The Benefits of Thin Clients to Business Organizations in Developing Countries

“A Case Study of Nigeria”
Abstract

Information and communication technology (ICT) is the principal driver of economic development and social change globally. Indispensability of ICT has impacted positively on the quality and quantity of developmental approaches adopted by various businesses, vis-a-vis improving their revenue base and profit margin cum customer satisfaction. Needless to say that ICT improves business performance through its vibrant, interactive, flexible, and appealing content. Unless the current generation, in developing countries, especially Africa, learn and engage computer skills in their socio-economic activities, they will fall further backward.

The developing countries will need to engage ICT skills in their socio-economic activities in order to be at par with their counterparts in developed countries. This question of how to secure ICT infrastructures has always arisen. However, the answer is not only about securing the infrastructures, but about securing effective and affordable ones, considering the not-so-good financial status of these developing countries.

This thesis work was channeled towards giving consideration to thin client technology as a means of providing an effective, efficient, and affordable information and communication technology for the business communities in developing countries, using Nigeria as a case study. Aside from the literature review, which was a secondary data, primary data was collected through administered questionnaire to 20 thin client experts in Nigeria, out of which 16 responded.

This study has revealed, through the literature review and the survey questionnaire conducted, that with the adoption of thin client technology, not only significant cost efficiencies can be achieved, but also savings in many other areas within information technology and business process, such as; deployment management, security management and data protection management.

The results of this study have confirmed that there are good reasons to believe that a number of opportunities abound if thin clients technology is adopted by the developing countries, majorly leading to very significant cost savings, creating efficiencies, enhanced ease-of-use of information technology, and improved services to business customers.

Keywords
Thin clients, ICT, business development, economy, developing countries, Nigeria

Supervisor
Dr. Seppo Pahnila
Foreword

This thesis is in partial fulfillment of the requirements for the award of the Degree of Master of Science in Information Processing Science. The purpose of the research is to identify the benefits of thin client technology, and ascertain whether it could bring solution to the lingering problem of information and communications technology (ICT) usage in developing countries. The subject of this thesis work falls within the scope of the master’s field because it deals with Information System.

The study is fully funded by the author, and the major work is being carried out here in Finland. Questionnaires were administered and sent, through emails, to selected ICT professionals and users of thin client technology in Nigeria, because of the financial constraint, which debarred the author from travelling to conduct face-to-face interview. Data collection was done through the questionnaire within one month of sending same to the participants. Thereafter, data analysis was done, and the results were extracted. It was discovered that thin client technology would apparently serve as a lasting solution to the lingering problem of ICT in developing countries.

This research work has started since the year 2015, and I have experienced this period as very interesting and instructive. Initially, I had little knowledge about the operation and benefits of thin client technology. However, I have been able to acquire tremendous knowledge through my exploratory research of the technology, and I have been able to achieve a satisfactory result.

At this point, I would like to give thanks to God Almighty, who has seen me through the stressful period. My appreciation also goes to my supervisors from the University, Professor Tero Vartiainen and Dr. Seppo Pahnila, for their valuable insights and directions given to me in the cause of carrying out the research and writing the thesis. Also, my thanks go to all the volunteer participants in the questionnaire administered who have made me fulfill the research part of the work.

Rasheed Akintunde
This work is dedicated to the Almighty God, the Most Merciful, the Omnipotent and omniscient God, for giving me the strength, ability, grace and courage to perform this study. I also dedicate this work to my two late icons, Pa Alimi Oyeleke and Chief Moses Olasupo Akintunde, for their unconditional love for me while they were alive, and for their good examples that taught me to be hard working for me to achieve my aspirations. Lastly, I dedicate this work to my one and only wife, Mrs. Bola Akintunde, and my two God’s gifts, Boluwatife and Fiyinfoluwa Akintunde, for their unwavering supports and encouragements during the challenges of my graduate school.
# Contents

Abstract ........................................................................................................................................... 2
Foreword ............................................................................................................................................... 3
Dedication ........................................................................................................................................... 4
Contents ............................................................................................................................................. 5
Figures ................................................................................................................................................ 7
Tables ................................................................................................................................................ 8

1. Introduction .................................................................................................................................. 9
   1.1 Background of the Study ........................................................................................................ 9
   1.2 Research Objective and Motivation ....................................................................................... 12
   1.3 Research Questions .................................................................................................................. 13
   1.4 Methodology ............................................................................................................................ 13
   1.5 Significance of the Study ........................................................................................................ 14
   1.6 Structure of the Thesis ............................................................................................................ 14

2. Literature Review ...................................................................................................................... 16
   2.1 ICT and Economic & Business Development .................................................................... 16
   2.2 ICT in Developing Countries (with particular reference to Nigeria) ............................. 17
   2.3 Definition of Thin Client/Server Based Computing ............................................................ 21
   2.4 Thin Clients Historical Background ...................................................................................... 22
   2.5 Using Thin Client Technology as a Solution to Nigeria's ICT Problem ..................... 24
   2.6 Types of Thin Clients ............................................................................................................ 25
   2.7 What Thin Clients is Appropriate for ................................................................................... 25
   2.8 Weaknesses of Thin Clients Technology ............................................................................ 26
   2.9 Different Platforms of Thin Clients ..................................................................................... 26
      a) Platforms for Operating System .......................................................................................... 26
      b) Platforms for Hardware ......................................................................................................... 27
   2.10 Thin Client Technology as an Alternative to Conventional Computer Networking System ........................................................................................................................ 27
   2.11 The Significance of Thin Client Technology ...................................................................... 29
   2.12 What Thin Clients Can Offer .............................................................................................. 30
   2.13 Producers of Thin Clients Technology .............................................................................. 31
   2.14 Advantages and Disadvantages of Thin Clients ................................................................. 32
      2.14.1 Advantages/Benefits of Thin Clients ........................................................................... 33
      2.14.2 Disadvantages of Thin Clients ................................................................................... 34
   2.15 Constraints for use of Thin Clients in Developing Countries ....................................... 35
   2.16 Factors to consider when choosing between Thin Client Technology and Conventional Computing ....................................................................................................................... 35

3. Research Method ...................................................................................................................... 38
   3.1 Research Design ...................................................................................................................... 39
   3.2 Research Reliability and Validity ............................................................................................ 40
   3.3 Research Rationalization ........................................................................................................ 40
   3.4 Modes of Data Collection ....................................................................................................... 41
   3.5 Process Taken in Administering Questionnaire and Survey Data Collection .................. 41

4. Results - Questionnaire Survey ............................................................................................... 43
   4.1 Analysis of the Results .......................................................................................................... 43
   4.2 Summary of Thin Clients Benefits ....................................................................................... 53
Figures

Figure 1  Global ICT adoption ranking, on country basis, as reported by the International Telecommunication Union (ITU) in year 2002  ........................................... 19
Figure 2  Displaying Terminal Services being used to provide the same operating systems to various workstations .............................................................. 21
Figure 3a  Displaying Early Mainframe Computer .................................................. 22
Figure 3b  Displaying Early Client Station ............................................................... 22
Figure 4  Displaying Personal Computers in the 80s .................................................. 23
Figure 5  Conventional Method of Networking ......................................................... 28
Figure 6  Displaying Diskless Thin Client ................................................................. 29
Figure 7  A Thin Client model (IBM CP20) Developed By Teradici of British Columbia (McMaster 2009) ........................................................................... 30
Figure 8  Thin client enabling connections to multiple users from a single-point control ............................................................................................................. 31
Figure 9  Displaying a centralized server being connected to the Internet and linked to numerous Personal Computers serving as Clients ......................... 37
Figure 10  Indicating the process involved in Exploratory Research ............................ 39
Tables

Table 1. Showing the differences between Thin Client and Fat Client .......................... 32
Table 2. Tabulating the age distributions of the participants ............................................. 43
Table 3. Tabulating the academic qualification distributions of the participants .......... 44
1. Introduction

This chapter will be used to outline the background, motivation and objective of this study, while it will also state the research questions and discuss the methodology, structure and significance of the study.

1.1. Background of the Study

The fact is glaringly undisputable that information and communication technology (ICT) is the facilitator, and the subsequent means of sustenance, of development in the socio-political economic and all other human activities in today’s global environment. There has been an unprecedented speedy improvement in the adoption of ICT in today’s world economy. Yekini, Rufai, Adetoba, Akinwole and Ojo (2012) defined ICT as the electronic means of facilitating the creation, storage, management and dissemination of information, which includes; radio, television, telephone, fax, computer and Internet. According to Kollberg and Dreyer (2006), ICT, which is being adopted in various business organizations in a wide range and areas of operations, has created new methods of storing, processing, distributing and exchanging information within and outside the companies. Rafi and Muhammed (2008) stated that various organizations, globally, are making use of ICT, not only to cut cost and improve their efficiencies, but also to enhance service improvements to their customers. Quoting UNCTAD (2004), they went further to state that ICT can only thrive in a business environment that gives room for competition, promotes confidence, security, interoperability and consistency, while it is also necessary to make funds available for the acquisition of ICT. The Conference Board (2011), in its research report on “How ICT is Transforming Societies, Cultures, and Economies”, submitted that ICT is an essential factor for global transformation, with its capability of enhancing corporate growth, global job distribution, and investment standards (The Conference Board, 2011, p.1). Apulu and Latham (2010, pp.56), quoting Evans and Wruster (1997), stated that ICT tends to increase richness and reach by enabling companies to communicate, collaborate, and conduct transactions with their customers, suppliers and distributors through the use of Internet. It is also said that ICT affords organizations easy access to new market opportunities and specialized information services. It enables organizations to exchange real-time information and develop close relationships with customers, suppliers and all business associates (Fulantelli and Allegra, 2003.) It is apparent that the employment of various infrastructural facilities of ICT, comprising hardware and software tools, enhances development. Thus, the importance of ICT, in today’s global economy, cannot be undervalued. The business sector has not, in any way, been excluded in this development facet. ICT has a significant effect on the efficiency, productivity and competitive improvements of the inter/ intra-organizational structures of a business establishment (Irungu, 2012, pp.21). Ali (2013), quoted Melville, Kraemer and Gurbaxani (2004) as saying that using ICT in business bring about customer satisfaction through improvement of service quality, which leads to new opportunities for companies. Consequent upon the fundamental nature of ICT, it has positively enhanced the business environment, as regards the excellence and magnitude of developmental strategies being employed by various business organizations, resulting in improvement
in their revenue base and profit margin, as well as upgrading their customer satisfaction. Therefore, it is sufficient to say that ICT adoption results in business performance improvement, through its exciting, interactive, flexible, and attractive content.

Therefore, it is essential to get equipped with the knowledge of ICT in order to remain significant in a jet-speed changing technology in this global environment. The United Nations Conference on Trade and Development (UNCTAD, 2003), in its review and evaluation of ICT development in various countries, classified African countries as ‘falling behind’ resulting from unequalled opportunity in access to hardware equipment and Internet usage. It went further to analyze the deficiencies of developing countries as: lack of telecoms infrastructure, inadequate computer and general literacy, lack of awareness of the Internet and inadequate regulation. UNCTAD declared that this problem of inadequate access to ICTs in the developing countries could make them lag behind in income, equality, and development, among other benefits, in the rapidly growing digitalized world (United Nations Conference of Trade and Development, 2003.) Also, in order to bridge the gap of inequality in access to ICT for most of the world’s population, the UN World Summit on the Information Society (WSIS) reiterated their commitment to establish a people-oriented and all-encompassing ICT development in the society, that would afford people the opportunity of creating, accessing, utilizing and sharing of information and knowledge. They resolved to assess what had been achieved globally to bridge the gap and also to support extensive agreements on the way of addressing the three related themes of; providing access to ICTs for all; ensuring that ICTs serve as a tool for social and economic development; and enhancing confidence and security in the use of ICTs (World Summit on the Information Society, 2003.)

It is apparent that the increased use of ICT has contributed immensely to the world’s economic development. Hence, it will be right to say that there will be a possible loss of opportunities and benefits on the part of any country that fails to belong to the new digital global society. However, in spite of the United Nation’s, and other organizations’ relentless efforts to bridge the gap in access to these technologies between the developed and developing countries, it is pertinent to note that Nigeria, and most other developing countries, are yet to have a place in the history of information technology; which is majorly as a result of their poor financial state and inadequate literacy status, among other causes. Hence, this study is being carried out to identify the ways by which Nigeria, and all other developing countries, could be brought into prominence and achieve their much desired position in information technology. According to Mathew, Joro and Manasseh (2015), the Federal Government of Nigeria, in the National Policy on Education acknowledged the degree of importance of ICT in modern global socio-political and economic activities, through the incorporation of ICT into the country’s educational scheme, and their decision to provide necessary infrastructure and training, as early as primary school level and up to the secondary school standard, towards the actualization of this goal (Federal Republic of Nigeria, 2004). Mathew et al. (2015), also quoting Federal Republic of Nigeria (2010), stated that the Federal Ministry of Education initiated an ICT project tagged ‘School Net’, targeted towards computerizing and equipping all schools in Nigeria with communications technologies. Mathew et al. (2015) stated further that the Federal Government of Nigeria also established a mobile Internet Unit, aimed at conducting mobile training and cyber centre, which is being managed by the Nigerian National Information Technology Development Agency (NITDA). In the Nigerian business sector, organizations’ demand for computer/ICT literates is fast growing because of the fact that employers of labour now realize that the adoption of ICT in business will really facilitate efficiency. On the other hand,
employees have also realized that lack of ICT knowledge could make them lose their jobs, and so they have to be computer literate. Nevertheless, despite the recognition that has been accorded ICT by the Nigerian government, and the awareness of its imperativeness by both the employers and employees, it is important to state that the intentions to promote the usage of ICT have not become evident till date. This is needless to say that the ICT rate of implementation and application is still very low in this part of the world. The reasons for this low rate of implementation and application can be ascribed to so many factors, prominent among which are; expensive ICT facilities/infrastructures, insufficient manpower in ICT, poor and inadequate power supply, inadequate budgetary allocation for ICT infrastructures, and non-availability of software facilities. The Nigerian Economic Summit Group, at their Breakfast Dialogue tagged “Trade, ICT and The Competitiveness of Nigeria’s Business Environment” (2013), stated that the then Nigerian minister for ICT, Omobola Johnson, argued that the rapid growth and telecommunications development in Nigeria had not effectively shown in ICT connected global competitiveness indicators. She was quoted as mentioning some of the factors militating against ICT adoption in Nigeria to consist of; Up to 70% domination of PC market, 100% mobile phone market and 78% mobile network market, by multi-national companies, low access to PC and its ownership by the Nigerian population, poor ICT infrastructure resulting from multiple regulation and taxation, coupled with unstable power supply, among others (The Nigerian Economic Summit Group, 2013). The primary constraint in ICT adoption in Nigeria is the fact that the rural communities are being denied access to the use of computer, Internet and other tools of ICT. These benefits are significantly limited to the urban areas, and consequently, the people in the rural communities, who are predominantly, 70% of the Nigerian population, are yet to know how to use the computer, Internet and other ICT tools. Hence, the lack of information has put these communities at a great disadvantage in various developmental measures. This is seen to be due to the high cost of acquisition of ICT infrastructures, which has gone beyond the affordability of these communities (Akinsola, Herselman & Jacobs, 2005.) It is crystal clear that failing to develop rural communities may lead to harmful consequences, such as; mass movement to urban areas, which results in congestion, unemployment, poverty, insecurity, and other vices. Hence, Akinsola et al. (2005), quoted Caspary and O’Connor (2003, 12) as submitting that there is need to identify affordable and low-cost ICT infrastructures for use in the rural areas and other low-income communities. Achimugu, Oluwagbemi, Oluwaranti, & Afolabi (2009) also agreed that it is necessary to consider the financial sustainability of ICT infrastructures, during enhancement. Hence, there is need to identify cheaper and complementary means for the rural communities whose resources cannot sustain the present infrastructures. Chiemeke and Longe (2007) identified the factors militating against the adoption of ICT in Nigeria as; inadequate infrastructures, high cost of ICT facilities that are not affordable to the large population of low income earners in Nigeria, lack of encouraging government support, and mass illiteracy rate in ICT tools. They also quoted Nwanko (2006) as saying that the then Executive Vice Chairman of the Nigeria Communication Commission (NCC) faulted the expensive bandwidth, computers and Internet infrastructures as being responsible for the low Internet usage in Nigeria (Chiemeke & Longe, 2007.)

