

## **An Evaluation of RFID Security Systems for Tracking of Parcels in Kenya**

Samuel Odoyo Nyiendo<sup>1</sup>

School of Informatics and Innovative Systems  
Jaramogi Oginga Odinga University of Science and Technology, Bondo, Kenya  
Email: odoyosn@gmail.com;

Collins Oduor Ondiek<sup>2</sup>

School of Science and Technology  
United States International University -Africa, Nairobi, Kenya  
Email: ondiekcollins@gmail.com

### **ABSTRACT**

Postal Corporation of Kenya (PCK), also known as Posta, and other courier service providers' deliveries have always been governed by fair user policy (FUP) to safeguard on the operational ethics. Posta is one of the parastatal organizations registered Communications Authority of Kenya (CA) that still enjoys partial monopoly in letter boxes services. The courier business segment has stiff competition brought about, not only by liberalization policies passed by parliament in 2005 but also new courier players using cheap motor cycle riders that have drastically lowered the revenue base for the PCK. Parcel tracking starts at dropping points, the process continues while being transported to destinations picking offices, that may take several hours. With Radio Frequency Identification (RFID) wireless systems organizations may increase business competitiveness and make better decisions while optimizing on safety of the transit parcels. The paper starts with literature reviews on RFID tracking systems, followed by comparisons of courier coding methods, RFID conceptual designs, applications and procedures that may be deployment on transit parcels. The results and findings presented at the discussions may benefit all stakeholders by increasing customers satisfaction, business values and safety of the courier service providers in Kenya, and for further courier security research.

### **KEYWORDS**

Courier, Fair User Policy, Parcels, RFID, Security, Wireless Tracking

### **1 INTRODUCTION**

Historically speaking, supply chain management (SCM) has always used fair user policy (FUP) in its service deliveries where the merchant, middleman and customers negotiate on acceptable terms (rules that are) applied to the carrier firms transporting the merchandises to safeguards on excesses in the industry [1]. Example, the parcel conveyance rules would apply to: the addresses of both the sender and the receiver, size of the parcel, safety of handlers, parcel status, and distance to be covered [2]. Courier delivery services may be traced back many years before the birth of Jesus Christ as far back as the year 475 the Before Common Era (BCE) during the reigns of the old Assyrian World Empires when the government of the day instituted first known standards for parcel delivery systems with horse-men and runners [3].

The defunct British East African Post Office (BEAPO) systems introduced the courier system in Kenya in the mid eighteenth century with letters coming from Europe. At the independence in 1963 through to 1976 the government started East Africa Posts and Telecommunications Corporations (EAP&TC) that applied traditional postal systems that used to have centralized offices as dropping and collection centers for light parcels and stamped letters in and out of the East African Region. Once a postal stamp is fixed on the letter, or a parcel and a registration number is

obtained at the counter, in some cases, the customer had very limited ways of tracing the item once it left the postal center [4].

The dissolution of the defunct East African community (EAC) in late 1970s created Kenya Posts and Telecommunication Corporation (KP&TC). Twenty years later, through a Parliamentary Act 1998 which was amended in 2013, further split the corporation into three independent bodies: the Telkom Kenya Limited (TKL), the Communications Commission of Kenya (CCK) today Communications Authority (CA) for enforcing the regulations, and the existing Postal Corporation of Kenya (PCK) who is still running parcel delivery services alongside other competitors [5]. The Act also opened used fair user policy (FUP) in courier service delivery to new entrants in the sector such as: private bus companies, Small and medium (SMEs) organizations that sub-contract motor cycle riders for the parcel dropping services [7].

While the substitute international courier services deployed express mail technologies in line with changes in wireless telecommunication technologies, PCK (locally known as Posta) continued with receiver and sender address ink inscriptions on the parcel as the only security marks used during the dispatch. In 2009 Posta initiated Express Mail Services (EMS) for countrywide deliveries that is extended to serve at 3,000 other centers worldwide [5].

