"*Design middleware architecture for mobile discovery of passive tags*"

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DECLARATION

I, MUGISHA GEORGE, hereby declare that this thesis is my own work and effort, and that it has not been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

SIGNATURE……

DATE ……

C E R T I F I C A T E

This is to certify that the thesis Work entitled *"Design middleware architecture for mobile discovery of passive tag"* is a record of the original confide work done by…(MUGISHA George) *(REF.No: 215036935)* in partial fulfillment of the requirement for the award of Master Degree of Science in Information system of university of Rwanda, during the Academic Year 2015-2016.

Supervisor | Head of Department

Prof. SANTHI Kumaran | *MATOVU Moses*

DEDICATION

I really dedicate this book to almighty God in whose vindication lies to my success

This particularly goes to mum BWINYANA ANASTAZIE and my interment brothers, sisters and cousin brothers whose names are not mentioned for their parental care, love and commitment to support me, through school morally and materially shall be remembered forever.

I predominantly dedicate this thesis to my brother RUDAHUNGA Frank who took the responsibility to find me invaluable and consistent contribution to my academic success and the University of Rwanda in particular.

I also thank my brothers, sisters, uncles, aunt, pastors, class mates and other relatives for their coherent encouragement and concurrent prayers, which have facilitated me to reach a wonderful completion of this research.

I dedicate this book.

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I would like to extend my profound appreciation to the University of Rwanda in particular that groomed me up to the time of conducting this research and for having facilitated me during my academic success.

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The family of Mr. and Mrs. RUTABINGWA PETER and BWINYANA ANSTAZIE my uncle should find my total appreciation for their invaluable and consistent contribution to my academic success.

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LIST OF ACRONYMS

TAO	: The ACE ORB
ACE	**:** Adaptive Communication Environment
CORBA	: Common Object Request Broker Architecture
OMG	: Object Management Group
API	: Application Programming Interface
HTTP	: Hyper Text Transfer Protocol
RMI	: Remote Method Invocation
DCOM	: Distributed Component Object Model
WMS	: Warehouse Management Systems
SQL	: Structured Query Language
WLAN	: Wireless Local Area Network
GSN	: Global Sensor Network'
MA	: Mobile Agent
RAM	: Random-Access Memory
ROM	: Read Only Memory
TCP	: Transmission Control Protocol
IP	: Internet Protocol
ESB	: Enterprise Service Bus
SOAP	: Simple Object Access Protocol
REST	: Web services, Representational State Transfer
JSON	: JavaScript Object Notation
EAI	: Enterprise Application Integration

ABSTRACT

Rwanda is among the developing countries in Africa facing the challenges of not having the enough resources of technology leading to met some difficulties in their service delivery for instance Rwanda revenue authority is a government institution with the responsibilities of providing income to the government like other institutions through taxing the products produced by different various internal organizations or companies and others that are imported from external organization, the works of checking and look for tax or charging penalties when necessary has proved to be difficult because the system that is used is not satisfying the needs of both customers who are responsible for paying taxes and Rwanda revenue authority employees themselves, some of the employees you find them with no tools for checking whether the products are illegally or legally produced and sold based on the tag attached on it, this is very difficult to understand because of using the local systems of looking on the product by their eyes others use the glasses and another system is by use of radio frequency identification reader, computer and scanner or printer, this system proves out the reality but with the limitation of being fixed not being anywhere.

This research aimed to design a new architecture that would facilitate the Rwanda revenue authority employees in decision making capacity through providing the reality of the electronic product code or information of the tag by passing the smart phone over the tagged product and eventually the middleware software installed and configured in the mobile phone senses the tag by sending the electromagnetic waves to trigger or charge the tag, establish the connection and therefore read the information from the tagged product in addition to the above giving the users the chance to take the decision based on the information obtained.

The system would use the smart phone and middleware software to capture data, store data, and manage data just by the use of the mobile phone therefore providing the portability and flexibility factors meaning that it would be simple to understand and use since it is installed in the mobile phones and most people are familiar with them and it would suit anywhere since it is embedded in the mobile tool.

CHAPTER ONE: GENERAL INTRODUCTION

1.1 INTRODUCTION

This research is aimed at designing middleware architecture for mobile discovering of passive tags, the middleware software is installed and configured on the smart phone to capture data, store data, manage data and converts the information in human readable format thereby allowing the communication between the middleware and the tags, therefore the architecture would be describing how the connections should be established and the data flows in the system more to that how the software triggers the passive tags in conjunction with the sensors, middleware is software systems that lets the sensors to read data from tag and it presents information to user. This chapter contains the brief introduction of the research specifying what the system would do, the motivation of research that flabbergast the researcher to design the architecture which would facilitate the system users in the performances, background of the study typically shows the case study of the research and what the company does and how the current system works, statement of the problem that leads the researcher to go under this research, objectives of the research indicating trend or the goal of the research and what the researcher would do to arrive at the main purpose, scope and limitation this shows the boundaries of the research of which the researcher would not go beyond, and finally the organization of the study, this shows how the chapters of this research are arranged in the dissertation and subchapters included .

1.2 Motivation

This system would facilitate the Rwanda revenue authority particularly in the department of taxation to the method of checking the product whether they are legally or illegally sold by the use of mobile phones, since smart phones are mobile tools people would go with them anywhere and whenever the employee meets a business person and doubts on what he or she has just gets his smart phone and passes it over the product and eventually the reality, further more the entrepreneurs would love this system because it won't take time to check and understand and eventually take decision without wasting the much of the time in the process.

1.3 Background of the study

Rwanda revenue authority is a government institution with the responsibilities of government development like other government departments its responsibilities lies in the area of taxation; this institution located or has offices almost in any area of the country with their headquarter located in the central part of the country (Kigali) at a particular place called kimihurura near by the pentagon or ministry of defense and about a hundred meters from the national institute of ID, this institution is responsible for taxing all the product both internal product manufactured by the internal organizations and items produced by the external organizations supplied to the country, this scenario say that after making the item the workers tag it with radio frequency identification and sell the items then the Rwanda revenue authority come to look for taxies as its responsibility.

1.4 Statement of the problem

The existing systems have employed the use of computers, scanners, and reader to sense or to interface with the tags there by recognizing it, capture data, store data, and finally display data to the user, this has proved to be complex work since it requires all the components to be used and connected. Another method is by use of glasses to sense the tag but this method does not provide all the required information, and sometimes people use the method of looking on the tag to see whether it is tagged in legal way or the tag is located in its real position and this method leads much doubtful on decision making capacity. This system termed middleware architecture for mobile discovery of passive tags was designed to mitigate the doubt and providing the good environment with the user in decision making, since this system would be installed and configured in the mobile phone, whenever users want to check the product code that is to say product tag they would pass the smart phone over the tagged product and the middleware sensor captures data written on the tag paper formats data, manages data and converts presents the information to the user in readable format.

1.5 Objectives the study

1.5.1 General objective

To design middleware architecture for capturing, recognizing, storing, establishing the connection and showing how the data flows between the reader and passive tags.

1.5.2 Specific objectives

1. To identify all possible components that are required to design the specific architecture for discovering the passive tags and how they should be arranged and connected in the system architecture.
2. To sensitize the organization to install and configure the middleware software in the smart phone and see how it would read the data using the sensor nodes through triggering the passive tags.
3. To ascertain the impact of using middleware architecture for mobile discovery of passive tags as far as the performance is concerned meaning that how it would capture data, store data and present information to the user.
4. To capture data written in machine code or low level language and converts it into the format that is suitable to the reader or high level language in such way that the user should know what to do.
5. This research tells in its architecture how middleware systems can read tags in harsh environments, without any human interference and transforms data into readable information.

1.6 Scope and limitation

This research was aimed at designing middleware architecture for mobile discovering of passive tags but not going beyond it to other type of tags like active ones in the massage communication systems, more to that the research would be conducted in the areas where this application would be applied but not everywhere in the whole country.

1.7 Significance of the study

This research would be important to the researcher since its part of the requirements to the award of a master's degree in information system, The study would further be part of the references to the students and staffs of University of Rwanda in the school of information and communication technology who would be interested in gaining knowledge about its subject and findings.

1.8 Organization of the study

This research is divided into six chapters: General Introduction, literature review, research methodology, system specification and data analysis and conclusion and recommendations.

Chapter one presents the motivation of the study, background of the study, statement of the problem, objectives of the study, scope of study, significance of the study and organization of the study.

Chapter two describes the literature review. It deals with defining and explaining the different concepts related to middleware architecture for mobile discovery of passive tags.

Chapter three describes the research methodology that was used in this study. It includes, sample size and sampling techniques, as well as data collection, processing and analysis methods and instruments.

Chapter four is the system specification; at this stage the researcher specified the system requirements and data analysis.

Finally, chapter five is composed of the system architecture, data flow diagram, and algorism and entity relationship diagram. This chapter is the heart of this research as it clearly describes the working abstraction in the form of diagrammatic way.

Chapter six is composed of Conclusion and recommendations

1.9 Conclusion

This part is the first chapter in this research which includes the problem statement of the research, the issue that promoted the researcher to undergo the procedures of finding the

solutions thereby handling the problem, so it enforces the researcher to set research objectives to achieve the goal; this chapter is the engine of other chapters meaning that after formulating it gives the researcher the ticket or chance to set literature review and methodology of the research other words it is like a campus which directs the researcher and readers what is next so this directed the researcher to know what to do in the second, third and corresponding chapters.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The chapter covers varying theories and arguments by different authors concerning the middleware architecture for mobile discovery of passive tags in its different dimensions and in relation to how its architecture works, what has been done in previous year and how effectively middleware can be used in automatic identification of tags attached to the certain items.

2.2 Definition of Middleware

Middleware is computer software that provides services to software applications beyond those available from the operating system. It can be described as "software glue". It is considered by many to be a rather vague term in that it is specially designed software that can link two separate applications together. This allows a user to request data from a database using forms displayed on a Web browser, while also allowing for the Web server to return Web pages based on the user's request [1].

2.3 History of Middleware

The term middleware first appeared in the late 1980s to describe network connection management software, but did not come into widespread use until the mid 1990s, when network technology had achieved sufficient penetration and visibility. By that time middleware had evolved into a much richer set of paradigms and services offered to help make it easier and more manageable to build distributed applications. The term was associated mainly with relational databases for many practitioners in the business world through the early 1990s, but by the mid-1990s this was no longer the case. The Message Oriented Middleware Association (MOMA) was formed in 1993, and MOM became a widely-used kind of middleware by the late 1990s. In the late 1990s HTTP became a major building block for various kinds of middleware, due to its pervasive deployment and its ability to get through most firewalls [2].

