ADOPTION OF OPEN SOURCE SOFTWARE BY THE TELECOMMUNICATIONS INDUSTRY IN KENYA

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DECLARATION

This research project is my original work and has not been presented for award of any degree in any University.

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This project has been submitted for examination with my approval as University of Nairobi supervisor.

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DEDICATION

This work is dedicated to my wife Judith, daughter Ivy and son Ian without whose caring support it would not have been possible to complete it. The long hours spent away from them in pursuit of academic excellence is highly appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BSD - Berkley Software Distribution

CAK - Communications Authority of Kenya

CCK - Communications Commission of Kenya

COTS - Commodity off the shelf

DHCP - Dynamic Host Configuration Protocol

DNS - Domain Name System

ERP - Enterprise Resource Planning

FSF - Free Software Foundation

FTP - File Transfer Protocol

GNU - GNU Not UNIX

ICT - Information and Communications Technology

IMAP - Internet Message Access Protocol

IP - Internet Protocol

LTE - Long Term Evolution

MVNO - Mobile Virtual Network Operator

NFV - Network Function Virtualization

OSS - Open Source Software

OTT - Over the Top Players

POP3 - Post Office Protocol

SDN - Software Defined Network

SMTP - Simple Mail Transfer Protocol

SQL - Structured Query Language

VoIP - Voice over IP

ABSTRACT

Open source software is software that is freely available and whose source code is available and can be modified by users to meet specific requirements. As the telecommunications industry look to be more innovative and seek to continue to be profitable, there is need to consider open source software to run some of their application requirements. The purpose of this study was to evaluate the adoption of open source software in the telecommunications industry in Kenya, establish the benefits that have been realized through adoption of OSS, determine the challenges faced by the adoption of OSS as well as establish if telecommunication companies plan to begin the use of open source in the future. The study was done in the four telecommunications service providers in Kenya namely Safaricom, Airtel Kenya, Orange Telkom and Equitel. The conclusion of the study is that there is significant adoption of open source software by telecommunication companies in Kenya with leading benefits of adoption being cost efficiency, increased software flexibility and avoiding vendor lock-in. The above benefits notwithstanding, there are challenges that are associated with the adoption as well and this include lack of proper software support, switching costs from proprietary software and quality of open source software which cannot be relied upon to run mission critical telecommunication services. However, with the rapidly evolving technology and changing consumer patterns that necessitates technological advancements and innovations, open source therefore offers a solution for the companies in the telecommunications industry to adapt and manage their costs so that they can remain relevant in the competitive environment they now operate in.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Technology and specifically Information and Communication Technology (ICT) in the enterprise has moved from being considered a support function to being used as a strategic tool for competitive advantage (Kovacheva, 2008). Investment in ICT has therefore to be aligned to the corporate strategic objectives. For majority of organizations especially in the telecommunications industry, cost management is a major strategic objective mainly driven by reduced average revenue per user (ARPU) as consumers spend less than ever before on their communication needs. Emergence of over the top (OTT) providers in the competitive communications space has also made the need to ensure telecommunication organization contain their network capital expenditure and operating costs for both hardware and software (Friedrich, Bartlett, Gröne, & Mialaret, 2013).

For this reason, open source software becomes an attractive option for the players in the telecommunication industry. This is mainly driven by their often reduced cost of ownership compared to proprietary software. The major cost associated with OSS is mainly in the support and maintenance of the application as well as training of staff, this compared to proprietary software that has licensing costs which is usually the significant cost in the total cost of ownership of applications (Almeida, 2009).

1.1.1 Open Source Software

Open Source Software (OSS) refers to software systems that are free to use and whose source code is fully accessible to anyone who is interested (Kumiyo,Yasuhiro, Yoshiyuki, Kouichi, & Yunwen, 2002). This is in contrast to proprietary software

which is very limited in access to the source code if at all possible and licensing restricts this access. By the nature of the software being free, open source creates an interest in users who face similar problems the applications are structured to solve and thus creating a developer community around it leading to improvement and extending the initial system. A good number of open source software are believed to be in use today across many computing needs such as Linux for operating systems, Mozilla for web browsers, Apache for web servers, Open Office for office applications and MySQL for databases just to name a few. With this fast adoption of OSS, there is growing interest in the use of the applications across many industries, telecommunications being no exception, as it's believed their adoption will reduce the cost associated with the often closed proprietary software.

Various benefits are expected with the adoption of open source software ranging from reduced cost of software, increase flexibility due to the ability to modify source code as the user would wish, independence from vendors of proprietary software, open innovation as a result of use of software developed by a community as well as increased security since software bugs are discovered and fixed by a large pool of users (Mohammad, Li, Guang, & Varun, 2005). There are however challenges too that are faced by users of open source software. These challenges range from lack of proper ownership of the software which also leads to fragmentation of the software (Liu, 2007), lack of proper support structure for the software (Hasan, 2009) and licensing models which can be challenging for organization to understand (Kieseppa, 2002).

1.1.2 Telecommunications Industry in Kenya

Since introduction of telecommunications services in Kenya until the collapse of the East African community in 1977, telecommunication services were managed as part of the regional network run by the then East African Post and Telecommunications Corporation of Kenya together with neighbouring Uganda and Tanzania. This ended after the dis-integration of the regional East African block and Kenya Post and Telecommunications Commission (KPT&C) was established through an act of parliament (Kenya Post and Telecommunications Act, CAP 411, 1998) and was mandated to manage telecommunications, postal and regulatory functions in Kenya. KPT&C was later disbanded in 1999 and split into three companies with distinct functions. The companies were Telkom Kenya to provide telecommunications services, Postal Corporation of Kenya to provide postal services and Communications Commission of Kenya (CCK) to provide regulatory services. Communications Authority of Kenya, CA, was established to replace CCK in 2013 as the regulatory authority for telecommunications services in Kenya through an act of parliament (The Kenya Information and Communications Amendment Bill, 2013) following the promulgation of the new constitution.

Telecommunications services in Kenya were liberalized at the beginning of twenty first century with the establishment of three major players in the industry. These were Kencell Limited (which later changed hands to Celtel, Zain and now Airtel Kenya Limited), Safaricom Limited and Telkom Kenya which later changed to Orange Telkom after France Telkom become a majority shareholder in the company. Essar Kenya which traded with the brand name YU, was established years later but due to cut throat competition in the industry, ceased operations in 2014.

Service offered by these players range from mobile services for both voice and data on 2G and 3G, fixed line services on Voice over IP (VoIP) and E1 services as well as other enterprise related services. Safaricom limited has also launched 4G services in limited part of the country based on Long Term Evolution (LTE) technology. Another major service offered by all the three telecommunications companies is money transfer services under the M-Pesa brand for Safaricom, Airtel Money for Airtel and Orange Money for Orange Kenya. Competition in the industry has been stiff in the last few years leading to reduced calling and data rate to some of the lowest on the continent. The last few years have also seen the introduction of mobile virtual networks (MVNO) in the local telecommunication competitive space with Equitel, a subsidiary of Equity bank being the most notable one. According to Communication Authority quarter two report of 2015, MVNOs have close to four hundred thousand users (Matinde, 2015) which is significant taking into consideration that they have been in operation for just over a year.

1.2 Statement of the Problem

Proprietary software is still widely used in the telecommunications industry compared to OSS. Major vendors of telecommunications solutions namely Huawei, Ericsson, Nokia and Cisco still have reign on software applications that run the value added services, voice and data services (Howard, 2013). It would be expected that with the severe competition and commoditization where the current Telco business model and services like voice and broadband are losing value causing a significant drop in average revenue per user (Birudavolu & Nag, 2011), new business models based on open innovation which are expected to have lower total cost of ownership would be adopted significantly to aid telecommunications companies survive through this

turbulent times. The delay to adopt OSS can be attributed to large investments made on proprietary software and perception over open source risks (Almeida, 2009). New services for telecommunications services are also expected to lead the adoption of OSS namely unified communications services, VoIP solutions and IP Multimedia Services for converged fixed and mobile solutions.

While previous studies especially in Kenya have been done on adoption of open source software in the various industries such as banks (Githaiga, 2012) who found out that 97% of banks had adopted open source software for some desktop services and 67% for some server applications. Research of OSS use in cybercafés (Kamau, 2011) found out that 87% use some form of OSS software, there is however limited use of OSS in government (King'oina, 2012) with a paltly 5% of government institutions using some form of open source software. Other OSS research include hospitals in the states of Baltimore, Washington and Northen Virginia in the United States where 27% had adopted OSS for general purpose application such as databases, operating systems and web development tools (Cornejo, Seaman, & Koru, 2007)

The area of open source adoption in telecommunication companies in Kenya has not been explored and thus there is a gap in this area. With these limitation, there is more research work needed to understand the extent of OSS adoption in local telecommunications companies. This gap leads to the research question: What is the extent of OSS adoption in telecommunications companies in Kenya, benefits realized as wells as challenges faced with the adoption of open source applications.

1.3 Objectives of the Study

The main objective of the study was to evaluate the of adoption of open source software in the telecommunications industry in Kenya and specifically to;

i. Determine the adoption of open source software in the Kenyan telecommunications industry.
ii. Establish the benefits that have been realized through adoption of OSS.
iii. Determine the challenges faced by the adoption of OSS by the telecommunications companies.
iv. Establish if telecommunication companies plan to begin the use of open source in the future.

