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SCHOOL OF COMPUTING AND INFORMATICS

SMART SCHOOL BUS SYSTEM TO ENHANCE CHILD TRANSPORT SAFETY USING RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY

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Project report submitted to the School of Computing and Informatics in partial fulfillment of the requirements for the award of the degree of Masters of Science in Distributed Computing Technology

Declaration

I hereby declare that this project proposal is entirely my original work and has not been submitted for assessment at this or any other university. Materials of work done by other researchers are mentioned by clear references.

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The project report has been submitted in partial fulfillment of the requirements for the Degree of Master of Science in Computer Science at the University of Nairobi with my approval as the University Supervisor.

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Abstract

Child safety is a critical concern from the parents as many children use school buses to commute to and from school every day. Parents find it challenging to monitor the safety of their children when they leave for school. A child may board the wrong bus or alight from the wrong drop off point or left in the bus, this may lead to getting lost or getting late for class or home. In the present time, attendance for school are taken manually and for parents to know the location of their children they have to call a teacher who in return looks if the child got to school, but if it's the other way; child leaving school, the teacher can only mention they left and another look is to find whether they alighted at the correct drop off point. The focal drive for this project is to enhance safety while apprising parents on the movement of their children from home to school and vice versa which in return reduces the hustle of parents calling the teachers every time the child is away from them. The project is useful for the school administration as it can give a daily attendance according to the report of those who were dropped in school and at what time. With use of Radio Frequency Identification (RFID) and geo-tagging, a solution to aid in notifying parents of their child's location via a Short Message Service (SMS). The parent is notified when the child boards or alights from the bus, the SMS containing timestamp and location details. RFID reader detects a tag carried by a child who is uniquely linked to parent details, and then the system triggers an immediate SMS to the respective parent. The parent can as well query the location of a student and the system sends similar SMS with location details of the bus where the child is an occupant. Different modules work hand in hand with each other to deliver the objective of enhancing safety for school going children.

Keywords: Radio Frequency Identification, Wireless Sensor Networks, SMS Gateway, Arduino.

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Chapter One: Introduction

1.1 Background of the Study

School transport is key area of concern to all stake holders mostly the parents and the administration. Young children have an attachment to their parents and thus every guardian want to be at the best in making sure their child is safe at any time. Across Kenya, school buses transport children every morning and evening for the pick-up and drop-off respectively. This raises concerns by the parents on the safety of their children. However, some parents prefer to drop their children to the school every morning and organize to pick them up in the evening; many schools' administration have also put weight in the transport department towards assuring parents of safety of children when using the school bus. This has had its challenges in that the driver and the children may operate on different scripts from the parents and administration to an extent. There is limited support given by the driver and sometimes additional staff to monitor the children during bus boarding and drop off.

At a time when technology is keeping us on toes, it gets to play most vital roles in day-to-day life. To keep up with these changing trends, schools have in different lengths invested in technology and the same should be reflected in the transport department. Identification and monitoring of school children can be achieved via innovative ways.

RFID being one of the most promising identification technologies due to its merits compared to the others like barcode technology for instance; it does not need line of sight, stores higher amounts of data compared, requirements less human intervention and also more it can identify more than one object simultaneously. There are many applications that use the Radiofrequency Identification (RFID) technology though most is in the supply chain management and also in corporate institutions for access control systems. RFID is a science of identifying objects by use of tags which carry information stored in them. The tags might be either active or passive. With active RFID tags, they have their own power source while the later rely on power from the nearby RFID readers. It is a contactless technology which distantly writes and or pulls data from an embedded memory chip. This technology mainly has two components: the reader and the tags in which the reader emits and receives radio waves of which in return the tags use it for communication. The major advantage for the passive tags have indistinct operational live span as the power needed for them to operate is retrieved from the reader.

The real implementation power of RFID does not come in by only retrieval of the serial number; but in combination with backend systems which can process data and further give more information of a tagged item. This backend adds the database part and sometimes perform computational. Several factors are out in place before implementation and key among these are the communication range between the reader and the tag or the transponder. The connection is established via Electronic EM field. Before the implementation of RFID systems, several types

of RFID need to be clearly understood as to aid in decision making; this affected the performance of the RFID technology when applied in real scenario. There are three types of tags in reliance on the source of their power. RFID technology will therefore have these divisions; active tags, passive tags and semi passive tags as show in the table below. Compared, the passive tags are cheaper than the other two and thus it is easily available in the market. The resulting prototype captures the capability to monitor school going children location using the RFID reader that proactively sends signals via cellular networks and use of geo-coordinates to track to location of the bus with the child.

Table 1.1: RFID Tags Comparison

	Active	**Passive**	**Semi-Passive**
Power	Battery	Induction by reader	Induction and Battery
Power Availability	Continuous	Only within reader	Continuous
Functional Distance	Up to 30 meters	3 meters or less	Up to 30 meters
Cost	Expensive	Cheap	Expensive
Tag Signal Strength	High	Low	High

The scanning of the child's tag gives identity of the holder which will then be transmitted via radio waves to a micro controller or a terminal; this is where information is processed and used in different references. Though not the primary, the driver will be able to tell the number of children on board at any particular time by a simple interface. This terminal is equipped with a GSM modem to be used in transmitting and exchanging data between the bus system and the

central database in the school. Moreover, this GPS modem has a cellular network functionality which can send notifications via SMS triggered by the system.

Global System for Mobile communication (GSM) is essential tracking tools. GPS provides precise location in longitude and latitude by calculation of the time difference of signals from different satellite to reach the receiver.

The United Nation Convention on the Rights of the Child (UNCRC) states that "every child has the right to enjoy childhood". Kenya among other countries have signed in to this, much has been done but we have few loopholes on the implementation; here being school going children.

1.2 Problem Statement

In recent years, with change of trends and even school operations, there is generally a point of concern resulting to a major problem when it comes to school bus transport system. Kids find themselves boarding the wrong bus in their pick-up point or even being dropped at wrong destinations. The school management is under constant pressure by the law to provide reliable service to students and parents.

According to Kenya's Penal Code "any person who takes a minor under fourteen years of age or under sixteen years of age if a male or female respectively, out of the keeping of a lawful guardian of the minor, without the consent of the guardian, is said to kidnap the minor or person from lawful guardianship. Further, any person who by force compels, or by any deceitful means induces, any person to go from any place is said to abduct that person" (Kenya Law Reform Commission (KLRC), 2009).

School going children face challenges which translate to inconveniences to the parents; in these are being at the bus pick up or drop-off points and wait without knowledge of the bus exact

location. A study by National Crime Research Centre indicates kidnapping on the rise in Kenya to the extent that Kenya is now ranked as number 17 out of 19 under countries where the threat of kidnapping and related criminal activities. Profiling victim profile in the same study, it shows out women (55.1%) and children (78.1%) are the most vulnerable. Children are an easy target because they lack the physical and mental capacity to resist the decoy of kidnappers.

This being not the primary, when parents leave children to be escorted by care givers, they are mostly not notified when or if the children are picked for school and vice versa thus impose a danger of kidnapping and abduction. Controlling entry and exit of children in a school bus remains critical issue both for the parents and the school administration.

Article 53 of The Kenya Constitution 2010 recognize children to be protected from any harmful environment; and this can be one as it's dangerous for a child to be by the road alone.

In emerging economies, such as Kenya, kidnapping among other crimes are expected to increase. This has prompted the National Police Service in Kenya to create a special unit to respond kidnapping criminal activities; this is as a measure to deal with the crime increase (Mugwang'a, 2013). An instance of a case in Kenyan is for the twin girls' kidnap, sources revealed how Special Forces from Britain had been sought because the victims were thought to be British citizens (Michira and Gisesa, 2013).

Children, for instance in Kenya, have fallen victim to kidnappers. Some cases reported include not limited to; a self-confessed serial killer Phillip Onyancha was accused of kidnapping and murdering a seven-year old child (Agoya, 2014). The kidnappers of twin girls in Kenya demanded a Sh86 million ($1M) ransom from the children's wealthy parents (Makana, 2013). In Kenya, kidnapping is mainly addressed through the Penal Code CAP 63 Laws of Kenya from

Section 254 to 262. The law provides dictates any persons found with unlawful guardianship is guilty of a felony and is liable to imprisonment for seven years (KLRC, 2009).

There have been different attempts to solve this particular issue of school going children safety with bias to tracking of the children using either RFID tags or video with image recognition in buses among others. In respect to a study by Anwaar Al-Lawati, (2015) which concluded on use of sensors integrated with RFID tags, it does not fully address the Kenya school setup and thus a study in getting a fit-in solution in which RFID readers will sent tag IDs to a central database using cellular network.

1.3 Justification of the Problem

It is noted that criminals now target children kidnapping from the streets as at home security systems like alarms are in place; in the streets is mostly when the children are dropped for school or from school waiting for pick-up by care givers. This creates a sense of insecurity and unsettledness to the parents when the children are away; this has always accumulated to calling of the teacher or administrator in charge to find out where and how their child is doing. With a single notification or via web access by the parents and guardians, they can easily query the location of a child over and above getting a SMS notification.

Governments across the world are currently discussing and in the implementation of tactics and systems to curtail the rising crime of child abduction. Some of these include training and deployment of security personnel, use of high tech gadgets among other policies being drafted towards cracking down child kidnapping networks (Mukinda, 2014; Nation Team, 2014).

A research by Ali Al-Mahruqi and Dr. Jayavrinda Vrindavanam (Ali-al Maharuqi, 2015) has shown more risks related to children riding on the wrong bus or even missing it; hence ending up

not being traced. This could have easily been resolved by a notification to the parent with the point where the child alighted and immediately trigger alarm to the relevant personnel before the child gets lost.

For case of parents picking or dropping students, they have to leave work and wait until the bus picks up the child. If the parent returns before the school bus arrival the problem is that the student might hold the wrong bus and alight at a wrong stop. If the kid is dropped at the wrong stop, parents won't get notified if their child has been dropped and still keep waiting at the correct bus stop (Arpitha B N and Dr M C Padma, IJMTST, ISSN: 2455-3778, 2016).

1.4 Research Objectives

1.4.1 Core Objective

To design, implement then test a prototype application with its integration towards enhancing school bus transport safety system using RFID technology in reference to Kenyan schools' approach.

