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Structural Design of an RFID-Based System: a way of solving some election problems in Africa

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ABSTRACT

In this thesis work, two major problems confronting elections system in Africa; multiple registrations and diversion/shortages of election materials, taking the Nigerian content into consideration is addressed. These problems have been described as being so corrosive in nature such that ICTs in the form of eVoting if fully implemented will only compound or exacerbate the current situation due to poor ICTs awareness in the continent. However, in order to contain these problems with some form of ICTs tools along side the traditional election system, we proposed an RFID-based framework where voter's identification and election materials are RFID-based. We believe this will enhance effective and efficient identification and tracking. Operations similar to the chain supply and inventory management are utilized. Also benefits resulting from the adoption of this framework; national ID card, national register, etc. are addressed.

Keywords: ICTs, RFID, Election Problems, EPC code, ID card

CONTENTS

Abstract

Table of contents

Chapter 1: Introduction

Chapter 2: Election Problem Descriptions/Effects

Chapter 3: The Required Solution Technologies

Chapter 4: Structural Design

Chapter 5: RFID-Based Election Problem's Solution

Chapter 6: Conclusions and Future Work

Chapter 1

Introduction

1.1 Background

The rapid spread of information and communication technology (ICT) is changing the way economic and social development occurs in developed countries of the world. ICT-tools and developmental platforms like ICT4D (ICT for Development) have the potentials to transform and make institutions, businesses, and organizations more productive, enhance skills and learning, improve governance at all levels especially in the area of democracy. It also makes it easier for the "poor" to have access to services that are considered beyond their reach and make them be part of the society.

With the impact created by ICTs in developed nations of the world, the story in its developing counterpart is different. We know that in most developing countries such as African nations where ICTs use are not quite common, its tools are seen as technologies that are unaffordable or inaccessible for the masses and their impacts are ignored. The impact of ICTs on democracy especially in election process, particularly eVoting has been predominantly advantageous as practiced by most developed nations. New ICTs pose both opportunities and threats for election, though both cannot be equated because the opportunities are always tremendous. On one hand, ICTs brings about increased participation in the political process, antidote to voter's apathy, greater convenience in terms of voting time and location, reduce cost, access to peoples with disabilities, and greater accuracy as well as transparency. On the other hand, ICTs also threaten to undermine democracy by compounding existing election problems. For instance considering the electoral fiasco that almost engulfed US Presidential elections in Florida, November 2000 etc, caused by Voting Machines. The problems showed numbers of deficiencies emanating from and the systems such as confusing ballots, registration mix up, systems failure on election day, software bugs preventing votes being recorded, interfaces hard to use, recount impossibility, mistakes in polling place operations, and even absentee ballot problems that caused the loss of millions of votes [8,9]. This type of situation reduces public confidence and trust on democratic processes.

However, none of this means that we should abandon ICTs in election system; the benefits of ICTs are too great to be thrown away. It does means that we need to recognize its limitations, and apply it considering the prevailing situation. Despite these recorded problems, in developing nations where ICTs in democracy such as eVoting cannot be fully implemented, efforts will be geared towards incorporating at least some form of it into the old and traditional election system for enhancement and smooth administration. Democracy as a modern form of government practiced by most nations of the world is typically used in the context of a political state and its principles are applicable every where. Viable decision making mechanism called election is employed in this context to fill in vacant offices through voting system, based on eligibility through citizenship, age, residency requirements etc. Election

processes and its conduct is one issue we believe could bring all people together irrespective of their level of social stratification in the society. With this, any problem emanating from it may be regarded as general problems. Winners of elections and the entire general public are usually satisfied with the outcome, but it is often more challenging to persuade the losers (and their supporters) that they lost [11]. But it is not sufficient that election results be accurate. The public must also know that results are accurate, and can only be achieved if conduct of the election is sufficiently transparent such that candidates, the press, and the general public can satisfy themselves that no errors or cheating have occurred [11].

Unfortunately, in Africa continent and Nigeria nation in particular such situation does not exist. Election processes, its conduct as well as its products are characterized by violence, wanton destruction to lives and properties, voting fraud, wide spread corruption, intimidations and to crown it all "War", which has long tarnished the image of Africa democracy due to selfish interest. This has assigned a question mark and reduces public confidence on the practice of democracy in the continent. Some of the problems are due to cases such as multiple registration/voting, diversion of election materials such as ballot papers for the purpose of rigging in favour of a particular candidate, stuffing of ballot boxes with ballot papers, hijacking of electoral officials and materials etc. All this happened as a result of lack of adequate security measures and necessary ICTs infrastructure in place.

In order to get rid of this problematic situation that has long tarnished the image of democracy in the continent, our intent is to present an RFID-based framework for the government of so-called democratic nations of developing countries in search for transparent and hitch-free means of conducting election especially on identification and tracking issues.

1.2 Purpose of the Thesis

Due to the existing problems posed by the processes, conducts and products of elections that is seen as threats to democracy and public security, our overall goal in this research is to find out a better way of improving the election system especially in the area of identification for both voters and election materials. With this, we intend to fully incorporate RFID (Radio Frequency Identification) into elections system in order to assist democratic nations (developing countries) to find a lasting and peaceful solution to the problems they faced. This method indeed can also be applied in other areas other than elections alone.

We will present a structural design of RFID-based system to solve two major election problems in Nigeria; multiple registrations and shortage or diversion of election materials which we believe can reduce the problems at least to a manageable level. These will facilitate the removal of election impediments, make better and faster elections result, and even worth practice. Also, the state of election system in Africa, its problems, causes will be explored. We will discuss why it is good for developing countries to start using ICTs in both parallel and pilot basis rather than going into full eVoting directly.

1.3 Research Questions

The research questions we intend to solve in this thesis work are as follows:

- What security measures should we adopt in order to stop multiple registrations during voter's registration exercise in Nigeria?
- Could RFID-based structured system solved issue of shortage and diversion of election materials during elections in Nigeria?
- Of what impact does our proposed RFID-based System create in election processes in Nigeria and beyond?

1.4 Expected Outcomes

The expected outcomes of this thesis work are as following:

- An understanding of different factors causing election problems and its effects on development in Africa.
- A useful description of structural design of RFID-based application that can be used during voter's registration exercises and in the distribution of election materials.
- Providing a complete RFID-based system which will serve as a solution for those stated problems.
- Outlining the benefits that can result from the implementation of the RFID-based project by both public and private sectors.

1.5 Some Problems with our Studies

The thesis searches for models (RFID-based) to provide an efficient support for elections system in developing countries. During the course of this project, we encountered lots of difficulties, though no practical work was conducted. The absence of funds, past related work and the complexity of a real world elections problem make it a difficult one. That is to say this project is one of a kind (unique). We found it difficult mapping all cause-effect relationships in the studied system. The elections problem studied is complex and there is probably no defined or experimented RFID-based framework of this kind already in place to solve these problems. This thesis work presents a suitable RFID-based framework and examines different solution techniques within the election system. It also suggests opportunities to be created by the system.

1.6 Research Methodology

In this research work, we will use qualitative research methods including case study. The detailed and comprehensive case study and literature review will be carried out to investigate the election system in Africa. We will use Nigeria elections system as a

case study to investigate the real election situation and see how best this proposed system can be used to stop the problematic situation arising from it.

1.7 Disposition of the Thesis

The disposition of this thesis is as follows:

Chapter 2 discusses the State of election system in African continent, why full implementation of ICT is impossible as well as Nigerian Elections problems description and effects. Because this thesis relies on solving election problems, we shall give full details of election system in Nigeria and indeed Africa, its causes and impact. Taking Nigeria context at hand, we shall analyze problems of elections in Nigeria as well as the two major problems in focus.

Chapter 3 provides an overview of the Election problem's solution technologies, tagged "Required Technologies". That is, the RFID technologies. Here we shall only brief on RFID system and its associated technologies that is applicable to our proposed system.

Chapter 4 renders the structural design of RFID-based model and the analysis of how it can be used in solving problems of multiple registrations/voting during voter's registration exercise and actual voting respectively and the distribution of election's materials to avoid shortages or diversion for the purposes of elections fraud.

Chapter 5 adumbrates on our expected outcomes, the benefits accrued to the proposed RFID-based Framework for our system as well as how the public and private sector can be impacted by it. Also, we suggested some visible factors that can probably hinder the takeoff or the implementation/adoption of this project by the Nigerian government.

Chapter 6 some conclusions and suggested ideas for future work that will aim at improving upon the proposed system as well as putting it into practical use to see its feasibility, benefits, etc as well as making it a viable project.

Chapter 2

Election Problems and its Effects

2.1 Background

2.1.1 Election System in Africa

Africa being characterized as “developing”, still practice election system practiced prior to eVoting system in the US and some other developed nations of the world. The system is still tied down to the traditional approach where no electronic device is involve rather interaction is between voters, ballot papers, polling place, ballot boxes, and definitely election officials and if any, observers. See figure 1.0 below. Each country has its own and independent way of implementing its election system such as open or secrete ballot system, single or multi-party system as well as the incorporation of voting stages. For instance, in countries like Mali, Burundi, Ghana, Liberia, etc second-ballot voting or runoff voting is common. Elections affairs are spearheaded by electoral commission board (e.g. INEC in Nigeria).

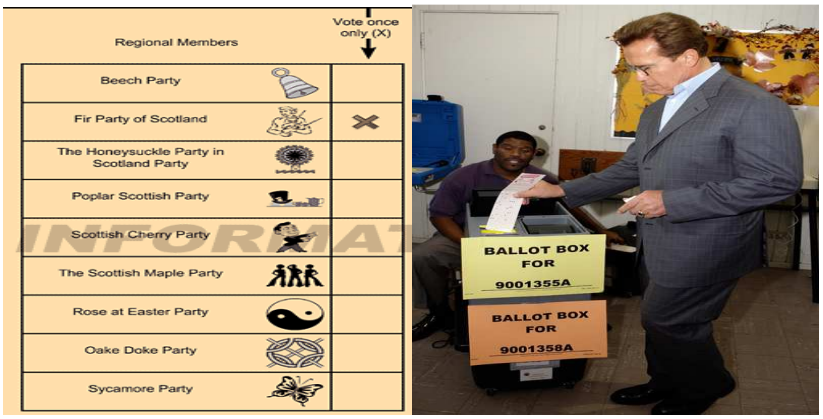

Figure 1.0 Example of Ballot Paper and Ballot Box

Election procedures begin by first identifying political party(s). This could be single party, two-party or multi-party system depending on each country desires. Electorates are registered, primaries are conducted by each political party to nominate their flag bearer, and dates are set by the commission for the actual voting. At the end of voting, ballot papers are counted, results are collated and the winners are announced. A process similar to the modern type (eVoting) but manually achieved thereby making it slow and labour intensive.

2.1.2 State of Election System in Africa

Based on the benefits assumed to be with electronic voting as practiced by some developed nations ranging from speed to accuracy, most African countries with the help of UNDP (United Nation Development Programme) and other non-

governmental organizations are beginning to have a look at the incorporation of some form of ICTs into to their old and traditional method as ways of improving and strengthening the existing system. This is because the modern system such as eVoting as being practice by the US and their eVoting allied cannot be fully and immediately adopted based on facilities or infrastructures on ground. With these ICT tools, they can maintain databases of voter's register, improve security of election materials, enhance communication etc.

For instance, Nigeria and other African nations are on the move for full incorporation of ICT tools into elections system. Late in 2006 and early 2007, Nigeria in what could be described as "experiment", introduced electronic methods in the registration of her citizens for their general elections. Though for the first time, there were lots of challenges faced by officials, electorates and the government. This includes huge cost of procuring the machines, inexperienced machine operators, lack of awareness and education, machine malfunctioning, and a host of other related problems which all resulted in delaying the registration processes to nearly three months as against two weeks stipulated period. The Commission attempted full implementation of the electronic voting system in their 2007 general election, but was vehemently apposed by many Nigerians.

In South Africa, ICTs implementation on electoral process begun during the 1999 parliamentary and presidential elections when the technology was used for voter's registration, the polling process, relaying of ballot collection and verification, and relaying of results of the elections throughout the country [2]. Also in other parts of Africa like Rwanda since 2003, the National Electoral Commission of Rwanda longed to enhance the use of ICTs to manage the country's voter list, assist the Commission to print high-quality voter registration cards, and improve communications between headquarters and their twelve provincial offices [7]. In Kenya, ICTs is not left out, the Electoral Commission of Kenya (ECK) recorded increased participation in the elections with an informed mind [6]. Also in Namibia, the Cabinet has only agreed in principle to consider electronic voting machines for their next national and presidential elections at the end of 2009. With this awesome development, many more countries are taking bold steps aimed at reforming their electoral system through the incorporation of ICTs [2].

But despite this bold steps taken, these ICTs in election system cannot be fully implemented (eVoting) due to certain constraints such as financial problems, lack of awareness and technical know how, corruption, inability to manage time and host of others. With issues arising from the traditional election system, African democracy is on the verge of breaking down. The level of corruption has almost ravaged the whole system, elections are rigged and results forged or marred by violence, materials are hijacked; properties both public and private destroyed and even throwing the whole nation into instability.

2.1.3 Effects of the Current State on the Continent

In Africa, about 97% of the crises faced by many nations are election related in nature. These have tarnished the image of the continent beyond expectation. Election crises are heavy and have tremendous impact on the continent. Most countries are still suffering what we could refer to as the aftermath of election outcome. Most

nations have been or are in war due to poor conducts of election exacerbated by multiple voters' registration, rigging and forging of elections result. See figure 2.0 below.

Figure 2.0 Aftermath of elections crises

Holocaust is always the end product. Properties estimated to worth millions of dollars are destroyed, innocent souls faced carnage and dozens displaced the rest of their life. Imagine the case of the present Kenya, Darfur in Sudan and the rebels' activities in other parts of the continent such as Sierra Leon, Somalia, etc are all linked to election problems. When shall Africans do things devoid of crises? Most of these crises are due to not following proper elections ethics. The amazing part is that some miscreants who succeeded in assuming office introduced new ways of continually and perpetually staying in office thereby giving rooms for all forms of frauds that is engulfing proper election conducts and always generate oppositions.