1.4 Importance of the Study

The findings of the study will be of great value to the management of telecommunications companies in Kenya and beyond. This is mainly attributed by the fact that the telecommunication industry is facing turbulent times with reduced revenues as over the top players become more aggressive with their products creating a disruption in the hitherto profitable industry. By evaluating open source software as well as the challenges faced by its adoption and benefits that are likely to accrue, industry leaders will be well informed if to adopt open source application or stick to proprietary solutions for their operations.

The study will also be of importance to developers of open source software such as the Linux community. The developer industry will be informed on the need to have software that is mature and ready to run this critical industry across the globe. Being a critical communication industry, telecommunications is sensitive to quality of services

and it’s therefore important that any applications that are chosen to provide any form of service does not compromise this. Lastly, the study is valuable to academic researchers as it will act as future reference particularly for open source software and the telecommunications industry in Kenya. This research will provide a base through which further research on the area can be done in future.

CHAPTER TWO: LITERATURE REVIEW

2.1Introduction

This chapter reviews the information and communication technology in desktop and server environment focussing mainly on open source software in use for management of the telecommunications companies. It also highlights the benefits and challenges of OSS use in the companies.

2.2 The Concept of Open Source Software

Open source software has been mainly driven by developer of applications who believe that software should be free. The history of collaborative software development which is at the core of open source can be divided into three phases or era, the first phase took place between early 1960s to early 1980s. This was the period that is of great important to the modern OSS software in use today. Use of open source then was majorly limited to academic and research institutions (Kieseppa, 2002).

The second period of open source software development lasted from early 1980s to 1990s. During this period ground rules for collaborative development were established, for instance Richard Stallman who was working for Massachusetts Institute of Technology as a programmer was dissatisfied to sell as proprietary software that he had developed together with employees of the client companies. This dissatisfaction led him to believe that selling software under ordinary licensing model was not ethical which led to his belief as follows;

“The idea that the proprietary software social system – the system that says you are not allowed to share or change software – is antisocial, that it is unethical, that it is simply wrong, may come as a surprise to some readers. But what else could we say about a system based on dividing the public and keeping users helpless?” (Kieseppa, 2002)

Through this belief, the GNU project which resembled UNIX (hence the term GNU not UNIX) was started in 1984 by Stallman. This project is usually seen as the first open source application that led to the emergence of the open source software movement. Licensing for GNU was under the General Public License (GPL) which is given by the Free Software Foundation (FSF), an organization created by the GNU project. Under GPL terms, any applications created using software that is GPL licensed would still remain so and this therefore meant copyright still remained with FSF.

The third phase of OSS development begun from the 1990s to date. During this phase there has been dramatic development of open source software. There is almost an alternative solution in open source for any proprietary software that is in use today. New open source licensing models have also emerged such as Apache License, BSD License as an alternative to the GNU license which was often viewed as ideological rather than pragmatic. In this third phase of development, OSS has become mainstream running enterprise applications as well as significant Internet infrastructure. Operating systems such as Linux is now used in major corporations around the world to run mission critical applications such as ERP and Database systems, while majority of Internet web servers run on Apache webservers and BIND

DNS servers. This explosion in the use of open source software led to Microsoft terming Linux as a major competitive threat in a leaked internal memorandum in 1999 (Nuvolari)

2.3 Open Source Software Environment

Open source software is in use across various industries for both desktop and server environments (Kusnetzky & Gillen, 2004). The emergence of Linux as a popular operating systems has specifically lead to this use. Other software applications both at server and desktop environments have gained popularity as a result of Linux adoption (Nathaniel, 1999).

2.3.1 Open Source in Server Environments

Server applications are backend software that clients in a networked environment request for various services such as web, email, domain name service etc. The impact of open source software has majorly been felt for server application especially for network infrastructure services such as DHCP, DNS and FTP service. Other major services include file servers, firewalls, domain controllers and network management servers. The Internet which is also built in a server-client model has also seen significant impact through OSS. According to Netcaract, a web statistics company Apache and Nginx which are open source web server hold over 66% of web servers serving content on the Internet as at September 2014 (Netcaract, 2014). This is significant and shows the impact these two web server applications on the Internet. BIND, a DNS software also is believed to control a sizable number of domain names as well (Theunissen, Boake, & Kourie, 2004) and DNS resolution servers.

Email service is also an important part of any modern organization. A variety of OSS solution are available today to play different function for a complete functional email system. For SMTP service, OSS applications such as sendmail, qmail, exim and the most popular being postfix are widely used today. IMAP and POP3 solutions are also available as OSS with solutions from vPOPMail and Cyrus playing their role for this functions. Database applications have also been significantly impacted by the OSS evolutions. Popular database applications such as PostgresSQL and MariaDB are widely used today for enterprise solutions. So advanced are these database application that Oracle, a major vendor of proprietary databases acquired MySQL, another popular open source database in 2009 raising a series of substantial competitive concerns (Vezzoso, 2011)

In the case of business supporting software there are solutions that are open source as well that are used for ERP, CRM and billing systems with applications such as Sugar CRM being popular with enterprises. There is indeed no part of server applications that open source software is lacking. Voice and data networks are also converging and through this there is also emergence of open source applications such as Asterisks and SipX that are playing a significant role for these services. This convergence heralds a new era where telecommunications companies must explore the need to adopt OSS otherwise new competitors are likely to emerge who's cost of operation is expected to be much lower hence able to charge much less for the same level and quality of services.

2.3.2 Open Source in Desktop Environments

The use of Open Source in desktop environment has also continued to grow despite proprietary software such as Window operation systems and office suites having a large user base compared to OSS. Uptake of Linux for example for desktop use has been to less than 20% of total user base (Vile & Atherton, 2009). According to (Dalvit, Terzoli, & Wolff, 2008) companies such as Canonical have started to even localize popular desktop application such as Ubuntu for use in countries such as South Africa showing growing interest in Open Source for desktop use. Other application however such as web browsers have seen a much higher uptake in the desktop environment. Firefox for instance is widely used by all type of computer users ranging from technical savvy to novice users. Other application that have seen good uptake include office applications such as open office and libre office which are an alternative to the Microsoft office suite.

2.4 Challenges of Open Source Software Adoption

For technical manager in the telecommunication industry, quality of service is a major pain area. Whichever solution that they deploy on their network, critical qualities such as scalability, availability and support are factors that they must consider. It is therefore important as they consider OSS for some of their needs to consider potential challenges that is associated with OSS. One of the potential challenges of OSS adoption is fragmentation of the OSS software usually as a result of conflict among developers, poor or lack of documentation, features creep and lack of friendly user interfaces (Liu, 2007). With this level of fragmentation, telecommunications companies will find it challenging to run their mission critical services on fragmented solutions.

Another major area of concern for telecommunication managers is support of the OSS applications. For proprietary software, one pays high fees to use the software as only the vendor of the applications has exclusive rights to the source code and can therefore be the only one to support it (Hasan, 2009). By paying the high support fees, vendors of the solution can therefore afford to have priority support extended to the telecommunication company. Some vendors of proprietary applications even afford to have on-site support who are exclusively available to the customer throughout the day.

However, for OSS, support in most cases would be charged at a small fee by companies that specialize on integrating the applications. Most of these companies lack the required level of support to be available on demand across the globe making it a challenge for telecommunication companies to rely on this level of support. Closely tied to support is lack of proper documentation for open source applications. This is attributed to the fragmented OSS software development discussed earlier. There is also unclear liability and responsibility for OSS software. Most of these applications are downloaded from the Internet without clear ownership and responsibility. Telecommunications companies fear ending up in situations with unclear liability where they will be unable to influence the provider of the applications where they would end up without clear support (Øyvind, Daniela, Reidar, Ketil, & Tron André).

Hidden costs is another area of challenge for those adoption OSS. It takes time to evaluate the software to find the right mix of solutions. Other costs that are usually hidden is the extensive user training and customization that may be done to ensure the

applications are delivering the required functionality. Some organizations that have adopted OSS have had to spend money on developer communities as sponsorships which was not a cost they had initially budget for. Licensing models are also very challenging for most organizations adoption OSS. A variety of licenses are available and guidance is required on how to interpret them. When required to integrated OSS and proprietary software there arises challenges on limitation of whichever licenses that guide both environments.

Lastly, lack of products is another challenge facing organizations that adopt OSS. While there may be a variety of OSS available for majority of business needs there still lacks OSS for specific requirements (Øyvind, Daniela, Reidar, Ketil, & Tron André) that businesses may require at that point in time leading to proprietary software which can be custom made based on customer requirements to fulfil the need.

2.5 Benefits of Open Source Software Implementations

Organizations around the world are saving millions of dollars through adoption of OSS and most of this were large companies with turnover of USD 50 million and above (Stephen, Dave, & Bruno, 2005). The use of open source software to save cost has generated great interest to a level where finance and other business executives are starting to ask how open source can help them reduce the burgeoning IT costs and gain clout over vendors of proprietary software. Cost reduction has been cited as among the major reason for adoption of OSS by organizations (Øyvind, Daniela, Reidar, Ketil, & Tron André). Advocates of OSS also claim that due to lack of licensing fees with OSS, then the total cost of ownership is reduced or eliminated

altogether. There however remains other associated cost due to adoption of OSS such as training of staff and any customization that may be required and this needs to be factored in before a conclusive position can be made. (Mohammad, Li, Guang, & Varun, 2005)

Open source software by its nature also means that the users of the applications have access to the source code. This brings great flexibility to the software as users can modify the applications to suit their needs. OSS also advocates for modularity which means a portion of the program can be designed, developed and tested relatively independent of the rest of the applications (Mohammad, Li, Guang, & Varun, 2005). This brings the much needed flexibility in the approach to applications use. Modularity also promises shorter development cycles and thus more robust products expected with OSS. Modularity also ensures that different developer communities can work on independent part of the larger applications which ensures that the time to deliver an open source project can be shortened significantly. The telecommunications industry around the world is also dominated for a few big players (Howard, 2013). Without open source, this is unlikely to change and telecommunications companies will be stuck with proprietary hardware and software which is locked and therefore expensive to buy and maintain.