1.4.2 Specific Objectives

- To analyze and understand the school transport operations and its requirements towards improving transport safety.
- To design and implement a solution for a school transport system using RFID Tags, Geo-location and GPRS on web enabled devices based on requirements and analysis of decisions.
- To test the prototype application using RFID technology

1.5 Research Questions

a) How is the school transport department operating in regard to children safety during pick up and drop off points?
b) Is the design and implementation of using RFID Tags, GSM and GPRS on web enabled devices based on requirements and analysis of decisions a solution for a school transport system?
c) Is the prototype feasible?

1.6 Scope

This study will seek to identify the experience of parents or an institution when a child is lost while on transit to or from school. With many questions to address trying to locate the child, a little care with use of RFID technology can enhance safety of the same. Currently, school management have advanced to a point of issuing every child with a school ID card in which the details of a child are captured. This ID card can be advanced to an autoID which can capture, store and identify children information integrating with legacy systems seamlessly. Parents will get notification each time a child gets into the bus and when they alight using the respective registered mobile numbers. This means, they can be at peace knowing the child arrived school safely and also when they are dropped at the pickup point, they can easily monitor.

To the school administration, the proposed system can automatically generate a register of all children who attended school assuming they used the school transport. Using the captured date, decision on routing of buses can be easily analyzed and action taken.

1.7 Assumptions

The major assumption of this study is that the school will have a dedicated school bus and also a central database for all the children thus from the RFID system itself, details for children are fetched directly from the administration and not the transport department. Data capture is accurate and less of anomalies as the RFID School bus system only queries from database and thus no adding of records apart from timestamps. This illustrates less human intervention in the way that even the driver or the bus attendant will not alter records in the system rather than monitor.

Also, at every drop off point or pick up point there is a guardian for the respective child till the bus arrives to pick or drop the child; this reduces the risk of caregivers leaving children unattended and thus exposing them to danger of kidnapping.

1.8 Definition of Important Terms

i) Auto-ID - automatic identification of objects by machines

ii) Radio-frequency Identification (RFID) – a kind of technology that uses radio in identification of objects with aid of a microchip and an antenna (RFID transponder).

1.9 List of Abbreviations

GSM Global System for Mobile Communication

RTCS Real Time Child Tracking

RFID Radio-frequency Identification

RF Radio Frequency

RFID Radio-frequency identification

SMS Short Messaging Service

Chapter Two: Literature Review

2.1 Introduction

RFID technology has been relatively in existence and still growing technology with vast fields of application. According to Golding & Tennant (2008), RFID is a form of data capture technology that can automatically recognize, monitor and store information electronically for an individual or group of items. This chapter is aiming at capturing, reviewing and assessing most relevant published work in quest to identify possible research gaps which will or are used to further strengthen the field's knowledge. This chapter will also look in to the depth about the RFID technology, classification of tags with the operating principle.

2.2 Background of RFID Technology in School Transport System

Different studies have been published on RFID in affiliation to either management or monitoring; though noticeably in supply chain management. However, different authors have different views on this particular field. This chapter therefore discusses the necessity for child tracking solutions and also various solutions that have been developed for this key purpose.

C. Kumar (2012) argue that the number of studies have been carried out to show how RFID technology transmits data via radio waves; this identity is in form of a unique serial number for distinguishing the object from the others.

In most areas, school buses are made to appear as unique as possible and thus they are commonly painted bright colors for visibilities and also contain specialized traffic warning devices. According to Gangopadhyay, dev, Ghoshal and Das, (2011), school buses operated and run under the school's administration stand to be safer compared to available public transport.

Further, Nirupama & Hafezi (2014) portrayed how decisions made by parents, school administration, government authorities as well as the bus drivers have substantial effect on school children's safety. The number of accidents occurred worldwide show that more of the school going children get injured or die in private cars than in school buses.

A study carried by (Osyk et al., 2012) on implementation of RFID technology in supply chain, it is noticeably that it faces some non-technical challenges like lack of standardization, cost, and resistance to adopt information transparency and privacy among others.

2.3 RFID Operating Principles

Out of the many studies, there comes also more recommendations which if not well researched might mislead due to the vast nature of the information available. Currently RFID tags are broadly in companies, schools, industries among others for identification and/or attendance. A good example where RFID technology is in environments where extensive security and privacy assessment is key in object identification, this informs the decision to adopt RFID technology.

Among the characteristics of RFID technology, one imperative characteristic is that the collection of data can happen without the knowledge of the individual: electromagnetic communication happens invisibly thus it does not "touch the senses", it penetrates obstacles such as bags or clothes, the size of RFID tags and readers can be very small, and there may be no sign that they are in operation. This technology comprise of three components: the tag, reader and the middleware which integrates with the back-end database. Kaur et al. (2011) denotes how a RFID transponder and receiver work together in that the RFID tag activates the transponder which sends a signal to transceiver. All these components are electronically programmed with unique identity.

RFID tags house an integrated circuit coupled to an antenna (Cybulski et al., 2003) which are then enclosed in relatively plastic sheet. A single tag contains a few bytes of memory which contain a unique identification number. In the tag, data is stored in a microchip and an antenna which is tuned to receive radio frequency waves emitted by a reader or transceiver for allowing wireless transmission of data to the reader.

An RFID tag can be likened to token carrying information where its security value depends on the asset it is attached to and the purpose for which it is being used, for example verifying identity using a car key, providing access to restricted areas using an access card, among others. If RFID tags are used as an electronic wallet or tickets in a subway card or to open doors, criminals may be interested in stealing, copying or modifying them. When RFID is used for access control to other systems and networks, a successful attack could compromise not just the RFID system itself but also all systems and networks it was supposed to secure.

From the different analysis of research findings in supply chain management, health sector systems, and privacy issues conclude a major trend in RFID. On these contributions on the RFID technology, the technological forecasts were also analyzed and concluded RFID will ubiquitously diffuse and assimilate our today's operations.

The RFID technology is leveraging Moore's law to the sense that the design in becoming smaller in size and cost reducing over time thus the general tag cost and motivation of use is impacted.

2.4 Radio Frequency Identification (RFID) Working Concept

A transceiver, antennae and a transponder form a basic RFID according to Kaur et al. (2011) which are enclosed within plastic or silicon or sometimes glass. A study by (Ilie-zudor et al. 2006) denotes how RFID systems can communicate by induction or propagation or scatter

methods. In the induction communication, close proximity electromagnetic or inductive coupling - near field are used. RFID in general can be described as an identity mechanism applying wireless protocols in object identification. Either unidirectional or bidirectional, RFID carry and transmit data from cards to readers and gradually to the host machines or servers for processing.

2.5 Related Work

Different types of studies have been carried out by different authors in the relationship to RFID technology in tracking objects, student tracking has also been an area of research under this. Generally, in the transport industry there have been transport challenges and more to the available solution in the market. With the rapid shaping of technology, the community is embracing it and this particular idea. The roles of any auto identification are to increase efficiency, error reduction and collecting of data processing and analysis.

(Paul Hamilton, 2013) describes a RFID Middleware as specialty software that sits between the reader network and the application to aid in the process of transmitting significant amount of data generated by the reader network. Middleware is can as well be used in the cleaning the data by eliminating false reads besides performing aggregation and filtering of data.

By using RFID enabled smart cards, RFID readers in buses can be made to get details on the number of students who are on board a bus at any particular time by the scanning of passenger held smart cards. This information would useful in tracing missing students or any anomalies. Additionally, and of importance is that the RFID reader affixed to a bus stop or traffic light will register the presence of a school bus outfitted with an RFID tag. All this information would then enable the transport manager to either inform the parents/guardians of the expected arrival time of bus or dynamically schedule the trip of a bus. (Paul Hamilton, 2013)

2.5.1 RFID System for School Children Transportation Safety Enhancement

Anwaar Al-Lawati, (2015), denotes in a similar system developed that, monitoring pick-up and drop-off points could reduce worry for the parent whether their children were pick and dropped or even forgotten. This particular system could only display the updated information to a LED screen for the driver thus had limited interaction to the parents.

(Anonymous), school bus architecture with functionality of a DVR was developed. The child could swap his/her school card as they enter and via a 2G/3G network the data could be transmitted to a central server. The installed DVR could capture various spots in the bus both audio and video while on transit. This was a worth system as it encompassed many other systems and also could accommodate legacy systems. The shortcoming and also the low acceptability in the school environment was that the return on investment and cost of operation seemed to be widening for the management to maintain the system operational.

2.5.2 Children tracking system on android mobile terminals

A study by (Saranya, J, 2013) proposed a system to monitor children movements by attaching a small chip to the child that transmitted data to a centralized database and a mobile device. Convenience for children and costly deployment in a wide-scale are among the key drawback for this system.

2.5.3 Active RFID based integrated tracking and sensing system

Active RFID system consists of the tag, reader and antennae which are attached to a coupling component or chip. The main distinguishing feature of this is that the reader identifies information without having direct contact and also without the distance factor being very close. The system principle is that the tag transmits signal which is should be in the field of reader

antennae. The reader receives the signal and forwards to the computer which receives it for processing.

2.5.4 An Intelligent Transportation System using RFID based Sensors

According to Chang Wang, (2013), a system prototype developed makes use of wireless sensors to provide intelligent transportation system. The high dependency of the sensors however proved a challenge as the hardware could regularly fail. More to that, the middleware developed for the same was a debate as it only operated on specific sensor models.

2.6 Benefits of RFID Technology

RFID technology seems mostly to compare with barcodes which it isn't replacing in the near future. There are some points which make RFID have added value compared to related technologies, there are several strengths in identification of it according to Ilie-zudor, et al (2006):

1. Human intervention is minimal in detection of tags thus less of human errors in data.
2. Line of sight is not a key factor.
3. Compared to barcodes, RFID has a longer read compared.
4. The capability to read many tags simultaneously is crucial
5. RFID can store data which fastens the process of data capturing
6. On adverse conditions, the tags can withstand environments with exposure to dust, some chemicals and even physical damages.

2.7 Concerns or Limitations of RFID Technology

Standardization – amount of information and format of data stored in tags depend on the manufacturer, this leaves the communication protocol at freedom to choose what suits best.

Frequency – there are three basic factors on this, there are: transmission mode, operating environment and reader malfunction. Transmission mode depends on the electromagnetic fields, the low frequency and high frequency; lower frequencies (LF Band) such as 125–134 or 13.56MHz in the high frequency (HF band), inductive coupling is applied.