2.2 Election Situation in Nigeria

2.2.1 Introduction

The federal Republic of Nigeria has a system of government modeled after the United State with executive power exercise by the president. Nigeria is the most populous and populated nation in the continent situated in western region with 140.003.542 estimated people out of which Men: 71.709.859 and Women: 68.293.083 courtesy of 2006 national census result. Nigeria covers an area of 923,768 sq. km with over 250 ethnic groups and is divided into six geopolitical zones with 36 states and federal capital territory and 760 local councils [5].

The Nigeria Electoral system is the single member constituency type with multi-party system structure. The method of voting used in four out of five past general elections held in the country; 1979, 1983, 1999 and 2003 respectively was the Open Ballot System (OBS) which employed the traditional voting system with confidential thumb impression on ballot papers in favour of the political party or candidate of choice in a secret voting compartment before dropping the ballot in the box positioned in the open, in the full glare of officials, security and party agents. During the 1993 general election, the modified Open ballot system was adopted following same traditional voting approach but party symbols or candidate's photograph was

allowed on the ballot papers and voters were physically counted instead of the ballot papers. The method was described as simple and produced something close to fairness but the election was unsuccessful due to annulment by the then Head of States for what he described as "lack of free and fair election atmosphere". The election was a two-party system, what gave birth to multi-party system of thirty something political parties of today. The election also suffered the flaws of not providing the anonymity of voters, a basic internationally acceptable standard.

In Nigeria due to circumstances surrounding the conducts of elections, results are always subject to complaints, petitions and even generate instability. The electoral system allow such disputed results to be challenged at elections tribunals or courts established to look into such cases. In Nigeria, the commission in charge of elections affair is the Independent National Electoral Commission (INEC). Details about the establishment are given below.

The Independent National Electoral Commission (INEC)
INEC established by the 1999 Constitution of the Federal Republic of Nigeria and Section 10 of the Independent National Electoral Commission (Establishment etc.) Act No. 17 of 1998 is vested with responsibilities of:-

- Organizing and supervising of all elections to the offices of the President, Vice-President, the Governor and Deputy Governor of a State and to Membership of the Senate, the House of Representatives and the House of Assembly of each State of the Federation;
- Registering Political Parties as well as to monitor their operations and finances if any;
- Arranging and conducting the registration of qualified potential voters, maintaining and revising the register of voters prior to election;
- provide the administration of oath of office as stated by law to all Electoral Commissioners, Electoral and Returning Officers;
- Perform any other functions as may be conferred upon it by an act of the National Assembly. [1]

Mission: INEC mission is to "provide credible and efficient electoral services that are consistent with principles of equity, justice and fair play for building a strong and viable democracy in Nigeria "[1].
Vision: INEC vision is to "facilitate the realization of a dynamic, formidable and independent organization committed to the institutionalization of an enduring democracy which allows for an effective and smooth political change" [1].

2.2.2 Problem Description and Analysis

The problems of election in Nigeria and indeed Africa are as old as election itself. Election problems have brought Nigeria and other African nations to crossroads of an emergency and the options available to save them from impending danger are now very few indeed. It has threatened the unity of the country which has been sacrosanct and the most likely danger is the long-feared collapse of the vibrant nation of 250 ethnic groups into tribal and religious warfare.

Considering reports from previous Nigeria elections and that of April 2007 general election where the present President, State Governors, members of the National Assembly, etc were brought into office, statements issued were that elections were marked by widespread voting irregularities and election-related violence. We witnessed vote rigging, intimidations, flawed and violence leading to wanton destruction to lives and properties as reported by the Nigerian Police Force. There were also reported cases of failed attempt to blow up INEC headquarters putting the security of the nation at risk. These reports were followed by widespread condemnation of the poll results as well as its conducts by some nations of the world like the US, UK, EU election monitoring team, and other international observers. For instance, the Chief EU observer, Max van den Berg on the just concluded 2007 general election in Nigeria reported as quoted "the handling of Nigerian poll had fallen far short of basic international standard" in addition, "the process cannot be considered to be credible", citing "poor election organization, lack of transparency, significant evidence of fraud, voter disenfranchisement, violence and bias" [3]. One group of observers reported that at one polling station in Yenagoa, in the oil-rich southern part of Nigeria, where 500 people were registered to vote, more than 2,000 votes were counted [4]. Lots of reports were received concerning the conduct of the poll and which need exigent attention.

Most of the malpractices or problems faced by Nigerian electoral system are explored below:-

- Multiple registrations and voting: A situation where voters are registered or allow voting more than once during voters registration exercise and voting in the poll respectively which is against election Act.
- Shortage of election materials (Ballot papers): this is a situation where materials meant for elections processes are not available or sufficient for use and use at the right place. This can be attributed to poor security measures, logistic problems or deliberately motivated to allow for election fraud.
- Stuffing of ballot box with ballot papers: the practice of padding materials with no genuine securities like Electronic Product Code (EPC).
- Hijacking/Abscond with ballot boxes with Ballot papers: A situation where thugs are raised by some miscreants to snatch and do away with ballot boxes with ballot papers to thumbprint for a particular candidate.
- Mutilation of election result sheets and falsification of voting figures as well as election results: This involves tampering with the election result either by tearing and falsifying it to favour particular candidates of interest. Results in this case are always marred by violence and crisis. Actual number of voters seen at the poll centre is falsified to favor candidates of interest.
- Miscellaneous election problems: These include situations where under-aged as well as unregistered voter's votes during elections, delaying voting times, shifting of elections to a later date, etc.

2.2.3 Causes of Election Problems and Its Impact

Nigeria and other parts of African continent always faced a high degree of corruption. We believed that corruption in the political systems is more corrosive than any other form of it. It is believed that any one who is willing to steal ballot boxes will steal public money and INEC officials are also part of this. They are

bribed by politicians to assist in committing elections fraud. Also, most of the problems of elections in Nigeria are due to the way election processes are being carried out by INEC. For instance, preparing for elections, involve registration of political parties, accreditation of election observers, and setting the election schedule. It is believed that INEC always make no initial clarification on the basis for making decisions on how it should be conducted thereby leaving it fairly open to criticism that only the ruling party is being favored. With this, we believe the perceived willingness and ability of INEC to manage elections impartially can affect the level of political violence.

The escalating political violence in Nigeria and the desperation among politicians to win by all means also poses a serious threat to the legitimacy of elections. Political parties themselves have failed to impose discipline on their own members thereby giving rooms for political violence. Right from party primaries, candidates began the recruitment of political thugs from cult groups and arming them to cause political violence resulting to hundreds of people being killed and thousands displaced. We know that not all of this violence can be directly linked to the elections, but the increased tension created by competition for public office exacerbate the existing conflicts and create new ones. Adding to the existing crisis, parties and candidates have sometimes been accusing their opponents of participating in political violence with little apparent basis, which aggravated tensions that could lead to violence between their supporters.

Lastly, most elections problems are due to security lapses everywhere. There are no adequate security measures in place to ensure full protection of lives and properties. Taking INEC election materials into consideration, there are no measures taken to secure these materials. Things are just allow being the way they are. The security agents available always allowed themselves to be used to commit election frauds.

2.3 Nigerian Election Problems in Focus

2.3.1 Multiple Registrations

There are many stages involved in elections process before finally concluded by producing the winner in which Voters' Registrations (VR) is the first. VR involves the process of registering or documenting and issuing out voter's card to eligible citizen who will participate in the election.

Current Registration Situation in Nigeria: In Nigeria, the current used procedure of voter's registration is paper-based and no security measures in place to address identification issues. In this regard, registration centers are set up in all the electoral wards of the federation. Potential voters are registered irrespective of any formal means of identification thereby giving room for multiple registrations. For instance, a father or mother can register all his/her children by proxy without means of seeing or identifying them. This is bad and weak situation. The process is exacerbated by issuances of "ghost names" for registration by the king's makers of the communities in attempt to commit voting fraud like rigging and as well, boost their population and other hidden agenda which they believed could attracts government presence in their community. We therefore consider this act as being against electoral law.

However, by following standard electoral Act, a voter is only entitled to one voters' card and to vote once. That is, single registration. We have found out that election officials are in some ways behind this mess as they are bribed to perform this multiple registration in order to favour candidates or parties of interest in order to commit voting fraud. These situations are of great consequences and concern which need exigent attention.

2.3.2 Diversion of Election Materials

Election materials especially the ballot paper and the result reporting sheet are considered indispensable to election itself. They are printed paper with each political party logos through which a voter indicate interest of his/her choice of candidature and reporting of final and publishable election results respectively. The documents are supposed to be safe-guard from the reach of unauthorized elements. Unfortunately, in Nigeria during election especially distribution processes, the Ballot papers are stolen in some case at gun point or diverted before election. There are violently hijacked at gun point and with the help of INEC officials for rigging purposes hindering the smooth operations of election. We learnt that there are no securities on the materials used for the elections to track them down and made it impossible to be used by unauthorized persons.

Chapter 3

The Required Technologies

3.1 Introduction

RFID technology has been around for over sixty years and is said to be one of the promising and anticipated technologies. Articles, television programmes, analyst papers, etc are sounding its potentials benefits to RFID users while in the bad scene, many misconceptions and terrible stories of failed implementations have contributed to the negative press of this re-emerging technology. With the assumed failed RFID implementations in organizations, the stories has been in all press headlines and is linked to cases of inadequate technology, deficient IT knowledge, budgetary constraints, and misunderstanding of the overall operational effectiveness of the technology and how it relates to its activities [16]. Despite this reports, RFID has be known as effective, low-cost solution for tagging and wireless identification and tracking.

However, interest in RFID technology began during World War II and has proliferated in the past few years. During the war period, radio waves discovered by a Scottish Physicist, Sir Robert Alexander Watson-Watt in 1930 were used to identify which approaching planes belonged to enemies or country's own pilot returning back from a mission [12, 15]. After then, the technology has been gaining more momentum and attraction. This shows that the exploration in radio ID technological research and development in commercial activities continued through the 1960s and evolved into notable advancements by companies, academic institutions, and government agencies today. See table 1.0 for more analysis of the RFID history.

Table 1.0: History of RFID

Date	Event
1930 - 1940	American navy research laboratories developed a system known as IFF (Identify Friend or Foe).
1940 - 1950	The first application of RFID consisted of identifying Allied or enemy planes during WWII through the use of the IFF system.
1950 - 1960	IFF technology was used to develop the modern air traffic control system. First RFID applications in the military sector, in research laboratories and in major commercial enterprises.
1960-1970	Sensormatic and Checkpoint Systems introduced new applications for RFID, such as electronic article surveillance (EAS) equipment.
1970 - 1980	Technological advancements led to the creation of the passive tag, and the first initiatives for animal tracking and factory automation took place.
1980 - 1990	Many American and European companies started to manufacture RFID tags. First RFID application for automatic toll payment.
1990 - 2000	Standards for RFID equipment interoperability were developed.
2003	The Auto-ID Center from MIT became EPCglobal, an organization whose objective is to promote the use and adoption of EPC technology.
2005	Wal-Mart launched an EPC pilot.

Table 1.0 the history of RFID [15]

The stimulant in the proliferation of RFID technology is linked to mandates by large retailers, manufacturers, logistic providers, and government agencies (e.g. Department of Defense (DoD)) requiring the use of RFID tags, along with technological advancements to track, secure and manage products from its raw state through the entire life of the product [12]. Through this, internal processes are made more efficient and improve the supply chain responsiveness as well as decrease costs. RFID technology is now increasingly being used in a variety of public and private-sector settings, ranging from inventory management, tracking books in libraries to authenticating a key in order to start a vehicle [14]. Also drivers have seen RFID in action at automatic toll collection stations used at bridges, tunnel, and turnpike. In business the benefits have been tremendously advantageous.

3.2 RFID Technologies in Focus

3.2.1 RFID System

Before getting tuned to RFID, organizations involve ought to understand the components of an RFID system, how the technology works, tag types and characteristics, organizational operation etc. However, in this thesis work we are not going give full details of what components actually comprised an RFID system; rather we will give account of the requirements needed for our proposed system. We will also discuss some of the application areas and benefits patterning to it which attracted us in adopting it as a solution to some elections problems.

The main technology components of an RFID system are; the tags, the readers and the middleware application that is integrated into a host system that processes the data. (See fig.3.1 below). This represents the minimum requirement for a functional RFID system to operate. RFID is said to be an enabling technology and it involves automatic identification of object or person wirelessly through the use of radio waves [12,15]. It is used to remotely or electronically identify, track, and store information contained on tags through a reader. The technology is referred to as wireless Automatic Identification and Data Capture (AIDC) technology and is grouped under the broad category of auto-ID technologies along side barcode, optical character reader, magnetic stripe cards, and some biometric technologies [15].

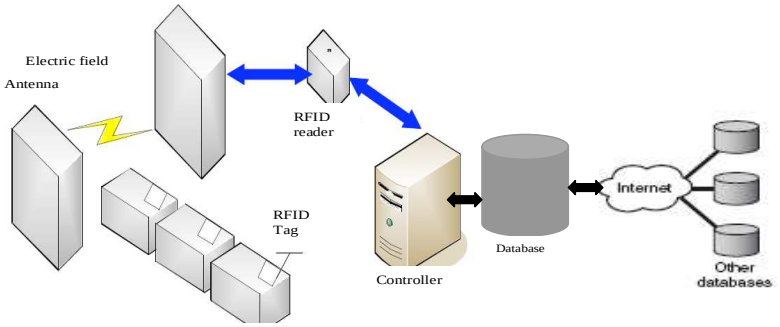

Figure 3.1: An RFID System

RFID being superior to other AIDC technologies offers several improvements over its predecessor technologies especially bar codes in that its design enables readers to

capture data on tags and transmitted it via computer system without human intervention [12,13].In addition, no line of sight to be read is required and can be read more rapidly and over greater distances [12]. The most interesting aspect is that, RFID system is used to reduced the amount of time and labour requires to input data manually, improving data accuracy as well as for automatic identification, tracking and tracing of objects [14].