According to Jim Zemlin, an executive director at the Linux foundation, open source has been proven to accelerate innovation (Linux-foundation, 2014). With OpNFV, service providers are expected to licenses through open source Apache license which will ensure that there will be no vendor lock-in and any contribution made to applications will be available to the community. Other projects driving independence from vendor locking include Open Daylight which is quickly becoming a de facto

software defined networking platform based on open source, OpenStack which is a cloud platform driving adoption of network function virtualization in the telecommunications industry and Open Switch which is an open source switching application (Linux-foundation, 2014)

OSS adoption also leads to open innovation which means that companies should make greater use of external ideas and technologies in their own businesses while letting their unused ideas be used by other companies (Birudavolu & Nag, 2011). Open innovation leads to faster time to market, cheaper cost of developing new services and reducing the risk involved in new business models. Telecommunication industry being service oriented greatly benefits from open innovation where services can be moved online and onto the cloud with more integration to device, mobility and business intelligence. Also, as products and services gets commoditized and become utility, there will be less and less competitive advantage tied to product differentiations. This reinforces the need to develop a culture of open innovation. With open innovation, there is need to move away from linear thinking to more exponential possibilities which can only happen in an open innovative culture. Product and services will also greatly benefit from a push approach where companies imagine they understand customer needs and hence proceed to manufacture what they believe is best for their customers to a pull approach where there is deeper understanding with the customers (Birudavolu & Nag, 2011)

Open source software is also believed against common misconception to be more secure than proprietary software as users of this software do not have to wait for the vendor of the applications to patch once vulnerability have been discovered. Users also have access to the source code and can therefore modify it at will. Once

vulnerabilities are discovered, they are communicated to the community and fixed in much shorter cycles than it would be the case with proprietary software (Mohammad, Li, Guang, & Varun, 2005). Having the software as open source also means that there is continuous and broad review of the source code by a larger community of users. This increases the chance of identification and elimination of software bugs that could have otherwise taken longer to be discovered. Organizations store a lot of information about their business. This could range from information about their customers, financial data, network statistics etc. In most of these cases, the information is usually sensitive and private and it's therefore critical to store it in formats that will be accessible in years to come. Open standards adopted by open source applications therefore ensures that these type of data will remain independent of any private interest which is very likely in the case of proprietary software. If a company was to adopt proprietary formats for such data, there is likelihood of vendors of such applications to take advantage of this and lock-in the companies that have purchased this kind of proprietary applications. Open source developers have often favored open standards because they ensure interoperability (Hwang, 2005) which is at the core of open source movement.

2.6 Empirical Studies on Open Source Software

In studying adoption of open source adoption, other researchers have done studies in in other countries where there has also been use of open source for various industries with telecommunications companies adopting open source for emerging services such as Cloud (Linux-foundation, 2014) with operators such as Telefonica deploying Openstack for customer focused cloud services (Clarke, 2015). Other industries that have adopted OSS include hospitals in the states of Maryland, Washington and

Northen Virginia in the United States where 27% had adopted OSS for general purpose application such as databases, operating systems and web development tools (Cornejo, Seaman, & Koru, 2007). Diomidis & Vaggelis (2009) investigated the use of open source in large US companies and found out that at least 94% of companies were using at least one open source software mainly related to web servers.

Locally, 97% of banks had adopted open source software for some desktop services and 67% for some server applications such as web servers only 8% used open source software exclusively (Githaiga, 2012). Research of OSS use in cybercafés (Kamau, 2011) found out that 87% use some form of OSS software but maily limited to desktop applications for web browsers. There is limited use of OSS in government (King'oina, 2012) with a paltly 5% of government instituitons using some form of open source software.

2.7 Open Source Software in Kenya

Open source software provides developing economies such as Kenya the opportunity to fast track the development of the growing ICT industry. The discussed advantages of OSS such as lower cost of ownership, increase software flexibility, open innovations and independence from software vendors can be of great value to industries that harness the power of technology to leverage on OSS to grow their companies.

In Kenya, open source use is growing. Many companies especially small and medium enterprises (SMEs) have adopted OSS in order to manage their costs in this era of reduced IT budgets and increase costs (Sunday, 2012). Adoption of OSS in Kenya is

also seen as a solution to the rampart software piracy in the country. Additionally, adoption of OSS in Kenya is shown by the establishment of community solutions that have specialized in deployment of open source software to support endeavors such as humanitarian solutions in Kenya and beyond. A popular example is Ushahidi Inc which develops non for profit software an example being Ushahidi which was deployed to monitory the 2007 general elections in Kenya to enable citizens, civil society, election observers and law enforcement agencies to monitor incidence in real time and take actions when necessary. The application was later used for similar functions in Haiti and Chile during the earthquake in 2010 (Giridharadas, 2010). This underscores the impact of open source even with origin from developing nations like Kenya.

2.8 Theoretical Foundation

There are several theories that have been established in relation to technology adoption. Two major ones that will be useful for this research are Technology Acceptance Model and Technology-Organization-Environment Framework which are discussed in greater detail below.

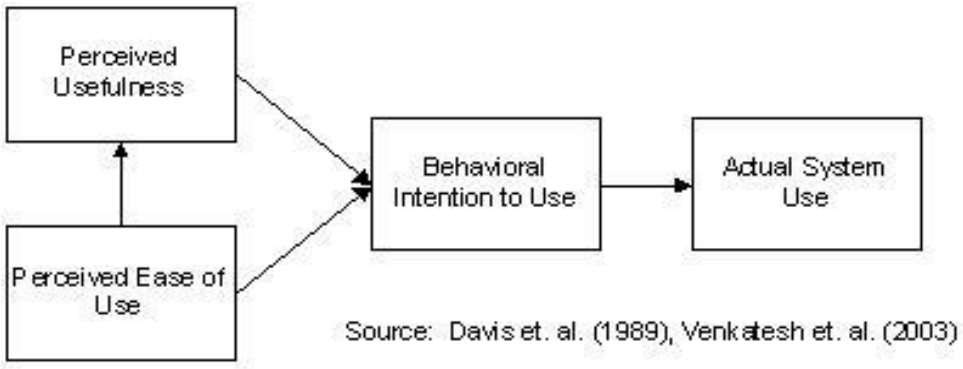
2.8.1Technology Acceptance Model in Relation to OSS Adoption

Technology Acceptance Model was developed to address system usage by facilitating understanding of factors and reasons that determine the use and adoption of new systems. It examines the mediating role of perceived ease of use and perceived usefulness in their relationship between systems characteristics and the probability of systems use (Legrisa, Ingham, & Collerette, 2001). Technology Acceptance Model has strong behavioral characteristics which assume that when someone has intention

to act, they will be free to do so without limitation but in practice constrains such as limited ability, time, environmental or organizational limits as well as unconscious habits will limit the freedom to act (Venkatesh, 2003).

The major objective of this study is to determine why the telecommunications industry in Kenya despite all the benefits related to the use of open source software are believed to be slow to adopt open source software for their operations despite the maturity of some open source applications that have been extensively deployed to build core Internet infrastructure and run research organization for a good number of years. Perceived usefulness will be outlined through benefits that accrue as a result of the use of open source discuss earlier such as cost efficiency, increase flexibility, independence from vendors, open innovation and future interoperability. Perceived ease of use shall be reflected by familiarity of users of the applications to open source technologies, availability of software support by the open source community as well as companies that have specialized in supporting open source and ability to modify the source code to meet the desired business need. The theory of Technology Acceptance Model is illustrated by the figure below

Figure 2.1: Conceptual Framework



Source: http://istheory.byu.edu/w/images/9/90/Tam.JPG

2.8.2 Technology-Organization-Environment Framework

This framework studies adoption of technology innovation at organizational level and provides the process by which firms adopt and implement technological innovations which according to this theory is influenced by technological context, the organizational context and the environmental context. Technological context refers to technologies that are relevant to firms, organizational context generally refers to organizational characteristics such as size, scope and resources available within a firm while environmental context involves the macro-environment in which a firm conducts its business, including industry, competitors, and the regulatory environment (Tornatzky & Fleischer, 1990).

2.9 Summary of Literature Review

With increase competition in the telecommunications industry mainly driven by the rise of over the top services (OTT) as well as the entry of new players through mobile virtual network operators' licensing, incumbent telecommunications companies are force to relook at their operating models. There is urgent need to reduce operating costs as well as capital expenditure on network services. With software requirements mainly for proprietary applications driven by the main providers of telecommunication solutions accounting for a large part of that budget, open source then becomes an attractive option to contain costs.

In addition to the benefits associated with cost savings, there are other benefits such as independence from vendors, open innovation, increase flexibility, and future operability that make it attractive for telecommunication companies to adopt open source despite challenges that may be associated with adoption of these applications

such as fragmentation of the applications, lack of clear ownership and responsibility as well as unclear support for the applications.

There is little study known to the researcher that focuses on open source adoption specifically for telecommunication companies in Kenya. Previous studies have focused on banks, government and cyber cafes. This presents a gap in the existing knowledge that this study will seek to fulfil.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

This study involved a descriptive research to gather information on the extent of open source software adoption by Kenyan telecommunications companies as little data is known to exist on this topic. A cross-sectional study was conducted during the month of September 2015 to collect the data. The survey entailed investigation on the extent of functions that have been deployed with open source software for desktop and server environments in the industry. Benefits that have been realized as well as challenges that have been faced by adoption of OSS by the telecommunications companies were also be investigated.

