIconClose:hover{
 box-shadow: 0 0 7px #222 ;
border-radius:20px;
                          }
#addUserIconClose,#addUserIcon{
box-shadow: 0 0 5px #444 ;
border-radius:20px;
}
  </style>
</head>
<body>
<?php
```

```
//process header inclusion based on user settings
            if(isset($_SESSION['sysAdmin_pwd_crypt'])){
                        include('sysAdmin_header.php');
            }else if(isset($_SESSION['admin_pwd_crypt'])){
                        include('manager_header.php');
            }
?>
<div class="main">
  <div class="page" id="mission">
    <div class="content container-fluid">
                        <div class="row">

<div  class="col-lg-12  col-md-12  col-sm-12  col-xsm-12"  style="height:relative;color:#fff;text-align:center;">
<b style="font-size:1.3em;color:#296122">Visitor Monitoring</b>
</div>
<div class="col-lg-12">
<div class="col-lg-2" style="background-color:#DF7401;height:84%;color:#fff">
<h4 style="padding-left:3px;"><b>Monitoring Guide</b></h4>
<br/><br/>
<ul style="font-size: 0.8em;">
<li>Hold CTRL+Mouse Wheell UP or Down to Zoom in or out</li><br/>
<li>Click on the markers on the map to see information about the place</li><br/>
<br/><br/>
<!-- Rounded switch -->
</ul>
<a href="manager_arch_tracking.php"><h4>Check History</h4></a><br/>
<?php
$trackingObj->getVisitorList("gps_coordinate");
?>
</div>
```

```
<div class="col-md-10 col-sm-10 col-xsm-10" >
<div id="map" style="width:100%;height: 84%; border: 3px solid #838186; border-radius: 5px;
">
<p style="color:296122; font-size: 3em;">Select Visitor in the left menu to check their
movements.<br/>
</p>
</div><!-- Map-->
<div id="infowindow-content">
<img src="" width="16" height="16" id="place-icon">
<span id="place-name"  class="title"></span><br>
<span id="place-address"></span>
</div>
</div>
</div><!--Whole form-->
</div><!-- row -->
   </div><!-- content container -->
  </div><!-- add program -->
</div><!--main-->

<?php include('manager_footer.php')?>

<script async defer
            src='https://maps.googleapis.com/maps/api/js?key=AIzaSyBwiqodRbtEX-U-
b3vXlwahF1QlOMw1fug&libraries=places&callback=initMap'>
</script>

<script src="mapGoefenceControls.js" type="text/javaScript"></script>

</body>
</html>
```

PHP Class Visitor_Tracking

```
<?php
    class Visitor_Tracking{

        private $dbConnection = NULL;

        public function __construct($conVar){ $this->dbConnection = $conVar; }
//get paths

        function buildPath($vIDVal,$tbl){
            $returnStr = "[";
            $getCord = mysqli_query($this->dbConnection,"SELECT * FROM $tbl
WHERE visitor_id='".$vIDVal."'");

            if(mysqli_num_rows($getCord)>0){
                while($coordInfo = mysqli_fetch_assoc($getCord)){
                    $returnStr                                    .=
"{lat:".$coordInfo['latitude'].",lng:".$coordInfo['longitude']."},";
                }
                $returnStr .= "]";
                $strWithoutLastComa = substr($returnStr,0,strlen($returnStr)-2);
                return $strWithoutLastComa."]";
            }else{
                return "[{lat:-15.3875259,lng:28.3228165}]";
            }

        }

        //get center point
        public function getCenterPoint($vIDVal,$tbl){
            $getCord = mysqli_query($this->dbConnection,"SELECT * FROM $tbl
WHERE coordinates_id=(SELECT MIN(coordinates_id) FROM $tbl WHERE
visitor_id='".$vIDVal."')

