

***Implementing Voice over Internet Protocol (VoIP) in
Ethiopia: Challenges and Opportunities***

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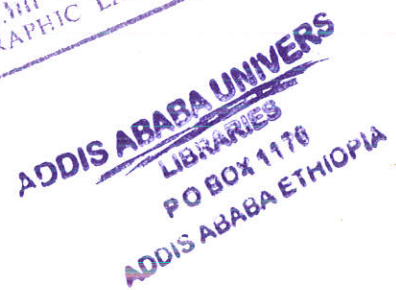
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***PRESENTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA
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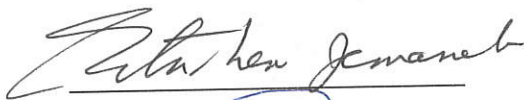
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DECLARATION

This thesis is my original work, has not been presented for a degree in any another university and all sources of materials used for the thesis have been duly acknowledged.

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This thesis has been submitted for examination with our approval as university advisors.

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Implementing Voice over Internet Protocol (VoIP) in Ethiopia:
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Mariye Yigzaw

ABSTRACT

This research has targeted to investigate the opportunities and challenges of VoIP in view of suggesting decisions to be made regarding its implementation in Ethiopia. From historical data of revenue from international telephone operation (under the existing circuit switched telephone system) and nominal data from users regarding their telephone consumption plan (if they are provided with Internet telephony), the envisaged big threat of VoIP on the revenue of ETC is proved to be non-realistic. Rather, the research found out that ETC gains revenue from VoIP more than what it gets from the existing traditional telephone system. It was found that VoIP also improves the telephone resellers' revenue and thereby government income.

As there is no justified reason for banning the VoIP technology and as there are enough grounds to deploy it in Ethiopia, it is a must for the concerned parties to let the people benefit from the technology.

CHAPTER 1: INTRODUCTION

1.1. Background

1.1.1. Technology and Societal transformation

The three major changes or revolutions in the history of mankind were resulted from change in technology. The agricultural revolution, which passed over the ancient nomadic society, was brought about by the technology of ploughing. The machine brought about the industrial revolution, which replaced the agrarian society. The industrial society is, in turn being replaced by the information society in which ICT (Information and Communication Technology) is the major driver. Societies of the modern world are totally dependent on digital information communication technologies more than that of the Stone Age on their stone tools that of the Agrarian society on land and plough, and more than that of the Industrial societies on their engines/machines (Fales, Kuetemeyer, and Brusic, 1997).

ICTs play crucial role in inspiring development and most of the changes in our lives would have been impossible without new information and communication technologies (Castells, 1999). ITCs enable us to visualize the world around us, to have clear information about our environment, and to communicate, analyze and understand that information (Laudon, Traver, and Laudon, 1994.). This information will in turn enable us to generate solutions to our problems, control our lives, and act on our environment and the entire societies. Thus, with the help of ICTs, we can develop the wisdom to make wise decisions about our future world. It is impossible to visualize our environment, understand it, and creatively control it without ICTs (Ibid).

The following Amharic poem, that was said on the introduction of telephone to Ethiopia around 1890 (after 15 years of its innovation by Alexander Graham Bell) by Menilk II, expresses the role of ICT to visualize our environment:

ባቡሩም ተጫነ ስልክም ተናገረ፤

ይኸ በማን ጊዜ ተደርጎ ነበረ፤

ምኒልክ ነቢይ ነው ሆኖ ጠረጠረ፤

የሀበሻው ንጉሥ ምኒልክ ነቢይ ነህ፤

ኃላፊውን ትተህ መጪውን ታውቃለህ። (Source: ETC 1996 wall calendar.)

The corresponding English translation is:

The train was loaded; Telephone also talked;

During whose time was this done?

I suspect Menilk, he is a prophet!

Menilk, the King of Habesha; you are a prophet;

For you know the future, leaving the past.

ICTs are enabling mankind to gather, process, store, disseminate, and utilize information for best decisions. The telecommunications industry is the most dynamic component of ICTs. The combined application of ICTs in Internet is totally changing the tradition of communication. A recent technological development called *Voice over Internet Protocol (VoIP)*, or simply *Internet telephony*, made it possible to use the Internet Protocol for telephony purpose. VoIP enables the transmission of packetized digital voice over data networks, eliminating the need for separate networks for voice and data.

VoIP converts analog voice to digital and then the digitized voice into data packets that are encapsulated over Internet Protocol, and hence, unites the telephony (voice) and data worlds. It compresses voice on the network so that the same bandwidth capacity can now carry greater amount of voice packets. Due to its efficient utilization of bandwidth resource and its ease of managing a single network for voice and data, which required different networks, it saves cost of telecom operators and enables them to provide telephone services at very low price that almost equates the costs of making international and domestic calls.

With the fast improvements being made on its voice quality problems and with its promise of low costs and new revenue generating services (Doshi, et al, 2003), VoIP has received much attention and is becoming the choice of many countries including Egypt, South Africa, Gambia, Ghana, Mali, Morocco, Nigeria, Senegal, Uganda, and Kenya (IBA Forum, 2004). It is predicted that most traditional public switched telephone services are likely to migrate towards VoIP with in few years (Beritelli, et al, 2003).

1.1.2. Telecommunications in Ethiopia

The telephone technology was introduced to Ethiopia in early 1890's during Emperor Menelik II. Its use was limited within the Emperor's palace in Addis Ababa until some time and soon expanded to regional towns. The technology, since then, has undergone the following milestones:

Year	Events (accomplishments)
1897	The Harrar-Addis Ababa telephone line completed.
1905	The 880 – kilometer Addis Ababa-Asmara telephone line completed.
1907	Emperor Menelik advocated Ethiopia's membership of the International Telecommunication Union (ITU).
1932	Ethiopia became member of International Telecommunication Union (ITU).
1934	170 towns and villages become the beneficiaries of telephone services.
1941	A 1,500 - line automatic telephone exchange installed in Addis Ababa.
1953	Ethiopian Telecommunication Board established.
1974	Ethiopian Telecommunications Authority (ETA) established.
1979	Establishment of Satellite Communication Earth Station to facilitate international telephone, telex, telegraph and television services.
1981	The Addis Ababa-Debre-Markos-Bahr-Dar Gondar microwave line goes operational.
1988	Digital exchanges go operational in Addis Ababa and other major towns for the first time.
1996	ETC gets establishment as a Corporation.
1997	Internet Service gets introduced.
1999	Mobile Telephone Service gets introduced.

Source: Ethiopian Telecommunication Corporation)

Table 1.1: Milestones in ETC

Ethiopian Telecommunications Corporation (ETC), a government owned establishment and the sole provider of telecommunications services in Ethiopia, was established in 1996 as a corporation to undertake the following major objectives (Proclamation no 10/1996):

- To engage, in accordance with development policies and priorities of the government, in the construction, operation, maintenance and expansion of telecommunication services;
- To provide domestic and international telephone, fax and other communication services;
- To provide communication services using integrated information technology, including rebroadcast of television broadcasts;
- To repair, assemble and manufacture telecommunications equipment;
- To render training services to telecommunication personnel;
- To engage in other related activities necessary for the attainment of its purpose

ETC, with more than 8000 permanent and 3000 contract employees and through its 6 Zonal offices and 8 Regional offices, is providing services to: 14,179 Internet subscribers, 536789 fixed telephone subscribers and 206,346 mobile subscribers (ETC Monthly Statistical Report, Feb. 2005).

Currently, it is undertaking huge projects to realize its vision of connecting the country with world-class ICT infrastructure to provide high quality, reliable services at affordable prices. The corporation is giving more priority to customer satisfaction, which will serve as the success measurement criteria. However, the digital divide still characterizes Ethiopia, as it is the least connected with ICT technologies. The following table depicts this reality.

Region	Tel Lines/100	PCs/100	Internet Users/10,000
Africa	6.0	1.2	99.6
Asia	12.1	4.0	557.6
Americas	35.3	27.5	2421.0
Europe	40.9	20.0	2079.0
Oceania	40.4	38.9	3330.5
World	18.0	9.2	972.2
Ethiopia	1.06		2.03 (as of 2004)

Source: ETC and Hudson, Derived from ITU, Basic Indicators and Internet Indicators, 2002.

Table 1.2: Internet Access Indicators

Besides, there is no customer satisfaction due to poor quality of service (years of waiting period for new subscription, frequent fault, delayed fault maintenance, exaggerated billing, high international telephone tariff, ...) and ETC is losing revenue amounting to tens of

millions from international telephone calls due to the uncontrollable, hidden/illegal operation of the latest telephone technology - Internet telephony (VoIP). Thus, although ETC seeks to bring home the latest telecommunication networks and technologies, there are cases where the customers are ahead of the corporation in deploying such new technologies.

1.2. Statement of the Problem

Since 2001, VoIP has been making great wave in Ethiopia as in other African countries (Balancing act news, 2004). When small operators engaged in providing international telephone service at a rate of Birr 4 per minute using VoIP when ETC continued its traditional service with the usual high tariff rate (Birr 17 per minute), many Ethiopians were not late to use the low cost opportunity brought about by the operators. This shift of telephone consumption brought a devastating reduction of ETC's revenue from international calls, which was contributing to more than 50% of its operational revenue. Since then, ETC's revenue from international calls is endangered and is still declining when compared to the revenue from domestic (local) calls.

Because of this great loss in revenue from international calls, the provision of Internet telephony is tagged as illegal act in Ethiopia, contrary to the world trend. ETC disconnected and dismantled the telephone service for the "illegal" providers and they were taken as prisoners for more than six months. Besides the government's measures against the "illegal" VoIP service providers, some are still in the operation and gaining non-taxed income. ETC is still announcing for the people not to use the Internet for telephony, which indicates it could not control the provision of VoIP.

Even before this, VoIP was pointed as a major threat to ETC's revenue. In a Company Analysis Report by the Ethiopian Privatization Agency (2000), it is stated that ETC's revenue from international calls is subjected to such major threats as VoIP and other forms of international competition.

ETC is also being affected by global competitions. With the need to organize global telecommunication networks, many leading companies in the telecommunication industry

are offering global communication services. AT&T WorldPartners Association, for example, offers a service called Worldsource (Bohlin and Levin, 1998). AT&T's implementation of Virtual Private Networks (VPN's) technology to establish global network will allow Internet Service Providers (ISP's) to offer IP telephony to 140 countries, with AT&T managing the routing service (Hermes Group, Ibid). This indicates that ETC will no more be the sole provider of telecommunication services in Ethiopia and people as such may benefit from the competition of various service providers.

The actions that are being exercised on "illegal" Internet telephony service providers couldn't stop their operation. As a result, the following problems are being observed in the country:

- ETC is losing its revenue due to uncontrollable Internet telephony users and it couldn't be the beneficiary of reduced operational costs from VoIP;
- The government is also losing tax from the income of the "illegal" Internet telephony service providers.
- The people is deprived from the fruits of VoIP technology and subjected to high cost of traditional circuit switched telephone calls.

This research was, therefore, initiated by the fact that:

1. VoIP is the cheapest technology for voice transmission, and it may help in creating an opportunity to narrow down the digital divide and build an information society in poor countries like Ethiopia;
2. There are potential global competitors that are using low cost VoIP technology in contrast to ETC's high cost traditional telephone service;
3. ETC couldn't actually control the hidden operation of VoIP in Ethiopia. It also neither set a competitive international tariff nor joined the technology; a threat for ETC to lose revenue from international calls and the government to lose revenue from collectable tax.

Thus, the research tried to answer the following questions:

1. What is the effect of implementing VoIP in Ethiopia on ETC's revenue?
 - VoIP resulted with lose of revenue in many cases and gain in some cases.

- What will be the effect of VoIP on ETC's revenue?
 - To what extent will the effect be?
2. What is the effect of VoIP on government tax?
 - It is losing tax from "illegal" Internet telephone providers and implementing VoIP will raise tax collection.
 - But, to what extent?
 3. To what extent will VoIP increase information transfer in Ethiopia?
 4. What will be the losses and gains of customers from VoIP? Will VoIP get their acceptance?
 5. What other impacts will VoIP have? Will it demand new telecom infrastructure and workforce or not?
 6. What decisions should ETC take regarding VoIP?