Collision – According to (Budet, 2004), attempting to read multiple tags at the same time might cause data loss due to signal collision. However, there exist possible algorithms for anti-collision in which most are patented or patent pending.

The benefits of RFID technology can well be ripped when tracking information from RFID devices and efficiently integrated into business processes and applications according to (Mylyy, 2007) as cited by (Kochar & Chhillar, 2010).

2.8 The Gap

The existing systems work well as independent entities. The shortcoming with most is that they focus on the delivery of monitoring via SMS notification. This makes it a challenge in case a parent has travelled and don't have the cellular network available. Unless they are on roaming network which is quite expensive, they might lack the peace of mind in regard to child's whereabouts. To add on this, children can be dropped on the wrong locations and still the parent gets notification in which they won't be able to tell if they were dropped on the correct location. The available solution which adds coordinates to the SMS notification proves a challenge as most parents won't know exact location by use of coordinates. With practical implementation,

effective notification service to a smart device connected to the internet; this will allow any parent no matter where they go they will be up-to-date by the notification system. This then continually provides touch between the different parties. Privacy concerns arise with adoption of RFID by school administrations and more by the parents where some suggest this technology might compromise their privacy in relation to that of their children

In case of any emergency on the road, (R. Malliga, 2016) states that, the main challenge will be that parents won't be notified as they will rely on SMS notification which is triggered by a child getting in and out of the bus. With things like traffic unrest or blockage, and when under the current Traffic Act that drivers should not use mobile phones while driving, the administration won't be notified immediately to trigger the SMS notification to parents.

A smartphone application is cost effective; this will combine with the SMS option and push notifications in which one can receive both according to their preferences.

Other researches done in relation to child safety in schools include Kid track system which use biometric features by (Coxworth, 2017) in which a palm reader is placed at the entry of the bus and infrared light technology is used to image the child's palm. A pre-registered database is then compared with the scanned image for cross-referencing. One key disadvantage of this was on the children placing their palms for correct scanning which led to inaccurate data capture or scanner failing to detect the child's palm.

2.9 Envisioned Solution

From the different reviews by different parties, this research has identified a gap in the existing systems. In brief, most of the available solutions complement each other but the only shortcoming is the manner in which one has functionality crucial for the other and vice versa;

this makes it limited for a conclusive solution. In most of the reviewed systems, data transfer is crucial and also communication interlinking the different stake holders is a major concern. This means the adoption of current cellular transmission of data is in application; this should however not become a liability for the company to keep it in operation. The system should use minimal resources including power and financial resources to keep it afloat.

Ke Xianwen, (2008) recommend the development of real-time systems for managing containers of data using RFID and electronic data interchange (EDI). Adoption of this sees a reduction of data entry times and improving container utilizations.

The proposed solution engages all the reviews to come up with a sharing factor of the functionalities in which most of the crucial services are addressed. The existing solution by Anwaar Al- Lawati (2015) has a pick-up and drop-off but the data collected cannot be transmitted out of the perimeter of the bus this leaving the school administration and the legacy system out of the picture.

Real time information concerning a child is captured as they enter using the RFID technology and with integration with GPS for current location via Google maps. From this information, parents can be updated via cellular network with aid of a GPRS enabled device. In the proposed solution, the school bus is equipped with a GPS enabled android mobile device and Radio-frequency identification (RFID) Reader. An Android application will be installed into the mobile device, preferably a tablet that capture location and can easily map a route for the bus. A smart tag is issued to each child and configured by the administration to make sure its unique ID matches with the contact information for the parent among other crucial information. RFID reader will scan the tag and uploads it to an android tablet by either wireless connectivity or USB; an alternative for the tablet having a built-in RFID reader or NFC reader. A successful

identification of a child having the smart card is confirmed by a beep and student details displayed on the tablet. This information is then transferred using the tablet to the system server (Students IDs), the server will then send notification to the parents updating them on either the child has boarded the bus or vice versa. The parents also will be able to query from the server on the location or status of their children.

2.10 Conceptual Design

The diagram below shows the actors of the conceptualized design.

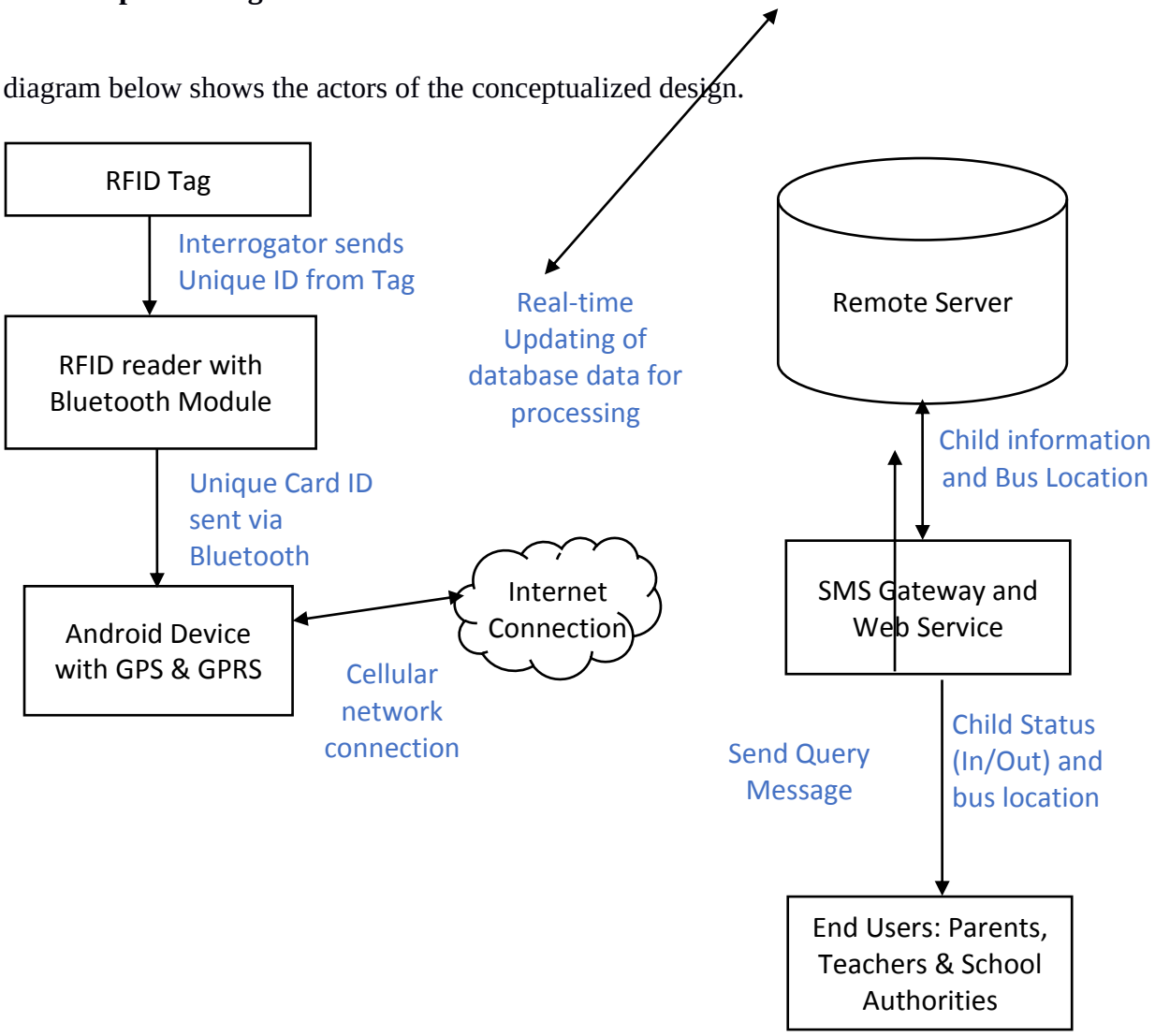

Figure 2.10: Conceptual Design

Chapter Three: Methodology

3.1 Overview

This project was an application research project with an experimental prototype being developed for purpose of evaluation geared to providing appropriate recommendations and conclusions. This chapter sought to establish the methodology to be used in carrying out the study in achieving the research objectives. It focused on the study design, population and sampling, data collection methods and data analysis procedures. It also describes the justification for the application of the specific procedures and methods for data collection and the analysis of the information obtained.

3.2 Rapid Aplication Development Methodology

In this project, Rapid Application Development (RAD) methodology was used. According to (Kothari, 2004), research design is the framework within which research is conducted which in this case constituted of sampling, data collection and analysis.

The study also entailed exploratory research design to ascertain the transport system challenge for school going children and its stakeholders. Prototyping was also used with code reuse and smaller stages within a limited time factor; a prototype of the foreseen solution was developed with constant advancement of the product to meet the requirements considered.

RAD methodology did not have a detailed preplanning but it made it easier to incorporate the changes within the development process. It was also keenly based on prototyping and iterative development. This model gave focus to iterative and incremental delivery of working models at the end. The development was in small pieces of the project. The RAD methodology minimized

on planning and intensified on prototyping hence was able to allow for quick shifting requirements where appropriate.

An essential aspect of using RAD was to develop a light version of the complete solution in limited time and resources. One of the key advantages of RAD is that it provided greater flexibility as redesign and revisions were done according to the findings realized.

Typically, this model entailed the below phases:

- Project Planning;
- User Design;
- Rapid Construction;
- Transition.

3.2.1 Requirements Planning

The objective of this stage was to establish an understanding of the school transport department operations which surrounded the development of the solution; and to identify business processes which would impact the implementation of the solution. The objectives of the school bus safety system were a core guiding factor.

Three key tasks in this stage were given attention; research on the available system, definition of requirements and analysis of the requirements. In scheduling the project, iteration approach was implemented. Work activities were repeated in which each phase and the previous result refined. This approach had one key assumption that no one gets it right the first time. An approval to proceed to the next stage was considered as cost and duration were already fixed.

3.2.2 User Design

In this stage, detailed business activities and data associated with the solution were analyzed. System structures in terms of automated or manual functions which will form the system were also analyzed and screen layouts for the automated functions developed. In order to select an appropriate construction approach, this phase was given a clear line to the system and thus a work plan was prepared defining the necessary steps and schedule for completion of the product. The completeness of the detailed system area model and outline system design were verified. With inconsistencies getting resolved, prototypes of screens were developed and a review or revision defined; any adjustments of open issues were made at this stage.