    ");
            if(mysqli_num_rows($getCord)>0){
                $point = mysqli_fetch_assoc($getCord);
                $coordinatesObj                                  =
"{lat:".$point['latitude'].",lng:".$point['longitude']."}";
                return $coordinatesObj;
            }else{
                $coordinatesObj = "{lat:-15.3875259,lng:28.3228165}";
                return $coordinatesObj;
            }
        }

        public function getCenterPointMap($vIDVal,$tbl){
            $retArr = array();
            $getCord = mysqli_query($this->dbConnection,"SELECT * FROM $tbl

    WHERE coordinates_id=(SELECT MAX(coordinates_id) FROM $tbl WHERE
visitor_id='".$vIDVal."')

    ");
            if(mysqli_num_rows($getCord)>0){
                $point = mysqli_fetch_assoc($getCord);

                $retArr['latitude'] = $point['latitude'];
                $retArr['longitude'] = $point['longitude'];

                return $retArr;
```

```
                        }else{
                                $retArr['latitude'] = "-15.3875259";
                                $retArr['longitude'] = "28.3228165";
                                return $retArr;
                        }
                }

                //get Route for specific visitor
                public function getRoute($vIDVal,$tbl){
                        $getCord = mysqli_query($this->dbConnection,"SELECT * FROM $tbl
WHERE visitor_id='".$vIDVal."'");
                        return $getCord;
                }

                //get Route for specific visitor
                public function getRouteFilter($vIDVal,$tbl,$start,$end){
                        $getCord = mysqli_query($this->dbConnection,"SELECT * FROM $tbl
WHERE visitor_id='".$vIDVal."'

        AND position_time BETWEEN '".$start."' AND '".$end."'

       ");
                        return $getCord;
                }

                //get visitor list
                public function getvisitorList($tbl){

                        $getCord        =        mysqli_query($this->dbConnection,"SELECT
DISTINCT(visitor_id) AS vid_item FROM $tbl");
```

```
            if(mysqli_num_rows($getCord)>0){

                echo '<h4>Current Visitors</h4>';
                echo ";
                echo '<p style="height:38%;overflow:auto;background-
color:#76a651;border-radius:7px;padding:10px;">';

                while($vID = mysqli_fetch_assoc($getCord)){
                    echo '<a
href="manager_tracking.php?vid='.$vID['vid_item'].'"><b>'.$vID['vid_item'].'</b><a/>';
                    echo '&nbsp&nbsp&nbsp<a
href="archiveTrackingInfo.php?vid='.$vID['vid_item'].'"><button class="btn btn-xs btn-
danger">Archive</button><a/><br/><br/>';

                }

                echo '</p>';
            }
        }

        //get center point
        public function getvisitorListArch($tbl){

            $getCord = mysqli_query($this->dbConnection,"SELECT
DISTINCT(visitor_id) AS vid_item FROM $tbl");

            if(mysqli_num_rows($getCord)>0){

                echo '<h4>Visitor list</h4>';
                echo ";
```

```
                    echo '<pstyle="height:38%;overflow:auto;background-
color:#76a651;border-radius:7px;padding:10px;">';

                        while($vID = mysqli_fetch_assoc($getCord)){
                            echo '<a
href="manager_arch_tracking.php?vid='.$vID['vid_item'].'"><b>'.$vID['vid_item'].'</b><a/>';
                            echo '&nbsp&nbsp&nbsp<a
href="restoreTrackingInfo.php?vid='.$vID['vid_item'].'"><button class="btn btn-xs btn-
success">Restore</button><a/><br/><br/>';

                        }

                        echo '</p>';
                    }
                }

?>
```

Perimeter gates page code listing

```
<!--DOCTYPE html-->
<html lang="en">
<head>
  <meta charset="UTF-8"/>
  <meta name="viewport" content="width=device-width, initial-scale=1"/>
  <title>Admin | Gates |</title>
  <link rel="shortcut icon" href="images/logo.ico" type="image/x-icon">
  <link rel="stylesheet" href="js/bootstrap.min.css"/>
  <link rel="stylesheet" href="css/style.css"/>
  <script src="js/jquery.min.js"></script>
  <script src="js/bootstrap.min.js"></script>
  <script src="js/myscript.js"></script>
  <script src="js/prefixfree.min.js"></script>
  <script src="managergatess.js"></script>