In addressing these issues, the researcher reviewed similar studies. There were plenty of researches world wide indicating that VoIP is the best technology in narrowing the digital divide and bringing economic development (Aochamub, A. et al, 2002; Chetty, M. et al, Canessa, et al, 2003, and Joslin, 2004). However, there was no previous research related to this one in Ethiopia. An inversely related work was proposed in May, 2003 by the Network Performance Management Division of ETC. The proposal "Method of Preventing IP Telephony" indicated the possibility of identifying IP telephony packets from the Internet packets and recommended the need to purchase appropriate VoIP traffic measurement software.

1.3. Objectives of the Study

The general objective of this research is to investigate the opportunities and challenges of VoIP in view of suggesting decisions to be made regarding its implementation in Ethiopia.

In order to achieve the general objective, the following specific objectives were undertaken:

1. To study the status of Internet telephony (VoIP) world wide and in Ethiopia.
2. To investigate the impacts of VoIP on ETC's revenue from international calls, on resellers' revenue and government's tax collection, and on information transfer.

3. To assess the effects of VoIP on telephone consumption of users and evaluate its acceptance in the market.
4. To assess the conditions for implementing VoIP in Ethiopia.
5. To draw conclusions and forward recommendations based on the findings.

1.4. Application of Results

The results of this research can be used:

- As an input for the development of full-fledged information policy framework for decision makers on legalizing VoIP in Ethiopia.
- As a scientific ground for officials on making decisions regarding the implementation of VoIP.
- As an input for ETC to strategically planning how to use VoIP for business advantages.
- As a ground for researchers on the technical implementation of VoIP in Ethiopia.

1.5. Scope of the Study

Digitized voice can be transported via such packet switched networks as IP, ATM, and Frame Relay. This research dealt with voice transmission over IP (VoIP), i.e., the Internet telephony. This quantitative research tried to address socio-economic and technological issues that are related to assessing the possibility of deploying VoIP in Ethiopia. It focused on estimating the impacts associated with implementing VoIP; on identifying the challenges and opportunities of VoIP in Ethiopia. Political considerations were not covered in this respect.

CHAPTER 2: REVIEW OF LITERATURE

The basic concern behind incumbent telecom operators over VoIP arises from the notion that it has a potential of negative effect on their revenue from international traffic. This impact has gained much attention from the operators and is really a challenge. But, aren't there other challenges and opportunities associated with VoIP that the operators should be concerned of and enjoy from? This question is well addressed in developed countries and this section of our research reviews previous researches on the challenges and opportunities as well as the current trends in manipulating the opportunities of VoIP resisting its challenges and the technology is briefly described first.

2.1. Circuit Switching vs Packet Switching Technologies

The content of data transmission is either analog such as voice and video, or digital such as text (character or integer). While digital data take discrete values on an interval of time, analog data take continuous values (Stallings, 2000). Voice, which is a continuous or analog data, travels over distance in a form of wave.

In terms of the speed and order voice travels, it is commonly concurrent between the sender (speaker) and the receiver (listener). Effective voice transmission requires, therefore, no delay between the communicating parties and no voice variation (Ibid). To guarantee these requirements of voice traffic, a constant transmission rate must be maintained, i.e., voice received by the destination must be in the same signal rate and in the same order with voice send by the source.

Telephone was primarily designed to transmit analog (voice) signals as far to a distance as there is some form of connection between the sender and the receiver. For over 100 years, therefore, communicating stations that are using Public Switched Telephone Networks (PSTN) have been exchanging voice in a continuous (analog) form via dedicated telephone lines (Flanagan, 1997). Such a communication that uses a dedicated path between two

stations is called circuit switching. The network hardware establishes a *circuit* between two communicating parties (Comer, 2004).

Circuit switching technology is designed to achieve the requirements of voice transmission. For this purpose, there must be a dedicated line that is ready to take voice data from every person or station that is connected to a public telephone switching. When a person handles the telephone handset to make a call, he will immediately get a dialing tone. When the caller dials the destination telephone number, therefore, the called number (the receiver's telephone) will ring as there is a dedicated path or circuit that takes the call to the destination. This way, voice will be effectively transmitted without delay or distortion.

Such a communication using circuit-switching technology involves three phases (Stallings, 2000):

1. An end-to-end circuit establishment;
2. Data transfer from sender to receiver;
3. Circuit disconnection or connection termination.

This indicates that in circuit switching, a connection path is established before voice transmission actually begins and this is wastage of channel capacity. Thus, adequate channel capacity must be reserved even at times when there is no voice transmission, and this creates idle (unutilized) channel capacity. Despite the fact that this monopoly of line by a call guarantees a reliable voice transmission, there is inefficient utilization of transmission bandwidth (ibid).

Packet switching is an alternative technology to circuit switching for digital data transmission. In packet switching technology, the digital data to be transmitted is first broken down into small, manageable pieces called packets, sender and destination identifying information (address) is then added to each packet, and finally, each packet is transmitted over the network (Bates and Gregory, 2000). The received packets are to be collected and reassembled by the receiving station in such a way that it resembles the original data.

Packets are the basic units of network communication. Data usually exists as large files. However, networks cannot operate if computers put large amounts of data on the cable at the same time. A computer sending large amounts of data monopolizes the network and causes other computers to wait. With data divided into packets, individual transmissions are accelerated so that every computer on the network has more opportunities to transmit and receive data.

While the sending computer breaks data into packets, it adds special control information (source and destination address identifier) to each packet. This ensures the arrival of packets to the desired destination, helps to reconstruct or reassemble the message in the correct order by the receiver, and check the data for errors.

Packetization facilitates the transmission of large data size over limited bandwidth. Besides, since there is no dedicated connection between the sender and the receiver, packets are transmitted in the network by selecting free or least congested paths and may arrive at the destination separately and from different paths. For this reason, packet switched technology enables efficient utilization of network resources.

The drawback of packet switching is that when packets took different paths, there is a possibility of arrival of messages in wrong order or message distortion, delay of message, and even packet loss (Tanenbaum, 2002 and Hermes Group, 2003). That is why packet switching, until recently, was not preferred for voice transmission as delay and packet loss can highly affect the quality of voice.

In short, while each packet in packet switching contains destination address, information flowing over circuit switching does not contain any address (Hsu, 1996). Voice in circuit switching is transmitted over a dedicated line, which makes the technology reliable but less efficient in network resource utilization and too costly (Stallings, 2000). Data over packet switching is transmitted over the least congested path, which makes the technology very efficient in network resource utilization and too cheap but unreliable means of communication as there is no dedicated connection.

However, it is possible to convert analog data to digital form and vice versa for the convenience of the network. Thus, we can transmit digital data using circuit switching. Technology is also making it possible to digitize analog data like voice and transmit it in packet forms using packet switching technology.

2.2. Internet, Internet Protocol, and VoIP

Internet is a vast collection of **interconnected networks** that all use the TCP/IP protocols for the transmission of packets. Unlike centrally controlled services, the Internet is decentralized by design. A computer connected to the Internet can get information from/or talk to any other connected computer using the TCP/IP protocols.

The Internet grew out of an experiment in 1960's by the US Defense Department. It was originally designed to enable computers to transfer data efficiently during a nuclear attack expected from the Russians. The successful launch of Sputnik by the Russians created a great fear on USA and, as a result, they designed a special decentralized network called ARPANET so that if part of it were destroyed, the remaining parts had to work properly.

A **protocol** refers to a set of rules that defines how computers interact, including the formats of the message to be exchanged, how errors are handled, and what actions to be taken on the transmission/receipt of information (Comer, 2004 and Kurose and Ross, 2003). **Internet protocols** are sets of rules that specify data compression and decompression formats, the packet size, addressing formats, error detection and control mechanisms, etc. **VoIP protocols** are again sets of rules that specify voice compression and decompression formats, the voice packet size, addressing formats, error detection and control mechanisms, etc. They enable the transmission of voice packets over data networks that use the Internet Protocol. The communicating parties have to follow these rules for better quality voice communications.

Voice over Internet Protocol (VoIP) is the transmission of data and voice across networks that use the Internet protocol. VoIP was initiated in 1995 by Israel firm VocalTec (Phillips, 1999 and afrispa, 2002) and is stated as the biggest move in the telephone industry since its

development by Alexander Graham Bell in 1876 (BusinessWeek, 2004). By converging the circuit switched voice transmission and packet switched data transmission technologies, VoIP converts digitized voice into data packets that are encapsulated over Internet Protocol, and hence, unites the telephony (voice) and data worlds.

VoIP covers such concepts as packetization (segmenting voice signals into packets), voice codecs (voice compression at the sender and decompression at the receiver), echo cancellation, and call processing (Shirasawa, et al., 2004). Voice calls are digitized, encoded, compressed, and packetized; and use a gateway to provide seamless connectivity between the different networks and technologies. As an alternative to the gateway, it is possible to use a gatekeeper that provides the system control functions such as caller authentication, routing tables, call accounting information, and billing associated details (Juneja, 2003).

In contrast to the public switched telephone networks (PSTN), there are three packet switched networks that transport digitized voice: IP, ATM and Frame Relay. ATM (Asynchronous Transfer Mode) is a connection-oriented packet switching and multiplexing technology developed for broadband signals (Anyion Group, 2005). Frame relay is a high speed packet switching protocol used in WANs often to connect Local Area Networks (LANs) to each other (Ibid). While IP is a connectionless technology, ATM and Frame Relay are connection-oriented (Comer, Ibid) and reliable, but more expensive than IP. Besides, while Voice over Frame Relay (VoFR) and Voice over ATM (VoATM) carry voice traffic over a *frame relay network* and an ATM network respectively, Voice over IP (VoIP) is used to transmit voice over an IP network -the Internet (Ahmed, 2005).

2.3. VoIP Connection Forms

VoIP connection can be between two PC users, between a PC user and a regular telephone user, between regular telephone users, or between an IP-enabled phone user and a PC or a regular telephone user (Darlington, 2004). The following sections will describe each VoIP connection type and how VoIP calls are processed.

2.3.1. PC-to-PC Connection

This is a common format of VoIP where users have to be connected to the Internet and need to have audio-capable PC (microphone, speakers, and sound card; or headsets instead of microphone and speaker). This form is a typical and easiest VoIP scenario that helps to integrate voice with other Internet services. The software that enables this connection is freely available on the Internet. <http://www.skype.com> is an example.

The following process will take place in PC-to-PC form of connection (Baxter, et al, 1998):
The call initiator computer:

- Records and generates the sound using appropriate equipment.
- Digitizes the recorded sound using an analog-to-digital converter such as modem.
- Converts the digitized voice into transmission units (packets) or compresses and breaks down into packets using codecs. This is done due to the fact that the sound is going to be transmitted on the Internet and all Internet traffics must be in packet forms.
- Adds the source and destination addresses to each packet.
- Routes these packets with other traffic on the Internet. Then they will be directed by Internet routers and servers over the Internet based on the identifying information until they arrive at the desired destination.

The computer at the destination:

- Collects, reassembles, and decompresses the received packets.
- Converts the packets into analog signals, i.e., into the natural sound form.
- Conveys the analog signals to audio tools (head phones or speakers).

A PC-to-PC connection model can be represented in the following figure:



Fig. 2.1: A PC-to-PC VoIP model

The service cost is a function of costs of ownership and maintenance of the PC (with modem and sound or a dedicated device) and the costs of Internet access including the local call while connected to the Internet.

2.3.2. PC-to-PSTN (or vice versa) Connection

The PC-to-PSTN or PC-to-Phone connection indicates the communication between a caller with an Internet connected PC (like PC-to-PC connection) and a receiver with any ordinary telephone connected to a Public Switched Telephone Network (PSTN). PC-to-PSTN connection needs a gateway to properly communicate with an ordinary telephone connected to PSTN. Gateways link the PSTN and the Internet and convert the Internet call that came from the caller to a PSTN call.

The service cost here is a function of costs of the PC (with modem and sound or a dedicated device), the costs of Internet access (including the local call while connection) and the cost charged by the gateway operator of the destination PSTN that is determined by the costs of the call placed from the gateway to the receiver.

