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DEPARTMENT OF COMPUTING AND INFORMATICS

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

A FRAMEWORK FOR ADOPTION OF SOFTWARE DEFINED WIDE AREA NETWORKS (SD-WAN) WITHIN THE ENTERPRISES IN KENYA.

BY:

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A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF UNIVERSITY OF NAIROBI IN MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT.

SEPTEMBER 2022

DECLARATION

This research project report is my own original work and has not been presented for a degree in any other university

Signature:  ---------- **Date:**9th September 2022----------

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This project report has been presented for examination with my approval as the appointed supervisor.

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DEDICATION

This research project is dedicated to my family, close friends and workmates for their prayers, support they provided throughout my studies and enable finalize the Master of Science Information Technology Management program. May the almighty God bless them abundantly.

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I take this opportunity to my family, friends and colleagues for their patience and moral support they provided as I studied and studied the master's program. The colleagues who despite the tight schedules and required workloads, provided me with extra time to study and complete the master's program. Thank you for all the organizations that were willing to participate as I collected data for analysis. I acknowledge my supervisor Prof. Elisha Opiyo for the countless times we had encounters that led to discussions, suggestions and guidance. Last but not least, I acknowledge panelists Prof. Robert Oboko and Prof. Agnes N. Wausi for the progressive support and positive criticism throughout the project.

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LIST OF ABBREVIATIONS

ICT	Information Communication and Technology
CAPEX	Capital Expenditure
OPEX	Operating Expenditure
CIO	Chief Information Officer
SDN	Software Defined Networking
NFV	Network Function Virtualization
CC	Cloud Computing
SD-WAN	Software Defined Wide Area Network.
ISP	Internet Service Provider
EY	Ernst & Young
QOS	Quality of Service
CPU	Computer Processing Unit
NAT	Network Address Translation
IS	Information Systems
MPLS	Multi-Protocol Label Switching
OSI	Open Systems Interconnection
ATM	Asynchronous Transfer Mode
MEF	Metro Ethernet Forum
NSE	Nairobi Stock Exchange
RFC	Request for Comments

ABSTRACT

The primary goal of this study is to formulating a framework that will assist Kenyan enterprises adopt the SD-WAN technology. To achieve this the study was guided by the following specific objectives: To investigate the influence of technology on the adoption of SD-WAN at the enterprise organizations in Kenya; To investigate the organizational issues on the adoption of SD-WAN at the enterprise organization in Kenya; To investigate the environmental issues on adoption of SD-WAN at the enterprise organizations in Kenya and to formulate a framework that can be used as guideline for Kenyan enterprises to adopt SD-WAN technology. This study reviews four models that have been developed and used in earlier research to explain technology usage and behavior. These models are: Technology Acceptance Model (TAM), Innovation Diffusion Theory (DOI), Technology-Organization-Environment (TOE) Model and Unified Theory of Acceptance and Use of Technology (UTAUT). A descriptive research design was used to obtain information concerning the current status of the problem. The target population of this study was the 64 enterprises listed on Nairobi Stock Exchange (NSE). The researcher used a questionnaire as the primary data collection instrument. After data collection, a thorough check will be done on the questionnaires before coding and entering the data in software (Statistical Package for Social Sciences) for analysis. The analysis of the respondent's data showed that indeed technological factors do influence the adoption of SDWAN. These factors technological factors constituted, security concerns within their environment, the challenges they face with the current WAN, service reliability, network reliability, bandwidth limitations and the current network management. The study analyzed organizational factors to assess the influence of organizational factors on the adoption of SDWAN. These specific factors included support from top management by providing support in key decision making, size of the firm/organization and the change process in the firm. The most emphasized factors were the size of their organization and support from top management. The study concluded that there is a significant relationship between existing internal technologies within the organizations and the SDWAN technology and the existing internal technology influences adoption of SDWAN technology in organizations. The study finally concluded that competitive pressure significantly contributes the adoption of new technologies including SDWAN adoption and that there is a statistically significant relationship between external support and adoption of the SDWAN technology.

CHAPTER ONE

INTRODUCTION

1.1 Problem Background

Accessible and excellent infrastructure is necessary need especially with the ever-growing market. Every industry in the modern world is competing against each other on the basis of Quality of Service (QoS) as well as performance regardless of whether the industry is in the motor vehicle business, customer care services, or even data networking. Enterprise networks play a significant role in the nation's economy in some countries, making it very relevant in those countries. The enterprise networks are continuing to change in a rapid speed. These traditional enterprise networks have hugely relied on Wide Area networks (Multi-Protocol Label Switching - MPLS circuits) from telecommunications service providers to be able to communicate from their data centers to the branch level. Telecom Service Providers have recognized the pivotal role that they are playing in enabling communications within the residential customers, small business as well as the big corporate entities and hence providing a global digital community. According to a telecommunications report conducted by Ernst & Young - EY (Global telecommunications study: navigating the road to 2020), the telecommunications industry has rapidly evolved over the last decade or so, increasing the number of internet users especially due to the smart technology, giving them the opportunity to access the internet anywhere, hence consuming a larger internet bandwidth. The consumption of these data hugely comes from the residential or mobile users.

Technology has evolved at rapidly recently and it is almost impossible to predict where the industry will be in the next few years. An annual report conducted by telecoms.com (Annual Industry Survey 2017), mentions that for organizations long-term business success, they need to face their greatest potential threats i.e., the evolution of technology and alignment with the current trend. The move to automation and autonomous systems has been gaining momentum and this is changing the way enterprise networks are setup. The cloud computing model includes having the network embed applications as well as data storage within it. The performance of cloud computing depends heavily on the performance of the enterprise networks and any limitations or any failures

on these the enterprise networks can breakdown or impair the performance of sensitive cloud applications (J. Moura, and D. Hutchison, 2014). Other factors that organizations need to look at are budgetary and headcount pressure, therefore this means that most enterprise organizations are now focusing on reducing their ICT costs and being innovative to create agile service models. These ICT costs are mainly associated with Capital Expenditure (CAPEX) costs, Operational Expenditure (OPEX) costs and time required for implementing new branches.

The current traditional or conventional networks that are being used mostly by the telecommunications industry to connect to the internet today has shown that it is evolving with with limited functionality and having high levels of operation expenditures. These high operation expenditures are brought about the consumption of resources by traditional networks e.g., power utilization and cooling. Other sources of operation expenditure are due to the manual maintenance of the devices and the cost of replacing devices when device failures occur. For organizations to compete effectively, they have to invest in ICT infrastructure that can quickly scale up to meet the dynamic business needs those current traditional/conventional networks systems cannot meet due to the lack of flexibility and scalability of these traditional or conventional networks.

Cloud computing is among the most important and relevant topics in ICT as the past few years have proven as opposed to traditional computing technology. This has created the need to improve performance of the Wide Area Networks by enterprise networks. Cloud computing is already changing the information structure with the associated business process that it brings with it. Sezer S. et al (2013) mentions that the demand of cloud services has been on the rise considering the customers views, which in turn impacts the need for high security for personal data and energy efficiency. These demands for services are cloud services, commercialization of ICT (people carrying their own devices), a change in the traffic patterns, big data and the internet of things. With these constantly increasing demands and more bandwidths requirement to accommodate cloud computing, ICT enterprise networks have to focus on two main objectives: enhancing the efficiency and flexibility of the Wide Area Networks and minimizing the cost of the deployed networks.

Software-Defined Wide Area Networks (SD-WAN) which is a new network paradigm is based on two main concepts which are the network function virtualization (NFV) and software defined

networking (SDN) that is applied to the Wide area networking (WAN). SD-WAN promises to help in overcoming the scalability and flexibility of the ICT infrastructure in organizations that the traditional networks had by making use of the network management centralization as well as fostering automation. SDN is defined as a new network design that disables the network control from forwarding, and one can program it directly by the Open Networking group. Software-defined networking is a model that, favors centralized network control and allowing programmability, eases network deployments and configuration and improve network resources performance. The current SD-WAN applications perform traditional functionalities like security enforcements, traditional routing, load balancing and switching. Other functionality's reliability of the data planes, Quality of Service (QOS), network virtualization. These functionalities will play a major force in fostering the adoption of SD-WAN (Mckeown, 2011).

1.2 Problem Statement

Traditional networks for example MPLS, which have been used by enterprise networks for connectivity of their sites that are not flexible, cost efficient, or scalable. CIOs or IT managers have tried to replace the expensive MPLS connections with internet links that are cheaper than the MPLS connections but these are unable to deliver security and relevant performance metrics to the networks that are necessary for critical applications and services. (Deloitte, 2021). Demand for cloud services means that there is a growing demand for an enterprise network that provides a reliable connectivity, security and optimizing the bandwidth procured by the organizations. This therefore is driving ICT departments in organizations to be more creative when building the enterprise networks and purchasing of connectivity to each site or branch (Futuriom, 2018). As consumers continue to consume digital services, more applications and services become highly dependent with the connectivity service providers' network (ISPs). This therefore poses a major challenge especially on security, performance and scalability of the network.

Recent studies, as shown by the 80% of enterprises having already moved or are in the process of moving from traditional centers as they are incompatible with the cloud (cloud misfit), prove that the world is embracing the utilization of cloud services is thriving globally. Meanwhile, around 87% of businesses have started implementing or intend to start using Internet based connectivity as its main WAN technology, at the expense of MPLS (Deloitte, 2021). The change of enterprises

moving their data from the on-premise data centers to cloud based applications has required network managers to rethink their mindset in approaching enterprise networking. Scalability, Security and performance are key features that have become more important in today's networks.

Software Defined Wide Area Networking (SD-WAN) responds to several challenging needs of the digital transformation era, by providing the relevant tools and intelligence to ensure a centralized management network that are scaled dynamically using one intuitive user interface. Adopting internet-based connectivity has prompted the shift towards a hybrid WAN which aims at a cost efficiency on the WAN. The shift towards a hybrid WAN, with relying on connectivity to adopt the internet, is paramount to allow for cost on the WAN. However, to handle an MPLS-Internet hybrid WAN, it is necessary for one to consider the use of an overlay technology which would act as the sole plane of glass for network management: Software Defined Wide Area Network (SD-WAN).

1.3 Purpose of the Study

This research intended to make an explanatory study into the Software Defined Wide Area Networking (SD-WAN) adoption readiness and the contribution that SD-WAN plays in ICT infrastructure and its contributions towards the business processes in minimizing the ICT infrastructure and maintenance costs as well as improving operational tasks within the enterprise network. The study aims at researching specifically into the enterprise networks within the Kenyan enterprises by examining how Kenyan organizations are ready for the adoption of Software Defined Wide Area Networking (SD-WAN) as well as the understanding SD-WAN as an emerging technology in network deployment and management. The study also aims at formulating a framework that assist Kenyan enterprises adopt the SD-WAN technology.

1.4 General Objective

The primary goal of this study is to formulating a framework that will assist Kenyan enterprises adopt the SD-WAN technology.

1.5 Specific Objectives

The study was guided by the following specific objectives

- **i.** To investigate the influence of technology on the adoption of SD-WAN at the enterprise organizations in Kenya.
- **ii.** To investigate the organizational issues on the acquisition of SD-WAN in various enterprise organization in Kenya.
- **iii.** To investigate the environmental issues on adoption of SD-WAN at the enterprise organizations in Kenya.
- **iv.** To formulate a framework that can be used as guideline for Kenyan enterprises to adopt SD-WAN technology.

1.6 Significance of Study

This research intends to benefit enterprise organizations who strive to embark on deploying SD-WAN networks. This study may also serve as a reference document for future research work. Network scalability and network performance has become a major need by the Kenyan organizations. It is therefore significant for the Kenyan organizations to recognize the acquisition factors of software defined wide area networks and how to be well prepared for the utilization of software defined wide area networks.

CHAPTER TWO

LITERATURE REVIEW

2.1 Traditional Networking

The control and data planes are put together in traditional networks within a network node. The node configuration is done by the control plane, and it is also responsible for programming the paths utilized by data flows. After the path determination, they are sent towards the data plane. At the hardware level, data forwarding is done and it is based on the control information. The flow management is defined and adjustments of the policies are made via changes in configuring individual devices. even though they are mostly used, traditional IP networks are both difficult to manage, and complex (Benson et al., 2009). This has increased the restrictions experienced by network operators, particularly those who have tried to scale their networks as a result of the changing traffic demands and cloud services.

2.1.1 Multi-Protocol Label Switching (MPLS)

Protocol agnostic forwarding mechanisms that are used to connect different networks is known as a Multi-Protocol Label Switching. MPLS was introduced as a replacement for wide area networks (WAN) protocols including ATMs and Frame Relay which were initially used. MPLS provided a reliable and secure way to connect enterprise networks from the data center/data recovery to all the branches. The result of interconnecting branch and DC networks via MPLS was a Hub and Spoke model with the responsibility of the internet breakout and being the sole responsibility of the data center or the headquarters.