  <style type="text/css">

                    #addUserIcon:hover,#addUserIconClose:hover{
                              box-shadow: 0 0 7px #222 ;
                              border-radius:20px;
                    }
                    #addUserIconClose,#addUserIcon{
                              box-shadow: 0 0 5px #444 ;
                              border-radius:20px;
                    }

  </style>

</head>
<body>
<?php
          //process header inclusion based on user settings
          if(isset($_SESSION['sysAdmin_pwd_crypt'])){
                    include('sysAdmin_header.php');
          }else if(isset($_SESSION['admin_pwd_crypt'])){
                    include('manager_header.php');
          }

          include('db_server.php');
          include('class_lib/class_lib_inc.php');
          $gatesObj = new gates($conn);
?>
<div class="main">
  <div class="page" id="mission">
```

```
   <div class="content container-fluid">
                    <div class="row">
<div class="col-md-12"   style="background-color:#DF7401; padding:1%;"><!-- blue band -->
<div  class="col-lg-12  col-md-12  col-sm-12  col-xsm-12"  style="height:relative;color:#fff;font-
size:2em;text-align:center;">
            Gates
</div>
</div><!-- blue band -->
<div class="col-lg-12" style="margin-top:30px;padding-left:2%;">
<span>
<img class="icon" id="addUserIcon" src="images/plusgreen.png" height="40"/>
                                                <b>Add Gates</b>
                                        </span><br/><br/>
                                </div>


<div class="col-lg-12" id="userDiv" style="margin-top:30px;padding-left:2%;">
<div class="col-sm-4 col-xsm-4" style="padding: 1%; border: solid 1px #ccc; border-left: solid
10px #ccc;border-radius:6px;" id="formPanel">
<img id="addUserIconClose" src="images/cancelflat.png" height="20"/><br/><br/>
                    <form id="userForm" name="userForm" method="POST" action="" >
                     <h4 style="color:#777;"><strong>Enter Gate Information</strong></h4><br/>
                    <label for="d_name">Gate Name</label>
<input class="form-control"  type="text" name="p_name" id="p_name" style="margin-top:6px;"
value="" placeholder="Gate name" max-length="60" autocomplete="off" />
            <div align="right">
            <input class="btn btn-danger" type="reset" style="margin-top: 6px;" value="Clear"/>
<input class="btn btn-success" type="submit" name="send" style="margin-top: 6px;"
value="Save!"/>
            </div>
            </form>
            <div class="col-md-12" id="mainserverResponseSignup" style="margin-top:5%;">
```

```
    </div>
    </div>
    </div><!--Whole form-->
    <div class="col-md-12"   style="padding:1%;"><!-- blue band -->
    <div class="col-md-6">
<form method="POST" action="">
<input id="searchField" name="sKey" placeholder="Search (Gate name)"/>
<input class="btn btn-info btn-sm" type="submit" name="search" value="Go!">
</form>

<?php
if(isset($_POST['sKey']) && $_POST['sKey']!==""){
    $sKey = mysqli_real_escape_string($conn,strip_tags($_POST['sKey']));
        $districtRes = $gatesObj->searchgatessByName($sKey,$ADMIN_ID);
    echo '<h4 style="color:green;">Search results for : <b>
'.$_POST['sKey'].'</b></h4><br/>';
echo '<a href="manager_gatess.php"><img src="images/reload.png" height="40"/> Show
everything</a><br/><br/>';
    }else if(isset($_POST['sKey']) && $_POST['sKey']==""){
    echo '<h4 style="color:red;"><b>Enter Gate name to search</b></h4><br/>';
    $gateRes = $gatesObj->getgatess($ADMIN_ID);
    }else{
    $gateRes = $gatesObj->getgatess($ADMIN_ID);
                    }
                ?>
            </div>
            <?php
        if(!$districtRes){
echo '<p class="alert alert-info"> <img src="images/info.png" height="40"/> There is no gate to
show, Add gates to get started!</p>';
}else{
```

