DESIGN AND MODELLING OF VOICE over INTERNET PROTOCOL (VoIP) ON A POINT TO POINT

BY

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2006/24386EE

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NOVEMBER, 2010.

DEDICATION

This Project work is dedicated to the Almighty God whom in his infinite mercies and grace has seen me through my academic pursuit for the past five years as an undergraduate student.

I also dedicate this project work to my wonderful parents Chief MarkAnthony I.K Nzomiwu & Late Mrs. Georgina N. Nzomiwu whom in their combined effort, love, care and tremendous support has made the programme a success.

My dedication also extends to Lady Uju Osuigwe, my sister MaryJane Kaosoluchukwu and my brother Valentine ChukwuNonso for their encouragement, marvelous advice and support.

DECLARATION

I, NZOMIWU CHRISTOPHER ONYEKACHUKWU declare that this work was done by me and has never been presented elsewhere for the award of a degree in Bachelor of Engineering (B. Eng). Information derived from published and unpublished work has been duly acknowledged. I also hereby relinquish the copyright to the Federal University of Technology, Minna, Niger state.

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ACKNOWLEDGEMENT

I give profound gratitude to the Almighty God whom in his infinite mercies, strength and grace has seen me through in my academic pursuit as an undergraduate. I am also grateful for the moral and financial support from my parents Chief MarkAnthony I.K & Late Mrs. Georgina N Nzomiwu and Lady Uju Osuigwe.

My gratitude also extends to the head of department Engr. Raji A.G, my supervisor, Mr. J.G Ambafi and my co-assessor, Mr. Bukola Olawuyi for their technical support and constructive criticism through which I was able to achieve the required result on this project. Their unwavering interest and the time they always spend with us going through the manifest. My gratitude also goes to the entire staff of Electrical/Electronics Engineering department for their support, reformation and training throughout my course of study in the school.

I am also very grateful to the Managing Director and the entire staff of Philips Project Centre, 8 Kofo Abayomi Street, Victoria Island, Lagos whose unwavering support and tremendous training during my industrial attachment has made me a better person. I am also grateful to my guardian, Alhaji Yahaya Ndatsadu and family for their care and encouragement and to my friends Casmir Nonso Okpala, Chinelo Happiness Igwilo, Akujobi Judith Chinoyerem, Keji Lukman Oyewumi, Leonard Ukoh, Abiola Shadrak, Otunuya Cadmus Chinwe and Rotimi Samuel Ogunsakin for always being there, I hold you all so dear to my heart and I wish you all the best in your life pursuit.

ABSTRACT

Voice over Internet Protocol (VoIP) on a point to point connection is geared towards the voice interactivity and network connectivity between two systems on small area coverage. The basic steps involved in originating an Internet telephone call are conversion of the analogue voice signal to digital format and compression/translation of the signal into Internet protocol (IP) packets for transmission over the Internet and the process is also reversed at the receiving end. The VoIP application was written in visual basic 6.0. When started, it initialises and loads data for proper functioning. Then it creates a server socket that binds to a port on the computer system so that it can listen for incoming calls. Whenever there is a request for communication, it accepts the IP address of the calling system and initialises for communication. To communicate, it captures media data from the microphone and transmits it through the created socket (point-to-point) connection to the other system. To initiate a call, the software creates a socket connection (not server socket this time) and tries to connect to the system whose IP address has been supplied ensuring a voice conversation.

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GENERAL INTRODUCTION

1.1 INTRODUCTION

Network Engineering is the design, modelling and implementation of networks and network connections from one network administrator to another. A network as the name connotes is an interconnection of two or more devices using networking components in order to share resources and information [1]. These devices may include servers, computers, printers, scanners etc. In the world of telecommunication, networking is the practice of linking two or more computing devices together for the purpose of sharing data and initiating voice conversation in association with the cable laying and connections [2]. Networks are built with a mix of computer hardware and computer software. Networks can be categorized in several different ways. One approach defines the type of network according to the geographic area it spans (Area Networks), another by their designs, then its layout (Topology), and finally, the communication language used which is known as protocol. Administering the network involves monitoring the network always and making sure of effective utilization at all time [3, 4].

A Communication Satellite is a radio relay station in the orbit above the earth that receives, amplifies and redirects analog and digital signal carried in a specific radio frequency [5]. Satellite communications operate at frequencies above 1GHz, hence the following frequency bands represent the frequency ranges for satellite communications; the L-Band (1-2 GHZ), the S–Band (2-4 GHZ), the C-Band (4-7 GHZ), the X-Band (7-8 GHZ), the Ku-Band (11-18 GHZ), the K-Band (18-26 GHZ), the Ka-Band (26-40 GHZ). Very Small Aperture Terminal (VSAT) is a satellite communications system that serves

home and business users. A VSAT end user needs a box that interfaces between the user's computer and an outside antenna with a transceiver. The transceiver receives or sends a signal to a satellite transponder in the sky. The satellite sends and receives signals from an earth station computer that acts as a hub for the system. Each end user is interconnected with the hub station via the satellite in a star topology. For one end user to communicate with another, each transmission has to first go to the hub station which retransmits it via the satellite to the other end user's VSAT. VSAT handles data, voice, and video signals. VSAT is used both by home users who sign up with a large service such as direct Personal Computer (PC) and by private companies that operate or lease their own VSAT systems [5]. VSAT offers a number of advantages over terrestrial alternatives. For private applications, companies can have total control of their own communication system without dependence on other companies. Business and home users also get higher speed reception than if using ordinary telephone service [4, 5].

Voice over Internet Protocol (VoIP) is a general term for a family of transmission technologies for delivery of voice communications over Internet Protocol (IP) networks such as the Internet or other packet-switched networks [6]. Internet telephony refers to communication services such as voice, facsimile, and voice-messaging applications that are transported via the Internet rather than the Public Switched Telephone Network (PSTN). The basic steps involved in originating an Internet telephone call are conversion of the analog voice signal to digital format and translation of the signal into IP packets for transmission over the Internet, the process is reversed at the receiving end [6]. VoIP systems employ session control protocols to control the set-up and tear-down of calls as well as audio codec which encode speech allowing transmission over an IP network as digital audio via an audio stream [7]. VoIP establishes voice interaction between

computer systems/laptops by initiating a link/loop connection between the server socket of the host and client.

1.2 PROJECT MOTIVATION

Network Engineering has been grossly under patronized and not emphasized in the Electrical/Electronics Engineering department of this institution, Federal University of Technology, Minna in spite of the vast implementations of Communication Engineering in the developed countries of the world and the catch-on in the developing countries. In view of the development and tremendous growth of Network Engineering, I decided to work on this project to express the need for imbibing the study of Network Engineering into the educational curriculum of academic institutions in both developing and developed countries of the world.

1.3 AIM AND OBJECTIVES

The aim of the project is to initiate an internet call between two systems/laptops in order to enable voice interaction.

The objectives of this project are;

1. To create an executable programme for Voice over Internet Protocol on a point to point.
2. To design and model a Voice over Internet Protocol on a point to point.
3. To enable voice message transfer on a point to point.
4. To implement a voice interaction/conversation between two systems.
5. To improve on the interactivity between two people and to stimulate the interest of the students to improve on their relevant field of study through extensive research work.

1.4 METHODOLOGY

In the course of the design and modelling of Voice over Internet Protocol on a point to point, the following steps need to be taken;

1. Writing an executable programme that will grant access to voice interaction between two systems on a point to point.
2. Initiation and execution of the programme software.
3. Establishment of a connectionless network (wireless) between the server/host and another host/client.
4. IP addressing through the wireless connectivity.
5. Calling/connection of the two systems through the wireless link.

1.5 SCOPE OF THE PROJECT

This project will cover the following areas;

1. Voice interaction on a point to point.
2. IP addressing and layout design for the server.
3. Network access connectivity for the voice conversation (wireless network).
4. Implementation of the voice connectivity between two systems/laptops on a point to point.

1.6 SOURCES OF MATERIALS AND CONSTRAINTS

The sources of materials used in the course of carrying out this project are;

1. Network connections and applications
2. Communications, Network and Telecommunications textbooks
3. Routing and Switching journals

4. CCNA/CCENT study manuals and guide
5. DVD plates and web pages from Wikipedia and Google
6. Programming textbooks and software applications
7. ICT workshop seminars and university laboratory.

The constraints of the project work are;

1. Specific operating system
2. Connection delay
3. Crosstalk
4. Signal noise/distortion.

1.7 PROJECT OUTLINE

Chapter One: This chapter introduces the project, discusses the aims and objectives of the project and the methodology. It also contains the scope, sources of material and constraints of the project work as well as the project outline.

Chapter Two: This chapter discusses the theoretical background and the concepts of which the project is based upon. It also discusses the technologies, implementations, benefits, adoptions and challenges of the project.

Chapter Three: This chapter contains the discussions and illustrations of the design, modelling and implementation of the project including the features of the project.

Chapter Four: This chapter contains the discussion of the project implementation processes, limitations, remedy to limitations and troubleshooting processes.

Chapter Five: This chapter contains the conclusion of the project, improvements on the project work with possible recommendations for further study.

CHAPTER TWO

LITERATURE REVIEW

2.1 CONCEPT OF NETWORK ENGINEERING

Network Engineering specializes in designing and implementing total Information Technology (IT) services solutions, both for clients creating a new network installation or migrating, upgrading, or expanding their current IT architecture. These solutions include network (Local Area Network/Wide Area Network) design, installation, connectivity, security, storage, and systems & application integration [8].

2.2 HISTORICAL BACKGROUND AND CONCEPT OF VOICE over INTERNET PROTOCOL

VoIP stands for Voice over Internet Protocol and may account for as much as 25 - 40% of international voice traffic. This phenomenon has made a profound change in the world of telephone communications. The traditional methods of making calls, the landlines are being fast replaced by this technology that has taken the world by storm. Not only is this method economical as this does not involve the telephony company charges that are pretty heavy, it also gives you better coverage. It began as a hobby for some people in Israel who were only able to communicate by computer. The roots of VoIP go back to 1995 when a small telecom company called Vocal technology (Vocaltec) released its first Internet phone software. The software had been designed for a home Personal computer and used similar attachments like headsets, microphones, sound cards and speakers. This software called 'Internet Phone' used the H.323 protocol instead of the currently prevalent SIP protocol. This software was very well accepted in the market and

by 1996 Vocaltec had a successful Internet Phone operation running. The drawback that this software suffered was the non availability of broadband and a resultant poor voice quality owing to modems. The voice quality was worse than the normal phone calls [18].

However the advancement of technology cannot be denied and it was a big leap forward. An employee of Vocaltec who is also amongst the founders of Whichvoip.com in 1998 saw VoIP traffic making about 1% of the total voice traffic in the United States. The heat was soon on and companies were head bent in creating softwares to enable Personal Computers (PC) to phone and phone to phone connections. Networking manufactures such as Lucent and Cisco soon came out with softwares that could route and switch the VoIP traffic and so by the year 2000 VoIP traffic accounted for 3% of the total voice traffic in United States. The revenue that has been made out of sale of VoIP equipment alone in the year 2008 has been around $8.5 billion. The reason behind this astounding figure is low cost unlimited calling plans and also abundance of various services and features in telephone communication related to VoIP technology [18].