In a reverse manner, a PSTN-to-PC or Phone-to-PC communication can be initiated by a telephone that is connected to traditional PSTN and terminate to an Internet connected PC. Here, the local PSTN to the caller needs to be connected to the Internet through a gateway or, as a low cost option to the investment on the gateway, can subscribe this services from Internet Telephony Service Providers (ITSPs) which provide gateways to traditional telephone networks, so that the calls from the local PSTN side are routed via the provider's gateways to the Internet.

The service cost is determined by costs charged by a gateway operator (if the local PSTN is a subscriber to ITSP's gateway) and the local call costs of the PSTN.

The following figure models a PC-to-Phone or Phone-to-PC connection:

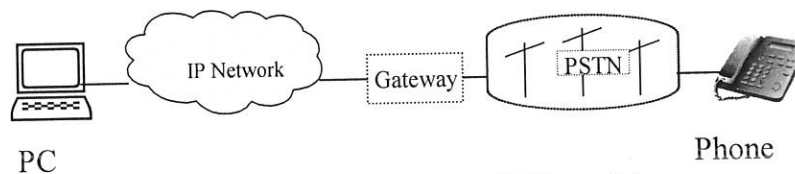


Fig. 2.2: A PC-to-Phone or Phone-to-PC VoIP model

It is possible to connect the telephone directly to the IP network with the help of special devices called an IP star or a special adaptor. A regular phone can be connected to the Internet or to a computer using an adaptor called **ATA** (analog telephone adaptor). The ATA is an analog-to-digital converter that takes the analog signal from a traditional phone and converts it into digital signal for transmission over the Internet (Tyson and Valdes, no year).

Providers like Vonage and AT&T CallVantage provide ATA freely on subscription of their service. The IP star or ATA adaptor enables the regular telephone to make a VoIP call to a PC (Phone-to-PC connection), or to a phone (Phone-to-Phone connection) where its server PSTN is connected to IP network through gateway or through service providers' gateways.

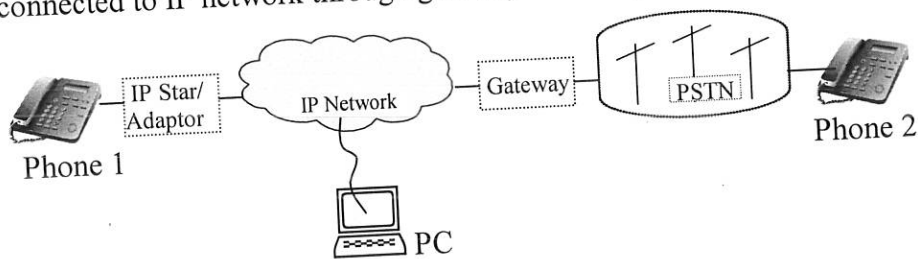


Fig. 2.3: A Phone-to-PC VoIP model using IP star or ATA adaptor

2.3.3. PSTN-to-PSTN (Phone-to-Phone)

Neither the caller nor the receiver has PC and connections to the Internet. If both parties use ordinary telephones (with no special adaptor) that are connected to their respective PSTNs, then gateways are required on both PSTN sides connect them to the Internet using gateways. That means, a call needs to pass one gateway to connect PSTN-to-Internet at the caller and another gateway to connect Internet-to-PSTN at the receiver. This connection can be shown in the following figure:

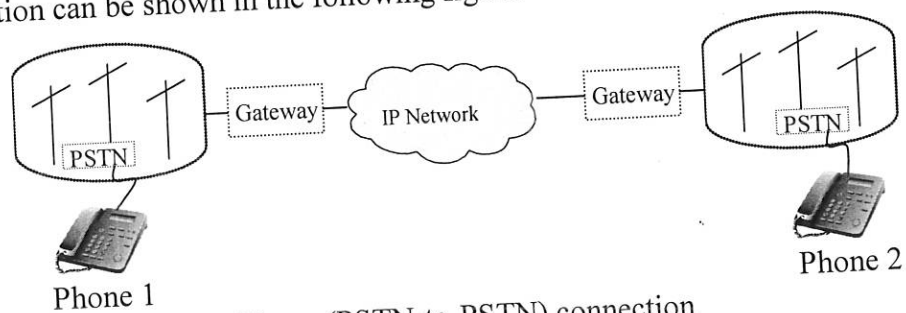


Fig. 2.4: Phone-to-Phone (PSTN-to-PSTN) connection

The process during Phone-to-Phone format is as follows (Baxter, et al, 1998):

- The caller, over the PSTN, connects to an Internet telephony gateway.
- The Internet telephony gateway answers the call and prompts the caller to enter the phone number of the person he wants to communicate.
- The Internet telephony gateway will look for the remote gateway that is local to the receiver. The second gateway will locate the receiver by placing a local PSTN call.
- Once the connection is established, voice travels from the caller side PSTN on the Internet to the receiver side PSTN.

The service cost of a phone-to-phone or PSTN-to-PSTN connection is a function of costs charged by both gateway operators and the local call costs of the PSTN at the caller. The costs charged by the destination gateway operator are determined by the costs of the call placed from the gateway to the receiver.

2.3.4. IP Phone-to-PSTN or IP Phone-to-PC

IP phones have the required hardware and software to handle VoIP calls. The caller with IP-enabled telephone dials a telephone number connected to a PSTN or to a PC connected to an IP network. The PSTN at the receiver side needs to be connected to the Internet through a gateway or can subscribe from Internet Telephony Service Providers (ITSPs) which provide gateways to traditional telephone networks as in the case of PC-to-Phone connection.

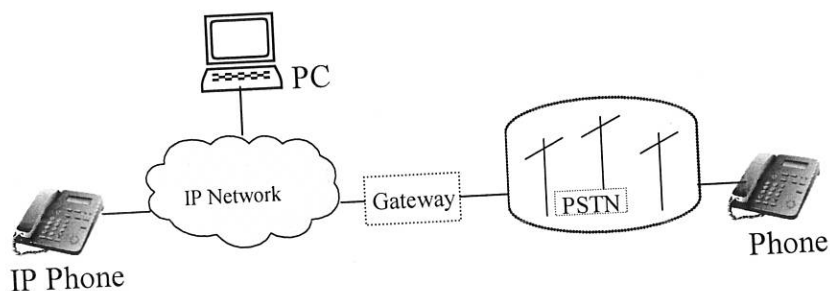


Fig. 2.5: IP Phone-to-Phone or IP Phone-to-PC VoIP model

2.4. Requirements of VoIP

Determination of detailed requirements for implementing VoIP technology need a careful study of organizational needs as requirements vary from one organization to another. Besides, the requirements depend on the selected products for VoIP and their vendors. This section tries to identify the high level general hardware and software requirements.

2.4.1. Hardware Requirements

Implementing VoIP requires such equipment as Gateways, PCs, and IP Telephones. However, there are various types of gateways and computers that have different capacities, indicating the necessity of linking hardware selection with company-specific requirements (Sunny Institute of Technology, not dated). Let's see them a little bit closer.

1. Gateways - are required to allow an IP telephony system to interoperate with PSTN or another IP telephone. The differences between IP based network protocols and the PSTN protocols can be bridged using gateways (Held, 2000) so that PC-to-PSTN or PSTN to PSTN connections of VoIP are achieved.

As stated by Comer (2004), we can see gateways in three categories:

- **Media Gateway** - is located at the interface between the PSTN and the IP networks and translates audio that is brought about by one of the networks to a form suitable to the other network. This device is also required during PC-to-PC connection if the IP networks at each end do not use similar encodings. Such a gateway takes a standard telephone (analog) signal and digitizes it before compression. The digitized voice signal is compressed using a Codec, the compressed data is placed into IP packets, and these packets are routed over the network to their destination.
- **Signaling Gateway** - accepts a call request from either side, translates the request as appropriate, and forwards the request to the destination on the other end.
- **Media Gateway Controller** - coordinates IP telephones and controls the functions of Media Gateway and Signaling Gateways.

2. PCs - are required at both ends (caller and receiver) in PC-to-PC connection and at one end in PC-to-Phone connection. It is possible to run VoIP on IP connected PCs that have the following components (Miniwatts International, 2004):

- Windows NT 4.0+ or Windows 98 or newer.
 - 166 MHz or higher and a 32MB RAM and 56 kbps Modem.
 - Full duplex sound card - enable caller and receiver to have real time communication (to talk at the same time).
 - Microphone or headsets - to receive voice samples from the caller.
 - Speakers or headsets - are required at the receiver to get the transmitted voice.
- While headsets can be used at both ends, microphones are used for input purpose at the caller and speakers are used for audio output at the receiver.

3. IP Phones - are IP-enabled telephones that have additional features besides to their function as regular telephones. IP phones are connected to an IP network unlike the regular phones that are connected to PSTN. They have an RJ-45 connector (see Fig. 6 below) so that they can be plugged to an IP network as opposed to regular phones having the standard RJ-11 phone connectors which can be plugged to local PSTN (Tyson and Valdes, no year). IP phones replace the requirement for PC.

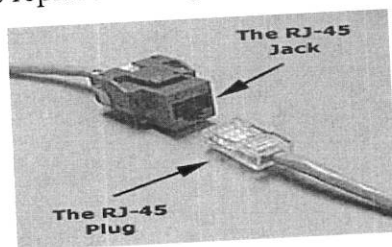


Fig. 2.6: The RJ-45 jack and plug.

2.4.2. Software Requirements

Although the specific software requirement can be chosen after the determination of organizational needs as stated earlier, VoIP needs software that contain Voice Processing, Voice Playback, Call Signaling, Packet Processing, and Network Management Protocol modules (Sunny Institute of Technology).

1. Voice Processing Module is required to prepare voice samples for transmission. It supports:

- A *Pulse Code Modulation (PCM)* Interface - to encode audio by continuously receiving samples from the telephony interface such as voice card, and forward them to the VoIP software for further processing.
- *Echo Cancellation* - to reduce or eliminate the echo introduced as a result of the round trip exceeding 50 milliseconds.
- *Idle Noise Detection* - to hold back packet transmission on the network when there are no voice signals to be sent.
- A *Tone Detector* - to discriminate between voice and fax signals.
- The *Packet Voice Protocol* - to encapsulate compressed voice and fax data for transmission over the network.

2. Voice Playback Module is needed at the call receiver to hold the incoming voice packets before they are sent to the Codec for decompression.

3. Call Signaling Module serves as a signaling gateway that allows establishing calls over a packet switched network such as the Internet.

4. Packet Processing Module is required to process the voice packet signals that are ready for transmission on the IP based network.

5. Network Management Protocol is required for fault, accounting and management purposes.

2.5. Challenges and Opportunities of VoIP

Many challenges are associated with VoIP. But it also has tremendous opportunities that attract the telecommunication's world. We will review what challenges and opportunities are identified from literature.

2.5.1. Challenges of VoIP

Revenue of Operators:

Since VoIP has an opportunity for making low cost international calls, there is a general trend that revenue of telecom operators which are derived primarily from international

traffic can be affected by VoIP. Taking this idea a granted, fact for many operators has been considering VoIP technology as the biggest threat in the telecommunications industry. However, it is not always the case and there is no general consensus among researchers. Before Internet telephony, there were other technologies such as call-back, international resale, and whipsawing that have been threats to revenue from international calls. These technologies were perceived as VoIP to have negative effect on the revenue. Researchers have argued that these technologies have put pressure on accounting rates for international telephone calls. It is clear that these services would have already reduced accounting rates to the point that VoIP should have no impact, and if there were a negative impact on infrastructure it would have happened in the early 1990s when call-back services were entering international telecommunication markets (Murillo, 2004).

Quality of Voice:

VoIP uses the Internet for the transmission of voice and the Internet or any network for that matter, is susceptible for data delay and even complete loss. Delays or even complete loss of voice packets is likely to occur in VoIP technology therefore. So while we use Internet telephony rather than the traditional PSTN, we may achieve band width utilization efficiency and cost effectiveness at the expense of quality of voice unless we meet quality of VoIP service standards.

As VoIP traffic is very sensitive and has a very low tolerance for delays, Quality of voice in VoIP can be assured by control delay not to be greater than an upper tolerable limit, 50 milliseconds (Held, 2000). Quality of voice, although depends on the type of hardware used, is a function of Transmission delay, Jitter, Packet loss, and Echo (Doshi, et al, 2003).