```
echo'<table class="table table-compact table-hover">
<tr class="danger">
<th>Gate Name</th>
<th>Date Created</th><th colspan="3">Options</th>';
 echo'</tr>';
while($propertiInfo = mysqli_fetch_assoc($districtRes)){
$date = date_create($propertiInfo['gates_timestamp']);
$dateOut = date_format($date,'l,F d - Y').' at '.date_format($date,'H:i:sa');
$pID = $propertiInfo['gates_id'];
$pNameDisp = $propertiInfo['gates_name'];
 echo '
<tr>
<td class="success">'.$pNameDisp.'</td>
<td class="warning">'.$dateOut.'</td>';
//check user status for shared access, show options if user is managerAddRoomAJAXProc
echo'<td class="warning">
<button class="btn btn-success btn-sm" data-toggle="modal" data-
productname="'.$pNameDisp.'" data-href="'.$pID.'" data-
target="#EditModal">Edit</button></td>
<td class="warning">
<button class="btn btn-danger btn-sm" data-toggle="modal" data-productname="'.$pNameDisp.'"
data-href="processgates.php?del_pID='.$pID.'" data-target="#DeleteModal">Delete</button>
</td>';
//show options ends here
echo'</tr>';
                                                }
                                        }
                                        echo '</table>';
                                ?>
                        </div><!-- blue band -->
```

```
                    </div><!-- row -->
        </div><!-- content container -->
      </div><!-- add program -->
    </div><!--main-->

            <div class="modal fade" id="DeleteModal" tabindex="-1" role="dialog" aria-labelledby="myModalLabel" aria-hidden="true">
                    <div class="modal-dialog alert alert-danger">
                            <div class="modal-content">

                                    <div class="modal-header alert alert-danger">
<button type="button" class="close" data-dismiss="modal" aria-hidden="true">&times;</button>
                                            <h4 class="modal-title" id="myModalLabel"><b>Confirm Delete gate</b></h4>
                                    </div>

                                    <div class="modal-body alert-danger">
                                            <!-- confirm modal dynamic contetn-->
                                    </div>

                                    <div class="modal-footer alert-danger">
                                            <button type="button" class="btn btn-default" data-dismiss="modal">Cancel</button>
                                            <a class="btn btn-danger btn-ok">Delete</a>
                                    </div>
                            </div>
                    </div>
            </div>
            <div class="modal fade" id="EditModal" tabindex="-1" role="dialog" aria-labelledby="myModalLabel" aria-hidden="true">
```

```
                <div class="modal-dialog alert alert-success">
                        <div class="modal-content">
                                <div class="modal-header alert alert-success">
        <button type="button" class="close" data-dismiss="modal" aria-
hidden="true">&times;</button>
                <h4 class="modal-title" id="myModalLabel"><b>Update gate
Information</b></h4>
                                </div>
                                <div class="modal-body alert-success">
                                        <!-- confirm modal dynamic contetn-->
                                </div>
                                <div class="modal-footer alert-success">
                <button type="button" class="btn btn-default" data-
dismiss="modal">Cancel</button>
                                        <!--<a class="btn btn-success  btn-ok">Ok</a>-->
                                </div>
                        </div>
                </div>
        </div>
```

PHP Class Visitor Registration code Listing

```
<?php
        class visitor_registration{
                private $dbConnection = NULL;

public function __construct($conVar){ $this->dbConnection = $conVar; } //construct with
connection
```