A label is the most important MPLS addressing. The label is located between Layer 2 and Layer 3 protocols headers on the OSI model, with the label being a 20-bit field. As such, in some cases, MPLS is considered as the layer 2.5 protocol, lying between 2 and 3. Below is a figure for the MPLS label format.

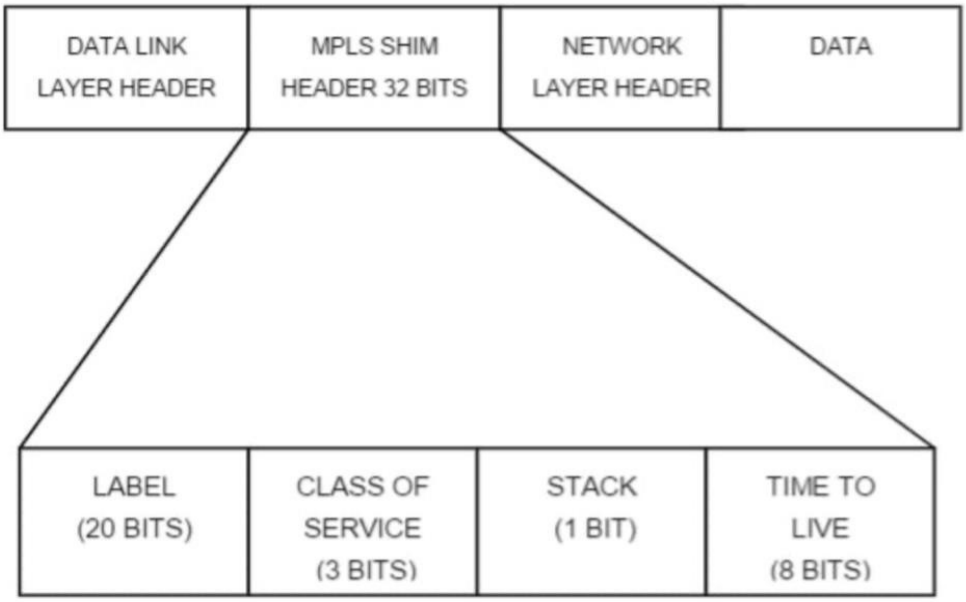

Figure 1: MPLS Label Format – Source Abinaiya and Jayageetha, 2015

Label distribution protocols can be used to distribute MPLS labels, or the labels can be statically configured instead. The Label Distribution Protocol (LDP) is the most preferred label distribution protocol. Through an MPLS network, the labels are distributed and utilized to encapsulate the inbound traffic and the mechanism is known as pushing labels. The Label Switch Routers (LSRs) do a precise lookup in relation to an MPLS label Forwarding Information Base to forward the labels through the MPLS network. Through the MPLS network, the labels can be switched. In the end, the MPLS label gets de-encapsulated as the traffic leaves the MPLS network towards the final destination network. Black explains further in detail the label construct as well as the label processing operation through the network.

One of the main successes of MPLS is because of the protocol encapsulation through the network. MPLS can be used for interconnecting purposes between several Layer 2 networks of same protocols. This type of MPLS is called Any Transport over MPLS (AToM). MPLS encapsulation as well as Border Gateway protocol (BGP), and Virtual Routing and Forwarding can also be used to virtually and logically segment traffic across different service provider networks using Layer 3 and VPNs.

2.1.2 MPLS Challenges.

i. *Bandwidth:* Enterprise networks are increasingly requiring more bandwidths due to the nature and diversity of the applications in the WAN such as video, cloud applications. The current MPLS technology does not provide reliable and high reliable connections to ensure reliability and scalability of the enterprise networks. (Jain et al., 2013).

ii. *Network Operations:* Establishing an enterprise network or adding a branch to the enterprise network requires manual intervention in terms of setting it up and configuring the network. The manual tasks are expensive, complex and slow to deploy and therefore can also lead to errors when setting up the enterprise networks via MPLS technologies. MPLS operations currently are not automated and leads to a nightmare in setting up the enterprise network and tedious when troubleshooting an issue on the network. (Sassi et Subedi, 2017).

iii. *Cost:* Organizations are always looking at minimizing the total cost of operations. These costs include maintenance costs, operational costs, configurations costs, allocations costs and all other associated costs for ICT spend in the enterprise networks. MPLS technology currently is costly in most aspects especially the operational cost and maintenance costs. Organizations are looking for new technologies to enhance high-speed networking at the lowest possible costs. An important aspect of the data centers also includes the cost of energy consumption which are increasingly exponentially. In order to provide a greener energy solution, enterprise networks need to adopt network function virtualization kind of networks.

2.2 Software Defined Networking Paradigm

The programmable networks idea has been there since 1996 and was controlled by the wish of network administrators to forward network notes through a controlled management. The definition of software defined networking (SDN) according to Open Network Foundation is; when the control and data planes are decoupled within the SDN architecture, the underlying network

infrastructure is abstracted from the applications, while the network intelligence and state are centralized logically. The idea of SDN is the split-up and domination of the control, the open interfaces between the controllers and the forwarding elements of the ability to program the network using applications outside the network. Akpovi et al (2016) provide some of the benefits of splitting the data from control plane (SDN) being the global network view, the horizon integration, elimination of middle boxes and the easy of deploying new network services and protocols.

2.2.1 SDN Architecture

The SDN architecture is made up of of the lower tier which involves the physical network apparatus which consist of the Ethernet routers and switches to form the data plane. The central tier follows and it includes the controllers which are facilitating the building and destroying the flows and paths embedded in the network. The next level, also known as the central tier connects together with the last tier via an application programming interface (API) which is known as the southbound API. Controllers are connected through a connection that is able to work with the east and west bound APIs. The northbound API is the controller application interface. The management application describes the different policies, which are sent to the southbound instructions that are responsible for how the forwarding devices behave. The northbound API is important when developing applications for network management and load balancing. According to Sezer, S. et al (2013), the SDN architecture consists of four main features; splitting the data plane from the control plane which provides a central network control and a general view, the ability of the network to be programmed by external applications, and open interfaces located between the devices in the data and control planes. The diagram below shows an SDN architecture.

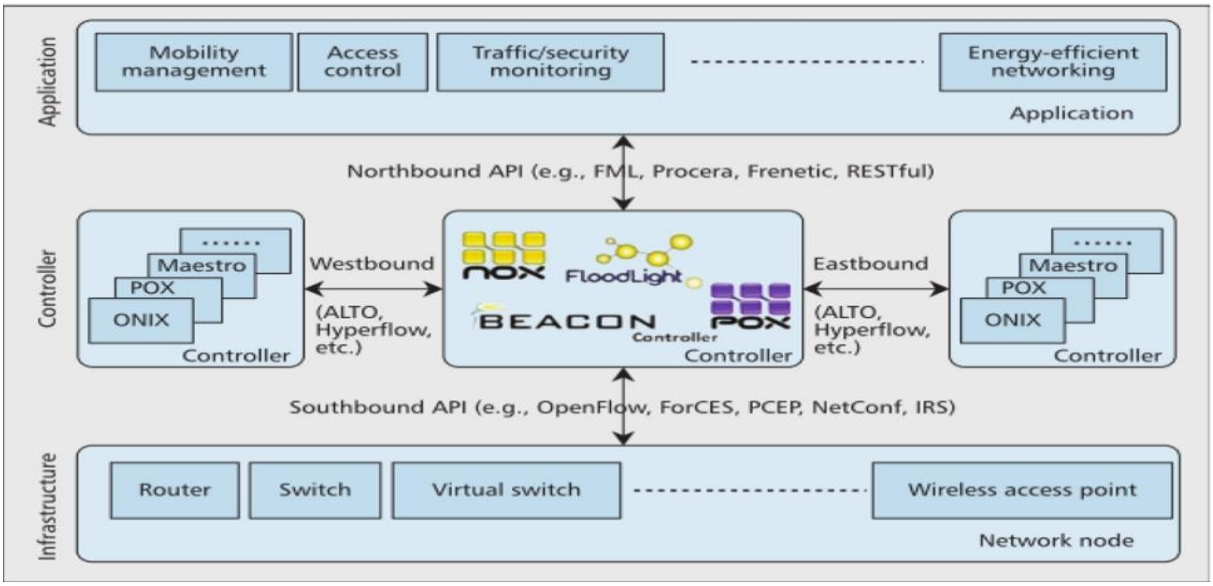

Figure 2: SDN Architecture – Source Sezer, S. et al (2013).

2.2.2 SDN Benefits.

The SDN features bring potentials benefits to the enterprise organizations to Kenya. These benefits are but not limited to improving the configuration, better performance of the network and encourages innovation within the operations as well as network architecture. The potential benefits of SDN makes new technology experimentation more convenient through the platform and this is mainly due to the programmability of the network. In this subsection, we shall look at 3 potential benefits of SDN as provided by Chen et al (2015).

i. *Enhancing Configurations*: Configuration plays an important function on network management especially when network engineers add new devices onto the network. The process of including more devices on the network is tedious and error prone and well as the effort required in troubleshooting in case a segment of the network fails. SDN will control the situation in network management. In SDN, one can configure network devices from an automated centralized point by using a software control as long as all the all the network devices are unified on the control plane. it is possible to configure network devices, such as routers, firewalls, switches, Network Address Translators (NATs), and load balancers from a central point which could be automated

using a software control as long as there is a merge of the control plane over all the network devices. Therefore, this enables the whole network to be configured programmatically and optimize in a dynamic way in regards to the present status of the network.

ii. *Improving Performance:* the network engineers strive to make use of the network infrastructure investments maximally. With the traditional networks, optimization is on the quality of user experience and this might lead to suboptimal performance on the network infrastructure. With the introduction of SDN, new opportunities of improving the network globally have come up due to the fact that SDN allows for a unified control with a that can observe the network globally as well as a feedback control which contains all the information that travels between the different tiers within the network architecture.

iii. *Encouraging Innovation*: The traditional networks have vendor lock ins, this is usually because the traditional networks usually use exclusive hardware in typical network components and therefore not allowing any form of changes for experimentation. With introduction of SDN, there is a programmable network that can be used to implement or experiment new ideas and even create and deploy new applications, hence promoting innovation in the process. SDN offers a distinct separation between the virtual networks through the high configurability, and allows experimentation on a seemingly real environment.

2.2.3 SDN Challenges

SDN is still in its infancy stages, as much as it gives a promise towards the enhanced configurations, improved performance as well as encouraging innovations. However, many issues still remain unsolved among them the standardization and the adoption being the most urgent ones. In research done by Aranda (2016), he identifies, Network Reliability, Network Scalability, Security as some of the major challenges for SDN. He looks at the network reliability as, main cause of failure due to the SDN architecture sharing one controller. Therefore, the entire network is reliant on the controller, and if it fails, it might lead to the network collapsing. As such, organizations that are implementing SDN must seek to exploit the main redundant controller functions which could increase network reliability. On network scalability challenges, the

performance of the SDN network is fully reliant on the performance of the Central Processing Unit and other switch resources, and on the controller, which is the software running the system. Therefore, if the controller has any issues related to its performance it results in the delay on the periodic updates for the switch forwarding information base therefore brings about general delays in creation of network flows. Organizations with Big legacy networks need to look at the scalability issues on the network resources before implementing SDN in their ICT infrastructure. Under security, due to the nature of SDN, the SDN network has centralized management and programmability hence increased the security risks. This therefore makes SDN a prominent target for attacker.

2.3 Software Defined Wide Area Networks.

Software Defined Wide Area Networking (SD-WAN) is based on two main concepts that is the software defined networking (SDN) and the Network function virtualization (NFV). SD-WAN provides a software abstraction that separates the software network services and the hardware network services and creating a network overlay over the existing connections (Mitchell, 2018). The network overlay provides an interface across different physical components to ease the network administration.

2.4 SDWAN Service Components

SD-WAN as defined by the metro ethernet forum (MEF) has the SDWAN Virtual connections, underlay connectivity services among other components. The service components are illustrated as per the below.