According to Williams (2015), many African countries are lagging behind in the use and application of ICT. He, however, quoted Okpaku (2002), as saying that the G8 Africa Plan of Action, in its Summit, held in Canada, in June, 2002, resolved to support the development of ICT capacity in Africa, and its taking advantage of enabling capacity of ICT and applications towards broad development enhancement. It is pertinent to say that acquiring ICT infrastructures for use in business may be too
expensive in terms of both the initial purchase and successive costs of sustenance. Economic conditions of most business organizations in developing countries may be a limitation for them to meet the expenses involved in the acquisition of necessary ICT infrastructures. A review by the Global Information Technology Report (2013) revealed that high cost of ICT infrastructure, inadequate skills and educational levels, and unfavourable business conditions are constrictions to the acquirement and leveraging of the potentials of existing ICT infrastructure (The Global Information Technology Report, 2013, p. xiii). Also, the factors affecting the use of Internet in African countries has been classified into five categories, namely; connectivity infrastructure, skills, ease of use, costs and perceived advantages of the Internet (United Nations University, 2003). In the case of Nigeria, the United Nations University (2003) ranked these constraints according to their levels of seriousness as follows; cost, skills, physical infrastructure, connectivity infrastructure and ease of use. Yekini et al. (2012), in their article titled “ICT, Tools for Poverty Eradication and Economic Growth in Nigeria” recommended that there is need for the availability of cost effective and locally adaptable software in Nigeria, for the country to fully enable ICT adoption and usage. Therefore, it is essential to conduct a study on an affordable, resourceful, high performing and easy to use information technology system.

This research work studies the input of thin clients with respect to its ability to deliver the above analyzed qualities in the enhancement of information technology in the current global business economy, particularly in developing countries. This research is being conducted with the intention of easing the setbacks in information technology in developing countries, with Nigeria as a case study. Thin client has been described as a server-based computing which enables all applications to be deployed, managed, supported, and executed from a central location, as opposed to the traditional desktop architecture model of managing applications on multiple PCs (Landry, 2006, pp 6-7.) It is said to be highly efficient and capable of reducing costs of acquiring several key areas of technology, such as; hardware cost, bandwidth cost, centralized support, low power consumption, reduction in required license support, high security control, centralized back-up system, reduction in risk of virus, and maintenance cost (Barrie, 2002, 6-10).

1.2. Research objective and motivation

The objective of this study is to ascertain the truism of thin client technology being cost effective, high performing, and of high security, and to determine the technology’s feasibility of the enhancement of information technology in the business and economic sectors of developing countries, using Nigeria as a case study.

AS expressed by Williams (2015), many African countries are lagging behind in the use and application of ICT. It is a well-known fact that obtaining ICT infrastructures for use in business, in terms of both the original purchase and successive sustenance costs, are a luxury. Economic conditions of most business organizations in developing countries may, possibly, pose a setback for them to be able to afford the necessary infrastructures. Some organizations may not even possess any infrastructure, due to exorbitant costs. A review by the Global Information Technology Report (2013, p. xiii) revealed that expensive price of ICT infrastructure, insufficient skills and literacy levels, and pitiable business situations are restrictions to the attainment and leveraging of the potentials of available ICT infrastructure. Thus, it is obligatory to perform a research on a cost effective, highly efficient, and high performing information technology system. Consequently, this research work has been targeted at establishing the input of thin clients regarding its ability to fulfill the above stated qualities in the enhancement of
information technology in the modern global business economy, particularly in the developing countries. This research will be conducted with intent of easing the predicament of the adoption of information technology in developing countries, using Nigeria as a case study.

1.3. Research questions

The aim of this research work is to look at the ways thin client technology can enhance information technology in the business and economic sectors of developing countries, using Nigeria as a case study. The result of this research work will establish the benefits that the developing countries can derive if they ultimately implement the project. In a bid to ascertaining the benefits derivable from thin client technology, I deal with the four different questions, stated hereunder, so as to accomplish the objective of this study, viz;

RQ1 - What are the perceived benefits of thin client technology?

RQ2 - What are the effects (advantages and disadvantages) of thin clients adoption and its prospective tendencies as information technology infrastructure?

RQ3 - Of what economic importance are these effects to the developing countries?

RQ4 - What is the scalability of thin client technology to the economic/business sector in a real-world set up?

It is pertinent to mention that the answers to the aforementioned research questions will be used to enhance the adoption of information technology infrastructures, via thin client technology, in the developing countries, which will put them at the same level with their counterparts in the developed countries.

1.4. Methodology

Research approach depends, fundamentally, on the types of research questions asked, control of the behavior, environment and existing events. This is determined by the subject being addressed and the rationale behind the research work. In view of the fact that the research questions are based on proffering answers to the questions “what”, and considering the fact that the rationale behind the research work itself is to have an in-depth knowledge of the benefits of the subject-matter and also establish the ways by which it could be beneficial to the developing countries, apparently, this research is classified as an exploratory method. The approach employed in this research is an exploratory study of the subject-matter, targeted at enhancing the easy access and use of ICT in developing countries. According to Kumar (2011), an exploratory research is usually conducted by a researcher to seek to have an in-depth knowledge of an area where he has little or no knowledge about, or to investigate the possibilities of carrying out a meticulous research study. Hence, in this study, exploratory research has been used to have a comprehensive knowledge of the operation of thin clients, and to ascertain whether the technology could be useful in proffering lasting solutions to the problem of ICT usage in developing countries, using Nigeria as a case study.
For this research work, a case study is employed, with the use of exploratory research, to determine the ways thin client technology can enhance information technology in the business and economic sectors of developing countries. A case study has been defined as “an intensive study of a single unit for the purpose of understanding a larger class of units”, while the units could be classified into formal and informal units. Formal units are said to comprise the units chosen for intensive analysis, such as; person, group, organization, country, region, etc (Gerring, 2004, 342-344.) Darke, Shanks and Broadbent (1998), quoting Cavaye (1996), said that case study research is often used to provide evidence for generating hypothesis and exploring areas where the researcher has limited knowledge. They also reported Benbasat, Goldstein and Mead (1987) as saying that case study has been suggested to be an appropriate tool for testing theory in performing information systems research. They concluded that information systems researchers have acknowledged case study research as a helpful means of investigating the development, implementation and use of information systems within organizations (Darke, Shanks, & Broadbent, 1998, pp. 275-276, p. 287.)

Exploratory research method is known to be a groundwork study of an unusual problem which researcher has slight or no knowledge about. It integrates the development of concept, theory and assumption. It enhances familiarity with a verifiable piece of information or to discover new approach into such information. (Kumar, 2008.) The purpose of this research work is to establish the importance of ICT and identify whether thin clients technology is capable of solving the problem of financial constraint that is depriving the developing countries to make use of information technology in their economic/business sectors. Hence, it is necessary to explore various mainstream theories and empirical frameworks in order to have a comprehensive understanding.

1.5. Significance of the study

It is pivotal to undergo this study so as to enhance accessibility of ICT by the developing countries. The prospective/intending users of ICT in developing countries will be opportuned to make use of easy-to-use, highly effective and affordable information technology infrastructures. For the scientific community, on the other hand, the review will enable researchers to discover the challenges in the use of thin clients and ascertain ways of surmounting same, for effective use of the technology in the business and economic environments.

1.6. Structure of the thesis

This thesis work has been divided into six different chapters. Chapter two of the work has been used to explore the literature review on thin client technology and ICT in general. It discusses the essentiality of ICT in the business/economic community. This chapter also deals with the operation of ICT in developing countries, using Nigeria as a case study. It analyzes the current ICT system in Nigeria as it relates to business sectors. It also defines thin client/server based computing, it analysis the historical background and different types of thin clients technology, and also discusses the cost concern of thin clients technology and the way it could be cost-effective for the development of ICT system in developing countries. The chapter is also used to discuss the limitations of thin client technology, the different platforms for using the technology, the producers of
the technology, the essence of using the technology, its advantages and disadvantages, and the factors to consider when choosing between thin clients technology and conventional computing models. Chapter three of this work has been used to detail the research method implemented for this work, the research design, modes of data collection, process taken in administering questionnaire and survey data collection and issues regarding research reliability and validity. Chapter four is used to analyze the results of the questionnaire administered for the purpose of this work, and summarize the benefits of thin client technology. Chapter five is used for the discussion and conclusion of this work, and the limitations of the study. Chapter six, which happens to be the final chapter, is channeled towards elocquently expressing research implications and the need for future research work on thin client technology.
2. Literature review

This chapter will be used to present literature reviews, knowledge and other information relevant to the subject matter of this study. Hence, this chapter’s center of attention will be to review ICT and economic/business development, ICT in developing countries (particularly relating to Nigeria), definition of thin clients/server based computing, historical background of thin clients, types of thin clients, limitations of using thin clients, different platforms used by thin clients, essence of using thin clients, what thin clients can offer, different producers of thin client technology, advantages and disadvantages of thin clients, and factors to consider when choosing between thin clients technology and conventional computing model.

2.1. ICT and economic & business development

ICT has successfully offered prospective opportunities and advantages to local business enterprises. It has gotten rid of the problems of distance and locale being experienced by these business organizations, and promoted internationalization (Gurstein, 1999.) Interestingly, Womboh (2008) in Sulaiman (2010) described ICT to encompass three essential concepts, namely; Information (which means processed data being transmitted to a potential user for the purpose of decision making), Communication (which is regarded as transfer or exchange of information from one person or place to another), and Technology (described as the use of scientific knowledge in creating tools for people to control environmental vulnerabilities and impediments to comfort). Sulaiman (2010) also described ICT to include the various technologies used in enhancing the creation, storage, processing, communication and dissemination of information. The development of ICT in the world economy has been beyond human reasoning. It has been moving at a very high speed, predominantly in the western countries. The swiftness of revolution brought about by these emerging technologies to the world economy can be said to be awe-inspiring. In today’s world, information technology has been having a highly significant impact on all spheres of life, not leaving out the business environment. The world is now a global village, where information is at your reach and access way anytime. The speed at which change is being experienced in information technology has really revolutionized business into a life-long activity; computerization has become the order of the day in every facet of life with advanced technology. Computers are now indispensable to run a successful business and to enhance educational development, and they are readily accessible to promote communication and convey information by electronic means. The use of Internet has revolutionized access to information for both the business and educational environments. Information technology has continually enhanced the information sharing, principally in the business and educational environments, thus, bringing about prompt and swift connections in business, and sustaining total global cooperation among individuals and business organizations. Every technological revolution has been said to always open new opportunities, and Internet is not an exemption with its extensive consequence on business and commerce; hence organizations are now making use of electronic tools to realize enormous gains, understanding the fact that using ICT in selling goods, supplies and services offers new means of finding customers, managing relationships and improving sales (Jun, 2005, p. 904.) The United Nations
Conference of Trade and Development (2003, pp. 8), suggested that the employment of the applications of ICT should be advantageous in all aspects of life. They posited that ICT supports employment generation, job creation, business, and poverty eradication, among other benefits. It is pertinent for businesses to experience significant transformations to facilitate their survival in the emerging digital economy in this 21st century, and the achievement of any organization is determined by the efficient management of their information technology. In a bid to promote competition and private sector investments, various governments have endeavored to create an enabling situation, through the provision of; intellectual property rights protection, steady and predictable legal systems: trade liberalization; education and capacity building; technology neutrality; and a regulatory framework that promotes competition and supports entrepreneurship (Jun, 2005, p. 904.) Information technology promotes knowledge sharing, and the importance of knowledge in economic/business development cannot be exaggerated. This has channeled the attention of various governments, organizations and educational bodies towards a networked society (Torres-Coronas, María-Arántzazu, & Ricard, 2010).

2.2. ICT in developing countries (with particular reference to Nigeria)

Information accuracy and responsiveness promotes successes in business and economy of a society. Adi (2015) quoted Norton (1992) as saying that ICT reduces both the costs of obtaining information and market participation, while he also quoted Roller and Waverman (2001) as saying that the resultant effects of improvement in ICT infrastructure are the reduction in transaction costs and increase in output for organizations in various economic sectors. Collaborative information systems enhance the accurate sharing and disseminating of information. Collaborative information systems is the use of computer-based systems to access, search, share, and store and publish information in a computer network (Jarvenpaa &Staples, 2000, pp. 130).