```
public function
addvisitor($fName,$lName,$dob,$gend,$Addr,$idType,$idNum,$phn,$eMail,$photo,$uID){
        $setD = mysqli_query($this->dbConnection,"INSERT INTO
visitor(`f_name`,`l_name`,`dob`,`visitor_gender`,`visitor_address`,

        `id_type`,`id_number`,`phone`,`e_mail`,`visitor_photo`,`admin_id`)

VALUES('".$fName."','".$lName."','".$dob."','".$gend."','".$Addr."','".$idType."',

                 '".$idNum."','".$phn."','".$eMail."','".$photo."','".$uID."'

                )
                        ");

                        if(!$setD){
                                return false;
                        }else{
                                return true;
                        }
                }

                //update visitor record

public function
updatevisitor($fName,$lName,$dob,$gend,$Addr,$idType,$idNum,$phn,$eMail,$photo,$fID){
                        $setD = mysqli_query($this->dbConnection,"UPDATE visitor SET
`f_name`='".$fName."',

                                        `l_name`='".$lName."',

                                        `dob`='".$dob."',
                `visitor_gender`='".$gend."',

                    `visitor_address`='".$Addr."',

                    `id_type`='".$idType."',

                    `id_number`='".$idNum."',

                    `phone`='".$phn."',

                    `e_mail`='".$eMail."',

                    `visitor_photo`='".$photo."'

WHERE visitor_id='".$fID."'
            ");

            if(!$setD){
                return false;
            }else{
                return true;
            }
        }

        //get visitors

        public function getvisitors($uID){
            $setD = mysqli_query($this->dbConnection,"SELECT * FROM visitor
WHERE admin_id='".$uID."' ORDER BY f_name ASC
            ");
            if(mysqli_num_rows($setD)>0){
```

```
                        return $setD;
                    }else{
                        return false;
                    }
                }

                //search visitors by name

                public function searchvisitorsByName($sKey,$uID){
                    $setD = mysqli_query($this->dbConnection,"SELECT * FROM visitor
WHERE f_name LIKE '%".$sKey."%' OR id_number LIKE '%".$sKey."%'

        OR phone LIKE '%".$sKey."%' OR e_mail LIKE '%".$sKey."%'

        AND admin_id='".$uID."'

        ORDER BY f_name ASC

                    ");

                    if(mysqli_num_rows($setD)>0){
                        return $setD;
                    }else{
                        return false;
                    }
                }

                //visitor exists on update

                public function visitorIDExistsOnUpdate($idNum,$fID){
```

```
            $setD = mysqli_query($this->dbConnection,"SELECT * FROM visitor
WHERE id_number='".$idNum."' AND visitor_id<>'".$fID."'
            ");

            if(mysqli_num_rows($setD)>0){
                return $setD;
            }else{
                return false;
            }
        }


        public function visitorPhoneExistsOnUpdate($phn,$fID){
            $setD = mysqli_query($this->dbConnection,"SELECT * FROM visitor
WHERE phone='".$phn."' AND visitor_id<>'".$fID."'
            ");

            if(mysqli_num_rows($setD)>0){
                return $setD;
            }else{
                return false;
            }
        }

        public function visitorEmailExistsOnUpdate($eMail,$fID){
            $setD = mysqli_query($this->dbConnection,"SELECT * FROM visitor
WHERE e_mail='".$eMail."' AND visitor_id<>'".$fID."'
            ");

            if(mysqli_num_rows($setD)>0){
                return $setD;
            }else{
                return false;
            }
        }