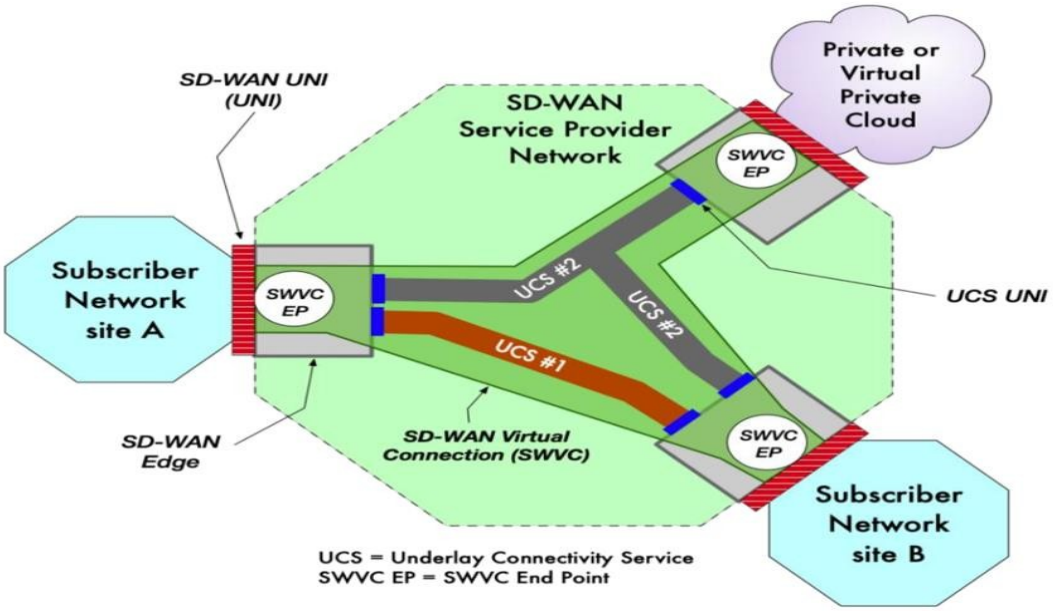

Figure 3: Components of an SDWAN service – Source MEF 2019.

i. *SD-WAN UNI:* The end user (SDWAN User) together with the network Interface is the demarcation point between the service provider and the end users who have procured the SDWAN service.

ii. *SD-WAN Virtual Connection (SWVC) and End Points:* These are the logical connections between end-points located at the UNIs. An SWVC End Point is a logical function focused on associating the incoming internet protocol packets alongside the application flows. To make necessary and appropriate forwarding decisions, it applies a policy for all the incoming internet protocol packets.

iii. *SD-WAN Underlay Connectivity Service (UCS):* this service provides a connection between one or more customer locations where the SD-WAN service is provided. There are various networks on the internet which can be used to deliver the UCS including; LTE, Fiber, 5G, among others. The UCS can be configured as either a public or a private UCS.

iv. *Tunnel Virtual Connection (TVC):* This is a forwarding relationship be- tween two points of SD-WAN Edges that have specific performance and security characteristics.

A TVC cuts through an Underlay Connectivity Service. A least one TVC to a particular SD-WAN Edge is necessary to allow the direct application flows into another SD-WAN Edge.

v. *SD-WAN Edge:* SD-WAN Edge is a group of different network functions that will be found between the pseudowire connections (UCS UNI) and end user interfaces (SDWAN UNI). An important function of the SD-WAN Edge is to select a pseudowire over which to forward each incoming and outgoing internet protocol packets at the SDWAN device end points.

2.4.1 SD-WAN Benefits.

Enterprises look at *cost reduction* as part of the strategies of doing business and for SDWAN this would be the first benefit. The connection of several geographical sites via traditional connection like MPLS VPNs contributes to a large cost. (Bouk, 2017). SD-WAN is just as reliable and secure as the traditional MPLS line, but it is more affordable. Service providers have the mandate to use cheaper options to affordably use their bandwidth at optimal point through the use of LTE, broadband, Internet and MPLS (Dey, Dhir, & Kumar, 2016). SD-WAN architecture is more affordable as it removes the relevance of network upgrades, redesign cost and any other associated cost.

Another advantage of SD-WAN deployment is the *quick deployment* of sites. Due to the simplified configuration in conjunction with the orchestration and rapid provisioning of an SD-WAN solution, Gartner approximated that to provision network changes there is time reduction of 50-80% (Lerner & Rickard, 2017). Traditional WAN setups have multiple appliances at every level to provide security. SD-WAN deployments provides a benefit on *enhanced security* by providing a single box as a solution with much lower costs that deploying several boxes at the branch level. SD-WAN solutions are capable of encrypting to protect corporate network access and assets. The controllers have a security advantage over the old traditional networks as result of the global network view.

2.4.2 SD-WAN Challenges

Network managers in organizations tend to change their network setup with a specific reason. These reasons tend to come due to probably the current devices have come to an end of life, MPLS WANs becoming complex to maintain or most probably the contracts with the current service providers have come up and with these reasons they might consider deploying SD-WAN solutions as part of their network upgrades. However, SD-WAN technology comes with its own challenges and obstacles (CDW LLC, 2019). A survey done by IDC indicated that 51% to 56% of the executives cited the two top concerns of SD-WAN as the interoperability with the existing infrastructure and the cost of purchasing the SD-WAN boxes on a capex model. 46% of the executives worried that their organizations might not have the required skill set to implement and manage SD-WAN (IDC Market Pulse Research, 2019). SD-WAN equipment's and systems are generally more expensive that traditional WAN vendors (routers and switches) and this requires a high capex cost in the initial phase at the same time reducing the OPEX cost in the long run. Most organizations will struggle during the scoping phase of deploying SD-WAN and therefore becomes difficult to deploy.

i. *Security*: Business applications while deploying SD-WAN means that the security is no longer at a centralized segment. Security is therefore implemented at each remote edge and this becomes a major issue to most IT managers. IT managers have to ensure that each security functions are correctly configured and implemented according to each remote site specifications and requirements. The challenge comes in when there is a need of skillsets to properly recognize and implement the appropriate security protocol.

ii. *Quality of service on links:* SD-WAN is known for load balancing between various links i.e. Internet and MPLS and can work with several technologies across the board. This means if the IT managers are not careful on selecting the last mile internet connections, users might experience degraded services especially for real time traffic (voice and video).

iii. *Lack of standardizations:* SD-WAN were conceived from the SDN concept and as much as SDN has an RFC (RFC 7426 and RFC 7149), SD-WAN has no recognized RFC. This lack of standardization has led the industry into a vendor proprietary solution in the market.

This approach has therefore let the industry into problems as monopoly and challenges in black-box testing.

2.5 Theoretical Frameworks

As an IT innovation, the acquisition of software defined wide area networks could come after the IT innovation adoption models. Below is a list and summary of common technology adoption theories that will be reviewed for the purpose of this study.

2.5.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model is a popular adoption model developed by Davis (1989). This model foresees the utilization of acceptance of information systems and technology by individuals. TAM has two factors which are the determinants of acceptance of a system. the assumption on the importance and ease of use is necessary in computer use behaviors. According to Davis, the key factors vary depending on the characteristics of every individual user. For instance, a user who is highly competent in the use of technology will use information technology easier as compared to those who have a lower competency. Perceived usefulness implies that job performance can be improved by better use of technology. However, majority of employees feel that only when their jobs are impacted directly in some way, can they see the importance of any new information technology.

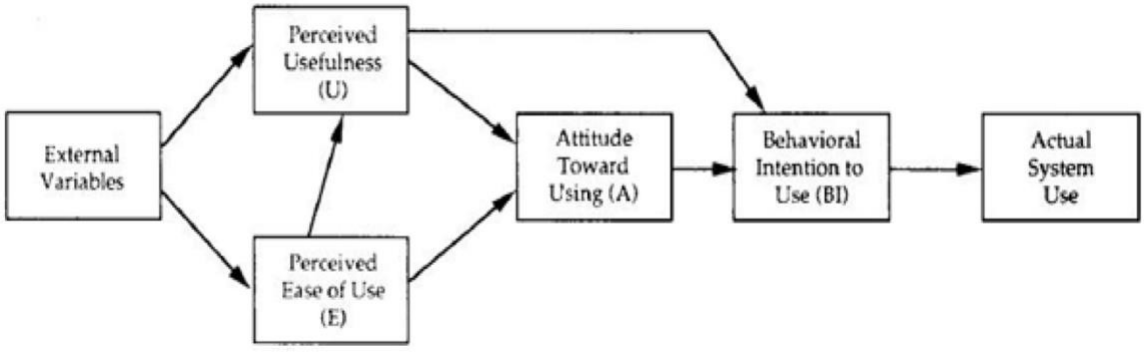

Figure 4: Technology Acceptance Model (TAM), Davis (1989)

2.5.2 Technology Organization Environment (TOE)

The Technology Organization and Environmental framework looks at the technological contexts such as the internal and external innovations that are important to the organization (Tornatzky et al., 1990). Aside from technology factors, TOE also has internal organization factors and external environment factors as the key determinants of the adoption of a new technology. The organizational context is based on the firm characteristics and its resources such as size, human resources, formalization and centralization extent, the firm's managerial structure, and linkages among employees. The environmental context mainly focuses of the outside elements surrounding the firm such as competitors, the regulations and laws affecting the firm and the structure as well. Below is the diagram of the theory.

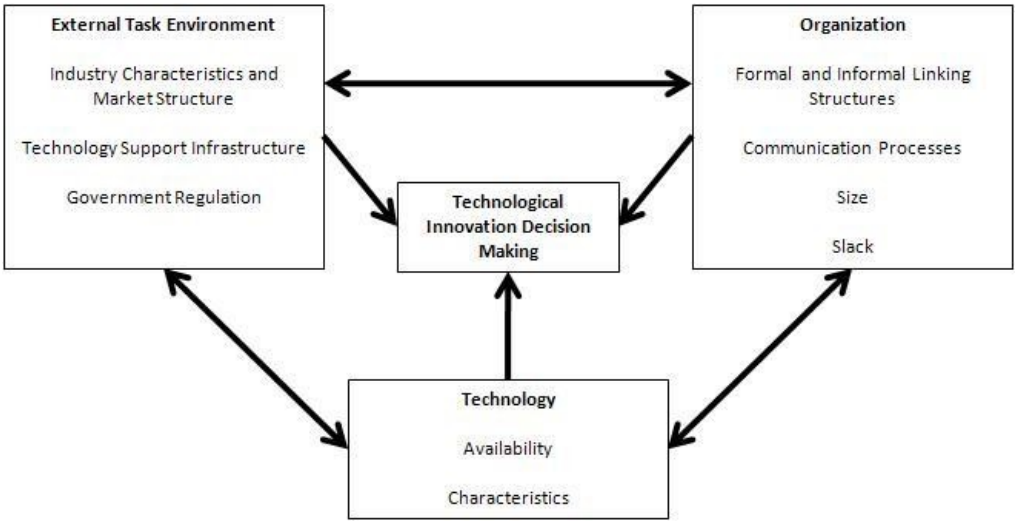

Figure 5: TOE Adoption Framework

2.5.3 Innovation Diffusion Theory (DOI)

Diffusion is the use of specific channels correspond innovation through different members of the society (Rogers, 1995). Diffusion of innovation has various factors that influence adoption as per below,

- *Relative Advantage*: The extent the innovation is considered better as compared to the idea or product it is replacing.
- *Compatibility*: the consistency of the innovation in accordance to the values, and requirements of the potential users.

- *Complexity:* the difficulty of the innovation to comprehend.
- *Trialability*: The permissible degree to which the innovation can be tried or experimented with before a final commitment to use is made.
- *Observability*: The degree to which reliable results are provided by the innovation.

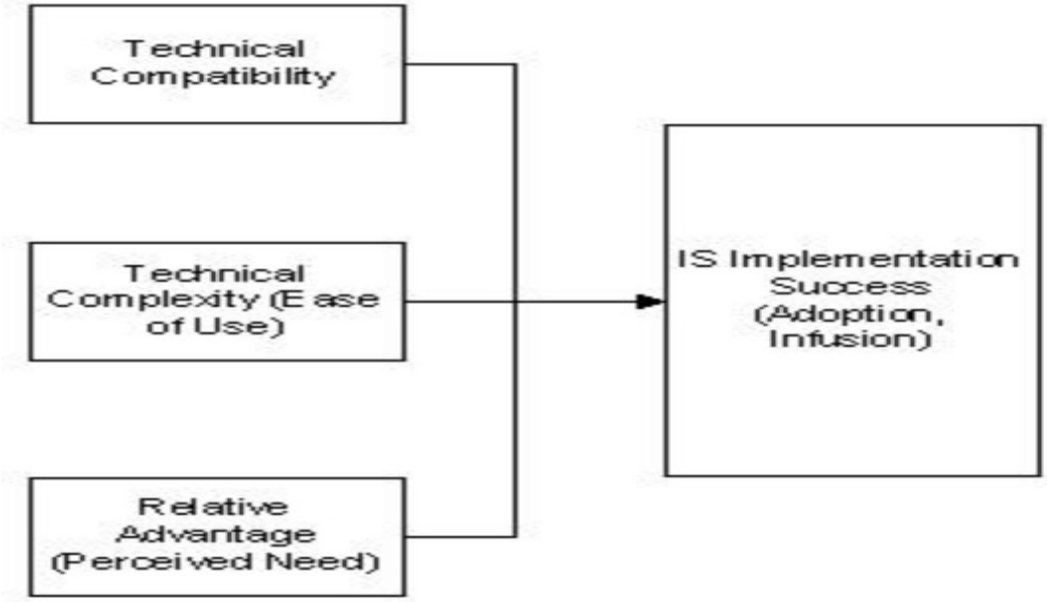

Figure 6: Innovation Diffusion Theory (DOI)

2.5.4 Unified Theory of Acceptance and Use of Technology (UTAUT).

The Unified Theory of Acceptance and Use of Technology (UTAUT) implies that the four major constructs (performance expectancy, effort expectancy, social influence and facilitating conditions) are directly determine intention and ultimately behavior, and that the constructs are in turn controlled by experience, voluntariness of use, and demographic factors like gender and age (Venkatesh et al., 2003). These four concepts are as below;

Performance expectancy: This is how much one assumes that utilizing the system will help them achieve success in their job performance

Effort expectancy: This refers to how easy it is to use the system.