3.2 The Population

The population of this study constituted technical departments of the four mobile service providers in Kenya. This were Safaricom, Airtel, Equitel and Orange Kenya.

3.3 Data Collection

The survey made use of a questionnaire that had both open and closed ended questions sent to 50 respondents across various departments with 30 for Safaricom, 10 for Airtel and 6 for Orange Kenya and 4 for Equitel based on the latest market share (CAK, 2015). The survey was limited to technical staff and managers within these three operators as they are responsible for selection of software to deploy in their networks with bias to the technical features such as open source or proprietary. Likert scale was also used for some of the questions where appropriate. The questionnaire had the following four sections. Section A collected demographic data which

identified the age, gender and level of education of the respondents and size of organization and departments they worked for. Section B collected information on the extent of Open Source adoption within the organization and any future plans for use of open source. Section C identified the benefits of adoption of Open Source by the organization. Section D covered the challenges faced as a result of adoption of Open Source applications. Google forms which is a free online survey tool was exclusively used as the mode of data collection.

3.4 Data Analysis

Data that was collected was validated, edited and coded accordingly then summarized using the following. Section A was analyzed using frequencies and percentages and classified using charts and graphs. Section B, C and D was analyzed using frequencies and means and represented using tables. Tools used in analysis were Microsoft Excel and SPSS.

CHAPTER FOUR: EMPIRICAL RESULTS

4.1 Introduction

In this chapter, findings of the study are discussed; descriptive statistics and detailed descriptions about the survey participants and organizations are provided. A summary of findings is reported which discusses the findings in relation to the research objectives and the implications for OSS adoption in the telecommunications industry in Kenya.

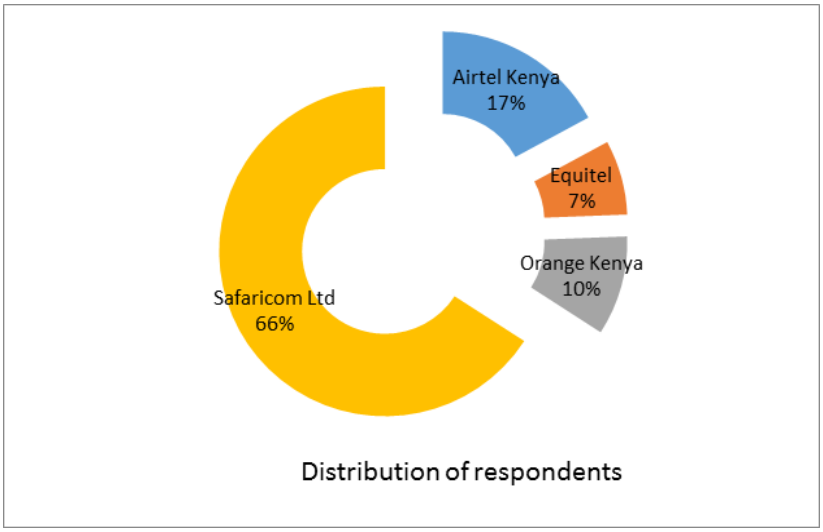
4.2 Descriptive Statistics

Descriptive statistics are used to summarized data in way that is useful to the intended users. Various measures of data such as frequency, means and percentages will be used to summarize the findings in the following sections.

4.2.1 Distribution of the Respondents

The total number of respondents from the four telecommunications companies who completed the survey was 41 indicating a response rate of 82%. The following table presents the demographic characteristics of the respondents.

Figure 4.1: Distribution of Respondents by Company



Majority of the respondents (31.7%) were System Engineers, 14.6% Network Engineers and an equal number of Network Managers and Security Engineers at 12.2%.

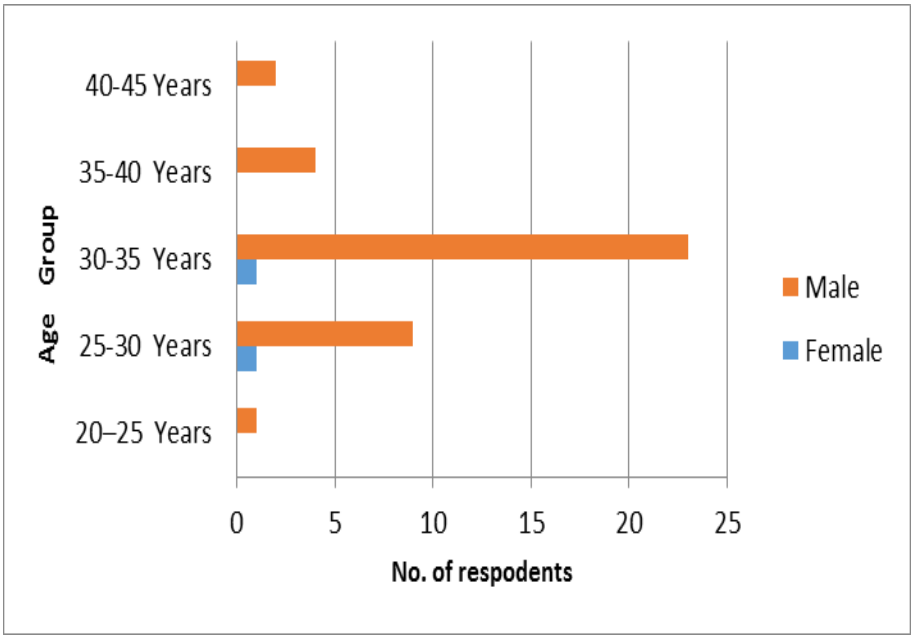
Table 4.1: Profile of the Respondents by Job Function

Occupation	*No. of respondents*	*Percentage*
Network Engineer	6	14.6
Security Engineer	5	12.2
Software Developer	1	2.4
Strategy & Architecture Engineer	1	2.4
Strategy Engineer	1	2.4
Support Engineer	1	2.4
Systems Analyst	3	7.3
Systems Engineer	13	31.7
Technical Manager, Network Systems	5	12.2
Technical Manager, Support Services	4	9.8
Technical, Head of Department	1	2.4

4.2.2 Demographic Characteristics

The distribution of the sampled respondents by age and gender is presented in Figure 4.2. Out of the total sample, 95.1% were male and 4.9% female.

Figure 4.2: Distribution of Respondents by Gender and Age



The results also show that the largest single proportion of the sampled population based on age structure were between thirty and thirty-five years (58.5%) followed by those between twenty-five and thirty years of age (24.4%).

With regard to the years of experience, the respondents had a range of 1 to 8 years of experience in various positions in the companies (Table 4.2). All of the respondents were engaged in various technical domains and thus assumed to be knowledgeable of OSS software's capabilities and utilization.

Table 4.2: Professional Distribution of Respondents

Occupation	*No. of respondents*	*Average years of experience*
Network Engineer	6	2.17
Security Engineer	5	3.4
Software Developer	1	3
Strategy and Architecture engineer	1	7
Strategy Engineer	1	3
Support Engineer	1	5
Systems Analyst	3	4.67
Systems Engineer	13	3.88
Technical Manager, Network Systems	5	3.6
Technical Manager, Support Services	4	7.5
Technical, Head of Department	1	8

4.3 Survey Results

The results indicate that 100% (n=41) of the companies within the survey sample have adopted OSS. All of the companies have adopted both desktop applications and server OSS (Figure 4.3). Of the total number of respondents interviewed, 68.3% use open source in both servers and desktop applications and only 24.4% and 7.3% use only servers and desktop applications respectively.