        //delete visitor

        public function deletevisitor($fID){
            $setD = mysqli_query($this->dbConnection,"DELETE FROM visitor
WHERE visitor_id='".$fID."'
            ");

            if($setD){
                return true;
            }else{
                return false;
            }
        }

        public function getvisitorsMenu(){
            $getH = mysqli_query($this->dbConnection,"SELECT * FROM visitor
ORDER BY f_name ASC");
            $outContent = '';

            if(mysqli_num_rows($getH)>0){
                while($rTypeInfo = mysqli_fetch_assoc($getH)){
                    $outContent .= '<option
value='.$rTypeInfo['visitor_id'].'>'.$rTypeInfo['f_name'].' '.$rTypeInfo['l_name'].'</option>';
                }
            }else{
                $outContent .= '<option value="">There is no visitors at the
moment!</option>';
            }
            echo $outContent;
        }

        public function __destruct(){}

    }

?>
```

The University of Zambia

School of Engineering

Multi-factor Authentication for Student and Staff Access Control based on Radio Frequency Identification and Barcode Technologies and Global Information System

By Consuela Simukali (2016145977)

Master of Engineering – ICT Security

For further details or any queries, kindly get in touch on 0977 676 706

Dear Respondent,

I am a final year Master of Engineering – ICT Security student at the University of Zambia. As partial fulfillment for the award of a Master's degree, I am conducting a baseline study on: "**Multi-factor Authentication for Student and Staff Access Control based on Artificial Intelligence, Radio Frequency Identification and Barcode Technologies**".

You have been purposively sampled to provide information for the topic indicated above. The information being collected is purely for academic purposes as such, it will be treated with maximum confidentiality. Subsequently, you are not supposed to indicate your name or any personal information that can lead to revealing of your identity.

Your co-operation will be greatly appreciated.

For more information queries in relation to the survey, you may wish to contact the following:

Research Supervisor: Dr. Jackson Phiri on Jackson.phiri@cs.unza.zm

Assistant Dean: Dr. Mwanaumo on Erastus.mwanaumo@unza.zm

A.2 Student Questionnaire

Part A: Bio Data - Please tick in the box as appropriate

1) **Sex:** (a) Male □ (b) Female □

2) **Age in years:**

(a)	18-22	□	**(d)**	30-34	□
(b)	22-26	□	**(e)**	30-40	□
(c)	26-30	□	**(f)**	40 and above	□

3) **Marital Status**

(a)	Single	□	**(e)**	Separated	□
(b)	Married	□	**(f)**	Divorce	□
(c)	Widowed	□			

4) **Please indicate the program you are enrolled in**:

(a)	Certificate/Diploma	□	**(e)**	Doctorate	□
(b)	Undergraduate	□	**(f)**	Other	□
(c)	Post Graduate	□			

Other specify …………………………

5) **Are you accommodated by UNZA?**

(a) Yes □

(b) No □

Please specify your hostel block? ....

Part B Access Control and Security (Tick the correct answer)

1) **How many copies of keys does your hostel room have?**

(a) One □

(b) Two □

(c) More than two □

2) **Have you ever lost or replaced your hostel room key?**

(a) Yes □

(b) No □

3) **If your answer to question (2) yes was the padlock changed?**

(a) Yes □

(b) No □

4) **Are the hostels or school main entrances secured (e.g. with such as grill gates, locks) at night?**

(a) Yes □

(b) No □

5) Are the hostels or school main entrances guarded by security guards 24/7?

(a) Yes □

(b) No □

6) Is there an identification system for students at the hostel entrances?

(a) Yes □

(b) No □

7) Is there an identification system for visitors at the hostel entrances?

(a) Yes □

(b) No □

8) How safe are your belongings in your hostel?

(a)	Extremely safe	□	(d)	Somewhat safe	□
(b)	Very safe	□	(e)	Not safe	□