Transmission Delay - which arises from the following sources:

- **Accumulation Delay** - is caused by the need to collect voice samples to be processed by the voice coder. The voice coder type used accounts to this delay.
- **Processing Delay** - is a function of the processor execution time and the type of algorithm used. It is caused by the actual process of encoding and converting the encoded samples into packets for transmission.
- **Network Delay** - is a function of the capacity of the links in the network and the processing that occurs as the packets travel over the network. It is caused by the

physical medium and protocols used to transmit the voice data and by the buffers used to remove packet jitter on the receive side.

Jitter - is the amount of variation in delay or transmission of packets at an uneven inter-packet time (Comer, 2004). Removing jitter to have even inter-packet time requires collecting packets and holding them (in **Jitter buffer** – a memory for placing voice packets) until the arrival of the slowest packets so that all packets can be played in the correct sequence. This by itself causes additional delay.

Packet Loss - is common in VoIP since IP networks are not reliable when compared to connection oriented transmission system and since voice packets are treated like data in IP networks. Voice Packet loss, like data packet loss, occurs during network congestion or at peak hours. But, while dropped packets of data can be retransmitted as they are not time sensitive, loss of voice packets cannot be handled by retransmission, as voice is time sensitive.

Echo - is a situation where the speaker's voice comes back into his ear during conversation due to signal reflections from the far end telephone equipment. Since echo is perceived as a significant quality problem, voice over packet systems must address the need for echo control and implement some means of echo cancellation.

Security Challenge:

Since VoIP traffic is really just data on the network, VoIP is exposed to all network-based security risks common to data traffic. Hackers, for example, could eavesdrop on conversations, interfere with audio streams, or disconnect, deflect or even answer other people's phone calls, and launch denial of service attacks (Ryan *et al*, 2005).

Unless there is proper management and configuration, the VoIP traffic itself can be subjected to interception, playback and tapping. When deploying VoIP, we have to take the necessary safeguards to protect the voice traffic and ensure privacy. Most suppliers offer security features such as voice encryption for VoIP. Successful implementation of VoIP demands a careful selection of the right manufacturer with capabilities that guarantee secured transmission of voice.

Integration with PSTN, Interoperability, and Scalability Challenges:

Implementing a VoIP system requires the consideration of utilizing existing resources. VoIP have to work in conjunction with PSTN as it allows the usage of the existing circuit switched networks to the foreseeable future and enable PSTN-to-PSTN and PC-to-PSTN connections. Gateway technologies are developed to link the two network worlds.

In order to make VoIP a communication tool for many users, products of various vendors must function with each other in a public network environment. But unless vendors follow similar standards, a multi-vendor product can have different qualities, making the same products incompatible. ITU's H.323 standard is recommended for software and hardware vendors. Implementation of VoIP demands selecting H.323-complaint products so that products can be compatible enough to functioning each other.

A VOIP system needs to be flexible enough to accommodate larger target market. The equipment to be chosen for implementing VoIP should have the capability of integrating the large-scale scalability and ease of administration requirements (University of Minnesota, 2005). There are many network management technologies and products to address the scalability issue.

2.5.2. Opportunities of VoIP

If the quality standards are maintained, VoIP is proved to have the following advantages over the traditional public phone (Department of Trade and Industry, 2005; IBA Forum, 2004; and Hermes Group, Ibid).

Effective network capacity utilization and Reduced phone bills:

Voice in VoIP technology is treated as data. As a result, IP telephony call takes up 6 to 8kbps when compared to circuit switched calls that take up 64kbps; making it easy to transmit many voice packets with a small bandwidth or at a lower cost. As a result, cost of international calls using VoIP is almost the same as making local calls. There is no reason to pay much more costs for international calls than for domestic calls. Specially, calls within a VoIP-enabled network and calls between subscribers of the same Internet

Telephony Service Provider (ITSP) are totally free of charge (Shirasawa, et al., 2004). For instance, the US\$ 5.67 cost of a minute's call from Japan to US in 1994 has drooped to US\$ 0.06 per minute in 2003 using VoIP (Joslin, 2004).

Simpler infrastructure and Improve productivity (cost saving):

It is easier to add telephones on a computer network and increase call capacity with no need of additional cabling. It reduces network management cost for service providers as it is easier to manage a single network that handles all-in-one (voice, data, and image) than to manage separate networks for each service. With VoIP, telecom service providers can merge their separate networks for voice, data, and videoconferencing services into a single network, reducing operational expenses associated with these separate services as a result (Morrow and Vijayananda, 2003). The fact that a US-based company (The Nasdaq) has cut off its US\$100million annual network cost by US\$40million by using VoIP to consolidate its 15 networks into one supports this idea (Comindico, 2000). The opportunity of VoIP to reduce operational expenses, therefore, avoids the risk of high initial investment.

Improved customer services and additional service opportunities:

It facilitates customer relationship as it makes possible for customer service staff to keep in touch with web users by adding a 'Click to talk' button to a website. Incoming calls could automatically activate screen displays with customer account information and contact history. The customers can be provided with such additional services that were not in PSTN technology as:

- IP multicast conferencing and telephony distance learning applications;
- Phone directories and screen popping via IP;
- Voice web browsing (interaction with the web page by speaking); and
- Sequential or simultaneous calls. VoIP calls can be sent to several phones at once, sequentially or simultaneously (Businessweek, 2004). So if the intended receiver is not at home, the call will go to his cell phone and if he does not answer it there, the call will proceed to his office or PC phone; allowing the receiver to answer calls at his convenience.

2.6. Current Status of VoIP

With the fast improvements being made on its voice quality problems and with its promise of low costs and new revenue generating services (Doshi, et al, 2003), VoIP has received much attention and is becoming the choice of many countries. This section will provide trends in using VoIP world wide, in Africa, and in Ethiopia.

2.6.1. VoIP Worldwide

The share of VoIP for international telephone traffic worldwide is rising rapidly as can be seen in the table below (TeleGeography, 2003).

Year	VoIP Traffic in minutes	Annual % growth	PSTN Traffic in minutes	Annual % growth	Share of VoIP
1998	150,000,000	-	93,000,000,000	-	0.2%
1999	1,655,000,000	1003%	108,000,000,000	16%	1.5%
2000	5,954,000,000	259%	132,027,000,000	22%	4.3%
2001	10,147,000,000	70%	146,095,000,000	11%	6.5%
2002	18,045,000,000	78%	155,165,000,000	6%	10.4%
2003	24,519,000,000	36%	166,615,000,000	7%	12.8%

(Source: Tele Geography Research, 2003)

Table 2.1: International VoIP and PSTN Traffic Summary, 1998 - 2003

The following facts depict what is happening on the world towards using VoIP (Comindico, Ibid; Darlington, 2004; FierceVoIP, 2005; IDC study, 2005; Lamb, 2004; and Voiceglo, 2004; Mendler, 2003):

- Telecom Italia built a national backbone network that is connected to VoIP at a national transit exchange level, thereby slashing 30% of its operational cost in 2003.
- VoIP, which has been in use mostly in universities and companies of the western world, is now implemented for residential or home use. A VoIP service provider IDC has 3 million residential subscribers in 2005 and planned to provide its service for 27 million residential users in 2009 in U.S.A. (IDC study, 2005).

- Over 25 million users currently signed up for Skype's service worldwide and this number is expected to increase to between 140 and 245 million by 2008 (Balancing act - Issue No. 246, 2005).
- Voiceglo, a global VoIP communications company, has more than 1,800,000 users on its global VoIP network.
- Boeing, which has 150,000 employees and offices in 70 countries, announced it would use VoIP for all internal calls.
- In USA, Vonage has over 100000 subscribers. It has residential plans ranging from \$14.99 per month for 500 anywhere minutes to \$34.99 per month for unlimited calls in the U.S. and Canada and provides international call services at rates of \$0.02 per minute to London, Hong Kong, and Rome; \$0.03 to Sydney and Tokyo; and \$0.04 to Singapore and Tel Aviv (Cahlin, 2004). AT&T, SBC and Qwest are aggressively moving towards Voice over Internet Protocol (VoIP) services. Verizon, the US's largest telephone company, has also finalized the conversion of its traditional circuit switch network into one that handles VoIP. IBM planned to move 80% of its 300,000 employees to VoIP phone systems by 2008.
- In Canada, Telus of British Colombia has pioneered VoIP and Bell Canada intended to migrate 100% of its traffic onto a national Internet Protocol backbone network within three years.
- In Britain, BT (British Telecom) is already giving VoIP services for all businesses with Cisco and Nortel Systems and its current telephone network with 5600 local exchanges, 1200 Digital Subscriber Line Access Multiplexers, and 25000 Remote Concentrator Units with 170 core switches will be replaced by a new network with no more than 10 core routers. Vonage, the US-based company, has started offering VoIP service in the UK so that UK residents can have access to international virtual phone numbers with US, Canadian and Mexico City.

VoIP technology is becoming highly attractive and, as nobody wants to be the last one to adopt the technology that seems inevitable, the competition between traditional telecom and cable companies like AT&T, Qwest, Time Warner Cable, and Sprint, and VoIP-only providers such as Vonage, Net2Phone, Packet8, and Skype is becoming stronger and stronger (Cahlin, 2004).

VoIP is legal in all North America and the European Union. Many other countries in Asia and Africa are legalizing it, although at a slower speed (Joslin, 2004). It is predicted that most traditional public switched telephone services that are based on circuit switched networks are likely to migrate towards VoIP with in few years (Beritelli, et al, 2003).

2.6.2. VoIP in Africa

Some African countries such as Egypt, Moritius, South Africa, Gambia, Ghana, Mali, Morocco, Nigeria, Senegal, Uganda, and Kenya have already deregulated the provision of VoIP (Paul Budde Communication, 2005). As a result, service providers such as Deltathree, ITXC, iBasis, Net2Phone and Viper Networks are entering the market. Some countries do not have clear regulations on VoIP and this also has created the chance for various service providers to operate freely.

The provision of VoIP is restricted to the state-owned *public telecom operators (PTOs)* in some countries and the use of VoIP is completely prohibited in many countries. However, study shows that at least 10% of international calls in almost every country on the continent and up to 90% in some countries are carried by “illegal” VoIP operations (Paul Budde Communication, 2005).

The following table indicates that VoIP is being provided in the 54 African countries, using Skype’s VoIP services which has 25 million users worldwide and its freely downloadable software, with or without the knowledge and will of the local telecom operators (Balancing act - Issue No. 246, 2005):

Country	No. of Skype Users
Algeria	105
Angola	88
Benin	50
Botswana	12
Burkina Faso	32
Burundi	22
Cameroon	51
Cape Verde	21

Country	No. of Skype Users
Libya	2
Madagascar	54
Malawi	28
Mali	54
Mauritania	13
Mauritius	65
Morocco	307
Mozambique	22

Country	No. of Skype Users
Central African Rep.	12
Chad	33
Comoros and Mayotte	14
Congo	21
Congo, Democratic Rep.	60
Cote d'Ivoire	51
Djibouti	50
Egypt	356
Equatorial Guinea	6
Eritrea	11
Ethiopia	76
Gabon	41
Gambia	20
Ghana	44
Guinea	48
Guinea-Bissau	3
Kenya	46
Lesotho	4
Liberia	3

Country	No. of Skype Users
Namibia	42
Niger	55
Nigeria	96
Reunion	125
Rwanda	22
Sao Tome and Principe	5
Senegal	194
Seychelles	40
Sierra Leone	17
Somalia	45
South Africa	427
Sudan	5
Swaziland	66
Tanzania	64
Togo	45
Tunisia	78
Uganda	52
Zambia	52
Zimbabwe	64

Source: *Balancing act - Issue No. 246*

Table 2.2: Skype VoIP users in Africa

VoIP can help African countries to achieve development targets and it can support socio-economic development, as individual consumers, small businesses, government agencies, and community organizations can benefit from efficient data network utilization and low cost calls (2/10/2005 VoIP News). A survey of VOIP in South Africa conducted by World Wide Worx on 100 companies regarding their anticipated adoption and expectations of Voice over IP (VOIP) indicated that the adoption of VoIP will increase from 31% in 2004 to 78% in 2005 (Perry, 2005). These are indications that VoIP is paving the way to be an inevitable technology in Africa.