It is a fact that ICT promotes personal relationships, through the use of Internet (Boase & Wellman, 2004). Kasigwa, Williams and Baryamureeba (2005) posited that knowledge and information are pivotal in enhancing rural development, and facilitating social and economic growth. In a report by the World Summit on the Information Society (WSIS, 2003), they agreed that a well developed information and communication network infrastructure, with easy access and affordability, is capable of enhancing social and economic development of a country, as well as promote the well-being of its communities and people. However, the use of ICT infrastructures for enhancing development has been an illusion in the developing countries, as the larger sectors of the population do not own a personal computer and/or Internet access (Baron & Gomez, 2012). As the developed countries are advancing technologically, the developing countries, like Nigeria, are lagging behind in all spheres of technological development. However, Nigeria has been observed, recently, to be experiencing development in ICT adoption. Several survey information, on the state of the economy in Nigeria; one of which was Elijah and Ogunlade’s (2006), revealed that over 70% Nigerians have been living in abject poverty. David and Adekunle (2012) declared that Nigeria is one of the poorest countries, in spite of her abundance of human and natural resources, and extensive oil wealth. It has been declared that there has been a persistent increase in the level of poverty in Nigeria. An average Nigerian could hardly afford to purchase essential needs of food, clothing and shelter. Consequently, it is apparent that he cannot afford the money to purchase a computer of his own, which is no doubt, very costly to obtain. The massively used information technology tools in Nigeria today, are;
telephone, radio, print, video, and television. Whereas, the use of computers and Internet still evades the massive majority, rather, it is still limited to the few people who can afford to purchase them in the urban areas. In view of the fact that ICT has been identified as a tool that can be employed to remove the barrier of access to information and communication in remote rural areas and poor communities, and also to eradicate poverty, it is best for the developing countries, including Nigeria, to promote Information Technology, amongst the citizenry, so as to support the delivering of efficient and effective services to them and their businesses (Elijah & Ogunlade, 2006.)

The imperativenes of promoting the adoption of information technology, notwithstanding, it is pertinent to note that conception of information systems, with the conventional models of computer technology, may be very costly for individuals and/or the government. For this reason, there is need for the recommendation of thin client technology, which is attested to be cost effective and will also provide high excellent performance.

Friday and Ismail (2013) described information technology as the conjunction of micro-electronics telecommunications and computer technology. Sulaiman (2010) posited that ICTs comprise; communication media (e.g. radio and television), information machine (e.g. computers) and telecommunications technologies and equipment (e.g. satellites, fibre optic cables, phones, and facsimile machines). Oluwatoyin (2015), quoting Ajayi et al. (1998), submitted that the existence of telecommunications in Nigeria dates back to 1883; with a cable connection between Lagos and the colonial office in London, while in 1893, telephone services were made available in Lagos government offices, and later extended to some other areas. 1923 witnessed the establishment of a commercial trunk telephone service between Itu and Calabar, while a three-channel line carrier was established between Lagos and Ibadan, between 1946 and 1952 (Oluwatoyin, 2015). The Nigerian independence, in 1960, paved the way for periodic national development plan. Between 1960 and 1985, the telecoms sector, which comprised; the department of Posts and Telecommunications (P&T) and Nigerian External Telecommunications (NET), provided gateway to the outside world. January, 1985 witnessed the separation of posts from telegraph department, and the merging of the Telegraph Department and the Nigerian External Telecommunications Limited (NET) to become a limited liability company known as the Nigerian Telecommunications Company (NITEL), primarily to orchestrate the planning and coordination of both internal and external telecommunications development (Friday and Ismail, 2013.) It is worthy of note that Nigeria’s bid to actualize her goals towards the development of its information and communications technology has never been an easy task. However, in spite of this difficulty, Nigeria’s telecommunications industry has contributed significantly to her economic growth and development. Before year 2000, Nigeria’s telecommunications industry had witnessed a severe impediment, having to deal with obsolete communications infrastructural facilities, epileptic services, and inefficiency among others. However, year 2000 brought about full revolution and liberalization of the industry, considering the immense growth and development witnessed that particular year. The deregulation of the sector rapidly increased the number of active subscription of telephone lines from 400,000, in 2001 to 89.8 million, in 2011 (Adi, 2015.) Figure 1 below indicates the global ICT adoption ranking, on country basis, as reported by the International Telecommunication Union (ITU) in year 2002.
### ITU Global Digital Access Index 2002

<table>
<thead>
<tr>
<th>HIGH ACCESS</th>
<th>UPPER ACCESS</th>
<th>MEDIUM ACCESS</th>
<th>LOW ACCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>0.85</td>
<td>0.69</td>
<td>0.49</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.83</td>
<td>0.68</td>
<td>0.48</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.82</td>
<td>0.67</td>
<td>0.48</td>
</tr>
<tr>
<td>Korea (Rep.)</td>
<td>0.82</td>
<td>0.67</td>
<td>0.48</td>
</tr>
<tr>
<td>Norway</td>
<td>0.79</td>
<td>0.67</td>
<td>0.48</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.79</td>
<td>0.66</td>
<td>0.48</td>
</tr>
<tr>
<td>Hong Kong, China</td>
<td>0.79</td>
<td>0.66</td>
<td>0.47</td>
</tr>
<tr>
<td>Finland</td>
<td>0.79</td>
<td>0.65</td>
<td>0.47</td>
</tr>
<tr>
<td>Taiwan, China</td>
<td>0.78</td>
<td>0.64</td>
<td>0.46</td>
</tr>
<tr>
<td>Canada</td>
<td>0.78</td>
<td>0.64</td>
<td>0.46</td>
</tr>
<tr>
<td>United States</td>
<td>0.78</td>
<td>0.63</td>
<td>0.46</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.77</td>
<td>0.62</td>
<td>0.46</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.76</td>
<td>0.60</td>
<td>0.45</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.75</td>
<td>0.60</td>
<td>0.45</td>
</tr>
<tr>
<td>Japan</td>
<td>0.75</td>
<td>0.59</td>
<td>0.45</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.75</td>
<td>0.59</td>
<td>0.45</td>
</tr>
<tr>
<td>Austria</td>
<td>0.75</td>
<td>0.59</td>
<td>0.44</td>
</tr>
<tr>
<td>Germany</td>
<td>0.74</td>
<td>0.58</td>
<td>0.44</td>
</tr>
<tr>
<td>Australia</td>
<td>0.74</td>
<td>0.57</td>
<td>0.43</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.74</td>
<td>0.57</td>
<td>0.43</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.72</td>
<td>0.57</td>
<td>0.43</td>
</tr>
<tr>
<td>Italy</td>
<td>0.72</td>
<td>0.56</td>
<td>0.43</td>
</tr>
<tr>
<td>France</td>
<td>0.72</td>
<td>0.55</td>
<td>0.43</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.72</td>
<td>0.55</td>
<td>0.43</td>
</tr>
<tr>
<td>Israel</td>
<td>0.70</td>
<td>0.54</td>
<td>0.43</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Russia</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>England</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>France</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Germany</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Italy</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Japan</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Australia</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Canada</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>United States</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Russia</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>France</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Germany</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>United States</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Russia</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>China</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>France</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Germany</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>United States</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.50</td>
<td>0.50</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Note: On a scale of 0 to 1 where 1 = highest access. DAI values are shown to hundreds of a decimal point. Countries with the same DAI value are ranked by thousands of a decimal point.

Source: ITU

**Figure 1.** Global ICT adoption ranking, on country basis, as reported by the International Telecommunication Union (ITU) in year 2002 (International Telecommunication Union 2008)
In the above report (Figure 1), International Telecommunication Union (ITU) rated ICT adoption in four hierarchical levels, namely; High Access, Upper Access, Medium Access, and Low Access. Unfortunately, Nigeria’s ICT adoption has been ranked as belonging to the lower level of the low access.

The resultant effect of the 2001 deregulation of the telecommunication industry in Nigeria was the introduction of the Global System for Mobile Communication (GSM). The first three sets of GSM network providers were; ECONET, MTN, and NITEL, while they were later joined by Globacom Nigeria Limited in 2003. Today, Nigeria has nine sets of mobile network operators, namely; Airtel (which used to be ECONET), MTN, Mtel (NITEL), Globacom, Etisalat, Multilinks, Visafone, and ZoomMobile.

It is obvious that the introduction of GSM, as a result of the deregulation policy of the government in the sector in year 2001, ushered in immense development in the telecommunications part of ICT in Nigeria. The sector experienced an amazing increase in the number of telephone subscribers. As at today, Nigeria is being rated as one of the fastest growing telecommunications industries in the world.

This remarkable development in the telecommunications sector has enhanced inestimable economic gains in Nigeria, vis-a-vis:

- Creation of employment opportunities
- Skills acquisition and local technology transfer
- Access to telephone services enhancement
- Inspiring local investments
- Boosting of foreign earnings
- Increase in tax revenue earnings for Nigeria
- Attraction of license fees amounting to over 1 billion US Dollars
- Facilitation of economic power to indigenous people
- Promotion of private local investments. (Ndukwe, 2006, pp. 5-6.)

This development has brought about improvement in social-economic activities in Nigeria. Akuoma (2012) reported Isoun (2003) to have said that Nigeria now regard ICT as a tool that enhances the country to become strong, prosperous and self-confident. However, it is apparent that communications ability is still drastically low and access to information technology is yet to be satisfactory, considering the large size of Nigerian population of over 180 million people. Besides, Nigeria requires more than telephones for genuine economic growth to occur, as the whole information and communication technologies are regarded as utilities for aiding and delivering of services in the business/economic environments. It is pertinent to mention that the bulk of the problems, which include; exorbitant cost of acquirement of Internet facilities, insufficient awareness, lack of technical know-how and low access to the ICT facilities have debarred many people from being part of the digital world, in Nigeria. ICT is still an odd experience in a poverty-stricken country like Nigeria. Predominantly, the bulk of the people are faced with the constraints of acquiring affordable computing and telecom resources.

It is also worth mentioning that the slight development in information technology in Nigeria has only been experienced in the urban areas. The rural areas are still lagging behind. They are highly marginalized by being deprived of the use of ICTs (Akinsola et al., 2005.) Considering the fact that the majority of the Nigerian population reside in the rural areas, substantial number of the people have been deprived of the opportunity to
use computer and its related infrastructures. Whereas, Caspary and O’Connor (2003, 5), in Akinsola, et al. (2005), mentioned that the problem of ICT affordability and low-cost access, in rural areas and other low-income communities must be resolved in order to enjoy the benefits of the Internet.

2.3. Definition of thin client/server based computing

Thin client, otherwise known as server based computing, has been defined as a desktop appliance which does not possess any moving component such as a hard drive, floppy drive, or CD-Rom, and executes applications from a central server instead of a traditional desktop PC (Landry, 2006). The theory of running all user applications on a central server is what is known as server based computing. Its quality of allowing all applications to be deployed, managed, supported, and executed from a central location is a great economic and time-sharing advantage to any company/business, as compared with the traditional desktop architecture model of managing applications on multiple PCs. Thin client technology provides the required solution to the problem of management and security, among others, that is confronting users of personal computers. It promotes centralized, secure and easy-to-maintain computing approach. A thin client computing system is made up of a server and a client that communicate over a network by using a remote display protocol, the client conveys user input to the server, while the server returns screen updates of the user interface of the applications to the client (Baratto, Kim, & Niel, 2005, p1.) Normally, the architectural design of thin client includes three components, namely: a powerful terminal server, one or more thin clients, and a communication protocol. The server runs an operating system that supports a multi user environment, while the thin clients run a stripped-down version of an operating system that is able to run a program that connects them to the server, and the protocol enhances the communication between thin clients and the terminal server by sending keystrokes, mouse clicks and screen updates via network. When more than one terminal server is used, load balancing software is required to distribute workload across the servers (Azhar, 2011, p. 5.) It is imperative to mention that terminal servers, through the installation of terminal services, is capable of enabling the use of the same operating system on many workstations, just as it could also provide each individual users with the operating system of their choice, which could be Apple, Windows or Linux environment. Terminal services are software installed on servers to provide a view into the image to be displayed on the thin clients for users (O’Donnell, 2014.) Figure 2 below displays terminal services being used to provide the same operating system to various workstations (O’Donnell, 2014).

![Figure 2. Displaying terminal services being used to provide the same operating system to various workstations (O’Donnell, 2014).](image-url)
2.4. Thin clients historical background

Although, not many people have heard about thin client technology, it is not a new concept. The concepts of thin clients have originally existed in mainframe computing. According to Williams (2002), quoting Sinclair and Merkow (2000), the history of centralized computing dates back to the 1960s and 1970s when mainframe computers were used as a shared resource, while dumb terminals served as client devices, which provided basic text based input and output, and subsequently, limited graphics as they became graphics terminals. The terminals could not process, but served as interface to the programs written for online applications. However, the maintenance costs of mainframe computing systems were very high, such that; the capital and operating cost were too high; the hardware, operating system and software applications were all proprietary. Moreover, Geoffrion and Powers (1995, p 110) posited that the mainframe architecture was slow and expensive to maintain, among other shortcomings. They went further to say that the personal computers were adopted in the 1990s, due to the fact that they are fast, user-friendly, and much cheaper, among other benefits. Figures 3a and 3b below are used to display the early mainframe computer, working like a thin client technology, with dumb terminals serving as client devices.

\[ Figure3a. \] Displaying Early Mainframe Computer (Olaya, 2014)

\[ Figure3b. \] Displaying Early Client Station (The one stop destination for System Z Professionals)
The 1980s witnessed the adoption of personal computers (PCs). The PCs adoption is principally targeted at decreasing the cost of computational power, which was in form of localized, instead of centralized information processing (Tyson, 2010.) With the introduction of PC, each individual computer had its own central processing unit, memory, hard drive, monitor, operating system and application software. Unlike mainframe computers, PCs are small and cost less than one percent of the price of a mainframe (Learning with Technology).

Campbell-Kelly and Garcia-Swartz (2015) tagged the rise of PCs as the most significant event, and they asserted that the PC was the fastest growing part of the information technology industry during the period. According to Campbell-Kelly and Garcia-Swartz (2015), the international ranking of mainframe and personal computers, between 1989 and 1995, revealed that the total mainframe revenue was declining while the total revenues for personal computer were tremendously on the increase. PCs were networked as a measure of cost-effectiveness and to empower individual workers or workgroups. Although, the PCs proved to be reliable, however, they were faced with the problem of high cost of acquisition and maintenance. They were also exposed to security breaches, such as; virus attacks, theft and general unauthorized misuse. In view of the unmanageable total cost of owning and maintaining the PCs, there was a great urge to go back to a more centralized and easier-to-manage computing model. Hence, thin client became the most favoured model, because of its goals of centralizing computing resources, easier maintenance and cheap upgrades, while still sustaining the same service quality provided by a dedicated workstation (Nieh, Yang, & Novik, 2000, p. 1.) Also, Landry (2006, p. 6) reported that the need to resolve the personal computers’ problem of high cost, management and security resulted in escalated interests in Thin Client/ Server Based Computing as an alternative business solution. With the reintroduction and adoption of thin client technology in the 1990s as an alternative to the PCs, business concerns are returning to the mainframe method of computing. Computing applications are being centralized on servers, while PCs and new generation of devices are being used as “dumb” terminals. The introduction of thin client technology was, basically, to reduce the total cost of ownership (TCO), via application access from any hardware platform, Bandwidth-independent performance, enhance scalability and elevating data security. Thin client is the best technology to reduce total cost of ownership by allowing you to get the most out of your technology investment with the least amount of unnecessary effort (Kanter, 1999.) According to Kanter (1999),
thin client technology has a lot of key benefits for small and large corporations, organizations, schools, system administrators, and also to an Internet service provider (ISP).