2.4 Middleware in distributed systems

Middleware is a class of software technologies designed to help manage the complexity and heterogeneity inherent in distributed systems. This significantly reduces the burden on application programmers by relieving them of this kind of tedious and error-prone programming. Middleware is sometimes informally called “plumbing” because it connects parts of a distributed application with data pipes and then passes data between them.

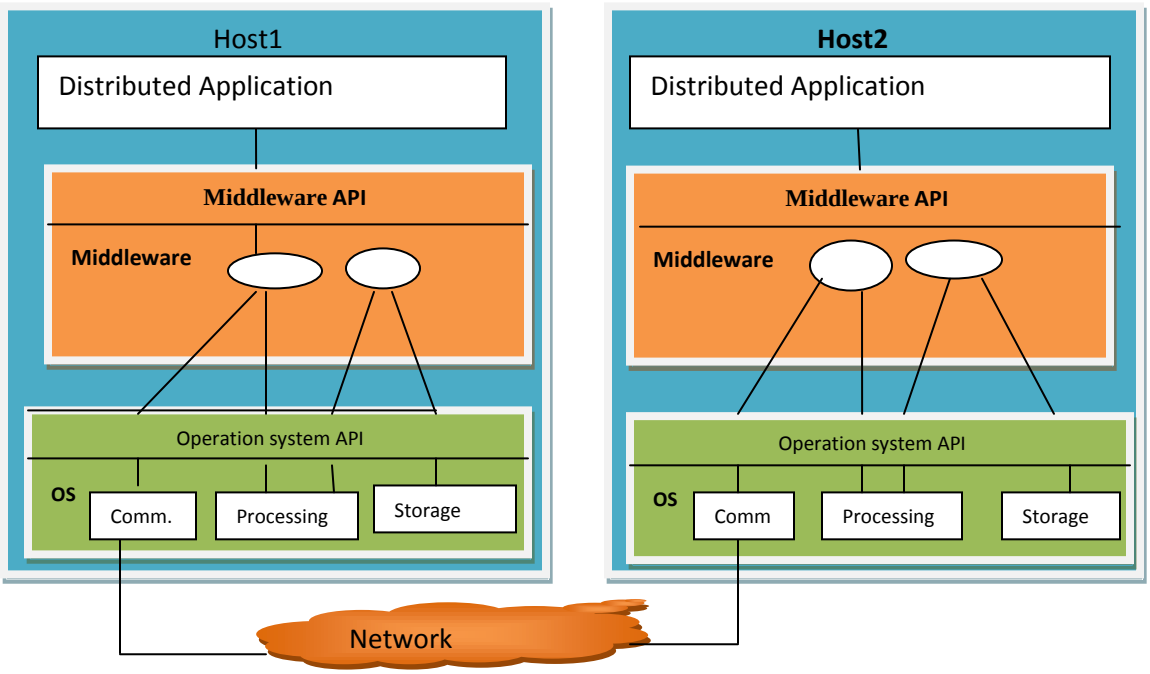

Figure1: Middleware layer in context

Middleware frameworks are designed to mask some of the kinds of heterogeneity that programmers of distributed systems must deal with. They always mask heterogeneity of networks and hardware.

The classical definition of an operating system is “the software that makes the hardware useable.” Similarly, middleware can be considered to be the software that makes a distributed system programmable [3].

2.5 Middleware bridges application and platform

Middleware is the "glue" that connects diverse computer systems. Typically, legacy systems store information in proprietary formats, use propriety protocols to communicate, and may even be running on hardware that's no longer manufactured or supported [4].

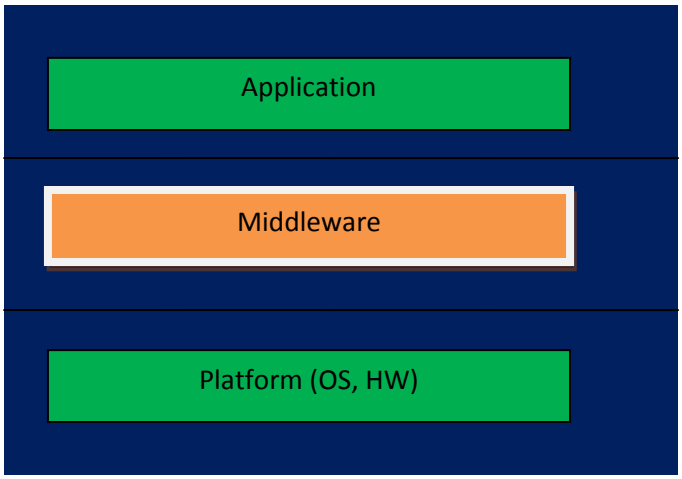

Figure2: middleware bridges application and platform

2.6 Passive tag

A passive tag is an RFID tag that does not contain a battery; the power is supplied by the reader. When radio waves from the reader are encountered by a passive rfid tag, the coiled antenna within the tag forms a magnetic field. The tag draws power from it, energizing the circuits in the tag. The tag then sends the information encoded in the tag's memory [5].

2.7 Middleware in a computing system

Middleware is all about integration. It is a software layer, which resides between applications and operating system and provides the applications a set of generic and commonly used services. In literature, the term middleware is used to define the software layer between the application layer and system layer.

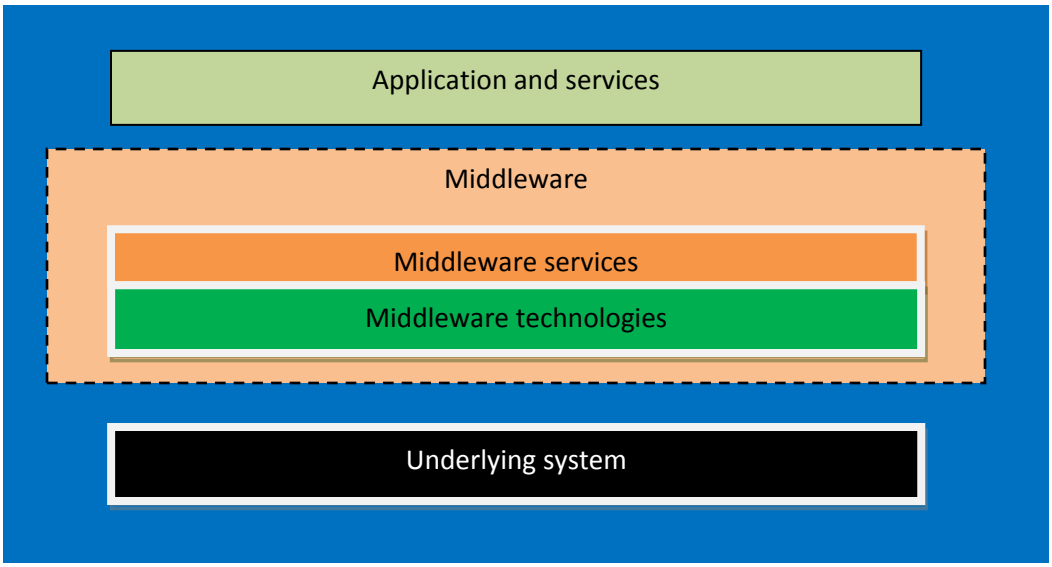

Figure3. Middleware computing systems.

Middleware can be further divided into two layers: middleware services and middleware technologies. Together with the application and system layers, the middleware constitutes the software architecture [6].

2.8 middleware in relation to the topic

The term "middleware" is broadly and loosely refer to software or devices that connect RFID readers and the data they collect to enterprise information systems. Middleware helps makes sense of RFID tag reads, but it is hard to get a reading on what RFID middleware is. Warehouse management systems (WMS) and other packaged software applications may have interfaces to accept RFID input; conversely, RFID-oriented middleware products increasingly perform application-like functions, such as directed put away or shipment verification [7]. According to the researcher design the middleware soft ware will be sensing the passive RFID tag, triggering the tag, capture data, format data and manage them as meaningful information.

2.9 Middleware for Mobile Phone Sensing

Mobile phone sensing middleware aims to turn smart phones into mobile sensors. The aim is to collect data about user behavior or the environment in which a user moves around, and send it to a central point for further analysis. Remote task deployment, although limited in nature, is

supported through runtime configuration of parameters like the type and rate of sensor information reported by the mobile devices; continuous queries written in SQL submitted to a central server further process and _lter this data, providing additional adaptability. A much more flexible approach is offered by PRISM, which allows deployment of executable binaries at the mobile devices themselves. [8].

2.10 Mobile device particularly smart pone

Ever-growing popularity of mobile devices, such as smart phones and net books, coupled with anytime and anyplace availability of high-speed network access is changing the ways how we compute and communicate. Mobile devices play an increasingly important role in our lives and tend to become representations of our digital selves when we trust these devices with sensitive information. [9] Under this researcher the mobile device such as smart phone will play a big role of holding the software that is responsible for recognition, capture, store, and retrieve of information of the item/ component tagged.

2.11 Need for mobile phone application in Africa

The low internet penetration and lack of electricity in the rule areas of the developing countries of Africa make the use of computer based solutions a big challenge. Today, for less than US$ 400, one can acquire a smart phone equipped with 1000MHZ clock speed, 512MiB (ROM+RAM), access to several types of data networks (CSD, HSCSD,GPRS, EDGE) and wireless local area network (WLAN) among other features [25].

2.12 Message-Oriented Middleware

Message-oriented middleware supports the communication between distributed components via message-passing: client components send a message containing the request for a service execution and its parameters to a server component across the network and the server may respond with a reply message containing the result of the service execution. The client is able to continue processing as soon as the middleware has accepted the message; eventually the server will send a reply message and the client will be able to collect it at a convenient time. [10].

2.13 Middleware in distributed applications

The term is most commonly used for software that enables communication and management of data in distributed applications. Middleware makes it easier for software developers to implement communication and input/output, so they can focus on the specific purpose of their application for instance an IETF workshop in 2000 defined middleware as "those services found above the transport (i.e., over TCP/IP) layer set of services but below the application environment (i.e., below application-level APIs).. Middleware includes web servers, application servers, content management systems, and similar tools that support application development and delivery [11]. According to the contents the middleware software sites between logical node and physical node to establish connection there by allowing communication between the above mentioned nodes.

2.14 Capturing Data using Global Sensor Network Middleware

Mobile phones play increasingly bigger role in our everyday lives. Today, most smart phones comprise a wide variety of sensors which can sense the physical environment. The process and the difficulty of manually connecting sensor devices to sensor data processing middleware systems are examined. We evaluated the performance of the system based on power consumption of the mobile client [12].