**Table 1.** Number of registered courier companies. Adapted from Communications Authority of Kenya

SELECTED INDICATORS	Apr-Jun 2017	Jul-Sep 2017	% change Q4 to Q1
<b>POSTAL AND COURIER SERVICES</b>			
Postal Outlets	623	623	0.0
Private Courier Outlets	997	997	0.0
Number of Letters (Up to 350 gms) Posted Locally (Millions)	15.722	16.027	1.9
Total Courier Items Sent Locally (Millions)	1.472	1.712	16.3
International Incoming Letters (Up to 350 gms) (Millions)	1.075	1.078	0.3
International Outgoing Letters (Up to 350 gms) (Millions)	1.074	1.083	0.8
Total Population in Kenya (Millions)	45.4	45.4	0.0

quarterly report, 2018. p. 32. Copyright 2018 by CA. Adapted with permission for educational purposes.

Table 1 shows the current number of the registered courier service providers as 1,520 by September 2017. Hitches on parcel delivery, however, continue to affect the processes, i.e. delays, tampering, and mail thieveries made the organization lose valuable customers resulting in low traffic to its centers and a big drop in its profit margins [16].

Transformation of CCK/CA regulations policies in the recent years, evolutions of E-commerce technologies over the Internet and the web data mining have turned out to be an opportunity for further innovations. An efficient and cost-effective Radio Frequency Identification (RFID) tracking system may be the universal survival niche for the Information Communications Technology (ICT) value addition leading to timely decision making [13]. To seize a competitive advantage in the courier industry an organization needs to design and implement improved IT business values in its operation processes. In spite of the spread of wireless GSM and WiFi technologies in Kenya, the country has put very little efforts in exploring the advantages of RFID as a business enabler in acquiring high-level technology its operational and security proficiency [6].

The paper explores RFID technology value chain in parcel tracing through literature review on

related tracking technologies while linking their applications and procedures to the design and deployment of the parcel RFID tags. The findings presented in the discussions and conclusions may benefit policy makers, the regulators, the courier service providers and business agents leading to increased customers intimacy, business returns and safety of parcels in the courier industry in the region. The information may also be used to identify gaps for future research in business strategic discussion in the courier parcel security.

### 1.1 Objective of the Study

To evaluate the impact of Radio Frequency Identification (RFID tracking systems in the courier service deliveries by reviewing various related scholarly literature that may guide on improvement of the ICT value chain in business competitiveness, adoption of the online parcels' tracking model and business sustainability.

### 1.2 Problem Identification

Challenges concerning safety and security of parcels while in warehouses or on transit include package tampering and threat of terrorism in the East African region need effective risk mitigations. Additionally, courier firm managers tend to use only cost ratios to determine effectiveness of the operations while omitting the ICT value chain in their strategic business decisions. Studies have established that with online RFID wireless tracking models, it is possible to improve efficiency and effectiveness in security through enhanced knowledge on the parcel location and its status while optimizing on business returns through customers intimacy.

## 2 REVIEWS OF THE RFID LITERATURE

The section looks through various accredited academic publications including: textbooks, policy papers, journals, and Kenyan Acts of Parliament. This segment also presents

assessments of supportive standards and regulations, applications of the RFID technologies in the supply chain management (SCM), and RFID frequency band management. The literature review focuses on research design that are scientific in nature, mixing experimental, inferential research and theory-based research models.

### 2.1 Acceptable User Policies

Acceptable user policy (also known as Fair User Policy, FUP) applies to ethical terms used in the business communications as well as in the transport industry to safeguard all users on illegal or any unlawful activity in the sector [1], [5], [7], [8], [9], [22]. Courier industry is highly versatile and thus has attracted very many business entrants in Kenya. PCK previously monopolized the sector in light parcels and post box letters, while Kenya Railways Corporation was handling transportation of large and medium sized goods [16].

Brown [7], state that the vender has personal responsibility of not accepting to transport illegal goods. This calls for the courier company to demand details of the parcel content before accepting to carry it over to another destination. RFID coding systems have flexibility of capturing the description of the parcel at the dropping points. This process also protects the transporters [7].

Ghafele and Gibert [22] base their views on the 2005 Free Trade Agreement while arguing that flexible fair use of rules in the courier market enhances economic growth by removing stringent price controls. It is a giver-and-taker business model that accommodates all operators in the sector but puts barriers that mitigate oversteppings, especially in the copyrights or unregistered riders. Courier industry may borrow a leaf, so to speak from the model, since almost all operators are registred with CA for the

business licencing and rules [5]. The regulator acts as watch dog in case of any reported unethical acts. Through public awareness forum, training, memos and clearly labeled posters at the courier centers and in the transaction documents all users of the light parcel transportation systems should be informed not to carry illegal items such as guns or banned drugs, [9].

