EFFECT OF OPTICAL FIBER ON BASE TRANSCEIVER STATION CONNECTIVITY: THE CASE OF SAFARICOM IN KENYA

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OCTOBER, 2014
DECLARATION

This proposal is my original work and has not been presented for a degree in any other university.

Signature                      Date

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This proposal has been submitted for examination with my approval as University Supervisor.

Signature                      Date

.................................  .............................
ISABELLA SILE
DEDICATION

I dedicate this proposal to my wife, my children, my parents, brothers, sisters, my lecturers and classmates at the Management University of Africa.

Thank you all for your support.
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I hereby acknowledge the following for their support and the role they played in making this research project a success. The Almighty God who makes all things possible, my lecturers and especially my supervisor Isabella Sile for her guidance and support, my colleagues for their cooperation and help, the administration of MUA university for providing me with the requisite background information, my family for their undying support and patience.
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ABBREVIATIONS AND ACRONYMS

BTS  Base Transceiver Station

ROI  Return on investment

CAK  Communications Authority of Kenya

CCK  Communication Commission of Kenya

SPSS  Statistical Package for Social Sciences

GSM  Global System for Mobile Communications

W.W.W  World Wide Web
DEFINITION OF KEY TERMS

**Apps**: a self-contained program or piece of software designed to fulfill a particular purpose; an application, especially as downloaded by a user to a mobile device. (In dictionary.reference.com


**Availability**: The probability that an item will operate satisfactorily at a given point in time when used in an actual or realistic operating and support environment. . This value is equal to the mean time between failure (MTBF) divided by the mean time before failure plus the mean down time (Barlow and Proshan, 1975)


**Backhaul**: the connection between the Base Transceiver Station (BTS) and the rest of the world to the core of the Internet service provider's network (via a point of presence). The term backhaul may be used to describe the entire wired part for example Optical fiber links of a Telecommunications network (Barlow and Proshan, 1975)

**Bandwidth**: represents the capacity of the connection. The greater the capacity, the more likely that greater performance will follow. (In compnetworking.about.com Retrieved, October 6, 2014 from http://compnetworking.about.com/od/speedtests/g/bldef_bandwidth.html)

**Base Transceiver Station (BTS)**: A fixed radio transceiver in any mobile network. These are equipment’s that enable wireless or Radio communication between user equipment which are mobile devices i.e. Handsets, Modems, Tablet Computers, laptops, smart phones and a Telecommunication Network. (In gartner.com Retrieved, October 6, 2014 from http://www.gartner.com/it-glossary/bts-base-transceiver-station)
**Base Transceiver Station Connectivity:** This is the dependent variable in this study. The term BTS connectivity may be used to describe the entire wired part of a Telecommunication network. In *gartner.com*. Retrieved, October 6, 2014 from http://www.gartner.com/it-glossary/bts-base-transceiver-station

**Broadband Services:** These telecommunication services are defined as Internet access speeds of 256 Kilobits per second or more. (In *www.itu.int*. Retrieved, October 6, 2014 from http://www.itu.int/osg/spu/ip/chapter_seven.html)

**Browser:** A computer program such as Internet Explorer or Mozilla Firefox that enables internet users to access, navigate, and search World Wide Web sites. Browsers interpret hypertext links ('hotlinks') and allow documents formatted in hypertext markup language (HTML) to be viewed on the computer screen, and provide many other services including email and downloading and uploading of data, audio, and video files. (In *businessdictionary.com*. Retrieved, October 6, 2014 from http://www.businessdictionary.com/definition/browser.html)

**Browsing:** Exploration of the internet or World Wide Web by following one interesting link to another, usually with a definite objective but without a planned search strategy. (In *businessdictionary.com*. Retrieved, October 7, 2014 from http://www.businessdictionary.com/definition/browsing)

**Competitive Advantage:** A competitive advantage exists when a company is able to deliver

the same benefits as its competitors but at a lower cost, or by delivering benefits that are superior to their rivals competing products. (Porter, 1995)

**Data communication:** refers to the transmission of this digital data between two or more computers and a computer network or data network is a telecommunications network that allows computers to exchange data. The best-known computer network is the Internet. (In *tutorialspoint.com*. Retrieved, October 7, 2014, from http://www.tutorialspoint.com/data_communication_computer_network)


Internet Protocol (I.P): This is the primary network protocol used on the Internet, developed in the 1970s. On the Internet and many other networks, IP is often used together with the Transport Control Protocol (TCP) and referred to interchangeably as TCP/IP. (In supportforums.cisco.com. Retrieved, October 7, 2014 from https://supportforums.cisco.com/document/6836/ip-internet-protocol)

Internet Connectivity: This is connection of devices to each other in order to transfer data back and forth through the internet. It may also refer to connecting a mobile phone, a home or office to the Internet or connecting a digital camera to a computer or printer. In pcmag.com Retrieved, October 7, 2014 from http://www.pcmag.com/encyclopedi a/term/40241/connectivity)


Optical fiber: This is the independent variable in this study. a very thin, flexible glass or plastic strand along which large quantities of information can be transmitted in the form of light pulses: used in telecommunications, medicine, and other fields. In (dictionary.reference.com.Retrieved October, 7, 2014 from http://dictionary.reference.com/browse/optical+fiber)

Smart phone: A mobile phone with more advanced computing capability and connectivity than basic feature phones. These typically include the features of a computer
with those of another popular consumer device, such as a personal digital assistant (PDA), a media player, a digital camera, and/or a GPS navigation unit. Later smartphones include all of those plus the features of a touchscreen computer, including web browsing, Wi-Fi, 3rd-party apps, motion sensor and mobile payment (Madgavkar A, Kaka N, Manyika J, Chui M, Boughin J and Gomes M, 2012)

**Surfing:** This is exploration on the internet or the World wide web without a definite objective or search strategy. In (businessdictionary.com. Retrieved October, 7, 2014 from http://www.businessdictionary.com/definition/surfing)

**Survivability:** In telecommunication this is the ability of communications systems to continue to operate effectively under adverse conditions, though portions of the system may be damaged or destroyed. Various methods may be used to maintain communications services, such as using alternate routing, different transmission media or methods and redundant equipment. In (citeseerx.ist.psu.edu from http://citeseerx.ist.psu.edu/viewdoc)

**World Wide Web:** A collection of Internet resources, hyper linked text, audio, video files and remote computers that can be accessed and searched by internet browsers. In techterms.com from http://www.techterms.com/definition/www)
ABSTRACT

The installation of optical fiber specifically to provide Base Transceiver Station (BTS) connectivity in mobile networks has an impact on the quality of services experienced by the customer, an impact on the pricing tariffs adopted by the mobile operator and eventually an impact on the profitability of the mobile operator. Internet connectivity on mobile phones been greatly enhanced by using optical fiber transmission links and networks. Optical fibre is now generally recognised to be the most powerful medium for transporting information due to its very low losses and extremely wide bandwidth (Koonen, 2005). Optical fiber when used as a Transmission media in Telecommunication have been very widely researched in the past. This study sought to find out the impact of installing and thereafter use of optical fiber for Base Transceiver Station (BTS) connectivity locally by mobile phone service providers specifically the case of Safaricom. The objectives of the study are as follows, to establish the effect of using Optical fiber for BTS network connectivity on network availability and examine the current strategies to mitigate against optical fiber cuts and vandalism, to establish the effect of Optical fiber on network congestion and network degradation on the network, examine the current strategies to mitigate against network congestion and network degradation. To establish the effect of the cost of installation of Optical fiber infrastructure on profitability and the returns on this investment(ROI) This study is significant because the use of optical fibre for BTS connectivity by Safaricom is a pre-requisite for introduction of new products and services such as Video streaming, Cloud computing, M-Banking, internet connectivity and social media services amongst others which cannot be cost effectively, efficiently and profitably provided if only the traditional legacy BTS connectivity technologies are used. The population of interest are 160 employees who work in the Regional operations department of the Technology division of Safaricom. The study will sample 50 employees in the Regional operations department based in the company’s headquarters building. In this study data is to be collected from the selected sample using structured questionnaires and survey reports. Tables and other graphical presentations as required will thereafter be used to present the data collected for ease of understanding and analysis.
CHAPTER ONE
INTRODUCTION

1.0 Introduction
This chapter covers the introduction and background of the research topic, statement of the problem, objectives of the study, research questions, significance of the study, scope of the study, limitation of the study and the chapter summary.

1.1 Background of the Study
Globally the Telecommunications Industry has been evolving over the years with a dramatic impact on the customer. In Kenya in particular where the Mobile phone was once a luxury in the late 1990s afforded only by the affluent in the society, the mobile phone has now become a commodity which is affordable by the average consumer and in addition has become an indispensable item which is carried around by everyone and carried around everywhere.

Chauhan (2011) defines mobile broadband as high-speed Internet access for portable devices where connectivity is provided by wireless technologies such as Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Evolution-Data Optimized (EVDO), Long-Term Evolution (LTE), and Worldwide Interoperability for Microwave Access (WiMAX) Zouganelli (2005) showed that in Western Europe mobile phones were indispensable items in everyone’s pocket or purse, used for surfing the internet, hot spots for internet access were to be found in hotels and petrol stations. One in two people (50%) had a laptop in Western Europe at that time, and downloading files and music from the internet is something many would do. Since then, the whole world has gone digital, global, and on the net and it ’has since become difficult to recall that only ten years ago most of us had neither laptops nor mobile phones.

As regards recent events in Kenya access to the internet, surfing the internet is not just for the affluent but is done by everyone with the 3G (Third generation) mobile networks being rolled out nationally and prices of Smart phones which are internet capable being reduced drastically (Ombok, 2014).
1.1.1 Optical Fibre as a cost effective Transmission media

Optical fibre is now generally recognised to be the most powerful medium for transporting Information due to its very low losses and extremely wide bandwidth (Koonen, 2005). As regards the global Telecommunication technological developments and evolution, internet connectivity been greatly enhanced by using Optical fiber transmission links and Optical fiber networks Zouganelli (2005) posits that the advent of optical fiber transmission in Telecommunication networks have been the key enabler for this evolution. Additionally the convergence between telecommunication and data communication and the prevalence of IP (Internet packets) in the network would simply not have been possible were it not for the abundant transmission capacity that the optical fiber provides.