Social influence: This is the extent to which one believes that other people think he deserves to use the new.

Facilitating conditions: This is the degree to which an one thinks the general organizational infrastructure, as well as the technical one is meant support use of the system.

In the UTAUT model, every user's technical capacity has a crucial role in the implementation of new innovation. It is particularly pronounced in the ease felt by the user when utilizing the new innovation and this eventually requires a higher adoption rate.

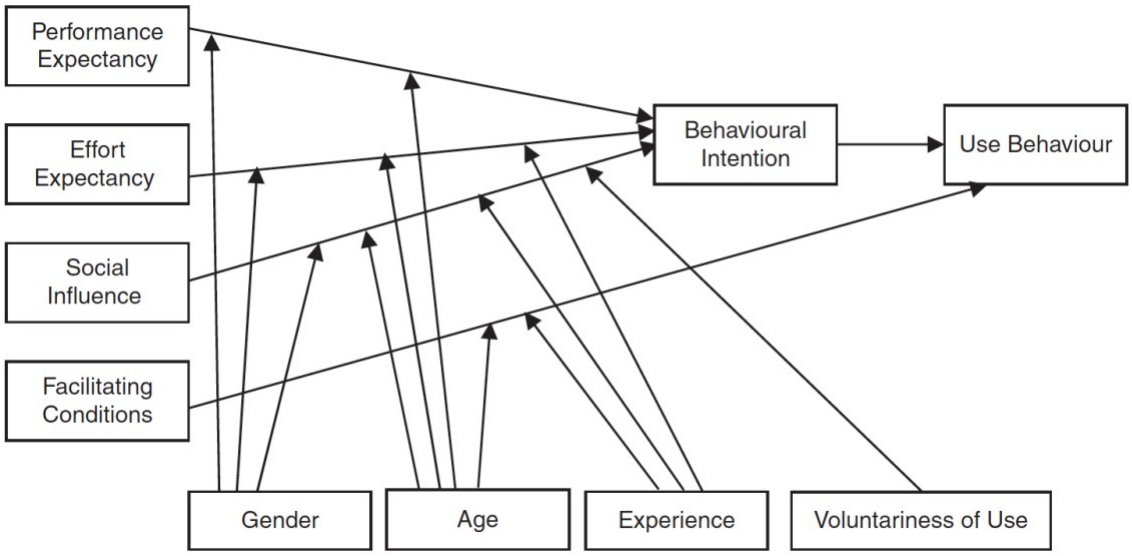

Figure 7: UTAUT Model - Venkatesh et al. (2003)

2.5.5 Technology Adoption Theories Summary

The IS adoption models that have been reviewed have focused mainly on the individual aspects and the organizations aspects. For example, Unified Theory of Acceptance and Use of Technology (UTAUT) and Technology Acceptance Model (TAM) have mainly focused on the individual acceptance of Information Systems (IS) whereas on the other hand, two other adoption models focus mainly on IT adoption at the organizational level. These two models are Innovation Diffusion Theory (DOI) and Technology-Organization-Environment (TOE). Innovation Diffusion Theory (DOI) has five determinants of an innovation adoption which are observability, relative advantage, compatibility, trialability and complexity. (Roger, 1995). On the other hand, TOE considers the contextual factors of the technology, organization and environmental factors.

In this study we therefore examine the implementation of software defined WAN in the organizational context and not the individual context. This therefore means that we shall use only the Technology, organization and environment and the Innovation diffusion theory for our study. Below is a summary of the comparisons on the 4 models.

Table 1: Theoretical Model comparisons

Theory	**Determinants of IT Adoption**	**Source**	**Individual**	**Organization**
Technology Acceptance Model	Perceived usefulness and perceived ease of use	Davis et al. (1989)	√	
Innovation Diffusion Theory	Innovation observability, relative advantage, compatibility, trialability, complexity	Rogers (1995)		√
The Unified Theory of Acceptance and Use of Technology	Performance expectancy, effort expectancy, and social influence	Venkatesh et al. (2003)	√	
Technology-Organization-Environment	Technology, organization and environment context	Tornatzky et al. (1990)		√

2.6 Related works of TOE

TOE framework (Tornatzky & Fleischer, 1990) has widely been used to investigate and predict whether a and organization is willing to adopt a certain technology. TOE framework is characteristics are categorized as technology, organization and environmental. Whereas the TOE framework appears to be simple and straightforward, determining the variables could be challenging due to the fact that research has to collect opinions from various individuals in the organizations. Most organizations depend on a small group making the decision for adopting a

certain technology and sometimes it can even be a single decision maker. (Li, 2020). Several scholars have tested the TOE framework who have mostly relied on input from the decision makers from the respective organizations. Awa, Ukoha & Igwe, (2017) reviewed several papers based on technology adoption by SMEs and noted that funding, internal infrastructure and personal capabilities was a technological factor influencing the adoption of technology. The characteristic of the organization in adoption looked at the organization structure, work culture and support from top management. The environmental factors also influence the adoption of the technology by SME. These environmental factors are the role of governments, availability of public infrastructure, level of competition and the characteristics of the business environment. (Nikmah et al, 2021).

2.7 Conceptual Framework

It is important for us to understand the determinants of IT adoption and the theoretical models that have arisen addressing IT adoption. We have looked at the Innovation Diffusion framework and the Technology, Organization and Environmental frameworks which look at the organization level of IT adoption in organizations. These models have factors that researchers examined in relation to the adoption of technology in terms of products and services. In this research we shall use the Technology Organization and Environmental adoption model to focus on the adoption of software defined wide area network in enterprise organizations. This is due to the fact that the TOE model provides most of the variables within our study of the enterprise organizations also considering that there has also been a recent research paper done by Awa (2016) on the Using T-O-E theoretical framework to study the adoption of ERP solution. Tornantzky and Fleischer (1990) provided the technology adoption that consisted of three variables (Technology, Organization and Environment). We will therefore look at these variables while doing our studies, however the model might have limitations since the characteristics of the individual might not be considered.

Adoption of software defined wide area networks determinants consist the relative advantage that SD-WAN will provide in terms of the technology, considerations of compatibility of SD-WAN with the existing technologies also needs to be looked at, How complex is SD-WAN to deploy or manage is another factor to be considered, does the organization have enough network engineers with the right skill sets to manage the SD-WAN networks, are there any business request from

stakeholders in terms of cloud services that require SD-WAN adoption and finally is vendor support that encourage the adoption of SD-WAN networks in the organizations.

The TOE framework provides a relation to all the three elements and all of them needs to be looked withing the enterprise organizations on how they influence the decision-making process of adopting SD-WAN technology. By using our three variables from the TOE framework, we can summarize the main determining factors under each of the three categories as per below,

Table 2: Determining Factors

T-O-E Factors	**Independent variables characteristics**
Technology	• Relative advantage of SD-WAN technology. • Compatibility of SD-WAN to the existing technology. • Complexity of the SD-WAN technology.
Organization	• Business Size. • Employees Skill Set. • Organization demographic composition. • Top management support • Satisfaction with existing infrastructure.
Environmental	• Competition from the market • External technology support from the vendors and partners. • Customer driven requests.

Therefore, the below diagram will depict the Independent and dependent variable that will be used during the research.

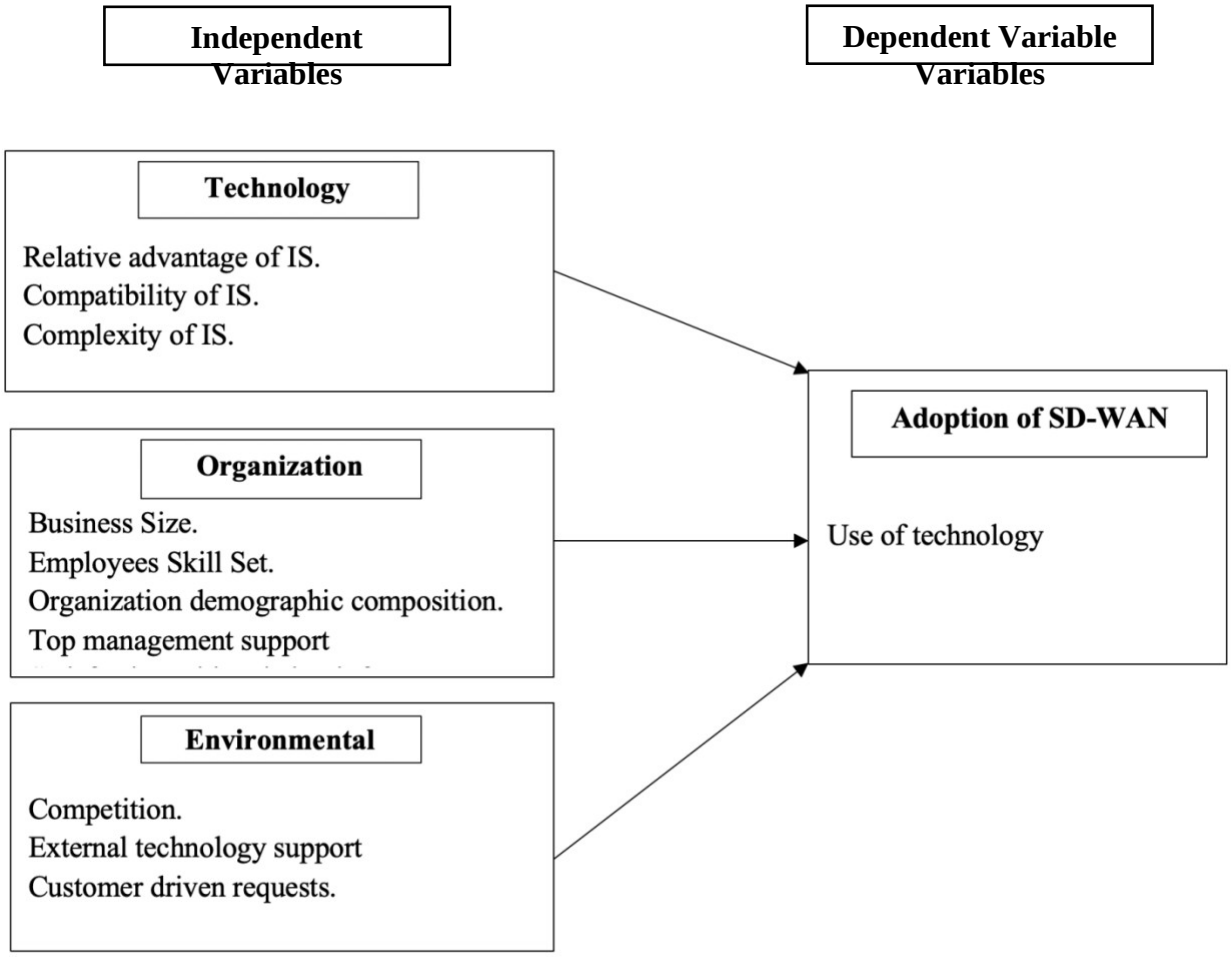

Figure 8: Conceptual Framework

2.8 Research Hypothesis Development

With the above conceptual framework TOE, we therefore propose the following hypothesized relationships for technological, organizational and environmental factors.

Table 3: Hypothesis Development

CONSTRUCT	HYPOTHESIS
Technological Context	H1.0 There is a significant relationship between existing internal technologies withing the organizations and the SDWAN technology. H1.1 The existing internal technology influences adoption of SDWAN technology in organizations. H1.2 The lower the perceived reliability of network services, the greater the potential adoption of the SDWAN technology.
	H2.0 The perceived compatibility between the SDWAN technology and existing platforms makes adoption of SDWAN technology possible.
	H3.0 There is a significant relationship between the complexity of the SDWAN technology in facilitating the adoption of the SDWAN technology.
Organizational Context	H4.0 The size of the firm does not influence the ability to adopt the SDWAN technology. H4.1 The demographic composition of an organization influences the ability to adopt the SDWAN technology. H4.2 The size of the firm influences the ability to adopt the SDWAN technology.
	H5.0 There is a significant relationship between employees' knowledge and technical skill set in an organization and the adoption of SDWAN Technology.
	H6.0 There is a significant relationship between decision-making team including the top management and adoption of the SDWAN Technology
Environmental Context	H7.0 Competitive pressure significantly contributes the adoption of new technologies including SDWAN adoption.
	H8.0 There is a statistically significant relationship between external support and adoption of the SDWAN technology.
	H9.0 Customer driven requests significantly contributes to the adoption of SDWAN technology.