### 2.2 RFID Systems Value Chain in the SCM

PCK is compelled by the government’s Universal Services Obligation (USO) business laws to extend delivery of its the services up to very interior country side [5]. Implementing the RFID system in such a sparsity may not be cost effective unless the organization develops and adopts an elaborate Go-Live plan that includes resource-based training on its existing technology with its large number of staff across the 300 postal centers spread in the counties. immensely increase return on investment by saving on storage inventory costs weighed against space [6]. The RFID / ICT value creation in the Supply Chain Management (SCM) is shown in Table 2 for the ICT business portfolio [12].

The courier SCM ICT business value chain encompasses business compatriot operations and value additions that drive the Business-to-Consumer (B2C) business services. At each stage RFID parcel tagging critical plays a critical role of automating the tracking events [12]. PCK is compelled by the government’s Universal Services Obligation (USO) business laws to deliver the services up to very interior country side [5]. Implementing the RFID system in such a large scale may not be cost effective unless the organization develops and adopts an elaborate Go-Live plan that includes resource-based training on its existing technology with its large number of staffs across its 300 postal centers spread in the counties [6].

**Table 2.** The courier ICT business value chain

Value Chain Position	B2B Logistics	Internal Operations	B2C Marketing	B2C Service
Tagable Entities Equipment Parts Products Packaging People	Transport vehicles Interface vehicles Vehicle operators Individual items Bundled items Item handlers	Transport vehicles Vehicle operators Individual items Bundled items Item handlers	Transport vehicles Individual items Sales personnel Customers Item handlers Promotion items	Transport vehicles Individual items Service personnel Service equipment Customers
Obstacles to Value Managerial Organizational Technical Economic Legal	Trading partner compliance Governance and ownership Cost/distance tradeoff RF-unfriendly packaging Pallet transparency Standards inconsistencies Labor privacy	Application integration Cost/distance tradeoff RF-unfriendly packaging Reader costs Pallet transparency Off-track items Labor privacy	Cost/distance tradeoff RF-unfriendly packaging Reader costs Labor privacy Customer privacy Mishandled promotional items Data flood	Cost/distance tradeoff Retrofitting equipment Labor privacy Customer privacy User alterations De(activation) Data flood

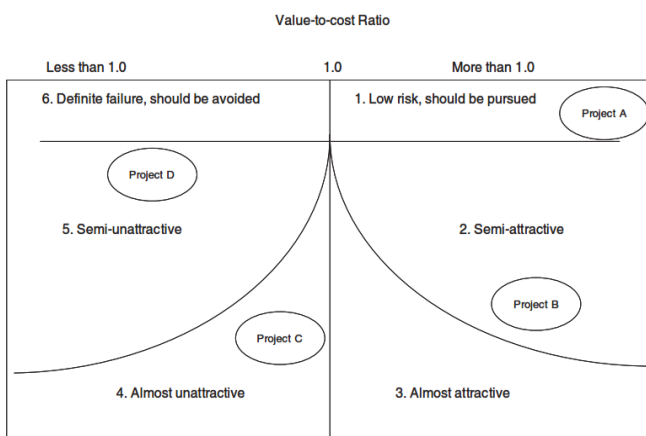
Different theorems exist in a number of literature reviews concerning RFID systems deployments in the [10], [11], [12] [18]. Bayes Theory discussed by Myerson and Bayes [11] argue that any likelihood of success of a technology innovation should be based to an existing tangible evidence. This theory rules that the process of logical interpretation on the new pattern changes the value of RFID technology in the supply chain successes, thus, would easily be turned into an efficient and a clear operational workflow. This belief should be the rationale for creating a competitive edge through the application of the RFID systems in the courier tracking processes management [11].

Wamuyu and Maharaj [18] highlights Technology Acceptance Model (TAM) theorem positioning five critical success metrics that may be adapted in the ICT radio technology for the system to be rated as valuable: its appropriateness in terms of performance, ease of implementation, its timeliness, cost effectiveness, the efficiency on recovery time in case of failures. The constructs are connected to the technical compatibility with existing systems and consumers’ perceived needs. The net effect is to improve performances in business courier industries [18].