2.6.3. VoIP in Ethiopia

While some individuals began to provide Internet telephony service in Ethiopia around 2000 for Birr 4 per minute international calls, its power and impact was not noticed as in

other African countries. After a year (in 2001 and 2002), however, it was perceived by the sole telecom operator in Ethiopia (ETC) as the greatest threat on ETC's revenue from international calls. The effect of Internet telephony was reflected in these years through reduction in international incoming and outgoing calls as indicated in the following table.

Year E.F.Y.(G.C)	Incoming Calls in Minutes	%age change from previous	Outgoing Calls in Minutes	%age change from previous year
1989 (1996/97)	38140076	17.34	10690183	3.32
1990 (1997/98)	38797299	1.72	11839351	10.75
1991 (1998/99)	38586910	-0.54	12453411	5.19
1992 (1999/00)	36734936	-4.80	13420355	7.76
1993 (2000/01)	35632887	-3.00	13415739	-0.03
1994 (2001/02)	37541834	5.36	12882848	-3.97
1995 (2002/03)	54886817	46.20	14312370	11.10
1996 (2003/04)	133679022	143.55	17700238	23.67

Source: ETC's Yearly Statistical Bulletin 1996 EFY (2003/04), 39th issue

Table 2.3: International incoming and outgoing calls of ETC

Although many of the "illegal" Internet telephony operators were using ETC's telephone line and Internet connection for their service, there were some "illegal" operators who by-passed ETC's networks using their own satellites and switches so that they made it possible to make international calls (reducing ETC's outgoing calls) and to be accessed from abroad (reducing ETC's incoming calls) without using ETC's resources. As can be seen from the following table, the contribution of international calls to the total revenue of ETC has fallen from 66.56% in 1989 to 33.87% in 1994 (2001/02).

Year E.F.Y.(G.C)	ETC's Total Revenue in Birr	Revenue from International Calls	Share of International calls
1989 (1996/97)	551,799,495	343,083,309	62.18%
1990 (1997/98)	624,343,057	373,545,178	59.83%
1991 (1998/99)	624,092,248	336,581,211	53.93%
1992 (1999/00)	720,370,447	316,598,074	43.95%
1993 (2000/01)	932,189,605	356,705,969	38.27%
1994 (2001/02)	914,823,983	309,885,844	33.87%
1995 (2002/03)	1,018,326,513	326,302,153	32.04%
1996 (2003/04)	1,138,263,490	305,081,146	26.80%

Source: ETC's Yearly Statistical Bulletin 1996 EFY (2003/04), 39th issue

Table 2.4: Contribution of International Calls to ETC's Total Revenue

Following the huge losses arising from Internet telephony in 2001/2002 using the Internet for transmitting voice (VoIP) is declared as illegal in Ethiopia. The “illegal” VoIP service providers had to accept measures ranging from telephone line disconnection to being prisoners. But, besides the government’s measures, the operation is still going on and ETC is still announcing for the people not to use Internet for telephony.

Internet telephony (VoIP) attracted the users, as it is by far better than ETC’s high cost of international calls (Birr 72 for the first 1-3 minutes and Birr 24 for every additional minute). VoIP has, therefore, forced ETC to take a major step in its 110 years history – making a 41% reduction of international calling charges (to Birr 10 per minute) as of March 2004.

IP telephony is being conducted in Ethiopia in the following formats:

1. Using Computers

PC-to-PC IP telephony form is conducted. The PCs must be connected to the Internet and supported the necessary hardware (modem and microphone designed for IP telephony) and software. The software is freely downloaded from the Internet (example, nettelephone) or an account can be acquired (for US\$10) so that the user will be provided with a PIN number.

2. Using IP star

An IP star hardware which has built-in modem can be used instead of PCs. The IP star is then connected to the Internet. There are different IP star models (Model 16, 17, 18, 19, and 21). The black-market cost of an IP star (model 21) is around Birr 3000. An account will be provided by the IP star company.

Using either PCs or IP stars, it is possible to call to anywhere in the world that is connected to the Internet directly (using similar equipment) or indirectly through gateways. Thus if the “illegal” VoIP service provider uses PC, it is possible to make PC-to-PC or PC-to-Phone connections; and if the “illegal” VoIP service provider uses PC, it is possible to make Phone-to-PC or Phone-to-Phone connections. The architecture of the Internet

telephony forms that are operational in Ethiopia can be seen in the following figure.

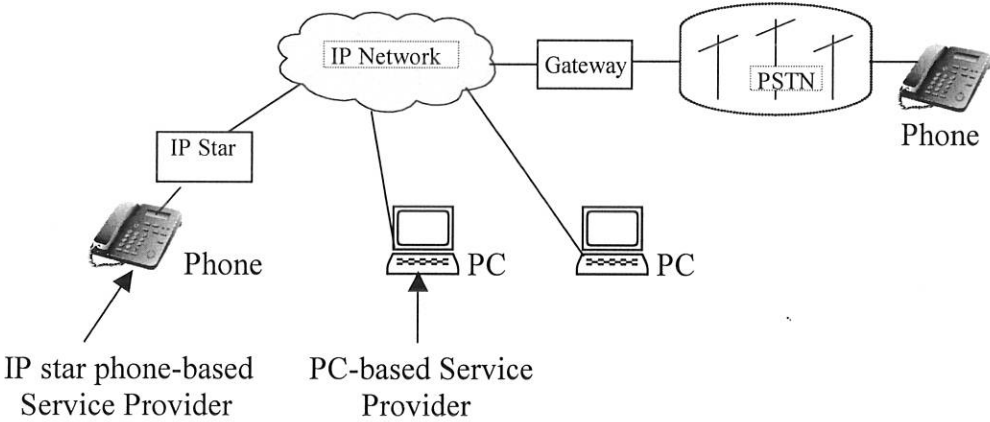


Fig. 2.7: VoIP connection alternatives in Ethiopia

CHAPTER 3: REASERCH METHODS USED

Achieving research objectives requires identifying the data type and source, data collection, presentation, and analysis methods and tools to be used. This chapter is a description of the methodologies used in the research.

3.1. Required Data and Data Collection Methods

For the purpose of comparing PSTN operation and VoIP and assessing the impact of VoIP in Ethiopia the following data were obtained from primary and secondary sources:

1. Data to evaluate impact of VoIP on ETC's revenue from international calls

Assessment of the impact of VoIP on ETC's revenue from international calls was done by predicting the revenue of ETC from international calls:

- i. From its current circuit switched telephone system – using secondary data from ETC.
- ii. From VoIP system had it been implemented – using primary data collected from international telephone users through survey (questionnaire). Since VoIP is not legally functional in Ethiopia, we cannot have actual data on VoIP. The primary data regarding VoIP is, therefore, the telephone consumption plan of the respondents if they are provided with VoIP service.

2. Data for Predicting Telecenters' Revenue and Government Tax.

3. Data for Predicting Information Exchange in Minutes.

Different methods were followed for collecting all these data.

3.1.1. Document Analysis

A review of relevant literatures was conducted to assess VoIP technology in general and its application in African countries in particular.

Data of ETC's revenue from international telephone calls and various statistical reports of ETC through the years 1981-1996 EC were collected to predict ETC's revenue from the current circuit switched technology. Then this was compared with the revenue estimate from VoIP operation which was gathered through questionnaire. The researcher preferred to take data of only international telephone calls as the impact of VoIP is highly reflected

on international than domestic calls. The revenue, before and after VoIP deployment, of telecom companies in countries that are already using VoIP technology was examined. Our revenue estimation was compared with actual achievements in cost and revenue of telecom companies in sample countries.

3.1.2. Questionnaire

The target populations for questionnaire were international telephone users and tele-centers. Separate structured questionnaires were designed and adopted for appropriate samples of customers in Addis Ababa and other (regional) towns. The acquired data was used in estimating the change in their telephone consumption assuming reduced (VoIP) international tariff rate.

The appropriate sample was selected using proportionate sampling technique. Proportionate sampling technique is a variant of stratified sampling that enables us to avoid under representation and/or over representation of one segment (Bordens and Abbott, 1988). International telephone users were segmented into frequent, average, and least users based on their average monthly international telephone charges. Then the proportional size from each class was determined to maintain the sample representativeness. The sample from tele-centers was selected using systematic sampling.

The questionnaire to international telephone users was designed to estimate their telephone consumption plan under reduced (VoIP) charges and to investigate their opinion on VoIP. For this effect, the researcher first established a competitive VoIP price Birr 4 per minute for international calls. This rate was set as it accommodates the Birr 0.2 per 3 minutes cost of inland (local) calls, ETC's cost for international circuit/trunk lines, and the international resettlement price of US\$0.2 per minute to be paid by ETC for using the network of call destination country. Besides, the Birr 4 per minute rate had been in use by the "illegal" VoIP operators in Ethiopia.

The information on telephone consumption plan was used to forecast the increase or decrease in revenue from international calls and the amount of information transfer if VoIP is implemented.

The questionnaire to tele-centers was used to estimate their revenue under the reduced (VoIP) charges and to see their opinion on VoIP. This same information was also used to look for the government's gain from tax.

3.1.3. Interview

A semi-structured interview was conducted with the concerned officials of the telephone service providing company (ETC) and that of the regulatory body (ETA). The information was used to identify and address threats of officials on implementing VoIP technology.

3.2. The Sample Selection Process

Samples of 500 international telephone users were selected from Addis Ababa (300) and other from Awasa, Nazreth, Gondar, and Dessie towns (50 each).

The selection process for Addis Ababa customers was carried out as follows:

1. A simple drawing selected North Addis Ababa Zone customers from the six Addis Ababa zones. 3033 international telephone users were identified from bill summary file of the selected zone for two months (February and March 2005 bill). A sample size of 10% was selected from each telephone exchange. The samples from each telephone exchange were classified into three categories or classes of users (i.e., Low, Medium, and High) based on the amount they spent on international calls:
 - Low if payment for international call < Birr 100;
 - Medium if payment for international call $\geq$ Birr 100 and < Birr 300;
 - High if payment for international call $\leq$ Birr 300.
2. Each class of subscribers who share the same exchange were randomized using the excel RAND function and 10% of the population were selected as sample.
3. The following table summarizes the population and sample sizes taken from each class:

Population				Proportional Sample			
Low	Medium	High	Total	Low	Medium	High	Total
1982	436	615	3033	198	44	62	303

4. This same procedure was followed in selecting the 200 samples from the four regions.
5. 60 telecenters were selected using systematic sampling.

3.3. Data Presentation and Analysis Methods

This research has purposes of assessing the impact of VoIP on ETC's revenue, on Telephone resellers' revenue, on the government's tax collection, and on the amount of time spent on telephone conversation (information exchange). To achieve these purposes, data gathered in the above methods were converted into forms suitable for statistical analysis and KnowledgeSTUDIO.

In presenting and analyzing primary data (from questionnaires and interview), some references suggest the need to prepare a code book for responses of all questions in the survey instruments for identification purpose (KaKooza, 1996). But, since there were two questionnaires with too large number of questions in each of them to code (38 and 46 questions respectively) and for the sake of simplicity and space problems, we used tables instead of code books. The tables used here have enabled us to present similar questions in different conditions (PSTN and VoIP) together for comparison. However, the following codes are used to identify questions in the two questionnaires whenever necessary:

[n] = n number of responses for an option that follows the [] response sign;

Example: [208] Yes = 208 respondents said "Yes".

Q1 = Questionnaire1..... (for international telephone users);

Q2 = Questionnaire2..... (for tele centers and Internet cafes);

I = Interview (for ETC and ETA officials);

IQ1, IQ2,...IQn = Interview question 1, question 2,... question n;

P1, P2,Pn = Part 1, Part 2,Part n;

q1, q2,...qn = question 1, question 2,... question n;

P2q3 = Part 2 question 3;

Q1P2q1 = Questionnaire 1 Part 2 Question 1.

In the secondary data analysis part, data preparation activities such as editing and cleaning were conducted on the collected data. ETC's international revenue from the current telephone operation (circuit switched technology was predicted using KnowledgeStudio time-series model. The reason of using a software such as KnowledgeSTUDIO instead of using simple time series arithmetic is that the variable revenue is dependent on seven

independent variables; too many to manually determine the relation among them and generate a formula for predicting the value of our dependent variable.