Kenya’s telecommunications and broadband internet services market has also been undergoing a revolution following the arrival of the following three international submarine optical fiber cables in 2010. SEACOM –This is a submarine cable operator with a network of submarine and terrestrial high speed fiber-optic cable that serves the East and West coasts of Africa which started commercial service in 2010. EASSY- The Eastern Africa Submarine Cable System is an undersea fiber optic cable System connecting countries in Eastern Africa to the rest of the world and which started commercial service in 2010. TEAMS (The East African Marine System) which started commercial service in June 2010 is an initiative spearheaded by the government of Kenya to link the country to the rest of the world through a submarine fibre optic cable. These optical fibre cables provided significant and increased internet transmission capacity, greater speeds and lower costs than the previous limited and expensive connectivity through satellite connectivity.

According to the Government of Kenya (Ministry of Information and Communication), for the National Broadband Strategy for Kenya 2013, Broadband connectivity in the Kenyan context are internet speeds defined as greater than or equal to 5 Megabits per second that is always on and indeed is critical to achievement of Vision 2030 within the period 2013 to 2017. This connectivity is to be delivered to homes and businesses to
enable high speed access to Voice, Data, Video and applications for development according to the draft National Broadband Strategy for Kenya strategy 2013.

With regards to Safaricom one of the most significant developments in 2009 was the landing of the two Indian Ocean undersea optical fibre cables TEAMS and SEACOM in Mombasa. Safaricom is today the largest mobile telecommunications operator in terms of customers in Kenya with over 21.5 million customers according to the Communications Authority of Kenya (CAK) Quarterly sector statistics report for the third quarter of the Financial year 2013/14 (January – March 2014). Safaricom therefore enhanced its ability to deliver new products that relied on the main features of optical fibre connectivity which are greater speeds/capacity/bandwidth and lower costs. To improve security of the optical fibre transmission connectivity for its base transceiver stations (Tang, 2005).

Nationally Safaricom also went into partnership with the national power utility KPLC (Kenya power and lighting company) who provided leased optical fibre using their power lines for intercity and metropolitan transmission connectivity. High speeds of data transfer coupled with higher capacity means the cost of communication is reduced hence the cost of doing business is also reduced (Kyasanur and Vaidya, 2005).

According to Zouganelli (2005), Optical transmission has led to an increase of the single cable transmission capacity by a factor of Three thousand and has the potential to increase it many times over. Optical Fiber has enabled transatlantic transmission without repeaters and many tens of parallel high capacity channels in one fiber cable. This massive capacity increase has meant that the cost of transmitting data has been dramatically reduced and is no longer dictated by transmission distance as has been the case with wireless links (Satellite/Microwave links) and copper cables.

Sudbo (2005) posits that most network operators now offer services where the charges are independent of the transmission distance e.g. allowing us to freely click on a web-link irrespective of where in the world the link points to, and letting us make phone calls to any country in the world via the internet through the Voice over Internet Protocol, without being charged for the time spend talking.
In Kenya the Companies that started out as Internet Service Providers (ISPs) – such as Access Kenya, Kenya Data Networks (KDN/Liquid Telecom), Jamii Telecom and Wanainchi Telecom are themselves in the meantime transforming themselves into second-tier telecom companies. This is by rolling out national and metropolitan optical fibre backbones and wireless Broadband access networks, offering converged voice, data and video/entertainment services hence competing directly with Safaricom and in the meantime leasing optical fiber connectivity to the same company. Safaricom has begun 4th generation broadband technology LTE trials which is however bandwidth intensive and therefore requires optical fiber BTS connectivity to effectively and efficiently provide services.

The use of optical fibre by mobile Telecommunication operators like Safaricom enables them to secure a larger part of the Data services market previously dominated by Internet services providers (ISPs) in Kenya. The use of Optical fibre for Base Transceiver stations connectivity by Safaricom enables them to be more cost effective in Network operations/Maintenance and efficient from a business point of view. Other advantages of the usage of optical fibre as compared to other transmission media which are.

**High speed internet connectivity**: Optical Fiber has the inherent capacity to transfer a higher volume of data than any other transmission media and hence are broadband (Data speeds in excess of 256kbit/second). The use of Optical fibre therefore also means higher speeds of data transfer and larger capacity.

**Security**: No external radiation is transmitted by optical fibres and hence they are secure and cannot be monitored. Sensitive information and on line business can easily be conducted over optical fiber since it is more secure than any other type of transmission media. Businesses, governments, organizations and institutions therefore prefer the high level of security/privacy provided by optical fibers in comparison to other transmission media.
1.1.2 Base Transceiver Station Connectivity and the launch of new mobile services

According to [http://en.wikipedia.org/](http://en.wikipedia.org/) a Base Transceiver station (BTS) is equipment that enables wireless or Radio communication between user equipment which are mobile devices i.e. Handsets, Modems, Tablet Computers, laptops, smart phones and a Telecommunication Network. To date the following Wireless communication technologies are being used globally.

i. Global System for mobile Communication (GSM) - This is the 2nd Generation mobile phone communication technology.

ii. CDMA (Code Division Multiple Access) this is the 3rd Generation mobile Phone communication technology.

iii. Wi-Fi – used by devices such as laptops/tablet computers/personal computers to access the internet as wireless local area network.

iv. WiMAX (Worldwide Interoperability for Microwave Access) used by fixed devices (non mobile) to access the internet. This is wide area network (WAN) technology.

Base transceiver stations (BTS) can also be referred to as the radio base stations (RBS), while in 3rd Generation (3G) Networks, these are referred to as Node Bs. Chundury (2008) posits that BTS (Base Transceiver Station) connectivity or the backhaul BTS environment is the part of a mobile network that connects base stations to network controllers (Base station controllers/Radio Network Controllers) within a coverage area. Backhaul is also sometimes referred to as first mile and last mile (Davey and Payne, 2005).

In recent times in the telecommunications industry there has been a consistent change in the usage of mobile phones from voice usage only to a new era where the growth of traffic is mainly driven by data and video usage. Mobile phones are now increasingly being used for data services such as mobile money transfer/payment services, Internet connectivity, video streaming and mobile banking within the Safaricom network (Chundury, 2008).
According to the Communications Authority of Kenya (formerly CCK) as per the third quarterly Sector statistics report for the financial year 2013-2014. The continued growth in data/internet market is largely driven mainly by the growth in mobile based internet penetration as a result of increased operators focus on growing revenue from the data market. Consistent promotions and special offers on smart phones have attracted subscribers of mobile services to acquire data bundle offers and other incentives to drive the use of data/internet services. As has been the trend, mobile data/internet sector maintained its largest share of 99 per cent of total internet subscriptions which indicates that the continued expansion of 3G (third generation) services as well as popularity in the use of social networking sites may be playing a major role in the growth of mobile data/internet service (Chebrolu, Raman and Sen, 2006).

During the quarter under review, the number of mobile data/internet subscriptions rose to 13.2 million up from 13.0 million posted during the previous quarter representing growth of 1.3 per cent. Deployments of WiMAX technology are underway and third generation (3G) mobile broadband services have been launched with the mobile operators developing new revenue streams (Lee, Narlikar, Pal, Wilfong and Zhang, 2006).

According to (Davey and Payne, 2005) Video and imaging services via mobile phones have also seen remarkable growth showing there is real latent demand for new innovative services, and which will require higher bandwidth connectivity as expectations and frustrations rise with delay and low quality limit usage. Image and Video transfer, richer content on the on the web, and the need to back up large amounts of personal data will all drive the demand for increasing access speeds and network capacity. To address the ever increasing needs and demands of the customers for the data services, optical fiber connectivity between Base Transceiver stations and the core network is mandatory (Sudbo, 2005).

1.2 Statement of the problem
The effect of using Optical fiber for Base Transceiver station connectivity has been the subject of much research by academics and practitioners. Wireless technologies when used for BTS connectivity suffer inherent bandwidth and capacity limitations which have
an impact on the customer in terms of the quality of service provided, resulting in mobile network congestion, and affecting voice traffic and network degradation for data services including internet connectivity. According to (Zouganelli, 2005) higher bandwidth per subscriber can be achieved when Wireless technologies are employed in point to point directional connections that however do not offer mobility.

According to (Davey and Payne, 2005) as Telecommunication operators and service providers move forward trying to meet the ever increasing demands for high capacity services, a major obstacle to sustainable profitability arises. The major obstacle and challenge arising is that the cost of installing the additional network capacity to meet the predicted growth in demand for bandwidth or capacity can easily exceed the expected and subsequent growth in revenues, the return on investment (ROI) and hence the overall profitability of the Telecommunication service provider.

However not withstanding this, the goal of any company in any business is how to achieve a sustainable competitive advantage. (Porter, 1990). A competitive advantage exists when the Telecommunication service provider is able to deliver the same benefits as its competitors but at a lower cost (cost advantage), or by delivering benefits that are superior to their rivals and delivering competing products (differentiation advantage). In conclusion a competitive advantage will enable a Telecommunication service provider to create superior value for its customers and superior profits for itself (Chen, 2007).

Locally the extensive use of optical fibre by Safaricom for BTS connectivity and core network connectivity most of which is currently leased from other telecommunication operators in recent years has also been greatly affected by Optical fibre cuts largely caused by road construction and by vandalism which has been the cause of network degradation, call drops, poor quality of services provided on internet accessibility and poor network coverage/poor network availability (Kyasanur and Vaidya, 2005).