2.15 Green Context-Aware Middleware

Despite the advances provided by hardware manufacturers and operating system vendors, continuous accessing of sensing resources in mobile devices to support location- and context-aware applications and services is still expensive in terms of energy. Because of the potential benefits, embedding energy-awareness in the design, in the device and the protocols of the networks is highly desirable. [13].

These components are highly modular, so that component functionality can be modified in isolation without affecting the others. On top of this layer, high-level application-dependent policies for energy-aware location and transmission can be defined and inserted [31].

2.16 Middleware is Part of a Broad Set of Information Technology Trends

Middleware represents the confluence of two key areas of information technology (IT): distributed systems and advanced software engineering. Techniques for developing distributed systems focus on integrating many computing devices to act as a coordinated computational resource. Middleware is the area of specialization dealing with providing environments for developing systems that can be distributed effectively over a myriad of topologies, computing devices and communication networks [14]. It aims to provide developers of networked applications with the necessary platforms and tools to formalize and coordinate how parts of applications are composed and how they interoperate and monitor, enable, and validate the (re)configuration of resources to ensure appropriate application end-to-end quality of service, even in the face of failures or attacks [15].

2.17 Middleware and Resource Management

The abstractions offered by various middleware frameworks can be used to provide resource management in a distributed system at a higher level than is otherwise possible.. Middleware's abstractions also are from an end-to-end perspective, not
just that of a single host, which allows for a more global and complete view to a resource management system [16].

Middleware category	Communication	Processing	Storage
Distributed Tuples	Yes	Limited	Yes
Remote Procedure Call	Yes	Yes	No
Message-Oriented Middleware	Yes	No	Limited
Objects Distributed	Yes	Yes	Yes

Table 1: Middleware in resource management

2.18 The Role of Middleware

The term middleware in this document refers to a set of services placed between the applications and the operating systems (Grigoras, 2006). The purpose for middleware is to identify devices and adapt content for those devices. Middleware has many applications in technology and Architecture designs. The ten selected resources collected in this section highlight the role of Middleware in mobile applications and content delivery [17] The term middleware encompasses many different types of software, most of which operate "behind the scenes." Middleware, which is sometimes referred to as the "glue that holds components together" is really an enabling technology that ties together applications, rather than the solution itself [24]. Middleware is traditionally defined as: Middleware is an important part of the enterprise software market because it is used to "tie together" the various "islands of technology." (See diagram below) Middleware enables enterprises to leverage their legacy systems, while at the same time introducing new technologies. Middleware provides a unifying layer between these disparate systems [28].

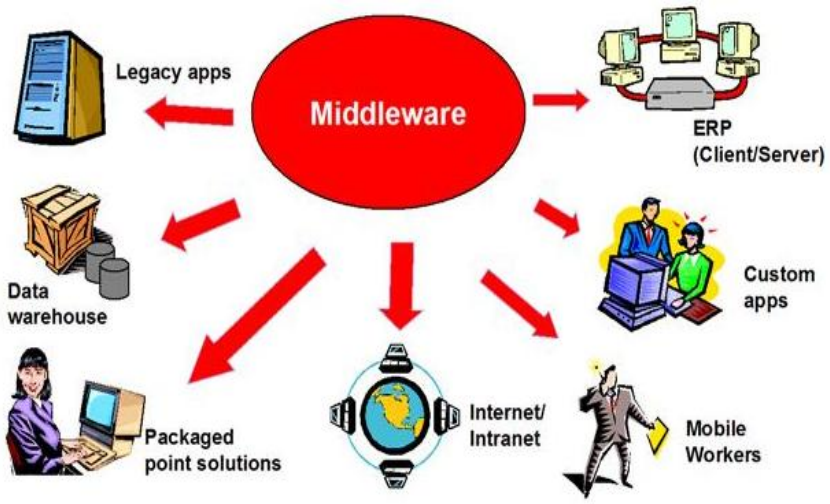

Figure4: middleware ties the various islands of technology

2.19 How middleware works in different servers

Middleware often sits between the operating system and applications on different servers and simplifies the development of applications that leverage services from other applications. This

allows programmers to create business applications without having to custom craft integrations for each new application. Typically, middleware programs provide messaging services so that different applications can communicate using messaging frameworks like Simple Object Access Protocol(SOAP), Web services, Representational State Transfer (REST) and JavaScript Object Notation (JSON). The systematic tying together of disparate applications, often through the use of middleware, is known as enterprise application integration (EAI) [18].

2.20 Mobile Middleware (MM)

MM is the software component that can be integrated with any application to add mobility. It constitutes services that can be transmitted over the mobile network to the clients on move. Also enables to add new features to an existing system quite easily. Mobile Agent (MA) is a software component that operates autonomously. MA allows codes to move freely around the network, thus enabling us to have much more flexible architecture with better network performance [19].

2.21 Semantic middleware used in design of triple space computing paradigm

When defining the required scenarios for the project, it came out that there would be different actors in the system concurrently communicating with each other and sharing information. Robots will need to access information stored in users' mobile devices; personal computers will need to access information stored in robots, different mobile devices will share information, while the amount of required network dependent information. A user can store information in his mobile phone anytime, and at any moment a robot could access this information [20]. The robot is not interested in processing something in the user's mobile device, but only in gathering some data. In the same way most of the scenarios were focused on sharing information rather than on requesting processes.[21] Nodes performing queries related with this new knowledge would retrieve it transparently.

2.22 Fault Tolerance

Fault tolerance has been essential in the adoption of middleware for traditional distributed systems. However, fault tolerance in mobile systems needs to be handled slightly differently. In

particular, two aspects of fault tolerance have been investigated by middleware researchers: connectivity and data sharing [23]. We treat the two issues separately and show examples of mobile middleware that offer support for them

2.22.1 Connectivity

Given the potential instability of wireless links, the possible low bandwidth or high costs, the frequent disconnections and the mobility involved, middleware for mobile systems should be able to provide support for fault tolerance in terms of connectivity [24].

2.23 Data-sharing

Mobility complicates the way data and services are shared among the hosts. In particular, the limitations of the resources on the device, and the unstable connectivity patterns make this task more difficult. [29]. They try to maximize availability of data and tolerance for disconnections, giving users access to replicas; they differ in the way they ensure that replicas move towards eventual consistency, that is, in the mechanisms they provide to detect and resolve conflicts that naturally arise in mobile systems.

2.24 Multi-agent integration middleware

As research shows, agent technology can well carry out the supply chain behaviors by inter-operation across the mobile network nodes at the abstractive level in a computational system because of its great potentials in supporting supply chain management. [22]. The Multi-agent integration middleware in our paper, containing all these agents, can integrate the functions of these different agents and furnish fine communication strategies for different agents, offering many kinds of personalized services to external application with uniform interfaces. [26]. The architecture of the multi-agent middleware is shown below.

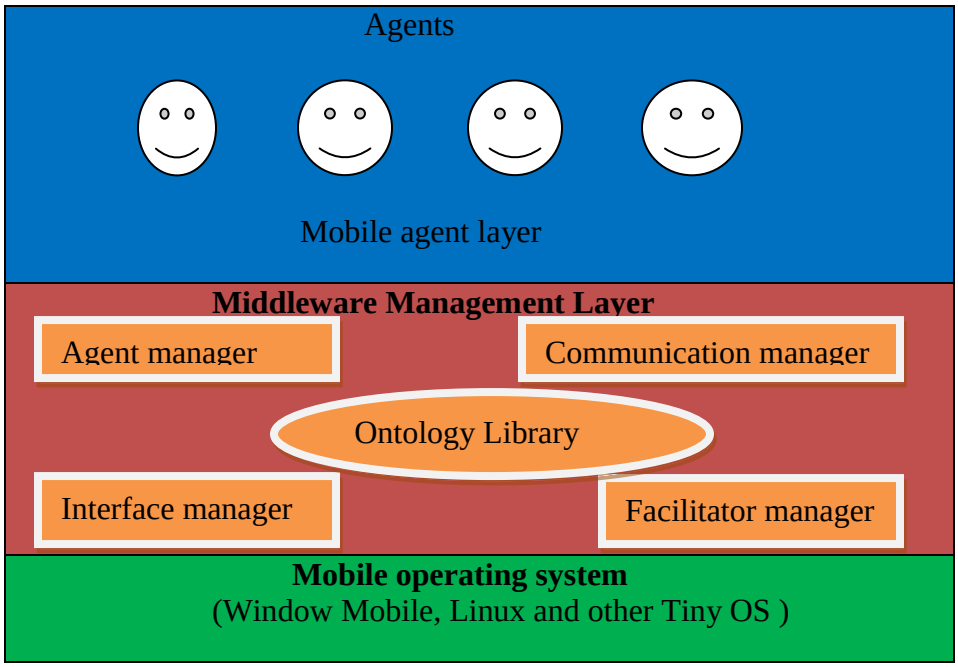

Figure5. Framework of the multi-agent middleware

2.25 RFID sensor tags types

Among the two dominating frequencies of RFID operation, i.e. HF and UHF, three categories of RFID sensor tags can be distinguished: active, semi-passive, and passive solutions. The available commercial passive and semi-passive solutions for wireless sensors and data acquisition systems mainly work at low operation frequencies and are based on short range inductive coupling [30][32].

2.27 Global Sensor Network

GSN-provides middleware to address challenges of sensor data integration and distributed query processing [33].

2.28 Middleware and gateways

There are some middleware components like behavior management middleware, which can be a layer between the client device and the application.

In mobile computing context we need different types of middleware components and gateways at different layers of the architecture [31] [34].

2.29 Summary of related literature

This chapter is a combination of architectures and comments of different authors about how the middleware works in relation to the topic or middleware architecture for mobile discovery of passive tags; so middleware is the glue that connects diverse computer systems. Typically, legacy systems store information in proprietary formats, use propriety protocols to communicate, and may even be running on hardware that's no longer manufactured or supported, it is all about integration. It is a software layer, which resides between applications and operating system and provides the applications a set of generic and commonly used services. The purpose for middleware is to identify devices and adapt content for those devices. it has many applications in technology and Architecture designs some of them are the ones which the researcher had taken as reference to be able to design middleware architecture for mobile discovery of passive tags; the comments of other researchers in this research helped to get to know what is required and how to put them in the architecture.