Figure 4.3: Application of Open Source Software

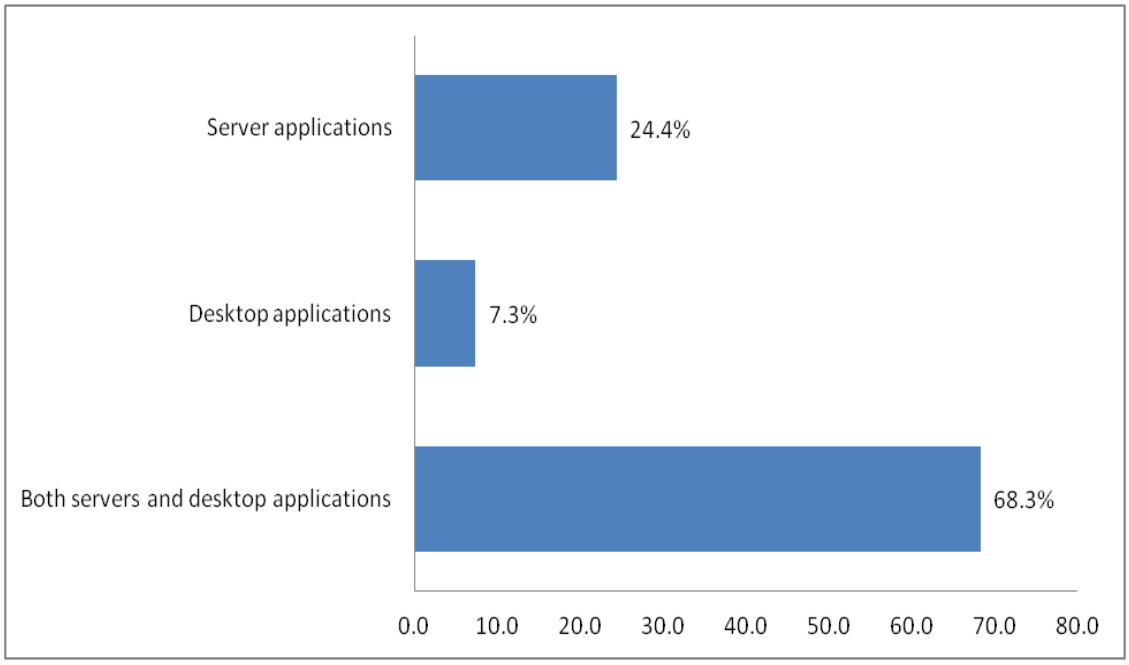


Table 4.3: Adoption of OSS by Department

Department	Both servers and desktop applications		Proportion of total %	Desktop applications		Proportion of total %	Server applications		Proportion of total %
	Count	%		Count	%		Count	%	
Engineering	6	75.0	21.4	0		0	2	25.0	19.5
Enterprise services	1	25.0	3.6	1	25.0	33.3	2	50.0	9.8
IT services	12	80.0	42.9	1	6.7	0	2	13.3	36.6
IT/ Network security	5	71.4	17.9	0		0	2	28.6	17.1
Network Support and Services	2	66.7	7.1	0		0	1	33.3	7.3
Product development & Innovation	2	66.7	7.1	0		0	1	33.3	7.3
Strategy and Planning	0		0	1	100	33.3	0		2.4

The study findings show that majority (42.9%) of IT Services departments of telecommunication companies used both server and desktop applications as compared to Strategy and Planning departments that did not use OSS in both server and desktop environments. IT services and Engineering departments had the highest levels of adoption of server applications at 36.6% and 19.5% respectively.

Data analysis using chi-square test revealed a statistically significant association between department and preferred OSS (chi-square value =19.46, p=0.078). This implies that there is evidence of significant relationship between telecommunication department and adoption of OSS (Table 4.4).

Table 4.4: Chi-Square Tests on Departments and Decision on OSS Adoption

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Phi Value	Cramer's V
Pearson chi-square	19.461a	12	0.078	.107	Value: 0.689	Value: 0.487
Likelihood ratio	13.106	12	0.361	.432	Approx. Sig:0078	Approx. Sig:0.078
Fisher's exact test	13.124			.263	Exact Sig: 0.107	Exact Sig 0.107
No. of valid cases	41				41	41

a. 19 cells (90.5%) have expected count less than 5. The minimum expected count is .07.

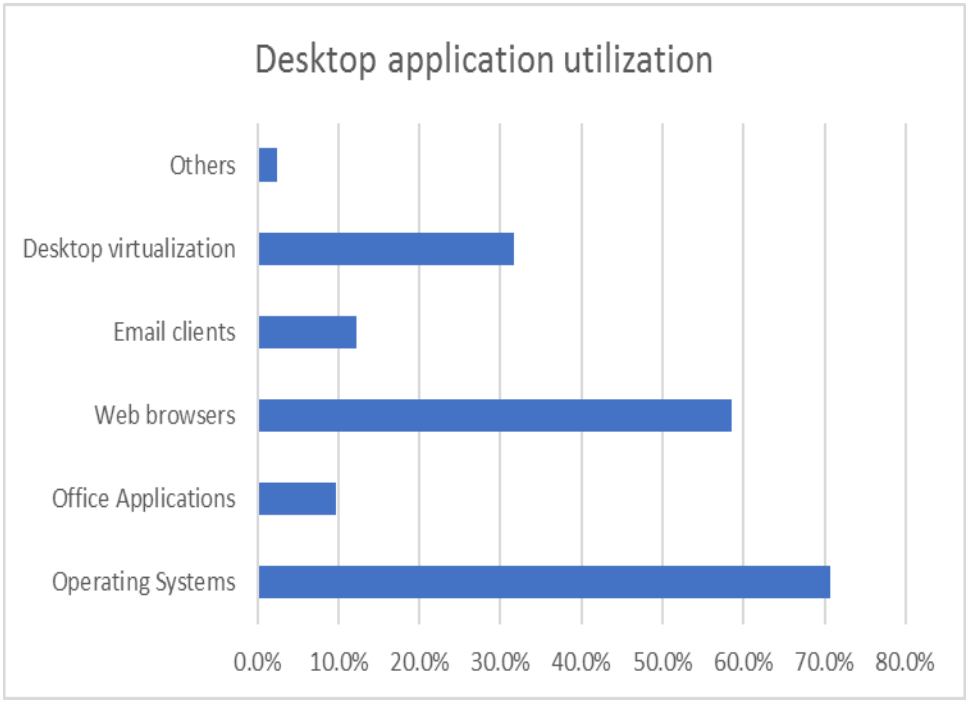
4.3.1 Adoption of Open Source Desktop Applications

Respondents were asked which open source desktop applications were being used in their departments. Table 4.5 shows the extent of implementation of various applications.

Table 4.5: Desktop Applications Adoption

Desktop Applications	*Frequency*	*Percentage*
Operating Systems	29	70.7%
Office Applications	4	9.8
Web browsers	24	58.5%
Email Clients	5	12.2%
Desktop Virtualization	13	31.7%
Others	1	2.4%

Figure 4.4: Desktop Applications Adoption



The results indicate that among the various desktop applications, operating systems such as Linux are the most popular (70.7%), with web browsers such as Firefox (58.5%) second, followed by desktop virtualization applications (31.7%). There is little adoption of office applications (9.8%) and email clients (12.2%) which may be attributed to the dominance of Microsoft office applications (Roe, 2013).

Data analysis revealed there was no significant relationship between the user department and adoption of open source desktop applications (chi-square value =81.57, p=0.369). However, the chi-square test revealed a statistically significant association between telecommunication companies' ownership structure and OSS desktop adoption (chi-square value =18.99, p=0.055) (Table 4.6).

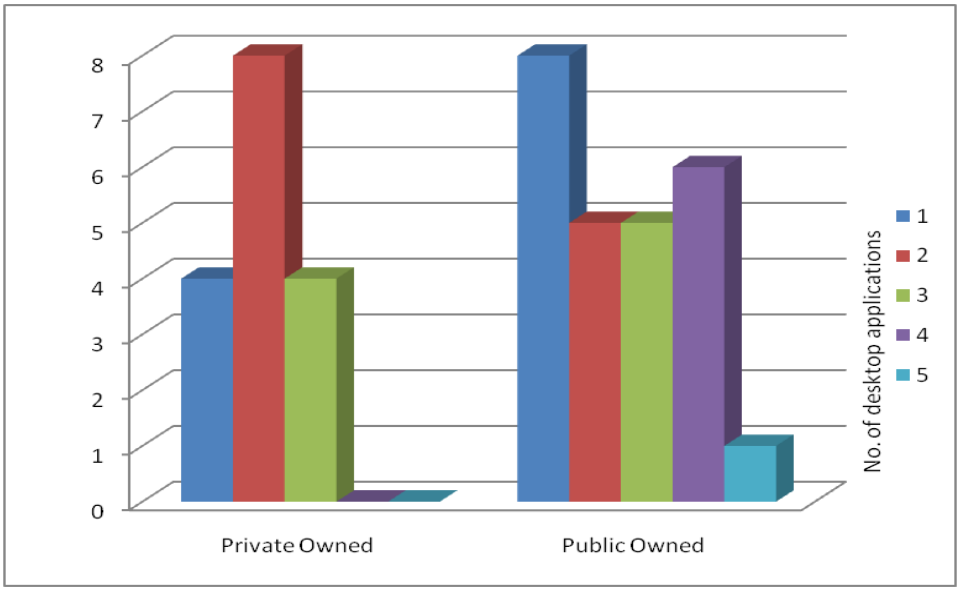
Table 4.6: Chi-Square Tests on Organizational Structure and OSS Desktop Adoption

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Phi Value	Cramer's V
Pearson chi-square	18.996a	13	0.123	0.055	Value: 0.681	Value: 0.681
Likelihood ratio	24.273	13	0.029	0.056	Approx. Sig:0.123	Approx. Sig:0.123
Fisher's exact test	16.903			0.075	Exact Sig: 0.055	Exact Sig 0.055
No. of valid cases	41				41	41

a. 27 cells (96.4%) have expected count less than 5. The minimum expected count is .39.

Open source desktop adoption occurred mainly in publicly owned companies, with average adoption of 5 desktop applications and systems as compared to the adoption of 3.2 applications by privately owned companies (Figure 4.6).

Figure 4.5: Number of Desktop Applications and Systems Adoption by Company Ownership



These findings are consistent with Almeida (2009) who argues that the delay to adopt OSS may be due to hefty investments made on proprietary software and perception over open source risks. In addition, privately owned telecommunications' companies are believed to have stringent company policies on what software they use on the desktop applications. The same may not necessarily apply for publicly owned companies.