3.2.3 Rapid Construction

To design, develop and test the solution proposed, a complete detailed design of the application was developed with the goal to achieve an acceptable working solution.

Documentation necessary on the operation of the application under development was achieved in this stage. Finally, the testing strategy for the system was completed and the acquisition of facilities necessary to operate the system after it is constructed was initiated. In construction of the system, detailed definition of the design of each function was completed, based on the requirements of the future end-users. Software to implement the automated functions was also developed and tested. On the same stage, test data were loaded to the system and the operational capacity of the system. Documentation explaining how the system was to be operated by users' guidelines was detailed in this level. The system was then put through a series of tests to ensure that each component of the system integrated well with the other units.

3.2.4 Transition

The prototype developed was regarded as successful if within the constrained time and resources, the defined requirements and performance were achieved. The acceptance of the system relied on the delivering of the objectives outlined for this solution. Also, the procedures and systems documentation for use were generated during this transition stage. Completion of this determined a measure of the progress achieved and also laid a foundation for any further study on the topic.

This methodology has a shortcoming in that the application utilized a prototype iteration which should have been in range of three iterations to avoid the time spent in design and testing.

3.3 Research Design

A literature review was carried out to get proper understanding on RFID technology, how it works and also to study related works in order to identify a missing link in enhancing safety in school bus transport for primary school pupils. Requirements feasibility was as well done through interviews and observation for the current operations towards safety for children which were less technological; the institutions relied on human interaction via phone calls to get information concerning safety of the children.

The RFID Arduino system was then developed using the RAD methodology which was effective for this project as it enabled for development of a prototype and also reuse of code which was done in modular approach. Different modules thus were developed and stitched together to deliver a complete working system according to the requirements. With the strict time and other resources, the RAD methodology ensured the deadlines were met without disruptive delays. Data collected in the elicitation of the solution were analyzed and evaluation of the same done to establish effectiveness of the system.

Systems Development Lifecycle (SDLC) methodology was used as a RFID prototype for a school bus safety system which involved these phases: planning, analysis, design, implementation, testing and support. According to (Chaffey, 1998) towards getting an active user engagement and product delivery to fit business process, Dynamic Systems Development Method lifecycle would also be put in place to enable quickened decision making. This helped in avoiding later repeat or complete redesign of the system which could then translate to high development costs.

3.4 Data Collection

Study carried out by (J. K. Visich, 2009) concluded that the implementations involving RFID had first-hand effect to the operational processes followed by informational effects used by the managers. They mentioned also this technology affected decision making quality and coordination.

The project utilized interviews and observation as primary procedures in data collection. Interviews included the stakeholders who interacted with the existing system while the observations were aimed at capturing how the users interacted with the RFID system and the response time for the system.

3.4.1 Interviews

In this study, interviews were carried out as the primary source of information as well as feasibility study of the problem. The research data sources entailed primary and secondary. Primary data comprised of interviews carried out with the school stakeholders within Nairobi County for selected schools that had an active school bus. Secondary data on the school transport system was obtained from school records.

The relevant stakeholders were considered to give their experiences and views with at least three interview sessions adopted from the school population; the sample taken included the transport department personnel, parents and a driver. The interview had both open-ended and close-ended discussions to clearly understand and analyze the problem. Samples from this population for the interviews were selected through convenience sampling given the time limitation. Data collected was then summarized, analyzed and conclusions were drawn to get a clear understanding of the current operations of the school transport and how the proposed system would be integrated.

3.5 Data Analysis

A prototype developed was evaluated using the system requirements and its functionality. Quantitative data analysis methods were applied where percentages and frequencies were used to present the quantitative data in form of tables and charts. As mentioned earlier, the iterative approach was repeated a maximum of three times where necessary before proceeding to the next phase. Alterations were then be made accordingly and the evaluation carried again. The designed prototype was testing to validate the functionality of the proposed. Implementing and testing of units individually to check if they were working properly was done. Integration and configuring of the units was done and the test for the whole system was then done. These tests include the RFID reader and tags, Geo-tagging from the Android device and the back-end server.

3.6 Limitations of the Methodology

There were two key limitations for the Rapid Application Development in this project: Flexibility of the respondents – since the study was interviewer based, some of the respondents were not available at the scheduled time or failed to provide the required data. Secondly, time

constraints due to the limited amount of time the design with possibility of unforeseen challenges.

3.7 System Requirements

3.7.1 Tools Design and Skills

The RFID safety system for children was developed using Arduino integrated development environment which connected to the Android device via Bluetooth module. MySQL RDBMS community edition was the key platform used for user interface. Based on the feasibility study, the functional requirements for the school bus system embedding RFID included:

1. Arduino IDE with Bluetooth module
2. Web Services
3. Android mobile phone with 4G data network
4. MySQL server hosting
5. Web development skills

3.8 System Design

The child safety enhancement system was designed using the Rapid Application Development (RAD) methodology. Key Focus was given to different components and how each relate with each other towards achieving the project's goals.

Chapter Four: System Design and Testing

4.1 **Introduction**

In the previous chapters; the tools, procedures and methods were identified for implementing the solution. This phase involved analysis and design of the proposed system which was geared to demonstrating of RFID technology in enhancing school going children safety through SMS notification to parents. The baseline of this session is to understand the proposed solution and ensure it fits the business requirements. Rapid Application Development has been used which is suitable for developing prototypes in a simple and iterative approach.

4.2 **System Analysis**

Fact finding retrieved from the literature review was done to understand system requirements and identifying of improvements or gaps on the available related solutions were done. Literature review for systems which can track school going children was done. In order to get precise system requirements, a study on existing systems was carried. One of the systems reviewed involved use of mobile terminals which required each pupil to have an Android mobile to enable logging of data; however, this could not solve the issues as still parents needed to call to get information on the Geo-location for the children.

4.2.1 Study of the Existing Solution

This analysis was done to understand the requirements of the system available and inform the system to be developed. User interaction with the existing system was observed; in this particular case, the available system allows parents to interact with the teachers' in-charge via phone calls or sending of text messages. However as mentioned on the review, this solution has some

shortcomings and thus motivated the development of the RFID based system. The latter, users interacted with the system with the following transactions:

- Using a cell phone, a parent sends an SMS or calls a teacher to find out where or how far the bus is.
- After receipt of the SMS or call, the teacher reverts with the approximate location depending on their knowledge of the geography of the area.
- The parent the estimates estimated time of arrival and when the child can be picked form the bus stop.

This process would run through several parents and the teacher would become busy in calls or text messages. To measure transaction span in this setting, a clock system was used which had a start stop mechanism. These transactions were carried for different parents and duration recorded.

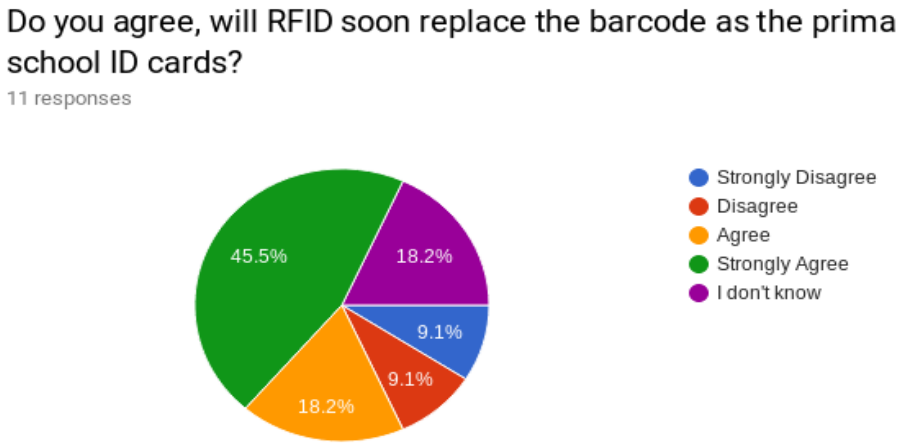

Figure 4.2.2.2: RFID Replacement of the Barcode in School IDs

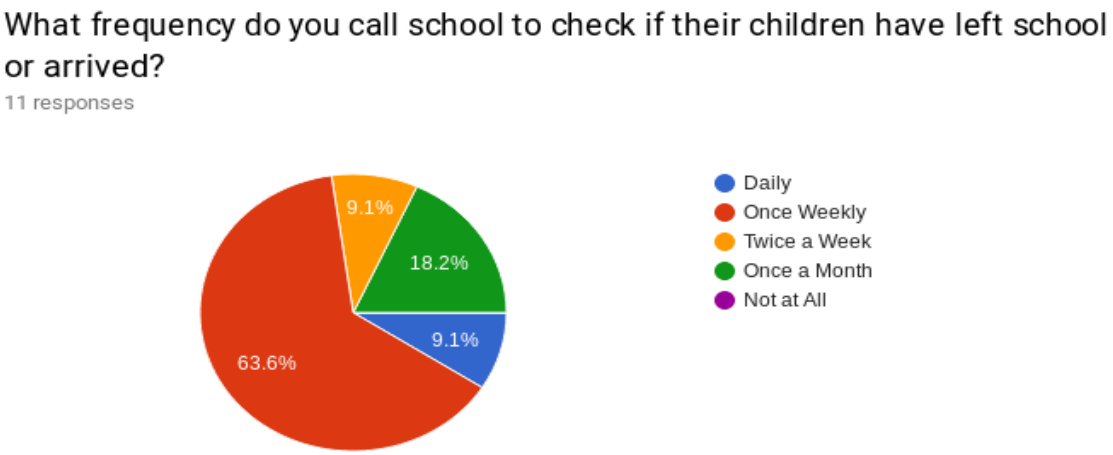

Figure 4.2.2.3: Frequency of Calling the School by parents

4.2.2 The New System

The new system was developed with the aim of illustrating and demonstrating how RFID technology can be integrated with android technology to deliver better and reliable outcome in terms of school administration, transport department and the stakeholders. This system focused on reducing the human error and effort in trying to locate the children during a trip either to school, from school or even an educational tour. Automatic recognition of children using RFID technology improved speed, efficiency and accuracy of the system.

The system also extends to drivers; the driver login denotes the start of a trip and a logout at the end. By logging out the system checks if there is any child who hasn't left the bus, this is from the database which shows those who got in to the bus and those who have left. This avoids instances of some children being left at the parking lot. Using GPS we can know the current location of the bus and also the route of the pickup point. It is very helpful for school administration and parents to enhance safety to the student/child. Detailed reports generated show data for student safety and can be used for decision making.