2.9 Operationalization of variables

Table 4: Operationalization of variables

Objective	**Variable**	**Type Of Variables**	**Indicators**	**Measurement Scale**
To investigate the influence of technology on the adoption of SD-WAN at the enterprise organizations in Kenya.	Technology Factor	Independent	Compatibility of IS Complexity of IS (developing, maintaining, upgrading) Relative advantage to IS	Nominal Ordinal
To investigate the organizational issues on the adoption of SD-WAN at the enterprise organization in Kenya.	Organizational Factor	Independent	Top management support Organizational Size	Nominal Ordinal
To investigate the environmental issues on adoption of SD-WAN at the enterprise organizations in Kenya.	Environmental Factor	Independent	Support infrastructure External technology Support	Nominal
To formulate a framework that can be used as guideline for Kenyan enterprises to adopt SD-WAN technology	Implementation of technology	Dependent	Use of technology	Nominal

CHAPTER THREE

REASEARCH METHODOLOGY

3.1 Introduction

This chapter highlights the methods and research design used in this study. The chapter encompasses the research design, population, sampling method, and data collection methods and data analysis technique.

3.2 Research Design

Research design is the planning for necessary conditions that will allow proper collection of data as well as its analysis in order to achieve relevance to the research purpose to the economy through the procedure (Kothari, 2004). The overall objective was to formulate a framework that will assist Kenyan enterprises adopt the SD-WAN technology. The study made use of a descriptive research design which is useful in obtaining information regarding the status and position of an issue. The design was chosen as the study did not intend to manipulate any variables, but report things as they were during the time the study was conducted. The design was also deemed appropriate as it would be helpful in collecting original quantifiable data that would give a description of the population under study which could prove too large for direct observation.

This design is applicable due to its ability to describe the characteristics of the population under study (Burns & Bush, 2009). Besides, descriptive research design is utilized to define the three key factors that stimulates the adoption of a framework that will assist Kenyan enterprises adopt the SD-WAN technology.

3.3 Target Population of the Study

The target population is a specific part of the population that has the desired information. Ngechu (2004) defines a population as a group of people, services, or group of things that are of interest in a study. Through this definition, it is evident that the population the study is interested in is homogenous. The researcher uses the term population to imply a consideration of all the sampling frames. The study will be based on 64 enterprises listed on Nairobi Stock Exchange (NSE), which is the population. Salant and Dillman (1994) observed that a prerequisite to sample selection is to define the target population as narrowly as possible.

The CIO/ICT Managers, Network Architects, Network & Support Engineers and Security Engineers will be chosen because of their key role in the decision making of adoption of SD-WAN in their respective organizations. The reason for targeting the ICT professionals is due to the fact that they are both involved with the current traditional/legacy networks and are aware of the SD-WAN related projects across the globe.

3.2.2 Sampling

A sample refers to a set of items or items or individuals selected from a larger aggregate or population (Snedecor and Cochran, 1980). Determining a sample size is a common responsibility for many different organizational researchers. Inappropriate, insignificant, or very large sample sizes have an impact on the quality and accuracy of research. Kothari (2004) refers to a sample as 'one which fulfils the requirements of efficiency, representativeness, reliability and flexibility'. The study will use purposive sampling that provided the ability to strategically choose the sample population based on the research objectives stated. The population selected was 64 enterprises organizations listed at the Nairobi Stock exchange and was guided by the Krejcie and Morgan (1970) sample size formula since the population is known. The sample size was then multiplied with the selected decision makers from each organization of 5 individuals per organization.

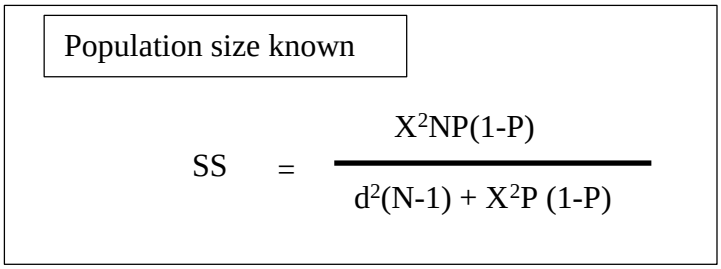

Figure 9: Sample Size Formulae (Krejcie and Morgan, 1970)

SS = required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.05).

We therefore calculate the sample size of the known population;

$$SS = \frac{(3.841) * 64 * (0.5) * (1-0.5)}{0.0025 * (64-1) + (3.841) * 0.5 (1-0.5)}$$

$$SS = 61.456 / (0.1575 + 0.96025)$$

$$SS = 54.98$$

Therefore, our sample size is at least 55 enterprise organizations from the Nairobi Stock Exchange. A stratified sample of 55 enterprises at Nairobi Stock Exchange will be used multiplying this number with the purposive sample population of 5 per organization will provide us with at least **275** (55*5) responded required for the study. To qualify for this study, the targeted audience/respondents were required to work in an IT related function. 5 respondents will be selected as the key decision makers. These respondents are majorly from the ICT departments consisting of network & support engineers, networks architects, IT managers and any other relevant ICT decision making personnel. The below table summarizes the targeted respondents.

Table 5: Sample Size

Category	**Target per Organization**	**Population**	**Percentage**

CIO/ICT Managers	1	55	20%
Network Architects	1	110	20%
Network & Support Engineers	2	55	40%
Security Engineers	1	55	20%
Total	**6**	**275**	20%

3.3 Data Collection

The objective on the study was to determine the adoption of SD-WAN. The following data will be crucial in the research. This data will be collected via questionnaire. These questionnaires will be distributed via online survey tools. Some of the crucial data to be collected will be; perception of individuals within the organization towards adoption SD-WAN, Level of understanding SD-WAN technology, the role that the individual play in the ICT team, any concerns towards SD-WAN technology, the perception towards the benefits of SD-WAN in regards to the organization. The questionnaire will include multiple choice and ranking type of questions organized as per below sections.

- *Section1*: Information based software defined wide area networks.
- *Section 2*: Participants details will be covered here, their demographics as well as the company background. This will also cover participants knowledge on software defined wide area networks and the significance to their organization.
- *Section 3*: This section will cover the participants perception of adoption of SD-WAN and what they think will be the impediments of adoption of software defined wide area networks.

3.4 Data Analysis

Data analysis will involve several stages. First, the data collected form the questionnaires were edited to make sure there is completeness and consistency in the data collected. The questioner was checked for clarity, how eligible they are, their relevance and how appropriate the feedback will be. The second phase was coding and processing of the data using excel and SPSS analysis software, then the output of the findings will be represented using graphs and charts.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The section highlights the research findings on the utilization of the defined software WAN Area within the enterprises in Kenya, including the data analysis, conclusions, presentation, and debate. Excel and SPSS were used in data analysis while the findings were presented using graphs, tables and pie charts which allowed comparison.

The data was investigated using tools such as frequencies and percentages, and statistically significant patterns such as mean and standard deviation.

4.2 Reliability Test

Below table shows the reliability coefficient of 0.719. This is acceptable according to the accepted 0.7 and above coefficient (Hair,1998).

Table 6: Reliability Test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.719	.755	28

4.3 Questionnaires' Response Rate

To be able to collect data, online questionnaires were used via the google forms method. Questionaries were posted on the website then the respondents were requested to fill in the form via their email addresses and others were sent a link to the form. Among the 275 respondents the study hoped for, only 163responded and returned their questionnaires, which translates to a 59.3% response rate. Babbie (1995) insisted that a minimum of 50% response rate is necessary when analyzing and reporting, although a 60% rate is better, and a 70% rate most preferred.

4.4 Demographic Information analysis

The demographic information included the respondents, industry they work in, job role, the respondents' years of experience and the respondents' level of education.

Table 7: Demographic Information Analysis

		Frequency	Percent
Industry	Agricultural	9	5.5
	Automobiles and accessories	3	1.8
	Banking	33	20.2
	Commercial services (Service Industry)	21	12.9
	Construction and allied	5	3.1
	Energy and Petroleum	10	6.1
	Insurance	21	12.9
	Investments and investment services	7	4.3
	Manufacturing and allied	3	1.8
	Telecommunications and technology	31	19.0
	Real investment trust	1	.6
	Others	19	11.7
	Total	163	100.0
Role	Management	46	28.2
	Network Architect	13	8.0
	Network and Support Engineers	72	44.2
	Network Security Engineers	6	3.7
	Others	26	16.0
	Total	163	100.0
Level of Education	Diploma/Certificate	20	12.3
	Undergraduate degree	90	55.2

	Post graduate degree	53	32.5
	Total	163	100.0

Years of experience	Less than 1 year	5	3.1
	Between 1 - 2 years	10	6.1
	Between 2 - 5 years	39	23.9
	More than 5 years	109	66.9
	Total	163	100.0

From the findings above, 20.2% of respondents worked in the banking majority, 19% in the telecommunications and technology, 12.9% in the commercial services (Service Industry), 5.5% in the agricultural sector, 1.8% in the Manufacturing and allied industries, 1.8%in the automobiles and accessories, 6.1% in the Energy and Petroleum industry, 12.9% of the respondents are in the Insurance industry while as 11.7% of respondents represented the others industries.

Majority of the respondents were Network & support Engineers (44.2%), followed by the Management at 28.2%, followed by the Network Architects at 8% and Security Engineers at 3.7% and respondents with other related roles at 16%. 55.2% of the respondents had an undergraduate degree followed by 32.5% who had a Post graduate degree, 12.3% of the respondents were diploma and certificate holders. From the findings, 3.1% of the respondents had been working in ICT for less than 1 year, 6.1% of the respondents had been working in ICT for between 1-2 years, most of the respondents (66.9%) had worked with the IT for over half a decade and 23.9% of the respondents had been working in ICT between 2 -5 years.

4.5 Technology Context

4.5.1 Technological information analysis

The research tried to identify the current size of the network you managed or operated by the respondents in the organization, the current WAN technology used, challenges on the WAN

technology, the current challenges with SDWAN implementation and the most important SDWAN capabilities to their organization.

Table 8: Number managed devices

		Frequency	Percent
Size of Network	Less 50 devices	40	24.5
	Between 50 - 100 devices	47	28.8
	Between 100 - 300 devices	28	17.2
	More than 300 devices	48	29.4
	Total	163	100.0

From the results tabulated above, most (29.4%) of the respondents managed or operated a network size of more than 300 devices, 28.8% of the respondents managed or operated a network size of between 50 and 100 devices, followed by 24.5% of the respondents who managed or operated a network size of less than 50 devices, and finaly 17.2% of the respondents managed or operated a network size of between 100 and 300 devices.

The study sought to establish the technology on which technology their current Wide Area Network (WAN) is running on.

Table 9: Current WAN Technology

		Frequency	Percent
Current WAN technology	Internet connections	52	31.9
	IP-VPN connections	16	9.8
	Point to Point connections	41	25.2
	Hybrid (Internet with IPVPN or Point to Point) connections	54	33.1
	Total	163	100.0

From the data findings above, 33.1% of the respondents indicated that the current Wide Area Network (WAN) running on Hybrid Networks (Internet with IPVPN or Point to Point), 31.9% of the respondents indicated that the current Wide Area Network (WAN) running on Internet connections, 25.2% of the respondents indicated that the current Wide Area Network (WAN) running on Point to Point connections while 9.8% of the respondents indicated that the current Wide Area Network (WAN) running on Internet Protocol Virtual Private Network (IP-VPN).

The study attempted to discover the challenges experienced due to connectivity as experienced by the respondents' current WAN technology via multiple choice question with a maximum of 3 choices per responded.

Table 10: Current Network Challenges

Multiple Choice		Frequency	Percent
Current Connectivity Challenges	Security concerns (branch and remote users)	77	19.3
	Network reliability	125	31.3
	Cost of the WAN connections	68	17
	Bandwidth limitations	71	17.8
	Network management	59	14.8
	Total	400	100.0

From the data findings above, 31.3 of the respondents indicated that there were Network reliability, 19.3% of the respondents pointed out that there were issues with Security concerns both at the branch level and the remote users, 17.8% of the respondents indicated the bandwidth limitations was a major challenge, 17% of the respondents sighted cost of the WAN connections while as 14.8% of the respondents pointed out that network management as a challenge.