### 2.3 RFID Systems Risk Portfolio Theory

Becerra and Sabherwal [10] argue that an ICT business investment unpredictability corresponds to its net value of input in costs. Much of the existing literature on wireless technologies pays particular attention to the vulnerability of such systems emerge mainly from mishandling by the courier operator staff in the process of loading, transporting, storage or at the offloading stages. Figure 1 is a portfolio showing relations between RFID business values and adoption costs [12].

Decision managers considering such alignment in its RFID business portfolio has to re-evaluate its organizational objectives to march the high level of me-too imitators. The business has to adapt some survival options based on its available resources such as competent staff who may be able to match with the speed of technological changes in a competitive environment. Any courier company that overlooks this speed of technological change driven by the RFID wireless system risks being left behind.



**Figure 1.** The Risk Portfolio Theory adapted from “Knowledge Management Systems and Processes”, by Becerra and Sabherwal, 2016, Copyright 2010 by M.E. Sharpe, Incorporation. Adapted with permission for educational purposes.



### 2.4 Merits of The RFID Wireless Tracking Models

A significant amount of literature on the Radio Frequency Identification systems (RFID) published over the past ten years have emphasized the RFID radio frequency allocations, merits and demerits and numerous applications of different RFID tags. For example: Lewis (2004) compares impacts of various parcel coding with the newly introduced RFID tagging as a means of locating parcel source by sharing its codes across open web networks, knowing its status, and description of the contents as well as its intended destination. The internet distributed channels, however, creates vulnerability along the routes such as malicious attacks even virus that require effective risk mitigations [20]. The RFID wireless signaling makes it appropriate to carry out faster inventory without moving around and over the pile of parcels since the radio signals can captured from any angle without contact with the item. Table 3 shows how the tiny size of an RFID tag is also an added advantage [13], [14], [15], [16].

Sheela [17] sentiments support Khator [21] that postal and courier RFID system is increasingly being implemented in the tracking of large number of parcel deliveries and automobiles fleet management. Any courier organization who fails to embrace new RFID technology in its parcel management and logistics would soon find itself incompatible with the market demands. For example, the Universal Postal Union (UPU) corporations control mail flows in RFID over 50 countries to Saudi Arabia Post tagging mails. Some centers have fully automated the mail delivery process, including the receiving, classification, fleet management and dispatching of the packages [18]. Kenyans courier companies may benchmark the Saudi Postal concept that increased customers confidence on the online shopping, created more jobs for the middle men, and boosted the economy with increased cash

flow to small scale traders and the country as a whole [11].

**Table 3.** Parcel tracking codes used in the Kenyan Courier industry compared to the RFID tags

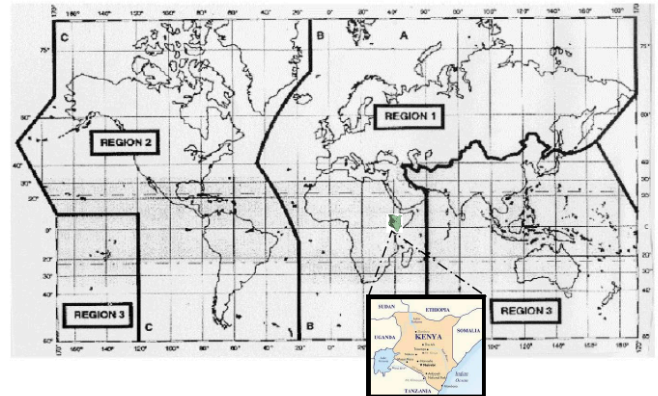
Application	UPU IFS CODE	BAR CODE	QR CODE	RFID
Code	EPG5080001XCH			Wireless Tag ●
Standard	UPU	EIS	ITU	EPC
Format	Digits	Ultra Violet Rays	Ultra Violet Rays	Radio waves
No. of Digits	13 digits Combination	72 digits Combination	Bar code with online hyperlinks	Combination of $2^{96}$ digits
Data Capture Process	Letters to be keyed manually	Reader requires Line of sight	Omnidirectional Reading	Reader requires No Line of sight
IT Value Proposition	Accepted by UPU partners Prone to errors	High capacity Internationally accepted	High quality Rich graphics	Wireless signals Can be captured at a distant