The impact of RFID has been tremendously advantageous and growing day by day. Auto-ID Lab and other research institutes are working tirelessly on the standardization and other related issues that has been an impediment of the operational aspect of the technology.

3.2.2 How RFID Works

RFID operation depends on storing and remotely extracting information/data with a device known as RFID tags [13]. Tags can be read automatically from several meters away and does not have to be in the line of sight of the reader for transaction to occur and it has a computer chip that is programmed with information that uniquely identifies each item. Information is exchanged when the tag is activated. Readers can be unattended standalone units, integrated with a mobile computer or incorporate into bar code printer etc [15]. Tags and readers both contain antennae because of the radio interaction they require. The antenna attaches to the IC (integrated circuit) to absorb and emit signals. When data between the tags and the readers are exchanged via radio waves, the reader sends a signal that is received by all tags present in the RF field tuned to the frequency [13]. See figure 3.1 above. Tag then receives the signal via their antennas and responds by transmitting their stored data. The read/write device receives the signal via its antenna processes or decodes it and transfers the data through a cable or wireless connection to a database [12]. The tag response to the reader is determined by the type of tag used. The computer on its own part is vested with various tasks aimed at processing the data such as record the reading, look up the tag ID in a database to direct further action or direct the reader to write additional information to the tag.

3.3 RFID Building Blocks

3.3.1 RFID Tags

We can consider an RFID tags as sine qua none to our proposed system. We believed that an understanding of the properties, capabilities, and limitations of each tag type will assist in the solution design. Tags are also known as transponders that inhabits chip and an antenna [12, 15]. The chip is activated by the antenna in order to respond to an interrogation signal transmitted from the RFID reader [12, 15]. The RFID tag can be attached to or embedded into a product, animal, or person for the purpose of identification via radio-waves. They have the ability to hold many types of data out of which are serial number, configuration instructions, activity listing (such as maintenance date, when tag passes a specific location, serial Id etc.) or even temperature and other relevant data assumed by the sensor [12,15] if any. RFID tags are highly characterized by its designs, (see Figure 3.2) power source, and carrier

frequency, communication method, read range, data storage capacity, memory type, size operational life, and cost [15].

RFID Tags could be either read only, write once/read many times or read/write capable, or as active, passive or semi-active [15]. Passive tags are generally less expensive because they have no internal power source nor can they initiate communication with a reader (i.e. uses the reader field as a source of energy), while Active tags on its own part; contain together a power source and a transmitter, in addition to the antenna and chip, and sends continuous signal. It has read/write capabilities that give room for information update, long read range, weight, generally expensive and support more complicated read applications.

Figure 3.2: Samples of RFID Tags

3.3.2 RFID Reader and Antennas

Another vital component of focus is the RFID readers also known as interrogators [12, 13, 15]. These devices are electronically in nature in that they send and receive radio wave through the antennas that is embedded in them. The basic function of RFID reader is to capture or read data embedded in RFID tags and transmit them via the RFID middleware. RFID reader has the ability to identify and read a large number of tags per second without any problem and this depends on the distance between it and the tags [13]. The read/write devices come in variety of shapes and sizes such as fixed reader, hand-held and mobile reader [15]. See Fig. 3.3 below. The Fixed type of readers can be mounted to walls, dock doors or conveyor belts while the Mobile and-hand held readers due to their flexibility and ease of use can be used at various locations [13, 15].

Figure 3.3: Types of RFID readers

3.3.3 The RFID Middleware

The RFID middleware is also known as the Savant and it assumes distributed architecture. The savants servers as interfaces or software buffer sits almost invisible between the RFID Readers and the application software (i.e. server storing the product information) [13]. It allows unstructured tag data obtained from many RFID readers to be process and aggregated as well as directing them to the appropriate information system [15]. They can perform many different operations such as monitoring, managing, filtering, and query an Object Naming Service (ONS). RFID middleware can be used to manage and control RFID readers' infrastructure. It is generally known as the nervous system of RFID system technology since major functionalities are provided by them [15].

3.4 RFID Network Services

3.4.1 The EPC Network

This is an RFID networking standard proposed and developed by the Auto-ID Center now called Auto-ID Lab. [15]. It is a suite of network services that enables seamless sharing of RFID-related data across the chain supply. This network is fueled by the RFID system in addition to other infrastructures such as the unique object identification through the EPC code, the local ONS (Object Name Service) and the PML (Physical Markup Language) or the EPC-IS (EPC Information Service and the EPC- Discovery) which are essentials in sharing information more easily within a supply chain system especially the EPC [15,17]. See figure 3.5 & 3.6 below. The network uses existing internet infrastructures to create services that are less expensive and standards-based set for all parties within the network. Each component has a unique and important role in enabling the secure discovery and sharing of detailed, real-time item information in the network [15].

3.4.2 EPC Code

Electronic Product Codes formed the first basic requirement of this network. It originated from the ideas that tags needed to be a simple as possible and act as pointer to server information in the same way internet operates [13]. EPCs has a layout similar to Universal Product Codes (UPCs) used in bar codes except that it provide the benefit of uniquely identifying products and fast/detail information of products at the item level, manufacturer , etc [15]. The number of manufacturers and products EPC code can uniquely identify depends strictly on the type and capacity of tag used. Figure 3.4 below shows example of a 96 bit EPC tag.

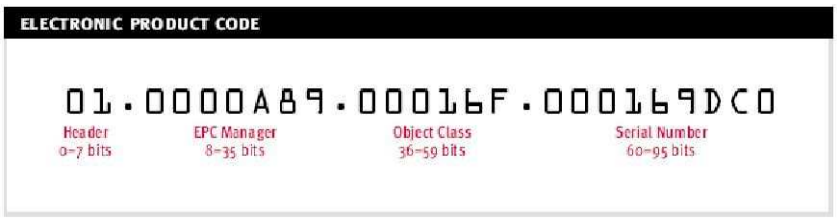

Figure 3.4: The Electronic Product Code (EPC): example of a 96 bit EPC tag [13]

- Header (0-7) bits: 8 bits and it defines the length of the code. For instance, 01 as seen in fig. 3.4 indicates an EPC type 1 number which is 96 bits and ranges from 64 bit to 256 bits [13,15].
- EPC Manager (8-35) bits: contains the manufacturer of the product the EPC is attached to.
- Object Class (36-59) bits: refers to the exact type of product.
- Serial Number (60-96) bits: provides a unique identification of up to 2^{96} products [13].

EPC code in this regard will be directly applicable to our proposed solution in the area of uniquely identifying every single items used for election.

3.4.3 EPC Network Elements

The ONS

This form one of the essential elements of the network which streamlined the operation of data sharing within the EPC. Based on the Auto-ID Lab. architecture, the ONS has two layers; the Root ONS which act as an authoritative directory of information sources of a particular manufacturer whose product information may be available on the EPC network and the Local ONS which is the directory of that particular product [13,15,17]. By this, ONS tells the computer system where information in the internet or local network about any object carrying an EPC is located. It matches the EPC code to the information about the product through a querying mechanism similar to Domain Name Service (DNS) which allow routing computer to locate where the pages associated with a particular WEB site resides [13,17]. ONS takes the EPC code of the objects RFID tag and returns a web address or Uniform Recourse Locator of the PML (EPC-IS) where all information about that object is stored.

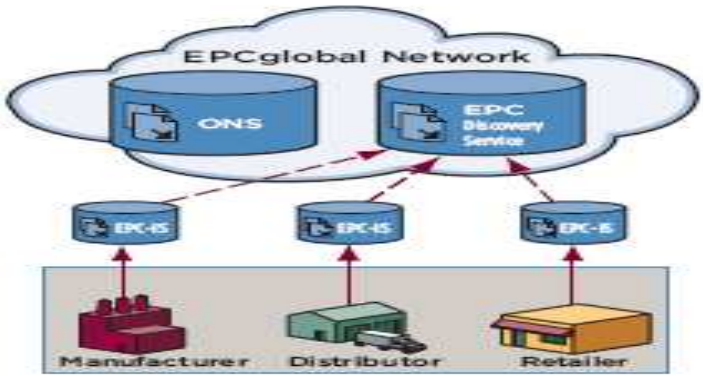

Figure 3.5: Elements of the EPCglobal Network system

ONS resolution procedures are as follows:

- ONS solver first search for the manufacturer or owner of the product in the Root ONS and in turn return the network location of the Local ONS for the manufacturer, and
- It then looks up the product in the Local ONS and return the location or the URL(Universal Resource Locator) of the PML OR EPC-IS where all information concerning that product is stored.

The PML (Physical Markup Language)
This is the second element of the EPC network and is also known as the EPC information service. It is new standard "language" for describing any physical object based on widely used and accepted extensive markup language (XML) designed as a document format to share information across the internet [13]. With EPC, ONS, PML finalizes the fundamental components needed to automatically linking information with physical product. That is, EPC does the product identification, PML describe the product, while ONS links them together.

EPC-IS (EPC Information Service) form the actual data repositories used to stored information about a unique item in the supply chain [15,17]. It stores, hosts and provide access to serial-numbered specific item information enable by RFID. A uniform programmatic interface is provided by the EPC-IS thereby allowing various clients to capture, secure, and access EPC-oriented data as well as the associated business enterprise. It is one of the many information services queries by ONS and provides a full information database of items it stores.

EPC Discovery Service (EPC- DS) on the other hand**,** performs the function of efficient track and trace throughout the network. It is a registry or keeps history of every EPC-IS that has information about the instance of a certain item or object [15,17].

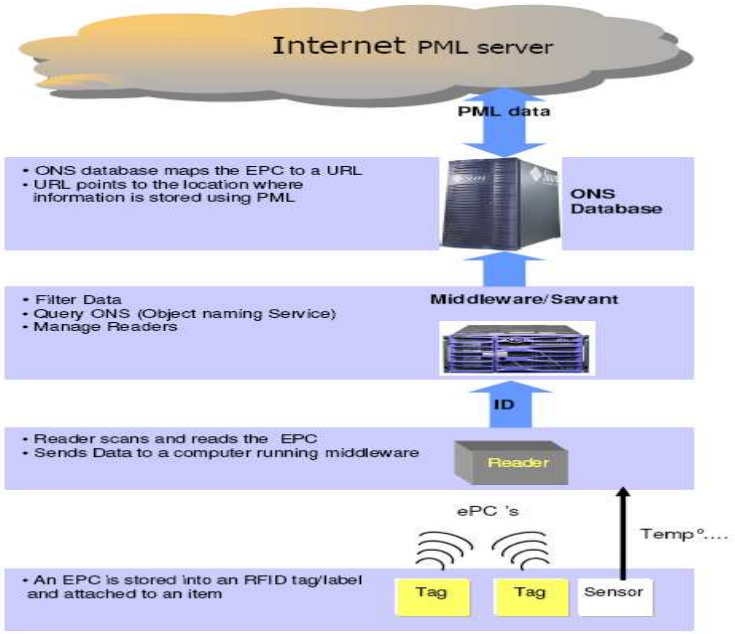

Figure 3.6 Summary of the basic steps of an EPC Infrastructure

Figure 3.6 shows the interaction between the RFID system and the EPC Network system. These will all be perfectly structured for our proposed solution especially in the area of accurate inventory of all election materials and real-time update of the required databases.

3.4.4 Mobile RFID Reader Network

It is a new service concept that involves the use of RFID technology in mobile Telecommunication. Mobile RFID reader involves the installation of RFID reader chips on mobile devices such as cellular phones or PDA (Personal Digital Assistant) [24]. Mobile RFID network poses a collection of various services with mobile station which is mobile RFID reader. Each node in the network equipped with mobile RFID-mobile station (m-RFID-MS) that can be accessed over mobile RFID network anywhere, any time. The proposed network framework by the Mobile RFID Forum, Korea [24] is shown in figure 3.7 below.

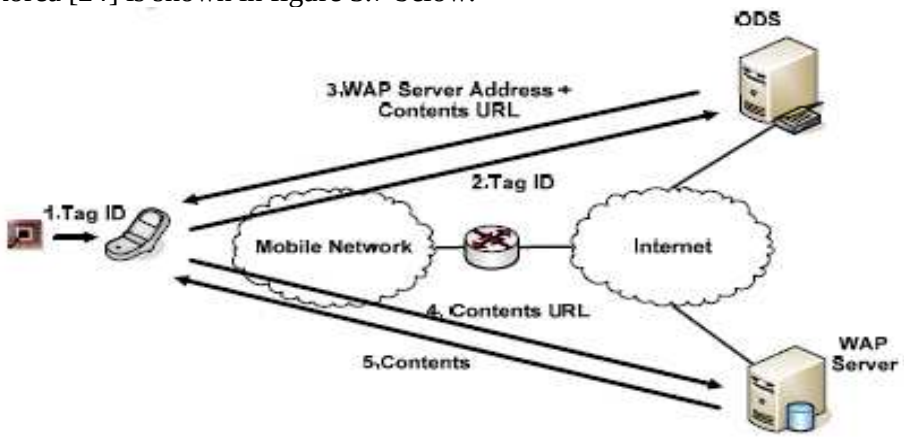

Figure 3.7: An Overview of Mobile RFID Network (as designed by the Mobile RFID Forum, Korea)

The above discussed technology infrastructure will form basic requirements for our proposed solution for those research questions to be addressed. The application of the interaction between the EPC network and mobile RFID reader network or simply the RFID system will be discussed in the next chapter where the integration of different technologies discussed here and proposed for our solution will be shown.

3.5 RFID Application Areas

The major application areas of RFID tracking is in the manufacturing and retail chains. Here are a few examples of how RFID technology is being applied in different areas:

- RFID chips for animals are extremely small devices injected via syringe under skin. When scanned, the tag can provide information relevant to the animal history and if required its owner's information. In most advanced countries, government is now proposing of using RFID technology in animal controls.
- RFID as used in retail stores is used for real-time inventory tracking that enables companies to monitor and take active control of inventory supply at all times.
- In Hospital and Health care each patient can be track RFID tag. RFID tag in form wrist-bands are now in use and available in the markets. Doctors and

nursing staffs see detailed information of the using hand PC or PDA just by the bed side.