Table 11: Most important WAN Goals

Multiple Choice		Frequency	Percent
Most Important WAN goals	Network optimization to support new technologies	111	37.9
	Network agility and responsiveness	102	34.8
	Simplifying change management	33	11.3
	Network expansion (number of sites and nodes)	47	16.0
	Total	293	100.0

This study also tried to evaluate the most important WAN goals for the respondents' organization. According to data findings most (37.9%) of the respondents' sighted network optimization to support new technologies as the most important WAN goals, followed by 34.8% of the respondents' who indicated that Network agility and responsiveness as the most important WAN goals, 16.0% were for network expansion as the most important WAN goals, while as 11.3% indicated that simplifying change management as the most important WAN goals.

4.5.2 Research and Development

The study sought to find out whether research and development in the respondent's organization improve the adoption of any technology.

Table 12: Research and Development Analysis

		Frequency	Percent
Research and Development in Improving adoption of technology	No	3	1.8
	Not Sure	24	14.7
	Yes	136	83.4
	Total	163	100.0

From the findings above, it was evident that research and development in the respondents' organization improve the adoption of any technology as shown by the majority (83.4%) of the respondents.

4.5.3 Familiarity with SD-WAN

The study sought to analyze the respondents' familiarity with software defined wide area networks (SD-WAN)

Table 13: Familiarity with SDWAN

		Frequency	Percent
Familiarity with SDWAN technology	Not conversant	20	12.3
	Moderately familiar	105	64.4
	Well conversant	38	23.3
	Total	163	100.0

The data findings above reveal that majority (64.4%) of the respondents were moderately familiar with SD-WAN. 23.3% of the respondents were well conversant with software defined wide area networks (SD-WAN) while 12.3% of the respondents were not conversant with software defined wide area networks (SD-WAN).

4.5.4 Challenges in SD-WAN adoption

The study sought to establish the challenges associated with SD-WAN adoption in the organization.

Table 14: Challenges of SDWAN adoption

Multiple choice		Frequency	Percent
Challenges with SDWAN adoption	Cost concerns	83	28.4
	Skillset needed to implement SD-WAN	63	21.6
	Interoperability with existing WANs	92	31.5
	Resistance from within the organization	18	6.2
	Lack of support from financial decision-makers.	36	12.3
	Total	292	100.0

The study findings established the challenges associated with SD-WAN adoption in the organization to include; Cost concerns at 28.4%, Skillset needed to implement SD-WAN at 21.6%, Interoperability with existing WANs at 31.5%, Resistance from within the organization at 6.2% and; Lack of support from financial decision-makers at 12.3%.

4.5.5 SD-WAN capabilities

The study sought to find out the most important SD-WAN capabilities to the respondents' organization.

Table 15: SDWAN capabilities

		Frequency	Percent
Important SDWAN capability	Secure local internet connectivity	39	23.9
	Cloud connectivity and Cloud SLAs	25	15.3
	Centralized policy and configuration management	51	31.3
	Real-time analytics and service control	34	20.9
	Application based routing	14	8.6
	Total	163	100.0

According to the study findings, 23.9% of the respondents highlighted that secure local internet connectivity as the most SD-WAN capabilities to their organization. 15.3% of the respondents indicated that Cloud connectivity and Cloud SLAs has the most SD-WAN capabilities to their organization. 31.3% of the respondents indicated that Centralized policy and configuration management has the most SD-WAN capabilities to their organization. Another 20.9% of the respondents indicated that Real-time analytics and service control has the most SD-WAN capabilities to their organization. While 8.6% of the respondents indicated that application-based routing has the most SD-WAN capabilities to their organization.

These study findings on technology factor are supported by Borgman, Bahli, Heier, & Schewski, (2018) who noted that the consideration as to which technological innovation should be used depends on the present infrastructure and how it fits between the innovation and changes in the technology landscape. They indicated that any technology can be referred to as "knowledge-embedded tool, and "combination of social or behavioral elements and physical elements", as it is an understanding that highly relies on the interaction between human beings and technology for one to understand the purpose of the technology, its operating mechanisms and the overall impact.

4.6 Organizational Context

4.6.1 Number of Branch offices

The study wished to find out the specific number of branch offices in the respondents' organization.

Table 16: Size of the organization

		Frequency	Percent
Number of Branches	Only 1	14	8.6
	Between 1 - 5	57	35.0
	5 – 30 branches	46	28.2
	30 – 100 branches	19	11.7
	More than100 branches	27	16.6
	Total	163	100.0

The study findings showed that 35% of the respondents had Between 1 – 5 branch offices, 28.2% of the respondents had between 5 – 30 branches, 11.7% of the respondents had between 30 – 100 branches and 16.6% of the respondents had more than100 branches.

4.6.2 Plans on SD-WAN adopting

The study sought to find out whether the organizations were planning on adopting SD-WAN technology.

Table 17: SDWAN adoption plans analysis

		Frequency	Percent
Plans to adopt SDWAN	No	28	17.2
	Not Sure	64	39.3
	Yes	71	43.6
	Total	163	100.0

The study the findings indicated that 43.6% of the organizations were planning on adopting SD-WAN technology, and that 39.3% of the organizations were not sure about their plans on adopting SD-WAN technology, and that 17.2% of the organizations were not planning on adopting SD-WAN technology at all.

4.6.3 Enough Trained Personnel

The study sought to find out whether the organizations have enough trained personnel to implement and support SD-WAN technology

Table 18: Staff skill set

		Frequency	Percent
SDWAN Trained personnel	No	100	61.3
	Not Sure	25	15.3
	Yes	38	23.3
	Total	163	100.0

23.3% of the respondents revealed that their organizations have enough trained personnel to implement and support SD-WAN technology, 61.3% of the respondents revealed that their organizations do not have enough trained personnel to implement and support SD-WAN technology, 15.3% of the respondents revealed that they were not sure whether their organizations have enough trained personnel to implement and support SD-WAN technology.

4.6.4 Migrating Strategy

The study sought to find out whether the organizations have a strategy for migrating from the current WAN setup to an SD-WAN setup.

Table 19: Migration strategy analysis

		Frequency	Percent
Organization migration strategy to SDWAN	No	50	30.7
	Not Sure	60	36.8
	Yes	53	32.5
	Total	163	100.0

From the table above, 32.5% of the respondents indicated that their organizations have a strategy for migrating from the current WAN setup to an SD-WAN setup. 36.8% of the respondents indicated that they were not sure whether their organizations have a strategy for migrating from the current WAN setup to an SD-WAN setup or not and 30.7% of the respondents indicated that may be their organizations do not have a strategy for migrating from the current WAN setup to an SD-WAN setup.

These findings are supported by Angeles, (2013) who noted that some attributes of an organization can either enable or hinder the innovation from adoption such as size of the firm and top management support. The formal and informal linkages both inside and outside the organizations, decision making and the communication process among employees, external communication involving the environment, and the quality of human resource in the organization can have a significant impact on technological innovations adoption.

4.7 Environmental Context

4.7.1 Support from SDWAN Vendors

The study sought to establish if there any support from SDWAN vendors and suppliers with implementing SDWAN.

Table 20: Support from SDWAN analysis

		Frequency	Percent
Support from SDWAN vendors	No	15	9.2
	Not Sure	40	24.5
	Yes	108	66.3
	Total	163	100.0

From the findings, 66.3% of the respondents revealed that they get support from SDWAN vendors and suppliers with implementing SDWAN. 24.5% of the respondents revealed that they are not sure of the support from SDWAN vendors and suppliers with implementing SDWAN, while 9.2% of the respondents revealed that they do not get support from SDWAN vendors and suppliers with implementing SDWAN.

4.7.2 Competition vs SDWAN adoption

The study sought to find out whether the competition from the market is driving organizations to adopt SDWAN.

Table 21: Competition from the Market

		Frequency	Percent
Market competition to adopt SD-WAN	No	37	22.7
	Not Sure	53	32.5
	Yes	73	44.8
	Total	163	100.0

On whether the competition from the market is driving organizations to adopt SDWAN. 44.8% of the respondents said yes, 22.7% of the respondents said no, 32.5% of the respondents said that they were not sure whether, the competition from the market is driving organizations to adopt SDWAN.

4.7.3 Services that require an overlay network like SD-WAN

The study sought to find out if there are any services that customers are requesting, that do require an overlay network like SD-WAN

Table 22: Overlay service requirement

		Frequency	Percent
Requirement for overlay service e.g SDWAN	No	27	16.6
	Not Sure	46	28.2
	Yes	90	55.2
	Total	163	100.0

The data findings revealed that 55.2% of the respondents indicated that there were overlay services that were required by the organizations, 28.2% of the respondents were not sure while 16.6% respondents indicated that there were no services that customers are requesting, that do require an overlay network like SD-WAN.

4.7.4 SDWAN Training

The study sought to find out if the vendors, suppliers and institutions offer any SD-WAN training and materials to organizations.

Table 23: SDWAN training analysis

		Frequency	Percent
SDWAN training/materials by vendors	No	13	8.0
	Not Sure	43	26.4
	Yes	107	65.6
	Total	163	100.0

65.6% of the respondents revealed that the vendors, suppliers and institutions offer SDWAN training and materials to organizations, 26.4% of the respondents indicated that they were not sure if the vendors, suppliers and institutions offer any SDWAN training and materials to organizations

while 8% of the respondents revealed that the vendors/suppliers and institutions do not offer any SDWAN training and materials to organizations.

The findings are supported by Awa, Ukoha, & Emecheta, (2017) who pointed out that in environmental context, the adoption of technological innovations of organizations is largely affected by how it mingles with its immediate business environment. The business environment consists of the entities existing within the industry and any other related factors facilitating the organization's operation area. For one, the social-cultural issues, the intensity of competition, regulatory environment, and the technology support a setup will bring significant impact towards the intention of the organization to utilize technology innovations in their business.

4.7.5 The level of respondents' agreement with statements on various statements

The study computed the mean and standard deviation to rank the respondents' level of agreement with each statement below. The findings were interpreted using a Likert scale of 1-5 (**where 1= strongly disagree, 2= disagree, 3= neutral, 4= agree and 5= strongly agree**).

Table 24: Additional statements analysis

	Mean	**Std. dev**
Does increase in cloud-based solutions and applications influence the adoption of SDWAN?	4.09	0.757
Does the rising demand for mobility services and enterprises focusing on OPEX and CAPEX reduction influence the adoption of SDWAN?	3.97	0.765
Does the need for a simplified network performance and management influence the adoption of SDWAN?	4.04	0.902
Does the need for a provision on reliable services in the network for example stable voice, video streaming and robust user experience influence the adoption for SDWAN?	4.14	0.860

Will SDWAN play a key role in enabling organizations transform their digital strategies and enable IoT applications?	4.22	0.868
Does the need to have a hybrid network with a local internet breakout from the branch as well as an MPLS link to enable branch to access resources at HQ influence the adoption of SDWAN?	3.90	0.893
Does the current WAN infrastructure challenges that organizations are facing influence the adoption of SDWAN?	4.09	0.932
Does the size of a firm highly influence the adoption of SDWAN?	3.61	1.080
Does competitive pressure from other players in the same field influence organizations to adopt new technologies like SDWAN?	3.82	0.977
Does customer driven requests a major contributor towards the adoption of SDWAN?	4.10	0.843
Does the support from the decision-making team (top management) a major contributor towards SDWAN adoption?	4.15	0.879

Asked whether the increase in cloud-based solutions and applications influence the adoption of SDWAN the respondents strongly agreed as shown by a mean of 4.09. On whether the rising demand for mobility services and enterprises focusing on OPEX and CAPEX reduction influence the adoption of SDWAN the respondents agreed as shown by a mean of 3.97. Asked if the need for a simplified network performance and management influence the adoption of SDWAN the respondents agreed as shown by a mean of 4.04. On whether the need for a provision on reliable services in the network for example stable voice, video streaming and robust user experience influence the adoption for SDWAN development the respondents disagreed as shown by a mean of 4.14. Asked whether SDWAN play a key role in enabling organizations transform their digital strategies and enable IoT applications, the respondents agreed as shown by a mean of 4.22.
On whether the need to have a hybrid network with a local internet breakout from the branch as well as an MPLS link to enable branch to access resources at HQ influence the adoption of SDWAN the respondents agreed as shown by a mean of 3.90. The respondents were asked whether the size of a firm highly influence the adoption of SDWAN, the respondents agreed as shown by a mean of 3.61. On whether the competitive pressure from other players in the same field influence

organizations to adopt new technologies like SDWAN, the respondents agreed as shown by a mean of 3.82. Finally asked, whether the current WAN infrastructure challenges that organizations are facing influence the adoption of SDWAN requirements the respondents agreed as shown by a mean of 4.09.