## 2.5 RFID Radio Frequency Management

Communications Authority of Kenya [6] is vested with powers to regulate the radio frequency allocations under the fair user policies to ensure ethical code of conduct is adhered to by all players in the courier sector [1], [6]. Kenyan courier stakeholders is probably aware that collective responsibility is mandatory for the successful implantation of the RFID projects countrywide. RFID Technology in tracking is relatively new in the developing world, thus, many organizations are complacent with older ways of mail handling adapting a wait and see attitude [14]. Challenges facing the courier organizations include: industrial espionage by competitors through eavesdropping using fixed or portable devices. Second, lack of competent RFID radio technologists. This, however, may be leveraged through vendor sponsored workshops where expertise demonstrations may be presented [17].

Additionally, the RFID parcel tags are highly disposable once used. This may be addressed by either licensing local vendors to supply large volumes of the same standardized web-enabled tags that are accepted by International Telecommunication Union (ITU-T) and the RFID European Commission standards [20]. Because

Kenya is mainly agricultural producer, it may be a tall order to re-invent the wheel, so to speak, in such a highly competitive technology field.



**Figure 2.** Kenyan RFID Frequency band allocation in the ITU-T spectrum R1. Adapted from “Optimization of Postal and Courier Business with the RFID Tracking and Quick Response Technology, A Sample Project for Postal Corporation of Kenya, p. 91 by Nyiendo, 2016. Copyright USIU-A Press, 2016. Adapted with permission for educational purposes.

The easiest way out, at this time, may simply be to copy the best practices witnessed in Wal-Mart and Tesco business models in which the two organizations have embraced the RFID real-time inventory tracking requirements for all business partners worldwide. The conformity require their partners to include: radio frequency ranges selection for standard tags and the RFID readers, content arrangement and its data types, and the RFID systems application guidelines [18].

According to Lewis [14], the worldwide ITU-T RFID radio frequency band spectrum or subdivisions shown in Figure 2 are used in identifying the source code origination, also, for security purposes. Kenya is placed in band one together with European countries operating under the umbrella of the RFID European Commission standards [14], [18].

Communications Authority plans to revise its radio frequency categories in compliance with the ITU-T/EU-Region-1 frequency band allocation as

shown in Figure 2 above. The Wangusi [19] guidelines classifying the RFID system tags and readers as short-range devices (SRDs) that are administered through business legislations and regulations fall within the globally accepted free frequency bands: CA-K5, CA-K11 and CA-K11 levels of HF 13.56 Megahertz for parcel tracking that includes airline baggage within a radius of two meters. The frequencies allocated in this range, however, are already allocated for devices such as fixed maritime mobile devices and radio navigation in Kenya [19].

The new entrants in the courier market adopted Fair User Policy model derived from Kantian and Utilitarian Theories that explore gaps in moral laws, culture and policies regardless of peoples' interests across the country, and the Theory of Adoption that examines innovations over time and their sustainability [22]. Due to the demand for conformity to international ITU-TS standards are being enforced by the regulator, the Communications Authority [6]. The old barcode and postal addresses have been overhauled into the new the RFID tagging systems for tracking of the parcels. The courier operators, therefore, need to adopt the technology with no excuse for lagging behind.