- RFID tacking can be used in any organization for employee/visitors tracking within its premise and control access to sensitive areas.
- In prison, RFID tag posed a useful security tool as it can be used to monitor inmates.
- In Airline RFID tags can use to track passengers baggage with 100 per cent accuracy.
- RFID tag especially in Europe can be used in transportation payment like toll collection etc [14].
- In large farms, dairies etc, RFID tags can be used in the tracking of live stock using active tag in the form of ear.
- In a city transport system, RFID tag can be used on high priority vehicle such as police cars, ambulance, fire van etc to turn the traffic light green in other to allow passage [13].

With these few examples given, it can be seen that RFID identification and tracking can be used efficiently in various ways, making life and operation much easier and helping business run smoothly.

3.6 Benefits Derived from the Use of RFID Technology

Tuning and using RFID technology in business or organization such as in the supply-chains, tracking and inventory management posed lots of benefits to them in a number indisputable ways. It is these benefits that we believe our proposed system will assumed in solving these problems at hand.

One of the major advantages being derived is complete manual labor saving for embarking on traditional bar-code scanning. RFID gives maximum accuracy without need for human intervention and line of side [13]. RFID technologies usage offers tremendous cost reduction which is the target for every business or organization. Also it brings about operation streamlining, supply- chain efficiency, improved stock management, ensuring anti-counterfeiting, shrinkage or product loss etc.

Chapter 4

Structural Design

4.1 Proposed RFID-based Framework

This research work is typically based on RFID and its application. Considering our purpose of studies as well as RFID's mode of operation, we will at this section look at the best way to apply it in order to solve the major problems that affects our election processes. The proposed RFID-based Framework is specifically designed to address the problematic situation created by elections and its conduct in Africa; multiple registrations during voter's registration exercise that always leads to multiple voting, and diversion of election materials for the purpose of rigging election leading to election's materials shortages. We designed it based on the level of ICT awareness, infrastructural availability and its overall understandings in the entire continent. The proposed Framework is also accorded with simplicity to ensure effectual comprehension by those we could refer to as "non-ICT men".

Our system is made up of three parts or subsystems. There are specifically designed to find at least good enough solutions to those two stated problems taking the Nigerian situation in focus and to effectively handle the complexity accrued to the elections system as a whole.
These sub-systems within our proposed RFID-based framework are:

1. Real-Time Voter's registration system
2. Election materials distribution system
3. Polling system (Note: our solution will not cover how a vote will be cast, rather it will explain the identification operation in a polling centre).

The details accompanying each area will be discussed as we progresses in subsequent sections.

4.1.2 Requirements on the Proposed System

The basic requirements on our proposed system are stated as follows:

- Provision of unique identification for each voter via the RFID-based voter's card,
- EPC code on RFID tag can be used to identify voters, materials and "Wards",
- A voter should not be able to get multiple voter's card or vote more than one time

- Election materials authentication. That is, Ballot papers, etc should be protected from counterfeiting, adulteration, diversion or cause artificial shortages by politicians.

- Falsification of voting figures should be protected through automatic recording of voter's register by the EPC Discovery Service.

4.2 Sub-Systems Components

Firstly, there are some important issues that we need to address which are of the essence to our proposed system before discussing about the various subsystems in detail. Just to mention few, these are the voter's card, unique code (EPC code), the National Data warehouse where every other database will reside, etc.

4.2.1 The Voter's Card

The proposed voter's card in this thesis will make use of RFID tag to store unique code (EPC code) for a particular holder in the National Data warehouse. There will be a passport photograph of the holder that will appear on the front side of the card. See figure 4.1 below. The card will assume a standard ID card structure accorded with simplicity, convenience etc. Other architectural design inclusion will be specified by the designer/manufacturers concern.
This card will be issued to every registered voter after the completion of the registration exercise and this will be used for the purpose of auto-validation before allowed to vote at Election Day. We will only give the specifications for the proposed card and illustrate how information can be trap/track for the purpose of the card and how it can be retrieve through Automatic Identification and Data Capture technology.

Figure 4.1: Sample of SmartMark™ - RFID CR-80 ID Cards

4.2.2 Object Tags

Due to nature of tags studied, we proposed Passive RFID tag for use in our system. We proposed it due to the fact that it has no internal power source but rely on energy emitted from the reader. That is, uses the reader field for any form of on/chip computation and communication back to the reader. Also, passive RFID tags are the most popular tag used in ID cards production, inexpensive to manufacture and ease of use as well as security. This tag is embedded on the card. The format the tag will assume will be the credit card or ID card size and flexible labels with adhesive backs. See example in figure 4.1 above.

This tag will be written once and read many times to boost security and access control. In some case, password could be applicable. The tag will conform to ISO18000-xx International RFID Standards, EPC Class 0/0+/1 and UHF Gen. 2 [34].

4.2.3 Tag Readers System

Based on the nature and complexity of this operation, the vastness of the country and the number of wards to be covered simultaneously during the distribution of election materials and polling center operations respectively, we proposed a mobile handheld system with integrated reader and antenna to be the best in this regard. It will consist of handheld RFID scanner or reader built into a handheld PC, PDA or mobile phone. Its design will also conform to standards and be compatible with the tags used. See figure 4.2 below.

Figure 4.2: Interaction between Mobile device, Reader System and RFID Tag

This is proposed because of the following reasons:

- Cost: one mobile reader per ward is enough for the operation than dozens of fixed reader,
- Convenience: it required no wired hassles or activities disruption, promote fast deployment of application and increased end user convenience.
- Client enable: it supports client side application such as searching or counting a particular item.

4.2.4 Middleware

With the complexity involves and the vastness of the country as a whole, our proposed middleware is will focus on web-based middleware that is incorporated into the EPC Network which will aid the processing, filtering and aggregation of raw data read by the reader. See figure 4.6 below. This will save the cost of installing dozens of middleware in every strategic location or localizing the reader.

4.2.5 Unique Code

There will be a code on each tag and will be unique to every individual or materials and it will be used to assign storage space for individual information on the proposed system, specifically on the data warehouse we will propose. The RFID passive tag on each card will have a unique EPC code embedded on it from the tag manufacturer equivalent to the one shown in Chapter 3, Figure 3.4. It will go along side the three

different uniquely and automatic generated codes used to identify different databases found in our proposed system.
This combined EPC codes on the embedded tag in each card will be the primary key to query the National Data warehouse (NDWH) as it will be called in this thesis work at any instance. It will serve as a pointer directly pointing to a specific object within the NDWH. This will enhance the accessibility and the rate at which information on the NDWH will be retrieved and it's available to all kinds of users in read only mode.

However, we suggest that both the tag manufacturer and the database architecture must work together in order to achieve the aim of using the EPC code embedded on each card to allocate storage space for individual on the National Data warehouse and in order to conform to Auto-ID Centre or EPC-global standards [17,21]. Our proposed national data warehouse could serve has National register for the country.

4.2.6 National Data Warehouse (NDWH)

In this regard we propose to make use of data warehousing technology, though we are not going to give any details of the structural architecture of data warehousing technology. This proposal is based on the nature of our proposed system, the information that will be stored, as well as the long-term benefits associated with it use. This is because the data saved in data warehouse are organized in a completely integrated structure, have natural internal connections and gain new properties that turn them to have status of information [20]. Figure 4.3A below shows the structural design of what we called National data warehouse within our proposed system, we integrate other databases within the data warehouse in order to have a compact structure of the system at the end.

Considering Nigeria political structure which assumes a hierarchical structure, the nation is presently structured into 36 States and the Federal Capital Territory, and 774 Local Government Councils. Each of the council is further sub-divided into Wards with a minimum of 10 and maximum of 15 wards [19]. Also there are six geopolitical zones but beyond the scope of our work. We will make use of these existing political sub-divisions/structures to create individual database for the instance of data collation during and after voter's registration exercise.

Based on these subdivisions, in the National Data warehouse, there will be two giant databases; the Voters Register (VR) and Election Materials Register (EMR). In the VR, there will a database for each ward known here as WARD-DATABASE. This database will be host in another called COUNCIL-DATABASE which in turn will resides in STATE-DATABASE maintained for each state.

These would provide a good and long lasting place where all data collected be stored for future use and help in imparting change in the situation of inaccuracy of data recorded in the instance of election processes in Nigeria as well as providing supports to other sector of the economy.

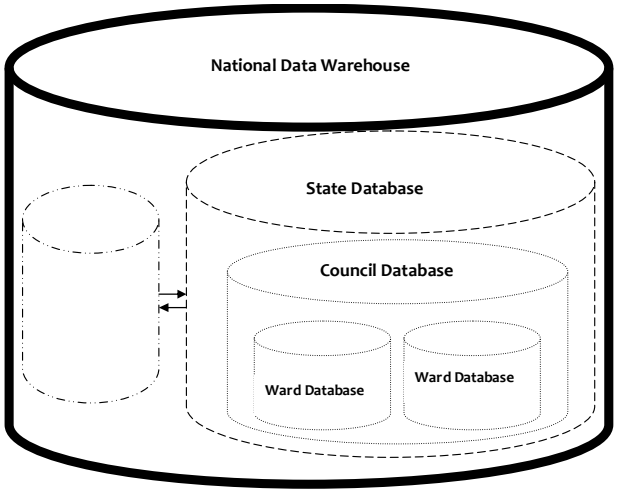

Figure 4.3A: Structure our NDWH (database of all databases)

Having the nature of our solution in mind, we intend to make the availability of the data warehouse read-only mode to the external users and the updating method will be incremental because we believe incremental update will inserts new data to a partition in the cube and aggregations updating [20].

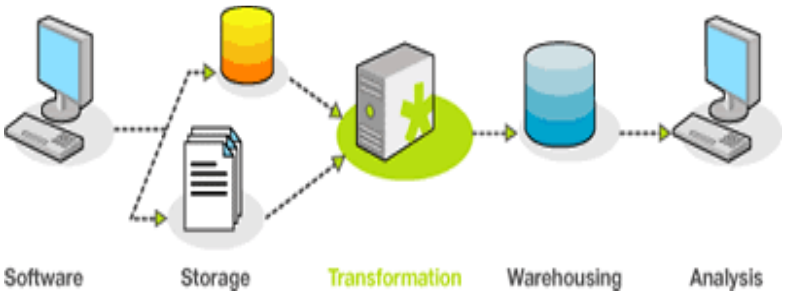

Figure 4.3B: Data warehousing Analysis

4.3 Sub-System Design

4.3.1 Proposed INEC Network Architecture

Our proposed INEC application network will assume the same architecture as the auto-ID Centre EPC Network [15,17] described in Chapter 3; ONS, the EPC-IS or PML server and the EPC Discovery Service and extending the network infrastructure to accommodate a large numbers of mobile RFID readers from different wards and distribution centres across the country. See figure 4.4 below. Since this work relies heavily on RFID technology where every INEC assets will be EPC code-oriented, we employed its application in the supply chain management especially the tracking and inventory management systems.

The EPC-global Network in this regard will help to integrate event data with INEC – IS by following a set of interfaces that facilitate sending and receiving real-time data to and from the system. Also, it will aid over-all event routing, collating, filtering and inventory management. The system is specifically designed to address large scale implementation in INEC's election processes that needs to integrate real-time data

from existing NDWH and poll/distribution centers through the use of Auto-ID technology know as the RFID tag.

However, architectural details are given as follows:

- At the end-node, the tag contains the EPC code embedded on it such as the voter's cards, election materials, etc. while the mobile reader will read the tagged object and send it to the EPC Event Manager. The EPC Event Manager or Savant will process the received data by filtering and aggregating them.
- The m-RFID network will coordinate several Mobile RFID Readers from different distribution and polling centre across the country to avoid problems of interference arising from reader collision problems.
- INEC Applications interfaces the NDWH that hosts the two giant databases; the VR and the EMR. The VR database is link to each voter's registration centre, the public (INEC service) and polling centre while the EMR is link to the product manufacturers, Polling Centre and the Distribution Centers.
- The NDWH itself will be link by the EPC IS called INEC EPC-IS made up of XML database and the Relational database ,
- Each INEC EPC-oriented (i.e. with EPC code) item stored in the NDWH via EPC IS will have a unique directory and each directory store in the Local ONS,
- All the directories found in the Local ONS will be store in the Root ONS for queries, and lastly,
- EPC Discovery Service will be integrated to take inventory or history of the EPC IS activities [17]. That is, it will take records of all deployed and used INEC materials as well as keep registers of voters at polling centre at Election Day. This will help prevent falsification of actual number of voters seen or vote at the centre.
- The INEC Application Integration layer encapsulates the existing application software component that acts as interface. It will use the web service to perform operation such as access to data, etc.

This structure will facilitate the sharing of data between the manufacturers of election materials, the electoral body as well as the registering and updating of INEC voter's register.

In the architectural design, operations involve are divided into two parts; (A) logical or virtual operation and (B) physical operation (i.e. activities at polling or distribution centres). The election activities as a whole is considered a physical operation and the interaction/sharing of RFID-based information along the network formed the logical operation.

Fig 4.7 shows the integration between both networks to enhance effective operation at both polling and election distribution centres. The aim of using this Mobile Reader is to allow for the update of information in the NDHW based on physical operation via logical operation. The m-reader network will allow many readers to be handled simultaneously to avoid problems of collision or interference. A situation caused by signal interference (that is, the RF fields of two or more readers may overlap and

interfere) as well as multiple reads of the same tag (that is, the problem here is that the same tag is read one time by each of the overlapping readers).