2.5. Using thin client as a solution to Nigeria’s ICT problem

The rapid development of ICT and its impact on the global socio-economic activities cannot be underestimated. It is pertinent that developing countries, of which Nigeria is one, should not be left out of the technological revolution. However, it is no more news that Nigeria is lagging behind in the use of ICT. There have been pointers, from various quarters, to the fact that Nigeria is facing numerous challenges in her ICT industry. According to The Nigerian Economic Summit Group (2013), during a breakfast dialogue titled “Trade, ICT and the Competitiveness of Nigeria’s Business Environment”, the then Nigerian minister of ICT, Mrs. Omobola Johnson, in her presentation, listed the challenges that are being faced by the Nigerian ICT industry to include; low PC access and ownership, and poor ICT infrastructure brought about by multiple regulation and taxation, destruction, security and unstable power supply.

Abdulsalam, Akinola, and Buwanhot (2008), in their study titled “Problems and Prospects of Information and Communication Technologies Application in Agriculture in Nigeria” stated that their results analysis revealed that the major problems of ICT usage include; poor access to ICT facilities, low sensitization on available ICTs, poor sources of power supply, and high cost of software and hardware. This is to mention, but a few.

In their determination to find a lasting solution to the lingering problems in the ICT usage in Nigeria, many stakeholders, mainly in the business and educational environments, have employed thin client solutions from various producers. For instance, Electronic Test Company, a company situated in Lagos, Nigeria, started to make use of Dell’s thin client product, called Wyse Technology (Windows Embedded) since 2008, in providing computer-based testing of candidates for tertiary institutions admission, semester exams, City & Guild, ACCA and other Nigerian examinations and qualifications (Dell Wyse Press releases, 2011.)

Subject 1 – The MD of Electronic Test Company Ltd has this to say “Testing can be a stressful experience for candidates and the Wyse devices are integral to how we provide the best possible environment for sitting e-examinations. The proven flexibility and robustness of their cloud client computing solutions is going to be even more important as we expand the service and have around 200,000 candidates taking tests every day by next year. It is also cost effective because we would deploy e-Learning and e-Library applications on this same infrastructure to bring teaching, learning and researching even closer to the teeming populace.”

Subject 2 - Vice President, EMEA, Wyse Technology has this to say: “What’s exciting about the Electronic Test Company Ltd is how our technology is helping Nigeria modernize its educational systems using state-of-their-art cloud client computing on a massive scale. They are demonstrating how our technology can be transformative in emerging economies, leveraging its reliability and low running costs to deliver a high quality service to Nigerian students and educators.”

Prominent among the employers of this technology is the Federal University of Technology, Minna. Also, most universities in Nigeria have engaged this technology in
conducting Post Unified Tertiary Matriculation Examination (PUTME), through Electronic Testing Company (Adebayo, Abdulhamid & Fluck, 2014). Apart from the educational institutions, there are appreciative numbers of business organizations, engaging in the distribution and/or making use of different thin client products, in Nigeria today. While most of the users are running cyber cafes, some make use of the technology in the day-to-day running of their businesses. Some of the business organizations are: Philmore Café, Adetwin IT Concept, Raydion Royal Resources Ltd., Electronics Test Company, Sailer Technologies Ltd., Soft Solutions Ltd., Pawapoint Technologies Ltd., RodNorth Nigeria Ltd., Teledom Group, Mamatech & ICT Consultancy Services Ltd., Servo Direct Ltd., CHERT Nigeria, DATAFLEX, Rack Centre Ltd., and Direqlearn, to mention but a few.

2.6. Types of thin clients

There are two types of thin clients, namely; Diskless thin clients and Embedded OS thin clients.

1. **Diskless thin clients** – this is a centrally managed low cost computer with no disks or CDROM at all. Diskless thin clients rely on the server to perform the data processing. It sends keyboard and mouse inputs to the server, while the server processes the inputs and sends the output to the thin clients. The server is otherwise known as Application Server.

2. **Embedded OS thin client** – this type of thin client does not rely on server for data processing. Rather, it performs the function of data processing by integrating CF, SSD and DOM Hard Drives. Applications, such as; web browser, playing audio files, office tools, etc, will perform well without actually connecting to the server, on Embedded OS Thin Client.

Thin clients can also be categorized into; hardware thin clients and software thin clients. Hardware thin clients can be compared with diskless thin clients, and they are particularly made to run thin client software, with better graphics. Software thin clients are applications that can run on any available host, whether a hardware thin client or any commodity hardware. The host does not need to be solely designed as a connecting client; it can be a PC with its own workload that will be running the thin client application along with other things. (Yegulalp, 2010.)

2.7. What thin client is appropriate for

There is need for us to consider the particular requirements of each computer-based environment in order to determine the appropriate technology solution. Looking at thin client technology, it will be highly beneficial if it is being used in the following environments:

- Business organizations with a well-defined set of tasks, including; office applications in medical, financial, educational, government, manufacturing, distribution, or call center environments. Thin clients enhances easy running of office software, such as; Microsoft Word, Excel, and PowerPoint, or specialized business applications.
- Business organizations requiring high networking of computers to be connected to a central server, such as; hospitals, insurance companies, airline reservation centers, and hotels.
- Business organizations engaging in highly computerized tasks, such as sales or service call centers, data entry departments, or technical support desks.
- Educational institutions, such as universities requiring hundreds or thousands of computers with latest software. (HP, 2007.)

A thin client technology will be an incentive to these environments because of its easy management and maintenance, high security, and low costs in both hardware and software. Thin client computing reduces costs and improves services in several areas of computing technology, such as; centralized support, reduction of power consumption, no license requirement, high security, and effective back-up/restore process. Becta (2004) revealed that thin client is now generally adopted by organizations having multiple locations, such as banks and estate agents.

2.8. Weaknesses of thin client technology

The thin client technology’s major weakness is the requirement of high level of bandwidth when needed to be used for powerful graphic intensive applications, such as; photoshop, coral draw autocad; Voice over IP (VOIP), Gaming applications or multimedia applications. Also, Stand alone PC cannot be a thin client. (McCherry, 2015.) Thus, thin clients are not an option for works that require powerful local processing and significant storage, such as; engineering, graphics arts, multimedia development, and designs (HP, 2007). However, it could be an optimal solution in the near future, as technical developments are being undertaken to overcome the above limitations. For instance, Dell and Hewlett-Packard (HP) claimed to have developed new thin client technologies that possess faster processor and capable of running high-definition graphics. They are capable of running multimedia and engineering applications over the cloud or in virtualized environments. (Shah, 2013.)

2.9. Different platforms of thin clients

a) Platforms for thin client operating system

Users of thin client technology have 3 options of Operating Systems (OS) to consider, namely; Linux OS, Windows XP embedded, and Windows CE.

- Linux –based thin client - otherwise known as Linux Terminal Server Project (LTSP). They are robust and flexible, as they provide support for all terminal servers, and can easily be customized by manufacturers. These thin clients devices can run both Linux and UNIX applications along with 32-bit Windows applications. Linux-based thin client terminals are perfect for open source environments that require secure server-based, enterprise-wide computing. Linux Thin Client devices can be: Professional Linux Thin Client (with Mozilla, Java Virtual Machine, known as JVM, and Flash) or Embedded Linux Thin Client. Unlike Windows-XP Embedded based Thin Client, Linux thin client requires no licensing fees.
• Windows-XP embedded based thin client (XPe) – this operating system requires a licensing fee. It possesses a PC-like power in a thin client. It is designed for a general-purpose computing, such as; home and business desktops, notebook computers, and media centers. This is an enhanced version of Windows XP for compact applications such as; PDAs, handhelds and other appliances that use the x86 CPU. These thin client devices support the entire range of Windows peripherals and Win32 API applications; hence, they are suitable for line of business applications.

• Windows – CE based thin client: known as Windows Consumer Electronics. It is affordable and productive. It is a version of the Windows OS system designed to operate on small devices, such as; Personal Digital Assistants (PDAs) or handheld PCs. Windows CE thin client is ideal for environments where access to Web-based applications is regularly required. It is of low cost and high functionality, and its terminals support many Windows drivers and peripherals. (Bosanova)

b) Platforms for hardware

• Desktop
• Wireless
• Integrated
• Laptop

2.10. Substituting conventional computer networking system with thin client technology

Conventional computer (which is also referred to as Fat Client or Personal Computers) are computers that run full operating system, have their own storage devises and applications, which completes its tasks through local processing, graphics and in-built memory in the system (Valencia, 2013).

However, business owners and educational institutions are fully aware that acquiring a large number of personal computers (PCs), procuring an unavoidable number of software to be installed on each of them, and at the same time, networking all of them, will be too expensive for their organizations or institutions to be able to afford (Clark, 2000). Figure 5 below displays how it looks like setting up this method.
Figure 5. Conventional Method of Networking. This picture is used to display the methods used in carrying out networking in conventional computing (Ems, 2017)

The high cost of setting up these conventional systems could be attributed to various factors; conventional systems, no doubt, require more technical supports because of their vulnerability to viruses and file corruption as well as the need for constant updating of operating systems and applications for current technology. Also, where a large number of computers are required, there is need to install the same software on each computer. Moreover, the available hard disk space in these computers is usually larger than the needed software, while created files tend to be too small to fill up the disk. As a result, the money expended on the disk space normally amounts to a waste, because the use of the hard disk is never maximized. Furthermore, all the organization/institution’s computers will require high-powered configuration, which makes it impossible for them to employ centralized processing system that could have afforded them the opportunity of using low-cost hardware. Top of it all, the maintenance system tends to be highly financially demanding, burdensome and time-consuming, as all the computers will require maintenance at the same time. Hence, there is need for these organizations and institutions to adopt thin client technology; so as to proffer lasting solutions to all the above analysed problems in the setting up of computer technology systems. Thin client technology supports the use of server-client architecture. Figure 6 below displays thin client technology operating system.
2.11. The significance of thin clients technology

There have been many written submissions about thin client technology, with which different theorists have evaluated its significance, as an information technology infrastructure. Mart’inez-Mateo, Munoz-Hernandez and P’erez-Rey (2010), while establishing the fact that outdated computers could be used to set up a thin client computing, posited that this technology is a preferred option for an institution with old computers, budget constraints and limited numbers of staff for maintenance, especially in the developing countries. Aviv (2006) also stated that thin client technology has created a distinctive opportunity for large organizations to deploy, resourcefully, and maintain large obsolete computers at a reduced total cost of ownership (TCO). Mathiske, Bush and Periakaruppan (2008), during their invention of “Low-latency ultra-thin-client infrastructure”, established that client-server computing (thin client technology) has contributed, to a large extent, to the success of information technology, through its typical low-cost computing devices. Davis (2008) observed that organizations are being prompted to consider replacing their traditional desktop systems with thin client technology because of their preferences for greener and more energy-efficient technology infrastructure. Davis (2008) further asserted that adoption of thin client technology results in the benefits of; cost-effectiveness, extended life span of hardware, reduced energy consumption, and reduction in the number of staff required to manage, secure and service a thin-client environment.
In spite of the fact that today’s global economies rely essentially on ICT for receiving, processing and disseminating information, it is no news that developing countries, which includes Nigeria, are yet to experience notable benefits of information technology (Apulu & Ige, 2011). This is as a result of Nigeria’s pitiable financial position and literacy level. Consequently, it is imperative to identify an affordable and effective information technology that will bring solace to the Nigerian business and economic communities. As it has been earlier asserted, thin client has been structurally designed to ensure the reduction of Total Cost of ownership (TCO) of ICT infrastructures. This is highly beneficial for businesses and individuals in a developing country, such as Nigeria, as the technology will give them the opportunity to financially afford the procurement, deployment and management of ICT solutions that promote information and business management. Hence, this research work is carried out to discover the ways by which thin client technology, which has been earlier ascertained to attract very low cost and of high performance (Citrix, 2013), could promote Nigeria to the much preferred position in the adoption of information technology. Figure 7 below displays the deployment of IBM CP20 model thin client on the workstation blade servers via a high-speed remote display protocol know as PC-over-IP. This was developed by Teradici of British Columbia.

![Thin Client Deployment](image)

**Figure 7:** A thin client model (IBM CP20) developed by Teradici of British Columbia (McMaster University, 2009).

### 2.12. What thin clients can offer

Management and Scalability – rather than providing support for each and every desktop computer in an organization, thin client technology concentrates databases, file servers, and application servers in a centralized position from which user access is being managed. This enables wide-reaching users to have access to the same centralized information. Hence, companies can prevent the problems of security, cost, reliability, and management that occur when companies have broadly separated databases. Moreover, users can deploy workstations having full provided software as required for a particular job. Scalability is another critical factor in information system. There may be a necessity for information system professionals to increase the number of system users in an organization. For instance, Citrix’s WinFrame (a thin client) load-balancing option gives room for exceptionally consistent deployment of thin client application solutions from a server “farm” (Kanter, 1999.) Scalability simply requires that a system is able to
support many users at a reasonable cost, and also being able to distribute workloads to multiple users simultaneously, and ensuring customer satisfaction by handling large volumes of transactions (Hanson, 1999). One of the major advantages of thin clients is that it is easy to have additional terminal added to the existing network and the installation/upgrading of software can be performed on the central server, instead of all the thin clients. Replacing faulty units can also be done on the server alone, without any need of diagnosing faults on the clients. (Becta, 2004.)

Access – by virtue of its centralization, thin clients technology enhances the effective management of users and enhances accessibility by multiple users, such as; users in an organization’s branch offices, telecommuters, and mobile professionals, from a single location that accommodates all the application servers, file servers and databases. In view of its efficiency of processing on the server and using of network bandwidth, thin client gives room for quick responses and shares information easily.