9) Is the place where you hang your washing (clothes) safe?

(a)	Extremely safe	□	(d)	Somewhat safe	□
(b)	Very safe	□	(e)	Not safe	□
(c)	safe	□			

10) Have you or anyone you know been a victim of theft while on campus?

(a) Yes

(b) No

If answer to question (10) is yes please specify what was stolen: ……..………………………………………….

11) Are there Access Control Systems employed (e.g. card-swipe, security locks, CCTV, intruder detection)

(a) Yes □

(b) No □

If answer to question 11 is yes please specify: ………………………………………….

12) Would you like to be notified via sms or any other means when someone enters your room without your knowledge?

(a) Yes □

(b) No □

13) In your opinion do you think Access Control System to Hostels has/would improve UNZA's security?

(a) Yes □

(b) No □

(c) Makes no Difference □

A.3 Staff Questionnaire

Part A: Bio Data - Please tick in the box as appropriate

6) **Sex:** (a) Male □ (b) Female □

7) **Age in years:**

(a) 18-22 □

(b) 22-26 □

(c) 26-30 □

(d) 30-34 □

(e) 30-40 □

(f) 40 and above □

8) **Marital Status**

(a) Single □

(b) Married □

(c) Widowed □

(e) Separated □

(f) Divorce □

(4) **Level of Education**

(a) Certificate □

(b) Diploma □

(c) Degree □

(d) Postgraduate □

(e) PhD □

(f) Other…………………………. □

Please specify your specialisation……………………………………….

(5) Please indicate the school or unit you belong to:

(a) Education □

(b) Mines □

(c) Medicine □

(d) Graduate Studies □

(e) Law □

(f) Library □

(g) Dean of Students □

(h) TDAU □

(i) Clinic □

(j) Engineering □

(k) Natural Sciences □

(l) Humanities and Social Sciences □

(m) Veterinary Medicine □

(n) Agricultural Sciences □

(o) CICT □

(p) UNZA Printer □

(q) Administration □

(r) Purchasing □

Part B Access Control and Security (Tick the correct answer)

1) **How many copies of keys does your office have?**

(d) One □

(e) Two □

(f) More than two □

2) Have you ever lost or replaced your Office key?

(a) No □

(b) Yes □

3) If your answer to question (2) yes was the padlock changed?

(a) No □

(b) Yes □

4) Is your **School/Unit's main entrances secured (e.g. with such as grill gates, locks,)?**

(a) Yes □

(b) No □

5) **Are your school/unit's main entrances guarded by security guards?**

(a) Everyday 24/7 □

(b) During working hours □

(c) After working hours □

(d) No Security Guards □

6) Is there a central receptionist?

a) Yes □

b) No □

7) Does the receptionist perform functions of identifying people that enter through the main entrance?

a) Yes □

b) No □

c) No receptionist □

8) Is an identification card or badge used to identify *members of staff* as they enter and exit main entrances to your school/Unit?

a) Yes □

b) No □

9) Is an identification card or badge used to identify *students* as they enter and exit main entrances to your school/Unit?

a) Yes □

b) No □

10) Is an identification card or badge used to identify *visitors or contractors* as they enter and exit main entrances to your school/Unit?

a) Yes □

b) No □

11) Are there written down procedures for the method of identification members of staff (e.g. date, time,) at the time of entering and leaving the office?

a) Yes □

b) No □

12) Are there written procedures relative to lost, damaged and/or forgotten identity cards or badges?

a) Yes □

b) No □

c) Don't know □

13) Are vendors, tradesmen, utility servicemen etc. issued a special or distinctive type of visitor badge?

d) Yes

e) No

14) Are visitors' details recorded as they enter and exit your school/unit?

a) Yes □

b) No □

15) Are there procedures that insure the return of identification badges or cards upon termination of employment or school for staff and students?

a) Yes □

b) No □

c) Don't know □

16) How safe are your belongings in your office?

(a) Extremely safe □ (b) Very safe □

(c) Somewhat safe □ (d) Not safe □