2.30 Conclusion

This chapter contains the theories, arguments and designs of middleware architecture for relating to middleware architecture for mobile discovery of passive tags stated and designed by different various authors, it helped the researcher to design the middleware architecture for mobile discovery of passive tag in the chapter five of this dissertation based on the references read from this chapter and again it helped the researcher to understand clearly the topic particularly the design.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses and elaborates the various approaches and methodological tools used in Data collection, processing, interpretation and analysis during the present study. It further tackles the research design, area of the study and study population. The various techniques and instruments applied in determining the sample size, methods of Data collection, processing, interpretation and analysis that were used in investigating the middleware architecture for mobile discovery of passive tags are herein discussed. The chapter closes with the limitations of the study.

3.2. Research design

A research design lays the foundation for conducting research in an effective and efficient manner. Like a good plan, it provides the specific details that guide the researcher. By definition research design is framework for the collection and analysis of data. or "a research design specifies the most adequate operations to be performed to test specific hypothesis under given conditions". In other words it says who is to be studied and how the subject/object of study is to be studied; for example it spells out the methods of data collection, instruments by which data is collected and how that data are to be analyzed as well as the techniques of data analysis.

In this investigation, the research design involved planning the methodology, approaches and timing of the research as well as its entire course.

3.3. Population.

Population is the entire group of persons having the same characteristics that are of interest to the researcher or study population is the entire population or universal objects over which research is to be carried out. It is the sum total of all units of analysis.

In view of this investigation, the study population was the, twenty employees of Rwanda Revenue Authority and fourteen entrepreneurs who acquire service from Rwanda Revenue

Authority specifically tax payers. However, for reasons of convenience and accuracy, a sample was selected using the sampling techniques as discussed hereunder.

3.4. Sample size and sample selection

A sample refers to a small proportion of population selected for observation and analysis. or sample is a sub portion of the total population to be studied. It is a selection, hopeful representative of the total population or universe that one desires to study. A 100 percent sample would be the entire population, but a 1 out of every 100 entities in the population is a sample of that population. The sample must always be viewed as an approximation of a whole rather that a whole in itself. If the sample is selected properly, the information collected about the sample may be used to make a statement about the whole population. In this investigation, due to limited resources and at the disposal of the researcher, it was not possible to gather information on the entire population that was made of managers, employees of RRA and entrepreneurs who offer taxes.

In this study the researcher selected a sample of 34 respondents. 2 managers of Rwanda Revenue Authority, 18 employees of Rwanda Revenue Authority and 14 entrepreneurs who acquire service from Authority specifically tax payers.

3.5. Sampling techniques

In this investigation, two sampling techniques were applied, namely; purposive sampling and systematic random sampling. It was therefore believed that the selected sample would effectively be representative of the entire population since it was selected from all individual divisions of the studied population were represented.

3.5.1. Purposive Sampling

The researcher used this sampling technique in two possible ways in such way the rich information may be obtained. Purposive sampling is a design in which the cases that make up the sample are chosen in a single process of selection from the sampling frame that covers the entire target population. The questionnaire was administered on non-randomly selected members of the

target community. Purposive non-probability sampling has been employed in this study when selecting respondent to be interviewed from management and entrepreneurs.

In another way purposive sampling or judgmental sampling is a non-probability sampling procedure in which the researcher uses his/her judgments to select those respondents that best meets the needs of the study. In regard to the investigation in question, to obtain the first 10 respondents, purposive sampling was evoked. These included the following classifications, RRA site managers and some few employees from institution. The reason for their selection was purposive in a sense that the investigator intended to obtain both administrative and technical information.

3.5.2. Systematic Random Sampling

Under this sampling technique, names of some respondents are written on single list and selection is done via systematically determined intervals. During the investigation in question, the researcher adopted a formula which is stated as follows;

K= N/n= B.

Where, K is the sample fraction which determines the sampling interview,

N is the remaining population after purposively drawing a sample from the study population,

n is the remaining sample size after purposively selecting a given sample.

Thus, K= 390/34= 11

Therefore, with regard to the above formula, a list of 390 respondents (entrepreneurs/customers) was made where every 11^{th} element on the list was selected for the sample, as illustrated below.

1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29,30,31,32,33,34,35,…. and so on. Under this formula, 24 respondents from among 390 entrepreneurs were selected.

In determining a sample, some respondents suggested 10% of the total population as a population estimate which if conformed to, should be representative of the whole population, but

this is applied to bigger numbers of the study population. Other researchers suggested 50% of the whole population to be representative of that universe. Under this investigation 10% was preferred as representative of the population under study.

3.6 Methodology used

At this point the researcher chose the approach to be used in this research such that the data would be actually collected in a well suited manner and the approach is the quantitative research.

Quantitative research is more objective than qualitative methods. In this type of methodology, the researcher would draft the architecture and check whether it suits the working abstraction through structured means. Instead of exploring or describing phenomena, quantitative methods deal with facts and design in statistical way.

3.6.1 Methods and instruments

Various research methods and instruments of data collection were applied during this investigation.

3.6.1.1 Interviews

Under this method, face to face or telephone interviews were held with respondents with the help of an interview schedule/ guide. This method was useful given its associated advantages which include the following;

Flexibility: The interviewer in most cases probe for more specific answers and repeat a question to respondent for to obtain accurate and relevant responses.

Spontaneity: As the respondent cannot withdraw some statements, the researcher obtains a variety of responses and records them spontaneously.

During this investigation, interviews were held with Managers, employees, customers and Entrepreneurs.

3.6.1.2 Observation

It is a systematic viewing of the phenomena in its proper setting or the specific purpose of gathering of data for a particular study. The method helped the researcher to know the interrelationships between Rwanda revenue authority workers and their customers/clients.

3.6.1.3. Questionnaire

Questionnaire would be designed and sent to the respondents comprised of close-ended questions where the respondents chose from alternative answers given as well as open-ended questions where the respondents would reply in their own words for their convenience.

3.6.1.3.1 Questionnaire distribution and return

The researcher used two methods of distributing the questionnaire as well as returning them

By hand (Personal)

This involved the act of printing the questionnaires and carry them directly to the concerned respondents whom they would fill them and the researcher had to go back to collect them.

E-mail

This method involved sending the questionnaires by means of E-mail to those who decided to use it therefore the researcher had to remind them to fill and answer the set question on time not keeping them in their e-mail box and keep quit.

3.7. Sources and forms of data, data processing and analysis methods

In this study, the sources of data were both primary and secondary sources.

3.7.1. Primary data sources

A primary data is one that is collected for the first time by investigators. Primary data gathering was done especially through interviews and questionnaire administration to respondents at all determined levels.

3.7.2 Secondary data sources

Secondary data means the data which have already been collected by someone and the record of which is available in the research papers, magazines and other documents .In Secondary data gathering was carried out through reviewing the various books and other records related to the subject matter of the research.

3.7.3. Data processing

Data processing is the transformation of respondents' views into meaningful form and classifying responses into categories in order to interpret and understand them. Data collected was analyzed and interpreted in reference to the established objectives. The results were presented in form of tables and interpreted accordingly.

3.7.3. 1. Tabulation

Tabulation deals with putting data into some kind of statistical tables showing the number of responses to particular questions. The researcher here, made tallies and frequencies to enable the interpretations of responses.

3.7.3. 2. Coding

During data collection and interpretation, the researcher used some codes like F to mean female; M to mean Male in order to facilitate tabulation.

3.7. 3. 3. Editing

After collecting data, the exercise of inspection and editing followed in order to identify items that were misunderstood by respondents to detect and remove gaps and other errors made during data collection.

3.8. Limitation of study and there overcoming

A number of problems were encountered by the researcher during the investigation but were overcome or endured. The major problem the researcher faced was limited time and scarcity of

resources to facilitate in transport and other necessary expenses during the investigation. This was overcome by devising other solutions such as seeking help with printings from friends and family members. Some of the respondents were not cooperative and could not find any academic purpose of eliciting information regarding RRA and their contribution to entrepreneurship. However, the investigator succeeded in persuading them to provide information, convincing them its relevancy in academic realms. Time was yet another hindering factor because the time required to collect data is limited and there are difficulties in conducting research simultaneously with duties/responsibilities assigned. This was overcome through hard working and endurance where sleepless nights were spent.

3.9 Model for designing architecture

Waterfall model: The waterfall model is a sequential system development process in which progress is seen as flowing steadily downwards through the phases of requirements, Analysis, Design, testing, implementation and maintenance. Under this study, the researcher used three phases sequentially to come up with a well designed middleware architecture for mobile discovery of passive tags and the phases are shown in the figure below.

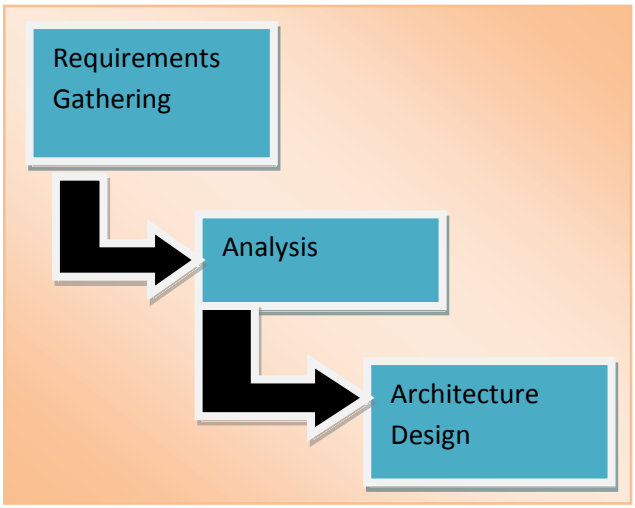

Figure6: Water fall model

3.9.1 Requirement gathering phase

Under this phase the researcher would use the methods and techniques of gathering data from the field and looked on what are the hardware and software that are required to design the middleware architecture for mobile discovery of passive tags.

3.9.2 Analysis phase

At this phase, data collected was analyzed and interpreted in reference to the set objectives and the results were presented in form of tables and interpreted accordingly in such way the researcher would directly go to the phase of designing.

3.9.3 Design phase

At this phase, the researcher brought and joined together all the required components of the system in relation to their functionalities in a way to fulfill what the established objectives say.

3.10 SYSTEM SPECIFICATIONS

The researcher's main concern on this part was to introduce the concepts of the user requirements, system requirements and feasibility study including technical feasibility, feasibility analysis and environmental feasibility to describe functional and non functional requirements of this system. This was done in such way to facilitate the researcher to design suitable architecture that would clearly describe the usefulness of the new system.

3.10.1 USER REQUIREMENTS

The middleware architecture was designed purposely to describe its benefits to the Rwanda revenue authority if it is implemented, this would provide the Rwanda revenue authority managers and employees with better or easy way of capturing and knowing whether the passive tags on the items or products produced by internal organizations or companies are rely correct or they are forged tags not from Rwanda revenue authority and this system when it comes to implementation phase it would improve the service delivery instead of using the glasses or eyes

in detecting and knowing whether the tag is legally accepted by the authorities or not and therefore it would permit portability factor where by the current system requires computer, reader and scanner to integrate their functionalities to be able to achieve the goal.