To achieve wireless access as per the technology used by mobile phones and other mobile devices, optical fibers which are point to point connections and have sufficient inherent capacity and bandwidth must be extended as close as possible to the wireless access equipment which in this case is the Base Transceiver Station (BTS). The mobile devices and phones within the coverage area of the BTS will therefore have sufficient bandwidth
and also benefit from the considerable transmission capacity extended by the optical fiber. Hence eliminating mobile phone network congestion for voice communication and in addition this also means higher speeds for data transfer and internet connectivity (Mombo, 2011).

To meet these ever increasing and changing demands by the customers Safaricom must use optical fiber for Base transceiver station (BTS) transmission connectivity in order to efficiently and cost effectively provide these requirements. According to the Safaricom Sustainability report, (2014) in order to achieve the status of the best network in Kenya data performance is a core requirement, where the customers requirements are fast data speeds and a high quality data experience. This goes hand in hand with upgrades of 3rd Generation (3G) sites and transmission links to ensure that high throughputs are achieved. As a result by October 2014, over 95% of the Safaricom 3G Base Transceiver Stations were able to achieve data speeds of 21 Mbps (Nuaymi, 2007).

In addition taking into consideration the competition in the industry Safaricom must also provide the services within the timelines demanded by the customers. In comparison to other Transmission technologies like Microwave and twisted pair copper cable, Optical fiber installation is however capital intensive although it better meets the technological requirements and the mobile customers quality of service requirements when used for BTS connectivity (Smitt, 2005).

This study therefore aims to establish the effects of the installation and use of optical fibre for Base Transceiver Station connectivity and also ascertain the contribution of optical fibre towards the sustainable profitability of Safaricom

1.3. Objective of the study

1.3.1 General Objective

The general objective of this research work is to establish the effect of the installation and thereafter use of Optical fibre for Base transceiver station (BTS) connectivity in the Safaricom network.
1.3.2 Specific objectives

i. To establish the effect of using Optical fiber for BTS connectivity on the profitability of Safaricom.

ii. To determine the effect of using Optical fiber for BTS connectivity on the network availability experienced by customers in the Safaricom network.

iii. To determine the effect of using Optical fiber for BTS connectivity on the network degradation experienced by customers in the Safaricom network.

iv. To assess the effects of using Optical fiber for BTS connectivity on the network congestion experienced by customers in the Safaricom network.

1.4 Research Questions

The study will seek to answer the following research questions

1.4.1 Specific Research Questions

i. To what extent does using of Optical fiber for BTS connectivity affect the profitability of Safaricom?

ii. What are the effects of using Optical fiber for BTS connectivity on the network availability experienced by customers in the Safaricom network?

iii. What are the effects of using Optical fiber for BTS connectivity on the Network degradation experienced by customers in the Safaricom network?

iv. What are the effects of using Optical fiber for BTS connectivity on the network congestion experienced by customers in the Safaricom network?

1.5 Significance and justification of the study

**Significance for Mobile and Telecommunication service providers**

For the Telecommunication industry using Optical fiber for BTS connectivity has a potential of providing a competitive advantage in terms of major network operation costs reduction in particular, cost advantage by reduction of frequency spectrum licensing costs and differentiation advantage by introduction of new and innovative services. This competitive advantage will enable a Telecommunication company to create superior
value for its customers and superior profits for itself. This is applicable to all the Telecommunication industry and mobile services providers globally and also in Kenya where the data/Internet market has continued to be dominated by mobile broadband/Internet subscriptions. This is due to the increased subscriptions in the mobile sector and the ease of accessing internet services though the mobile phone. The continued growth in data/internet market is largely driven by growth in mobile device internet penetration as a result of increased mobile operators focus on growing revenue from the data market. In addition, consistent promotions and special offers have attracted subscribers of mobile services to acquire data bundle offers and other incentives to drive the use of data/internet Services. Mobile data and internet connectivity is a significant and critical revenue stream for Safaricom.

According to CAK (Communications Authority of Kenya) quarterly sector statistics report for the third quarter of the FY 2013/14 (Jan-Mar 2014), the quarter witnessed growth in data/internet subscriptions by 1.3 per cent to reach 13.3 million subscriptions from 13.1 million subscriptions for the previous quarter. In relation to the same period of the previous year, an increase of 1.9 per cent was recorded. As has been the trend, the mobile data/internet sector maintained its largest share of 99 per cent of total internet subscriptions which indicates that the continued expansion of third generation (3G) mobile services as well as popularity in the use of social networking sites may be playing a major role in the growth of mobile data/internet service. This indicates that there is still a lot of unexploited potential and therefore projects geared toward utilization of optical fiber transmission capacity for BTS connectivity should be considered as this will ultimately stimulate growth in this sector even further.

It is therefore clear that if Safaricom is to retain its market leadership and also sustain profitability then the main driver for this is through increasing Data/Internet subscriptions and mobile Broadband subscriptions, hence going forward this area must be its competitive advantage. This Competitive advantage can easily be achieved through Cost advantage by delivering Data/Internet services at a lower cost and also through delivering benefits that are superior to their rivals competing products (differentiation
advantage) for example applications riding on and working with M-PESA like M-Banking.

Globally according to the Vodafone Group Plc. Annual Report 2014 mobile voice and texts which have been the traditional revenue sources, have reached maturity in a number of markets. To deliver future growth opportunities Vodafone is investing in newer revenue areas such as data. As the demand for data grows, mobile networks must be reconfigured to data, while still be meeting the need for traditional texts and voice calls. The data services which are most in demand all over the world in mobile networks are video streaming and internet browsing. Mobile data and internet connectivity is therefore a significant and critical revenue stream for Safaricom which is the leading mobile telecommunications operator in Kenya. The use of optical fibre for BTS connectivity by Safaricom is required because the newly introduced products and services such as Video streaming, Cloud computing, M-Banking, internet connectivity and Social media services cannot be cost effective, efficiently and profitably provided if the traditional legacy BTS connectivity technologies, microwave transmission links/Coaxial cables transmission links were to be used. Optical fibre cuts in both overhead and underground routes are however resulting in significant revenue losses and degradation of the network connectivity and network quality for internet users. The optical fibre cuts affecting Safaricom BTSs will therefore potentially in the short term lead to degradation of both voice services/internet services provided on mobile phones and in the long term to possible migration or churn to other mobile operators or the traditional non mobile/Fixed line internet service providers.

**The Government and Regulatory Authorities**

The Government and regulatory authority which is the Communications Authority of Kenya will find the information useful in diagnosing the problems affecting the Telecommunication industry and thus formulating policies that enhance and guide Telecommunication investments in Kenya. The Kenya Revenue authority will now be better informed on the main drivers for profitability of mobile service providers and possibly introduce a different taxation regime to factor in the use of Optical fiber for provision of Telecommunication services
Customers: The findings of the study will be beneficial to the customers due to improvement in the network coverage and improvement in the quality of services by elimination of network congestion/call drops and improvements of internet connectivity speeds occasioned by the use of Optical fiber for BTS connectivity. Since the installation of Optical fiber results in a massive transmission capacity increase this means that the cost of transmitting data will be dramatically reduced and is no longer dictated by transmission distance as has been the case with wireless links (Satellite/Microwave links) and copper cables. This reduction in cost of transmission translates into a reduced cost especially of international calls and reduced cost of internet connectivity and video streaming directly benefitting the customer.

Scholars: The research conducted thus contributes to the existing knowledge on the use of optical fiber for BTS connectivity while considering the local environment and recent events which have seen at least one mobile operator closing shop because of various issues.

1.6 Justification of the Study

According to the Safaricom Sustainability report (2011-2012) Safaricom was leasing optical fiber Infrastructure to provide the additional capacity required by the large volumes of data and voice traffic that was being handled. However the local leased fiber network had been and to date remains significantly impaired by frequent Optical fiber cuts and vandalism. To address this challenge the local mobile service providers could design, build, operate and maintain reliable and resilient optical fiber Networks for their own use, thereafter saving on Optical fiber leasing costs while leasing any surplus capacity to other telecommunication operators as an additional revenue stream. This study will benefit all the local Mobile service providers including Safaricom as they build their own Optical fiber infrastructure in order to support growth in volumes of data and voice traffic and also ensure sustainable profitability of the business.

With regards to tax payments to the government it is important to note that Safaricom has been the most profitable mobile service provider in Kenya and has for six consecutive
years emerged the country’s highest taxpayer in the country (Kenya Revenue Authority, 2013)

1.7 Scope of the Study
This study is on the effects of the use of Optical fibre for Base Transceiver Station connectivity specifically the case of the Safaricom network and the study is to be conducted through questionnaires given to the Staff working in the Technology division, Regional Operations department of Safaricom based in Nairobi.

1.8 Limitation of the study
The study is limited to Kenya which has only one mobile service provider, Safaricom which has been providing 3rd Generation (3G) mobile services (mobile broadband) on a commercial basis since 2007. Other limitations are as follows, the company has sustained profitability for more than 6 years, again the only mobile services provider to achieve this and Safaricom is currently building its own Optical fiber infrastructure to be used for BTS connectivity. In terms of literature, there is a gap as to the most cost effective and efficient techniques that can be used to ensure survivability, reliability and Return on investment of the Optical fiber infrastructure being installed by Mobile service providers including Safaricom. The effects on the profitability of Safaricom after installing its own Optical fiber to be used for BTS connectivity may be different from the effects on the other Mobile service providers in Kenya who are leasing optical fiber from other Telecommunication service providers.

1.9 Assumptions
Assumptions of the study are that the sample/respondents selected for the study will fairly represent the whole population. In addition the research instruments (questionnaires) are assumed valid and should measure the desired views and it is assumed that all the respondents will answer the research questions honestly.