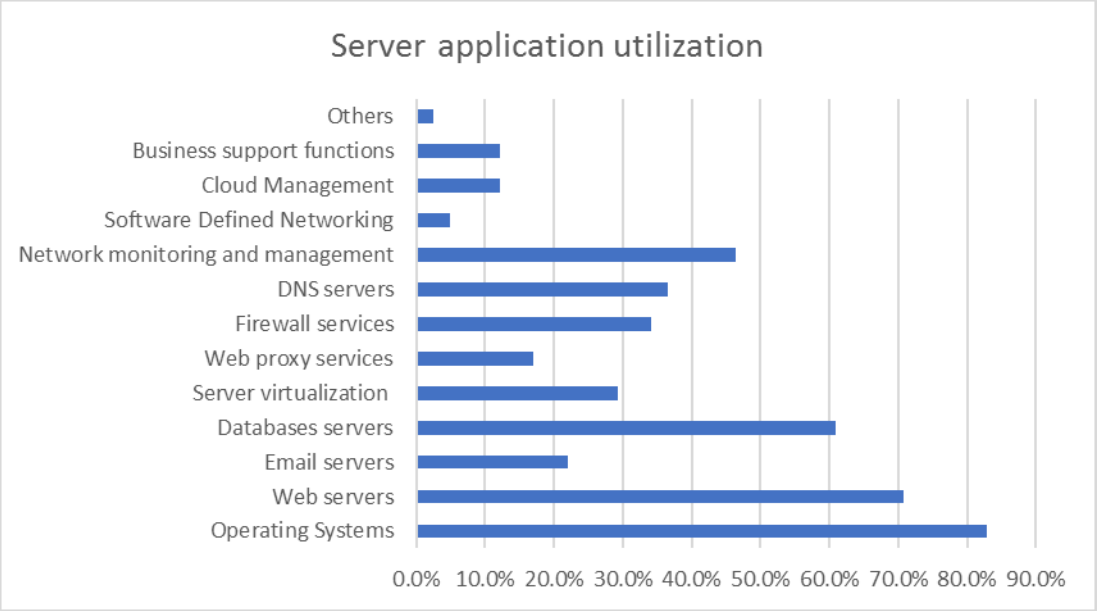
4.3.2 Adoption of Open Source Server Applications

Respondents were asked which open source server applications were being used in their departments. Table 4.7 shows the extent of implementation of various applications.

Table 4.7: Combined Utilization of Various Open Source Server Applications

Server Applications	Frequency	Percentage
Operating Systems	34	82.9%
Web servers	29	70.7%
Email servers	9	22.0%
Databases servers	25	61.0%
Web proxy services	7	17.1%
Firewall services	14	34.1%
DNS servers	15	36.6%
Network monitoring and management	19	46.3%
Software Defined Networking	2	4.9%
Cloud Management	5	12.2%
Business support functions	5	12.2%
Others	1	2.4%

Figure 4.6: Server Applications Adoption



Results show that OOS server applications for various services were also widely used. The data shows that operating systems (82.9%), web servers (70.7%) and database server (61%) were the most widely used open source applications. Software defined networking (4.9%), Cloud management (12.2%) and Business support function (12.2%) were the least used applications.

A comparison based on the company's department was made of the different server uses (Table 4.8). The results show there is no significant association between the company's department and adoption of open source domain applications (chi-square value =2.117E2a, p=0.239). It is therefore adequate to conclude that the user specific department is not essential in determining domain specific adoption.

Table 4.8: Chi-Square Tests on Department and OSS Server Adoption

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Phi Value	Cramer's V
Pearson chi-square	2.117E2a	198	.239	.b	Value: 2.273681	Value: 0.928
Likelihood ratio	125.301	198	1.000	.220	Approx. Sig:239	Approx. Sig:239
Fisher's exact test	263.419			.220		
No. of valid cases	41				41	41

a. 238 cells (100.0%) have expected count less than 5. The minimum expected count is .02.

The Pearson's chi-square test also revealed that there was no significant association between company ownership and adoption of server applications and systems (chi-square value =36.80, p=0.297). The findings therefore suggest that the company structures did not affect the decision on OSS server/domain technology adoption.

Table 4.9: Chi-Square Tests on Organizational Structure and OSS Server Applications Adoption

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Phi Value	Cramer's V
Pearson chi-square	36.798a	33	0.297	0.113	Value: 0.947	Value: 0.947
Likelihood ratio	49.301	33	0.034	0.113	Approx. Sig:0.297	Approx. Sig:0.297
Fisher's exact test	34.109			0.113	Exact Sig: 0.113	Exact Sig 0.113
No. of valid cases	41				41	41

a. 68 cells (100.0%) have expected count less than 5. The minimum expected count is .39.

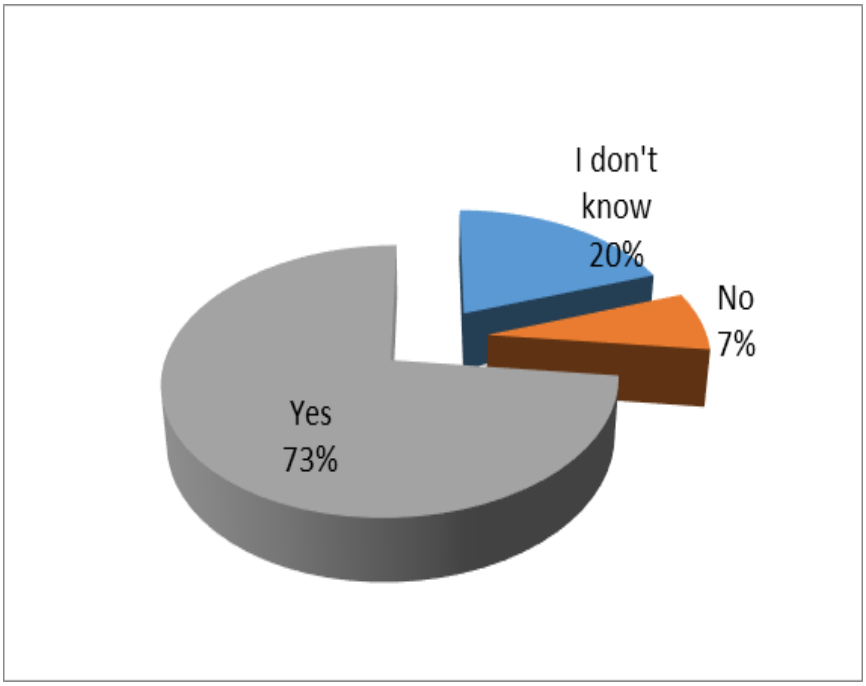
The finding may be attributed to the fact that telecommunication companies spend significant financial resources on server applications as compared to desktop applications. In an effort to manage these costs, it is possible that irrespective of the ownership structure, there is a shared need to adopt OSS at the server level as a measure to manage such costs.

4.3.3 Future Trends of Open Source Adoption.

The respondents were further asked about their future company plans in regard to use of OSS. Majority (73%) indicated that they intend to increase or begin using various OSS in future, whereas only 7% had no plan to adopt OSS (Figure 4.6). This signifies

a rising trend towards telecommunication companies intensifying their use open source in the future.

Figure 4.7: Adoption of Open Source Software in Future



Intention to use open source in future was measured using a 5-point Likert scale ranging from 1 (least extent) to 5 (large extent) and shown in Table 4.10. The data shows that telecommunication companies had a mean score of 2.73 and therefore intended to use open source in future.

Table 4.10: Plan to Increase OSS Applications Adoption

	LEAST EXTENT (1)		2		3		4		LARGE EXTENT (5)		MEAN SCORE
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
a) Operation Systems such as Linux, FreeBSD			1	2.4	3	7.3	2	4.9	22	53.7	3.46
b) Email service applications such as Postfix and Exim	8	19.5	5	12.2	7	17.1			6	14.6	1.69
c) Database service applications e.g MySQL, MariaDB, PostgresSQL			3	7.3	5	12.2	5	12.2	14	34.1	2.71
d) Server virtualization applications such KVM			3	7.3	6	14.6	10	24.4	8	19.5	2.54
e) Web proxy services such as Squid			8	19.5	9	22.0	4	9.8	4	9.8	1.93
f) Firewall services such as IPTables, Firewalld	2	4.9	8	19.5	7	17.1	3	7.3	7	17.1	2.10
g) DNS Service applications such as BIND, UNBOUND and NSD	1	2.4	3	7.3	7	17.1	4	9.8	12	29.3	2.56
h) Network monitoring & management applications such as Zabbix, Cacti, Nagios etc.			4	9.8	2	4.9	6	14.6	15	36.6	2.80
i) Software define Networking such as OpenDaylight	1	2.4	5	12.2	3	7.3	8	19.5	9	22.0	2.37
j) Cloud management applications such as OpenStack & CloudStack	1	2.4	3	7.3	3	7.3	10	24.4	13	31.7	2.95

k)	Business support functions such as CRM, Billing, Data analytics			10	24.4	9	22.0	3	7.3	5	12.2	2.05
l)	Desktop Applications such as Firefox, Open Office etc	1	2.4	1	2.4	5	12.2	6	14.6	15	36.6	2.85

The findings revealed that open source operating systems, cloud applications, desktop and network monitoring and management applications were the most likely to be adopted (Table 4.10).

4.4 Perceived Benefits of OSS

The perceived benefits of adopting OSS can be largely categorized either as being financial, technical or business as ranked by the number of respondents citing them as being relevant to the adoption decision are outlined below. Respondents were asked several questions relating to their perceptions towards benefits realized through open source on a five point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Table 4.11 presents the number of responses for each rating and the corresponding percentages.