3.4. Limitations of the Research methodologies

One limitation of the methodologies can be the tendency that some respondents may not give realistic responses. To minimize this risk and assure the validity of the questions, a pre-test was conducted on 20 actual respondents and the questionnaire had been revised several times before being administered.

This research, however, faced a big problem in administering the questionnaire. Among the intended 500 sample size (300 Addis Ababa and 200 at Gondar, Dessie, Awasa, and Nazereth), the questionnaire was administered to only 250 samples (190 of Addis Ababa, 30 of Nazereth, and 30 of Awasa samples). Other intended samples were not reachable may be due to the instability occurred following the election in the country. The political instability made it totally impossible to distribute and collect the questionnaire to Gondar and Dessie samples.

The absence of previous researches in Ethiopia regarding VoIP did not enable this research to learn from their findings.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

To see the impact of VoIP on ETC's revenue from international calls, it was a must first to predict the revenue of ETC from international calls of its current circuit switched telephone system and then from international calls if VoIP system is implemented. The prediction of revenue from the existing PSTN operation was carried out from secondary data of previous years. Where as, since VoIP is not yet implemented and there was no data for the prediction purpose, the revenue from VoIP operation was done from primary data gathered through questionnaires on telephone consumption plan under a reduced tariff rate. This chapter presents the primary data for predicting data for the two predictions.

4.1. Primary Data Analysis

We have presented responses to questions that are relevant to our research questions, leaving those that were added to stimulate the respondents' interest. The tabulated responses (for indicated questions in bracket) are preceded by short introductory summaries.

4.1.1. Responses to Questionnaire 1: International Telephone Users

A. Responses on Quality of Telephone Service:

Regarding the reasonability of international tariff rates, as indicated in the table below, more than half of the respondents said that PSTN international tariff (Birr 10) is expensive and very expensive, and 63.01% said the Birr 4 per minute price under VoIP is fair.

Price/Tariff	PSTN (Birr 10 per minute)	% of the total	VoIP (Birr 4 per minute)	% of the total
Very cheap	10	4.37%	30	13.70%
Cheap	11	4.80%	24	10.96%
Fair	87	37.99%	138	63.01%
Expensive	94	41.05%	15	6.85%
Very expensive	27	11.79%	12	5.48%
sum	229	100.00%	219	100.00%

Table 4.1.1: Appropriateness of tariff rate for international calls (P3q1 and P5q2).

Measured against different quality parameters (see table below), the response regarding the frequency of problems during making international calls is:

- PSTN: 12.91% face problems frequently, 51.97% face sometimes, and 35.12% never face such problems.
- VoIP: 8.78% face problems frequently, 51.90% face sometimes, and 39.32% never face such problems.

Problems that indicate service quality	Frequently		Sometimes		Never Faced		Total	
	PSTN	VoIP	PSTN	VoIP	PSTN	VoIP	PSTN	VoIP
Problem of congestion	38	-	120	-	71	-	229	-
Problem related to security of messages on telephone conversation	6	0	79	71	144	96	229	167
Interference of unwanted voice on conversation (cross talk)	6	4	109	65	114	70	229	139
Delay of partner's voice	58	32	130	83	41	44	229	159
Reflection of own voice during conversation (echo)	37	15	142	81	50	43	229	139
Interruption of communication	12	16	170	96	47	47	229	159
Exaggeration of bills for international calls	50	-	83	-	96	-	229	-
Sum	207	67	833	396	563	300	1603	763
Average	12.91 %	8.78 %	51.97 %	51.90 %	35.12 %	39.32 %	100 %	100 %

Table 4.1.2: Occurrence of problems while making an international call (P3q2-P3q8 and P4q5.1-P4q5.4).

The general level of satisfaction of customers is:

- PSTN: 36.28% high satisfaction, 49.30% medium, and 14.42% low.
- VoIP: 61.31% high satisfaction, 35.12% medium, and only 3.57% low.

Level of Satisfaction	PSTN		VoIP	
	Response	%	Response	%
High	78	36.28%	103	61.31%
Medium	106	49.30%	59	35.12%
Low	31	14.42%	6	3.57%
Sum	215	100.00%	168	100.00%

Table 4.1.3: General level of satisfaction of international telephone services under PSTN and VoIP (P3q9 and P5q5.5).

B. Responses on International Telephone Consumption Plan under PSTN (at Birr 10 per minute) and VoIP (at Birr 4 per minute)

On the average, a respondent makes international calls for:

- PSTN: for 2.25 persons.
- VoIP: 3.63 persons.

The responses are presented in the following table:

Number of persons to dial for (X)	PSTN (Y)	XY	VoIP (Z)	XZ
1	78	78	14	14
2	70	140	50	100
3	30	90	54	162
4	18	72	25	100
5	8	40	24	120
6	3	18	38	228
7	3	21	2	14
8	1	8	2	16
9	1	9	1	9
Sum	212	476	210	763
Average	2.25		3.63	

Table 4.1.4: Average number of persons to make an international call for under PSTN and VoIP (P4q1 and P5q1.1)

On the average, sample makes international calls:

- PSTN: 2.63 times for a person.
- VoIP: 3.92 times for a person.

Number of calls for a person (X)	X	PSTN (Y)	XY	VoIP (Z)	XZ
1	1	86	86	33	33
2-3	2.5	76	190	81	202.5
4-5	4.5	30	135	48	216
6-7	6.5	12	78	18	117
8-9	8.5	8	68	30	255
Sum		212	557	210	823.5
Average		2.63		3.92	

Table 4.1.5: Average number of calls for a person (P4q2 and P5q1.2)

The average duration of an international call is:

- PSTN: 3.92 minutes.
- VoIP: 6.5 minutes.

Duration of a call in minutes	X	PSTN (Y)	YX	VoIP (Z)	ZX
1-3	2	117	234	31	62
4-6	5	73	365	81	405
7-9	8	9	72	63	504
10-12	11	7	77	17	187
13-15	14	6	84	12	168
Sum		212	832	204	1326
Average		3.92		6.5	

Table 4.1.6: Average duration of a call in minutes (P4q3 and P5q1.3):

C. Responses on Preference from PSTN and VoIP

Respondents were asked to make a comparison between PSTN and VoIP based on the parameters indicated in the following table and that over all preference was:

- **PSTN: 31.30%.**
- **VoIP: 68.70%.**

Criteria for comparison	Respondents' Preference		
	VoIP	PSTN	Sum
Price of International calls	199	11	210
Congestion	120	83	203
Security of messages	113	89	202
Interference of unwanted voice	154	48	202
Delay	155	47	202
Echo	130	73	203
Communication interruption	108	95	203
Overall preference	979	446	1425
Average	68.70%	31.30%	100.00%

Table 4.1.7: Comparison of PSTN and VoIP quality for making international calls (P5q5.6)

D. Responses on whether VoIP shall be implemented or not (P5q5.7):

[208] Yes; Reasons:

- Enables cheap, reliable quality, and immediate service;
- It is better for the country;
- Due to globalization and the “must to” use the technology.

[3] No; Reasons:

- It reduces ETC's revenue and, as a result, the regular telephone service can be affected.

E. Responses whether customers need to use VoIP or not (P5q6-7):

[190] Yes

[22] No; Reasons for No (one or more responses):

- Do not know benefits
- Do not know the requirements
- Do not have the capacity to have the requirements
- Hearing that it is illegal

F. Customers' preference to get VoIP service if it is implemented in Ethiopia (P5q8):

[52] ETC alone; Reasons:

- For its longer experience and reliability of service.
- It is bringing new technologies.
- Others may increase price as they want.
- There is no other provider as a better alternative.

[117] ETC & others: Reasons:

- To get better services (price and quality) from competition.
- To have instant services anywhere and any time.
- To share the benefits and to develop the country all together.

[45] Others alone: Reasons:

- ETC has prevented and delayed Internet telephony.
- ETC is proved to be not good for providing services efficient and effective.
- For better customer service and job opportunities.

G. Other ideas/comments (P5q9):

- Internet telephony should be implemented legally; otherwise, as it is uncontrollable, the country will continue to be affected by the hidden operation.
- Its implementation will avoid illegality/unlawfulness.
- If widely implemented in the country, it may bring rapid economic growth.
- Since Internet telephony is not known by the population at large, promotional works should be done first and it is better to implement it partially and side by side with the traditional telephone.

Average monthly telephone bills and the share of international calls under PSTN:

- *Total: Birr 1011.11.*
- *International calls: Birr 371.33.*

Telephone bill in Birr	Midpoint (X1)	International calls in Birr (X2)	Frequency	X1Y	X2Y	Share of international calls
251-500	375	127.5	20	7500	2550	34.00%
501-750	625	103	6	3750	618	16.48%
751-1000	875	90	2	1750	180	10.29%
1001-1250	1125	300	6	6750	1800	26.67%
1251-1500	1373	375	7	9611	2625	27.31%
1501-1750	1625	500	5	8125	2500	30.77%
1751-2000	1875	850	4	7500	3400	45.33%
2001-2250	2125	1350	5	10625	6750	63.53%
Sum			55	55611	20423	
Average	1011.11	371.33				

Table 4.1.11: Tele-centers' average monthly telephone bills and the contribution of international calls (P2q4.2-4.3):

Average monthly internet bills of Internet cafés under PSTN: Birr 672.41.

Monthly Internet bill in Birr	Midpoint (X)	Frequency (Y)	XY
1-200	100	5	500
201-400	300	6	1800
401-600	500	4	2000
601-800	700	4	2800
801-1000	900	3	2700
1001-1200	1100	2	2200
1201-1400	1300	2	2600
1401-1600	1500	1	1500
1601-1800	1700	2	3400
Sum		29	19500
Average	672.41		

Table 4.1.12: Internet cafes' average monthly Internet bills (P2q5.3):

Average monthly telephone bills of Internet cafés under PSTN: Birr 556.03.

Telephone bill in Birr	Midpoint (X)	Frequency (Y)	XY
1-150	75	3	225
151-300	225	5	1125
301-450	375	5	1875
451-600	525	4	2100
601-750	675	4	2700
751-900	825	2	1650
901-1050	975	3	2925
1051-1200	1125	2	2250
1201-1350	1275	1	1275
Sum		29	16125
Average		556.03	

Table 4.1.13: Internet cafes' average monthly telephone bills for the Internet services (P2q5.4)

C. Quality of PSTN and VoIP telephony services

More than half of the respondents said that PSTN international tariff is very expensive, and 70.91% said the Birr 4 per minute price under VoIP is fair.

Price/Tariff	PSTN (Birr 10 per minute)		VoIP (Birr 4 per minute)	
	Frequency	%	Frequency	%
Very cheap	0	0.00%	2	3.64%
Cheap	0	0.00%	7	12.73%
Fair	8	14.55%	39	70.91%
Expensive	16	29.09%	5	9.09%
Very expensive	31	56.36%	2	3.64%
Sum	55	100.00%	55	100.00%

Table 4.1.14: Appropriateness of tariff rate for international calls (P3q1 and P4q2):

Frequency of problem occurrence while making international calls:

- PSTN: 18.37% face problems frequently, 49.34% face sometimes, and 35.12% 32.28% never face such problems.

- VoIP: 21.21% face problems frequently, 55.30% face sometimes, and 23.48% never face such problems.

Problems that indicate service quality	Frequently		Sometimes		Never Faced		Total	
	PSTN	VoIP	PSTN	VoIP	PSTN	VoIP	PSTN	VoIP
Problem of congestion	5	8	29	24	19	10	53	42
Problem related to security of messages on telephone conversation	3	15	17	21	33	10	53	46
Interference of unwanted voice on conversation (cross talk)	6	4	22	17	27	25	55	46
Delay of partner's voice	15	13	32	22	8	7	55	42
Reflection of own voice during conversation (echo)	11	4	32	32	12	8	55	44
Interruption of communication	2	12	35	30	18	2	55	44
Exaggeration of bills for international calls	28	-	21	-	6	-	55	-
Sum	70	56	188	146	123	62	381	264
Average	18.37 %	21.21 %	49.34 %	55.30 %	32.28 %	23.48 %	100 %	100 %

Table 4.1.15: Occurrence of problems while making an international call (P3q2-8 and P4q4.1-4.6):

Level of satisfaction:

- PSTN: 9.09% high satisfaction, 30.91% medium, and 60.00% low.
- VoIP: 69.57% high satisfaction, 23.91% medium, and only 6.52% low.