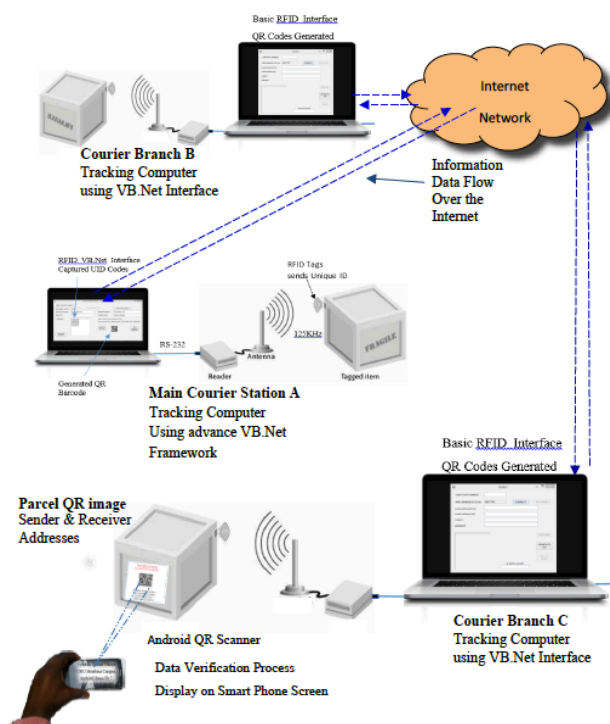
The introduction of mobile money transactions in the East African region further increased business competitiveness. Kenya has the highest rate of tele-density rate of about one telephone link to one person in the region [6]. This is a very important factor in boosting economic growth since the more goods are being transported the more people want to talk to each other to find out their parcel status. For example, the Mobile Money payment model deployed by the courier service providers have engendered customers trust towards security of the transactions, resulting too on huge benefits to the Mobile Service Providers and the government in form of taxes on the charges.

### 3 RFID TRACKING SYSTEM THEOREM

This segment considers on two research theorems that may be considered in deciding on the RFID parcel tracking system: contemplation theoretical and experimental frameworks. The VB Dot.net software, used for configuring the RFID readers and tags in portable devices such as laptops or tabs, may freely be obtained from open source in Google search engine or elsewhere.

Theoretical framework consists of online Gmail platform offering heterogeneous signal paths for the captured codes virtually to various destinations with essential digital foot-prints for need of tracing security breaches. At the receiving counters patrons are supplied with the parcel RFID security codes to aid in their online tracking processes. There is a provision for querying the online database in real-time for the movements of the transit parcels by the customer and at dispatch offices [16].

The experimental design may comprise of RFID kit pugged onto a laptop USB input that is loaded with special software, an RFID reader, active tags attached to the parcel. The readers pick the coded radio signal within a radius of not more than two meters. When goods arrive at a center the readers are able to scan all available tags in search of a particular parcel. There is a feedback loop for good that have not been collected within a certain time-frame. One major challenge is how to create a uniform awareness for the large number of courier operators within a large geographical area with some Internet gaps such as Kenya [16].



**Figure 3.** An RFID radio parcel scanning model. Adapted from “Optimization of Postal and Courier Business with the RFID Tracking and Quick Response Technology, A Sample Project for Postal Corporation of Kenya”, p. 95; by Nyiendo, 2016. Copyright USIU-A Press, 2016. Adapted with permission for educational purposes.

The VB.Net interface generates data that relays a specific RFID tag code from one branch or courier center A to B. The stored data are kept in an internal database as it is being transmitted online but may as well be stored in the cloud. The tags require no line of sight for the RFID readers to pick the signals, hence its added advantage for updating the shelf inventory [21]. One other challenge, however, in using the freeware is lack of any service level contract with google.com such that in case of delays of the code transmission, misuse, or a malicious there in no one to be questioned. It is an acceptable user package at one’s own risk [20]. Figure 3 illustrates the courier RFID system concept that may effectively be deployed at various points at low costs.

## 4 CONCLUSIONS

Decisions to implement a nationwide technological innovation such the Radio Frequency Identification (RFID) tracking system is indeed a major task. The number of courier market players is very large and have varied educational background that may not be easily harmonized within a short period of time. Implementing the RFID tracking systems in the courier service deliveries in the region is likely to improve the ICT value chain, resulting in increased customers trust in parcel transportations market, thus, enhancing business competitiveness, parcel security and its sustainability.

However, in a demography where product fitness frequently changes due to varied factors such as the unpredictable terrorism threats and advancements in information technology decision to adopt this kind of business model should not be overly delayed. The new entrants attracted by the open governmental policies have indeed taken advantage of the laxity of the incumbents.

Future research initiatives may look into better means of applying the RFID systems for Mobile Microsoft Applications (or Apple Apps) through the Global System Positioning (GPS) across the entire globe. For need of conformity with the global courier best practices there is no option, Kenya has to adopt the RFID system tracking model to its supply chain management to remain competitive in the worldwide courier industry. Any courier operator ignoring the RFID system application on its parcel tracking is likely going to lose its market share in the very near future.



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