1.10 Conclusion
This chapter has reviewed the background of the study on the effects of using optical fiber for BTS connectivity specifically the case of Safaricom, it also reviews the
statement of the problem, the objective of the study, research questions, justification of the study and scope/ limitations of the study
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is devoted to reviewing literature relevant to the same field from other researchers and practitioners. It gives a theoretical review of literature on the use of optical fiber for BTS connectivity and telecommunication networks in general and the impact of optical fiber on the Network availability, Network congestion and Network degradation applicable to internet connectivity as experienced by the mobile phone subscriber. In addition the effect of optical fiber on the overall profitability of Mobile service providers is looked at. The chapter also outlines a critique of the literature and closes with a summary and a highlight on the research gaps this study is expected to fill.

2.2 Theoretical Review

2.2.1 Moore’s law and the use of Optical fiber for BTS Connectivity

Moore’s law is the observation that, over the history of computing hardware, the number of transistors in a dense integrated circuit doubles approximately every two years (Moore, 1965).

Smitt (2005) posits that as per Moore’s law the field of Information and Communication Technologies is showing a development speed which is unprecedented in history. Over a period of fifty years key features like processor speed and memory size are roughly doubling each 18 months, and experts believe that this development will continue. Due to this development a steadily increasing performance of components and systems can be offered at an essentially constant price, a development that we experience in the fact that the price of our new laptop or Smart phone does not differ much from what we paid three years earlier for the previous one, which incidentally had only a quarter of the speed and memory size.

According to (Davey and Payne, 2005) the relentless progress in consumer technology has also continued unabated with processor speeds continuing to increase roughly in line with Moore’s Law.
In particular Video and imaging services and accessing social media via mobile phones have seen remarkable growth showing that there is real latent demand for new innovative services, and these services require higher capacity BTS connectivity or bandwidth as per customers expectations of good quality services.

According to http://en.wikipedia.org/wiki, Photonics includes the generation, emission, transmission, modulation, signal processing, switching, amplification, and detection/sensing of light. The term photonics developed as an outgrowth of the first practical semiconductor light emitters invented in the early 1960s and optical fibers developed in the 1970s (Sen and Huson, 2006).

Smitt (2005) suggests that Moore’s law is also valid in micro-photonic integration technology which is used in the manufacture of optical fiber components and systems. It is clear that the development of Photonics, which has a much larger diversity in devices and technologies than electronics, shows a more complex behavior than electronics. Technological developments in Photonics are happening much faster than Moore’s law where key features like processor speed and memory size are roughly doubling each 18 months. Higher network capacity, Internet access speeds, quality of service improvements are demanded by ever increasing customers using cheaper smart phones and other mobile devices. The increasing network capacity requirements arising from increasing numbers of cheaper smart phones and mobile devices can therefore be addressed in a cost effective and sustainable manner by using Optical fiber for BTS connectivity (Tang, Xue and Zhang, 2005).

2.3 Profitability
According to the Safaricom annual report for the year ending March 2014, the company made a profit of 34.98 billion shillings before tax. After paying income tax of 11.97 billion shillings to the Kenya revenue authority the net profit was 23.02 Billion shillings ($264 million). It was noted that the contribution of revenue from fixed data and mobile broadband where the BTS connectivity used was leased optical fiber has been steadily rising from 2.97 Billion shillings in 2010 to 8.42 Billion shillings in 2013 and finally to 11.88 Billion in 2014, according to the Safaricom annual report for the year ending March 2014. According to the Sunday Nation 20thOCT2013 Safaricom also undertook to
enlist the services of an additional contractor to fast track the completion of its own 10 Billion Optical fiber network which was being installed by Huawei and Ericsson Companies (Vaughan - Nichols, 2004).

The reason for enlisting a third supplier to rollout the fiber was to match the market demand for Data and internet services which was and still is a growing revenue base for Safaricom unlike revenue from Voice traffic which had been declining from 88% in 2008 to 62% in 2013. (Safaricom Half year Financial results 2012-13).

From a global perspective according to an article by Chaksfield, M.”Vodafone looks to take on BT - snaps up Cable & Wireless” at .http://www.techradar.com/news 23rd April 2012 Vodafone decided to diversify its business to broadband by buying the then beleaguered British telecommunication company Cable & Wireless. In a deal worth £1 billion, Vodafone bought the biggest optical fiber network in the UK (United Kingdom), which placed the company in direct competition with the likes of BT (British Telecommunications) - although the company at the time did note that the acquisition was more for the ‘enterprise’ segment of the market. It was also understood that Vodafone would use its newly acquired optical fiber network to offload some of the pressure caused by congestion on its mobile networks and in turn increase its data capacity. In addition speaking about the buyout, Vittorio Colao, Vodafone's Chief executive officer, said: "The acquisition of Cable & Wireless Worldwide creates a leading integrated player in the enterprise segment of the UK communications market and brings attractive cost savings to our UK and international operations (Ombok, 2014).

Locally building and installation of Optical fiber routes is very capital intensive as was evident from the recent case of Safaricom building its own fiber and indeed this has been the reason many mobile services providers have not built their own fiber network but have been reliant on leasing from other Telecommunication service providers who had historically invested in Optical fiber. The Capital costs of laying optical fiber are relatively high when compared to installation of other transmission media such as microwave transmission and Satellite transmission. In order to sustain profitability and a competitive advantage the costs of providing Telecommunication services need to be recouped by Telecommunication services Providers which fundamentally is about getting
a Return on Investment. Therefore as a result of the very high capital expenditure in laying optical fibre the benefits of lower prices introduced by using optical fibre for transmission connectivity cannot be immediately transferred to customers by reducing prices of services, as the company still needs time to recoup its costs and thereafter achieve profitability (Soldatos, Vayias and Kormentzas, 2009).

When a company sustains profits that exceed the average for the industry the company is said to possess a competitive advantage over its rivals. The goal of any company in any business would therefore be how to achieve a sustainable competitive advantage. (Porter, 1995). A competitive advantage exists when the company is able to deliver the same benefits as its competitors but at a lower cost (cost advantage), or by delivering benefits that are superior to their rivals competing products (differentiation advantage). Therefore a competitive advantage will enable a company to create superior value for its customers and superior profits for itself. When a company sustains profits that exceed the average for the industry for example the case of Safaricom, the company is said to possess a competitive advantage over its rivals (Wanyeki, 2010).

2.4 Network Availability

The fundamental objective of Availability Management in Information and Communication Technology is to ensure that all the Information Technology services including the mobile networks are available and are functioning correctly whenever customers and users want to make use of them in the framework of the Service level agreements (SLAs) in force. According to Ryder (2009) Information Technology Infrastructure LibraryV3 (ITILv3) describes Service Design, Service Transition (deployment), and Service Operation as these three major phases in the service lifecycle. Within Service Design, the Availability Management effort is a high-level management process that translates Information Technology (IT) capacity into an agreed service level consistency. This means that the availability of services provided through Optical fiber must be factored in and provided for in the design and planning process before the actual laying and installing of the optical fiber before service deployment.

ITIL v3 is distinguished by its emphasis on IT’s strategic alignment to business benefit. Business benefit can be defined in many ways, but ITIL has generally provided guidance
for balancing and improving the cost/quality ratio for services. Survivability is the property of a Transmission system or Transmission network like Optical Fiber to completely or partially maintain its services in the presence of failures affecting some of its elements (resilience). This property is achieved by implementing in the system suitable mechanisms of failure reaction (resilience strategy or resilience mechanism), usually based on signal duplication or traffic rerouting (Ryder, 2009).

From the customer’s perspective, service value consists of two primary elements: utility or fitness for purpose and warranty or fitness for use as applied to the use of optical fiber for BTS connectivity. Utility is perceived by the customer from the attributes of the service that have a positive effect on the performance of tasks associated with desired outcomes, removal or relaxation of constraints on performance is also perceived as a positive effect. Warranty is derived from the positive effect of being available when needed, in sufficient capacity or magnitude, and dependably in terms of continuity and security. In order to achieve proper planning of network services availability a Telecommunication services provider has to establish levels of availability that match the real needs of the business and the capabilities of the organization (Soldatos, Vayias and Kormentzas, 2009).

Therefore in order to prevent total network outages and maintain network availability it is prudent to invest in and design redundancy and protection fibers to protect the main fiber carrying traffic. The protection fiber should not follow the same route and should not be geographically in the same area or region. Locally according to the Safaricom sustainability report (2014) the resilience of the Safaricom transport platform has been enhanced through the installation of more than one Optical fiber cable for connectivity of any major service. To fully achieve automatic switching between multiple Optical fiber cables, a technology called Wavelength Switched Optical Networks has been employed.

According to Nelson and Kleinrock (1995), the Internet Intelligence Authority which provides internet information services to the majority of the worlds Telecommunication companies the main reason for Optical fiber cuts continuing to disrupt services is due to lack of investment in redundancy fiber routes. However given the rationale of most Telecommunication service providers to ensure costs for building Optical fiber are kept
low with the intention of keeping their customers prices of services low, Optical fiber
cuts and outages are therefore inevitable and unavoidable because building fiber routes is
highly capital Intensive.

According to Ryder (2009) proper planning of network services availability must therefore include:

i. The current availability status of the Information Technology services which is
   updated periodically.


iii. Analysis methods and techniques to use.

iv. Relevant and precise definitions of the metrics to use.

v. Availability improvement plans.

vi. Expectations about future availability.

Contrary to these opinions Zouganeli (2005) however posits that the deployment of the
relatively new MPLS (Multi-Protocol Label Switching) technology has provided
IP/MPLS networks embedded in Optical fiber networks with two important features that
pure Internet Protocol networks lack:, forwarding capabilities at LSP(Label Switching
Protocol ) level, and more efficient restoration using tunneling techniques in fast reroute,
when optical fiber cuts are experienced in Optical fiber Transmission networks.