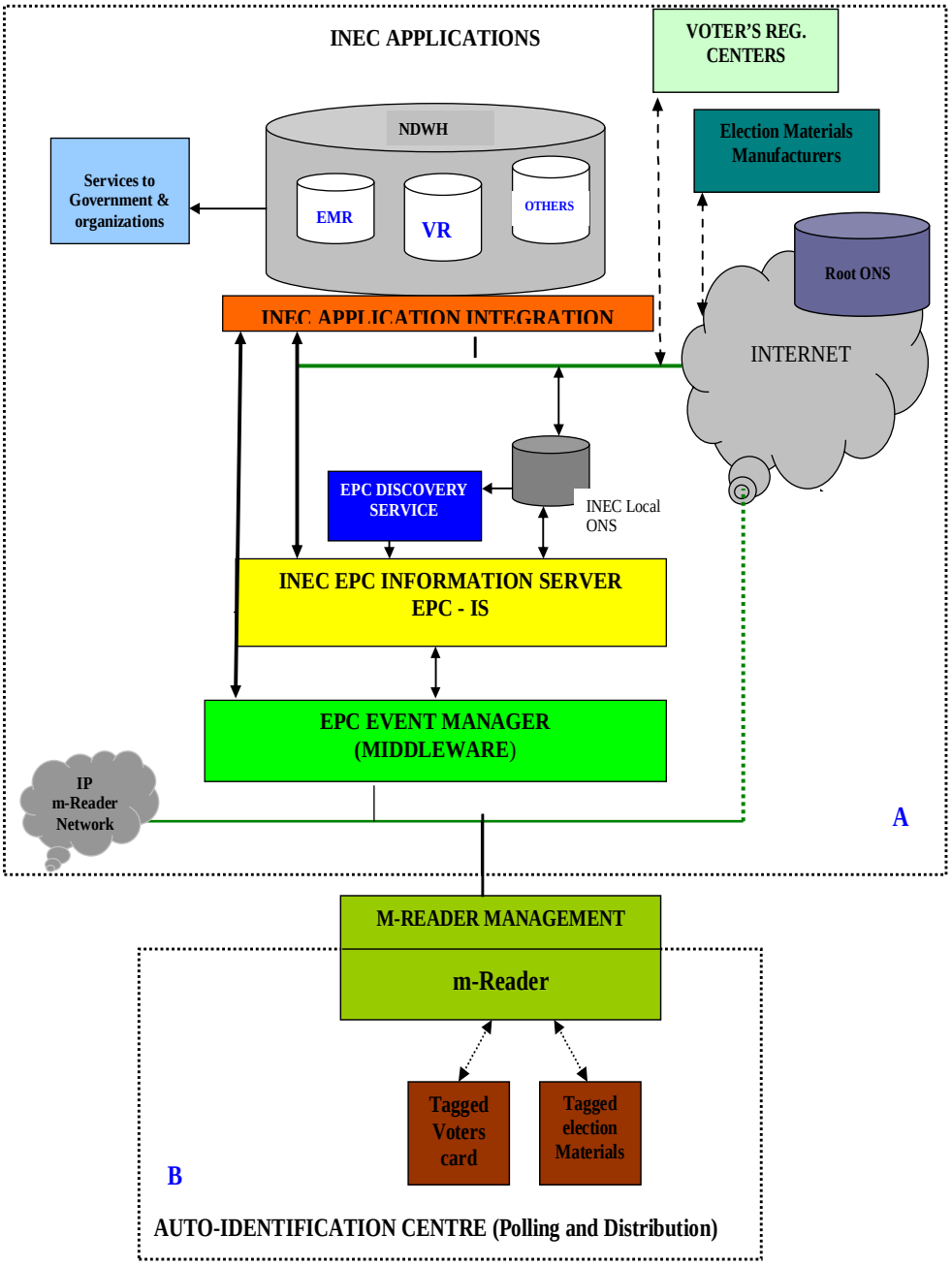

Figure 4.4: INEC Network Architecture (EPC Network,Mobile Reader and INEC-IS)

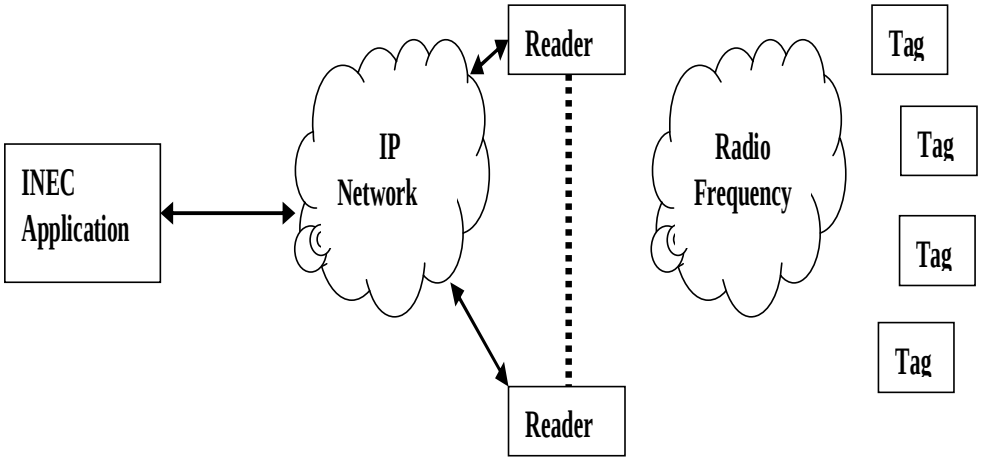

Figure 4.5 RFID End-nodes showing the interaction between INEC's application Reader, Radio frequency and the tagged object (like voter's card, election materials, ward etc) where the EPC code resides

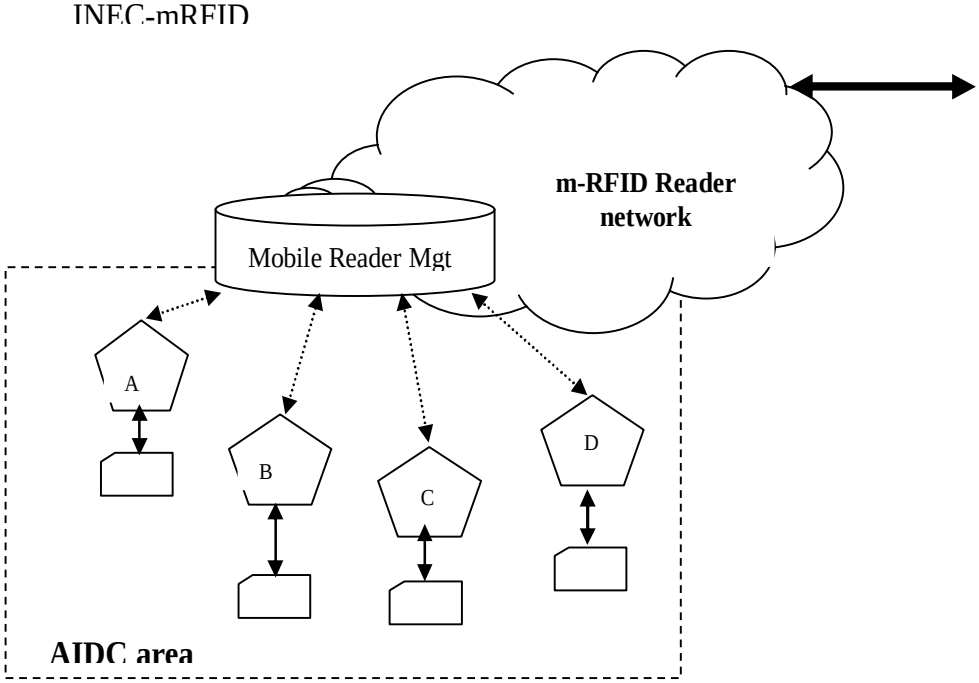

Figure 4.6 INEC Mobile RFID reader network supporting many mobile readers together at the Polling and INEC distribution centres. The arrow shows the flow of data from RFID tag to network support systems and the flow of control and data back to readers and tags.

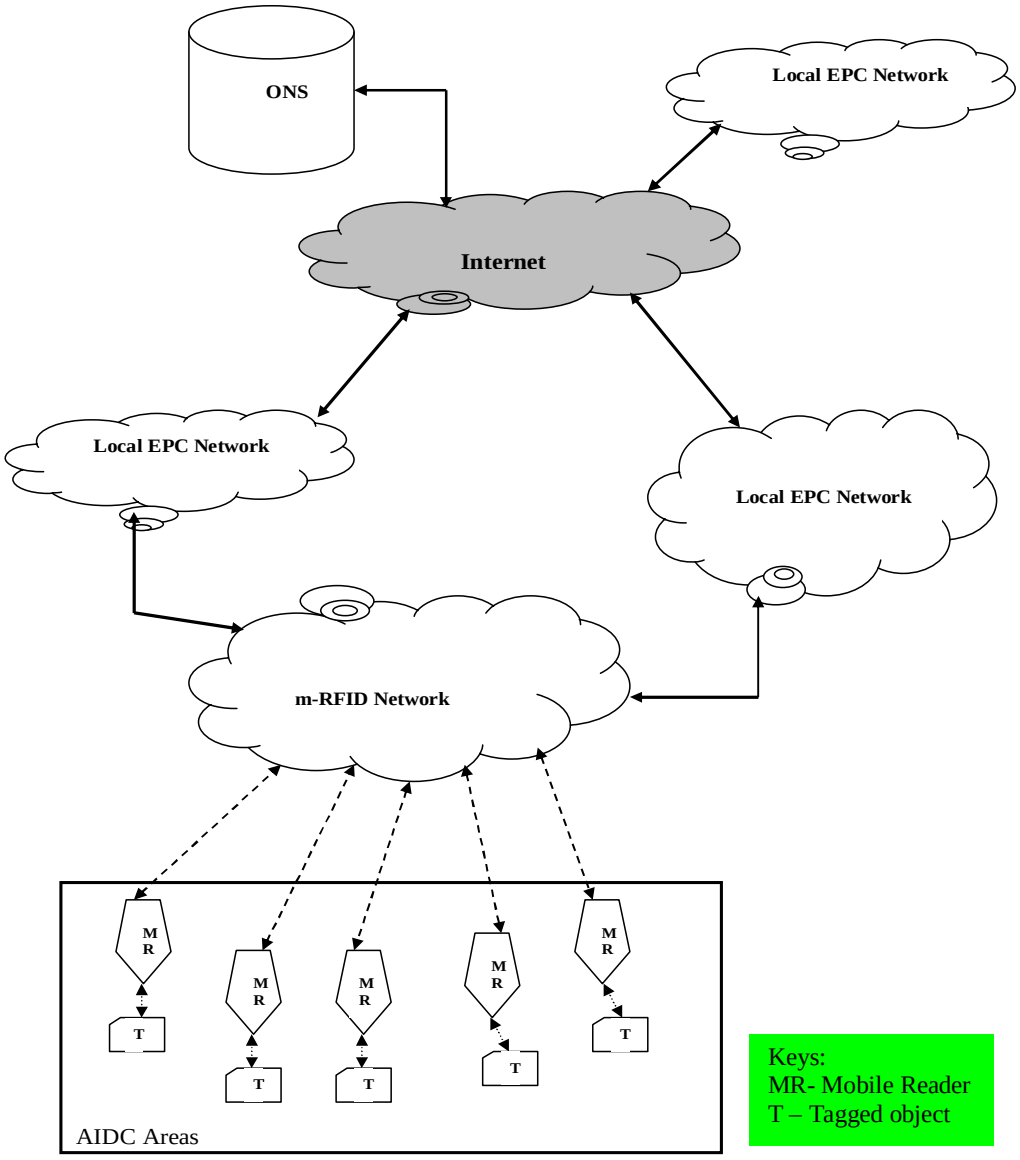

Figure 4.7: The integration and interaction between the EPC network and the Mobile RFID reader network. The AIDC Area is where auto identification and validation take place (polling or distribution centre).

4.3.2 Connectivity Requirement

To provide connectivity to a large number of RFID readers from different wards requires extending the INEC networks to every nook and corner of the country. This is the basis where Mobile RFID readers' network comes in. This will requires wireless TCP/IP network nodes that use dynamic host configuration protocol (DHCP), etc and connected to intermittent server using proprietary data transfer application. Typically, the RFID readers will be configure to ensure compatibility

and so that there is no or little chance of interference with WLAN (Wireless Local Area Network) [23]. This will ensure flexibility and eliminates fears of network coverage.

4.4 Operation in the Proposed System

4.4.1 Real-Time Voter's Registration

In any election process, operations always start from the registration of voters to distribution of election materials.Voter's registration exercise is the first and a very crucial exercise in every election. Started from time immemorial up till present, procedure for voter's registration in Nigeria has been paper-based and no strong security measures in place to address identification issues. With this procedure, there has been a culture of someone registering for another or anyone going back to the centre for re-registration or multiple registrations during the exercise, after considered successfully erasing the identification mark given to them on their fingers if any. The mark is assumed to prevent people from being registered many times. However, we considered it a very weak security measures. For instance, a father or mother can register all his/her children by proxy without means of seeing or identifying them. This process is worsen by the issuances of what we called "ghost names" for registration by the king's makers of the communities in attempt to commit voting fraud like rigging and as well, boost their population and other hidden agenda which they believed could attracts government presence in their community. We therefore consider this act as being against electoral law.

Also being paper-based, there is lack of good storage facilities and management for all collected data during this important exercise. In every election period, new registers are created and no form of reusability is adopted. This posed sub-problems that are to be addressed by our RFID-based voter's registration exercise. With this research, we proposed a voter's registration exercise that will primarily produce a unique identification card (RFID-based voter's card) for each potential voter and a viable reusable/updatable national voters' register called the central database for the nation embedded with external support's capabilities.

4.4.1.1 Registration Procedures

We proposed that for this exercise to be successful, the following procedures are of essences:

Step 1: Awareness Building
General awareness of this exercise is very important, in order to allow general public to be aware of what to be done and for what purposes. The information and education about this should be given through difference means. Media houses, religious organizations, civil societies, Non-governmental Organizations (NGOs). Both public and private sectors must not be left out in disseminating the information to the both literates and illiterates citizen of the country. This awareness building must come a long way prior to the commencement of this proposed solution, in order to have a good change management and strategic planning on the sustainability of the project.