4.8 Regression Analysis

A linear association was assumed between dependent and independent variables. To ascertain the linear relationship, a multiple regression was carried out to assess the extent to which the predictor variables could predict the likelihood of adopting SD-WAN technology withing the Kenyan organization listed in NSE. Application of multiple regressions for the study was used using the SPSS tool.

Below is a regression model shown in the below table,

Table 25: Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.781[a]	.610	.417	.561
a. Predictors: (Constant), Technology, Organization and Environmental Context				
b. Dependent Variable: Adoption of SD-WAN technology				

Coefficient of determination explains the extent to which changes in the dependent variable can be explained by the change in the independent variables or the percentage of variation in the dependent variable **(**Adoption of SDWAN at the enterprise organizations in Kenya). That is explained by all the three independent variables (Technology, Environmental and Organization factors). The study findings indicated that over 78.1% of the data used in the regression model could be accounted for R Square = 0.61, which implies that the independent variables explain 61% in the overall adoption of SDWAN technology. Further research should be conducted to investigate the other factors which are 39 percent contributing to the decision to adopt SD-WAN at the enterprise organizations in Kenya. The result also reveals higher relationship as indicated

by the correlation coefficient 0.781. The table for regression analysis shows that technological factors, organizational factors and environmental factors contribute to about 61% of the likelihood of adoption of SDWAN technology in the Kenyan enterprises listed by Nairobi Stock Exchange.

ANOVA

Table 26: ANOVA (Analysis of Variance)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	41.921	42	.998	3.166	<.001b
	Residual	26.797	85	.315		
	Total	68.718	127			

The significance value is .0000 which is less than 0.05 thus the model is statistically significant in predicting Technology factors, Environment factors and Organization factors.

Table 27: Coefficient of Determination

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.976	1.384		0.978	0.003
Technology factors	0.877	0.159	0.897	0.997	0.001
Environmental factors	0.705	0.085	0.455	0.707	0.002
Organization factors	0.605	0.145	0.326	0.769	0.003

a. Predictors: (Constant), Technology factors, Environmental factors and Organization factors
b. the adoption of SD-WAN at the enterprise organizations in Kenya.

The study conducted a multiple regression analysis so as to determine the relationship between Y and the three variables. The equation ($\mathbf{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon}$) becomes:

$\mathbf{Y=}$ 2.976 + 0.877X_1+ 0.705X_2+ 0.605X_3**+ε**

Whereby Y = the adoption of SD-WAN at the enterprise organizations in Kenya

X1 = Technology Availability,

X2 = environmental factor and

X3 = Organization factor

According to the regression equation established, taking all factors into account (Technology, Environmental and Organization factors) constant at zero, the adoption of SD-WAN at the enterprise organizations in Kenya will be 2.976. Specifically, the study findings indicated that there was a significant relationship between Technology, (p = 0.87), Environment, (p = 0.705), and Organization (p = 0.605) when regressed with the adoption of SD-WAN at the enterprise organizations in Kenya.

4.9 Summary

From the data collected and analyzed, the study shows the factors that significantly influence SDWAN adoption. Data was collected using quantitive method of an online questionnaire. SPSS was the application used to analyze the data recorded.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings and conclusions from the study, with recommendations that were made after considering the findings and conclusions of the study.

5.2 Results objectives achievements

The study managed to archive the research objectives. The first research objective was to investigate the influence of technology on the adoption of SDWAN. This was achieved via the mapping of the objectives with the literature review that was documented as well as the data collected using online targeted questioners shared to organizations listed at the Nairobi stock exchange (NSE). The data collected was analyzed under section 4.5.

The second objective was to investigate the influence of organizational factors on the adoption of SDWAN. This objective also used literature review and data collected to analyze the data to meet the objective. The analysis and discussions are under section 4.6

The third objective was to investigate the influence of Environmental factors on the adoption of SDWAN. This objective also used literature review and data collected to analyze the data to meet the objective. The analysis and discussions are under section 4.7

The fourth objective for formulating a framework that can be used as a guideline by enterprises to adopt the SDWAN technology was met by using the SPSS tool to analyze the data collected so as to formulate a framework to be used as a guideline to adopt the SDWAN technology.

All the objectives were tested using the descriptive analysis using the SPSS tool that showed the factors that influence the adoption of SDWAN technology. All the independent variables were investigated and the below section outlines the summary of findings as per the study objectives.

5.2.1 Technology Factor

The first objective for the study was to investigate the influence of technology on the adoption of SD-WAN at the enterprise organizations in Kenya. The analysis of the respondent's data showed that indeed technological factors do influence the adoption of SDWAN. These factors technological factors constituted, security concerns within their environment, the challenges they face with the current WAN, service reliability, network reliability, bandwidth limitations and the current network management. Other technological factors influencing adoption of SDWAN were Interoperability with the existing infrastructure, bandwidth limitations. There was however a drawback that was noted based on the technical skillset of employees. Few respondents were not well conversant with SDWAN technology and this contributed to the levels of SDWAN adoption in Kenya.

5.2.2 Organizational Factor

The study analyzed organizational factors to assess the influence of organizational factors on the adoption of SDWAN. These specific factors included support from top management by providing support in key decision making, size of the firm/organization and the change process in the firm. The most emphasized factors were the size of their organization and support from top management. From the analysis, the stated factors showed influence of organizational factors on SDWAN technology adoption. It was also noted that change management and SDWAN migration strategies by the organization was key towards adopting SDWAN technology and therefore organizations should emphasize more change management and migration strategies for adopting SDWAN by creating sustainable policies for adopting any new technology in the organization.

5.2.3 Environmental Context

The study also aimed at to evaluate the environmental factors that do affect the adoption of SDWAN technology. Environmental factors looked at how competitive pressure significantly contributed to the adoption of new technologies including SDWAN adoption and how does

customer driven significantly contribute to the adoption of SDWAN technology. The study also examined external support towards the adoption of technology based on vendor support by providing training to individuals in organizations as well as providing reading materials that can be referenced pre and post adoption of the SDWAN technology. The results depicted that SDWAN vendors have a crucial role in driving adoption of SDWAN technology.

5.3 Conclusion

The study concludes that there is a significant relationship between existing internal technologies within the organizations and the SDWAN technology and the existing internal technology influences adoption of SDWAN technology in organizations. The perceived compatibility between the SDWAN technology and existing platforms makes adoption of SDWAN technology possible. The lower the perceived reliability of network services, the greater the potential adoption of the SDWAN technology and that there is a significant relationship between the complexity of the SDWAN technology in facilitating the adoption of the SDWAN technology.

The study also concluded that the demographic composition of an organization influences the ability to adopt the SDWAN technology and there is a significant relationship between employees' knowledge and technical skill set in an organization and the adoption of SDWAN Technology. There is also a significant relationship between decision-making team including the top management and adoption of the SDWAN Technology.

The study finally concluded that competitive pressure significantly contributes the adoption of new technologies including SDWAN adoption and that there is a statistically significant relationship between external support and adoption of the SDWAN technology. Customer driven requests also significantly contributes to the adoption of SDWAN technology.

Based on the findings, below is the final conceptual framework based on findings.

Recommended Conceptual Framework

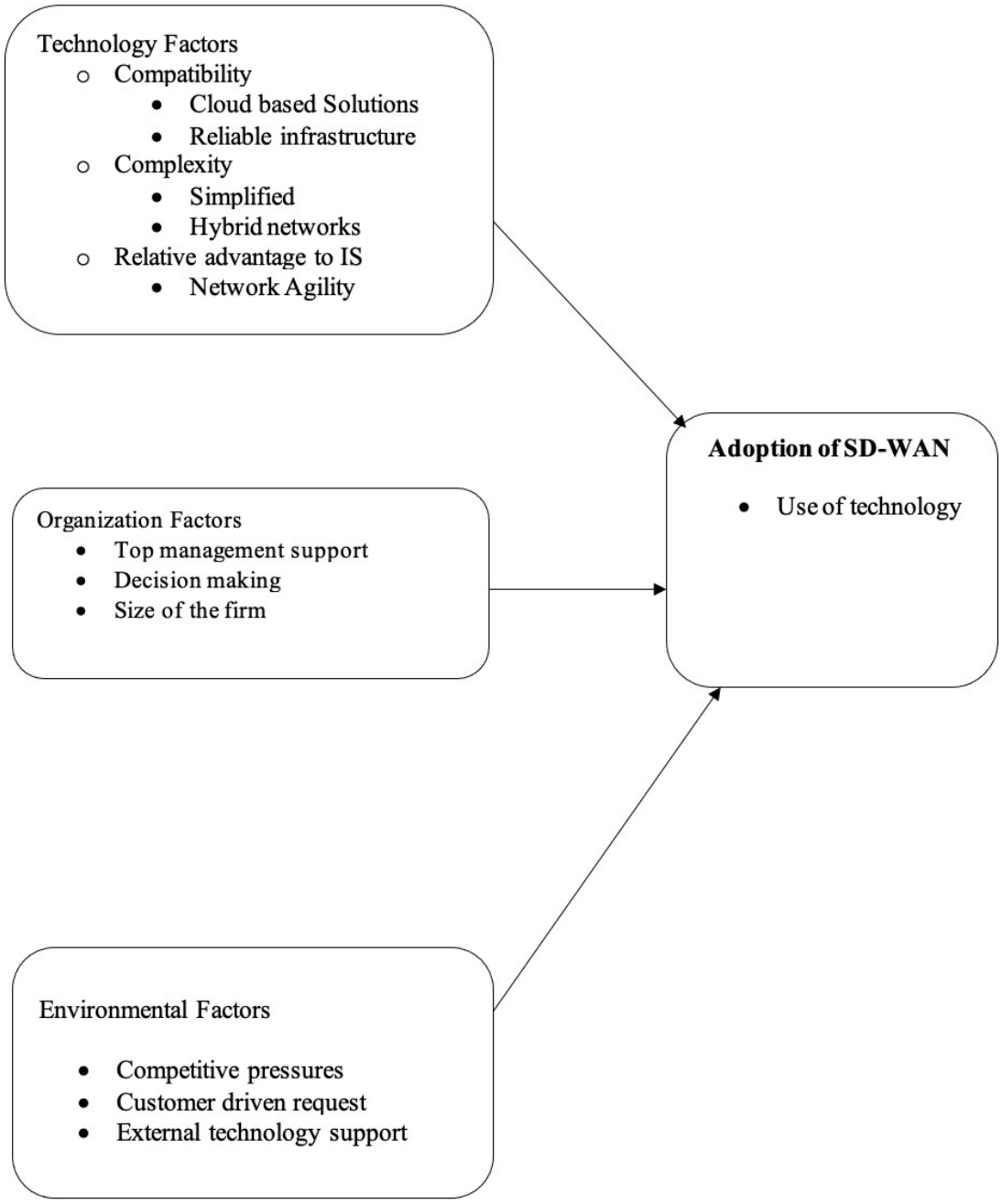

Figure 10: Final Conceptual Framework

5.4 Limitations of the research

The limitation to the study were the limited timeframe to collect data. Collecting more data would have meant a more conclusive result taking into account that there were several organizations that did provide feedback and only a response rate of 59.3% was achieved. Research focused on the organizations listed at the Nairobi Stock Exchange and therefore results should be applied cautiously in other sectors for example SME in each county.

5.5 Further works

In the study, there was a missing aspect of the individual factors that needed to be incorporated to the study. The study therefore recommends a study of SDWAN technology adoption be done with a mixture of two models possible TOE and Diffusion of Theory frameworks. Other recommendations are as per below;

- Organizations should continuously train their employees so that they can update their skillsets and therefore staying relevant on new technologies, this encourages a higher adoption rate of new technologies.
- Technology vendors should be providing training to ICT personnel on new and upcoming technologies to encourage adoption of those new technologies such as SDWAN.

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APPENDIX

Appendix 1: Enterprises listed at Nairobi Stock Exchange.