Security – with thin client’s central management of application servers, sensitive data are well secured and the loss or stealing of a terminal cannot result in the loss of data. Moreover, updating of security programs, or applications, and monitoring of the systems for unauthorized software would be done only on the central server. Hence, users cannot add unauthorized programs and applications that could have some malicious lines of codes to the system. Also, thin client has no CD-ROMs or floppy drives, and so data cannot be copied and taken elsewhere or corrupted by systems from other places. Figure 8 below displays the thin client enabling connections to multiple users from a single-point control, with great performance and high level of security.

Access – by virtue of its centralization, thin clients technology enhances the effective management of users and enhances accessibility by multiple users, such as; users in an organization’s branch offices, telecommuters, and mobile professionals, from a single location that accommodates all the application servers, file servers and databases. In view of its efficiency of processing on the server and using of network bandwidth, thin client gives room for quick responses and shares information easily.

Security – with thin client’s central management of application servers, sensitive data are well secured and the loss or stealing of a terminal cannot result in the loss of data. Moreover, updating of security programs, or applications, and monitoring of the systems for unauthorized software would be done only on the central server. Hence, users cannot add unauthorized programs and applications that could have some malicious lines of codes to the system. Also, thin client has no CD-ROMs or floppy drives, and so data cannot be copied and taken elsewhere or corrupted by systems from other places. Figure 8 below displays the thin client enabling connections to multiple users from a single-point control, with great performance and high level of security.

![Figure 8. Thin client enabling connections to multiple users from a single-point control (Kanter, 1999).](image)

2.13. Producers of thin clients technology

Producers of thin clients technology include, but not limited to; Dell, Hewlett-Packard (HP), Huawei, ZTE, Guoguang, Start, Cloud Times, and Native Centerm, most of which are situated in China. Typical thin clients are built in diverse classes of software and hardware, and are light weighted, small sizes and low configuration technologies. CPUs (Hardware X86-base) thin clients are produced by Intel, AMD and VIA. Thin client technology may be adapted to many virtualization platforms. They are used for a variety of application needs, such as; office automation, call centre, service hall and operation and maintenance centre (Wu et al., 2013, p 1687.)

Table 1 below analyzes the differences that subsist between thin client terminal and the conventional computing systems (otherwise known as fat client).
Table 1: Showing the differences between thin client and fat client (Webopedia, 2006)

<table>
<thead>
<tr>
<th>THIN CLIENT</th>
<th>FAT CLIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>All applications are run from the terminal server, and no other programs are run locally.</td>
<td>All programs are stored and run from the local hard drive, and data is either stored locally or on the central server.</td>
</tr>
<tr>
<td>Easy to deploy as they require no extra or specialized software installation</td>
<td>More expensive to deploy and more work for IT to deploy</td>
</tr>
<tr>
<td>Needs to validate with the server after capture</td>
<td>Data verified by client, not server (immediate validation)</td>
</tr>
<tr>
<td>If the server goes down, data collection is halted as the client needs constant communication with the server</td>
<td>Only needs intermittent communication with server</td>
</tr>
<tr>
<td>Cannot be interfaced with other equipment, such as in factory settings.</td>
<td>Reduced server demands</td>
</tr>
<tr>
<td>Clients run only and exactly as specified by the server</td>
<td>Can store local files and applications</td>
</tr>
<tr>
<td>More downtime</td>
<td>Robust technology provides better uptime</td>
</tr>
<tr>
<td>Portable – all applications are on the server, so any workstation can access</td>
<td>More expensive to deploy and more works for IT to deploy</td>
</tr>
<tr>
<td>Opportunity to use older, outdated PCs as clients</td>
<td>Require more resources but less servers</td>
</tr>
<tr>
<td>Reduced security threat</td>
<td>Increased security issues</td>
</tr>
</tbody>
</table>

2.14. Advantages and disadvantages of thin client

Many companies, and other users of technology, have resolved to use thin clients because of its benefits of providing access to certain applications and functions. Moreover, the more prevalence of cloud computing makes the use of thin clients technology to be potentially significant for expansion, because of its ability to provide access to a vast number of Web-based applications. However, thin clients are not suitable for all situations. This section deals with both the advantages and disadvantages of using thin client technology in a computing environment. The section also goes further to analyze the constraints for use of thin clients in developing countries.
2.14.1 Advantages/ benefits of thin clients

Thin clients technology has numerous advantages such that it establishes its capability to provide a long lasting solution to the problem of information technology in the developing countries, especially in the business and economic sectors. Granville, Leonard and Manning (2000, p 18) declared that thin client is a cheap technology, and could meet the users’ functionality desire, suggesting that it could be developed for developing countries in order to tremendously increase consumers’ access to Internet. Below are the advantages of thin client technology:

- Costs reduction:
  i. Initial purchasing costs
  ii. Capital costs
  iii. Lower IT administration costs
  iv. Licensing costs
  v. Total administration and operating cost
  vi. Lower noise
  vii. Less Wasted Hardware

- Reduces energy bill through:
  i. Less energy consumption (power consumption of thin client is an average of 8W to 20W compared to 150W for PC). According to Balneaves et al., 2009, p.10, a study was conducted for the comparison of the energy and resource consumption of a regular PC and thin client technology. The result indicated that thin clients consume half the energy of traditional workstation. This does not only save costs, but is also ecologically effective in avoiding electronic waste and high carbon emissions.

- Thin client management benefits:
  i. All software and hardware upgrades, security policies, application changes, and other things can be made in the data centre.
  ii. Unlike the PCs, IT personnel do not have to fix individual problems at the end user desktop location
  iii. Centralized and simplified back up for desktops, laptops, and other client access devices.

- Enhanced security:
  i. Protection from the use of unauthorized software or the infection of virus
  ii. Data cannot be copied to a disk or saved to any other location than the server
  iii. Systems are easy to manage and monitor because of the centralized processing method.
  iv. Simplify security, protect intellectual property and ensure data privacy

- Increased productivity:
  i. Thin client technology can be practically preconfigured, packaged and put into operation in few minutes. Its setup is very fast and it is flexible, as it does not require special expertise.
ii. Unlike the PCs, thin client does not have a long repair time that can cause delays in operation, and it attracts very low cost of repair.

iii. Thin client access the same apps and data from virtually anywhere

iv. Less network bandwidth

v. No moving parts

vi. More efficient use of computing resources

vii. Simple hardware upgrade path (Devon IT)

2.14.2 Disadvantages of thin clients

In spite of the remarkable advantages of thin client technology, it is noteworthy that it also has its disadvantages as follows:

- **Poor multimedia performance** – Thin clients technology may not effectively process multimedia programs and graphics intensive applications; such as in video and audio. However, Winter, Simoens, and Deboosere (2006) offered a solution to this problem by proposing the development of a real-time desktop streamer that would stream the graphical output of applications to a thin client device.

- **Highly powerful PC servers required** – the server does all the processing, while thin client systems require a high level of performance from the server, hence, a very high grade server is required.

- **User resistance to change** – it is normal for users to be reluctant in changing from their familiar systems to a new idea. Conventional PC users will find it difficult to embrace thin client technology. Their inability to make use of CD, access a floppy drive, save their works on CD or floppy disk, or install personal software; as they are used to, would tend to be highly discouraging to them. Nevertheless, the long run effect brings an immense benefit to the IT staff.

- **Bandwidth limitations** – because of the fact that all processing is performed on the server, there is considerably more network traffic than in a networked PC environment. Therefore, number of users utilizing a server determines the available bandwidth for each user.

- **Lack of compatibility** - with some applications and need for improvements in thin client network management software

- **Single point-of-failure requires a full back-up server** – all the users on thin client network share the same server. This means that any failure on the server could have a significant impact on multiple end users of the system. Hence, it is essential for the server to be highly reliable. Also, there is need for the provision of back-up system or any other arrangement to resolve the problem of server failure (Landry, 2006.)
2.15 Constraints for use of thin clients in developing countries

Despite the benefits and opportunities abound in the deployment of thin client technology by the developing countries, there are some constraints standing against its adoption, such as:

- **Irregular power supply in developing countries** – power supply system is extremely irregular in developing countries. Despite the fact that thin client technology has been proven to consume low energy, there is still need for a constant power supply. Hence, a standby generating set is necessary to enhance continuous and undisturbed operation.

- **Thin client as a new technological innovation** – the current computer system that is commonly used in most of the developing countries is personal computer (PC). Thus, adopting thin client technology operation may initially be difficult. However, using this technology continuously will certainly promote skillfulness and users may possibly be acquainted with it.

- **Low level of technological proficiency in developing countries** – very few people are actually computer literates in developing countries. The knowledge of computer operation is only limited to the urban areas, while the larger population are residing in the rural areas. It is essential for the various governments in developing countries to inculcate computer programs into the syllabus of every component of academic environments in order to encourage the culture of ICT usage.

- **Government policy on ICT** – thin clients technology still involves some funds in setting it up, despite its cost effectiveness. The ICT sector is experiencing underfunding, to a large extent, by the various governments in developing countries. Most business organizations are also faced with poor economic wherewithal. This is to say that they are constrained to cope with the little available resources to accomplish their aim of possessing adequate information technology infrastructures.

2.16. Factors to consider when choosing between thin client technology and conventional computing models

It is advisable that users should check and consider some important factors when choosing between thin client technology and conventional computing models, vis-a-vis:

- **System performance** – according to Williams (2002) citing Citrix (1999), an end user determines the performance or usability of a system by its responsiveness and the perceived speed of operation when he or she is performing typical tasks. While using a thin client machine, time measurement will be determined from a user mouse click to a graphic change on the screen. Responsiveness is determined by how quickly the results of a given user action produce the resultant change in displayed graphics.

- **Costs** – this is an essential factor to reckon with when procuring a computer system. However, determining what make up costs is a problem. Does cost stop at the initial purchase of hardware and software or does it extend far
Beyond this? Below are the factors to be considered when measuring the cost of a computer system:

i. **Initial hardware costs** – which include the servers, clients, peripherals and networking

ii. **Software costs** – the clients and server licenses, and any remote client access licenses.

iii. **System development time** – this accounts for the IT labour costs. Development time would be affected if the development team is not familiar with the technology chosen or if the technology chosen is inherently more complex to implement than the other.

iv. **Upgrade cost** – the working life of a computer is somewhat short, while it is important to protect the initial capital investment. Hence, systems that can be upgraded cheaply and easily is definitely going to protect that investment much longer.

v. **Maintenance costs** – these include maintenance staff cost, repair or replacement of damaged equipment cost, and the cost incurred in loss of business of any downtime. While one type of system may require a larger inventory of spares, another may need common components or even less components. These factors are also important to be considered.

vi. **Administrative costs** – software development is a critical and regular part of Personal Computer technology, and it can be costly and time consuming. Administration costs comprise; admin staff, performance tuning and adjustments, upgrades and modifications.

vii. **Power consumption cost** – this includes the power consumption costs for the entire system. It will be converted into consumption costs as a basis for comparison with the costs of other systems.

viii. **Training costs** – the type of computer technology system chosen by an organization may determine its training budget. The development team, as well as maintenance and administrative staff may require trainings on a new technology and technical training respectively. Management staff may also require training to understand the concepts and larger picture, while operational staff may require on-the-job training. All these training costs must be included in the overall system costs (Williams, 2002.)

- **Security** – corporate security of data is also an important factor to be considered while considering the choice of a computer system. Security breaches can take various forms, which may include:
  
i. Physical theft of client and server machines
  
ii. Data theft, which include unauthorized access to the systems data, either locally by an unauthorized user into a client or server machine, or remotely from outside the organization via a dial up or internet connection.
  
iii. Virus resilience, which includes the ability of a system to resist or prevent virus infection of the data by a user, authorized or unauthorized.

- **Scalability** – this determines the ability of a system to continue to function well, even when a change in size and volume (usually adding more clients to the
system) occur in order to meet the users’ needs, and the ease with which it does so. Normally, the requirements for a system’s scalability are in respect of future expansion of the business. Hence, there is need to assess the flexibility of the hardware and software of the system.

- **Maintenance** – this includes the upgrade and modification of the hardware and software. It is essential to determine the ease with which the system can be maintained and the time taken to complete various maintenance tasks (Williams, 2002.) Figure 9 displays how a centralized server is being connected to the Internet and linked to numerous PCs serving as clients.

![Figure 9: Displaying a centralized server being connected to the Internet and linked to numerous PCs serving as clients](Campbell, 2010)

The above diagram (figure 9) indicates that many computers (known as clients) are connected to a high-powered server. The users request and receive information from the server, through the clients, while the server processes each request and delivers results to the users, through the clients. The connection between the server and the clients is established over the Internet.
3. Research method

This chapter has been used to describe, in details, the research method and methodology employed in this thesis. Research involves a process of discovering, which is capable of transforming our knowledge and understanding of the world around us (Ryan, Scapens & Theobold, 2002). Rajasekar, Philominathan and Chinnathambi (2013) defined research methods as ‘the procedures, schemes and algorithms used in research’ while defining research methodology as ‘the procedures by which researchers go about their work of describing, explaining and predicting phenomena’. Needless to say that research methodology deals with the research design, the population to be studied, and the required tools to perform the research work.

In order to achieve the aim of this research work, which is to determine the ways thin client technology can enhance information technology in the business and economic sectors of developing countries, a case study has been employed, making use of exploratory research. Gerring defined a case study as “an intensive study of a single unit for the purpose of understanding a larger class of units”. He further stated that units could be classified into formal and informal units. Formal units are said to comprise the units chosen for intensive analysis, such as; person, group, organization, country, region, etc (Gerring, 2004, pp 342-344.) Darke, Shanks, and Broadbent (1998) quoted Cavaye (1996) as saying that case study research is often used to provide evidence for generating hypothesis and exploring areas where the researcher has limited knowledge. He also reported Bendasat et al. (1987) as saying that case study has been suggested to be a suitable tool for testing theory in conducting information systems research. He concluded that information systems researchers have identified case study research as a valuable means of investigating the development, implementation and use of information systems within organizations (Darke, Shanks & Broadbent, 1998, pp. 275-276, p. 287.) Moreover, Benbasat, Goldstein, and Mead (2001) stated that case study is promising information systems research approach because; it avails the researcher to study information systems in a natural setting, gain knowledge about the state of the art, and generate theories from practice.