3.10.2 SYSTEM REQUIREMENTS.

To design the neat middleware architecture for mobile discovery of passive tags, the researcher used the following components: mobile phone particularly smart phone including both hardware and software which encompasses all applications including middleware that acts as a glue between application software and platform like operating system and hardware purposely to connect their working abstraction, addition that there is sensors that would be used to sense the passive tags and transfer data to middleware where it would be managed and controlled

3.10.3 FUNCTIONAL REQUIREMENTS

This architecture details the theoretical way of how the system should work when it comes to implementation phase it applies filtering, formatting in logic way to data captured/ sensed by a reader/sensors from tagged component so the data can be processed into meaningful. Since middleware is used to connect a database system with a web server and this would allows a user to request data from a database using forms displayed on a Web browser, while also allowing for the Web server to return Web pages based on the user's request.

3.10.4 NON-FUNCTIONAL REQUIREMENTS

The design of the architecture should be matching with the working abstraction Rwanda revenue authority with its clients/ entrepreneurs or tax payers not only that and details the structure on how the service would be delivered to their customers and if it comes implementation the language to be used should be known and understandable by the users of the system to mitigate errors and wrong use brought in by the complexity of the system language.

Conclusion

This chapter includes the approaches, methods and techniques of data collection it helped the researcher to know how to approach the respondents and how to gather rich information using

the techniques in short period of time therefore it is the base on which the researcher used to draw the chapter four and five according to the information obtained from the field, when reading this chapter you would eventually come to understand the what the was supposed to undertake in this journey of research

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This part presents the findings from a research conducted in Rwanda revenue authority under the Topic; "design middleware architecture for mobile discovery of passive tags: A Case study of Rwanda revenue authority". In this research data was collected using questionnaires, oral interviews and observation. The interviews attracted a group of respondents made up especially by top management in Rwanda revenue authority, while Questionnaires were administered to the Rwanda revenue authority general staff.

This part depicts the views, feelings and comments from respondents regarding the performance or impact of service delivery on the design and development of middleware architecture, with specific reference to existing system. Data obtained from the questionnaires and interviews were presented, interpreted and analyzed in form of tables or charts with their frequencies and percentages presented. Some inferences were also made on specific observations by respondents.

4. 1.1 Demographic characteristics of respondents

The population targeted in this research was made up of the top managers, general staff within Rwanda revenue authority and taxpayers. The profiles of the respondents were both qualitatively and quantitative analyzed and the questionnaires and interview schedules comprised both open ended and closed ended questions.

4.1.2 Classification of respondents by Sex

During the investigation, the researcher found it vital to classify respondents in line with their sex. This was intended to verify whether both sexes are on the same level of understanding the impact of technology in the development (service delivery/performance improvement) particularly from the Rwanda revenue employees to the entrepreneurs, under this perception the researcher wanted to see whether people would accept the new system based on their levels of understanding technology and be able to use emerge it in their business activities.

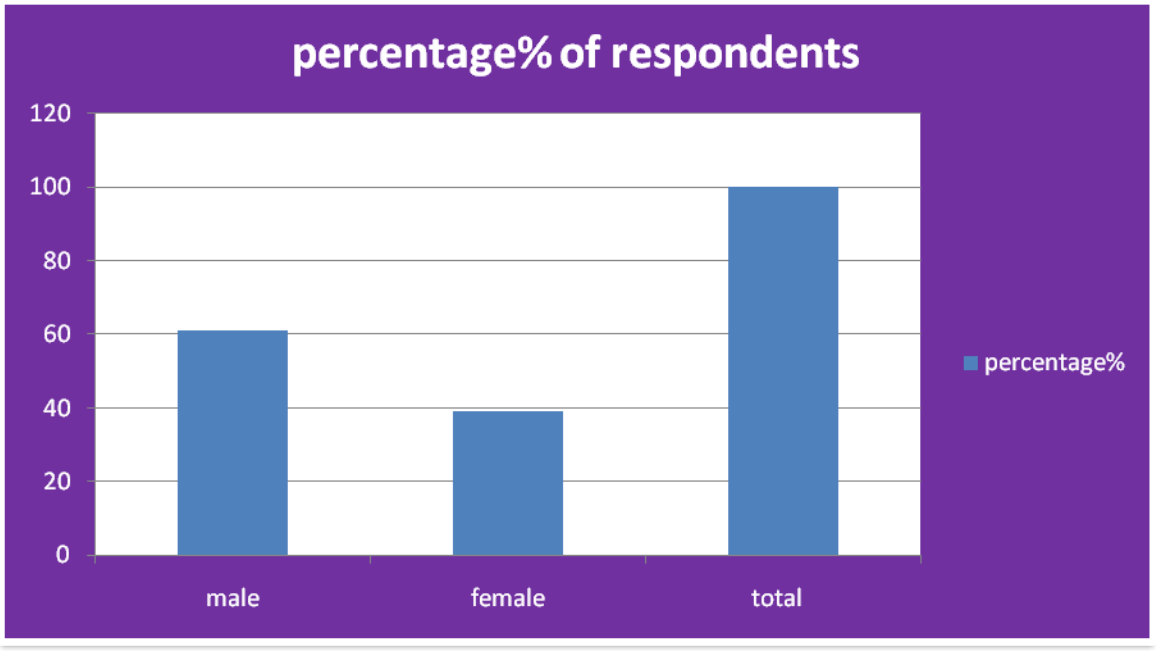

Figure 7: Classification of Respondents by Sex

From the results presented in Table 1 above, it is noted that 61% of the respondents were male while females were 39% of the total respondents. The implication here is that, although women and girls are largely involved in entrepreneurship and revenue activities, males remarkably out number their female counterparts. Hence, males covered the bigger fraction of the studied respondents.

4.1.3 Distribution of respondents according to their age

The rationale of distributing respondents according to age groups during the investigation in question was to determine the dominant age group among the employees of Rwanda revenue authority based on the level of acceptance of the new system "middleware for mobile discovery of passive tags", so as to be able to draw some inferences on given observations made on age distributions. The figure below presents the distribution of respondents by age groups.

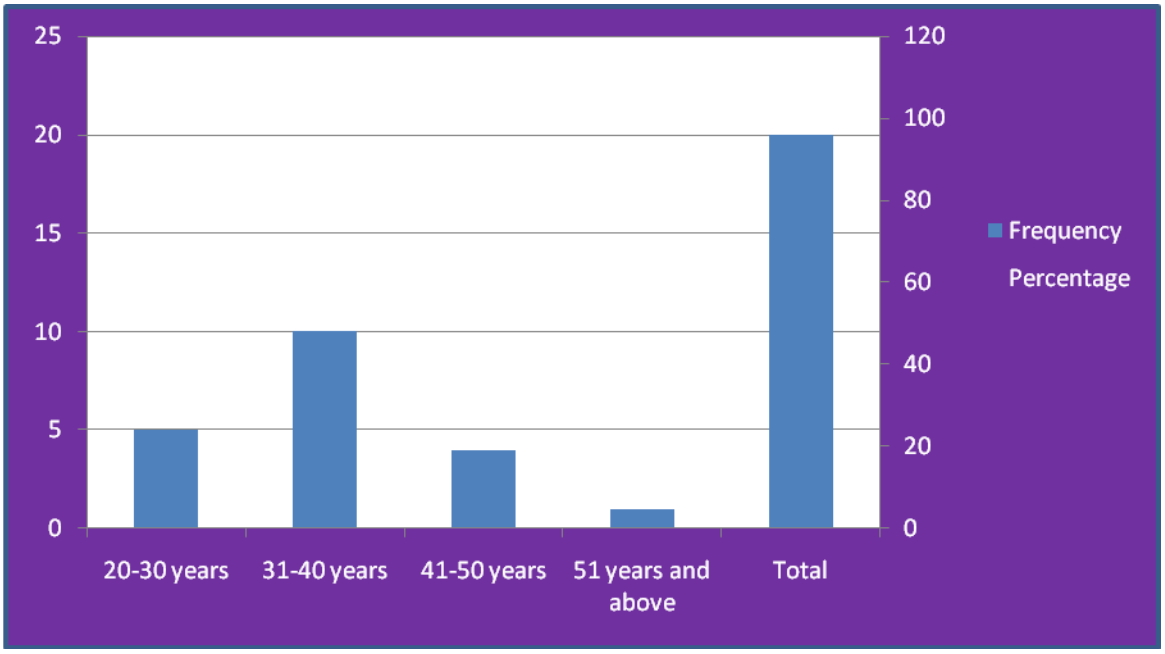

Figure 8: Distribution of respondents according to their age

As shown from the representation above, the largest number of respondents falls into the age group of 31-40 that makes up the percentage of 50%. It is followed by 25% falling into the age group of 20-30, and by age group of 41-50 years with 20%. The smallest age group of above 51 years makes only 5% of total respondents.

Given these percentages, it can be inferred that the most active age group is that of 31-40. This is because; this group is very much involved in income generating activities in order to be able to meet development needs as far as technology is concern, another words they are too much in love with the technology advancement. The fact that it is followed by those of 20- 30 years is because this age group is also fond of being involved in different Jobs especially at the execution levels, meaning that they could apply the experience in another job where they would probably get the best employment. Since, running the new system "middleware architecture for mobile discovery of passive tags" requires people to have knowledge base of smart phone and sharp minds to be able to cope up with the new coming changes of technology, people with 51 and above years are few reason being they are worried thinking that they would fail to run the new system leading to lose of job. Hence, this category of respondents was the smallest fraction within the studied respondents.

4.1.4 Impact of the new system on effective performance of RRA

This part deals with understanding how middleware architecture for mobile discovery of passive tags when it comes into implementation would boost performance and of service delivery in Rwanda revenue authority to its customers particularly taxpayers. The investigator intended to elicit information from respondents of different categories regarding the status of research (middleware architecture for mobile discovery of passive tags) and its impact on performance and ultimately provides the RRA with the quality of service to their clients. The central intention here was to determine whether good service delivery would boost performance in the revenue authority, disclose the tangible indicators of the impact of service delivery, and highlight the attitudes or perception of customers towards services offered to them by the revenue authority.