Voice over Internet Protocol (VoIP) is a general term for a family of transmission technologies for delivery of voice communications over Internet Protocol (IP) networks such as the Internet or other packet-switched networks [6]. Other terms frequently encountered and synonymous with VoIP are IP telephony, Internet telephony, Voice over Broad Band (VoBB), Broadband telephony, and Broadband phone. Internet telephony refers to communication services such as voice, facsimile, and voice-messaging applications that are transported via the Internet, rather than the Public Switched Telephone Network (PSTN). The basic steps involved in originating an Internet telephone call are conversion of the analogue voice signal to digital format and translation/compression of the signal into IP packets for transmission over the Internet, the process is reversed at the receiving end [6, 7].

VoIP systems employ session control protocols to control the set-up and tear-down of calls as well as audio codec which encode speech allowing transmission over an IP network as digital audio via an audio stream [7]. Codec use is varied between different implementations of VoIP (and often a range of codec are used) [6] while [7] some implementations rely on narrowband and compressed speech, others support high fidelity stereo codec.

2.3 VoIP TECHNOLOGIES AND IMPLEMENTATIONS

Voice over Internet Protocol has been implemented in various ways using both proprietary and open protocols and standards. Examples of technologies used to implement Voice over Internet Protocol include;

- H.323
- IP Multimedia Subsystem (IMS)
- Session Initiation Protocol (SIP)
- Real-time Transport Protocol (RTP)

A notable proprietary implementation is the Skype network [6]. Other examples of specific implementations and a comparison between them are available in other VoIP software [7].

Tools for the implementation of Voice over Internet Protocol on a point to point are;

2.3.1 Programming Language

A Programming Language is an artificial language that can be used to write programmes which control the behavior of a machine, particularly a computer or other devices like printers, scanners etc. Programming languages are defined by syntaxes and

semantic rules which describe their structure and meaning respectively. They facilitate the computer to perform some kind of computations or algorithms. Many programming languages have some form of written specification of their syntax and semantics while some are defined by their official implementation [9].

Programming languages are used to develop computer applications that perform specific tasks as envisaged by the programmer. Thousands of programming languages have been created so far and new languages are created every year. Programming languages differ from natural languages in that natural languages are only used for interaction between people, while programming languages also allow humans to communicate instructions to machines. The different programming languages are machine languages, assembly languages, visual basics, Pascal, java etc [9].

2.3.2 Wireless Local Area Network (WLAN)

Many people use WLANs on a regular basis today. PC sales continue to trend towards more laptop sales versus desktop computers, in part to support a more mobile workforce. PC users need to connect to whatever network they are near, whether at work, at home, in a hotel, or at a coffee shop or school. The migration toward a work model in which you find working moments wherever you are, with a need to be connected to the internet at any time, continues to push the growth of wireless LANs [10].

The wireless-capable laptops communicate with a WLAN device called an Access Point (AP). The AP uses wireless communications to send and receive frames with the WLAN clients (the laptops). The AP also connects to the same Ethernet LAN as the desktop's own devices, allowing both laptops and desktops to communicate with other sites [10, 11].

Wireless LAN standard organizations include;

- ITU-R worldwide standardization of communications that use radiated energy particularly managing the assignment of frequencies
- IEEE standardization of wireless LANs (802.11)
- Wi-Fi alliance industry consortium that encourages interoperability of products that implement WLAN standards through their Wi-Fi certified program
- Federal Communications Commission (FCC) agency that regulates the usage of various communications frequencies [10].

Of all these organizations listed, IEEE develops the specific standards for the different types of WLANs used today. Those standards must take into account the frequency choices made by the different worldwide regulatory agencies, such as the FCC in the U.S. and the ITU-R, which is ultimately controlled by the United Nations (UN).

The IEEE introduced WLAN standards with the creation of the 1997 ratification of the 802.11 standard. This original standard did not have a suffix letter, whereas later WLAN standards do. This naming logic, with no suffix letter in the first standard followed by other standards with a suffix letter is like the original IEEE Ethernet standard. That standard was 802.3 with later more advanced standards having a suffix, such as 802.3u for Fast Ethernet [10, 11].

2.3.3 Internet

Internet is a computer based global information system. It is composed of many interconnected computer networks. Each network may link tens, hundreds or thousands of computers enabling them to share information and processing power [12]. The internet has made it easy for people all over the world to communicate with one another effectively and inexpensively. An individual who has internet access can communicate directly with anyone else on the internet, post information as well as retrieve the information being sent.

Uniform Cerf created the internet in 1973 as a project headed by Robert Kahn and conducted by the advanced Research Projects Agency which was part of the United States department of Defense. Thereafter it was handed over to private sector and scientific agencies for further research and development [12]. The use of the internet has grown tremendously since inception and its success arises from the flexibility in the network interconnection [13].

2.3.4 Internet Protocols

It is practically impossible to find a computer today that does not support the set of networking protocols called Transmission Control Protocol or Internet Protocol (TCP/IP). Every Microsoft, Linux, and UNIX operating system includes support for TCP/IP. Hand-held digital assistants and cell phones support TCP/IP [11]. Cisco sells products that create the infrastructure that allows all of these computers to talk with each other using TCP/IP, and they also include extensive support for TCP/IP. The world has not always been so simple. Once upon a time, there were no networking protocols, including TCP/IP. TCP/IP defines a large collection of protocols that allow computers to communicate. TCP/IP defines the details of each of these protocols inside documents called Requests for Comments (RFC). By implementing the required protocols defined in TCP/IP RFCs, a computer can be relatively confident that it can communicate with other computers that also implement TCP/IP [7].

An easy comparison can be made between telephones and computers that use TCP/IP. You go to the store and buy a phone from one of a dozen different vendors. When you get home and plug in the phone to the same cable in which your old phone was connected, the new phone works. The phone vendors know the standards for phones in their country and build their phones to match those standards [11]. Similarly, a computer

that implements the standard networking protocols defined by TCP/IP can communicate with other computers that also use the TCP/IP standards [7].

2.4 ADOPTION OF VOICE over INTERNET PROTOCOL

Voice over Internet Protocol could be adopted in the following areas;

2.4.1 Consumer Market

A major development starting in 2004 has been the introduction of mass-market VoIP services over Broadband Internet access services, in which subscribers make and receive calls as they would over the PSTN. Full phone service VoIP phone companies provide inbound and outbound calling with Direct Inbound Dialing (DID). Many offer unlimited domestic calling and some to other countries as well, for a flat monthly fee as well as free calling between subscribers using the same provider [14].

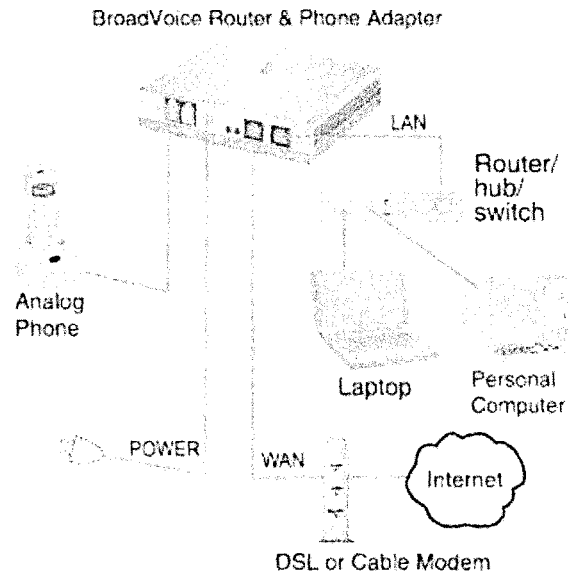

Fig 2.1 Example of VoIP adapter setup in residential network

There are three common methods of connecting to VoIP service providers;

- An Analog Telephone Adapter (ATA) may be connected between an IP network (such as a broadband connection) and an existing telephone jack in order to provide service nearly indistinguishable from PSTN providers on all the other telephone jacks

in the residence. This type of service, which is fixed to one location, is generally offered by broadband Internet providers such as cable companies and telephone companies at a cheaper flat-rate traditional phone service.

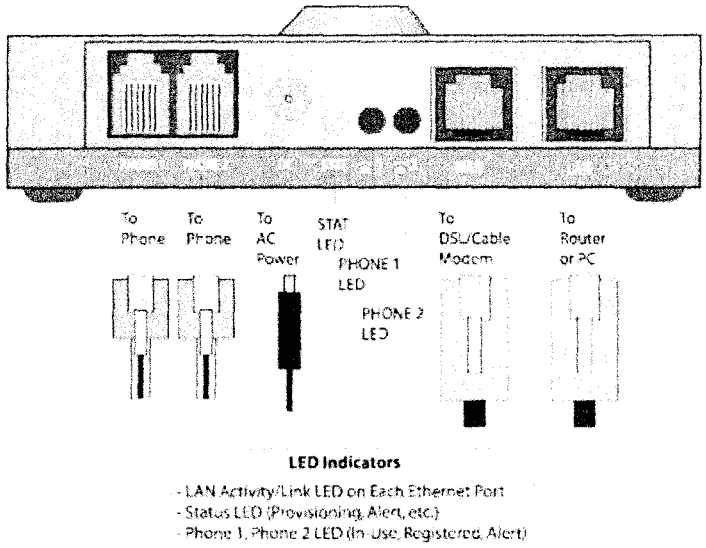

Fig 2.2 Typical Analog Telephone Adapter (ATA) for connecting an analog phone to a VoIP provider

- Dedicated VoIP phones are phones that allow VoIP calls without the use of a computer. Instead they connect directly to the IP network (using technologies such as Wi-Fi or Ethernet). In order to connect to the PSTN they usually require service from a VoIP service provider, most people therefore will use them in conjunction with a paid service plan.
- A soft phone (also known as an Internet phone or Digital phone) is a piece of software that can be installed on a computer that allows VoIP calling without dedicated hardware [6].

2.4.2 PSTN and Mobile Network Providers

It is becoming increasingly common for telecommunications providers to use VoIP telephony over dedicated and public IP networks to connect switching stations and to interconnect with other telephony network providers, this is often referred to as "IP backhaul" [14]. Many telecommunications companies are looking at the IP Multimedia

Subsystem (IMS) which will merge Internet technologies with the mobile world, using a pure VoIP infrastructure. It will enable them to upgrade their existing systems while embracing Internet technologies such as the Web, email, instant messaging, presence, and video conferencing. It will also allow existing VoIP systems to interface with the conventional PSTN and mobile phone networks [15].

2.4.3 Corporate Use

Because of the bandwidth efficiency and low costs that VoIP technology can provide, businesses are gradually beginning to migrate from traditional copper-wire telephone systems to VoIP systems to reduce their monthly phone costs. VoIP solutions aimed at businesses have evolved into "unified communications" services that treat all communications (phone calls, faxes, voice mail, e-mail, Web conferences and more) as discrete units that can all be delivered via any means and to any handset, including cell phones. Two kinds of competitors are competing in this space, one set is focused on VoIP for medium to large enterprises while another is targeting the Small-to-Medium Business (SMB) market [6, 14].

VoIP runs both voice and data communications over a single network which can significantly reduce infrastructure costs. The prices of extensions on VoIP are lower than that for PBXs and key systems. VoIP switches run on commodity hardware such as PCs or Linux systems so they are easy to configure and troubleshoot rather than closed architectures, these devices rely on standard interfaces. VoIP devices have simple, intuitive user interfaces so users can often make simple system configuration changes [6].