2.5 Network Congestion
Locally in the Kenyan market just like the developed world the mobile
telecommunication operator’s customers are consistently demanding more efficient,
faster, better quality and convenient services and this is not only on the traditional
voice/telephony services but on the new products such as Money Transfer Services, M-
Banking (Mobile banking services), Video streaming and Internet connectivity through
their mobile devices. The introduction of M -Banking, M-PESA, data and video
streaming/entertainment/Social media services in Safaricom which are now becoming a
rapidly growing revenue stream has reduced the company’s reliance on the traditional
Voice traffic as a revenue stream as customers are now demanding better quality of
services and faster and more efficient services from Safaricom. The introduction of new
services and products which also comes with new customers is however resulting in more instances of network congestion being experienced by the same customers. Locally according to studies by a previous researcher on the factors affecting of Quality of service in Fixed Line Telephony in East Africa (Mombo, 2010) additional Transmission bandwidth or Transmission capacity can only be efficiently provided by use of Optical fiber cables.

Zouganelli (2005) observed that Telecommunications has been transformed from being the business of providing voice connections to becoming a very advanced sector that embraces a whole range of services and transactions, at work and leisure in and out of the home.

The way we do business, retrieve and store information, learn, entertain ourselves, shop communicate at all – has been and is continuously being dramatically changed by the new global digital space. In Optical fiber next to space and time multiplexing, the wavelength division multiplexing offers unprecedented opportunities to extend not only the data traffic transport capacity, but also the traffic routing possibilities in optical fiber networks. Optical fiber backhaul represents the most effective means for mobile phone operators to drastically release bandwidth pressure and network congestion (Tang, Xue and Zhang, 2005).

According to an article by Chaksfield, M.”Vodafone looks to take on BT - snaps up Cable & Wireless” at .http://www.techradar.com/news 23rd April 2012, Vodafone decided to diversify its business to broadband by buying the then beleaguered British telecommunication company Cable & Wireless. In a deal worth £1 billion, Vodafone bought the biggest optical fiber network in the UK, which placed the company in direct competition with the likes of BT (British Telecommunications) - although the company at the time did note that the acquisition was more for the 'enterprise' segment of the market. It was understood that Vodafone would use its newly acquired optical fiber network to offload some of the pressure caused by congestion on its mobile networks and in turn increase its data capacity (Sen and Huson, 1996).
According to (Chen and Shingling, 2008), as Third Generation Mobile (3G) services develop, the impact of Abis (BTS connectivity) optimization has become insignificant. Abis optimization is insufficient to fully mitigate transmission bandwidth pressures and network congestion, and can only be applied as a supplementary or temporary measure. The primary means of solving backhaul network (BTS connectivity) bandwidth pressures lies in the construction of self-built transport networks, such as microwave with software modulation technology or Optical fiber backhaul (Tang, Xue and Zhang, 2005).

Locally according to the Communications Authority of Kenya (formerly CCK) as per the third quarterly Sector statistics report for the financial year 2013-2014. DSL (Digital Subscriber Line) and Optical fiber subscriptions grew by 4.4 and 2.8 per cent respectively. Consequently, the number of estimated internet users increased by 1.9 per cent to reach 21.6 million compared to 21.2 million estimated during the last quarter. Internet penetration stood at 53.3 per cent up from 52.3 per cent during the preceding quarter (Smitt, 2005).

On the other hand, international internet available bandwidth increased to 865,714Mbps up from 862,473.9Mbps recorded in the previous quarter representing 0.4 per cent growth. Used (connectivity) international bandwidth grew substantially by 22.3 per cent to stand at 447,064 Mbps up from 365,413 Mbps recorded in the last quarter. Total used capacity represented 51.6. Per cent compared to last quarter’s 42.4 per cent (Narlikar, Wilfong and Zhang, 2006).

The annual growth in the mobile data/Internet subscriptions increased by 82.7 percent in the FY 2011/12 from 4.1 million subscriptions posted in the FY 2010/11. According to the CCK quarterly report for the period April to June 2012 the tremendous annual growth and the continued increase in mobile data/Internet subscriptions could be attributed to competitive data/Internet tariffs and special offers and promotions offered by the Telecommunication operators during this period and increased uptake of mobile data services and products. More recently according to CAK (Communications Authority of Kenya) quarterly sector statistics report for the third quarter of the FY 2013/14 (Jan-Mar 2014), during this quarter of the FY 2013/14, the number of mobile subscriptions rose by
1.7 per cent to reach 31.8 million subscriptions up from 31.3 million subscriptions registered during the previous quarter (Zhang, 2006).

However according to the same CAK quarterly sector report despite the growth in mobile subscriptions, there was a recorded decline in local mobile voice traffic of 2.7 per cent to post 7.6 billion minutes down from 7.8 billion minutes recorded during the previous quarter. Moreover subscriber average minutes of use was recorded at 80.3 minutes per month compared to 84.1 minutes registered in the last quarter (Koonen, 2005).

2.6 Network Degradation

According to an article by Ombok, E.” Safaricom of Kenya Annual Profit Jumps 31% on Data Revenue"http://www.bloomberg.com/news/2014-05-12.Wireless carriers across Africa have been investing in Internet-enabled services as customers increasingly turn to smart phones and tablet computers as a means of communication and mobile banking. Mobile service providers are therefore compelled to formulate innovative products and services to meet the customers’ needs and not merely compete on pricing / tariffs which is likely to boost the sector even further, but sometimes leads to services degradation being experienced on the existing network. However according to http://www.ietf.org/rfc/rfc2544.txt. Mobile network operators need to deliver the best possible user experience, and highest network performance to their mobile data subscribers (Davey and Payne, 2005).

The high volumes of small packet, less predictable mobile broadband applications have made this task even more difficult for operators trying to provision their network to meet demand and also avoid network degradation which manifests itself to the customers as service degradation (Hamilton, 2011).

Zouganelli (2005) had earlier observed that despite some ups and downs in the network traffic forecasts, the fact remained that mobile phone network traffic had continued to increase with a staggering 115 per cent, per year on a global basis in the past years. However at this time voice traffic and the corresponding revenues fell gradually but steadily and more and more services began to be delivered over IP (Internet Protocol) at that time. Wanyeki (2010) in an earlier study on the effect of optical fiber on the
provision of internet services had concluded that internet services had become less costly, more reliable, much faster and voice communication became more clearer due to the use of optical fiber. According to Chauhan (2011) growth in wireless broadband will assist in developing non-voice revenues for telecommunication companies with increased value added services (VAS) uptake. Increased market accessibility bodes further innovation and manufacturing in the sector.

Kyasanur and Vaidya (20058) state that a typical mobile service provider typically has multiple revisions of multiple generations of mobile phone technologies simultaneously operating. For example, in a given mobile service provider's network, some mobile devices may support GSM technology, some may support revisions up to 3rd Generation (3G) High Speed Data Packet Access, some may support revisions up to 3G HSPA+, and some may support revisions up to Fourth Generation (4G) or Long Term evolution (LTE) technology. As the customer switches from one generation of technology to another or from one revision to another, the performance can vary quite significantly and network degradation may occur. User mobility across different technologies needs to be properly managed by the mobile service provider.

This involves complex network management according to Reed & Tripathi (2011). In addition increased broadband penetration will help embrace new technologies faster and keep pace with worldwide technology standards. This increase in traffic has not always translated into increase in revenue from voice traffic but on the contrary network congestion and network degradation leading to service degradation has occasionally increased for some customers.

As mobile network operators under take the transition from Voice centric to Data centric oriented they are becoming increasingly vulnerable to new types of Data networking outages. According to Donegan (2013) this is due to the growing complexity of the mobile network as it becomes increasingly Internet Protocol centric.

Donegan (2013) argues that incidents of network degradation for mobile phone service providers occur most often in the Radio Access network and transmission networks which means that issues or incidents on the Base Transceiver station connectivity are the
most likely root cause of any services degradation experienced by the customers. However any network degradation experienced by mobile phone customers is now becoming an increasingly important factor for mobile services providers in gaining and keeping customers. Locally according to the Safaricom Sustainability Report (2014) as customer numbers continue to grow, and the industry becomes more competitive, it is important to maintain an exceptional customer experience. This creates satisfaction and trust and encourages customers to retain Safaricom services.

2.7 Base Transceiver Station Connectivity

According to Cao, Raghunathan and Kumar (2006) Base Transceiver station (BTS) is equipment that enables wireless or Radio communication between user equipment which are mobile devices such us Mobile phones, Modems, Tablet Computers, laptops, smart phones and a Telecommunication Network.

Dirisu and Iyiola (2013) state that to date the following Wireless communication technologies are being used globally.

Global System for mobile Communication (GSM)-This is the 2nd Generation mobile phone communication technology, where the BTS connectivity is referred to as Abis

CDMA (Code Division Multiple Access) this is the 3rd Generation mobile Phone communication technology, where the BTS connectivity is referred to as IUB.

Wi-Fi – used by devices such as laptops/tablet computers/personal computers to access the internet as wireless local area network .

WiMAX (Worldwide Interoperability for Microwave Access) used by fixed devices (non mobile) to access the internet .This is wide area network (WAN) technology.

Base transceiver stations (BTS) can also be referred to as the Radio base stations (RBS), while in 3rd Generation (3G) Networks; these are referred to as Node Bs

Chundury (2008) posits that BTS (Base Transceiver Station) connectivity or the backhaul BTS environment is the part of a mobile network that connects base stations to network controllers (Base station controllers/Radio Network Controllers) within a coverage area. Base Station connectivity is also sometimes referred to as first mile and last mile (first
mile from a fixed or Wire line perspective, and last mile from a wireless or mobile perspective).

In recent times in the telecommunications industry there has been a consistent change in the usage of mobile phones from voice usage only to a new era where the growth of traffic is mainly driven by data and video usage. Mobile phones are now increasingly being used for data services such as mobile money transfer/payment services, Internet connectivity, video streaming and Mobile banking within the Safaricom network (El-Sayed and Jaffe, 2002).