4.2.3 Analysis Using Rapid Application Development

RAD methodology was used in this phase to come up with a working prototype with the constrained time and resources. It combined system planning and analysis in which the users and the developer continue with a close interaction on the development progress.

4.3 System Design

This phase identified system inputs, outputs and external data which described system interface relative to the environment. Also, system functionalities were outlined using goals and scenarios. The requirements were defined in reference to: use case scenarios, system interface and the system functionalities.

4.3.1 Architectural Goals and Constraints

The software and hardware requirements which have a significant impact on the architecture are described in this section.

4.3.1.1 Hardware Constraints

- Server Platform: 4GB RAM, 500GB Hard disk
- Android Device: Android OS 5.0 and above, 2GB RAM, Support Google Geo-tagging
- Arduino UNO board installed with RFID reader and Bluetooth Module
- RFID Tags

4.3.1.2 Software Constraints

- Linux Operating System
- Persistence: MySQL relational database
- Security: SHA2 Hashing for passwords

- Performance: Search Query response time should be <5sec
- Design Software: Netbeans and Android Studio

4.3.2 User Requirements

The expected output is discussed in this section. For system to be acceptable, system requirements must be included. These include:

- User login
- RFID Card scanning
- SMS notification
- Location ID reporting
- Reporting and reports

4.3.2.1 Functional System Requirements

These include activities or processes the system must perform or rather what the system should do. Can also describe business logic or rules following that are applied. Technical requirements describe an operating environment or a performance objective. From the analysis, the system functional requirements are:

- All system database operations should be authenticated.
- For a parent to get notification, they should have their mobile numbers registered by school administration.
- The system should capture location of pickup, time RFID card scanned and differentiate an in and out movement of the card owner.
- Users should be able to query bus location anytime and get real-time reports.

4.3.2.2 Non-Functional Requirements

These are requirements which describe the qualities or rather characteristics of the system. These requirements judge the quality of the system or in other words how the system behaves. They include:

- Interface requirements; this cover how the proposed system interface with the operating environment and the user friendliness plus interfacing with other systems.
- Performance requirements; time or scope of response time as well as reliability of the system, for instance the system should process 50 SMS requests per second. Downtime of the system should as well be minimal.
- Security and privacy; that should access different information tiers in the system is clear and in the proposed system it is clearly defined by user privilege levels.
- Economic requirements, these dictate on the costs for running the system whether short term or long term.

4.3.3 System Architecture

The system based on RFID technology in notification of child status during their trip to and from school buses; it generates a message to the parent's phone informing them that their child has boarded the bus or alighted at the school premises then give a pin of the location they've boarded or alighted.

The process is initiated by a tag holder in which it is scanned at thereunder point, depending on the time or status of child in terms of picked or not, it then triggers a process to send SMS notification to the parent. This process happens from the tag reader to the android transmitting device which links to the school databases and application server to send the SMS. The system

also informs the management when a driver packs the bus and with this, the administration can tell if there is any sleeping children who are trapped in the bus as a result of driver's negligence.

The figure below outlines the implementation architecture of the developed prototype:

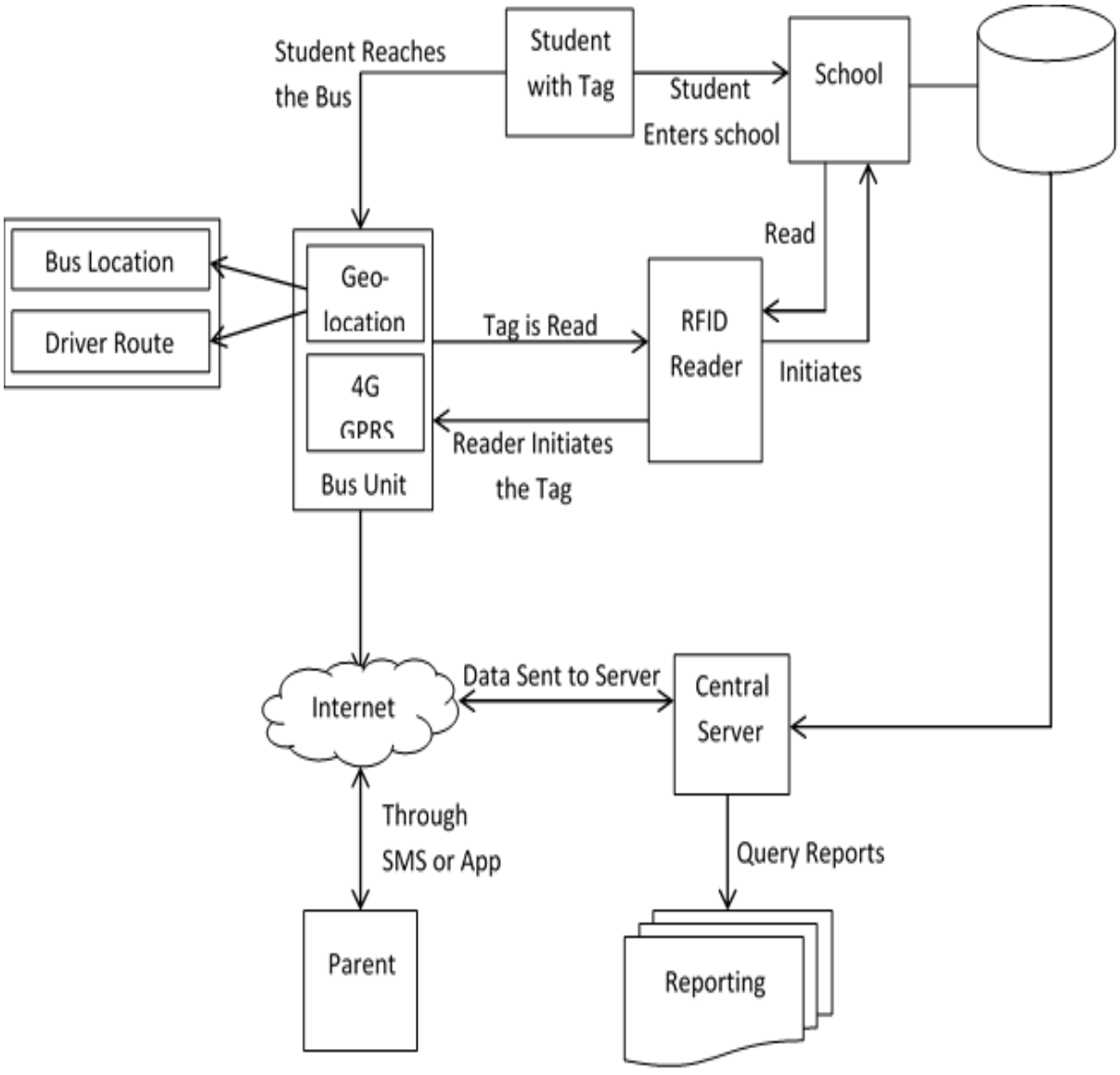

Figure 4.3.3: System Architecture

From the above architecture, a student has to be registered to use the system and parent get notification as expected. The scenario is; a student can be picked from wherever the bus route passes, once picked the system lock all other drivers from picking the same child until they are

dropped to the school. A control was also included to make sure the child once picked can only be dropped in school coordinated, failure it will sent a notification to school administration and the parent that the child was picked from home and dropped away from school. This triggers the administration to take up the matter and find out the possible reasons.

On the same, once a child is in the bus, for the parent to know the exact location of the bus, using the parent application, they can query bus location which picks from the control Android device with the picking/dropping application mostly under custody of the driver or the bus aid.

The prototype architecture presented in Figure 4.3.3 comprises of four parts:

- Bus Unit – with Android device for geo tagging, RFID reader connected via Bluetooth
- Server – Hosted in the school premises with MySQL Database Server and the Apache Tomcat as the Web Server. SMS Gateway is as well hosted in the server.
- WAN – It connects all the above units to harmonize in communication.

4.3.4 Data Flow Diagrams (DFD)

These are process models which show the systems input, processing and output of data; they illustrate movement of data from and to both external and internal entities with the processes involved to the data store.

The flow chart depicts that there are two different sources of student date; from the school existing system or by directly capturing details during new child registration. This system integrates with the existing system in that the database fields can be fetched directly from what is in the legacy system making it easier to control child registration.

Figure 4.3.4 shows the flow of registering a child and capturing the parent details to the system.

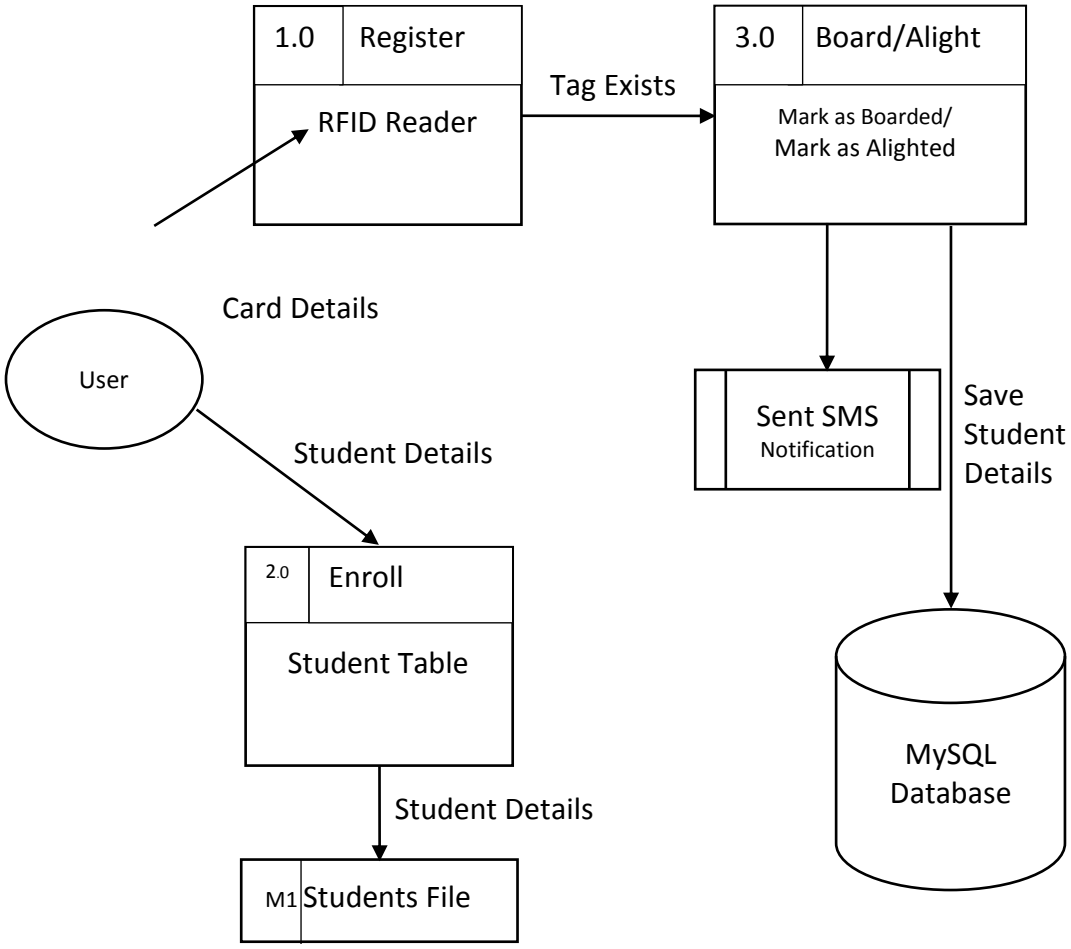

Figure 4.3.4: Level 1 DFD

The flow of data in the above Figure 4.3.4 shows from the user who is the school administrator, the tag details captured and processing done by adding more secondary data like child parent's details where it will help in sending notifications to the right parent mobile. This data is stored at the school database server where the application fetches are information from for processing.