Step 2: Data collection

Mobile PC and AIDC (Automatic Identification and Data Capture) technology like the biometric technology will be used to collect important data from all the potential voters at the registration centers. Both systems would be connected together to enhance the information or data collection during the registrations exercise. The mobile PC will be used to collect the Names, Sex, Date of birth, Height, Place of birth, Blood Group, Permanent home address, Local government Area, State of origin and Nationality. While the AIDC technology or biometric technology will be used to collect some physiological traits such as Fingerprint and Passport photograph of the potential voter.

Step 3: Data Collation/ Management
During the course of the exercise, all information collected from a potential voter will be documented and updated under real-time operation in the appropriate database. The emphasis here will be only on the WARD-DATABASE because that is where operation will take place. It will automatically reside on their respective Council and State-Database as there are store in the NDWH.

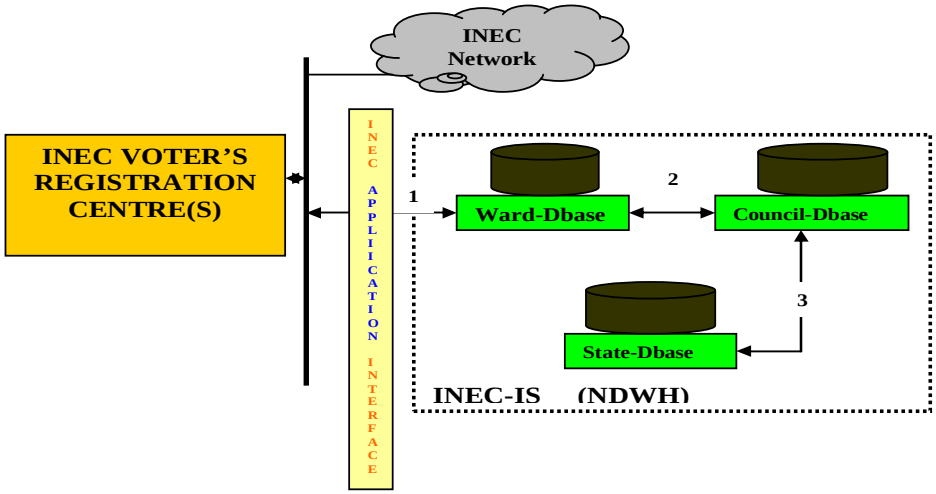

Figure 4.8: INEC Voters' Registration Data Management

Figure 4.8 shows that during the registration exercise where online operation is used and data collected are managed as follows:

1. At registration centre, potential voter's data are collected/captured and stored directly into the WARD-DBASE located of the NDWH in a real-time basis via INEC APPLICATION INTERFACE. A unique identification code is automatically generated once that will securely identify the WARD-DBASE within a local council.
2. All the WARD-DBASE within a local council will be merged together automatically after the registration and store in the COUNCIL-DBASE. Furthermore, another identification code will be given to the Council-Database.
3. Lastly, same data collation process will apply to the State level where a collection of related COUNCIL-DBASE will reside in the STATE-DBASE with another given code that will uniquely identify each state.

Step 4: Data Verification
During the registration exercise, onsite verification will take place, and this will be in the form of automatic printing of all information collected from individual before such information could be saved on the WARD-DATABASE. This same method was used during voter's registration exercise for 2007 general election in Nigeria, but unfortunately the same print out was used as voter's card during the general election. In our case, this print out will serve as a receipt during the voter's card distribution and collection.

Step 5: Card Issuance
At the end of the registration exercise, normally after a period of one to two months and after card production, the RFID-based voter's card will be issue to all registered voters or citizens. The RFID passive tag on each card will have a unique EPC code from the tag manufacturer together with the three different uniquely automatic generated codes will be used to query relevant database or the data warehouse that contain the card holders' information from the ward level, local council level to the State level and will form a perfect unique identification for individual card holder.

4.4.2 Proposed RFID-based Distribution System

Based on the above INEC architecture shown in figure 4.4, the key functional components of our proposed RFID-based election distribution system are:

> m-RFID reader
> IP WLAN network
> EPC-global network
> EPC code-oriented materials

Links between the manufacturers of election materials and the electoral body as well as INEC distribution centres are created.

4.4.2.1 Materials Distribution Requirements

For the distribution of election materials to be successful and perform to expectation, the following requirements are necessary:

Step 1: Working Data
The electoral body as customer in this regard, will present their requirements for the election materials and also furnished it with up to date and 99.999% accurate working data to the selected manufacturers of election materials. This working data presented will be the exact and accurate data collected during voters registration exercise, and all the manufacturers will also have access in read-only mode to the national data warehouse. This will allow all the manufacturers to verify as much time as they wish that a given product was manufactured by them in case of counterfeit problems.

Step 2: EPC codes and Election Materials
For successful operation, there should be some representatives from the electoral body that will work closely with all manufacturers involves in the production of election materials, especially in the area of assigning EPC codes based on wards, council and states respectively. These representatives should be outstanding

consulting firm, with professional knowledge in this area and ensure that standardization is effected. They should also guide manufacturers on the actual number of election materials to be produced and the actual number of extra materials needed in case of any wastage before and during elections.

Step 3: Package
During voters registration exercise, there are some unique codes used to identify each political ward, local council, and State databases in the NDWH respectively. All these codes together with the manufacturer's identification code will form the final EPC unique code. After the production of the materials with information about the total amount needed in each state, council and ward respectively, the materials should be package ward-by-ward and assigned an EPC code embedded as tag. The collection of all packaged wards material formed the Council pack with EPC code embedded as tag. Also, the collection of all related packaged councils pack form the State Pack with another EPC code embedded as tag. At this point, these EPC codes will be used to allocate storage space for individual packaged election item or material on the INEC EPC-IS (EPC Information Service) Server.
These materials should be package in such a way that if tampered with especially due to diversion in transits, the tag will be destroyed and render invalid for election purpose. This nature of packaging will serve as a security to the tag by showing the no material was collected outside the polling stations.

Step 4: Transportation
The transportation of elections items will be done in a way that each distributor will be provided with a delivery card that have information on which and where the elections materials are going. This card will be RFID-based, and it will be read at the point of loading and at same at point of delivery in order to be sure of accurate delivery of election items from source to destination point.

4.4.2.2 Verification Operations at Distribution Centres

In this regard, all INEC distribution centre must have same unique structure right from the central distribution point, through the state level to the local council where the materials will go to each political ward for election purpose. Each centre will be link via the mobile RFID Readers to the INEC local network as shown in Fig.4.4. This action is necessary in order to ensure 100% security and inventory taking of election materials as well as checking if there are getting to the right destination or if tampered with.

Each manufacturer after production and packaging have to send the inventory of each election item to the electoral body in charge (INEC).Then INEC in turn will store them in the appropriate databases as shown in the INEC EMR residing in the NDWH. This will securely be link to the EPC IS Server with directories stored in the ONS. This information will be shared among all distribution centres within the system.

The verification procedure:

- At the point of delivery and receiving, each packaged election material will be scanned by Mobile RFID readers.
- The reader will then prompt for the tag password (if any),

- The tag on the packaged material will communicate its EPCs to the mobile reader which switches it on and off,
- The reader will then transmit the EPC through the m-RFID network to the EPC network's savant or middleware which in turn process, filter, aggregate and communicate the filtered EPC over the internet to the Root ONS which host the Local ONS directory for that material,
- The Root ONS then queries the Local ONS for the material location or URL of the material as stored in the EPC- IS, and lastly
- The EPC-IS is queried and information about the particular material is verified. At this point if the material is confirmed valid, it will be deliver and put to use otherwise it will not be delivered or put to use.
- EPC Discovery Service will take account of all distribution information of each item on ward, council and state basis respectively.

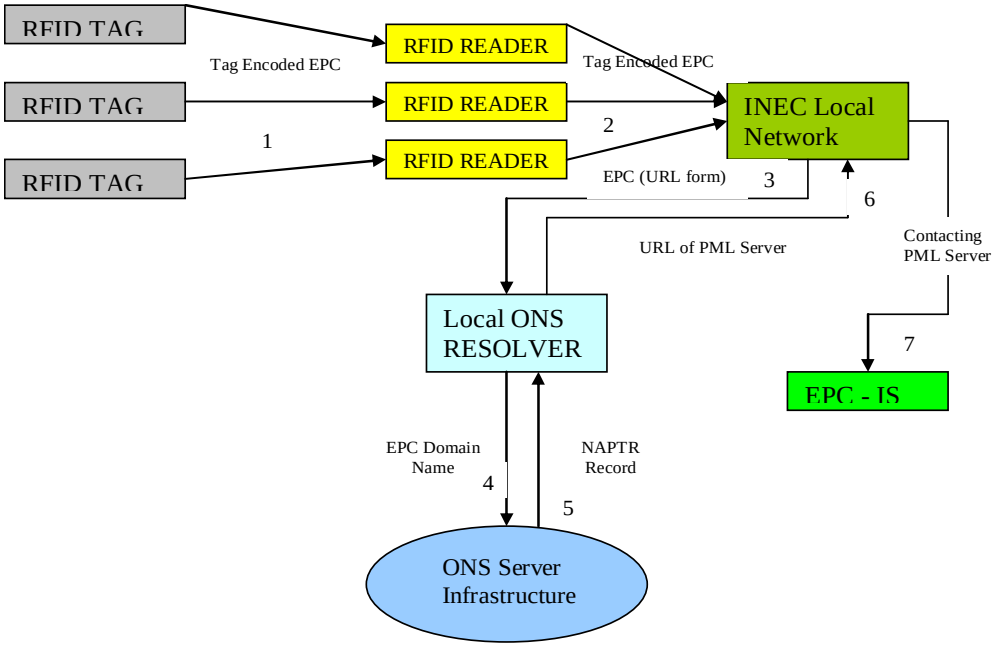

Figure 4.9: An Overview Verification Operation

4.4.2.3 Description of ONS Process during Verification Process

- A reader interrogates a tagged object (material or Voter's card) and obtains the appropriate EPC in binary form,
- The EPC obtained in the form of binary numbers which is structured into Header, Manager no, Object class and Serial no respectively is passed to the local network application processes.
- The EPC is then transformed into URI form (converting binary into integers) Example: [urn: epc: id: gid: 2.22.200]
- Then the URI obtained is transformed into domain name form. That is, >Remove urn:epc

Example [id: gid: 2.22.200]
>Remove serial number
Example [id: gid: 2.22]
>Invert the string by replace ':' with '.'
Example [22.2.gid.id]
>Append ".onsepc.com"
Example [22.2.gid.id.onsepc.com]

- The ONS in this regard will generate a set of possible URLs that Serve as pointer to one or many services which EPC-IS is among Example: [http://bara.com/epcis.php, http://advoka.com/sensor_is.asp]
- The correct URL is picked and extracted from NAPTR (Naming Authority Pointer) record. Example: [http://www.bara.com/epcis_php]
- The Application systems then send a request to the URL and the object is identified.

4.4.3 Identification Operation at Polling Centre

Based on figure 4.4 which shows the INEC network architecture, a step by step operation at the polling place on the issue of identification of individual before actual voting commences aimed at stopping multiple voting is given here.

Step 1: Polling Centre Setup
Each polling station will be equipped with mobile-RFID Reader, optical fingerprint sensor, and compact RFID mobile printer. The biometric fingerprint scanner/sensor connected with a TCP/IP networked standalone controller connected to the mobile RFID network for verification of the scanned fingerprint at the polling place, mobile RFID printer and INEC officials.

Step 2: Voters Identification
As potential voters come to the polling centre with their RFID-based voter's card, the card will be scanned with RFID mobile reader by the electoral official. The same logical operation used in the distribution operation is applicable here, except that biometric fingerprint scanner/sensor is involved. The EPC code on the card will be used to verify the stored data and the fingerprint scanned at the polling station will be checked automatically against the stored one. If a match occurs then automatic print out will be made to the card holder by the mobile-RFID printer at the polling station and the holder will be allow to vote for the candidate of his/her choice.

Step 3: Verification of Ballot Papers
After the automatic print out that certified the true identification of the card holder for the election is established, the same process will be done to the ballot paper before handing it over to the certified potential voter. This will be done within a jiffy because time is of the essence. Updating will be make to the NDWH via the EPC-IS within the EPC network, and information like the date, time and where that ballot have been used will be registered automatically for that particular ballot paper.

Chapter 5

RFID-Based Election Problem's Solution

5.1 Solutions

Based on the design and operation of our proposed system as described in chapter four, our chapter five provides the techniques we applied as solutions that will make it absolutely difficult if not impossible for any person or group of persons to be registered more than once or have more than one voter's ID card in his or her possession. Also, we give the techniques that will stop the diversion or artificial shortages of election materials in Nigeria.

The solution to our research questions provided here are based on the techniques implored to identify every potential voter at every poll centre through the central database otherwise called the National Data-warehouse (NDWH) as well as the identification of election materials at item level (i.e. to identify individual election materials e.g. Ballot papers, results sheet, etc). We believe if these objectives could be achieved, definitely cases of multiple registrations or double voting and other forms of election malpractices will soon be things of the past

5.1.1 Multiple Registration Solutions

As shown in Figure 5.2, where voter's registration centre is being connected to the polling centre and central database, the main techniques we employed to make it absolutely difficult for any individual or group of people to register more than once or having more than one voter's card is as follows:

Provision of Central Database: with this, the operation is in real-time (online) mode where all registration centers will be networked to the central database (NDWH) containing details of every registered potential voter. That is, data collected from potential voters are store directly into the NDWH via their respective databases. This is connected via the INEC Application interface in order to enhance its updates.

How it works: A real-time verification of individual voter with information stored already in the NDWH (central database) will be carry out to check if such individual has been registered already or not so as to prevent multiple registrations. For instance, if a voter registered in ward A, all data collected from that voter in that ward will be recorded in their respective databases in a real-time basis and a print out will be issued to confirm the registration. If by mistake or by deliberate act, this same voter moves to ward Z for another registration, the system will first match all the bio-data supplied (especially the fingerprint) about the voter at Ward Z with respect to stored data in the NDWH through State database to verify if it matches. If a match occurred then a print out of date, time and place where the voter performed the first registration will be issued in order to prove his or her disqualification for a second registration.