Sr.	Organization	Sector
1	Eaagads Ltd	AGRICULTURAL
2	Kapchorua Tea Co. Ltd	
3	Kakuzi	
4	Limuru Tea Co. Ltd	
5	Rea Vipingo Plantations Ltd	
6	Sasini Ltd	
7	Williamson Tea Kenya Ltd	
8	Car and General (K) Ltd	AUTOMOBILES AND ACCESSORIES
9	Absa Bank Kenya PLC	BANKING
10	Stanbic Holdings Plc	
11	I&M Holdings Ltd	
12	Diamond Trust Bank Kenya Ltd	
13	HF Group Ltd	
14	KCB Group Ltd	
15	National Bank of Kenya Ltd	
16	NCBA Group PLC	
17	Standard Chartered Bank Ltd	
18	Equity Group Holdings	
19	The Co-operative Bank of Kenya Ltd	
20	BK Group PLC	
21	Express Ltd	COMMERCIAL AND SERVICES
22	Sameer Africa PLC	
23	Kenya Airways Ltd	
24	Nation Media Group	

25	Standard Group Ltd	
26	TPS Eastern Africa (Serena) Ltd	
27	Scangroup Ltd	
28	Uchumi Supermarket Ltd	
29	Longhorn Publishers Ltd	
30	Deacons (East Africa) Plc	
31	Nairobi Business Ventures Ltd	
32	Athi River Mining	CONSTRUCTION AND ALLIED
33	Bamburi Cement Ltd	
34	Crown Paints Kenya PLC	
35	E.A.Cables Ltd	
36	E.A.Portland Cement Ltd	
37	Total Kenya Ltd	ENERGY AND PETROLEUM
38	KenGen Ltd	
39	Kenya Power & Lighting Co Ltd	
40	Umeme Ltd	
41	Jubilee Holdings Ltd	INSURANCE
42	Sanlam Kenya PLC	
43	Kenya Re-Insurance Corporation Ltd	
44	Liberty Kenya Holdings Ltd	
45	Britam Holdings Ltd	
46	CIC Insurance Group Ltd	
47	Olympia Capital Holdings	INVESTMENT
48	Centum Investment Co Ltd	
49	Trans-Century Ltd	
50	Home Afrika Ltd	
51	Kurwitu Ventures	
52	Nairobi Securities Exchange Ltd	INVESTMENT SERVICES
53	B.O.C Kenya Ltd	MANUFACTURING AND ALLIED
54	British American Tobacco Kenya Ltd	

55	Carbacid Investments Ltd	
56	East African Breweries Ltd	
57	Mumias Sugar Co. Ltd	
58	Unga Group Ltd	
59	Eveready East Africa Ltd	
60	Kenya Orchards Ltd	
61	Flame Tree Group Holdings Ltd	
62	Safaricom PLC	TELECOMMUNICATION AND TECHNOLOGY
63	Stanlib Fahari I-REIT	REAL ESTATE INVESTMENT TRUST
64	New Gold Issuer (RP) Ltd	EXCHANGE TRADED FUND

Appendix 2: Survey Questionnaire.

You are invited to the participate in a research study investigating adoption of software defined wide area networks (SD-WAN) withing the enterprise organizations in Kenya. The purpose of the following questionnaire io to collect data in partial fulfillment in Master of Science in Information Technology Management (ITM) titled a framework for adoption of software defined wide area networks (SD-WAN) withing the enterprises in Kenya. Data that will be collected will solely be used for purposes of this research project with the ultimate aim of contributing to the adoption of SD-WAN technology in organizations. The information shared will only be used for research purposes and will be held with high confidentiality. Kindly assist and answer below questions as accurately as possible.

DEMOGRAPHIC DATA

1. What industry is your organization in?
   - _____.
2. What is your job role in the organization?
   - ☐ Management
   - ☐ Network Architect
   - ☐ Network & support Engineers
   - ☐ Security Engineers
   - ☐ Others
3. What is your level of Education?
   - ☐ Post graduate degree
   - ☐ Undergraduate
   - ☐ Diploma and certificate
   - ☐ N/A
4. How many years of experience do you have in IT?
   - ☐ Less than a year
   - ☐ Between 1-2 years

- [ ] Between 2-5 years
- [ ] More than 5 years

TECHNOLOGY CONTEXT

1. What is the current size of the network you manage or operate?
   - [ ] Less than 50 devices
   - [ ] Between 50 - 100 devices
   - [ ] Between 100 - 300 devices
   - [ ] More than 300 devices

2. What technology does your current Wide Area Network (WAN) running on?
   - [ ] Internet connections
   - [ ] IPVPN connections
   - [ ] Point to Point connections
   - [ ] Hybrid (Internet with IPVPN or Point to Point) connections

3. What is your current top 3 connectivity challenges being experienced with your current WAN technology? Choose a max of 3

   - [ ] Security concerns (branch and remote users)
   - [ ] Network reliability
   - [ ] Cost of the WAN connections
   - [ ] Bandwidth limitations
   - [ ] Network management

4. What are the most important WAN goals for your organization?
   - [ ] Network optimization to support new technologies.
   - [ ] Network agility and responsiveness
   - [ ] Simplifying change management
   - [ ] Network expansion (number of sites and nodes)

5. Does research and development in your organization improve the adoption of any technology?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure

6. How familiar are you with software defined wide area networks (SD-WAN)?
   - ☐ Well conversant.
   - ☐ Moderately familiar
   - ☐ Not conversant

7. What are the challenges associated with SD-WAN adoption in the organization?
   - ☐ Cost concerns
   - ☐ Skillset needed to implement SD-WAN
   - ☐ Interoperability with existing WANs
   - ☐ Resistance from within the organization
   - ☐ Lack of support from financial decision-makers

8. What is the most SD-WAN capabilities to your organization?
   - ☐ Secure local internet connectivity
   - ☐ Cloud connectivity and Cloud SLAs
   - ☐ Centralized policy and configuration management
   - ☐ Real-time analytics and service control
   - ☐ Application based routing

ORGANIZATIONAL CONTEXT

1. How many branch offices does your organization have?

- ☐ Only 1
- ☐ Between 1 - 5
- ☐ 5 – 30 branches
- ☐ 30 – 100 branches
- ☐ More than100 branches

2. Is your organization planning on adopting SD-WAN technology?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure

3. Does your organization have enough trained personnel to implement and support SD-WAN technology?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure

4. Does your organization have a strategy for migrating from the current WAN setup to an SD-WAN setup?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure

5. Does your organization have a change management team?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure

6. How long does it take for a change management request to be approved in your organization?
   - ☐ 1 – 2 days

- ☐ 3 – 5 days
- ☐ 5 – 15 days
- ☐ 16 – 30 days
- ☐ More than 30 days

ENVIROMENTAL CONTEXT

1. Is there any support from SDWAN vendors and suppliers with implementing SDWAN?
   - ☐ Yes
   - ☐ No
   - ☐ Not Sure
2. Is the competition from the market driving your organization to adopt SDWAN?
   - ☐ Yes
   - ☐ No
   - ☐ Not Sure
3. Are there any services that your customers are requesting, that do require an overlay network like SDWAN?
   - ☐ Yes
   - ☐ No
   - ☐ Not Sure
4. Do the vendors, suppliers and institutions offer any SDWAN training and materials to organizations?
   - ☐ Yes
   - ☐ No
   - ☐ Not Sure

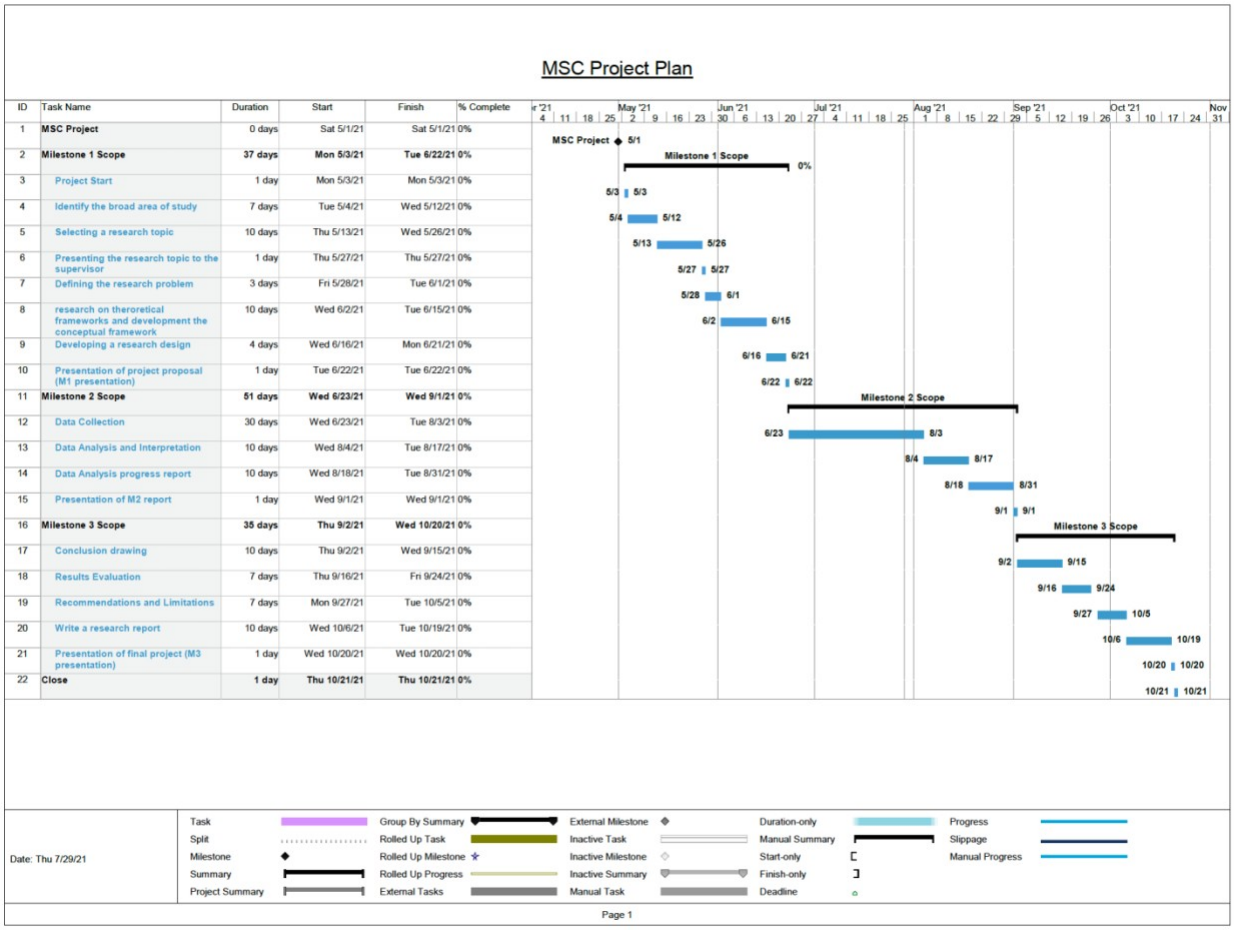
ADDITIONAL STATEMENTS

Please fill in one option for each question/statement below.

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Does increase in cloud-based solutions and applications influence the adoption of SDWAN?					
Does the rising demand for mobility services and enterprises focusing on OPEX and CAPEX reduction influence the adoption of SDWAN?					
Does the need for a simplified network performance and management influence the adoption of SDWAN?					
Does the need for a provision on reliable services in the network for example stable voice, video streaming and robust user					

experience influence the adoption for SDWAN?					
Will SDWAN play a key role in enabling organizations transform their digital strategies and enable IoT applications?					
Does the need to have a hybrid network with a local internet breakout from the branch as well as an MPLS link to enable branch to access resources at HQ influence the adoption of SDWAN?					
Does the current WAN infrastructure challenges that organizations are facing influence the adoption of SDWAN?					
Does the size of a firm highly influence the adoption of SDWAN?					
Does competitive pressure from other players in the same field influence organizations to adopt new technologies like SDWAN?					
Does customer driven requests a major contributor towards the adoption of SDWAN?					
Does the support from the decision-making team (top management) a major contributor towards SDWAN adoption?					

Appendix 3: Gantt Chart



Appendix 4: Required Resources

Sr.	Resource
1	Internet
2	Laptop
3	Flash drive
4	Mobile phone
5	Airtime
6	Microsoft Office Home & Student 2019
7	Statistical Package for Social Sciences (SPSS)
8	Printing and Binding papers
10	Printer

Appendix 5: Budget

ITEM	Budget request	Description
Internet Charges	Ksh 16,000/=	To help with researching online materials
Laptop	Ksh 50,000/=	To be used to research and documentation
Flash drive	Ksh 2,000/=	For backing up data
Research Fees	Ksh 145,000/=	Research fees to the institution
Facilitation Fees	Ksh 50,000/=	To aide with collecting data and movement
Mobile phone	Ksh 25,000/=	For communication purposes
Airtime	Ksh 15,000/=	For communication purposes
Microsoft Office Home & Student 2019	Ksh16,999/=	For documentation
Microsoft Project	Ksh 10,000/=	For developing the project plan and following up to completion as per the time schedule
Statistical package for social sciences (premium)	Ksh 9,000/=	For data analysis
Printing papers	Ksh 200/=	For output of research work
Binding	Ksh 7,000/=	For output of research work
Printing expense	Ksh 1,000/=	For output of research work
Graduate school posting of research paper	Ksh 7,800/=	University Fees
Miscellaneous expenses	Ksh 20,000/=	For any unforeseen eventualities
Total estimate	**Ksh** 374,999/=	