4.3.5 Flow Charts

4.3.5.1 Student RFID Card Registration Flow Chart

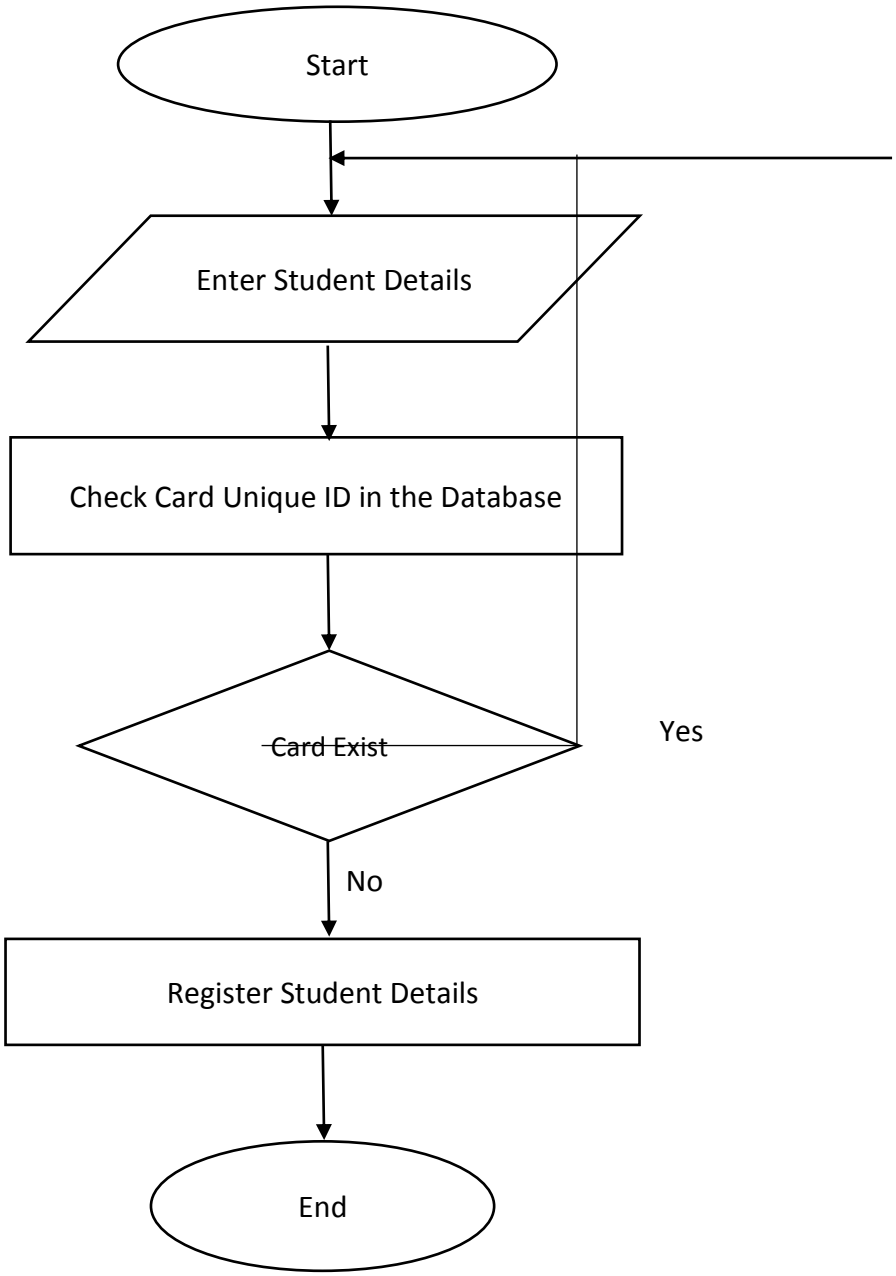

Figure 4.3.5 1: Student Card Registration

The above flow chart shows the process of registering a student RFID; this process has only one check which is to verify if the particular card is owned by any other student to avoid conflict in notifications.

4.4 System Implementation and Testing

4.4.1 System Development

The system was developed towards achieving the objectives of the system, this project applied two main approaches to achieve the different functionalities:

a) Front End - comprised of Web Application and Android Application
b) Back-end or hosting - this comprised of the server application for both processing and string of data.

For the hardware programming, Arduino IDE was used to create a link interface between the Arduino board and its components; this linked to the Android device using Bluetooth connectivity. Android Studio for the Android device application and NetBeans IDE 8.2 for Java application development as the server side application were used. With these applications, a web interface for the user was as well developed using PHP linking to a MySQL database. For the Web Server hosting, Tomcat was used.

After the design phase was complete to satisfaction, the system had to be tested, implemented with iterated functionality tests. The tests included hardware test and software tests. Hardware test included analysis of read rates. For instance, in a bus trip in the morning type of implementation, students were each given an RFID tag, which was picked up by a reader when they walked into the bus. The reader did not miss many tags except when the students had placed the tags out of the close range or completely had their tags missing.

Software testing included things like debugging the code and interface design. Failure accelerated tests were run on the system to test its reliability. The speed of reading and

processing was optimized. Another important test parameter was that the new software would easily integrate existing software platforms without compromising their smooth running.

Once this independent testing of hardware and software was complete, the complete system was clear for rolling out for use. System testing was as well done which included aspects like integration problems, network traffic analysis, tag identification and removal of data ambiguity. Another important test domain applied was data security and integrity which was basically from the RDBMS, the MySQL security features. Based on these tests, feedback obtained helped in improving the system finally product.

4.4.2 System Modules

The SMS gateway is hosted in the school premises or it can be hosted at an PRSP SMS Provider then linked to the school databases. There is a MySQL database server which as well hosts the web server for processing the requests triggered from the Android device in the bus. The bus unit has two key components; the Android device which acts as both geo-location identifier and as as the interface between the RFID Scanner and the school hosted server. The link from school to the bus is via a cellular internet from the mobile device having the driver application. For the RFID reader to trigger an activity to the school, a Bluetooth connection is used to link the RFID Reader to the Android device.

4.4.2.1 Server Module

The server module receives data from the reader via Internet connection to an application hosted by Tomcat. This data is processed and displayed for reporting showing the students present and absent as well as the time and location they were picked. In this module, most data processing and storage is carried out or done here. The host server located at the school premises hosts the database and the application as well as the SMS gateway.

The server reports are accessed via a web portal provided for the administration or the transport department and on the same is where management of student information is done. Some of the reports that can be queried from the system include; absent student information, Student details, Vehicle and driver information Report among others. The reports are retrieved from the DBMS via simple query statements.

4.4.2.2 GPRS Module

In GPRS module, it fetches details captured by the reader and sent it to the central server for processing. This module is hosted on the Android device which uses a 4G SIM card to link the bus and the school server via cellular network. This initiates a trigger for SMS from the server upon sending of location and time the RFID tag was scanned. SMS is sent to the parents through the Internet from the school server which hosts the SMS gateway.

4.4.2.3 Administrator Module

It consists of many administrative and information entry forms where the information required data is captured into the form and that is stored in the server for the further use of the data in the other modules. Administrator inputs all the required data from the student, parent and driver.

It also informs about the attendance when the student enters the bus. Some crucial data captured includes: Student information with parent details, Driver information and Vehicle information.

4.4.3 System Testing

A series of different tests was undertaken; an end to end testing was to ensure integration of all applications including the external peripherals with the goal of checking how they interact with one another and the system as a whole. During the testing, the software was checked of its optimal use of the RFID hardware and its control of data flow efficiency which was stored in a database. After design, a comprehensive testing was taken to validate that all the requirements

were being met. This testing included component level (hardware, software) testing and system level testing. The software was checked of its capacity to allow for certain levels of automation as determined by the organizations requirements and policies.

Generally, it was aimed at checking the functionality of the complete system in respect to the system requirements. The system was tested as a whole as the first level of testing. Then the functional requirements were tested to check if the system meets all requirements. A prototype of the proposed solution was then tested under a lab environment consisting of an Arduino board with RFID reader attached, an off-site Linux operating system with SMS gateway and several RFID tags. The Arduino board hosted the RFID reader and a Bluetooth chip for connectivity to the Android device which then connected to the Internet. The mobile number was captured during enrolling of a tag to a child and thus tethered to a particular RFID card unique number.

In order to validate and verify the application architecture and business requirements, this system testing was crucial. The system was also tested in an environment that particularly assumes an effective school transport environment where it would be lastly deployed. For the solution to be ready, it passed through various test as outlined as follows:

4.4.4 Unit Testing

This test was done on the modules during development process with the aim of verifying the correctness of the module. Individual units in this case included the RFID reader functionalities, the tags identification and the database correctness making it stable for use. Each individual unit tested to ensure accurate operation according to the requirement. The result test showed all modules or units were working as required.