2.5 BENEFITS OF VOICE over INTERNET PROTOCOL

The benefits of Voice over Internet Protocol are;

2.5.1 Operational Cost

VoIP can be a benefit for reducing communication and infrastructure costs. Examples include;

- Routing phone calls over existing data networks to avoid the need for separate voice and data networks.
- Conference calling, call forwarding, automatic redial, and caller ID features that traditional telecommunication companies normally charge extra.
- Costs are lower, mainly because of the way Internet access is billed compared to regular telephone calls. While regular telephone calls are billed by the minute or second, VoIP calls are billed per megabyte (MB). In other words, VoIP calls are billed per amount of information (data) sent over the Internet and not according to the time connected to the telephone network. In practice the amount charged for the data transferred in a given period is far less than that charged for the amount of time connected on a regular telephone line [14].

2.5.2 Flexibility

VoIP can facilitate tasks and provide services that may be more difficult to implement using the PSTN. Examples include;

- The ability to transmit more than one telephone call over a single broadband connection without the need to add extra lines.
- Secure calls using standardized protocols such as Secure Real-time Transport Protocol.
- Location independence: Only a sufficiently fast and stable Internet connection is needed to get a connection from anywhere to a VoIP provider [14].

2.6 CHALLENGES OF VOICE over INTERNET PROTOCOL

The challenges of Voice over Internet Protocol are;

2.6.1 Quality of Service (QoS)

Because the underlying IP network is inherently less reliable in contrast to the Circuit-Switched public telephone network and does not provide a mechanism to ensure that data packets are delivered in sequential order or provide QoS guarantees, VoIP implementations may face problems mitigating latency and jitter. Voices and all other data travel in packets over IP networks with fixed maximum capacity [13].

This system is more prone to congestion and Duration of Service (DoS) attacks than traditional circuit switched systems. A circuit switched system of insufficient capacity will refuse new connections while carrying the remainder without impairment, while the quality of real-time data such as telephone conversations on packet-switched networks degrades dramatically. Fixed delays cannot be controlled as they are caused by the physical distance the packets travel however some delays can be minimized by marking voice packets as being delay-sensitive [7, 14].

2.6.2 Susceptibility to Power Failure

Telephones for traditional residential analog services are usually connected directly to telephone company phone lines which provide direct current to power most basic analog handsets independently of locally available power. IP Phones and VoIP telephone adapters connect to routers or cable modems which typically depend on the availability of mains electricity or locally generated power. Some VoIP service providers use customer premise equipment (e.g. cable modems) with battery-backed power supplies to assure uninterrupted service for up to several hours in case of local power failures. Such battery-backed devices typically are designed for use with analog handsets [16].

2.6.3 Emergency Calls

The nature of IP makes it difficult to locate network users geographically. Emergency calls, therefore, cannot easily be routed to a nearby call center. Sometimes, VoIP systems may route emergency calls to a non-emergency phone line at the intended client [6].

In the IP world it is not so simple. A broadband provider may know the location where the wires terminate, but this does not necessarily allow the mapping of an IP address to that location. IP addresses are often dynamically assigned, so the Internet Service Provider (ISP) may allocate an address for online access or at the time a broadband router is engaged. The ISP recognizes individual IP addresses but does not necessarily know what physical location to which it corresponds [7].

2.6.4 Lack of Redundancy

With the current separation of the Internet and the PSTN, a certain amount of redundancy is provided. An Internet outage does not necessarily mean that a voice communication outage will occur simultaneously, allowing individuals to call for emergency services and many businesses to continue to operate normally. In situations where telephone services become completely reliant on the Internet infrastructure, a single-point failure can isolate communities from all communication including Enhanced 911 and equivalent services in other locales [6, 14].

2.6.5 Number Portability

Local number portability (LNP) and Mobile number portability (MNP) also impact VoIP business. In November 2007, the Federal Communications Commission in the United States released an order extending number portability obligations to interconnected VoIP providers and carriers that support VoIP providers. Number portability is a service that allows a subscriber to select a new telephone carrier without

requiring a new number to be issued. Typically, it is the responsibility of the former carrier to "map" the old number to the undisclosed number assigned by the new carrier [14].

2.6.6 Security

VoIP telephone systems are susceptible to attacks as are any internet-connected devices. This means that hackers who know about these vulnerabilities can institute denial-of-service attacks, harvest customer data, record conversations and break into voice mailboxes. Another challenge is routing VoIP traffic through firewalls and network address translators. Private Session Border Controllers are used along with firewalls to enable VoIP calls to and from protected networks.

There are open source solutions such as Wire-shark that facilitate sniffing of VoIP conversations. A modicum of security is afforded by patented audio codec in proprietary implementations that are not easily available for open source applications however such security through obscurity has not proven effective in other fields. The existing security standard Secure Real-time Transport Protocol (SRTP) and the new Zeal Real-time Transport Protocol (ZRTP) are available on Analog Telephone Adapters(ATAs) as well as various soft phones [17].

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 PROGRAMME/VoIP APPLICATION OVERVIEW

Voice over Internet Protocol can be developed using several programming languages on different operating systems so as to enable voice conversation from one system to another. VoIP application on a point to point used in this project was written in high level programming language, Visual Basic 6.0 and is run on windows operating system with target latency of 200 milliseconds.

When started, it initialises and loads data for proper functioning. Then it creates a server socket that binds to a port on the computer system so that it can listen for incoming calls. Whenever there is a request for communication, it accepts the IP address of the calling system and initialises for communication. To communicate, it captures media data from the microphone and transmits it through the created socket (point-to-point) connection to the other system. To initiate a call, the software creates a socket connection (not server socket this time) and tries to connect to the system whose IP address has been supplied.

3.1.1 Visual Basic 6.0 Environment

Visual Basic 6.0 provides the tools one needs to create windows with familiar elements like menus, text boxes, command buttons, option buttons, check boxes, list boxes and scroll bars. Visual Basic is an object-oriented programming (OOP) and event driven programming. They do not follow a sequential logic. In Visual Basic programming, objects are formed first e.g. forms and controls, then the property is named. This is followed by the necessary action required in the form of methods [9].

Each window can be resized, opened and closed. The form window is where the form that makes up the user interface is designed. The project explorer window holds the filenames for the files included in the project (.vbp) file. The properties window is used to set the properties for the objects in the project. The form layout determines the position of the form on the system when the execution of the project begins. The toolbox holds the tools you use to place controls on a form. The main Visual Basic window holds the VB menu bar, toolbar, form location and size information. The three distinct modes of VB are Design Time, Run Time and Break Time [9].

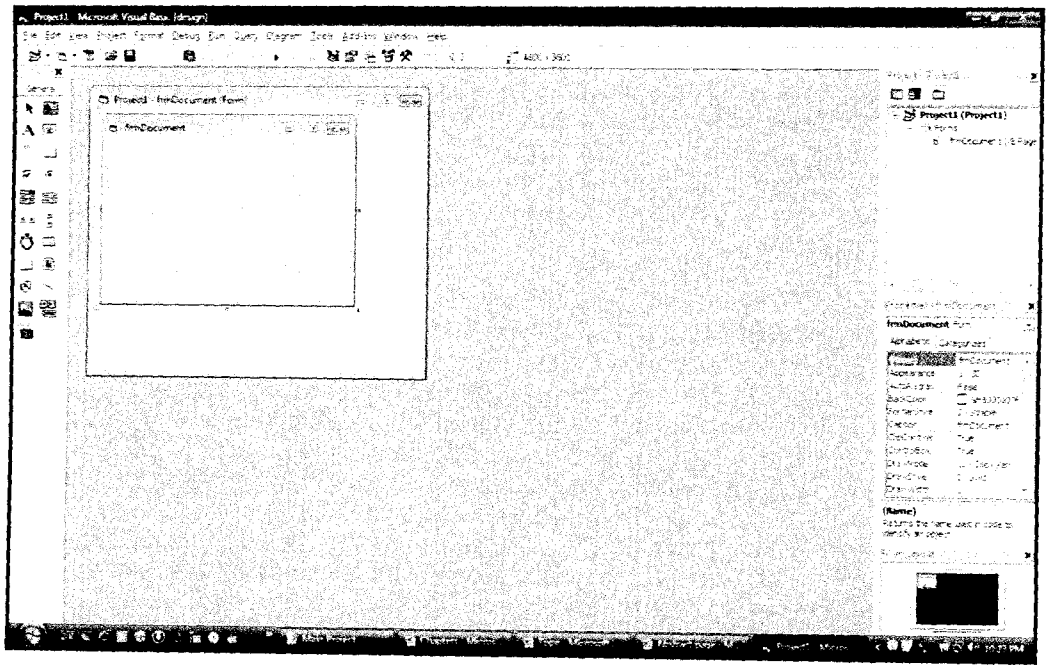

Fig 3.1 Visual Basic 6.0 work sheet

3.1.2 Windows Operating System

Windows operating system is one of the most popular and widely used operating system because of its flexibility. They range in different versions such as windows 97, windows 98, windows 2000, windows XP, windows vista and windows 7. The operating system used in this project is Windows Vista.

3.1.3 Programme Flow Chart

The programme flow chart is drawn both for initiating a call and receiving a call.