According to the Communications Authority of Kenya (formerly CCK) as per the third quarterly Sector statistics report for the financial year 2013-2014. The continued growth in data/internet Market is largely driven mainly by the growth in mobile based internet penetration as a result of increased operators focus on growing revenue from the data market. In addition, consistent promotions and special offers on smart phones have attracted subscribers of mobile services to acquire data bundle offers and other incentives to drive the use of data/internet services. The same report states that as has been the trend, mobile data/internet sector maintained its largest share of 99 per cent of total internet subscriptions which indicates that the continued expansion of 3G (third generation) services as well as popularity in the use of social networking sites may be playing a major role in the growth of mobile data/internet service (Koonen, 2005).

During the quarter under review, the number of mobile data/internet subscriptions rose to 13.2 Million up from 13.0 million posted during the previous quarter representing growth of 1.3 per cent. In addition deployments of WiMAX technology are underway and third generation (3G) mobile broadband services have been launched with the mobile operators developing new revenue streams from third-generation broadband and mobile banking services. More advanced services such as Cloud computing, IPTV/triple-play, e-commerce, e-learning and e-government are in addition rapidly evolving and being developed by Safaricom (Hamilton, 2011).

According to Davey and Payne (2005) Video and imaging services via mobile phones have also seen remarkable growth showing there is real latent demand for new innovative
services, and which will require higher bandwidth connectivity as expectations and frustrations rise with delay and low quality limit usage. Image and Video transfer, richer content on the on the web, increasing popularity of on line services and the need to back up large amounts of personal data will all drive the demand for increasing access speeds and network capacity.

To address the ever increasing needs and demands of the mobile service provider’s customers for the data services, optical fiber is the most cost effective and scalable in capacity transmission media that can be used for Base Transceiver stations connectivity.

2.8 Operationalization
According to (Mugenda and Mugenda, 2003), the operational definition of a variable is the description of the operation that will be used in measuring the variable. The effect of Optical fiber (independent variable) on Base Transceiver Station Connectivity (dependent variable) can be assessed by measuring the effects on profitability, network availability, network congestion and network degradation. This is as per the conceptual frame work on Figure 2.1: illustrated by the diagram depicting the relationship between theory, independent and dependent variable.

**Profitability:** Initially just after completion of the installation of Optical fiber due to the very high and capital intensive installation costs, there will be reduced profitability. Following this phase they would be a period of recouping of the costs or return on investment, mainly characterized by reduction of network operation costs of the frequency licensing costs payable to the Communication Authority of Kenya as the optical fiber would be replacing microwave transmission links. Eventually the recouping of costs or return on investment would end to be followed by a gradual increase in profitability mainly driven by revenue generated by the mobile broadband business. This is a result of more products being introduced due to the capacity available by using optical fiber for BTS connectivity and more customers being attracted due to these new products an example being social media and Video streaming.

**Network Availability:** The effect on network availability would be mainly experienced by the subscriber or customer in terms of utility and warranty. As regards the customer,
utility in this case is whether they are able to make and successfully complete mobile phone calls and have mobile internet connectivity on their phones no matter what time it is or their locations at this time (Moore, 1965). Warranty as regards the customer is being able to make and successfully complete mobile phone calls and have mobile internet connectivity at any time or any location in the future.

**Network Congestion:** This congestion is as a result of more and more mobile devices being connected to the network due to their affordability driven by technological developments without necessarily an increase of prices of the mobile devices (Moore, 1965). The effect of optical fiber on network congestion would be mainly experienced by the customer or subscriber where the network congestion is measured by the number of call drops and the number of silent calls experienced while using a mobile phone.

**Network Degradation:** This degradation is as a result of more and more mobile devices being connected to the network due to their affordability driven by technological developments without an increase of the prices of the mobile devices (Moore, 1965). Network degradation which is manifested by slower internet browsing, slower M-banking services, slower internet access would be mainly experienced by the customer or subscriber. Network degradation would be measured by the change in speeds of internet access, internet browsing, social media services access and speeds of accessing M-banking services while using a mobile device. These are services which are dependent on internet connectivity using a mobile device.
2.9 Conceptual Framework

Figure 2.1: Relationship between theory, independent and dependent variable

Independent Variable

Moore’s law

Network Availability

Network Congestion

Network Degradation

Profitability

Dependent Variable

Base Transceiver Station Connectivity
CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction
This chapter will provide the methodology of the study. It will give the specific procedures that will be followed in undertaking the study. The research design, population, data collection methods and data analysis will be described in this chapter.

3.2 Research Design
This study adopted a descriptive research design approach in form of a survey. According to (Mugenda and Mugenda, 2003) descriptive survey is a process of collecting data in order in order to answer questions concerning the current status of the subject in the study. The primary use of descriptive statistics is to describe information or data through the use of numbers hence creating pictures of the information. According to Gay, (1997) the characteristics of numbers representing information or Data are called descriptive statistics. In addition according to (Mugenda and Mugenda, 2003) descriptive research is used to describe such things as possible behavior, attitudes, values and characteristics. The descriptive survey method was used for the purpose of this study as the intention was to investigate the effect of optical fiber on Base Transceiver Station connectivity in Safaricom.

3.3 Population
The target populations were the 160 employees of Safaricom in the Technology Division-Regional Operations Department based in the Safaricom Headquarters building. The reason for choosing this target population is because this team has responsibility for the maintenance of the BTS network, Telecommunication implementation and Fixed Data Implementation work within the company. This includes employees from all cadres, senior management, middle management and staff working at the headquarters as well us staff in headquarters but responsible for the three regions of Eastern Kenya, Nairobi and Western Kenya. The number of employees working in the regional operations department had been obtained from the Human resources division of Safaricom.
3.4 Data collection methods and Techniques

The study adopted a questionnaire as the only data collection tool and the developed questionnaires were administered to the respondents. The questionnaires had two sections: the first part was intended to acquire the demographic profile of the respondents while the second section contained a set of attitude statements. The intention of using the attitude statements was to determine the level of agreement or disagreement using a five-point Likert scale (Underwood, 2004). The questionnaires contained a mix of open ended and close ended questions. The respondents were given options of checking several boxes and questions in which the respondents would give their views in their own words and the structure of the questionnaire derived from the research question. A questionnaire was used primarily due to the practicality and applicability to the research problem. The questionnaire was divided into four sections each covering each of the specific study objectives. In conclusion, the use of questionnaires was to enhance the collection of quantitative data.

3.5 Pilot test

A Pilot study was carried out to clarify instructions, determine appropriate levels of independent variables, determine the reliability and validity of the observational methods (Bordens, 2008). The study handed out Questionnaires to 16 employees of Safaricom who were not to be included in the final sample. The intention was to validate the questionnaires as a measurement tool in order for them to be an accurate indicator of what the study intended to measure (Mugenda and Mugenda, 2003).

3.6 Ethical Considerations

The researcher ensured that the objectives of this study remained aimed at improvement of the mobile phone operator customer’s quality of service rather than for personal gain. Efforts were made to ensure that all references in this study were acknowledged and included in the proposal and final project report and at no time did the researcher claim the work of other researchers or students. The respondents were also informed as to the real reasons why the study was being done and also on the intended use of the findings to allow them to make a decision whether to participate or not. (Mugenda and Mugenda, 2003).
On collection of data the researcher ensured that the data is genuine was not faked or obtained from another researcher. The data collected was not used maliciously against any of the respondents, and was kept strictly confidential especially where sensitive information was provided by the respondents.

3.7 Data Analysis and presentation
Before processing the responses, the completed questionnaires were edited for completeness and consistency. A content analysis and descriptive analysis was employed and was used to analyze the respondents’ views (responses) about the effect of optical fiber on Base Transceiver connectivity in the case of Safaricom. The questionnaires were coded to each section to give an easy guide to grouping the information. Descriptive statistics such as means, median, mode and standard deviation were used to help in data analysis. At this point data was presented using tables, graphs, pie charts and figures as appropriate. Additionally a multiple regression was used to measure the quantitative data. The regression equation is:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \epsilon \]

Y= is the Base Station Connectivity

\(\beta_0\) is the constant. \(\beta_1, \beta_2, \beta_3, \beta_4\) are the coefficients for the independent variables.

\(X_1\)= is the Profitability.

\(X_2\)=Network Availability

\(X_3\)= Network Congestion

\(X_4\)= Network Degradation

\(\epsilon\)= is the error term
3.8 Summary

This chapter discusses the methodology approach for the study and highlights the research design, target population, pilot study, data collection instruments and data analysis and presentation
CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.1 Introduction
This chapter considers the results and findings from the questionnaire survey. The findings of the study are presented according to the research questions. There were 160 questionnaires which were distributed to selected respondents at Safaricom Headquarters building in Nairobi. This was a study which involved all the employees in the Regional operations department since these are the employees thought to have the requisite information to be inputted into the study.

4.2 Response Rate
Of the 160 questionnaires distributed, 105 were filled and successfully collected which translated to a response rate of 66%. According to Mugenda and Mugenda (2003) a response rate of more than 60% of the sample is adequate in small populations whereas a response rate of more than 40% is required for big populations. Mugenda and Mugenda indicated that high response rates reduce the risk of bias in the responses and if the response rate is very low the researcher should find out the reason behind non response and whether these reasons can jeopardize the outcome of the study. All questionnaires provided important information for the study.

4.3 Demographic information

4.3.1 Gender of the respondents.
The study sought to find out the gender of the respondents. According to the findings in figure 4.1, 80% (84) of the respondents were male and 20% (21) of the respondents were female.