We consider this proposed method to be better and more preferable to the traditional method used by Nigerian INEC which is paper-oriented. Time and resources

wastages are the product of the old system which could be channel to other areas of national development for the benefit of masses. Others include omissions, errors, and inaccuracies. These make people to doubt its credibility in the country. With our proposed system, a single process will collect the data, collate the data, and verify its authenticity. At the end, the same system will still store the data in a secured central database thereby making its accuracy be high and unique compared to the old or traditional method.

5.1.2 Diversion/Shortages of Election Materials Solutions

In our second solution, the measures we adopted aimed at stopping the diversion or artificial scarcity of election materials is stated below:

Provision of EPC code-oriented election materials: Here, every election material is given an EPC code from the manufacturers and stored in the RFID tags embedded on them which are used to tract or identity them.

How it works:

- The operation of the distribution system allows for real-time verification of items in the NDWH's databases any time anywhere in the distribution centers.
- For effective election materials tracking and tracing right from the manufacturer down to item level in the distribution center, we employed the use of EPC code that is embedded on the tag.
- This system will provide information about where a particular election material is coming from and where it's going to be used. Movement of any election materials will be registered in the EPC Discovery Service and the NDWH will be updated accordingly. Prior to the election time, electoral officer or presiding officer at distribution centre will verified all materials at their centre to know if there are meant for that particular centre.
- Based on the packaging method proposed, if any material is tampered with, definitely the tag in it is destroyed thereby rendering those materials invalid and the proposed system has the capabilities of disabling any election material in case of misuse or diversion.
- All the tools at each distribution centre and polling centre will have a logical unique code based on the RFID tag used for them. For example, each RFID mobile station will be identify by the logical unique code associated with it. These codes will be unique for each polling station as well as the distribution centers together with individual items in that particular centre such as ballot papers and boxes that already been coded with RFID tag.

5.1.3 Identification Solutions

Measures taken to effectively verify and identify each voter before he or she is allowed to vote in order to eliminate multiple voting or not allow unqualified persons to vote is stated as follows:

1. Voters' identification

Provision of RFID-based Voter's Card: In this regard, when a voter comes to the polling centre his/her RFID-based card will be scanned by the mobile reader and the

EPC code ID will be communicated to the EPC network via the m-RFID network. The EPC code is used to track the information as stored in the NDWH along side the fingerprint verification. If all the information matches with the one already stored, such voter will be allowed to vote otherwise he/she will be send away.

2. Ballot Papers

Each ballot paper will be registered before use. This process involved the mobile RFID station to verified from the EPC network, specifically form EPC-IS, if any single item is pre-registered in the system and if particularly it is meant for that particular station. Simultaneously, this item will be registered against the polling centre, the time of used and the date. We must note here that the anonymity of the voter is part of electoral law as such there will no be link between the voter and the actual ballot paper used for election.

5.1.4 Other Solutions

One of the problems indirectly solved by our proposed system is the issue of falsification of election results figures. In the same real-time operation, during every operation, the EPC Discovery Service found in the INEC EPC Network will automatically be keep register or records of all voters verified and voted ward by ward to avoid figure falsification during counting which is a serious issue in Nigeria. In the system still used by INEC, it is always cumbersome to do anything to correct reported case of figure falsification and diversion of election material. Politicians always take advantage of the old identification method to commit election fraud that is hard to correct. As a result, the masses are not always satisfied with the result produced by this election process in Nigeria.

5.2 Integrated System Structure

Here, we provide the structure of our proposed RFID-based Framework based on the integrated operations of different sub-systems discussed in Chapter four of this thesis work. The analysis of each part of the structure is given below in Table 2.0.

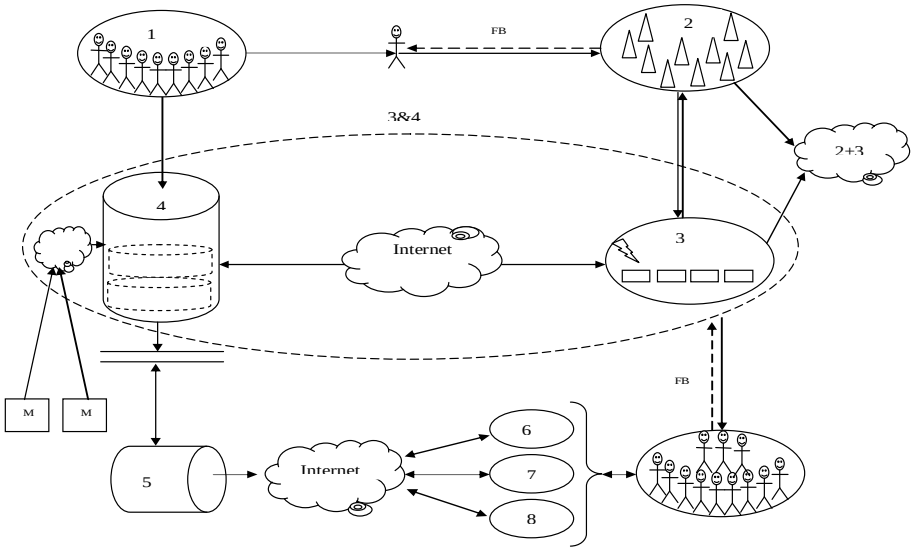

Figure 5.1: Integrated RFID-based Framework

Table 2.0 Description of the various functionalities of the whole system

Symbol	KEY	Description
1	Voters Registration Exercise	First election exercise and real-time operation aimed at registering potential voters with information collection forming the national register as well as issuance of RFID-based voters' card or nation ID card.
2	Identification operation at polling centre	An auto validation operation aimed at identifying a voter before allowed to vote and ensuring that a voter votes only once in any election.
3	Distribution system of Election's materials(M)	A real-time system that aimed at distributing election materials as well as ensuring that no election material is diverted, tampered with, forged, get to wrong destination as well as used by unauthorized persons.
4	National Data warehouse	A storage house maintained by INEC where EPC code-oriented election materials and voters' information are stored for use during and after election. Storage with compact structure made up of three different databases; Wards, Councils and States databases respectively.
5	Public Access database	A database which is part of the NDWH which open access to the public for use such as the National population commission (NPC), etc on read-only mode.
6	Private sectors	Private bodies such as companies etc that requires access to the database
7	Public sectors	Public organization such as the NPC, UNDP that requires access to the database
8	NGOs	Non Governmental Organizations such as charity organizations that requires access to the database
2+3	Communication point between the m-RFID and the EPC networks	The point of interaction between the two networks used that facilitate the sharing of data between the tagged INEC object and INEC Application. M-RFID network manages the different mobile RFID readers used at different polling and distribution centre while EPC network manages the identification of the stored object in the NDWH.
3&4	Feedback(FB) area	The area where feedback are collected between the registration exercise and the identification operation at the polling station.

Table 2.0 Analysis of the Integrated System Framework

From the integrated structural design shown in Figure 5.1 above, the inter-operability within sub-systems is illustrated. That is, the structure illustrates how all the different subsystems within our proposed system act or communicate together to meet the objectives surrounding this research work. It also shows how the private, pubic

sector etc can benefits from the system especially, the NDWH. The details of the interaction are given in Table 2.0 above.

5.2.1 Connectivity within Proposed System

Here we present a graphical view of how the sub-system framework operates and interacts. This is shown in Figure 5.2 below. That is, the interaction between the Registrations Centre, Polling Centre and Distribution Centers respectively.

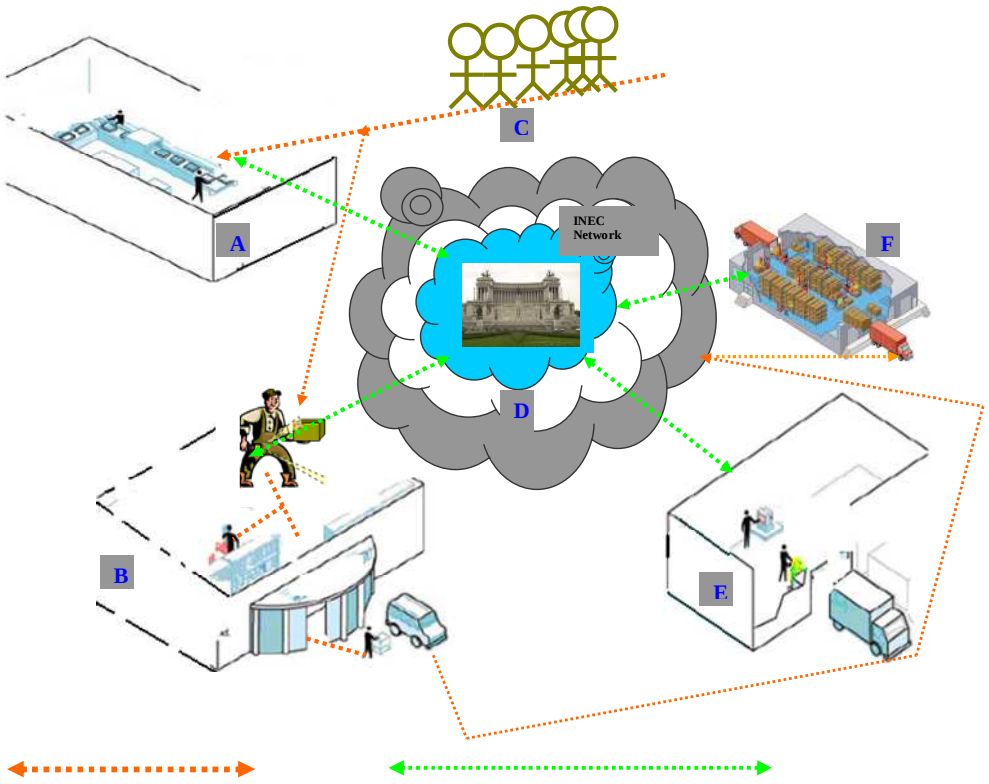

Figure 5.2: The interaction existing between our sub-systems and the INEC, voters

Keys:

A	Registrations Centre
B	polling Centre/INEC receiving canter
C	Voters or Potential Voters
D	National Electoral Headquarter
E	INEC distribution centre
F	INEC election material's factory

From the above figure 5.2, it shows that all operations will be online to ensure real-time operation in updating the different databases, identifying voters and materials as well as tracking them.
The basis of the connectivity is given below:

- To directly capture and store information collected from potential voters accordingly into the INEC's NDWH on real-time basis during registration

exercise. Linking the various databases as such is to ensure that no work is duplicated or done twice because it could attract additional costs which might pose hindrances. Information or data from various wards, councils and states can be access any time any where by authorized agencies even during the exercise period.

- Basically, since election materials are RFID based, every polling centers and registration centers are networked or connected to the NDWH so that all information about potential voters and inventory management of INEC's materials could be effectively track, trace and identify. This is to ensure that:

1. Voter's information tally with the one stored at the NDWH, otherwise he/she not be allow to vote.
2. election materials are not diverted to unknown destinations thereby preventing artificial shortages election rigging
3. Inventory of election materials are well accounted for before and after the election or voting. There is good enough approach for real-time and accurate updating of EPC-IS(s) in the system. The EPC Discovery service in this aspect will keep history of all used and unused materials as well as voters that participate in voting.
4. Any form of figure falsification etc could be trap/track immediately

5.3 Why this System and not e-Voting?

Basically, the development and use of ICTs differ in many dimensions: between countries (developed/developing) and within countries. We believe such differences are due to the quality of human resources especially in skills, knowledge, awareness, technology and education. Its application depends on several factors such as the existence of ICT infrastructure, etc. For example, internet technology would first require good telephony infrastructure, before later going wireless.

In the same way, there are several ways of cheating during any king of election around the world that is peculiar to a particular region. By looking at different operations of the electronic voting (eVoting) as popularly called; we realized that embarking completely on eVoting is a good idea because of the benefits accrued to it which is centered specifically in the area of accuracy of compiled election results using some of ICT tools and impressive participation. However, the problematic side is that the problems arising from it are very complex and cannot be easily handle by these developing countries based on their level of ICTs orientation. eVoting poses both opportunities and threats for election. Going by the threats, it threatens to undermine democracy by compounding existing election problems. For instance, considering the election problems in the US caused by Direct Recording Electronic (DRE) voting system's technologies (i.e. Voting Machines) the problems showed numbers of deficiencies emanating from and the systems. We believe this type of situation could reduce public confidence on democracy.

Taking the existing situation in African continent into consideration, implementing ICTs fully (i.e. eVoting) in election processes would not be easy. Adopting it will result in exacerbating the existing problems. And again, the cost of repairing damages is always a great and not easy task. To gradually migrate towards it, we try

to incorporate elements of ICT in pilot into the existing traditional election system. Our African election problems are unique one which needs to be tackle right from the root. We consider the root of all known elections problems in Africa to be in the area of poll events and material distribution which need urgent attention. If this proposed system is implemented successfully, it will serve as a pathfinder for the smooth takeoff of full eVoting system in Africa.

We in this research specifically adopt this proposed system based on what could be its end product especially on the issues of unique identification and the structured NDWH. For instance, Nigeria for the past 47 years of existence, identification management and structured national database has never been in place and has been a problem. It is just of recent the government established or inaugurated a body to look into the problems of identification in Nigeria which is very bad. Our proposed system will not only stop election problems but will go along way impacting other sector of the economy in a tremendous manner. We however believed that if issue of identification in election process can be solved, most of the crimes embarked upon will definitely reduce. Also, electronic counting of election result and compilation will be an easy thing, faster and even more accurate than what eVoting is currently doing.