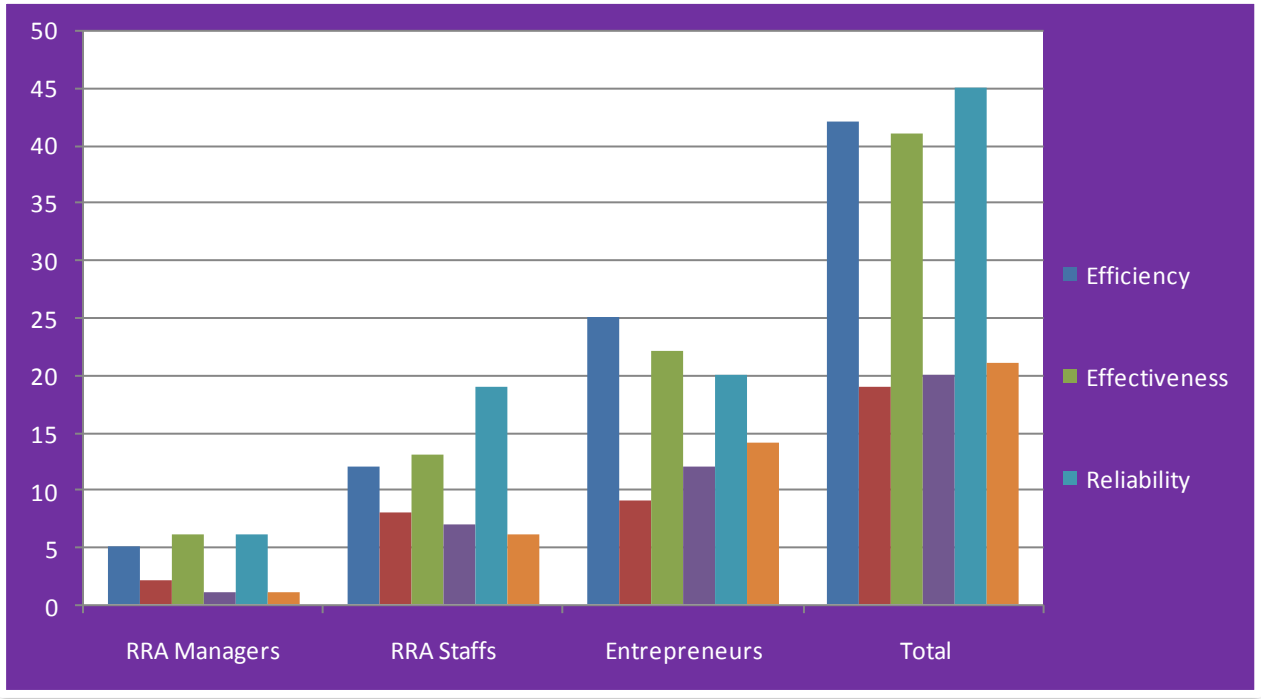

Figure9: effective performance of the system

From the figure above the respondents were asked about three aspects efficiency, effectiveness and reliability of the system as far as performance is concerned, the respondents point of view

appreciated the design as well as its implementation, since it would be an application that would be running in the mobile phone particularly smart phone and at most Rwanda revenue staffs are using smart phones, so it would probably be simple for every employee to understand and run it clearly, further more it could facilitate the RRA employees to capture, recognize, filter, store, manage, display and share the information in simplest manner to all employees and to the server since the smart phones are wirelessly connected

4.2 Data flow diagram of the system architecture

The data flow diagram is a physical representation of how data flows in system architecture; it details the movement of data according to the interconnections on the components of the system. So this diagram explains the flow of data beginning from the product, after manufacturing the product they tag it with radio frequency identification tag then whenever the Rwanda revenue employee passes the smart phone over the tagged product the middleware reads the data by the use of sensors and encodes the electronic product code tag and converts to uniform resource locator before passes the information to the electronic product code information systems and to the local object naming service therefore the electronic product code information system sends information to application interface where it would be displayed to the user and to the electronic product code information system server where information would kept for long.

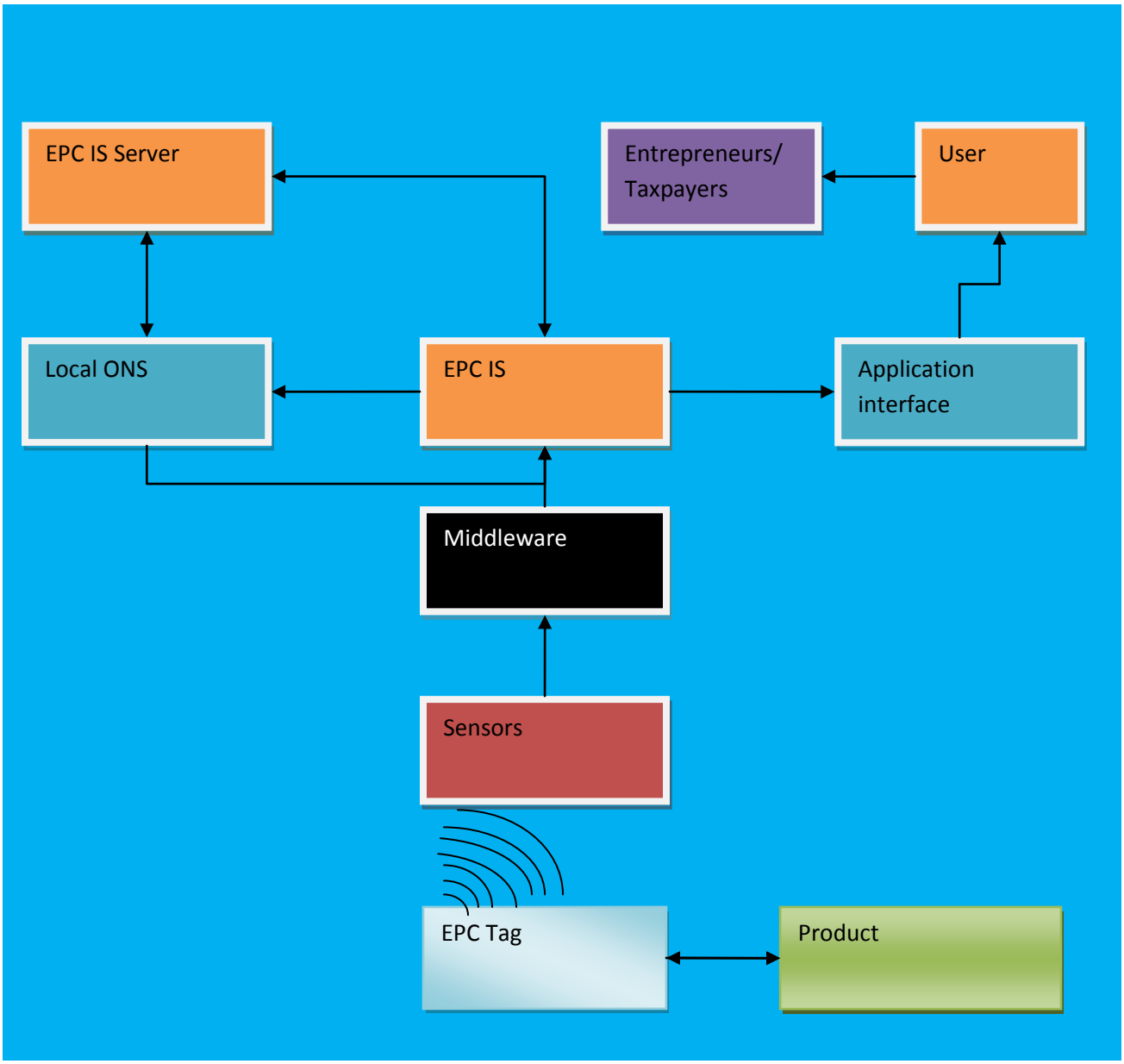

Figure10: Data flow diagram of the system architecture

4.3 Entity Relation Diagram of system

The researcher here explains the dependences of the entities in the system, the diagram below indicates that for the operation to be done; the employee should have the smart phone with the embedded middleware software to sense and capture the data from the product tagged with the passive tags and displays the information with the application interface to the user and then be able to know that the product would be taxed or be charged penalties.

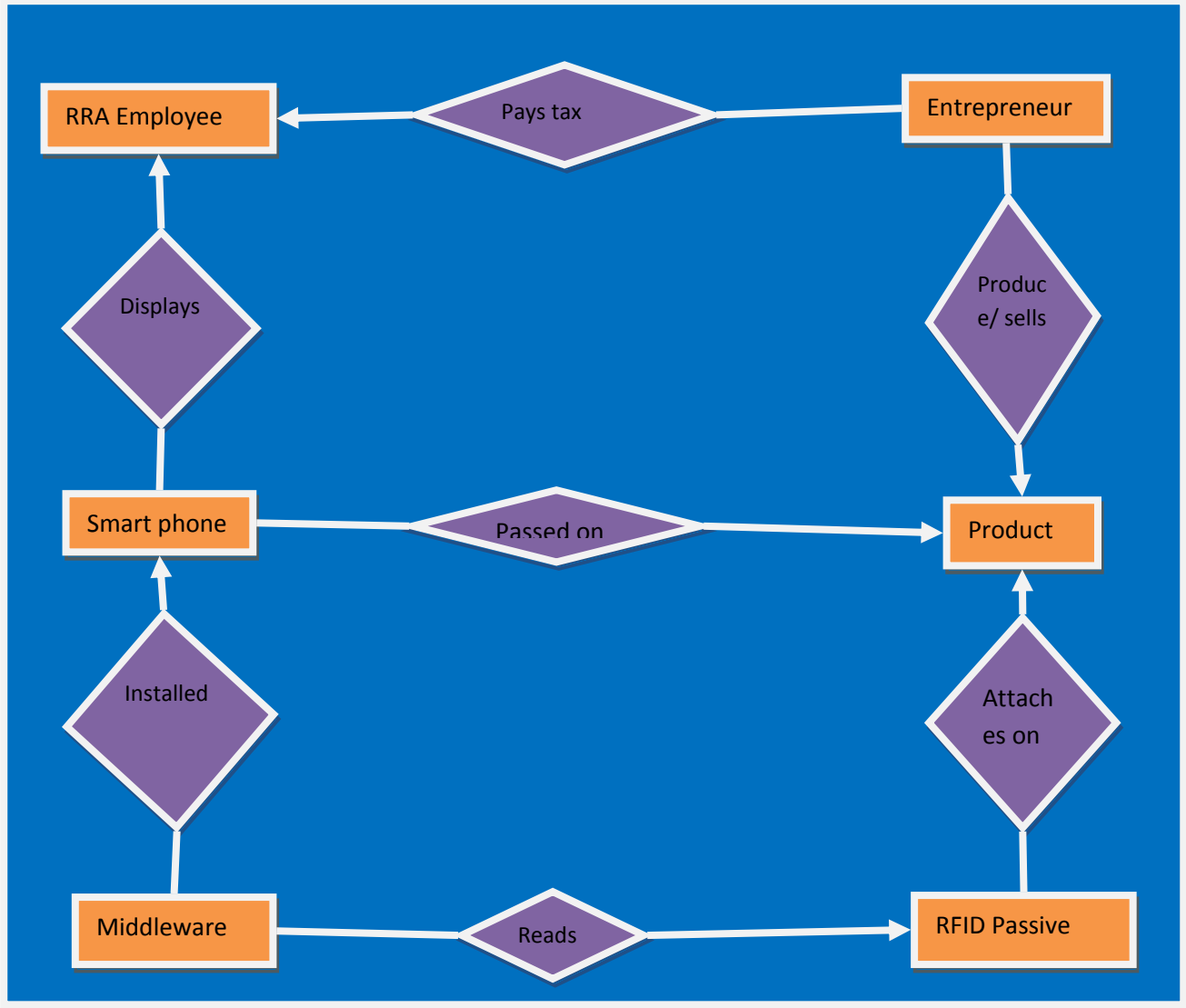

Figure11: Entity Relation Diagram of system

4.4 Conclusion

This part involves putting data collected from the together and analyze by scrutinizing it thereby transforming un meaningful data into information that is meaningful to the researcher and to the reader the report and giving the researcher the way to structure the entity relationship diagram and show how data flows in the system particularly middleware architecture for mobile discovery of passive tags.