Exploratory research method has been described as the act of undergoing a groundwork study of a situation, looking out for new approach and creating ideas and hypothesis for new research (Runeson & Höst, 2009). It enhances knowledge acquisition of information or enables the attainment of new insight into it. Runeson and Höst (2009) acknowledged that case study research methodology is primarily meant for exploratory purposes. They went further to assert that case study is carried out in real world situations, and as such, it commands a high degree of practicality. Figure 10 below shows the process involved in exploratory research, which involves four different stages, namely; Literature search, Experience survey, Focus groups, and Analysis of selected cases. Churchill (1999) explained “Analysis of selected cases” as a type of exploratory research which is referred to as the analysis of insight-stimulating examples. The method is said to entail the painstaking study of selected cases of the event being investigated, with a recommendation of the consideration of existing records,
observation of the occurrence of the event, and conducting unstructured interview. It was further said that attention may be on individuals or institutions or group of entities. (Churchill, 1999.)

**Figure 10.** Indicating the process involved in exploratory research (Churchill, 1999)

Using Nigeria as a case study, with the adoption of exploratory research method, an in-depth study will be conducted to ascertain the ways thin client technology could enhance the usage of information technology in the country, for the purpose of understanding its applicability in other developing countries, which represents a larger class of units. Comprehensive studies of the operation of thin client technology will be performed to understudy the technological know-how of its operation, while its deficiencies, if any, will be identified, and solutions established where it is possible, or suggestions made, where needed. Adopting this method will result in having essential information concerning the economic benefits of thin client technology to the underprivileged in the ICT world. This research work is aimed at making available undemanding access to information systems by developing countries, with Nigeria as a case study.

### 3.1. Research design

Research purposes determine the research designs and analysis techniques to be adopted. Case studies are mainly based on qualitative data, which affords the researcher richer and deeper description of the subject (Runeson & Höst, 2009.) Hence, for the purpose of this study, the comprehensive approach to qualitative content analysis has been employed. This approach involves the identification and quantification of certain words or content in text with a focus to understand the contextual use of the words or content (Hsieh & Shannon, 2005, p 8). According to Hsieh and Shannon (2005), quoting Holsti (1969), a comprehensive content approach to qualitative content analysis is not limited to word counts alone, but also includes latent content analysis, which is the process of interpreting contents. This approach enhances the word frequency counts and calculation of identified words by hand or by computer, with the identification of the source. It gives room for the interpretation of the context related with the use of the word or phrase. In summative content analysis, keywords are derived from interest of the researcher or the literature review (Hsieh & Shannon, 2005.)
Unlike quantitative research method, qualitative research does not rely on statistics or numbers, rather, it reckons with case studies where the collection of information can be received from a few studying objects. According to Golafshani (2003), he quoted Strauss and Corbin (1990) as defining qualitative research as “any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification”, and also described qualitative research as the kind of research that produces findings arrived from real-world settings where the phenomenon of interest unfold naturally. Myers (1997), quoting Yin (2002) defined case study research, which is the most common qualitative method, as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. Case study research is one of the examples of qualitative methods, and qualitative data sources comprise observation, interviews, questionnaires, documents and texts, and the researcher’s impressions and reactions (Myers, 1997.) Also, according to Myers (1997), qualitative research methods assist researchers in understanding people and the social and cultural contexts within which they live. Myers also quoted Kaplan and Maxwell (1994) as saying that the goal of understanding a phenomenon from the point of view of the participants and its particular social and institutional context is largely lost when textual data are quantified.

3.2. Research reliability and validity

Regardless of how data for a research work is being collected; whether through observations, questionnaires, or interviews, the quality of research is usually being determined by the validity, reliability and trustworthiness of the research methodology and data. Reliability of a study depends on the extent of the consistency of the results and accuracy of the representation of the population under study, while validity is determined by the extent to which the study has truly measured what it was intended to measure. Although, the term validity and reliability are more often used in quantitative researches, Golafshani (2003) submitted that Stenbacka (2001) explained the concept of reliability as one of the quality concepts in qualitative research that is to be resolved if a study is to be regarded as part of proper research. He also said that Patton (2002) stated that any qualitative researcher should concern himself with validity and reliability in the process of designing a study, analyzing results and judging the quality of the study. Lietz, Langer, and Furman (2006), quoting Lincoln and Guba (1985), said that the establishment of trustworthiness entails close reflection, by the findings, of the descriptions by the participants in a qualitative research. According to Sinkovics, Penz, and Ghauri (2008), they posited that a researcher must ensure that his qualitative research is credible, dependable, transferable and confirmable, in order to establish its trustworthiness.

3.3. Research rationalization

This thesis work is targeted at establishing the ways by which ICT can be improved in the business environments, through the use of thin clients, in the developing countries of the world, using Nigeria as a case study. Literature reviews have shown the importance of ICT to business and the ease of use and affordability of thin client technology infrastructures. It is pertinent to mention that this work is a case study, using exploratory research.
3.4. Modes of data collection

Information for this exploratory research was collected from two major data sources, namely: primary and secondary data sources. Primary data are referred to as the data that are collected for the particular research problem at hand, using procedures that best fit the research problem. Needless to say that primary data are the information gathered by the researcher himself, through the use of questionnaires, interviews, observations and tests. Secondary data are data collected earlier by other researchers, which were used for other purposes than the research at hand. In order to be able to use secondary data, the researcher must identify sources that may be useful for his own research problem, be able to retrieve the relevant data, and evaluate how well the data meet the quality requirements of the research at hand (Hox & Boeije, 2005.) Secondary data includes literature, documents and articles published by other researchers and institutions. For this work, primary data has been collected in the form of questionnaire, while secondary data has been gathered through various sources, such as; scientific articles and internet sources. These secondary data have been used to compensate for the loopholes of the primary data. All sources of data used in this thesis are treated and appraised to be of high quality and the range of sources and nature of data is in agreement with the comprehensive and holistic approach this work is based on.

3.5. Process taken in administering questionnaire and survey data collection

In the first instance, volunteers for participation in administering the questionnaire were solicited by means of email system and telephone calls, after having searched for the users of thin client technology in Nigeria. A list of twenty information technology professionals, who were also using thin client technology, was compiled in order to accomplish a broad scale of information technology experts.

Once the consent of the volunteers has been secured, suitable questions to fulfil the objective of the study were prepared. These questions were made to be open-ended so as for the participants to be able to include as much information, including his/her feelings, attitudes and understanding of the topic. It would also allow researchers to better access the participants’ true feelings on the topic. This is unlike the closed-ended questions which give room for limited answers from the respondents and do not allow them to express their real feelings.

The questionnaire was designed to obtain the participants’ unbiased views and observations of their experience while using thin client technology. Twenty questionnaires were sent out to these volunteers who are users of thin clients in Nigeria, through email, out of which sixteen participants completed and returned their own. The questionnaire contained a total of thirty-seven questions, empirically addressing a number of issues of importance in ascertaining the benefits of thin clients to the developing countries. The participants were given one month, from the receipt of the questionnaire, to return their responses through the researcher’s email address.

The answers provided by the sixteen participants, who completed and returned their questionnaires, were categorized into: Age group, qualifications, nature of business, participants’ experience in the use of ICT, cost effectiveness of thin clients, scalability evaluation, Ease of use evaluation, and Performance evaluation, for the purpose of data collection and analysis. Most of the answers provided for these categories were illustrated with graphs or tables for effective analysis and thorough understanding of the
study. Answers were extracted for each of the questions, from the returned questionnaires, and were subsequently collated for the purpose of result analysis. Results were analyzed, thereafter, and deductions for the interpretation of results were made based on the analyzed results.
4. Results – questionnaire survey

This chapter deals with the analysis of the results of the administered questionnaire, and also summarizes the benefits of thin client technology.

4.1. Analysis of the results

The primary objective of this work is to determine whether thin clients technology could serve as a solution to the lingering problem of inadequate ICT usage in the developing countries, based on the fact that it is said to be a cost-effective, efficient, and high performing information technology system which is capable of providing easy access to information systems. This will be the metric that would be used to evaluate the research result.

Questionnaire has been administered for the purpose of this research work. The questionnaire has been designed to obtain the participants’ unbiased views and observations of their experience while using thin client technology. Twenty questionnaires were sent out to users of thin clients in Nigeria, through email, out of which sixteen participants completed and returned their own. The questionnaire contained a total of 37 questions, empirically addressing a number of issues of importance in ascertaining the benefits of thin clients to the developing countries. The issues addressed are being categorized into: Age group, qualifications, nature of business, participants’ experience in the use of ICT, cost effectiveness of thin clients, scalability evaluation, ease of use evaluation, and performance evaluation.

Tables 2 and 3 have been used to analyze the age distributions and academic qualification distributions respectively. Out of the 16 participants, 15 were male while only one was a female.

*Table2.* Tabulating the age distributions of the participants

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 -20</td>
<td>1</td>
</tr>
<tr>
<td>21- 30</td>
<td>8</td>
</tr>
<tr>
<td>31-40</td>
<td>6</td>
</tr>
<tr>
<td>41 and above</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
</tr>
</tbody>
</table>
The age distribution of the participants shows that only one participant falls within the age group of 10-20 years, eight participants fall within 21-30 years of age, six participants within 31-40 years, while one falls within 41 years and above. This is an indication that the usage and development of ICT in developing countries is being dominated by the age group of the youths in those countries.

1. What is your academic qualification?

<table>
<thead>
<tr>
<th>Qualifications</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary education</td>
<td></td>
</tr>
<tr>
<td>Secondary education</td>
<td>5</td>
</tr>
<tr>
<td>Ordinary national diploma</td>
<td>5</td>
</tr>
<tr>
<td>Higher national diploma</td>
<td>3</td>
</tr>
<tr>
<td>Bachelors degree</td>
<td>2</td>
</tr>
<tr>
<td>Masters degree or higher</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
</tr>
</tbody>
</table>

The academic qualification distribution indicates that the highest categories of participants posses only secondary school certificate and Ordinary National Certificate (OND), with five participants each, Higher National Diploma (HND) having three participants, two participants with Bachelors degree, while only one participant possesses Master’s degree certificate. This indicates that the acquisition of ICT knowledge in the developing countries is still being viewed more as a vocational study than an academic exercise. The nature of business distribution indicates that only six participants have information technology as their majors businesses, while the remaining ten participants are engaged in other business services, such as; sales, marketing, facility management, etc. The implication is that virtually every field of business will require the use of ICT for sustainability in this global modern business environment. The position in organization distribution shows that the majority of the participants are the owners of their businesses (Directors) with nine participants, while five participants were management staff, and only two were junior staff. Out of the participants, eight of them posses 5-10 years of ICT experience, six participants posses 2-5 years, while only two participants posses 10-15 years of experience. This indicates that the awareness and development of ICT is still very recent in the developing countries.

Below are the questions asked in respect of the various categorized issues to ascertain the benefits of thin client technology to developing countries of the world. In view of the qualitative method adopted in this work, open-ended questions were asked to give the participants enough room to express their minds as regards the use of thin client technology infrastructure. The following questions were designed to ascertain the fact...
that the participants are well-experienced in the use of information technology infrastructures. The whole of the 16 participants responded to this question, eight of them posses 5-10 years of ICT experience, six participants posses 2-5 years, while only two participants posses 10-15 years of experience. This indicates that the awareness and development of ICT is still very recent in the developing countries. Out of the 16 respondents, three participants assert that the use of ICT has really been very informative, as it enhances their knowledge in new innovations, data sharing, security, and social media, and has allowed seamless working between communities and the global environment. 12 participants stated that ICT has improved their knowledge in software, hardware, operating system and peripheral installations/repairs, networking and website creation and development, and that it has made communications very easy through email, mobile devices and virtual communications. One participant affirmed that ICT has really enhanced his relevance in business and made him offer superior services to his clients.

Subject 1 - “My experience in ICT has been really educative, informative and interesting to mention a few. Its impact in new innovations, data sharing, security, and social media has really transformed my life and many others, and has allowed seamless working between communities and worldwide”.

- Importance of ICT to businesses in Nigeria

The following questions were asked to determine the importance of ICT to various businesses in Nigeria, and by extension, the developing countries.

1) Can you tell us the importance of ICT to your business?

Five participants declared that ICT is very important to their businesses considering the nature of their businesses as graphic designers and mini cyber café owners. They pointed out that the essentiality of ICT in every business cannot be overemphasized. Ten participants affirmed that ICT plays an important role in today’s business world, as it makes business easier to execute with clients, suppliers, and distributors. They said that access to ICT increases productivity, and as such, it cannot be separated with our daily needs. One participant claims that the use of ICT enables us gain access to various important information worldwide.

Subject 2 - “ICT is very essential in almost every business, from SME’s to large organizations, and to my business it is very important because it creates room for file and printer sharing, internet access, software usage and its security. And all these are very for me simply because I manage a graphic designing venture and also complemented with a mini cyber café”.

2) What features do you feel are necessary in a technology to be adopted to enhance successful operation?

Five participants suggested that speed, cost effectiveness, efficiency, space, power and reliability are necessary ingredients for a technology to be adopted, while two participants mentioned that good networking infrastructure and Host server (CPU) with high RAM are necessary for a technology to be adopted, and the remaining nine participants submitted that adequate budgeting for ICT, standard power availability, high level of ICT skills and standard facilities are required for ICT adoption.
3) **Do you feel thin clients technology possesses these necessary features?**

All the 16 participants agreed that thin clients technology possesses all the features necessary in a technology to be adopted to enhance successful operation.

- **Problem of low rate of ICT in Nigeria**

1) **In your opinion, what factors are responsible for low rate of ICT adoption and usage for companies in Nigeria?**

Out of the 16 participants, one participant declared that the low rate of ICT adoption in Nigeria is caused by high cost of acquisition and low level of technology appreciation, while five participants said that the low adoption is a product of factors like; inadequate capital, erratic power supply, inadequate infrastructure, weather, and poor governance. Two participants pointed that the problem is brought about by lack of awareness, while the remaining eight participants said that the problem is due to lack of commitment by institutional management in companies, lack of adequate budget for ICT in companies, erratic power supply in companies, low level ICT skills in companies, low level of staff with ICT skills in companies, low level of education and training on ICT in companies, inadequate telecommunication facility in companies, poor level of computer literacy among companies, poor level of computer facilities among companies, poor level of awareness of internet facilities among companies, and poor information on ICT.