However, most countries that are using electronic system (eVoting) for their election today are not really sincere about the use of the said technology because the issue of identification at polls is not settled before going or directly using the system. Good example of this voter identification problem during election generated in the US just of recent which is still pending in the court of law and has raised political tension [22]. Our situation in this regard is not a paperless election system; unlike eVoting where touch screen and some other ICT tools will be used for the purpose of election rather we consider what this system could do in the long-run. We considered the eVoting system used in the US to be top-down approach of solving election problems though it may produce quick result, but we considered bottom-up approach in our solution to the election problems in Nigeria which is basically good for sustainability and enhanced change management.

5.4 Impact of Proposed System on Nigeria's Infrastructure

1. Reusability of Tools

Our proposed system could be described as a sine qua none in terms of reusability. It poses to be economical in the area of reusable tools. Same sets of RFID tools used during voters registration exercise will be more useful during election period, and they can be kept for years for the same purpose. Unlike the old method whereby tools used for voter's registration or actual election are no more useful or easily become obsolete during election in subsequent period. This we believe will save the Nigerian government a lot of time and money in procuring sets of new tools.

2. National ID Cards

Providing identity card for Nigerian citizens has always been a problem. For decades, Nigerian government is still on an endless process of getting identity card for all its citizens. Identity card project was awarded and till today no account can be given for what is going on within the project due to corruption which has been

described as being corrosive in nature. This poses ugly situation which needs to be address. Here, this research work has indirectly renders a simple and easy way of getting what may turn to be multipurpose national ID card that is RFID based for the citizens.

3. National Register

Presently most Africa countries like Nigeria cannot maintain or present at least 50% accuracy of their national register. This always results to wastage of recourses, especially in the instance of national population census where this problem is always the order of the day because new registers need to be created all the time. Our proposed system will provide accurate and maintainable national register that will provide supports to other sector of government (e.g. the national population census etc.) and non-governmental organizations (NGOs).

4. Promoting ICT4D

As we stated earlier, the level of ICTs awareness in Nigeria in particular and the continent in general is very low in spite of the benefits accrued to it. Therefore, our proposed system by considering its mode of operation will provide a way of promoting the use of ICTs tools for socio-economic development. By this, ICTs tools like the Internet facilities will be in place and use in every nook and corner of the country that can be use for social, education as well as commercial purposes.

5. Other impacts

Another impact this system could create on the Nigeria's infrastructure is in the area of power supply. Right from time immemorial, power supply in Nigeria has been epileptic in nature crippling businesses and causing untold damages to electronic infrastructure. With our proposed system, we believe the issue of power supply will be a thing of the past as the system needs constant power supply for sustainability and operation.

5.5 Suggested System Problems

5.5.1 Factors that can Affects System Operations

There is no system that operates without impediments. Some of the factors we assumed will affects our system from taking off or function as expected are stated below:

a. Resistance to change: one of the key impediment that can hinder the takeoff of our proposed system is people resisting to change; a situation where individual and group takes action to oppose the occurring change when they perceive that it will serve as a threat to them or their selfish interest [38]. This is because most people don't like change due to the fact that they don't want being changed especially the politicians and the government of the day. In pronouncing the change this proposed system would bring, fears, anxieties and resistance to change will follow despite the benefits because they feel there is no room to satisfy their selfish interest or corruption and even election fraud.
b. Selfish-interest: due to resistance to change that might occur there is the possibility that, this project might not be approved or gain financial support due to selfish interest of continually committing election fraud.

c. Attacks: there is no way attacks cannot be lunch on our system if resistance to change succeed or not. Attacks in this regard can be in two forms, logical and physical.
   Logical Attacks- this could be classified into four categories; spying, Deception, denial of service and protection of privacy [35, 36]. Spying could be by falsification of readers and blocking, Deception could be by deactivation, detaching of tags, falsification, while denial of service is even the most dangerous as it can render the whole system non functional especially on election day. It could involve deactivation, blocking and jamming. The protection of privacy could be reduced by deactivation, jamming, blocking and detaching of tags.
   Physical Attacks – this form of attack involves the physical vandalism on the system infrastructure either by sponsored means or accidentally. This could fire outbreak, environmental factors or activities of terrorist group.
d. System maintenance: the regular maintenance of the system is another great issue that could hinder it. Since database requires regular updates to make it ever useful, we believe this will be a difficult task to do except when another round of election is at the corner. We advise that the databases or the NDWH in general should be regularly be updated to enhance the supports for other sector.

5.5.2 Possible Ways to Cheat

Going by the way our system is designed to operate, we believe cheating through polling activities or during materials distribution will not be possible due to the security and identification measures in place. However, we believe the only way election fraud can come in will be through electoral officers compromising their responsibilities and the electorate being bribed to channel their vote cast for a particular candidate. Though, this situation will not affect our system but the desire candidates of the masses because our system creates no room for any fraud to be committed.

5.5.3 Dealing with System Failure

System failure especially on Election Day is one of the dangerous and ugly things that can happen to our system. This will be as a result of different forms of attack that can be lunch on the system which could impede election processes thereby rendering the system to criticism. However, we advise that all forms of security measures either logical or physical will be put in place to make sure that the infrastructures are protected and remain safe.
Going by the method of implementation which we proposed to be the parallel method where the new system is introduced in parallel with the old one, we believe this could save it from impediment. Assuming on Election Day, if the new system fails then the old system can continue without causing a hitch to the election.

5.6 Implementation Issues

Because of the complexity and cost of implementing this proposed system, we only concentrated on the sub-system analysis and functionalities. However, concerning

the implementation issue, the two areas we need to address are the technology aspect and the Electoral body (INEC) aspect and the method.

5.6.1 The Technology Aspect

1. Environmental Factors

Radio Frequency system's signals are not deterministic and no guarantee or that each RF transmission will definitely reach its destination or within stipulated timeframe. Factors such as environmental conditions; metals, walls, humidity, reflection or absorption materials, electrostatic discharge always and greatly affects their clarity along side other environmental noise from wireless based RF communication systems; wireless LAN, other appliances and equipments, etc. These mentioned elements can seriously affects the performances, degrades the clarity of RF signal or strength thereby resulting to a decrease in the RF read range effectiveness or even null read at all [13]. Therefore these must be taking into consideration when this system is put to work to ensure a huge success.

2. Operating Frequencies

The operating frequencies any RF system should be taking into notice. For instance, passive and active RF based system operates in the HF, UHF, microwave 802.11b (Wi-Fi), and ultra wide band frequency range [13]. By this, the greater the frequency, the greater the distance and accuracy obtained from the system. This is why we recommend the m-RFID readers' network to avoid possible interferences or collision problems that might occur when using dozens of fixed readers.

3. Management and Integration

Each RFID system components; RFID tags, RF antenna, RFID reader, and host applications need to be consider first individually and secondly, as an integrated whole when planning the installation.

- Firstly, the user or parties involve together with experts or RFID-based consultants have to decide upon the RFID tag which best suit the application to be deployed. In our case, we proposed the passive RFID tag type of the Auto Centre EPC 915MHz Class I standard [17,21].
- Next, the reader type is determined. The critical issues here should be on the ability of the reader to read both frequency and protocol of the tag chosen for use as well as the read range and read proceeding speed.
- Next is the issue of antenna placement which is very essential. The placement involves considering two factors; orientation and placement of RFID tag and the effective read range of the reader given numerous environmental factors. In this regard, we suggest the Handheld Mobile Reader because of its flexibility and the integration of both antenna and reader chips together for effective utilization.

4. Numbers of Readers needed

The next issue is determining the numbers of readers needed. In our proposed system, due to the vastness of the country (Nigeria) and the complexity of electoral wards and distribution centre to be managed simultaneously, we then recommended the extension of INEC network infrastructure to accommodate thousands of readers with different IP address together to eliminate the problems of interference resulting from reader collision and the cost of procuring dozens of RFID readers. We

recommend at least two mobile readers per ward or distribution center to compensate for environmental elements.

5. RFID Network and Application Software
This aspect constitutes the logic and operation. RFID Network otherwise know as the EPC Network is required and the application software to serve as an interface in handling the operation of the network is required.

5.6.2 INEC Aspect

For INEC to successfully implement this proposed ICTs or RFID-based election system strategy, a clearly understood and well-supported plan from all angles and measures for change management is required. However, the following steps should each be taken into consideration:

- Creating an RFID policy for the nation: This first basic step requires INEC to create RFID election policy, the objectives of the ICT or RFID implementation, the technologies involves, as well as the define data structure. The document will requires regular updates as the implementation issues are resolved and make sure they obtained a high level backing especially from the national assembly.
- Document the Reasons of Adoption: INEC here should be able to describe and qualify why the country or INEC particularly is implementing RFID or ICTs in their election system. These should include the mandate for information system such as national ID card, national register, streamlining their internal processes devoid of wastages of resources, time and energy, need for free and fair election devoid of fraud, falsification, rigging, violence, diversion and shortages of materials. All financial cost as well as benefits of adoption should be estimated and documented.
- Develop an implementation plan: This should involves the implementation strategy, including such things like the proposed technology, network coverage, safety issues, staff training and communication plan, testing processes, etc.
- Initiate the deployment plan: through the use of experts or consultants, INEC should choose the fastest and easiest implementation application so that the nation can see the implementation benefits. They should avoid implementation failure that could raise opposition that can engulf the whole project.
- Manage the various constituents involves(change management): INEC should ensure that the whole plan is fully supported at all levels right from the ward via council, state to the national levels respectively, so that those directly involved or imparted by the introduction knows what the aims are and are supportive of the change. Also get the technology suppliers involve.

All these measures when carefully adopted will ensure a hitch-free RFID based election system and the benefits to derive from it will be tremendously explored.

5.6.3 Implementation Method

The implementation method we suggest for this system is the parallel run method. By this method, the old system and the new system can be in operation at the same time on Election Day in at least 5 out of the 36 states of the federation for some

period of time to ascertain its feasibility and credibility before going direct run. Based on this, the results from both systems can be compared to see which one worth adopting. Though this method might pose some disadvantages like doing same job twice, it may save the system a lot from criticism or opposition as well as embarrassments on election day especially when the new system fails due attacks or other causes which cannot be resolved immediately at polling place.

5.7 Validity of Study

Validity of this study could be tested based on pilot method (Pilot project) in order to verify if truly the proposed system is capable of putting end to those election problems and this can be done in conjunction with electoral body is an artificial election setup.

Though the validity of this proposed system can be affected by factors such as government policies, resistance to change, technical problems (e.g. network coverage, etc), different forms of attack, etc., its trustworthiness cannot be over emphasize. Due to the nature of the research method adopted in this thesis work, that is qualitative method where no practical work was carried out or data being collected for analysis, however the design of our proposed system and the solutions it renders is validated based on its operation and by two factors; the central database and the EPC on RFID tag. Details are given below:

Central Database: With the central database adopted where all information concerning registered voter is stored, the case of identification and verification is valid. This is due to the fact that it is the method now used by most developed countries and is working perfectly. For instance, in Sweden with the central database, it is easy and simple to get information of a particular citizen based on the personal number that is unique to that person.

EPC on RFID tags: We see RFID as having incredible potential to impact a wide array of businesses with the promise of applications that would result to massive cost savings, efficiency gains, and unparalleled visibility into the supply chain. Without conducting formal test, we believe the operation of RFID technology in the supply chain management which is the same procedure adopted here is suitable in validating or ascertain the trustworthiness our proposed system.

For instance, the Electronic Product Code on RFID tag is a globally unique serial number that identifies each item to which it is attached and it serves as globally unique pointer for making enquiries about the individual item irrespective of where it is within the global supply chain being leveraged by EPC-global Network framework that enhances the immediate, automatic identification and sharing of information on items in the supply chain. With this in place, we believe that as it works in the supply chain in identifying and tracking products, so shall it be valid in our RFID-based system to solve election problems where election materials and voter's identification and verification are the target.

Chapter 6

Conclusions and Future Works

6.1 Conclusions

We observed that incorporating ICTs fully into election processes requires gradual and parallel implementation based on the technological infrastructure available and the quality of human resources especially in skills, knowledge, awareness and education. Our proposed system is designed to supplement the traditional election system by helping to solve major problems arises from it and to create avenue for full eVoting system implementation if needed. This means that before fully embarking on eVoting system, there must be an element of it already on the system to be successful. However, this only form a part of the basis for this thesis work. The main issues we addressed are given:

- The thesis work addresses two major election problems confronting African nations; multiple registrations that leads to multiple voting and diversion of election materials for rigging which in turn lead to artificial shortages of material taking the Nigerian content into consideration.

- In order to contain these ugly situation and based on the nature of facilities in Africa in terms of ICTs infrastructure and poll centre orientation, we proposed an RFID-based Framework that will help curb the situation.

- Models or what we could call network models was adopted based on the Auto ID Lab. EPC standard to effectively handle all processes involve. With this, we propose that all items patterning to election should be RFID-based with EPC code embedded on the tag for quick identification and tracking purposes.

- We suggested a voter's registration exercise that could produce RFID-based voter's card and which would serve as national ID for every citizens.

- To effectively contain the complexity involves in operations at both distribution and polling centre, application of RFID in the supply chain and inventory management as well as tracking was employed.

- In order the effectively manage all information collected about potential voters as well as INEC election materials, we propose the adoption of the data warehousing technology for the system.

- The impact to be created by our proposed system to the nation as a whole; public sectors, private sectors, NGOs etc were highlighted other than election system alone.

- Some problems that might impede the operation of the system, possible ways election fraud can occurs and possible ways to deal with the problems especially system failure was discussed.

- Due to the nature of election problems and the mode of operation of this proposed system, we believe if successfully implemented, this system will produce a free and fair election that is devoid of fraud, falsification, rigging, corruption and wanton destruction to lives and properties that characterized Nigerian election system.

- The system will serve as a path-finder for the implementation of full time eVoting system that requires gradual implementation and understanding.

6.2 Future Works

Future works could possibly include:

- Make a comprehensive study as well have physical contact with each of the RFID components,

- Present a proposal to the INEC for consideration and adoption,

- Explore the validity and tractability of the presented network model further and adapt it consequently,

- Develop and implement a software prototype that will effectively handle this complex operation,

- This proposed idea as part of supply chain management system could also be consider applicable to other relevant and related areas.

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