CHAPTER FIVE: DESIGN OF MIDDLEWARE ARCHITECTURE

5.1 Introduction

During this phase, the researcher assembled the information gathered from the respondents during the requirements capture phase through identifying all the components of the middleware architecture for mobile discovery of passive tags, the output of the design phase is the system specification and it is like a set of blueprint that the researcher follow when go on with the implementation phase, father more this phase explains in details what are the components required?, what are their functionalities? How they are interrelated and interdependent to each other, the researcher went ahead by designing the middleware architecture to illustrate the concept explained above

5.2 Basic components in the middleware architecture

The basic components of the above mentioned architecture are mobile phone particularly smart phone that holds the middleware software which sends the radio frequency signal to wakeup or trigger the passive radio frequency identification tag therefore read the data, filter data, format data, normalize data and finally manage all other operations to done, product to be tagged as well as buy and sell, and Radio Frequency Identification tag which has electronic product code which in turn uniquely specifies the product.

Basic system components of mobile discovery of passive tags

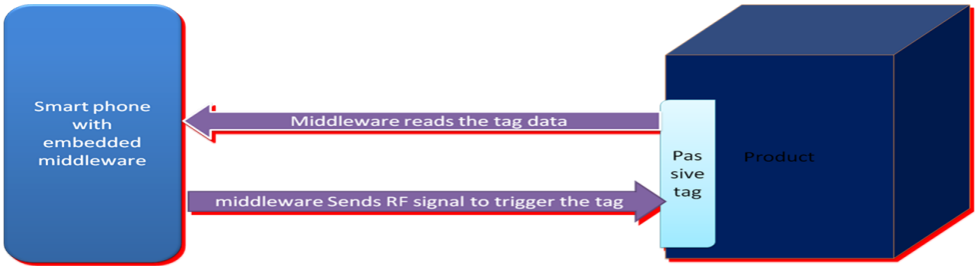

Figure12: the basic system components

From the above figure, the middleware software embedded in the smart phone is responsible for capture radio frequency identification data when the user passes the smart phone over the tagged product to ensure whether the product is tagged with legal or illegal tags and facilitates the RRA employee to tax the product or set the penalties according to the set raw governing the taxation.

5.3 How information flows in the system

The researcher at this point of view tried to clearly show how information flows in the system from the component where the tag is attached to the smart phone that holds the middleware software then information flows through the wireless connection to the server.

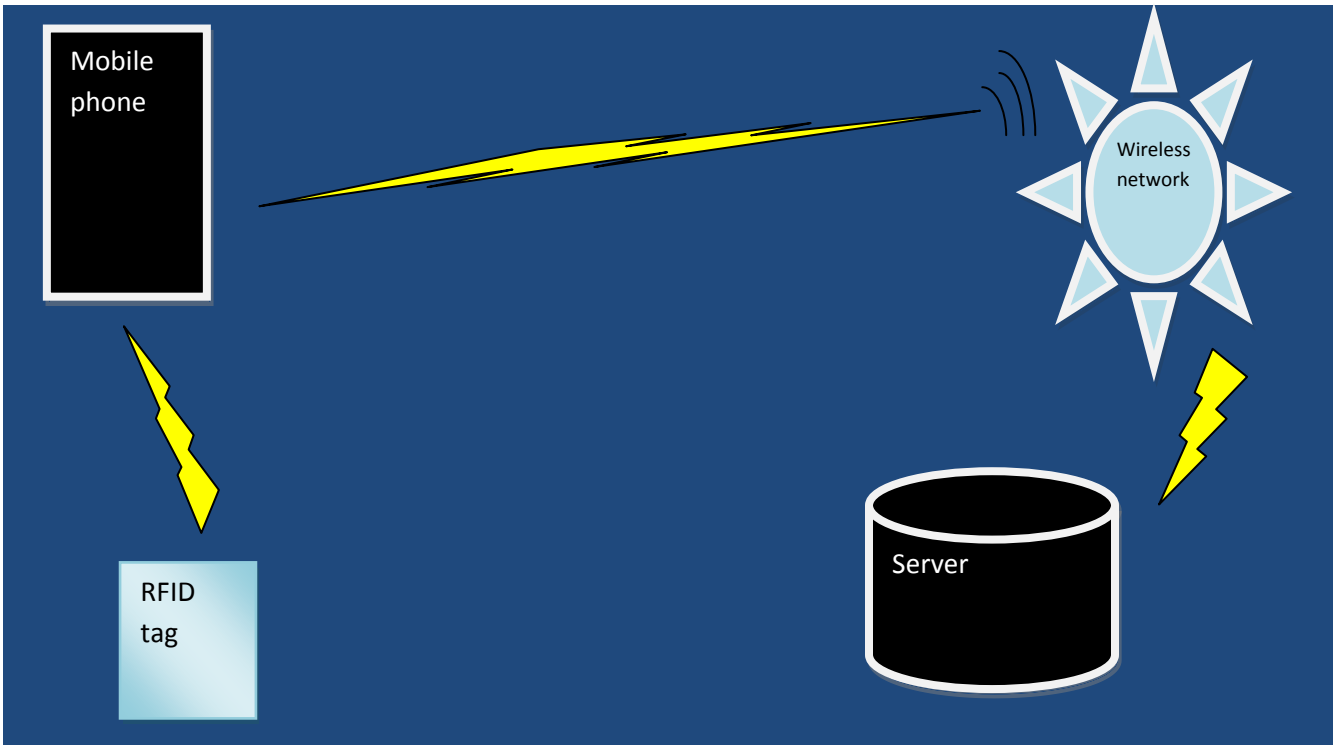

Figure13: information flow in the system

From the figure drown above; the researcher indicated that the information to flow from radio frequency identification tag to mobile phone goes by means of wireless connection, this means that the employee would pass the mobile terminal over the product with radio frequency identification tag to capture the data by the way of sensing the tag data using middleware sensors

or sensor nodes and pass the information through the wireless network to the server machine where the information could be stored and managed.

5.4 Detailed design of middleware architecture for MDPT

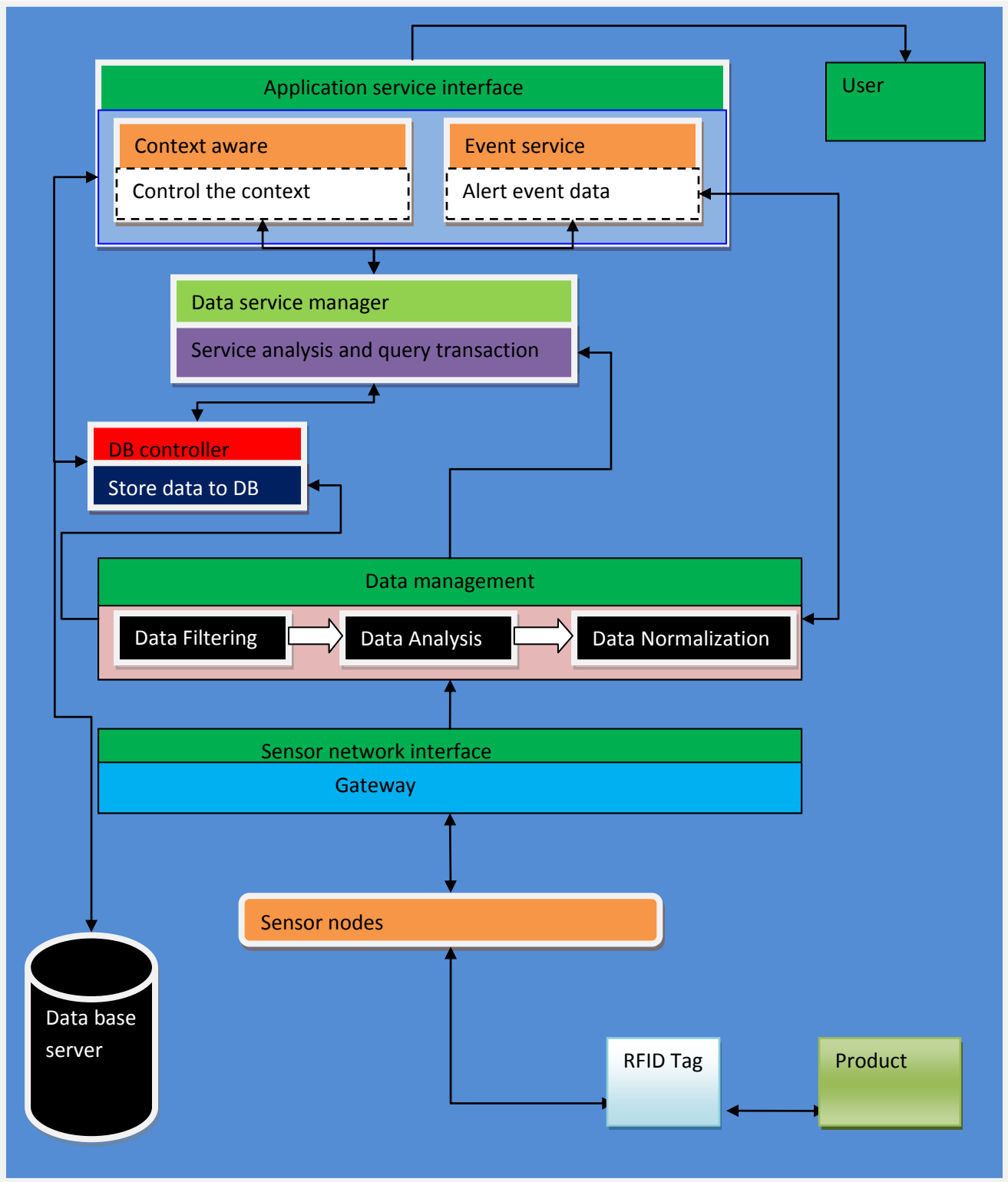

Figure 14: Middleware architecture for mobile discovery of passive tags

The detailed explanations of the above figure are arranged according to the functionalities of the system components based on their interrelations and interdependencies in the middleware architecture for mobile discovery of passive radio frequency identification tags.