**Subject 3 - “factors responsible for low rate of ICT adoption and usage in Nigeria:”**

- *Lack of commitment by institutional management in Companies*
- *Lack of adequate budget for ICT in Companies*
- *Erratic power supply in Companies*
- *Low level ICT skills in Companies*
- *Low level of Staff with ICT skills in Companies*
- *Low level of education and training on ICT in Companies*
- *Inadequate telecommunication facility in companies*
- *Poor level of computer literacy among Companies*
- *Poor level of computer facilities among Companies*
- *Poor level of awareness of internet facilities among companies*
- *Poor information on ICT”*

- **Participants’ experience in using thin clients technology**

1) **How long have you been using thin clients?**

According to the information gathered from the participants, six of them have been using thin clients for four years, nine of them for 5 years, while one has been using it for 6 years.
2) **Can you tell me about when your interest in thin clients first began, please?**

Out of the 16 participants, eight of the participants said that their interest in thin clients arose when they started learning about software and computer engineering, while seven of them said that thin clients technology was introduced to them by their friends abroad, and one participant said that he developed interest after his visit to a cyber café, with his boss who happens to be a supplier/technician, for installation. He was impressed by its shape, size, speed, power consumption, and operation.

3) **What do most people around here think of your services with your use of thin clients?**

Majority of the 16 participants submitted that people around them are excited and they see thin client as a very good technology to use, while some said their clients see thin client as an excellent technology which speed and efficiency is superb.

- **Impact of thin clients on Infrastructures and network related problems**

1) **What is the impact of thin client on infrastructure and network related problems, such as; access to Internet, logging on to the server, and ease of printing?**

Out of the 16 participants, 15 of them responded to this question. All the 15 respondents agreed that thin clients technology has brought about solution to the problem of access to Internet. They declared that it is very easy to log in to the server, and that printing from the client is very fast, easy and efficient, since the printer is connected to the centralized server and the server shares printer with the clients easily.

- **Cost effectiveness of thin clients technology**

1) **What are the perceived benefits your company experience by using thin clients instead of fat clients?**

The common and major benefits, as stated by all the participants, are; cost effectiveness, low power consumption, low space consumption, speed and high rate of accessibility, and easy administration and centralized management system. Whereas, some went further to mention that thin client technology tends to eliminate multiple software installations, reduces maintenance and repair costs, and it is highly secured due to its data centralization. Data cannot be deleted, stolen or lost when the terminal is damaged or stolen or unwanted programs are downloaded to desktop.

*Subject 4 - As indicated by one of the respondents, he stated the benefits of thin clients by his company to include:*

“Centralized management, support and control lower support costs."
Higher security at the desk as desktop can be “locked down” – data cannot be deleted, stolen or lost when the terminal is damaged or stolen or unwanted programs downloaded to desktop

Easier and cheaper software upgrades as this happens only on the server

Better and easier software license management as this is centralized on server only

Easy and after installation of clients requiring simple plug into network and switch on

According to Wyse (which has a whole lot of whitepapers in support of thin clients), teachers adapt better to thin clients because of their simple “plug –in and switch on” operation

Eliminates multiple software versions, compatibility issues hence reducing costs

No software and hardware debugging for new software deployments

Consistent look and feel of desktop makes it easier for students and teachers to use from one terminal to another

According to Becta, energy saving because of lowers energy requirements of terminals

Teachers can better control employ access to information

Old computers can be salvaged and put to use with newer applications

Purchase price of thin clients is lower because requires high speed.

Installation costs - the higher for thin clients because required high speed and no need to install software on clients

Maintenance and support- maintenance for thin clients is very low cost, MTBF for thin clients is longer thereby saving on maintenance and repair costs.

Less power: thin clients use up less power, generate less heat and therefore are cheaper to run in the longer term

Thin clients don’t need to be replaced as often as fat clients since they can survive software advancements”.

2) What is your opinion about the hardware costs of thin clients when compared with the cost of fat clients?

Out of the 16 participants, 15 of them responded to this question. All the 15 respondents agreed that hardware costs of thin clients are cheaper than the hardware costs of fat clients. Four of them mentioned further that, although, the server in thin client must be robust enough to handle several client session at once, the hardware requirements are minimal to that of fat client, as most thin clients have low energy processors, flash storage, and memory. One respondent also pointed out that if there is anything to be replaced in thin client hardware, it is the power pack, which could even be avoided if there is constant power supply.
• **Energy consumption of thin clients**

1) **What is the effect of your thin client technology on your power consumption?**

15 participants also responded to this question, and all of them considered it to be cost effective, as they agreed that thin client technology consumes less power and generates less heat; and so, it could be operated for a longer period of time, when compared with fat clients. One respondent pointed out that thin client 5 watts while fat client consumes 200 watts of electricity, thereby, saving 195 watts on each terminal of thin clients.

• **Scalability evaluation**

1) **What model of thin clients do you use?**

All the 16 participants responded to this question. One participant said he uses both Thin Station N380, which runs on win ce, and Sunde H4, which runs on Linux embedded Operating System. Six participants said they use ViewSonic SD-T225, while the remaining nine participants make use of HP (HP T210, HP T410, HP AiO) and/or Dell model of thin clients.

2) **How many clients ‘notes’ did you start with?**

Only two participants started with 2 clients, while five of them started with 10, two of them started with 15, two of them started with 17 and five started with 20 clients.

3) **How many clients are you using currently?**

All the participants have successfully increased the number of their clients’ terminals. While the two respondents originally using 2 clients have increased the numbers to 5 and 6 respectively, four participants have increased to 15, seven participants have increased to 24, one participant has increased to 21 and two have increased to 30 client terminals respectively. One of them said he has successfully set up 800 thin clients, for himself and other customers, till date.

4) **Do you find it easy to increase the number of client computers you use without any negative effect on the thin client’s efficiency?**

All the 16 participants responded in affirmative that they found it easy to increase the number of client computers without any negative effect on the thin client’s efficiency.

*Subject 5 -* One of the participants simply said “Yes, the integration of additional thin client work stations has always been easy “.

• **Security evaluation**

1) **How effective is the issue of security (unauthorized access) of the thin client system?**

15 out of 16 participants responded to this question. While 11 respondents are of the opinion that thin clients technology is highly secured, two respondents said that the issue of security depends, mainly on the person handling the Host Server configuration, and the remaining two said that thin clients security depends on how the external software (antivirus) are being installed on the system.

*Subject 6 -* According to one of the respondents “Thin client is highly and very security to use in companies”.

2) **If a thin client is stolen, what impact will it have on your business as regards the files on the system?**

Also, 15 out of 16 participants responded to this question. All of them agreed that there will be no adverse effect on the business, if a thin client is stolen. This is because all files are stored on the central server, while thin clients are just virtual boxes which have no storage facilities.

*Subject 7 - One of the participants claimed that “If my thin client is stolen it have no impact to my business as regards the files on the system because Higher security desktop Computer Server can be “locked down” – data cannot be deleted, stolen or lost when the terminal is damaged or stolen or unwanted programs downloaded to desktop Computer Server”.*

- **Ease of use evaluation**

1) **With the use of thin clients, what is your opinion about your current distribution of time and resources across these three areas of responsibilities: Set-up and maintenance, troubleshooting, and effective integration?**

There were 15 respondents to this question. All of them agreed that thin client is easy to set-up and maintain because of its low cost price and low power consumption. They also said that there is little or no troubleshooting that will be required in thin client because of the fact that the major work is being carried out on the server. Likewise, effective integration is high in thin client and it is faster when using program application software. According to them, faults are easily detected, so less time and resources are consumed. One of them further stated specifically that there is 90% reduction on maintenance cost as compared to fat client, 90% savings on power consumption, 60% savings on cost of computer CPU box price, and also space saving, as it can be mounted behind any LED/LCD screen or on any wall or table.

2) **Do you consider the development time of thin client to be shorter or longer when compared with fat client development time?**

All the 16 participants responded in the affirmative that the development time of thin client is apparently shorter than the development time in fat client.

3) **In your own view, how easy is it to develop a thin client system?**

Out of the 16 participants, seven of them said that the development of thin client is not an easy task, while two of them just said it is easy, and the remaining seven said it is very easy to develop.

- **Performance evaluation**

1) **Do you use thin client network to communicate beyond your office?**

15 out of the 16 participants responded to this question. While ten of the respondents said they make use of thin client network to communicate beyond their offices, through the Internet, the remaining five said that they do not use it, except when they are in their offices.
2) **How do you consider the reliability of using thin client system?**

Also, 15 out of the 16 participants responded to this question. One respondent said that using thin client system is very efficient, ten of them said it is reliable, easy to know and understand, and the remaining four said that using thin client could only be said to be very reliable, and considered as a very good technological medium, where there is adequate computing facilities, while it is not so in countries lacking in these facilities.

3) **What is your opinion about the overall response time of thin client system (from a user mouse click to a graphic change on the screen)?**

Out of the 15 respondents to this question, one submitted that the overall response time of thin client is very fast; seven respondents said it does not take much time, depending on the configuration, while the remaining seven respondents pointed out that it is not easy to work on graphics when using thin clients.

4) **What do you get from using thin client that you could not get from fat clients?**

Only 15 participants responded to this question. All of them agreed that thin clients technology is easier and cheaper to maintain, as it cost less, consumes less power, portable (which makes it take less space) and very efficient. They further said that they enjoy the privilege of using cheaper software upgrade, and software management because of the centralization. One of the respondents mentioned that thin clients will bring about development in technological know-how of all countries.

*Subject 8 - One of the respondents simply said “Portability, low power consumption, low cost of maintenance, to mention a few”.*

- **Other benefits**

1) **Of what economic benefit is the use of thin client technology to your organization?**

15 out of 16 participants responded to this question. They all agreed that thin client reduces the Total Cost of Ownership (TCO). They said that it reduces cost of consumables, unlike fat clients where you have to change memory cards, big power packs, processors, expansion cards and some other things. All these, they said, lead to less financial impact and low rate of financial maintenance.

2) **What is the impact of thin client infrastructure on your technology staff’s workload?**

15 out of 16 participants responded to this question. They all agreed that thin client has enhanced the centralization of their staff workload documents on the main server. They said it has made the staff work together as a unit, and they do little running and minimized troubleshooting.
3) **What is the impact of thin client environment upon network administration tasks?**

There are 15 responses for this particular question. While 14 of them said that thin clients has made network administration very easy, because of the fact that it is possible to monitor every operation on the other users’ desk from the central server (e.g. monitoring the screen, sending of messages to the clients, etc), the remaining one person said that in spite of the fact that thin client has a great impact on network administration tasks, there is no much difference in the setup of networking in thin clients and fat clients, just that they work in much different ways.

4) **What is the impact of thin client infrastructure on the use and management of peripherals, such as; printers, scanners, etc.?**

There are also 15 respondents to this question. All of them agreed that printing, scanning, faxing, photocopying, etc on thin clients’ network has really been easy. Five of the respondents further pointed out that the installation of these peripherals cannot be done directly on the thin clients, but on the server desktop administrator, from where they can be automatically accessed by any terminal on the same network. However, keyboard and mouse can be easily installed on a thin client USB port or through wireless.

5) **Are you satisfied with the effectiveness and timeliness of technical support?**

There are also 15 respondents to this question. While ten of them said that they are satisfied with the effectiveness and timeliness of technical support, the remaining five respondents said they are not satisfied because they barely get support from the official manufacturers in Nigeria. They only have to troubleshoot with a given sample or with their past hardware and software experiences.

- **Participants’ general opinion**

1) **What is your general opinion about using thin client technology in the developing countries?**

There are also 15 respondents to this question. While all of them agreed that thin clients technology is good for business, office use, and school development, five of them further pointed out that it will strengthen technological development of the countries, and bring about development in computer engineering in the universities of those countries. Moreover, two of them further said that thin clients technology, if adopted, will save more cost on the long run, because it does not require changing of memory or hard disk, does not generate heat, consumes less power, and does not need servicing, except the host server.

*Subject 9 - One of the participants simply said “It will bring inherent in information communication technology Thin client will bring about educational institutions equipped to provide new basic training modern life. Thin client will strength technology development to all countries. Thin client will bring about development in computer engineering in universities in all countries”.*
4.2. Summary of thin clients benefits

In summary, the benefits that can be extracted from both the literature review and the case study are as follows:

- **Reduced cost of hardware deployment and management** – normally, PC hardware is projected to be upgraded in estimation of every 3 years after purchase. However, thin clients allow old PCs to be used as clients until they die. Moreover, all upgrades of hardware are performed on the centralized server, thus, only one IT personnel will be needed to fix individual problems at the end user desktop location, unlike the fat clients. This result in saving a lot of money that could have been expended on replacement of hardware, by the organization, over several years. The cost of recruiting many IT personnel is also saved by the organization. This will be beneficial for developing countries, which have been said to have inadequate financial means to acquire needed IT infrastructures.

- **Reduced cost of software installations and maintenance** – also, all software installations, updating and removal are performed on the centralized server. Moreover, monitoring of disk space, memory and processor usages is a lot easier and cheaper on one centralized server, as it obtains in thin clients, than having to check many computers, as it obtains in fat clients.

- **Reduced cost of software distribution** – new software and upgrades can be speedily set up in thin clients than in fat clients. Hence, only few IT staff are required to track and ensure successful distribution.

- **Reduced total administration and operating costs** – upgrading a fat client requires using manual and on-site support staff to manage all desktop devices. Whereas, thin client upgrading requires few IT staff to perform. Software Update, for hundreds or thousands of thin clients, can be automated and managed remotely, from the server. Also, technical support and help desk administration can be performed through management software tools, which allow administrators to monitor users’ desktop remotely, or even take over the user’s mouse and keyboard functions to accelerate the support process. This reduces training costs and salary obligations.

- **Reduced energy bill through less energy consumption** - thin client devices need just about 10% of the power required to run PCs. Thus, it saves organization a lot of money that could have been expended on paying for energy consumption. Energy/power saving is an important issue, particularly in developing countries, where there is irregular power supply, and persistent increase in the cost of energy. Thin clients use less power/energy than fat clients. Considering the prevalent situation of irregular power supply in the developing countries, thin client technology will, obviously, be a perfect solution to the problem of ICT in these countries because of its low consumption of energy.

- **High level of security as data maintained centrally** – thin client has no facility for local storage as it is obtainable in fat client. It stores on the centralized server, and so, disk cannot be corrupted. Also, there is no data loss in thin client environment. Furthermore, the security of the network in thin client can be enhanced by adding levels of encryption to the network data. It is possible for users to carry out any work on thin client remotely from the office environment through a dial-up connection. Moreover, data backup/reinstallation is carried out only on the central server, as all data in a thin client environment is stored in one
place. This saves the cost of having to perform these functions on each PC as it is obtainable in fat client. Additionally, the incapability of thin client to establish data locally has enormously reduced its attraction to viruses. Also, thin client devices are not as visible and attractive as PCs, so, they are not prone to theft. This is because thin clients are worthless until they are connected to the correct environment. Even where they are being stolen, no data will be lost because all files are stored on the central server.