According to the Safaricom Sustainability report (2014) in terms of the Safaricom employees statistics, 50.3% (2032) of the employees are male, while 49.7% (2005) of the employees are female making a total of 4037 employees, showing a gender balance. However the statistics of the respondents indicate that there is no gender balance in the regional operations department within the Technology division of Safaricom as shown by
the number of female employees who responded compared to the male employees who responded

**Figure 4.1: Gender of the respondents**

This is not a gender balanced population when compared to the total number of employees in Safaricom and the overall gender balance in Safaricom but is however representative of the actual situation in the Regional operations department of the Technology division of Safaricom. There is therefore a need for a gender balance in the regional operations department by recruitment of more women into the department.

4.3.2 Highest level of education of the respondents.

The research sought to find out the highest level of education of the respondents. The findings presented in figure 4.3 indicate that 21 respondents (20%) had Diploma as the highest educational level attained, 63 respondents (60%) had Undergraduate Degrees as the highest level of education attained and 21 respondents (20%) had Postgraduate degrees as the highest level of education attained. 84 respondents (80%) had degrees. There were no High school certificate holders amongst the respondents.
Figure 4.2: Highest level of education of the respondents

With that level of education the respondents were considered knowledgeable enough on the subject under study as all the respondents were professionally and technically qualified.

4.3.3 Age of the respondents

The research sought to find out the age of the respondents. According to the research 13% (14) of the respondents were aged 31-35 years, 33% (35) of the respondents were aged between 36-40 years, 33% (35) of the respondents were aged between 41 - 45 years, and 7% (7) of the respondents were aged between 26-30, 7% (7) between 46-50 years and 7% (7) over 50 years. This gives a total of 105 respondents. However according to the Safaricom Sustainability report (2014) in terms of the Safaricom employees statistics, 30% (1206) of the employees were aged 20-29 years, 60% (2428) of the employees were aged between 30-39 years, 9% (366) of the employees were aged between 40 - 49 years, 1% (35) of the employees were aged between 50-59 years and 0.5% (2) were aged between 60-69 giving a total number of 4037 Safaricom employees. The mean age of all the respondents was 40.13 years while mean age of the Safaricom employees as per the Safaricom Sustainability report (2014) is 34.10 years, this indicates that the Regional operations department workforce is skewed towards middle age and are sufficiently experienced in their work.
Figure 4.3: Age of the respondents.

Table 4.1: Age of the respondents

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<thead>
<tr>
<th>Age in Years</th>
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<th>Midpoint m</th>
<th>fm</th>
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</thead>
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<tr>
<td>26-30</td>
<td>7</td>
<td>28</td>
<td>196</td>
</tr>
<tr>
<td>31-35</td>
<td>14</td>
<td>33</td>
<td>462</td>
</tr>
<tr>
<td>36-40</td>
<td>35</td>
<td>38</td>
<td>1330</td>
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<tr>
<td>41-45</td>
<td>35</td>
<td>43</td>
<td>1505</td>
</tr>
<tr>
<td>46-50</td>
<td>7</td>
<td>48</td>
<td>336</td>
</tr>
<tr>
<td>50-60</td>
<td>7</td>
<td>55</td>
<td>385</td>
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<tr>
<td>Total</td>
<td>105</td>
<td>245</td>
<td>4214</td>
</tr>
</tbody>
</table>

The mean age of all the respondents was 40.13 years while mean age of the Safaricom employees as per the Safaricom Sustainability report (2014) is 34.10 years.

4.4 Profitability

The study sought to establish whether the use of optical fiber affected the profitability of Safaricom. Findings are presented in figure 4.4. The findings in figure 4.4 indicate that 51% of the responses perceived that the use of optical fiber affects the profitability of Safaricom to a very great extent, 46% of the responses perceived that the use of optical fiber affects the profitability of Safaricom to a great extent and 3% of the responses perceived that the use of optical fiber affects the profitability of Safaricom to a moderate
extent. None of the responses perceived that the use of optical fiber affects the profitability of Safaricom to a little extent and none of the responses perceived that the use of optical fiber affects the profitability of Safaricom to no extent.

**Figure 4.4: Does the use of Optical fiber affect the profitability of Safaricom?**

In conclusion 100% of the responses perceived that the use of optical fiber affects the profitability of Safaricom.

### 4.5 Network Availability

The study sought to establish whether the use of optical fiber affected the availability of Safaricom. The findings in figure 4.5 indicate that 58% of the responses perceived that the use of optical fiber affects the Network availability of Safaricom to a very great extent, 16% of the responses perceived that the use of optical fiber affects the network availability of Safaricom to a great extent and 18% of the responses perceived that the use of optical fiber affects the network availability of Safaricom to a moderate extent. 3% of the responses perceived that the use of optical fiber affects the network availability of Safaricom to a little extent and 5% of the responses perceived that the use of optical fiber affects the network availability of Safaricom to no extent.
Figure 4.5: Does the use of Optical fiber affect the Network Availability of Safaricom?

In conclusion 95% of the responses perceived that the use of optical fiber affects the Network availability experienced by the customers of Safaricom.

4.6 Network Degradation

The study sought to establish whether the use of optical fiber affected the internet connectivity of the customers of Safaricom. The findings are presented in figure 4.6. The findings in figure 4.6 indicate that 67% of the responses perceived that the use of optical fiber affects the internet connectivity of Safaricom to a very great extent, 9% of the responses perceived that the use of optical fiber affects the internet connectivity of Safaricom to a great extent and 21% of the responses perceived that the use of optical fiber affects the internet connectivity of Safaricom to a moderate extent. 3% of the responses perceived that the use of optical fiber affects the internet connectivity of Safaricom to a little extent and none (0%) of the responses perceived that the use of optical fiber affects the internet connectivity of Safaricom to no extent.
Figure 4.6: Does Optical fiber Affect the Internet Connectivity of Safaricom?

In conclusion 100 % of the responses perceived that the use of optical fiber affects the mobile device internet connectivity experience of Safaricom customers.

4.7 Network Congestion

The study sought to establish whether the use of optical fiber affected the network congestion of the customers of Safaricom. The findings are presented in figure 4.7. The findings in figure 4.7 indicate that 53% of the responses perceived that the use of optical fiber affects the network congestion of Safaricom to a very great extent, 17% of the responses perceived that the use of optical fiber affects the network congestion of Safaricom to a great extent and 22% of the responses perceived that the use of optical fiber affects the network congestion of Safaricom to a moderate extent. 3% of the responses perceived that the use of optical fiber affects the network congestion of Safaricom to a little extent and 5% of the responses perceived that the use of optical fiber affects the network congestion of Safaricom to no extent.
In conclusion 95% of the responses perceived that the use of optical fiber affects the Network congestion experienced by the customers of Safaricom.
CHAPTER FIVE
DISCUSSION OF FINDINGS CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction
This chapter summarizes the outcome of the study and provides a summary of findings, their interpretation and then lays down the conclusions from the findings. Recommendations are then provided on the gaps identified in the study. Finally the researcher gives recommendations on further research studies to be carried out in the area.

5.1 Summary of findings
The study had the following objectives to establish the effect of using Optical fiber for BTS connectivity on the profitability of Safaricom, the network availability, the network degradation and the network congestion as experienced by Safaricom customers using their mobile phones and devices. The target population of this study was 160 employees of Safaricom working in the Regional operations department within the Technology division. The presentation of findings from quantitative data was by use of pie charts and tables. The study established that using Optical fiber for Base Transceiver connectivity affects the overall profitability of Safaricom, affects the network availability, the network degradation and the network congestion as experienced by customers using their mobile phones and devices.

5.2 Answers to research questions

The extent that the use of Optical fiber for BTS connectivity affects the profitability of Safaricom.

According to the Safaricom sustainability report (2014), the company’s capital expenditure for optical fiber and network capacity upgrades was 27.8 billion Shillings and the revenue for the same period for high speed internet connectivity through fixed and mobile broadband was 11.88 billion shillings, contributing to total revenues during this period of 144.67 billion shillings. According to the Safaricom annual report for the year ending March 2014, the company made a profit of 34.98 billion shillings before tax.
After paying income tax of 11.97 billion shillings to the Kenya revenue authority the net profit was 23.02 Billion shillings ($264 million).

If the capital expenditure of 27.8 billion shillings is also considered then the overall profitability is greatly affected by the high capital expenditure required to install optical fiber as this reduces the profitability.

**The effect of Optical fiber on Network availability**

According to the Safaricom sustainability report (2014), the resilience of the Safaricom transport platform has been enhanced through the installation of more than one Optical fiber cable (redundancy) for connectivity of any major service. To fully achieve automatic switching between multiple Optical fiber cables, a technology called Wavelength Switched Optical Networks has been employed. The resilience of the Base transceiver station (BTS) connectivity when optical fiber is used, affects the network availability positively.

**The effect of Optical fiber on Network Degradation**

Network degradation is manifested by slow speeds of internet access and internet browsing. To achieve the coveted status of the best network in Kenya according to the Safaricom Sustainability report (2014), upgrades of 3rd Generation (3G) Base Transceiver stations connectivity to ensure high throughputs had to be done by upgrading by using the optical fiber. As a result by October 2014, over 95% of the Safaricom 3G Base Transceiver Stations were able to achieve data speeds of 21 Mbps which is a very high speed of internet access and internet browsing. Optical fiber therefore affects network degradation positively by increasing the internet access and internet browsing speeds.

**The effect of Optical fiber on Network congestion**

Network congestion is manifested by silent calls and call drops as experienced by the customer. Due to the very high capacity of optical fiber when used for Base transceiver
station connectivity it reduces the network congestion experienced by customers using mobile phones and hence results in the reduction of silent calls and dropped calls. Optical fiber therefore affects network congestion positively by reducing the number of call drops and the number of silent calls experienced by the customers.