3.1.3.1 Call Initiation Flow

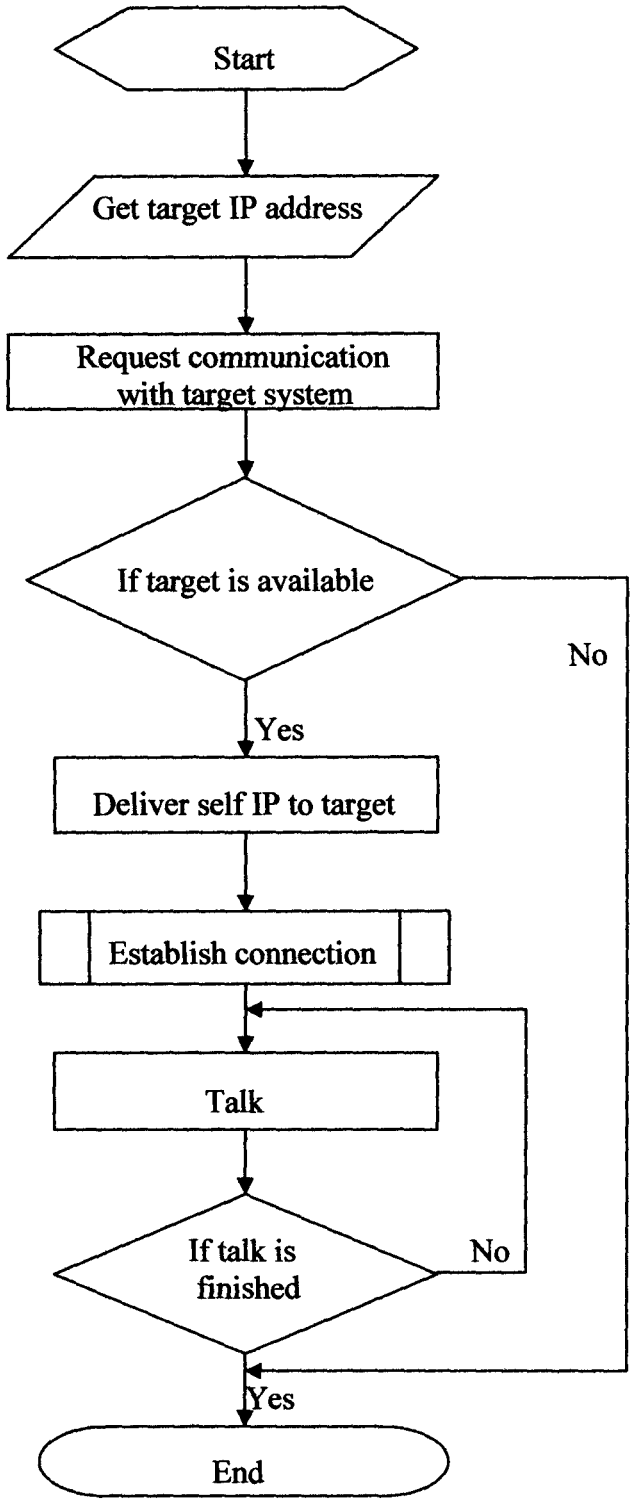

Fig 3.2 Call initiation flow

3.1.3.2 Call Reception Flow

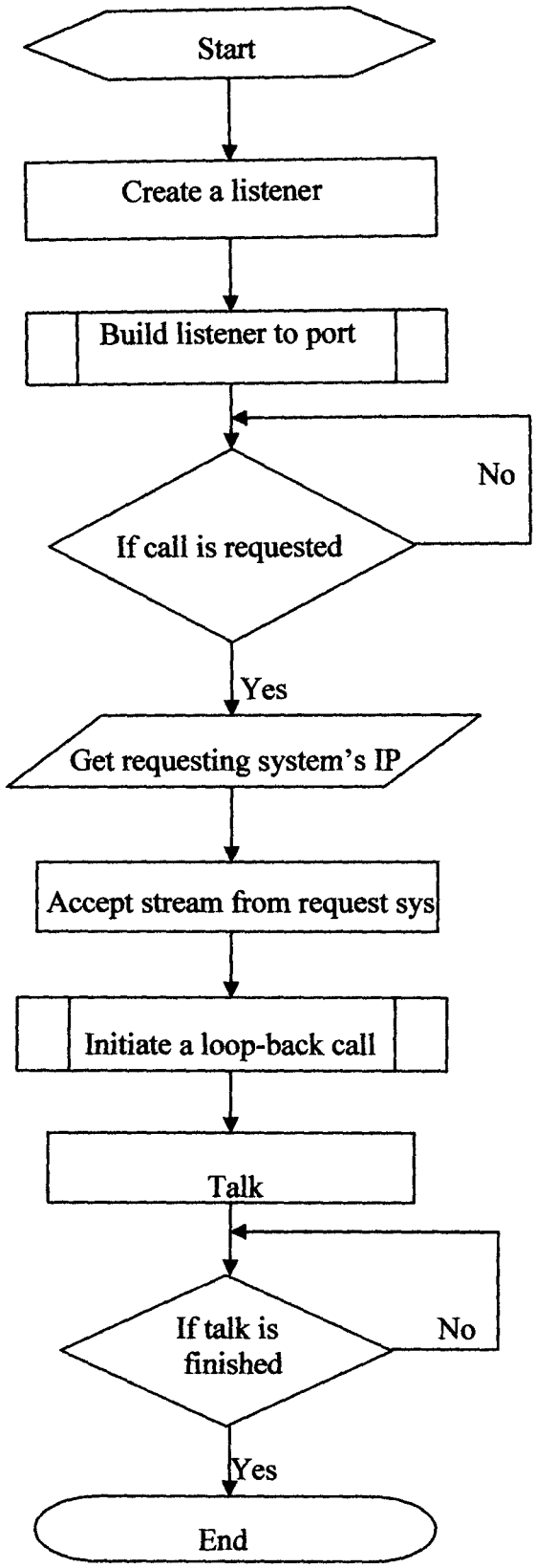

Fig 3.3 Call reception flow

3.1.4 Programme Features

Voice over Internet Protocol programme set-up is developed with certain features that make its execution easy and implementable. These features include;

3.1.4.1 VoIP Background

This feature opens the background for the VoIP which is done before the set-up application is initiated. The VoIP is planned, the user interface defined and the required properties were set.

The Visual Basic code statements (the REMARK statement, the ASSIGNMENT statement and the END statement) are used. The remark statements are used for the VoIP documentation and are not considered to be executable. The assignment statement assigns a value to the property or variable. The end statement stops the execution of the VoIP.

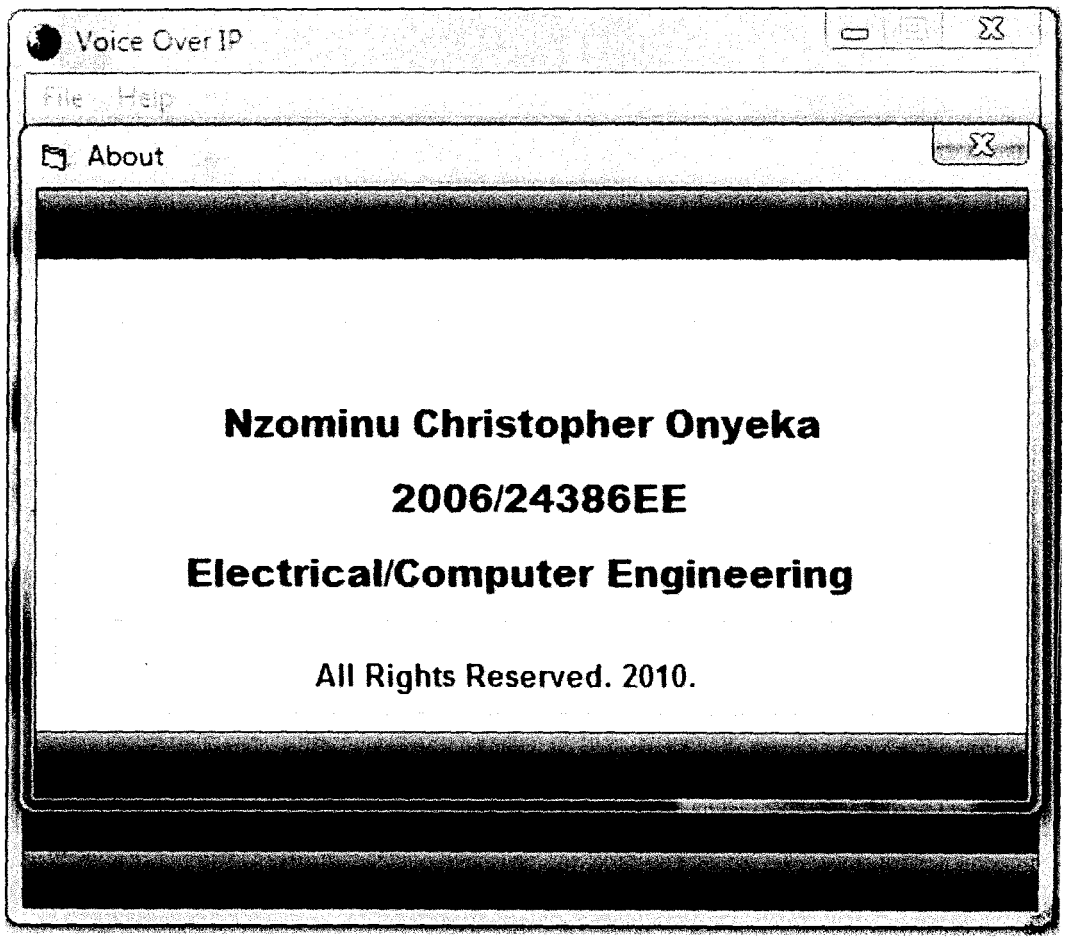

Fig 3.4 VoIP background

The programme source codes used in the course of the software programming and application for Voice over Internet Protocol are copied in the disc attached to the report.

3.1.4.2 Run VoIP

After the code statements have been written and the VoIP background initiated, the main page programme set-up is drafted and the application programmed before the project is ready to run. There are three methods by which these could be achieved. They are;

1. Open the RUN menu and choose START.
2. Press the START button on the toolbar
3. Press F5, the shortcut key for Start command.

The features of the Run VoIP programme execution includes;

- **SPLASH PAGE**

This is the first page that the windows load when the VB of the application is entered. It initiates the SET-UP of the application checking the promptness and availability of the windows programme.

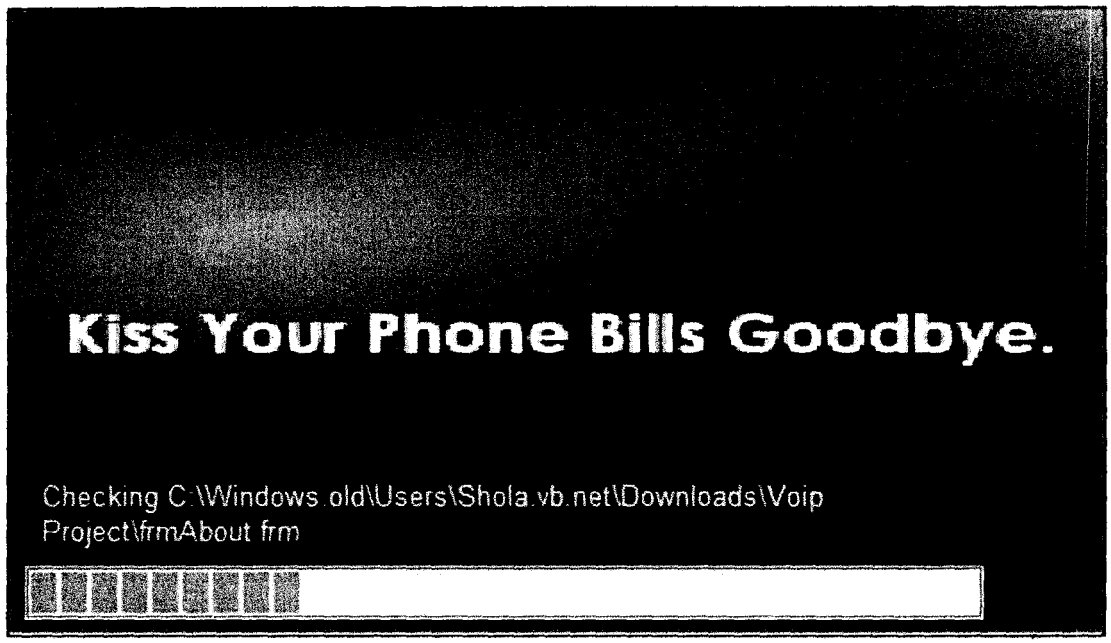

Fig 3.5 Splash page

❖ **MAIN PAGE**

This is the next page that displays when the splash page ends initializing. The main page contains the IP address of the host/server system and the inputted IP address of the client to ensure user validation and network accessibility to the application full functions. It also contains the CALL icon in which a call can be connected and conversation initiated as well as the HANG UP icon which can as well terminate the call.

The features of the CONFERENCE LIST, ACTIVATE and DEACTVATE keys were not necessarily utilized in this project since it is based on a point to point connection. In the case of where the IP address of the system is not known, the user can as well go to the FILE menu to acquire the IP for its system.