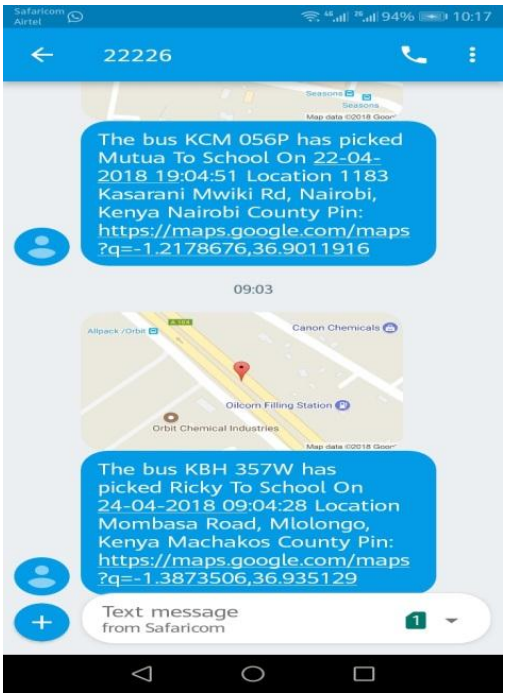

Figure 4.4.4: A Sample SMS Notification to the Parent

External User Testing - Parents and drivers access to data using their respective interfaces was tested. The driver application needs Bluetooth, mobile data and location enabled so as to connect to the reader via Bluetooth connectivity for receiving tag identity, it then captures the location of the device at that particular time and transmit it to the school database via cellular network.

The security of the system as well was test where logon module was tested as well as creation on new students. The location pin sent to parents was as well tested of its correctness of the locations. Bluetooth chip was also tested individually to establish its capability.

4.4.5 Integration Testing

In this step, testing of individual units was done; previously they were combined into one and tested for working together as a single entity. This meant the RFID reader drivers or firmware should have been able to be integrated with the other software like for the cellular network to be used. The main aim for this was to verify if the system met the specified requirements. It was the

first end to end testing of the system before revision of any code or functionality. Evaluating the system's compliance was also tested for the whole integrated system. A simulation of a school transport bus environment was tested having a child board and alight the bus, and on the other end the parent’s phone received a SMS either during a check-in or check-out, this meant the system for sending notifications was working well. Improvement of the prototype was then done where appropriate and a repeat test was performed.

Cellular modem which in this case is the Android device with Internet capability was responsible for connection of the school server, SMS gateway and the bus unit and having independent software or firmware was tested for the port opening and closing together with the network commands. The mobile device was tested to see if independently it can send and receive cellular network before it was integrated. Also in this step, defects were exposed in the interfaces and in the interactions between integrated components or systems.

4.4.6 Acceptance Testing

The compliance with business requirements and assessing whether it was acceptable for delivery was carried out in this stage. A beta product was put into operation and possible feedback received on how the solution was getting implemented and if it addressed the problem at hand. This test was in respect to user needs and business processes to determine if the system was acceptable by the users.

System acceptance was done in a real user environment with the aim of validating the successful implementation of the prototype as well as identifying minor itches or errors which the previous tests might have skipped detection. This is the test phase where business process flow was checked.

In an instance where parents want to locate the location of the bus; using the parent application, a trigger is sent to the system and location ID determined by the GPRS device placed in the bus and below response is received. With the link, a parent can open and have exact location.

Chapter Five: Results and Discussion

5.1 **Introduction**

In this chapter, the system acceptance and how the consumers see it fetched from the Usability questionnaire is discussed; tests done using the prototype and the outcome. This chapter contains the results, discussion and presentation of the research findings. The main objective of this research work was to design and develop a prototype that utilizes RFIS technology to capture time in/out and geo-location for school going children. This required installation of a RFID reader and configure it to communication to a mobile divide held by the driver or the bus aid; this was achieved via Bluetooth connectivity.

Statistical data involving factors that affect bus location and connectivity of the prototype such as packet loss, pin location and delay were collected using WireShark packet analyzer software.

The results and discussion sections present the findings and the project's analysis of the findings. Data was collected from respondents drawn from two primary schools; Rusinga Group of Schools and Braeburn School both located along Gatanga Road. The study had questionnaire approach which collected information prior the prototype and post prototype from which findings were drawn.

System users' response on the importance of the RFID system would help a school as opposed to earlier systems with a response rate of 11/14. There was a 78% response rate to the distribution of questionnaires to system users. Below pie chart shows the four categories regarding the foreseen importance and appreciation of the parents interacting with the system in the following order: Very High, High, Low and Very low.

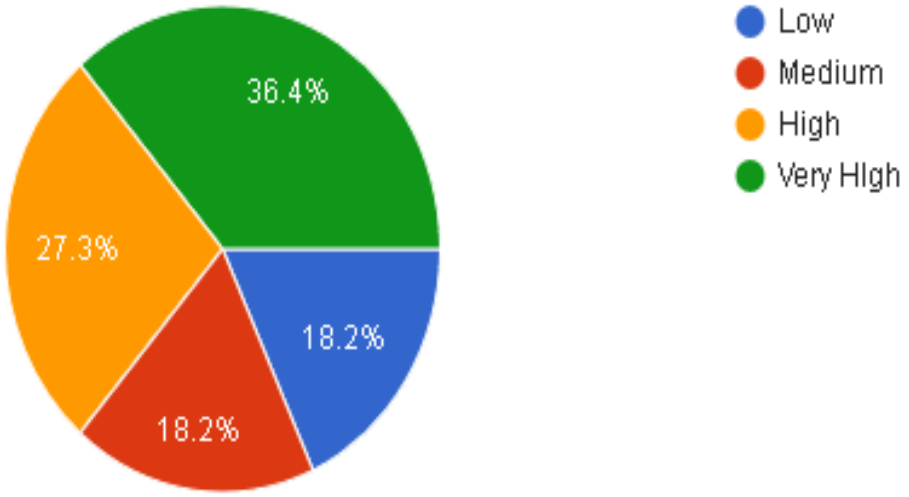

Figure 5.1: User Acceptance to the System – Importance

From the interviews carried to find how the reception of the new solution was by the stakeholders, 54.6% were above satisfactory which translates to more than half of the stakeholders were in positive about the RFID technology being adopted in the school. Noticeably, from the targeted sample, only 73.3% managed to give feedback. The minor percentage that didn't response had different reasons with 50% of that saying they didn't understand what RFID was and could prefer to remain with what they've been familiar with.

5.2 **System Evaluation**

A complete performance assessment of the system included interface design, system usability and connectivity were the key elements under scrutiny in this phase. Protocol analyzer software was used to collect the network communications data, quantitatively analyze it and display the results. This was achieved by the protocol analyzer following each RFID tag scan from start when child is entering the bus to finish when they are exiting from the bus.

In order to evaluate the prototype and determine whether it meets research objectives, it was necessary to establish whether it provides notification via SMS to parents on pick up and/or drop

off, measure parameters that affect the data transmission from the reader to the mobile phone device with the bus driver triggering a SMS form the school SMS gateway included delay, semantics error and packet loss.

5.3 **Response Time**

This is the time taken for the system or the application to respond to requests. In this project, the time between when a RFID can is scanned and when data is received by the android application via Bluetooth as well as the time to get the unique code sent to central server for notification processing. In the case of the device fetching the Geo-location of where the card was scanned, a slight delay is experienced as this depends of the availability and visibility of GPS satellites. The below bar graph shows the response from system users' opinions under a scale of 1 to 5 where 1 represented strongly agree while 5 represented strongly disagreement.

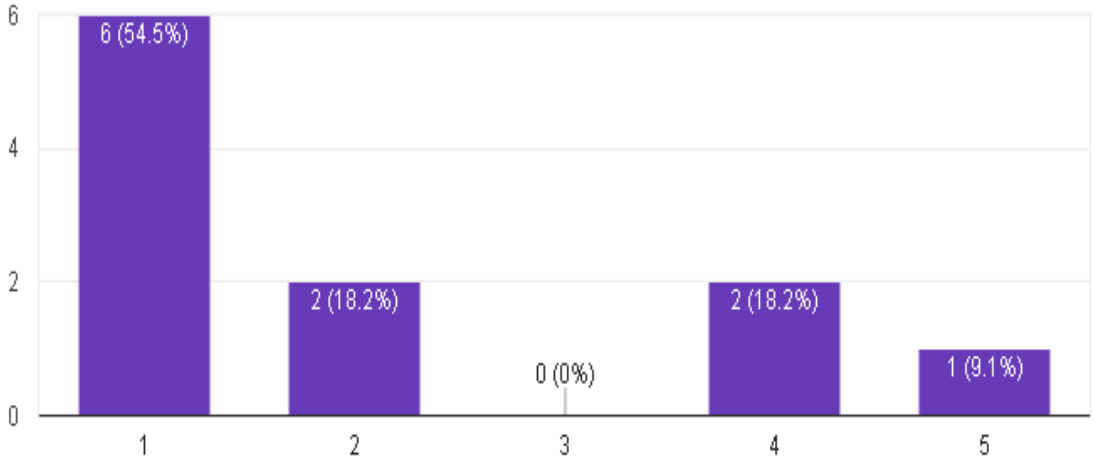

Figure 5.2: Response Time by Users

From the above, it is evident that parents as well as school administration were positive about the new system and thus this is a viable solution and can be built on. Undeniably improved response time compared to before is evident; this gives the new system a positive point towards achieving

the objectives. It should be noted that the study relies of communication between parents and the school transport section, this communication is available currently but needs an enhancement to fit the changing trends.

The response time for getting location as mentioned is affected by environmental factors and thus the slow response time compared to other parameters of the system. Below is a summary table showing time taken to a query for student location by parent's mobile phone.

Table 5.4: Parent Application Response Time

Sample	Time Request Sent	Time Response Received	Time Taken
Parent 1	00:02:64	00:05:889	3.249 secs
Parent 2	00:05:889	00:09:991	4.102 secs
Parent 3	00:12:151	00:15:283	3.132 sec

Chapter Six: Conclusion and Recommendation

6.1 Achievements

The study had several objectives and which were achieved during the project implementation. The key objective of this project was to design, implement and test a prototype using the RFID technology. A prototype was developed which has the capacity to capture child details while they are entering or exiting the bus, in return this triggers a notification being sent to the respective parents hence this achieved the design and implementation objective.

Overall feedback was very positive from parents and other stake holders since the process had been improved and enhanced by the new system.