5.3 Conclusion

On the effect of optical fiber on profitability the findings are that 100% of the responses perceived that the use of optical fiber affects the profitability of Safaricom. According to the Safaricom sustainability report (2014), the company’s capital expenditure for optical fiber and network capacity upgrades was 27.8 billion Shillings and the revenue for the same period for high speed internet connectivity through fixed and mobile broadband was 11.88 billion shillings, contributing to total revenues during this period of 144.67 billion shillings. In order to contribute to the overall profitability Safaricom must continue expanding and growing the optical fiber infrastructure. According to the Safaricom sustainability report (2014), installation of 770 kilometers of optical fiber had been completed by October 2014, with a further 640 kilometers of fiber in progress to be used mainly for Base Transceiver connectivity in the key metropolitan areas in Nairobi, Nakuru, Mombasa and Kisumu. These are part of the 2nd generation (GSM) and 3rd generation BTS connectivity upgrade projects. This study’s results where 100% of the responses indicated that optical fiber affects profitability and similar studies from earlier researchers and practitioners also supports the statement that Optical fiber affects the profitability of Safaricom.

On the effect of optical fiber on network availability the findings are that 95% of the responses perceived that the use of optical fiber affects the Network availability experienced by the customers of Safaricom.

Recently according to the Safaricom sustainability report (2014) the resilience of the Safaricom transport platform has been enhanced through the installation of more than one Optical fiber cable for connectivity of any major service. To fully achieve automatic switching between multiple Optical fiber cables, a technology called Wavelength
Switched Optical Networks has been employed. From this study’s results where 95% of the responses indicated that optical fiber affects network availability and similar studies from earlier researchers and practitioners, the conclusion is that Optical fiber affects the Network availability of Safaricom.

With respect to the effect of optical fiber on network degradation the findings are that 100% of the responses perceived that the use of optical fiber affects the mobile device internet connectivity experience of Safaricom customers. According to the Safaricom Sustainability report, (2014) in order to achieve the status of the best network in Kenya where the customers requirements and expectations are fast data speeds and a high quality data experience. Upgrades of 3rd Generation (3G) sites and transmission links to ensure high throughputs had to done through the use of optical fiber for Base Transceiver (BTS) connectivity. As a result by October 2014, over 95% of the Safaricom 3G Base Transceiver Stations were able to achieve data speeds of 21 Mbps. From this study’s results where 100% of the responses indicated that optical fiber affects network degradation and from similar studies from earlier researchers and practitioners, the conclusion is that Optical fiber affects the Network degradation of Safaricom.

On the effect of optical fiber on network congestion the findings are that 95% of the responses perceived that the use of optical fiber affects the Network congestion experienced by the customers of Safaricom. This congestion is as a result of more and more mobile devices being connected to the network due to their affordability driven by technological developments without necessarily an increase of prices of the mobile devices (Moore, 1965). However Smitt (2005) suggests that Moore’s law is also valid in micro-photonic integration technology which is used in the manufacture of optical fiber components and systems. Technological developments in Photonics are happening much faster than Moore’s law where key features like processor speed and memory size are roughly doubling each 18 months.

From this study’s results where 100% of the responses indicated that optical fiber affects network degradation and from similar studies from earlier researchers and practitioners, the conclusion is that Optical fiber affects the Network congestion of Safaricom.
5.4 Recommendation

As regards the effect of optical fiber on profitability since the installation of optical fiber is known to be capital intensive, then it is of critical importance for a Cost –benefit analysis to be done before any installation of fiber to justify the expenses of installing the fiber. The study recommends that since optical fiber has a huge carrying capacity, which may far exceed the immediate capacity requirements then the owner of the fiber should lease this surplus capacity and not use it exclusively for Base transceiver station (BTS) connectivity. This will assist in recouping the installation costs and contribute towards breaking even and eventually to profitability.

On the effect of optical fiber on network availability in order to prevent total network outages and maintain network availability, the study recommends that at the planning stage of the optical fiber installation project it is prudent to invest in and design redundancy and protection fibers to protect the main fiber which is being used for Base transceiver station (BTS) connectivity.

On the effect of optical fiber on network degradation the study recommends the consistent use of optical fiber for Base transceiver station (BTS) connectivity as this will enhance the the mobile device internet connectivity experience of Safaricom customers and help the company to secure a larger market share in this very competitive industry currently dominated by companies that also lease optical fiber to Safaricom,

As regards the effect of optical fiber on network congestion the study recommends the consistent use of optical fiber for Base transceiver station (BTS) connectivity as this will reduce the call drops and silent calls on mobile phones as experienced by Safaricom customers and enable the company to meet quality of standards requirements and the regulatory standards set by the Communications Authority of Kenya.

5.5 Suggestion for further study

This study has only looked at one mobile service provider in this country which has 4 mobile service providers; a more inclusive study which includes all the mobile service providers would be very beneficial and informative to the customers, the
telecommunication industry, the regulatory authorities, the Kenya Revenue Authority and the Kenya government in general.
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APPENDICES

Appendix I: Letter to the Respondents

Herman Joseph Mutebi

P.O.BOX 14281,

00100

Nairobi

Dear respondents,

RE: REQUEST TO COMPLETE RESEARCH QUESTIONNAIRE

This is to kindly inform you that I am a student at the Management University of Africa pursuing a degree of Executive Masters of Business Administration. It is a requisite that students carry out research project in the final year of the course as a partial fulfillment of the award of the degree. It is for this reason therefore that I humbly request you to assist in filling in the questionnaire issued to you. The answers provided in this questionnaire will only be used for the purpose of this study which is basically academic. The information you provide will not be used in any other way other than for the purpose of this research project. I sincerely request you to respond to the questions. All the information gathered will be handled responsibly with up most confidence, secrecy and due respect.

Thanking you in advance for your support.

Yours faithfully

Herman Joseph Mutebi
Appendix II: Questionnaire

Kindly tick in the space provided ( ) the correct answer or supply the required information where required, please specify and elaborate.

Part A: Respondents Information

1. Name……………………………………………………………Optional

2. Age of the respondent
   20-25 years ( ) 26 to 30 years ( ) 31 to 35 years ( )
   36-40 years ( ) 41 to 45 years ( ) 46 to 50 years ( )
   Above 50 years ( )

3. Gender of the respondent
   Male ( ) Female ( )

4. What is the highest level you have reached?
   Post graduate ( ) Degree ( ) Diploma ( ) Certificate ( ) Form 4 ( )

Part B: Profitability

5. Does the use of optical fiber affect the profitability of Safaricom?
   Yes ( ) No ( )

6. To what extent does the use of Optical fiber affect the profitability of Safaricom?
   Very great extent ( )
   Great extent ( )
   Moderate extent ( )
   Little extent ( )
   No extent ( )
What is the level of your agreement of the following statements relating to the use of optical fiber on the profitability of the Safaricom network?

Scale 1 = Strongly Agree  
Scale 2 = Agree  
Scale 3 = Moderately Agree  
Scale 4 = Disagree  
Scale 5 = Strongly Disagree

<table>
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<tr>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
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<td>The installation of Optical fiber is Capital intensive (Costly)</td>
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<tr>
<td>Maintenance of Optical fiber is costly.</td>
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<tr>
<td>The revenue generated from the use of Optical fiber contributes to profitability of Safaricom.</td>
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<tr>
<td>The use of Optical fiber for BTS connectivity has an impact on BTS Network Operation Costs.</td>
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</table>

8. How else does Optical fiber affect the profitability of Safaricom?

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PART C: Network Availability

Does the installation of optical fiber affect the network availability/service availability of subscribers? Yes ( ) No ( )

10. To what extent does the installation of Optical fiber affect the network availability and service availability experience of the mobile phone subscriber?

- Very great extent ( )
- Great extent ( )
- Moderate extent ( )
- Little extent ( )
- No extent ( )

11. What is the level of your agreement of the following statements relating to the use of optical fiber within the Safaricom network?

Scale 1 = Strongly Agree Scale 2 = Agree Scale 3 = Moderately Agree Scale 4- = Disagree

Scale 5 = Strongly Agree

<table>
<thead>
<tr>
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<th>2</th>
<th>3</th>
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<tr>
<td>The installation of Optical fiber leads to increased network and service availability</td>
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</tr>
<tr>
<td>The installation of Optical fiber leads to customer migration to other mobile service providers due to network availability</td>
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<tr>
<td>The installation of Optical fiber leads to reduction of Network and service availability.</td>
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</tbody>
</table>
**PART D: Network Degradation**

12. Does the installation of optical fiber affect the internet connectivity of mobile subscribers?

   Yes ( )  
   No ( )

13. To what extent does the installation of Optical fiber affect the internet connectivity experience of the mobile phone subscriber?

   - Very great extent ( )
   - Great extent ( )
   - Moderate extent ( )
   - Little extent ( )
   - No extent ( )

14. What is the level of your agreement of the following statements relating to the use of Optical fiber within the Safaricom network?

   Scale 1 = Strongly Agree  
   Scale 2 = Agree  
   Scale 3 = Moderately Agree  
   Scale 4 = Disagree  
   Scale 5 = Strongly Disagree

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<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>The installation of Optical fiber leads to increased internet connectivity speeds</td>
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<tr>
<td>The installation of Optical fiber leads to customer migration to other mobile service providers due to internet connectivity issues</td>
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<tr>
<td>The installation of Optical fiber leads to reduction of internet connectivity speeds</td>
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</tbody>
</table>
PART E: Network Congestion

15. Does the installation of Optical fiber affect the network congestion experienced by subscribers?
   Yes (   )
   No (   )

16. To what extent does the installation of Optical fiber affect network congestion experienced by subscribers?
   Very great extent (   )
   Great extent (   )
   Moderate extent (   )
   Little extent (   )
   No extent (   )

17. What is the level of your agreement of the following statements relating to the use of Optical fiber within the Safaricom network?

   Scale 1 = Strongly Agree   Scale 2 = Agree   Scale 3 = Moderately Agree   Scale 4 = Disagree
   Scale 5 = Strongly Agree

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>The installation of Optical fiber leads to customer migration to other mobile service providers due to network congestion.</td>
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<tr>
<td>The installation of Optical fiber leads to increased network congestion</td>
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Thank you for your time