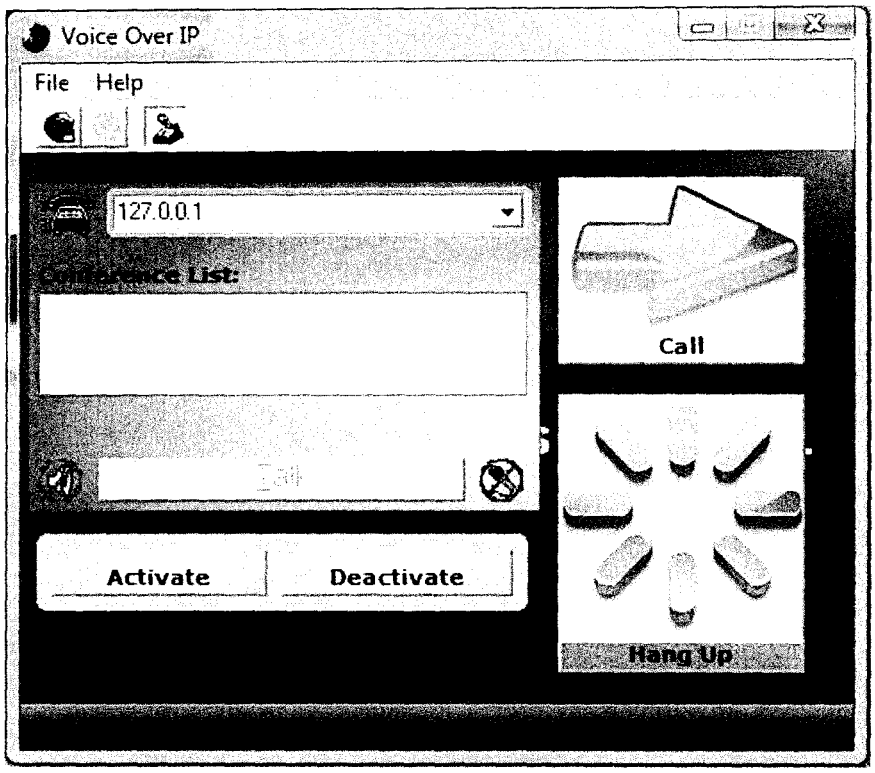

Fig 3.6 Main page

❖ **Call Initiation**

This feature is also contained as a part of the main page VoIP application. This feature is being indicated by the CALL icon and is designed to enable the application

initiate a conversation with another system/client whose IP address has been input by clicking the CALL icon.

❖ **Hang Up**

This feature terminates the ongoing conversation between the two systems that is the server/host and client. It ends the call and stops the connection between the two links.

3.2 NETWORK OVERVIEW

3.2.1 Windows Wireless Local Area Network (WLAN) Connection

3.2.1.1 Making a Wireless Connection

To use the wireless network you must apply for access. This is done by using the web form. After this is filled in, your wireless connections details will be provided with which the wireless connection is enabled. The system will need the following to make a wireless connection;

- A suitable network card or built-in device.
- Details of the key and network name that you will be supplied with after your application is processed.

3.2.1.2 Connecting to the Wireless Network

There are two methods for connecting to the wireless network either by connecting using a VPN client or using 802.1x / WPA.

❖ **Connecting using WPA-Enterprise**

WPA-Enterprise authentication allows you to connect securely to the wireless network without having to make a client connection.

This connection mechanism is supported by a number of operating systems and wireless cards [10].

❖ **Connecting using VPN**

Connecting to the Wireless Service using VPN for security involves two steps; establishing a connection to the wireless network and then opening a VPN connection in order to gain connectivity to the network and the Internet [10].

❖ **WPA-Enterprise on Windows Vista**

The steps involved in making WPA-Enterprise on windows vista are;

➢ Right click on the network icon by the clock and select Connect to a network.

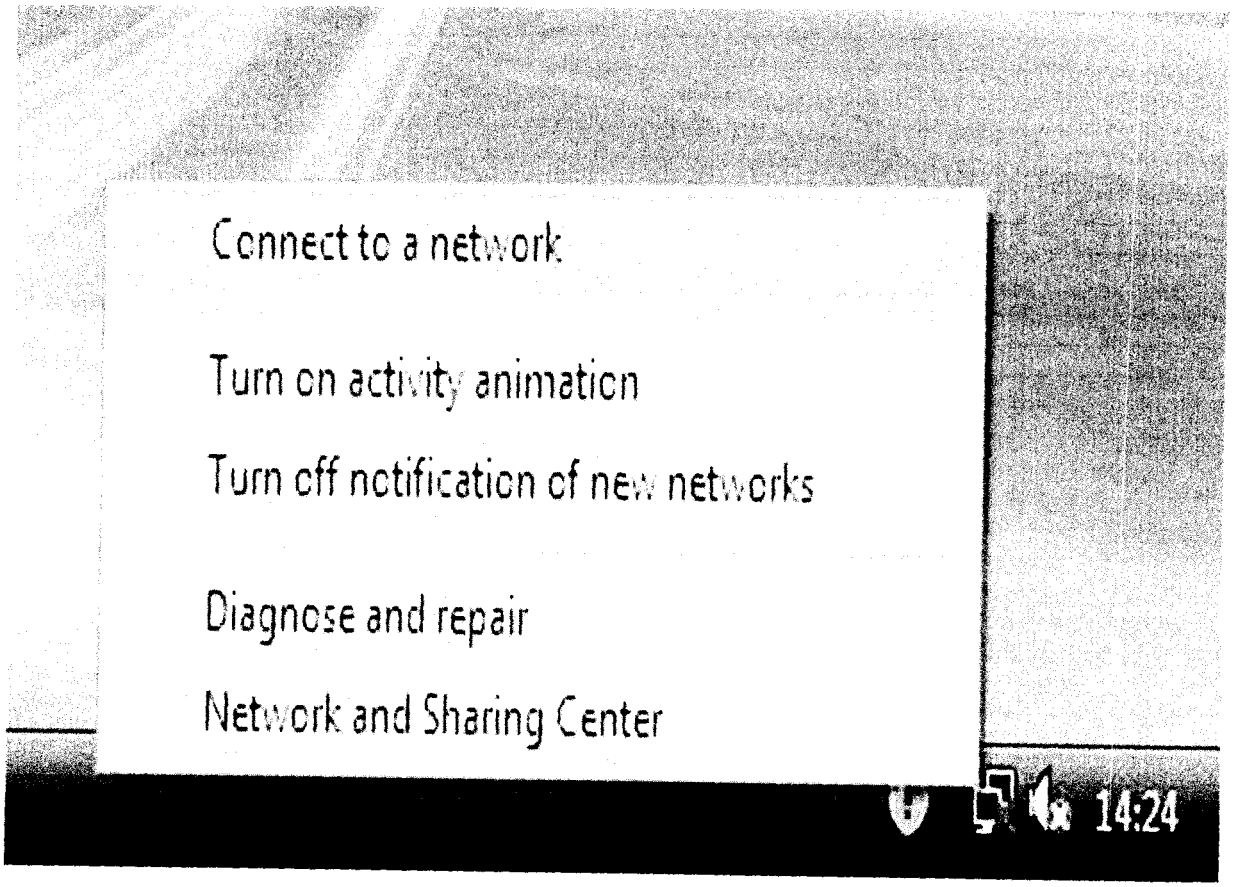

Fig 3.7 Network connection

➢ Select Imperial-WPA and click Connect.

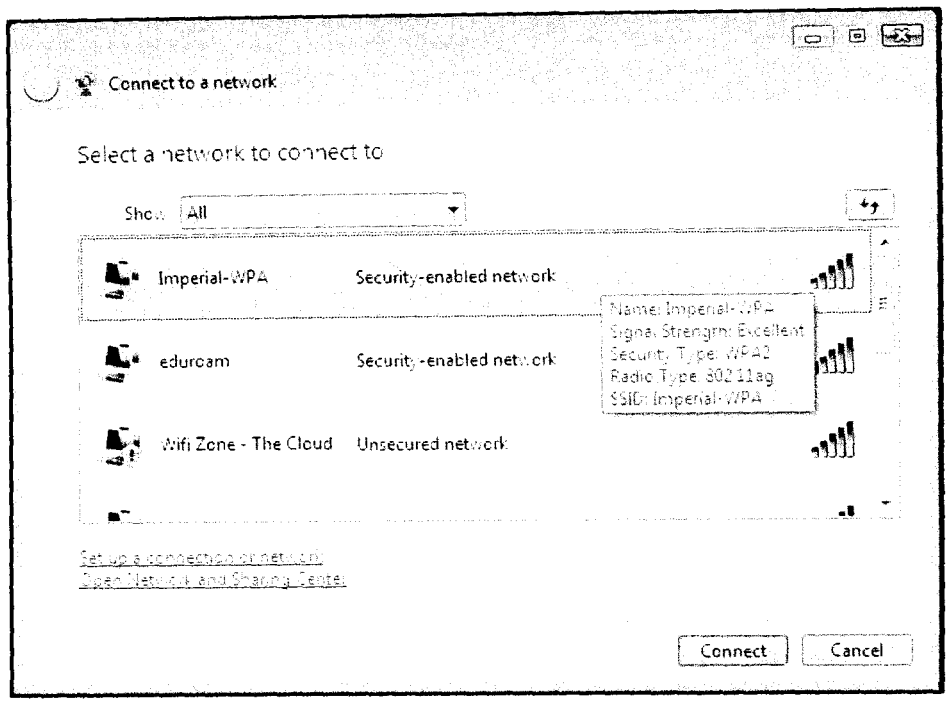

Fig 3.8 WPA-Enterprise selection

- Windows will try to connect then prompt for Additional log on information, Enter/select addition log on information.

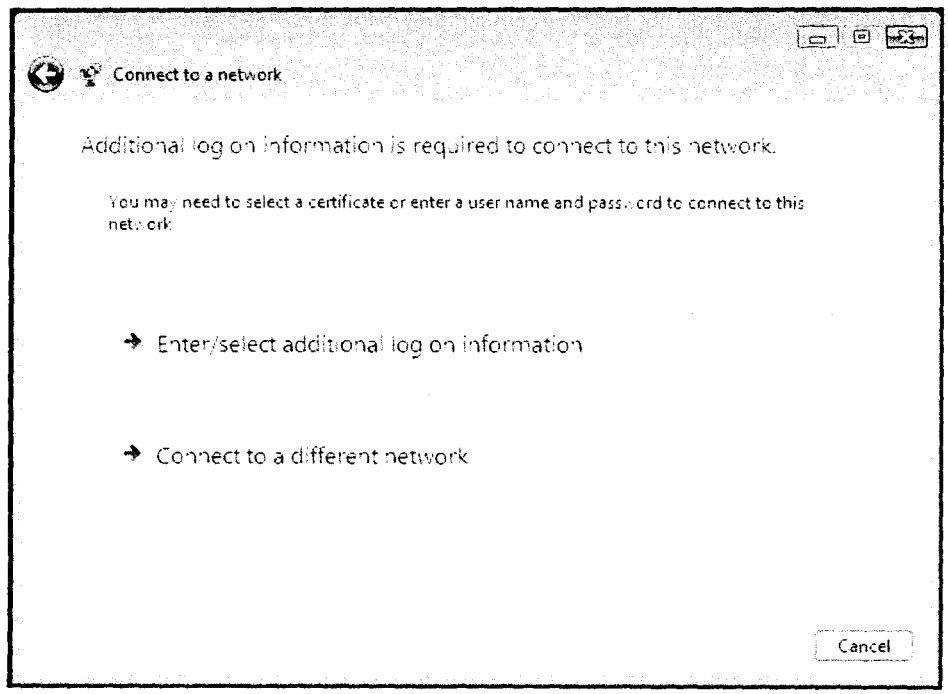

Fig 3.9 Log on information

- Windows will now prompt for your details, enter your Username and Password. You do not need to enter the domain.