- **Environmental costs savings** - using thin client results in less carbon impact, due to the fact that it generates less heat. It also enhances less electronic waste outputs, since there are fewer parts to replace. Moreover, less complexity involved in slim PC manufacture reduces costs from the point of production at the supplier’s chain. It also cuts down the associated costs of transport from producer to distributors and to retailers due to the PC’s compact dimension which is only a fifth of a regular PC. This results in reduction in the required numbers of infrastructures in transport.

- **Centralized usage tracking and capacity planning** - thin client guarantees a firm management of data technology, since it is designed to store information on the server. These results in cost reduction and the reduction of the security-related issues, as there are only few things to monitor.

- **Simplified security, protect intellectual property and ensure data privacy** – thin clients are protected from unauthorized software and viruses. It ensures data privacy, since data cannot be copied to a disk or saved to any other location than the server.

- **Increased productivity through more efficient use of computing resources** – client computing enhances efficient allocation of IT expertise, and increased productivity from highly available applications and infrastructures. Set up of thin clients is very fast and flexible, requiring no special staff. Also, thin clients have short repair time, and so, it does not cause delays, and reduce costs of repair. It is also possible to access the same application and data from virtually anywhere.
5. Discussion, conclusions and limitations of study

5.1. Discussion

The objective of this study was to provide answers to the research questions of the thesis work. The study, which was performed with the administration of questionnaire, had 37 questions for the purpose of gathering the primary data. Thereafter, the gathered data was analyzed using qualitative method. Case study research was adopted for the purpose of this work, using qualitative methods, through the administration of questionnaires. During the course of this study, 20 questionnaires containing 37 questions were sent out to participants in Nigeria, while only 16 of them responded. These participants are majoring in business and ICT sectors of the economy. The questionnaires were used to establish the inadequacies in the use of information technology in developing countries; using Nigeria as a case study, and to ascertain the reasons behind the low level of its adoption in their business/economic environments.

The results of the qualitative analysis of the survey data (questionnaire) and the literature review have confirmed that the essentiality of information and communication technology in the development of business, and all other facets of life, cannot be overemphasized in this present world. According to Torres-Coronas et al. (2010), information technology promotes knowledge sharing, and the importance of knowledge in economic/business development cannot be overemphasized. This has geared the interest of various governments, companies and educational institutions towards a networked society. Also, Jun (2005, p. 904) posited that every technological revolution has always given birth to new opportunities, and Internet has not been an exemption with its radical effect on business and commerce. He further stated that organizations are now employing electronic tools to realize enormous gains, appreciating the fact that selling goods, supplies and services through the use of ICT provides new ways of finding customers, managing relationships and improving sales.

It has also been established that the developing countries, using Nigeria as a case study, are really lagging behind in the use of ICT, thereby giving them setback in their business and economic development. Ogunsola and Aboyade (2005, p. 7), described ICT as a technology that could be used in sharing, distributing, and gathering of information, and communicating through computers and computer networks. However, in spite of the fact that ICT is known to promote personal relationships, through the use of Internet, it has been a mirage in the developing countries, as the larger sectors of the population do not own a personal computer and/or Internet access (Baron & Gomez, 2012.)

This study has been embarked upon to discover an affordable and effective information technology infrastructure that could bring succor to the protracted problem of information technology adoption in these developing countries of the world, in order to enhance their active participation in the business world. This study has shown that it is possible to obtain the benefits of reduced total cost of ownership, technology ease-of-use, and highly performing information technology, by employing thin client technology. Doyle et al. (2009) claimed that thin client, as a technology, is endowed
with series of financial, technical and administrative benefits. This was manifested in their article ‘Case Studies in Thin Client Acceptance’. They further stated that thin clients technology provides users with the opportunity to access centralized resources using full graphical desktops from remotely located, low cost, stateless devices. Baratto et al. (2005, p. 1) also submitted that thin client technology provides the required solution to the problem of management and security, among others, that is confronting users of personal computers. It promotes centralized, secure and easy-to-maintain computing approach. The scalability of thin client technology in a real-world installation, to economic environment, is also not in doubt. Scalability results in reduction in the cost of expansion, where such expansion is required by an organization. It is, therefore, in order to say that all the benefits of this technology will bring solace to the developing countries which have been constrained because of the excessive cost of technological facilities, and which power generation is at low rate. It will serve as a great opportunity for them to be part of the modern information technology world, as it is not only cheap to set up, but also cheap to maintain. This is to say that the technology will be economically beneficial to the developing countries, if it is eventually adopted.

5.2. Conclusions

This study has been conducted to ascertain the truism of thin client technology being cost effective, high performing, and of high security, and to confirm whether the technology can enhance information technology in the business and economic sectors of developing countries, using Nigeria as a case study. Literature review has revealed the fact that thin client had originally existed in main frame computing, but almost went outdated in the 1980s when personal computers were introduced. Its strong re-emergence since the middle of 1990s was primarily due to its quality of having total cost of ownership and low cost of maintenance. This study further described the general characteristics of thin client technology in terms of hardware, software, and performance. It also discussed the different operating system platforms used in thin clients, vis-à-vis Linux-based OS, Windows-XP Embedded and Windows-CE based thin clients. This study dealt with the background information of thin client technology, appraising both the advantages and disadvantages related to thin clients. The fundamental advantages discussed are; cost reduction, reduced energy consumption, easy management of software and hardware, enhanced security, increasing productivity, and scalability of thin client technology. The possible disadvantages include; multimedia performance deficiencies, single point of failure, user resistance to change, bandwidth limitation and high powerful servers required. This study also mentioned the different producers of thin client technology, which include, but not limited to; Dell, Hewlett-Packard (HP), Huawei, ZTE, Guoguang, Start, Cloud Times, and Native Centerm. Going by the information gathered during the literature review for this study, it is right to say that thin clients technology may be adapted to many virtualization platforms. During the course of this study, questionnaire, containing 37 questions, was also administered in the case study, to obtain primary data. Fundamental questions were asked from the selected users of the technology in Nigeria, which was used as the case study. While 20 questionnaires were sent out to users of the technology, in Nigeria, only 16 of them were returned. Considering the responses from the participants, it is apparent that the technology had a very high user acceptance as a viable alternative for fat clients, which acquisition has been said to be highly expensive, or absolutely unaffordable, for majority of the intending and/or prospective users of information technology in developing countries. The study has shown, through the literature review and the survey questionnaire conducted, that with the adoption of thin clients technology, not only
significant cost efficiencies can be achieved, but also savings in many other areas within information technology and business process, such as; deployment management, security management and data protection management. Moreover, there are good reasons to believe that a number of opportunities abound if thin clients technology is adopted by the developing countries, majorly leading to very significant cost savings, creating efficiencies, enhanced ease-of-use of information technology, and improved services to business customers. Considering the fact that acquiring ICT infrastructures for use in business are too expensive in terms of both the initial purchase and subsequent maintenance costs, due to the economic situations of most business organizations in developing countries, the ideal technology required by the developing countries is a technology that is cost effective, efficient, high performing, and of high security, and the technology that is capable of enhancing information technology in the business and economic sectors of developing countries. Going by the revelations of findings in this study, it is apparent that thin client technology possesses the ability to meet all the above stated qualities in the enhancement of information technology in today’s world business economy, particularly in developing countries. Therefore, it is my utmost conclusion that thin clients technology is the ideal solution to the lingering problems of ICT in the developing countries' business and economic sectors, to ease the problem of development brought about by inadequate provision of information technology system. If thin clients technology is adopted, people will have to spend little and affordable amount to secure access to information needed for the development of their businesses and/or economies. Thin clients technology will promote the use of Internet facilities, and this will enhance access, not only to useful business information and opportunities, but also to academic resources for the students, teachers and researchers.

5.3. Limitations of study

Although, this thesis work has achieved its objectives, there were some inevitable limitations. First, case studies are difficult to generalize in the conventional sense, as they cannot be regarded as being typical. As a case study, there is no way we can know, empirically, to what extent Nigeria is similar or different from other developing countries, in the context of ICT usage. Moreover, in view of the fact that the sample is small and peculiar to Nigeria, and because data is predominantly non-numerical, there is no way to establish the probability that the data represent a larger population. Second, due to time and resource constraints, a limited number of questionnaires were administered. More questionnaires would have enabled to cover more organizations, and the possibility to generalize the findings of this study would have been greater. Third, quotes were only drawn from a small number of participants. Much of what was written by the participants, in the questionnaires, could not be published. It is possible to find other issues and aspects of these questionnaires that will be as interesting and important as those that were chosen for analysis. Lastly, a case study research allows the researcher to determine what questions to ask, and how to ask them, what to observe and what to record. Thus, case study researchers make decisions on the significance of the data, and this makes them the primary determinant of the quality of the research work. No matter how rigorous a case study research attempts to be, the research cannot be said to be completely objective, and all the judgments made cannot be easily claimed to be transparent.
6. Research implication/ future work

6.1. Research implication

The study will be beneficial to both users of information technology, in developing countries, and the scientific community. For the users in developing countries, this study will avail them the opportunity of discovering a cost-effective and efficient information technology infrastructure, that could make them compete with the developed community. On the other hand, for the scientific community, the review will enable researchers to identify the challenges in the use of thin clients and establish ways of overcoming same, for effective use of the technology in the business and economic environments.

6.2. Future work

The distinctiveness of this research work in developing countries, as revealed by the information gathered on the Internet, from other research works, is an indication that there is need for further research. This research suggests possible implications for further research. For instance, since this work is based on only the business sectors in developing countries, there is need for further research for ICT to be promoted in other sectors of the countries’ economy. This is because of the variations in the rationales behind using ICT in the various sectors.

Moreover, it is necessary to establish common understanding among the users of technology in the various sectors. This is crucial in order to fashion out meaningful interdisciplinary research structures and models. If not, the research approaches will continue to be divided and benefits of multiple discipline research works will not be achieved. This also, has acknowledged the need for further research.

Finally, the exclusive purpose of this research work is to provide a lasting solution to the lingering problem of ICT in developing countries’ business sectors. Since thin client technology is not the only technology that can be adopted for this purpose, there is room for future research on a technology that could even be more effective and cheaper to use than thin client technology.
References


Appendix - administered questionnaire

The Benefits of Thin Clients to Business Organizations in Developing Countries “A Case Study of Nigeria”

This questionnaire is being administered in partial fulfillment of the requirements for the award of my Masters Degree in Information Processing Science. It is aimed at establishing the benefits of Thin Clients technology to business organizations in developing countries, using Nigeria as a case study.

Your response will be highly appreciated, as a professional in the use of thin client technology. I am seeking to understand the opinion of thin client technology users in Nigeria. The confidentiality of all your answers here is highly guaranteed. No identifying information will be provided for public consumption. The questionnaire will be reported in a summary version only, and will not disclose the identity of any participant.

Thank you for your time.

This questionnaire will take about 30 minutes to complete.

Please, print/ download and complete this questionnaire on or before 10th February, 2016. You can return same to me by email.

I look forward to receiving your response in due course.

Yours sincerely,

Akintunde Rasheed.
Consent: I have read and understood the above information, and I willingly consent to participate in this study. I understand that if I should have any questions about my rights as regards this research work, I can contact the Researcher, Mr. Akintunde Rasheed, by email (bolu4life@yahoo.com).

Name…………………………………………………………………………………………

Business Address…………………………………………………………………………

Gender……………………………………………………………………………………

Age…………………………………………………………………………………………

Phone……………………………………………………………………………………

Email……………………………………………………………………………………

Survey questions

2. What is your academic qualification?
   - Primary education
   - Secondary education
   - Ordinary National Diploma
   - Higher National Diploma
   - Bachelors
   - Masters or higher

3. What is your position in the organization?
   - Junior staff
   - Supervisor
   - Management staff
   - Director
4. How long have you been in the employ of the organization?
   - Less than 2 years
   - 2-5 years
   - 5-10 years
   - 10-15 years
   - 15 years and above

5. What is the nature of your business?
   - Business services
   - Information technology
   - Financing and Insurance
   - Manufacturing
   - Wholesale/Retail trade
   - Agriculture
   - Real Estate
   - Transport
   - Others

6. How many years of experience do you have in ICT, please?
   - Less than 2 years
   - 2-5 years
   - 5-10 years
   - 10-15 years
   - 15 years and above

7. Can you tell me about your experience in ICT, please?
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
8. Can you tell us the importance of ICT to your business?

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

9. In your opinion, what factors are responsible for low rate of ICT adoption and usage for companies in Nigeria?
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

10. What are the perceived benefits your company experience by using thin clients instead of fat clients?
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

11. How long have you been using thin clients?
........................................................................................................................................
........................................................................................................................................

12. Can you tell me about when your interest in thin clients first began, please?
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

13. What model of thin clients do you use?
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

14. How many clients ‘notes’ did you start with?
........................................................................................................................................
........................................................................................................................................

15. How many clients are you using currently?
........................................................................................................................................
16. What has been your experience about thin clients since you have been using it?

17. What do most people around here think of your services with your use of thin clients?

18. What features do you feel are necessary in a technology to be adopted to enhance successful operation?

19. Do you feel thin clients technology possesses these necessary features?

20. With the use of thin clients, what is your opinion about your current distribution of time and resources across these three areas of responsibilities: Set-up and maintenance, troubleshooting, and effective integration?

21. In your own view, how easy is it to develop a thin client system?
22. Do you consider the development time of thin client to be shorter or longer when compared with fat client development time?

23. What is the effect of your thin client technology on your power consumption?

24. Of what economic benefit is the use of thin client technology to your organization?

25. What is the impact of thin client infrastructure on your technology staff’s workload?

26. What is the impact of thin client environment upon network administration tasks?

27. What is the impact of thin client infrastructure on the use and management of peripherals, such as; printers, scanners, etc.?
28. What is your opinion about the hardware costs of thin clients when compared with the cost of fat clients?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

29. Do you find it easy to increase the number of client computers you use without any negative effect on the thin client’s efficiency?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

30. Are you satisfied with the effectiveness and timeliness of technical support?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

31. What is the impact of thin client on infrastructure and network related problems, such as; access to Internet, logging on to the server, and ease of printing?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

32. Do you use thin client network to communicate beyond your office?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

33. How do you consider the reliability of using thin client system?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
34. What is your opinion about the overall response time of thin client system (from a user mouse click to a graphic change on the screen)?

35. How effective is the issue of security (unauthorized access) of the thin client system?

36. If a thin client is stolen, what impact will it have on your business as regards the files on the system?

37. What do you get from using thin client that you could not get from fat clients?

38. What is your general opinion about using thin client technology in the developing countries?

Thank you for your cooperation!