Level of Satisfaction	PSTN		VoIP	
	Response	%	Response	%
High	5	9.09%	32	69.57%
Medium	17	30.91%	11	23.91%
Low	33	60.00%	3	6.52%
Sum	55	100.00%	46	100.00%

Table 4.1.16: General level of satisfaction of international telephone services under PSTN and VoIP (P3q9 and P4q4.7)

Preference of the respondents:

- VoIP preferred by: 56.86%.
- PSTN preferred by: 43.14%.

Criteria for Comparison	Respondents' Preference		
	VoIP	PSTN	Sum
Price of International calls	40	8	48
Congestion	23	23	46
Security of messages	21	28	49
Interference of unwanted voice	21	18	39
Delay	23	19	42
Echo	24	16	40
Communication interruption	22	20	42
Sum	174	132	306
Average	56.86%	43.14%	100.00%

Table 4.1.17: Comparison of PSTN and VoIP quality for making international calls (P4q9):

D. International Telephone Service Plan under PSTN (at Birr 10 per minute) and VoIP at Birr 4 per minute):

On the average, resellers serve 15 international calls monthly with an average duration of 2.8 minutes per call under PSTN and 34 calls with 5.06 minutes per call under VoIP system.

Average number of international calls per month through service centers:

- **PSTN: 15 persons.**
- **VoIP: 34 persons.**

Number of persons to make international call	Midpoint (X)	PSTN (Y)	XY	VoIP (Z)	XZ
1-10	5	37	185	13	65
11-20	15	7	105	6	90
21-30	25	3	75	7	175
31-40	35	2	70	5	175
41-50	45	0	0	2	90
51-60	55	2	110	3	165
61-70	65	2	130	6	390
71-80	75	2	150	7	525
Sum		55	825	49	1675
Average		15		34	

Table 4.1.18: Average number of international calls through service centers (P3q10 and P4q8.1):

Average duration of an international call at service centers:

- **PSTN: 2.8 minutes.**
- **VoIP: 5.06 minutes.**

Duration of a call in minutes	Midpoint (X)	PSTN (Y)	XY	VoIP (Z)	XZ
1-3	2	48	96	26	52
4-6	5	3	15	7	35
7-9	8	1	8	9	72
10-12	11	2	22	3	33
13-15	14	1	14	4	56
Sum		55	155	49	248
Average		2.8		5.06	

Table 4.1.19: Average duration of an international call in minutes at service centers (P3q11 and P4q8.2):

D. Opinion on whether VoIP shall be implemented or not (P4q10):

[53] Yes; Reasons:

- For cheaper price.
- It avoids illegal operations, increases the number of telephone users, and brings better revenue for the country.
- Due to globalization and the need to use the technology.

[2] No; Reasons:

- It reduces ETC's revenue and regular telephone service can be affected.

E. Service centers' preference of VoIP service provider if it is to be implemented in Ethiopia (P4q11):

[0] ETC alone;

[21] ETC & others: Reasons:

- To enable the public to have alternative service providers.
- To enable the government not to lose control.
- To enable the provision of sufficient telephone service.

[34] Others alone: Reasons:

- ETC has not been good service provider and cannot be unless privatized.
- For having instant services anywhere and any time.
- For free market.
- To in reach the service to the public at large.

F. Other ideas/comments (P4q12):

- It is better to have competitive service providers for having sufficient and improved services for the people.
- It is better to reduce the tariff of the traditional telephony than implementing Internet telephony.

4.1.3. Responses to Interview Questions

Question 1: *We know that Internet telephony is illegal in Ethiopia and that ETC has been taking actions to control the illegal operation. How are the results of the actions taken so far? Has the organization achieved full control of Internet telephony operation?*

- Both ETC's revenue from international traffic and ETC's Internet service suffered from illegal VoIP operation. The purpose of the control is to protect ETC (and the country) from losing return on investments on the traditional telephone system and the people from low quality telephony as the previous Internet (before broadband Internet) does not support quality voice.
- Full control of the illegal operation is impossible as the VoIP technology is changing so rapidly that the country cannot even identify VoIP equipment from others and control them. VoIP enabling software is available freely on the Internet in wide variety. So trying to have control mechanisms for one equipment or software needs to invest for the necessary SW & HW. As the technology is rapid, the illegal operators will bring new systems the control of which need other software and hardware. Generally, the controlling itself requires a huge and continuous investment. Due to this, we will not take controlling as the final or optimal solution; we thinking of providing VoIP after maintaining return on the existing infrastructure.
- However, although the control of illegal VIOP operation was not fully achieved, it is now minimized and ETCs outgoing traffic has shown greater improvement after 1994 E.C; the year in which illegal VoIP operation reached its peak.

Question 2: *How do you identify a VoIP user?*

- We don't identify voice signals from other data on the net using VoIP snipers as they are costly & can be by passed by new software. We receive information from

the society. Tele centers, international telephone users (Ethiopian leaving abroad) and the police are the sources of information on illegal VoIP.

Question 3: *What impact (advantage and disadvantage) will VoIP have on ETC (especially on revenue), the customers, and the government?*

- We expect VoIP will reduce ETC's revenue from international calls. However, the reduction will not be long lasting due to the possibility that low priced opportunity of VoIP will boost traffic and balanced revenue can be achieved from huge traffic.
- The country will get what ETC gets from VoIP. As to the customers, they will benefit from cheap price opportunity of VoIP for international calls, but they may not get good quality.
- If we make enough preparation for implementing VoIP, it will not affect ETC and the country.

Question 4: *Is there any previous work on the impacts of VoIP you mentioned in Q.4?*

- No previous study was carried out on VoIP in Ethiopia. But we have registered the greatest traffic loss in 1994 and while we take action on VOIP operators, the traffic was improved. So we account the traffic loss for the illegal VoIP operation.

Question 5: *VoIP is being in use in many countries. Does your organization have short and long term plans regarding VoIP as an option for providing cheap international call services for poor Ethiopia and bridging the digital divide?*

- VoIP is the next generation technology and we have known that it is inevitable. As it is becoming in use in many countries, we believe that it will replace the traditional PSTN system in the near future. Ethiopia will not be out of this world situation since international telecom service providers, telecom equipment manufacturers, ITU and others are turning to VoIP and insisting ETC to use the technology. ETC may face problems unless it does something now or if it remains isolated from the technology. Thus, although we do not have actually short & long term plans at hand regarding VoIP, we think that we have to begin doing something. Such a study as yours may help us to start and act on how to implement VoIP to the benefit of the country.
- We think VoIP should be implemented phase-by-phase (first for non-profit purpose, i.e. for companies PBXs to use for internal communication). Broadband can enable

us to do so. We will think of letting companies to use VoIP for internal communication.

- But implementing VoIP fully (for residential telephones & resellers) will take time (3-5 yrs), and until that, we will serve the people by decreasing the international tariff rate to the possible minimum.

Question 6: *How challenging will it be for ETC to implement VoIP and provide IP telephony to all your customers? Will it be manageable?*

- Now that we have implemented broadband, it will reduce the congestion problem & ETC can sell even prepaid VoIP services to companies with large PBX intranets.
- It is easier to manage a single network than separate networks for voice & data. But VoIP brings its own complexity and big telecom service providers and international vendors are working on it. So, we too have to work a lot. Otherwise, things may go worse. Managing VoIP will not be that much challenging if we join it with enough preparations.

Question 7: *Any other idea/comment related to VoIP?*

- We will not resist the VOIP technology as we have to follow the world trend. But, we have to see the VoIP market in the country and regulatory issues governing the role of the private resellers should be established first for the betterment of the telephone service.

Summary of responses for the interview:

The officials expressed that it will be a great loss for ETC & the county to retire the PSTN infrastructure and invest on VoIP before a return that equates its cost is obtained. The possibility of implementing VoIP on the existing PSTN infrastructure is not sought by the officials. Generally, officials know that controlling VoIP is too costly and impossible especially broadband. Controlling VoIP is impossible even if the required cost is paid for and even if ETC and ETA were the inventors of the technology. VoIP has got enough recognition by the officials to be a topic of discussion. There are global pressures on ETC that insist ETC to use the technology. Ethiopia will not go against global interests and implementing VoIP will be inevitable.

4.2. Secondary Data Analysis

The purpose of collecting secondary data in this research was to predict the revenue of ETC from international calls under the current circuit switched telephone system. This information is to be used with the revenue estimate ETC could get from VoIP through survey.

4.2.1. Data Source and Preprocessing

Prediction of PSTN revenue was carried out using KnowledgeSTUDIO's Time-Series model. *Data preprocessing* is a pre-requisite task in using KnowledgeSTUDIO (or any data mining technology). In order to make successful prediction with this tool, therefore, data preprocessing tasks such as data preparation, selection, cleaning, reduction, and attribute selection were conducted on data collected from ETC's Yearly Statistical Report of 2005. Attributes that are related to the revenue of ETC from international calls were selected from each of the three tables in the following manner:

1. *Operational Revenue* for the years 1976 to 1996 E.F.C. with following column headings (attributes).

Year	Urban Telephone (In Birr)	Interurban & International (In Birr)	Telegraph & Telex (In Birr)	Mobile (In Birr)	Internet (In Birr)	Miscellaneous (In Birr)	Total (In Birr)
------	------------------------------	---	--------------------------------	---------------------	-----------------------	----------------------------	--------------------

The revenue from international calls is indicated in the "Interurban & International (In Birr)" column. Although this column includes revenue from interurban calls (local long-distance calls made through operator 99), ETC does not keep separate column for international calls alone due to the small contribution of interurban calls to the column value. From this table, therefore, the columns "Year" and "Interurban & International (In Birr)" were taken as relevant attributes. The variable "Interurban & International (In Birr)" was later named as "Revenue in Birr".

2. *Traffic table* for the years 1973 to 1996 E.F.C. showing the amount of international incoming and outgoing calls in number of calls and in minutes with the following column headings.

Year	Calls		Ratio In/Out	Minutes		Ratio In/Out
	Incoming	Outgoing		Incoming	Outgoing	

The columns "Year", "Minutes Incoming", and "Minutes Outgoing" were selected from this table.

3. *Customers table* indicates the ETC's capacity and customers from 1981 to 1996 E.F.C. with the attributes the following attributes.

Year	Capacity	Subscriber Lines	Waiting	Expressed Demand	Subscriber lines as % of Expressed Demand	Expressed Demand as % of Capacity
------	----------	------------------	---------	------------------	---	-----------------------------------

The relevant columns from this table were "Year", "Capacity", "Subscriber Lines", and "Waiting". "Capacity" refers to ETC's exchange capacity expressed in number of lines available. The "Expressed Demand" is the sum of existing subscribers and waiting list customers. Taking the existing subscribers alone may falsify the prediction as the exclusion of waiting customers will not tell us the potential telephone users. I preferred, therefore, to take the variables "Subscriber Lines" and "Waiting" separately instead of taking their sum "Expressed Demand" to handle their individual effects.

The selection of attributes for predicting the revenue is based on the fact that revenue generated from international calls is a function of the number of telephone users (that actually subscribed or requested to subscribe a telephone line), ETC's capacity to supply telephone lines (to existing subscribers and to new customers), and incoming and outgoing international calls. "Year" is the key attribute in all the tables that helped us to join them and a new table was formed with the following relevant attributes:

Year	ETC's Capacity	Expressed Demand	Minutes Incoming	Minutes Outgoing	Interurban & International (In Birr)
------	----------------	------------------	------------------	------------------	--------------------------------------

These attributes are not the only factors affecting revenue from international calls. Price per minute of international calls and income growth of telephone consumers (GDP per capita growth, whose effect can be reflected on the demand for a product) were also important for telephone usage and revenue generation. These new attributes were added to the attributes selected above. The preprocessed data presented in the following table was finally ready and was imported to the KnowledgeSTUDIO.