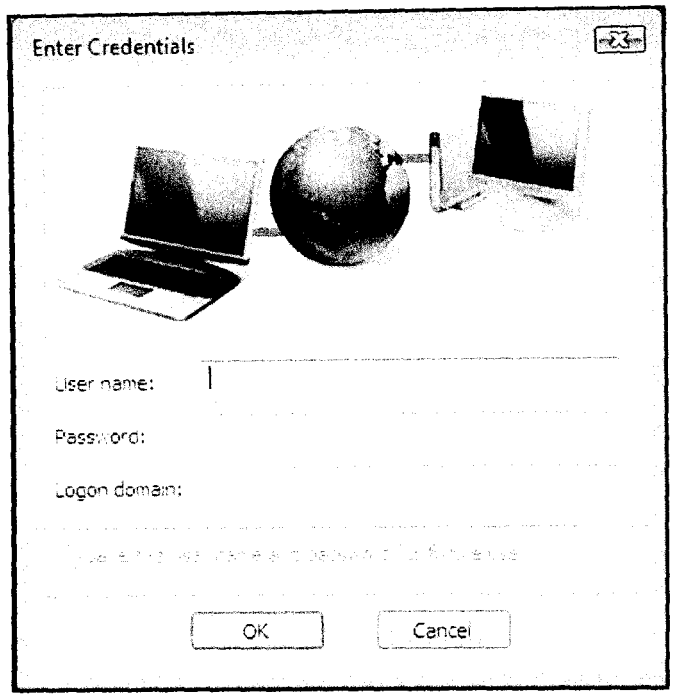

Fig 3.10 Log on domain

- You will get a second prompt to provide additional information, again Enter/select additional log on information.

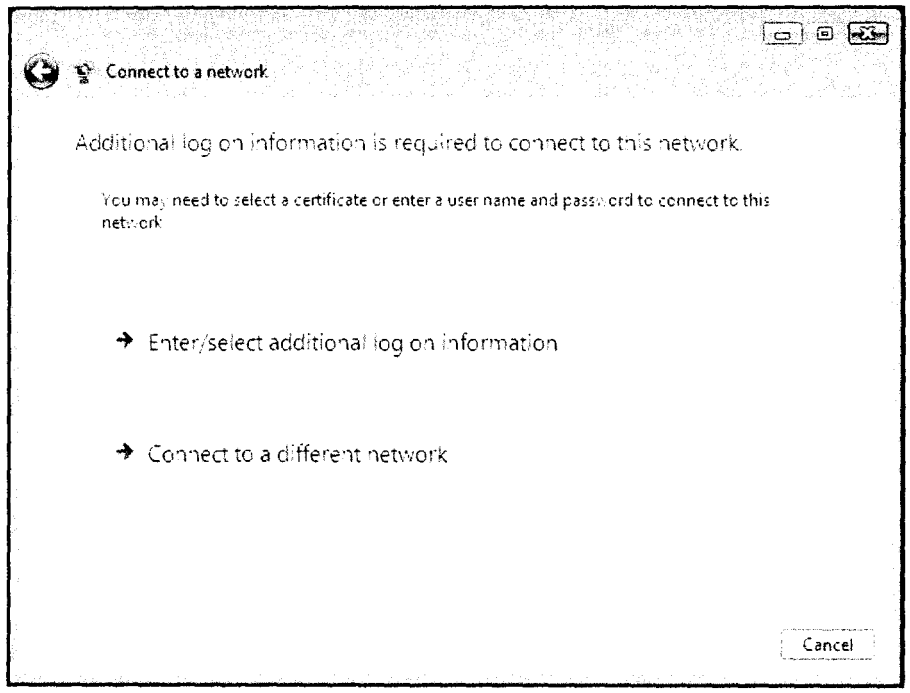

Fig 3.11 Additional log on information

- You will be asked to validate the Server Certificate, Accept it by clicking **OK**. You do not need to view the certificate.

Fig 3.12 Validation page

- **Select the checkbox to Save this network and Start this connection automatically. Click Close to finish the setup.**

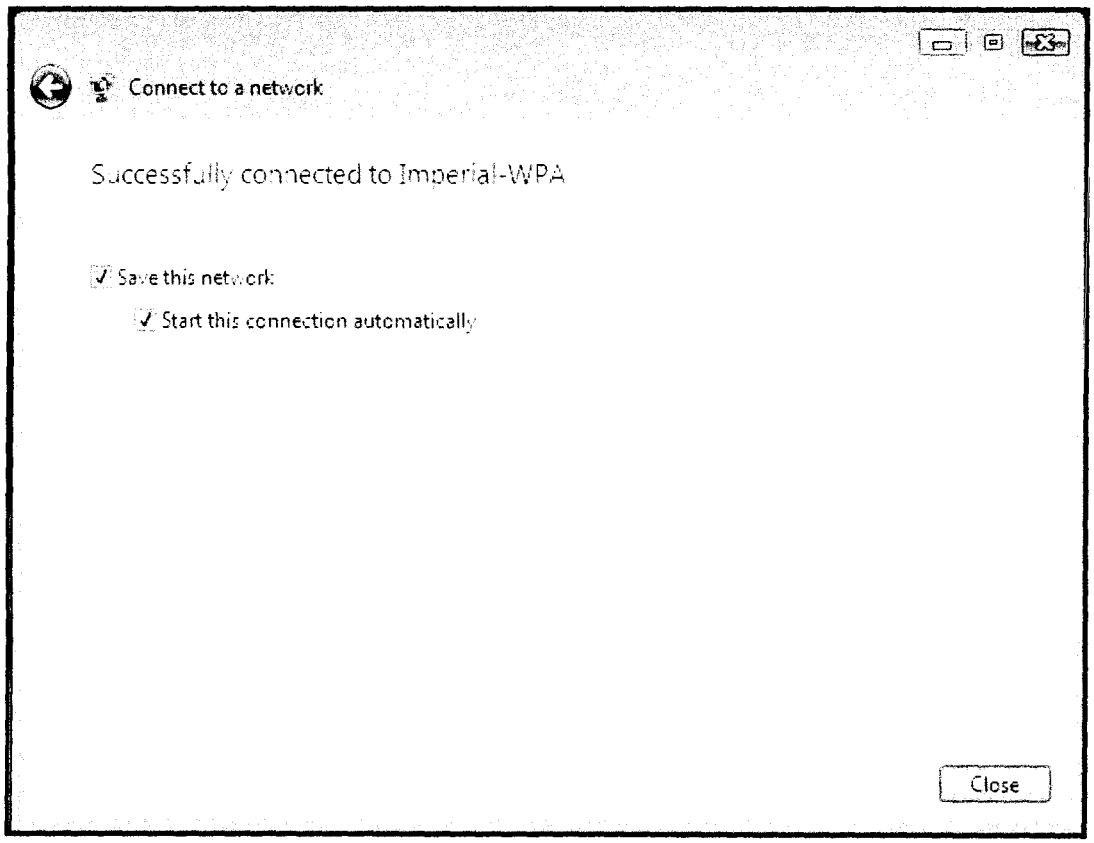

Fig 3.13 Check box

- **When prompted chose Work as the location for the 'Imperial-WPA' network.**

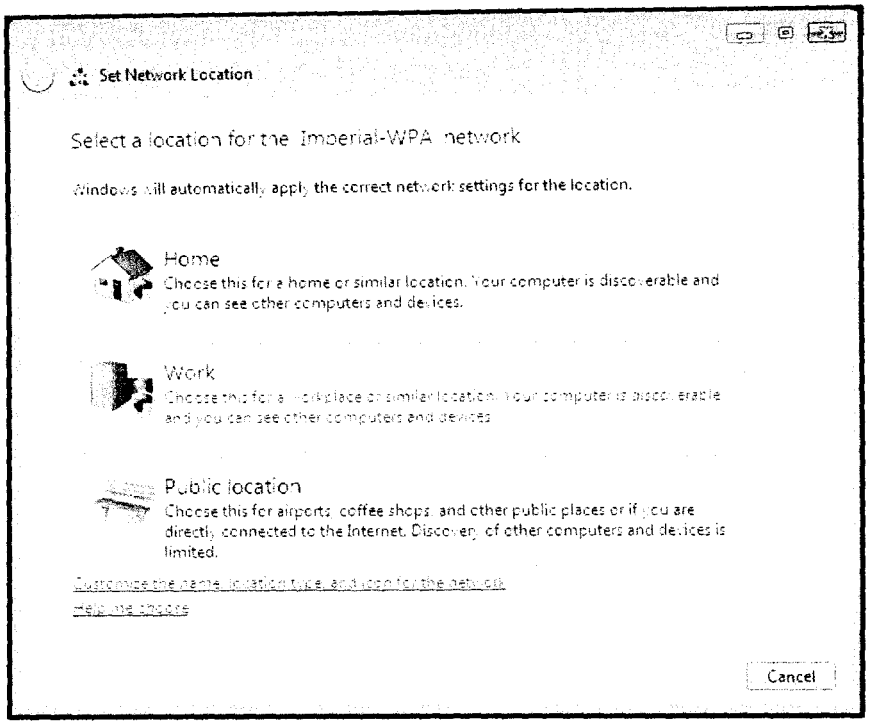

Fig 3.14 Network location

- **A final window will appear telling you the network was created successfully. You can close this window and work on the wireless network.**

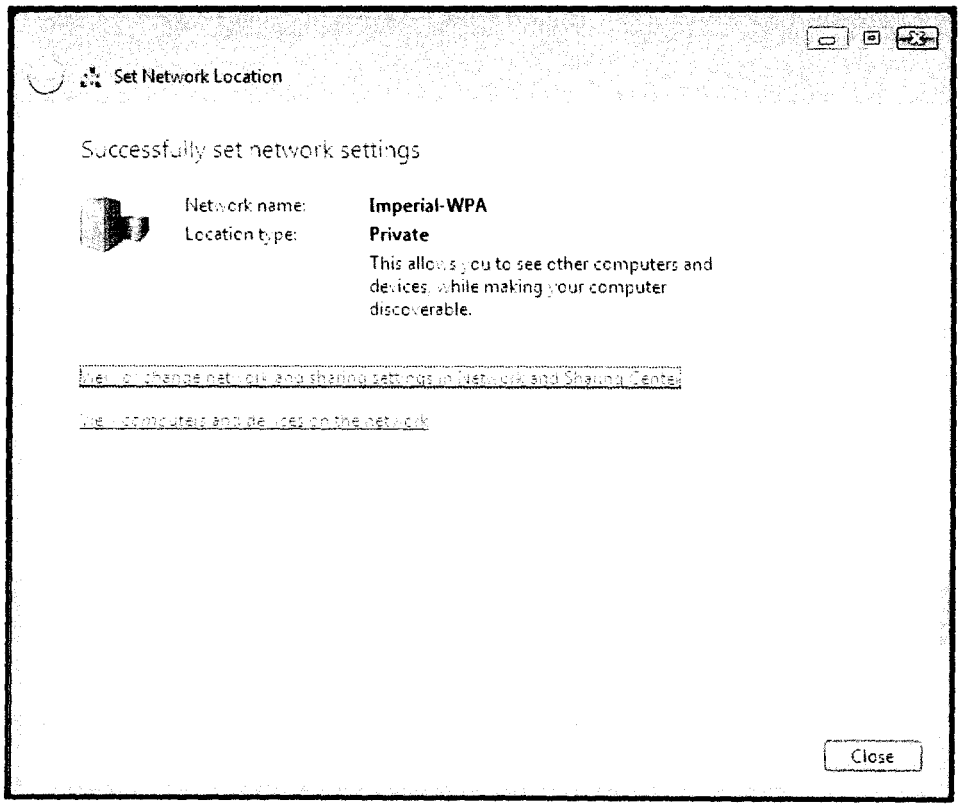

Fig 3.15 Network settings information

3.3 PROTOCOL OVERVIEW

3.3.1 TCP/IP Protocol Architecture

The Transmission Control Protocol/Internet Protocol or TCP/IP is the most pervasively used networking model in the history of networking. You can find support for TCP/IP on practically every computer operating system in existence today; from mobile phones to mainframe computers.TCP/IP defines a large collection of protocols that allow computers to communicate. TCP/IP defines the details of each of these protocols inside documents called Requests for Comments (RFC). By implementing the required protocols defined in TCP/IP RFCs, a computer can be relatively confident that it can communicate with other computers that also implement TCP/IP.