Table 4.11: Benefits of OSS Applications

Benefits	Strongly Disagree (1)		2		3		4		Strongly Agree (5)		Mean score
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
a) Open source has saved the company money that would have been used in purchasing and supporting proprietary solutions.	1	2.4	1	2.4	5	12.2	7	17.1	27	65.9	4.41
b) Open Source applications have increased flexibility of software as we can modify the source code as we wish.	2	4.9	4	9.8	14	34.1	11	26.8	10	24.4	3.54
c) We have avoided vendor lock-in with Open Source which has brought freedom in use of software.	2	4.9	1	2.4	6	14.6	15	36.6	17	41.5	4.05
d) The company is more innovative as a result of use of Open Source.			11	26.8	13	31.7	11	26.8	6	14.6	3.31
e) Open source has scaled well for majority of applications.			8	19.5	20	48.8	9	22.0	4	9.8	3.24
f) Increase security e.g. almost free from viruses	4	9.8	9	22.0	15	36.6	9	22.0	4	9.8	2.93
g) Open source is available on demand from the Internet.			2	4.9	8	19.5	15	36.6	16	39.0	4.12
h) Availability of support from a large community of users	3	7.3	3	7.3	10	24.4	14	34.1	11	26.8	3.61
i) Variety of open source applications for various needs			2	4.9	13	31.7	11	26.8	15	36.6	3.98

Financial gains were reported as being very significant especially in saving the company resources that would have been otherwise used in purchasing and supporting proprietary solutions. The cost saving aspect is of importance to companies operating in a competitive environment such as the telecommunication's industry at present. Second to that was availability of open source on demand from the Internet, the removal of vendor lock-in, and increased flexibility as the third and fourth core benefits of adoption. This implies that there is convenience and perceived ease of use by being able to access the software and modify source code that allows the customization of OSS to a company's specific requirements and product innovation.

4.5 Challenges in Adoption of Open Source

Table 4.12 shows the responses relating to factors inhibiting OSS adoption using a 5-point Likert scale. The findings indicate that lack of executive support, lack of proper software support, lack of quality guarantee, ownership and inability of OSS to run critical telecommunication services are hindrances to the adoption.

Table 4.12: Factors Inhibiting OSS Adoption

Challenges	Strongly Disagree(1)		2		3		4		Strongly Agree (5)		Mean score
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
a) Lack of proper support for the applications	2	4.9	4	9.8	8	19.5	14	34.1	13	31.7	3.76
b) Lack of executive support for open source applications	1	2.4	3	7.3	5	12.2	11	26.8	21	51.2	4.17
c) Majority of our systems are only available as proprietary applications	3	7.3	3	7.3	11	26.8	14	34.1	10	24.4	3.56
d) We do not understand Open Source licensing models	6	14.6	15	36.6	13	31.7	4	9.8	3	7.3	2.46
e) Switching costs from proprietary application to open source are too high	3	7.3	12	29.3	5	12.2	16	39.0	5	12.2	3.15
f) We cannot guarantee quality of service will be achieved with open source software	5	12.2	6	14.6	7	17.1	11	26.8	12	29.3	3.37
g) Open source solutions lack ownership and cannot be relied to run critical telecommunicatio n services.	4	9.8	7	17.1	6	14.6	16	39.0	8	19.5	3.34
h) There is lack of proper documentation with open source software.	5	12.2	11	26.8	18	43.9	6	14.6	1	2.4	2.59
i) We cannot quite establish all costs related to open source adoption.	4	9.8	8	19.5	13	31.7	14	34.1	2	4.9	2.98
j) Our software vendors understand telecom operations and are therefore better placed to develop proprietary applications to run our services.			8	19.5	10	24.4	17	41.5	6	14.6	3.54

These findings are consistent with other studies (Tomas Yakel, 2001) who argued that open source adoption is influenced by executive and managerial involvement and positive disposition in supporting the use of OSS. This study also established that majority of the telecommunication systems being available only on proprietary applications and telecommunication vendors being trusted to run the industry are also major barriers of open source adoption.

Overall, the results indicate that economic gains and open source technical capability are major drivers of adoption while software support, security, quality guarantee, associated migration costs, lack of alternative open source applications and telecommunication equipment vendors are inhibitors of OSS adoption by telecommunication companies in Kenya.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This section presents a summary of the study findings, conclusions and recommendations based on the analysis presented in the previous chapter.

5.1 Summary of the Findings

The objective of this research was to investigate the extent of OSS adoption in telecommunications companies in Kenya, benefits realized as wells as challenges faced with the adoption.

Telecommunication companies in Kenya have adopted various OSS applications, but utilization varied between companies and departments within the telecommunication companies. The cross tabulation tests reveal that majority of the companies use open source in both servers and desktop applications. The analysis reveals that telecommunication department influences adoption of desktop OSS. Among the various desktop applications, operating systems and web browsers were found to be widely used. The results indicate that the company ownership structure within the industry has a substantial influence regarding adoption of desktop OSS.

In regards to server specific applications, the results show that the companies adopted a combined use of operating systems, web servers, database and network monitoring and management applications. The results indicate that user specific department and ownership structure is not essential in determining server applications. The findings

reflect the cost management strategies implemented by the telecommunication companies as mainly leading the adoption of OSS.

5.2 Conclusion

Open source integration into the telecommunication industry has the potential to optimize and reduce costs associated with proprietary software. This study revealed that open source applications are already in operation in all of the telecommunication companies with anticipated economic benefits being the key driver of adoption as compared to technical benefits. Availability of open source on demand, removal of vendor lock-in and increased flexibility also make OSS a very attractive option for the industry. The findings also indicate that lack of executive support for adoption of OSS, lack of support for the OSS software and vendors of telecommunication solutions driving operations of telecommunication companies as major hindrance for the adoption of OSS.

With the rapidly evolving technology and changing consumer patterns that necessitates technological advancements and innovations, open source therefore offers a solution for the telecommunication industry to adapt and manage their costs. This is supported by the large percentage of respondents who plan to adopt new OSS applications or increase the use in the near future. With the rapidly evolving technology and changing consumer patterns that necessitates technological advancements and innovations, open source therefore offers a solution for the telecommunication industry to adapt and manage their costs. This is supported by the large percentage of respondents who plan to adopt new OSS applications or increase the use in the near future.

5.3 Recommendations

From the study, there is need for telecommunication companies to embrace open source software for their operations. There is however need to involve all the key stakeholders in the company, especially the executive, in the adoption decision since lack of executive support was cited as major hindrances of adoption. In addition, capacity building developers of open source software would minimize resistance to adoption since support and quality of OSS was also cited as another major concern hindering the adoption of OSS.

5.3.1 Research Limitations and Areas of Further Research

The research findings and their implications are not without limitations, although industry representation was adequate. Any conclusions are therefore primarily applicable to telecommunication industry but could as well apply for related industries in the technology area but this would require further research. It was not possible to use policy variables such as company specific software policies and a comparison of adopters and non-adopters of open source within the same industry. Other researchers can address these factors and explore this area further.

REFERENCES

Almeida, F. L. (2009). Creation of Value with Open Source Software in the Telecommunications Field.

Birudavolu, S., & Nag, B. (2011, November). A Study of Open Innovation in Telecommunication services: A Review of Literature & Trends. Indian Institute of Foreign Trade.

CAK. (2015). *Quarterly Sector Statistics Report, Third Quarter Of The Financial Year 2014/15.* Nairobi.

Clarke, G. (2015, March 3). *Telefonica seals deal with HP's 'carrier grade' OpenStack phone cloud*. Retrieved from http://www.theregister.co.uk/: http://www.theregister.co.uk/2015/03/03/telefonica_picks_hp/

Cornejo, G. M., Seaman, C. B., & Koru, K. A. (2007). An Empirical Investigation into the Adoption of Open Source Software in Hospitals.

Dalvit, L., Terzoli, A., & Wolff, F. (2008). Open-source software and localisation in indigenous South African languages with Pootle.

Diego , K., Fernando , M. R., Paulo, V., Rothenberg, E. C., Azodolmolky, S., & Uhlig, S. (2014). Software Define Networking: A Comprehensive Survey.

Diomidis, S., & Vaggelis, G. (2009). *Open Source Adoption In Large Us Companies.*

Friedrich, R., Bartlett, C., Gröne, F., & Mialaret, N. (2013). *Enabling the OTT revolution: How telecom operators can stake their claim.* Booz & Company.

Giridharadas, A. (2010, March 13). *Africa's Gift to Silicon Valley: How to Track a Crisis*. Retrieved from The New York Times: http://www.nytimes.com/2010/03/14/weekinreview/14giridharadas.html?_r=0

Githaiga, G. M. (2012). *Open Source Applications in Commercial Banks in Kenya.*

Hasan, N. (2009). *Issues and Challenges in Open Source Software.*

Howard, M. (2013, August 19). *Tight race between Huawei, Ericsson and Cisco at the top of Infonetics telecom vendor scorecard*. Retrieved from Infonetics Research:http://www.infonetics.com/pr/2013/Telecom-Scorecard-Highlights.asp

Hwang, S.-y. (2005). Adopting open source and open standards in the public sector: five deciding factors behind the movement. *Michigan Journal of Public Affairs*.

Kamau, F. M. (2011). *Open Soure Software in Cyber Cafes in Kenya, A survey of Cyber Cafes in Nairobi.*

Kenya Post and Telecommunications Act, CAP 411. (1998).

Kieseppa, I. A. (2002). *Open Source Softwre and Economics.* Helsinki: Helsinki University of Technology.

King'oina, J. M. (2012). *Strategic Interventions to enhance adoption of Open Source Applications and Creative commons licensed Open Content in the Kenyan Government.*

Kovacheva, T. (2008). Information Technologies for Strategic Management. *Information Science and Computing*.

Kumiyo , N., Yasuhiro, Y., Yoshiyuki, N., Kouichi, K., & Yunwen, Y. (2002). Evolution Patterns of Open-Source Software Systems and Communities. *Japan Society for the Promotion of Science*.

Kusnetzky, D., & Gillen, A. (2004). *Linux and Open Source Soft ware as a Desktop Platform.* IDC Research.