5.4.1 Product

Product is any item produced by the internal organization which needs to be tagged and sold on the market, meaning that in the process of tagging the product the Rwanda revenue authority has to ask for tax of the manufactured product and be given permission of selling such product after clearing the necessary requirements.

5.4.2 Radio Frequency Identification passive tag

An RFID tag is comprised of an integrated circuit attached to an antenna that has been printed, etched, stamped or vapor-deposited onto a mount which is often a paper substrate or Polyethylene Therephtalate (PET). The chip and antenna combo, called an inlay, is then converted or sandwiched between a printed label and its adhesive backing or inserted into a more durable structure. The passive tag derives its power from the energy waves transmitted by the reader and responds to the reader‘s radio frequency emissions, therefore the passive tag relies entirely on the reader as its power source

5.4.3 Sensor nodes

These nodes are varying in size and totally depend on the size because different sizes of sensor nodes work efficiently in different fields. Wireless sensor networking have such sensor nodes which are specially designed in such a typical way that they have a microcontroller which controls the monitoring, a radio transceiver for generating radio waves which triggers the radio frequency identification tag thereby facilitating the reader to capture the data from the tag to the middleware

5.4.4 Sensor network interface

The sensor network interface plays a big role in the system architecture by providing the interface or act as getaway between sensor nodes and data management therefore allowing data to pass through the conduit to data filtering.

5.4.5 Data filtering

The volumes of data generated by the reader require significant data filtering to extract the most important information. Also, different applications are interested in different subsets of data captured. There are filtering policies available in the data management policy of the middleware, therefore the data filtering service filters data depending on the filter characteristics provided by the application.

5.4.6 Data analysis

The middleware application applies data analysis in the department of data management to scrutinize the data passing from data filtering to data normalization with intention removing unnecessary data thereby sending clear information.

5.4.7 Data normalization

During this phase, data are checked clearly to remove all data redundancies meaning that all data duplications should be handled at this point in the data management under the control of middleware software before data are sent to data service manager and database controller.

5.4.8 Database controller

The database controller is responsible for acceptance of data from data management chamber and then store data to database by arranging them in their respective positions and again communicates with data service manager bi-directionally meaning that exchange of operations that to say queries and responses are done in a well organized manner ; in addition database controller communicates with both database server for storing and retrieval of data when necessary and cooperates with application service interface for data display to the user.

5.4.9 Data service manager

At this stage the middleware analyses the coming data as well as the transaction made(requesting and responding) between database controller and data service manager, not only that and even t manages the operation communication to application service interface for batter way of content management.

5.4.10 Application service interface

According to the concept of application software, it where the conversion of machine code into readable manner or human readability or high level language be done then the middleware at this stage converts the data into a format that is readable to human being and finally present data the based on the interface established and the user takes decision drown from the contents.

5.5 Algorithm on how middleware discovers the passive tags

The algorithm mentioned above is the diagrammatic way of describing the stapes under go to complete the operation of how middleware architecture for mobile discovery of passive tags, the researcher tried to make it clear for the reader who would want to understand the phenomena of above mentioned operation.

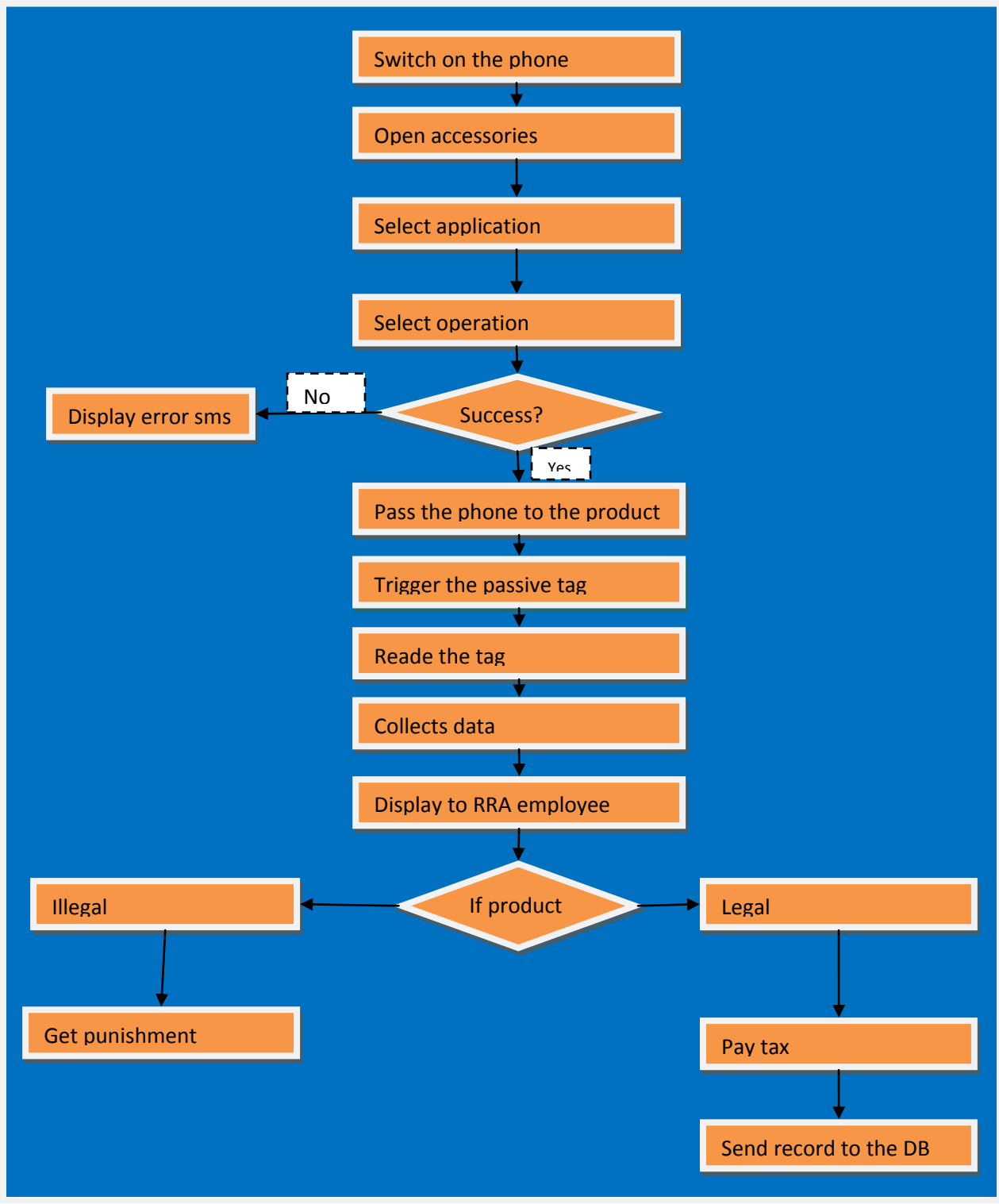

Figure15: Algorithm on how middleware discovers the passive tags

5.6 Conclusion

This chapter is the design of middleware architecture for mobile discovery of passive tags so at this point the researcher attempted to design the well architecture based on the contents or data gathered from chapter three and analyzed in chapter four thereby drawing the architecture which shows how middleware reads the electronic product code or passive tag and sends or presents the information to the system user whenever the user passes the smart phone over the tagged product in such way he/she would know whether the product is illegal or legally tagged and sold and this is the body which describes the what was the aim in this researcher.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusion of the discussion made between the researcher and the respondents and it became a base to structure to recommendation to the two possible areas according the structure of research.

6.2 Conclusion

This research has presented the possible way of using the middleware architecture for mobile discovery of passive tags. The system architecture presented was based on a combination of smart phone, middleware software, wireless and the items with radio frequency identification passive tags and would be able to accurately read, format , manage and display information to the user using the above mention software and interrelated components functioning together to achieve the objectives. The most noteworthy advantage of this system is that there is no contact between the tag and the reader/ sensors, and the system requires no line of sight. The tags can be read whenever the user passes the smart phone over the tagged product then the sensor sends the electromagnetic waves called radio frequency signals to trigger the electronic product code by hitting on the electronic product code circuit. They can also be read at extremely high speeds. Zero power consumption of the passive tags is the key strength of this system; due to the factor most people are familiar with mobile phones they became attracted toward the use of middleware system.

6.3 Recommendations

The researcher draw the recommendations in two ways, to the organization and to the future research based on the information got and the structure of the system architecture to improve efficiency and effectiveness of the service delivery to the customers leading to attraction of the more and more clients.

The Rwanda revenue authority should employee this system to improve their performance in service delivery in a way of meeting the customer needs and builds the pleasure to the minds of entrepreneur therefore resulting in attracting outsiders in joining the group hence establishing new companies. it should encourage all their employees to own or have smart phone because this system would effectively be used by the user who have those particularly phone and be able to hold middleware software as well as performing its responsibilities there by facilitating the employees since it mitigates the doubt. The organization would need to train its employees about how the system works more especially the people with the age between 45and 60 because those are people educated before technology spurned around meaning that by that age technology was not considered as most important tool in the sustainable development but now days people are aware of the importance of technology. The companies would use passive tags because of its low price based on its advantage of not acquiring battery and of the factor that lasts for long, so for that reason they could lead to extensive development of accurate systems and encourage businesses to use it more and more.

The researcher strongly recommends further researches to deepen the research on this subject matter to increase the evidence base and promote service delivery in Rwanda revenue authority to the tax payers. The study was limited only to Rwanda revenue authority particularly in the department of taxation on the products of local companies or organization; hence, further studies need to be conducted on how this system would work on the local and global with the supply chain management.

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