Similarly, a computer that implements the standard networking protocols defined by TCP/IP can communicate with other computers that also use the TCP/IP standards. Like other networking architectures, TCP/IP classifies the various protocols into different categories or layers [11].

Table 3.1 Main categories in the TCP/IP architectural model and example protocols.

TCP/IP Architectural layer	Example Protocol
Application	HTTP, POP3, SMTP
Transport	TCP,UDP
Internet	IP
Network Access	Ethernet, Frame Relay

The TCP/IP model represented in column 1 of the table lists the four layers of TCP/IP and column 2 of the table lists several of the most popular TCP/IP protocols.

3.3.1.1 Application Layer

TCP/IP application layer protocols provide services to the application software running

on a computer. The application layer does not define the application itself, but rather it defines services that applications need such as the capability to transfer a file in the case of HTTP. In short, the application layer provides an interface between software running on a computer and the network itself.

3.3.1.2 Transport Layer

The TCP/IP transport layer consists of two main protocol options: the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP). UDP provides service for applications to exchange voice messages. Unlike TCP, UDP is connectionless and provides no reliability, no windowing, no reordering of the received data and no segmentation of large chunks of data into the right size for transmission. However, UDP provides some functions of TCP, such as voice/data transfer using port numbers and it does so with fewer bytes of overhead and less processing required than TCP.

3.3.1.3 Internet Layer

The internet layer of the TCP/IP networking model primarily defined by the Internet Protocol (IP) works much like the postal service. IP defines addresses so that each host computer can have a different IP address just as the postal service defines addressing that allows unique addresses for each house, apartment, and business.

3.3.1.4 Network Access Layer

The network access layer defines the protocols and hardware required to deliver data across a network. The term network access refers to the fact that this layer defines how to connect a host computer to the media, in this case wireless over which data/voice can be transmitted [11].

3.3.2 Internet Protocol Addressing

Device that can send and receive IP packets is called an IP host. IP addresses consist

of a 32-bit number, usually written in dotted-decimal notation. The "decimal" part of the term comes from the fact that each byte (8 bits) of the 32-bit IP address is shown as its decimal equivalent. The four resulting decimal numbers are written in sequence, with "dots," or decimal points, separating the numbers hence the name dotted decimal.

For instance, 168.1.1.1 is an IP address written in dotted-decimal form; the actual binary version is 10101000 00000001 00000001 00000001. Each decimal number in an IP address is called an octet. The term octet is just a vendor neutral term for byte. So, for an IP address of 168.1.1.1, the first octet is 168, the second octet is 1, and so on. The range of decimal numbers in each octet is between 0 and 255, inclusive. Finally, note that each network interface uses a unique IP address. Most people tend to think that their computer has an IP address, but actually their computer's network card has an IP address [11].

CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.1 VOICE over INTERNET PROTOCOL IMPLEMENTATION

Voice over Internet Protocol on a point to point connection is implemented using servers/sockets on a Protocol address which enables the host/server to call and connect to another host/client as the call recipient.

4.2 VoIP EXECUTION TEST

The VoIP execution was systematically carried out using certain features;

4.2.1 Run VoIP Set-up

The application set-up which has already been programmed using the Visual Basic 6.0 is run on the system. The Set-up icon is been clicked and it starts initializing to check the availability and promptness of the system being utilized.

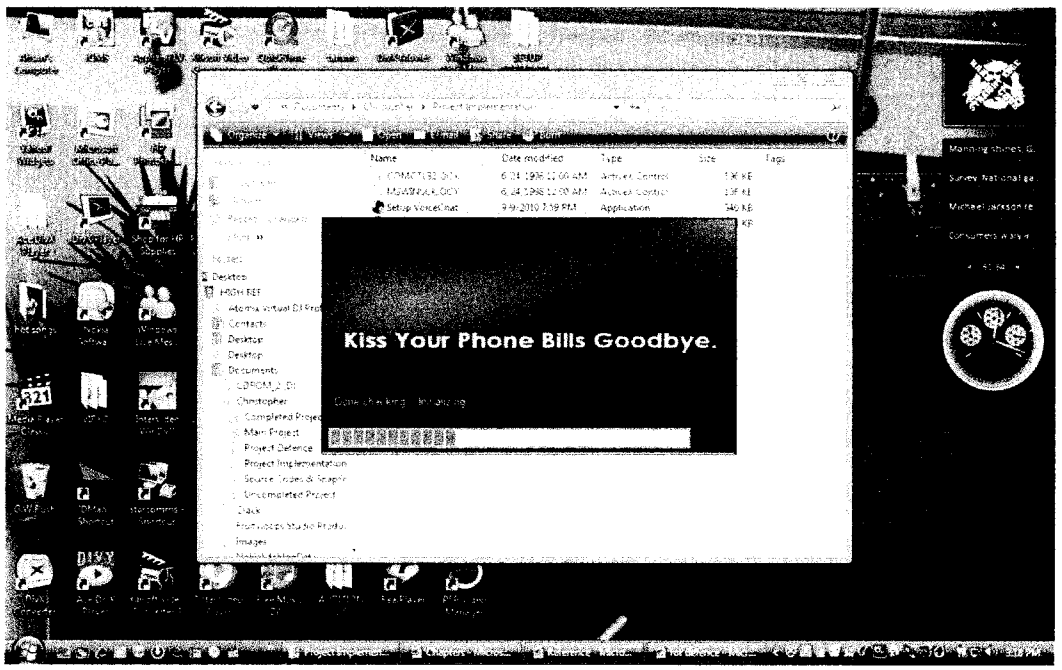

Fig 4.1 VoIP set-up page

4.2.2 IP Acquisition and IP Addressing

This feature of the Voice over Internet Protocol requires the host to acquire the client/recipients' IP address to enable the VoIP application initiate a call and start up a conversation between the two systems. The IP address is input in the IP address slot.

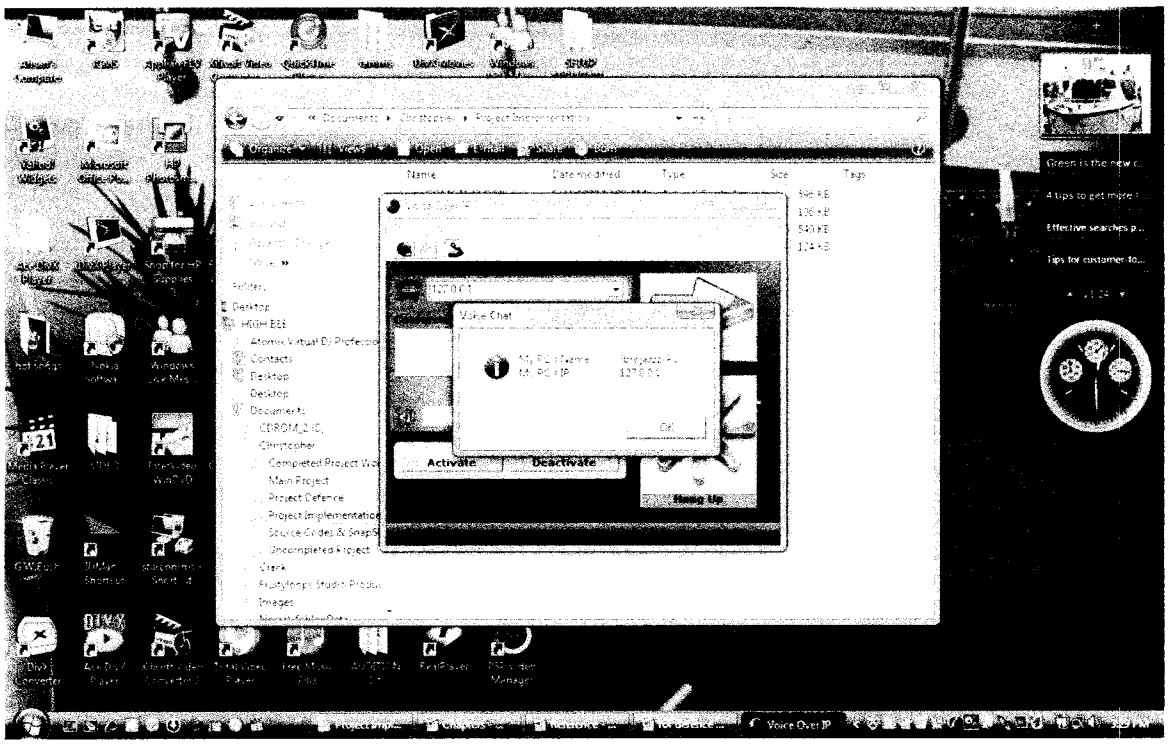

Fig 4.2 IP acquisition and addressing

4.2.3 Calling

The calling feature of the Voice over Internet Protocol involves acquiring the recipients IP address through the File menu in the main page display of the client/recipients' system and inputting it on the server/host IP address slot. The CALL icon is then clicked, this connects the host to the client/recipient and conversation resumes. The same process can as well be implemented in the recipients end with the client/recipients' system serving as the host and the host/server system serving as the recipient/client.