Legrisa, P., Ingham, J., & Collerette, P. (2001). Why do people use Information Technology? A critical review of the technology acceptance model. *Information & Management*.

Linux-foundation. (2014, Septemeber 30). *Telecom Industry and Vendors Unite to Build Common Open Platform to Accelerate Network Functions Virtualization*. Retrieved from http://www.linuxfoundation.org/: http://www.linuxfoundation.org/news-media/announcements/2014/09/telecom-industry-and-vendors-unite-build-common-open-platform

Liu, H. (2007). *Examining Open Source Telecommunications.*

Matinde, V. (2015). *Equity Bank MVNO moves in on Kenya's mobile money market - See more at: http://www.itwebafrica.com/mobile/309-kenya/234445-equity-bank-mvno-moves-in-on-kenyas-mobile-money-market#sthash.9ZSuJaz8.dpuf*. Retrieved from IT Web Africa: http://www.itwebafrica.com/mobile/309-kenya/234445-equity-bank-mvno-moves-in-on-kenyas-mobile-money-market

Mohammad, A., Li, Z., Guang, R., & Varun, G. (2005). *Open Source: Concepts, Benefits, and Challenges.*

Nathaniel, A. (1999). The Emergence of the Linux Operating System.

Netcraft. (2014, September). *http://news.netcraft.com/*. Retrieved from September 2014 Web Server Survey.

Nuvolari, A. (2005). Open Source Software Development, Some Historical Perspectives. *Eindhoven Centre for Innovation Studies*.

Øyvind, H., Daniela, S. C., Reidar, C., Ketil, S. V., & Tron André, S. (n.d.). *Risks and Risk Mitigation in Open Source Software Adoption: Bridging the Gap between Literature and Practice.*

Republic of Kenya. (2013). The Kenya Information and Communications Amendment Bill.

Roe, D. (2013, October 23). *Microsoft Office Is Still the Productivity Suite Leader*. Retrieved from CMS Wire: http://www.cmswire.com/cms/document-management/microsoft-office-is-still-the-productivity-suite-leader-022908.php

Stephen, W., Dave, G., & Bruno, V. R. (2005). *The Growth of Open Source Software in Organizations.* Optaros Publications and Thought Leadership.

Sunday, F. (2012, January 11). *SMEs opt for free and open source software to cut costs*. Retrieved from http://www.businessdailyafrica.com/: http://www.businessdailyafrica.com/SMEs-opt-for-free-and-open-source-software-to-cut-costs-/-/1248928/1303852/-/lgibtqz/-/index.html

The Kenya Information and Communications Amendments Bill. (2013).

Theunissen, W., Boake, A., & Kourie, D. (2004). A Preliminary Investigation in the Impact of Open Source Software on Telecommunication Software Development. *University of Pretoria*.

Tornatzky, L., & Fleischer, M. (1990). *The processes of technological innovation.* Lexington Books.

Venkatesh, V. M. (2003). User Acceptance of Information Technology: Toward a Unified View. *User Acceptance of Information Technology: Toward a Unified View*. Retrieved from IS Theory: http://istheory.byu.edu/wiki/Technology_acceptance_model

Vezzoso, S. (2011). Open Source and Merger Policy: Insights from the EU Oracle/Sun Decision. *International Review of Intellectual Property and Competition Law, Vol. 1, 2011* .

Vile, D., & Atherton, M. (2009). *Linux on the Desktop.* Business Community Research report.

APPENDICES

APPENDIX : QUESTIONNAIRE

Section A: Demographics and General Information

This section requires your input of general information regarding you and your company. Kindly tick appropriately or input information where required.

i. Name of your organization

[ ] Safaricom Limited

[ ] Airtel Kenya

[ ] Orange Telkom

[ ] Equitel

ii. What is the ownership structure of your organization?

[ ] Public owned

[ ] Private Owned

iii. How long in years has your organization been in operation?

……

……

……...

iv. How long in years have you worked in the organization?

……

……

……

v. Which one of the following best describes your role in the organization?

[ ] Technical Manager, Network Systems

[ ] Technical Manager, Support Services

[ ] Systems Engineer

[ ] Technical, Head of Department

[ ] Systems Analyst

[ ] Support Engineer

[ ] Security Engineer

[ ] Other, (Specify) ……

vi. What is your age bracket in years?

[ ] 20–25

[ ] 25-30

[ ] 30-35

[ ] 35-40

[ ] 40-45

[ ] 45-50

[ ] 50-55

[ ] 55-60

vii. What is your gender?

[ ] Female

[ ] Male

viii. What is your highest academic qualification?

[ ] Certificate [ ] Diploma

[ ] Degree [ ] Master's Degree [ ] Doctorate

ix. How many employee does your company have?

[ ] 1 – 100

[ ] 101 – 500

[ ] 501 – 1000

[ ] >1000

x. What functions best describes your department

[ ] Engineering

[ ] Customer Support

[ ] IT services

[ ] Network Support & Services

[ ] Product development & Innovation

[ ] Enterprise Services

[ ] IT/Network Security

[ ] Other, please list……

xi. How many employees does your department have?

[ ] 1 – 50

[ ] 51 - 100

[ ] >100

Section B: Extent of Open Source Software Adoption

1. Are you aware of open source software?

   [ ] Yes

   [ ] No

2. Does your organization use open source software applications?

   [ ] Yes

   [ ] No

   [ ] I don't know

3. If yes, in question 2, is the use of open source in the following areas

   [ ] Server applications

[ ] Desktop applications

[ ] Both servers and desktop applications

4. Which of the following open source desktop applications and systems are in use in your department.

   [ ] Operating Systems such as Linux

   [ ] Office applications such as Open Office or Libre Office

   [ ] Web browsers such as Firefox

   [ ] Email Clients such as Evolution or Thunderbird

   [ ] Desktop virtualization applications such a Virtual Box or KVM

   [ ] Other, (Specify) ……

5. Which of the following open source server applications and systems are in use in your department.

   [ ] Operation Systems such as Linux, FreeBSD

   [ ] Web server applications such as Apache and Nginx

   [ ] Email service applications such as Postfix and Exim

   [ ] Database service applications such as MySQL, MariaDB, PostgresSQL

   [ ] Server virtualization applications such KVM

   [ ] Web proxy services such as Squid

   [ ] Firewall services such as IPTables, Firewalld

   [ ] DNS Service applications such as BIND, UNBOUND and NSD

   [ ] Network monitoring and management applications such as Zabbix, Cacti etc

   [ ] Software Defined Networking such as OpenDaylight

   [ ] Cloud management applications such as OpenStack and CloudStack,

[ ] Business support functions such as CRM, Billing and Data analytics

[ ] Other, (Specify) ……

6. Do you plan to increase or begin the use of open source software in future?

   [ ] Yes

   [ ] No

   [ ] I don't know

7. To what extent do you plan to start the use of open source software in the future for the following functions?

	Least Extent				Large Extent
	1	2	3	4	5
m) Operation Systems such as Linux, FreeBSD					
n) Web server applications such as Apache and Nginx					
o) Email service applications such as Postfix and Exim					
p) Database service applications such as MySQL, MariaDB, Postgres SQL					
q) Server virtualization applications such KVM					
r) Web proxy services such as Squid					
s) Firewall services such as IPTables, Firewalld					
t) DNS Service applications such as BIND, UNBOUND and NSD					

u) Network monitoring and management applications such as Zabbix, Cacti, Nagios etc.					
v) Software Define Networking such as OpenDaylight					
w) Cloud management applications such as OpenStack and CloudStack					
x) Business support functions such as CRM, Billing, Data analytics					
y) Desktop Applications such as Firefox, Open Office etc					
z) Other, (Specify) ……..					

Section C: Benefits of Adoption of Open Source Software Adoption

8. What benefits would you say your department has realized as a result of adoption of open source applications.

Benefits	**Strongly Disagree**				**Strongly Agree**
	1	**2**	**3**	**4**	**5**
j) Open source has saved the company money that would have been used in purchasing and supporting proprietary solutions.					
k) Open Source applications have increased flexibility of software as we can modify the source code as we wish.					
l) We have avoided vendor lock-in with Open Source which has brought freedom in use of software.					
m) The company is more innovative as a result of use of Open Source.					
n) Open source has scaled well for majority of applications.					
o) Increase security e.g. almost free from viruses					
p) Open source is available on demand from the					

Internet.					
q) Availability of support from a large community of users.					
r) Variety of open source applications for various needs.					
aa) Other, specify……					
bb) Other, specify……					
cc) Other, specify……					
dd) Other, specify……					

Section D: Challenges of Open Source Software Adoption

9. What are the challenges faced or hindering the adoption of open source by your department?

Challenges	Strongly Disagree				Strongly Agree
	1	2	3	4	5
k) Lack of proper support for the applications					
l) Lack of internal skills to install and manage the applications					
m) Lack of executive support for open source applications					
n) Majority of our systems are only available as proprietary applications					
o) We do not understand Open Source licensing models					
p) Switching costs from proprietary application to open source are too high					
q) We cannot guarantee quality of service will be achieved with open source software					
r) Open source solutions lack ownership and					

	cannot be relied to run critical telecommunication services.					
s)	There is lack of proper documentation with open source software.					
t)	We cannot quite establish all costs related to open source adoption.					
u)	Our software vendors understand telecom operations and are therefore better placed to develop proprietary applications to run our services.					
v)	Other, specify ……					
w)	Other, specify ……					
x)	Other, specify ……					
y)	Other, specify ……					