17) Have you or anyone you know been a victim of theft while on campus?

(a) Yes □

(b) No □

18) If answer to question (17) is yes please specify what was stolen:

What was stolen………………………………Year of theft ……...

19) Are there Access Control Systems employed (e.g. card-swipe, digital security locks, CCTV, intruder detection) in your school/Unit's main entrance?

(a) Yes □

(b) No □

20) If answer to question 11 is yes please specify:

…………………………………………………………….

21) In your opinion do you think Access Control Systems has/would improve school/unit's security?

(a) Yes □

(b) No □

(c) Makes no Difference □

A.4 Security Department

This part to be filled by UNZA security Personnel

Part A: Bio Data - Please tick in the box as appropriate

9) **Sex:** (a) Male □ (b) Female □

10) **Age in years:**

(a) 18-22 □

(b) 22-26 □

(c) 26-30 □

(d) 30-34 □

(e) 30-40 □

(f) 40 and above □

11) **Marital Status**

(a) Single □

(b) Married □

(c) Widowed □

(e) Separated □

(f) Divorce □

(4) **Level of Education**

(a) Certificate □

(b) Diploma □

(c) Degree □

(d) Postgraduate □

(e) PhD □

(f) Other…………………………. □

Please specify your specialisation……………………………………….

(5) Please indicate the school or unit you belong to:

(a) Education □

(b) Mines □

(c) Medicine □

(d) Graduate Studies □

(e) Law □

(f) Library □

(g) Dean of Students □

(h) TDAU □

(i) Clinic □

(j) Engineering □

(k) Natural Sciences □

(l) Humanities and Social Sciences □

(m) Veterinary Medicine □

(n) Agricultural Sciences □

(o) CICT □

(p) UNZA Printer □

(q) Administration □

(r) Purchasing □

Perimeter Security

1) Does a fence or other type of physical barrier define the perimeter of the entire UNZA campus?

a) Yes □

b) No □

2) Is the physical barrier considered a security safe guard?

(a) Yes □

(b) No □

(c) No Fence □

3) If your answer to question (2) is yes does the fence cover the perimeter 100%?

(a) Yes 100% □

(b) Covers more 50% □

(c) Covers less 50% □

(d) No Fence □

12) **How many entrance or exit points does UNZA campus have?**

(a) 1-2 □

(b) 2-4 □

(c) 4-6 □

(d) More than six □

13) **How many entrance points in perimeter barriers guarded or secured?**

(a) 1-2 □

(b) 2-4 □

(c) 4-6 □

(d) More than six □

14) **How many entrance points in the perimeter barriers lockable?**

(a) 1-2 □

(b) 2-4 □

(c) 4-6 □

(d) More than six □

15) **Are the keys to the entrances kept in one central place?**

(a) Yes □

(b) No □

(c) Not lockable □

16) **Is there a way of identifying students as they enter or exit campus?**

(a) Yes □

(b) No □

17) **Is there a way of identifying staff as they enter and exit campus?**

(a) Yes □

(b) No □

18) **Is there an official procedure to routinely check visitors and log them in the visitor's book?**

(a) Yes □

(b) No □

19) **If answer in question (10) is yes, are there appropriate signs that notify the visitors that activity in question (10) is mandatory?**

(a) Yes □

(b) No □

20) **Are there "No Trespassing" signs posted on all perimeter barriers at such intervals that at least one sign is visible at any approach to the barrier for a minimum distance of 40 meters.**

(a) Yes □

(b) No □

21) **Are all normally used pedestrian and vehicle gates lighted to allow proper identification and examination of interiors of vehicles?**

(a) Yes □

(b) No □

(c) Some □

22) **Are the lighting sources at theses entrances provided with dependable source of power?**

(a) Yes □

(b) No □

(c) No lighting □

23) **Are there Security communications equipment exclusive for security personnel?**

(a) Yes □

(b) No □

24) **Is there a written down procedure to report crime?**

(a) Yes □

(b) No □

25) **Is the university of Zambia community availed with a number to call the Security in case of an emergency.**

(a) Yes □

(b) No □

26) **Is there a record of reported thefts?**

(a) Yes □

(b) No □