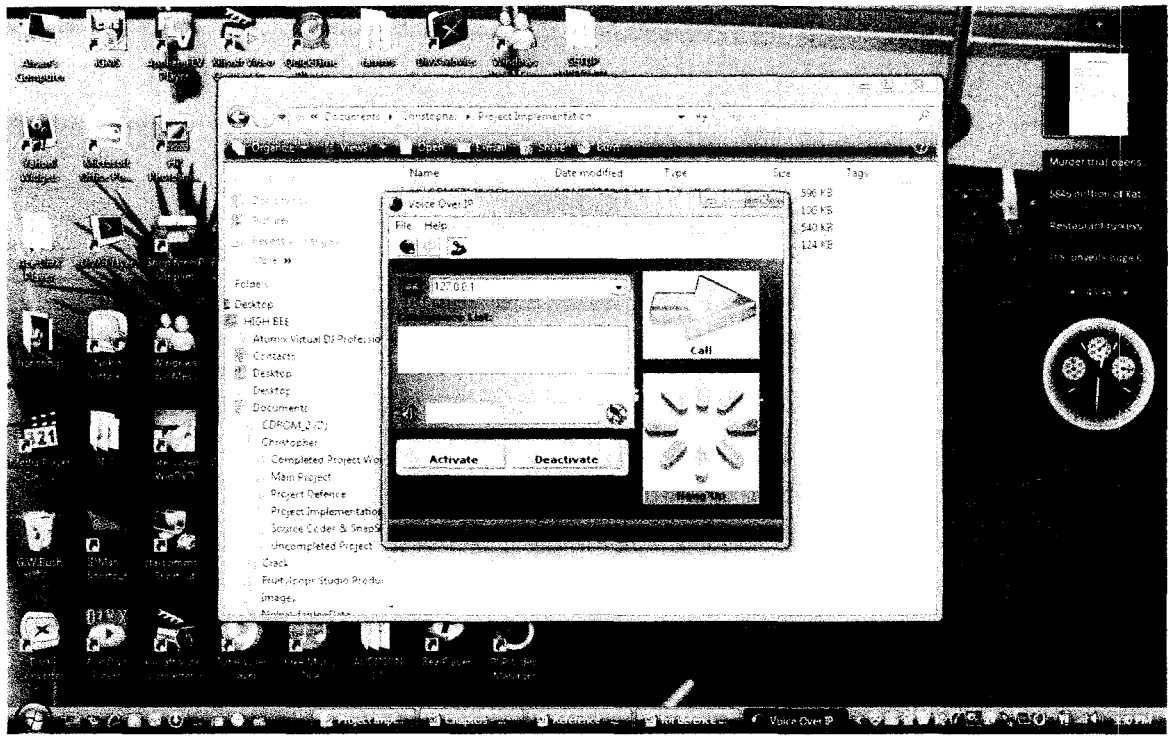

Fig 4.3 Call initiation page

4.2.4 Hang up

This is the termination of the conversation between the host and the client/recipient.It terminates the connection link between the two systems making the channel to be available for another link or IP address to initiate another conversation.

4.3 DISCUSSION OF RESULTS

The Internet Protocol (IP) address of the client/recipient system after being input in the IP address slot of the host/server and the CALL icon on the main page is clicked, a loop/link is established creating a server socket between the two systems. This enables the initiation of voice conversation between the two systems, hence host/server and client/recipient. One system serves as the host/server while the other serves as the host alone. The process is reversed by enabling the client/recipient initiate the call by inputting the host/server IP address on its system and clicking on the CALL icon to enable voice

conversation between the two systems.

Voice conversation through the internet protocol is very convenient and efficient for both staff and students of the school for effective communication within the school premises thereby saving cost and minimizing expenses for them. The process is not security threatened since the application of VoIP on a point to point only involves having knowledge of the corresponding IP address of the clients. This is like the phonebook on the mobile cellular network.

4.4 LIMITATIONS

The Voice over Internet Protocol (VoIP) application is however limited in the following ways;

- The application is designed to work on windows operating system since that is the most conversant and popular operating system used by the staff and students of the school.
- VoIP on point to point is network based and connectionless hence will not be applicable in the absence of network.
- The Voice conversation is based on a point to point therefore will not initiate a conversation between multi-users.
- The VoIP on point to point is not flexible since it was designed to initiate conversation between two systems.

4.5 REMEDY TO LIMITATIONS

- A programme application for VoIP should be created to enable voice conversation irrespective of the operating system on the laptops.

- VoIP should be extended to multi-user so that many clients can initiate a call when a conversation is already going on to ensure flexibility.

4.6 TROUBLESHOOTING TO VoIP

- The target latency of the VoIP is 200 milliseconds and in the case of lesser speed, all the applications on the system should be closed before the set-up is run.
- In the case of unclear voice signal, the speaker settings should be reset and adjusted until a clear voice conversation is ensured.
- When running the set-up of the VoIP and it refuses to run, disable the antivirus and firewalls on the system before initiating the set-up again.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Conclusively, Voice over Internet Protocol (VoIP) on a point to point was successfully developed and implemented on a connectionless network based server/socket between two systems with one serving as the host/server and another serving as the client/recipient. The IP address enables the server/host system to establish a link/loop with the client/recipient system and vice versa initiating a voice communication between the two systems irrespective of the relative connection delay experienced.

The project which is intended to initiate a voice interaction/conversation between two systems was successful with the rebirth of a new and cost effective way of communication and information exchange among staff and students of the school. The VoIP application criminates the need for relatively expensive mobile phone network with which the staff and students of institution communicate with providing effective and efficient means of information exchange within the university vicinity at a relatively cheap cost.

5.2 IMPROVEMENTS

- Further research to extend the VoIP conversation on multi-user basis should be extensively improved on.
- The target latency should be greatly improved to enable fast connection of the link in order to reduce the connection delay.
- A stable network should be established to enhance the connectivity of the link.

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APPENDIX

APPENDIX 1

- **Visual Basic 6.0/VoIP Environment**

```
Object = "{6B7E6392-850A-101B-AFC0-4210102A8DA7}#1.3#0"; "COMCTL32.OCX"
Object = "{248DD890-BB45-11CF-9ABC-0080C7E7B78D}#1.0#0"; "MSWINSCK.OCX"
Begin VB.Form frmChat2
  BorderStyle    =  1  'Fixed Single
  Caption        =  "Inter Net Voice 2"
  ClientHeight   =  4230
  ClientLeft     =  2625
  ClientTop      =  1530
  ClientWidth    =  4590
  FillColor      =  &H00808080&
  Icon           =  "chat.frx":0000
  LinkTopic      =  "Form1"
  LockControls   =  -1  'True
  MaxButton      =  0  'False
  ScaleHeight    =  4230
  ScaleWidth     =  4590
  WhatsThisButton =  -1  'True
  WhatsThisHelp  =  -1  'True
  Begin ComctlLib.Toolbar Tools
    Align        =  1  'Align Top
    Height       =  390
    Left         =  0
    TabIndex     =  5
    Top          =  0
    Width        =  4590
```

```
    _ExtentX      = 8096
    _ExtentY      = 688
    ImageList     = "ImgIcons"
    _Version      = 327682
    BeginProperty Buttons {0713E452-850A-101B-AFC0-4210102A8DA7}
      NumButtons    = 5
      BeginProperty Button1 {0713F354-850A-101B-AFC0-4210102A8DA7}
        Key         = ""
        Object.Tag          = ""
        Style       = 3
      EndProperty
  End
```

APPENDIX 2

- **VoIP Background**

```
        BeginProperty ListImage2 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
      Picture       = "chat.frx":11BA
      Key           = ""
    EndProperty
    BeginProperty ListImage3 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
      Picture       = "chat.frx":14D4
      Key           = ""
    EndProperty
    BeginProperty ListImage4 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
      Picture       = "chat.frx":17EE
      Key           = ""
    EndProperty
    BeginProperty ListImage5 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
      Picture       = "chat.frx":1B08
```

```
    Key          = ""
  EndProperty
  BeginProperty ListImage6 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
    Picture      = "chat.frx":1E22
    Key          = ""
  EndProperty
  BeginProperty ListImage7 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
    Picture      = "chat.frx":213C
    Key          = ""
  EndProperty
  BeginProperty ListImage8 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
    Picture      = "chat.frx":2456
    Key          = ""
  EndProperty
  BeginProperty ListImage9 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
    Picture      = "chat.frx":2770
    Key          = ""
  EndProperty
  BeginProperty ListImage10 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
    Picture      = "chat.frx":2A8A
    Key          = ""
  EndProperty
  BeginProperty ListImage11 {0713E8C3-850A-101B-AFC0-4210102A8DA7}
    Picture      = "chat.frx":2DA4
    Key          = ""
  EndProperty
EndProperty
End
```

APPENDIX 3

➢ Main Page

```
Object = "{6B7E6392-850A-101B-AFC0-4210102A8DA7}#1.3#0"; "COMCTL32.OCX"
Object = "{248DD890-BB45-11CF-9ABC-0080C7E7B78D}#1.0#0"; "MSWINSCK.OCX"
Begin VB.Form frmChat1
  BorderStyle    =  1  'Fixed Single
  Caption        =  "Voice Over IP"
  ClientHeight   =  5055
  ClientLeft     =  2625
  ClientTop      =  1830
  ClientWidth    =  6510
  FillColor      =  &H00808080&
  Icon           =  "chat1.frx":0000
  LinkTopic      =  "Form1"
  LockControls   =  -1  'True
  MaxButton      =  0  'False
  ScaleHeight    =  5055
  ScaleWidth     =  6510
  StartUpPosition =  2  'CenterScreen
  WhatsThisButton =  -1  'True
  WhatsThisHelp  =  -1  'True
  Begin ComctlLib.Toolbar Tools
    Align        =  1  'Align Top
    Height       =  390
    Left         =  0
    TabIndex     =  5
    Top          =  0
    Width        =  6510
    _ExtentX     =  11483
```

```
_ExtentY      = 688
   ButtonWidth    = 635
   ButtonHeight   = 582
   ImageList      = "ImgIcons"
   _Version       = 327682
   BeginProperty Buttons {0713E452-850A-101B-AFC0-4210102A8DA7}
     NumButtons    = 5
     BeginProperty Button1 {0713F354-850A-101B-AFC0-4210102A8DA7}
       Object.Tag          = ""
       Style         = 3
     EndProperty
     BeginProperty Button2 {0713F354-850A-101B-AFC0-4210102A8DA7}
       Object.ToolTipText    = "Call"
       Object.Tag          = ""
       ImageIndex     = 4
     EndProperty
     BeginProperty Button3 {0713F354-850A-101B-AFC0-4210102A8DA7}
       Enabled       = 0  'False
       Object.ToolTipText    = "Hangup"
       Object.Tag          = ""
       ImageIndex     = 5
     EndProperty
     BeginProperty Button4 {0713F354-850A-101B-AFC0-4210102A8DA7}
       Object.Tag          = ""
       Style         = 3
     EndProperty
     End
```

INDEX

Terms Definition:

VSAT: Very Small Aperture Terminal

PC: Personal Computer

VoIP: Voice over Internet Protocol

IP: Internet Protocol

PSTN: Public Switched Telephone Network

IT: Information Technology

LAN: Local Area Network

WAN: Wide Area Network

Vocaltec: Vocal Technology

VoBB: Voice over Broad Band

IMS: IP Multimedia Subsystem

SIP: Session Initiation Protocol

RTP: Real-Time Transport Protocol

WLAN: Wireless Local Area Network

AP: Access Point

FCC: Federal Communications Commission

IEEE: Institute of Electrical/Electronics Engineers

UN: United Nations

TCP: Transport Control Protocol

RFC: Request for Comments

ATA: Analogue Telephone Adapter

SMB: Small-to-Medium Business

PBX: Private Branch Exchange

MB: Mega Byte

QoS: Quality of Service

DoS: Duration of Service

ISP: Internet Service Providers

LNP: Local Number Portability

MNP: Mobile Number Portability

SRTP: Secure Real-Time Protocol

ZRTP: Zeal Real-Time Protocol

VB: Visual Basic

OOP: Object Oriented Programming

UDP: User Datagram Protocol

HTTP: Hyper Text Transport Protocol

DID: Direct Inbound Dialing

WPA: Wi-Fi Protected Access.