The third objective which involved testing and evaluating the performance of our scheme was also accomplished. The evaluation involved verifying that the initial project requirements specifications were met in comparison to the output of the implemented solution. A successful testing process then signifies the prototype is viable for adoption. The main features tested include generation of short response timings, high detection rate and low misdetection ratio.

The questions contained in the user usability test using the usability scale show the system is user friendly and with few adjustments it will sort the transport strains in terms of communication between parents and transport department. See below measure of user feedback and reaction to the new system:

How do you rate the current system (calling teacher on duty and ask) in terms of:

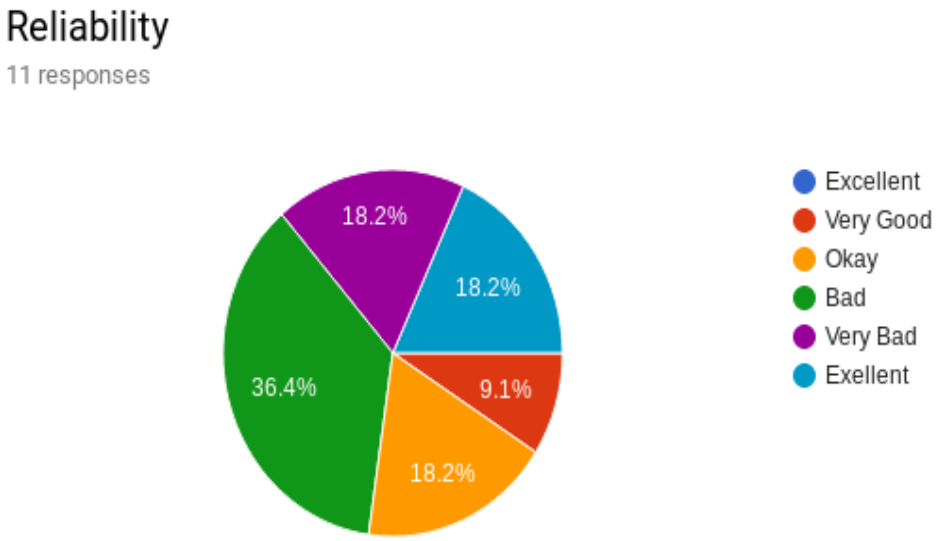

Figure 6.1.1: Reliability Rating – Old System

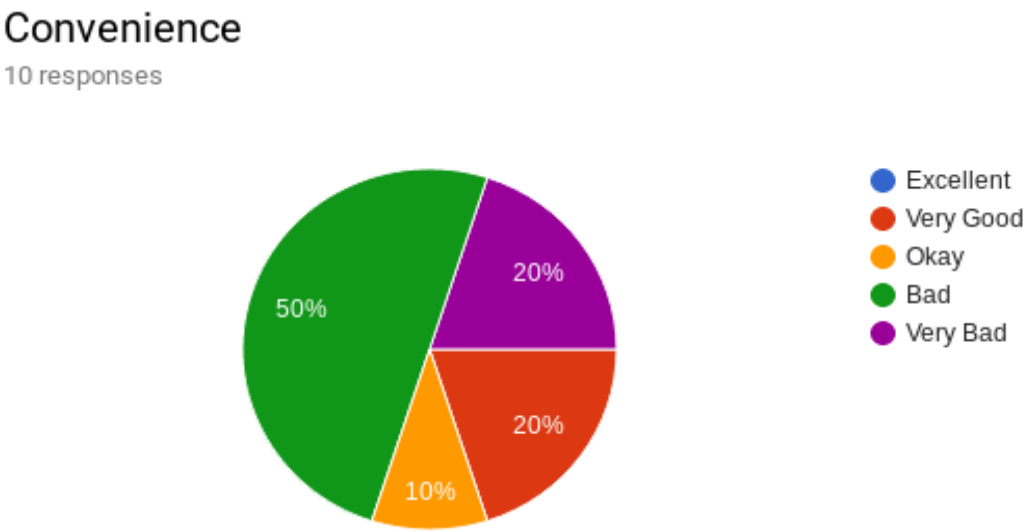

Figure 6.1.2: Convenience Rating – Old System

From the above charts which were drawn from a sample population of between 10 to 15 entities, it had a extensive bias in the positive adoption of the system. For the convenience, approximately 20% are the ones who didn't feel the convenience. Further to this, the 20% included those who had not used the system.

6.2 Recommendations

The use of RFID tags and attaching them to the entry points of school buses is a simple solution for information capturing; with the integration with other services then information sharing and distribution is greatly improved. Further study should establish integrations of active RFIDs in school environment which can communicate by sending signals to a central server capturing every movement in school and that the school and parents together can be able to understand and build on information like movement patterns or active time for a child. Further study on the particular solution is recommended to inclination to more functionalities which can be used to validate existing services; for instance with the meals application where food is served for those who were checked in as well in in its financial part where billing is done once a child picks their food. All this information can be used even for route mapping depending on the pick-up times and locations.

6.3 Limitations and Assumptions

Several challenges and limitations were encountered while undertaking the project, at the same time a number of assumptions were made. These are:

i) The SMS transmission cannot be compromised by an adversary otherwise the attacker can launch any possible attack against the SMS gateway upon taking control of the host server and sent SMS not triggered by RFID reader.

ii) The connection via 4G cellular network connecting the Android device and the central server based at school has reliable bandwidth and guaranteed uptime of 99.9%.

iii) The RFID reader has the capacity to withstand adverse environmental factors like dust and heat within the bus.

iv) The Bluetooth connection for transmitting card details from the RFID reader to the mobile application for forwarding to the school server is secure from wireless attacks.

6.4 Conclusions and Future Work

From the foregoing discussion, the following conclusion can be drawn. This system is open and flexible, which means that it may be extended by adding more modules.

6.4.1 Conclusions

The results of this report deduced that with constant communication or notification of stakeholders in what is going on with the whereabouts of their children, smooth operations and delivery of better services was evident. Comparatively, with the introduction of ICT systems in learning institutions, administration is highly improved thus translating to improved class performance and peace of mind for the stakeholders.

The prototype testing revealed that the use of RFID based system which includes on the existing legacy school ID cards that are integrated is a viable solution for parent-school communication in terms of transport. This is because this system can be added and scaled without affecting the existing services. The shortened time of receiving notification on location using an Android application demonstrates a higher level of efficiency compared to the current flow of information.

Other conclusions deduced from this project include:

- Enhancement of student safety while on transit
- Reduced parent engagement and headache on location of the children or the bus.

- Automatic attendance register upon children alighting from the bus which helps in class teachers' administration
- Using the Geo-location, exact location of the bus can be shown and the best route determine.

6.4.2 Future Work

The application that was developed was ranked to fit the requirements to a satisfactory level except less was achieved in the exact location naming. We therefore recommend further work to investigate how to incorporate Google Maps locations to get exact local points like the stage or any other related landmark.

Another area of concern is the security of the RFID tags which can be read by any RFID, it is suggested an algorithm be developed to hinder tag reading by specific RFID readers and be controlled from the administration side. The school system should be integrated to use these tags to track where students are located throughout campus by having more RFID readers. This will enhance to monitor movement and attendance of classes to the students.

Appendices

Appendix A: Interview Questions

1. Does the school give focus of transport safety?

2. What is the primary factor concerning children safety while in transit?

3. Are you using any technology in your organization in the transport section?

4. Do you have any plans to explore new technology towards enhancing transport safety?

5. Does the school have any system using RFID cards or other Auto-ID systems?

6. Does the transport department have a budget which they can invest towards its operations and innovation?

7. Are there systems which use barcarole in the organization?

8. How do the school ID tags operate and are they integrated in any system?

9. Do you personally support implementing a new system which uses RFID technology?

10. Where else in the learning operations do you think the appropriate tags should be applied?

11. Should cost for tagging system affect school fees?

12. How vast in knowledge do you have in regard to RFID implementation by other learning institutions?

13. Have you received any show of interest towards improving or automating the transport operations

14. What are the basic information do you have for students in the transport department?

Appendix B: Questionnaire

1) Rate the significance of RFID in school environment?

None Low Moderate High Very High

2) Do you agree: RFID technology will replace the barcode technology in school ID cards?

Yes No

3) What frequency do parents call school to check if their children have left school or arrived?

Daily Once Weekly Twice a Week Once a Month None

4) How do you rate the current system in terms of:

Reliability	:	Excellent	Very Good	Okay	Bad	Very Bad
Convenience	:	Excellent	Very Good	Okay	Bad	Very Bad
Accessibility	:	Excellent	Very Good	Okay	Bad	Very Bad

Appendix C: User Acceptance Questionnaire

This questionnaire is aimed at getting user review and has two sections; first section requires opinion under a scale of 0 to 5 in which 1 represents strongly disagree while 5 represents strongly agree, the other section is an open question aimed at getting user's personal views of the system.

1. You are satisfied with the simple or user-friendliness of this system

    1 2 3 4 5

2. The online help or screen tips helpful during system use.

    1 2 3 4 5

3. System Response time did NOT change.

    1 2 3 4 5

4. This system will be accepted by many users without challenges.

    1 2 3 4 5

5. I would recommend this system to other school or learning institution.

    1 2 3 4 5

6. What are your thoughts about the effectiveness of the prototype system in improving school transport safety?

……
……
……..

7. What suggestions would you make to improve the acceptability, uptake and usability of the system?

……
……
……..

Appendix D: Sample Arduino IDE Code

```
#include <SPI.h>
#include <MFRC522.h>
#define SS_PIN 10
#define RST_PIN 9
MFRC522 mfrc522(SS_PIN, RST_PIN);   // Create MFRC522 instance.
#include <SoftwareSerial.h>
 #define rxPin 2                    // define SoftwareSerial rx data pin
#define txPin 3                    // define SoftwareSerial tx data pin
SoftwareSerial blueTooth(rxPin, txPin);  // create instance of SoftwareSerial
void setup()
{
Serial.begin(9600);   // Initiate a serial communication
SPI.begin();      // Initiate  SPI bus
blueTooth.begin(9600);
mfrc522.PCD_Init();   // Initiate MFRC522
mfrc522.PCD_SetAntennaGain(0x07<<4);
Serial.println("Approximate your card to the reader...");
  Serial.println();
}void loop()
{  // Look for new cards
  if ( ! mfrc522.PICC_IsNewCardPresent())
  {
    return;
```

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