Year	Exchange Capacity	Telephone Subscribers	Waiting, fixed tel.	GDP per capit growth	Incoming minutes	Outgoing minutes	Price per minute in Birr	Revenue in Birr
1981	162260	115843	90684	-2.1	12248225	4722587	17	51762954
1982	171386	125398	108908	-2.1	15085296	7313113	17	69721398
1983	175653	133091	123140	-2.1	17922367	8865471	17	97340766
1984	164273	127041	122066	-2.1	20759438	10030634	17	106700063
1985	169622	132478	141035	2.1	22880589	10915704	17	155453346
1986	172742	137731	160939	2.1	23172247	11472100	17	182947464
1987	179094	142452	178992	2.1	26154134	10499396	17	294353291
1988	190177	148739	193499	2.1	32502997	10346291	17	330308236
1989	196322	156538	206562	2.1	38140076	10690183	17	367258117
1990	211108	164140	230225	2.1	38797299	11839351	17	406187516
1991	372885	194494	224788	2.1	38586910	12453411	17	359880947
1992	458247	231945	196883	2.1	36734936	13420355	17	351470779
1993	511474	283683	155208	2.1	35632887	13415739	17	334401267
1994	600337	353816	139095	0.5	37541834	12882848	17	347150756
1995	649593	404790	146062	-5.6	54886817	14312370	15.25	365630559
1996	722548	484368	156963	4.8	133679022	17700238	10	346839690

* The estimated annual percentage growth of GDP per capita for the years 2003-2007, Ethiopia at a glance; The World Bank Group; 10/15/04.

** Average price of Birr 17 per minute for 9 months and Birr 10 per minute for the remaining 3 months; $(17 \times 9/12 + 10 \times 3/12)$.

Table 4.2.1: Data imported to KnowledgeSTUDIO

4.2.2. Developing the Prediction Model

The preprocessed data indicated in the above table (Table 4.2.1) was imported to the KnowledgeSTUDIO. A Time Series predictive model was selected from KnowledgeSTUDIO as follows.

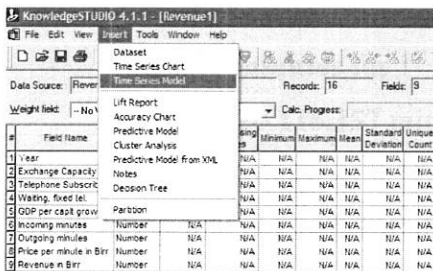


Fig.4.1: Selecting Time Series Model from Insert menu of KnowledgeSTUDIO.

Two algorithms were available in KnowledgeSTUDIO's - Time Series Model; **ARIMA** (Autoregressive Integrated Moving Average) and **Exponential Smoothing**. ARIMA models are supposed to be more powerful in prediction since they consider the effect of independent variables and predict further into the future when compared to Exponential Smoothing, which predicts only one period into the future and which is less effective at

overlap with the red line for the years where actual and predicted revenue are more closer, and the confidence interval from minus 95% to plus 95% (light green dotted lines).

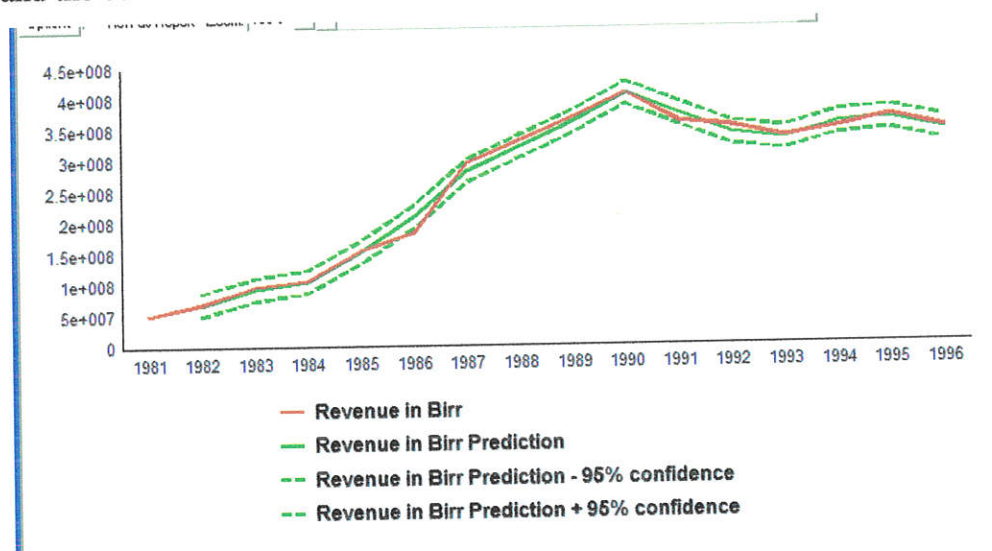


Fig.4.5: Time series chart produced by KnowledgeSTUDIO.

At 95% confidence, ETC's revenue for 1997 was predicted to be around Birr 301 million as indicated in the following time series dataset.

Year	Revenue in	Revenue in	Revenue in	Revenue in	Exchange C	Telephone	Waiting, t	GDP per	Incoming m	Outgoing n	Price per
1981	???	0	???	51762954	162260	115843	90684	-2.1	12248225	4722587	17
1982	69298865	9456972.2	422533.3	69721398	171386	125398	108908	-2.1	15085296	7313113	17
1983	92878001	9456972.2	4462764.9	97340766	175653	133091	123140	-2.1	17922367	8865471	17
1984	105704425	9456972.2	995637.87	106700063	164273	127041	122066	-2.1	20759438	10030634	17
1985	152290068	9456972.2	3163278.1	155453346	169622	132478	141035	2.1	22880589	10915704	17
1986	208151729	9456972.2	-25204265	182947464	172742	137731	160939	2.1	23172247	11472100	17
1987	281738391	9456972.2	12614900	294353291	179094	142452	178992	2.1	26154134	10499396	17
1988	320991826	9456972.2	9316409.8	330308236	190177	148739	193499	2.1	32502997	10346291	17
1989	359969468	9456972.2	7288649.2	367258117	196322	156538	206562	2.1	38140076	10690183	17
1990	405334853	9456972.2	852663.24	406187516	211108	164140	230225	2.1	38797299	11839351	17
1991	372642598	9456972.2	-12761651	359880947	372885	194494	224788	2.1	38586910	12453411	17
1992	340414953	9456972.2	11055826	351470779	458247	231945	196883	2.1	36734936	13420355	17
1993	330955915	9456972.2	3445352.5	334401267	511474	283683	155208	2.1	35632887	13415739	17
1994	354729271	9456972.2	-7578514.7	347150756	600337	353816	139095	0.5	37541834	12882848	17
1995	361958438	9456972.2	3672121.2	365630559	649593	404790	146062	-5.6	54886817	14312370	15.25
1996	344100170	9456972.2	2739519.9	346839690	722548	484368	156963	4.8	133679022	17700238	10
1997	300835316	9456972.2	???	???	1022548	684368	146226	4.8	182424674	20118157	10

Table 4.2.2: The time series dataset indicating the prediction result for 1997 E.C.

In trying to improve the accuracy of the prediction, the need for the inclusion of all the attributes (independent variables) was revised to see if there are irrelevant variables that weaken the strength of the prediction. I have tried to improve the accurate prediction by removing one variable at a time. The variable GDP per capita was included in the model as its increase (which means an increase in the level of income) may bring a rise in the consumption of a product or service in market situations that are governed by the law of

demand and supply. But in the Ethiopian market for telecom services, the supply has always been so small that hundreds of thousands of people are waiting for years to get the service. Besides, as the effect of GDP per capita is reflected on the demand for a particular product or service, its effect could have been reflected on the users' need to buy the telephone service. The best prediction was achieved while GDP per capita was ignored in the following "Identify Columns" dialog box.

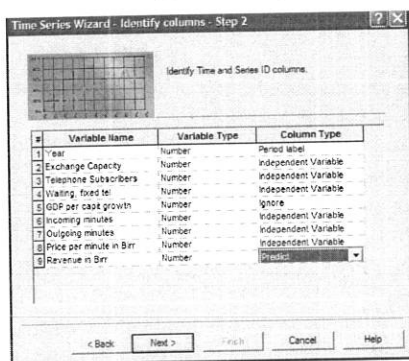


Fig.4.6: Identifying dependent & independent variables for the Best Model.

The values of the independent variables were specified in the "Specify Values" box:

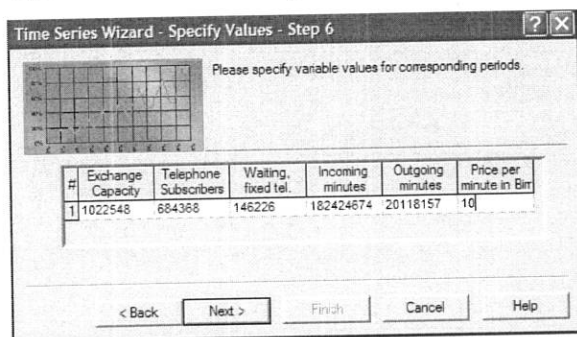


Fig.4.7: Specifying values of independent variables for the Best Model.

The software generated the following model report:

Forecast Model Report

Created: Thursday, May 13, 2004 18:16:58

Model Parameters

Algorithm: ARIMA

Prediction variable: Revenue in Birr

Independent variable(s): Exchange Capacity, Telephone Subscribers, Waiting, fixed tel., Incoming minutes, Outgoing minutes, Price per minute in Birr

Period label: Year

Training period: [1981,1996]

Forecast periods #: 1

Series ID

Topology: (1,1,1)

Equation: $(1 + 0.678031 \cdot B) \cdot (1 - B) \cdot y = 1.54725e+008 + (1 + 1.54725e+008 \cdot B) \cdot e$

Process variance: 8.994e+013

Process bias:

Ljung-Box-Pierce Statistics:

Autoregressive Parameters:

Moving Average:

Value	StdErr
1.54725e+008	1.071e+007

K	df	Q	P
12	4	3.097	0.542

Parameter	Shift	StdErr
-0.678031	1	0.04375

Parameter	Shift	StdErr
1.04512	1	0.04568

Fig.4.8: Forecast model report of KnowledgeSTUDIO for the Best Model.

The equation to make prediction for Year 1997 was given by the formula:

$$(1 + 0.678031*B)*(1 - B)*y = 1.54725e+008 + (1 + 1.84512*B)*e - 890.640000* x_1 + 1714.420000* x_2 + 697.860000* x_3 - 1.899090*x_4 - 5.694600* x_5 - 10430800.000000* x_6;$$

where: B is the backward shift, which indicates the difference of a year from its successor year ($y_i - y_{i-1}$); y is the revenue to be predicted; x_1 to x_6 are the 6 independent variables; and e is the exponential factor (for example, $1.54725e+008 = 1.54725 \times 10^8 = 154,725,000$).

In the following Time Series Chart, the actual (red) and predicted (green) lines seem overlapped for recent years, indicating a better performance of prediction by this model.

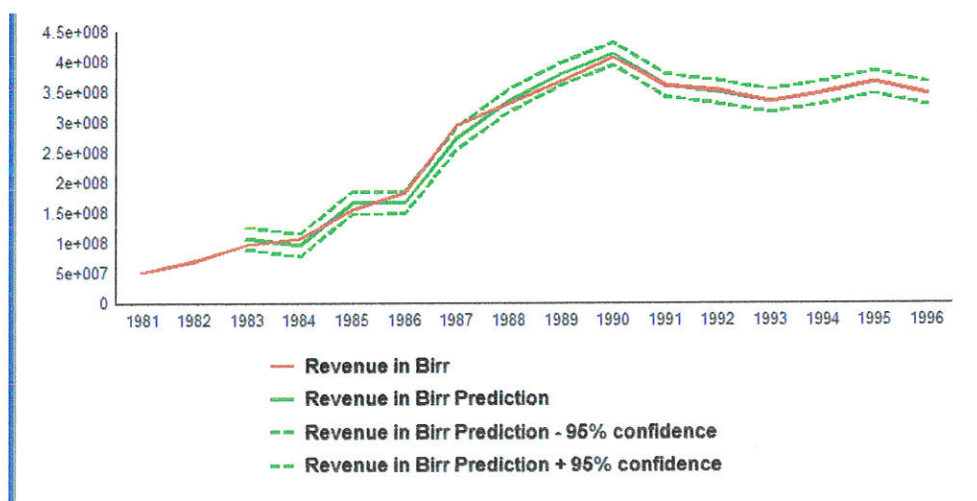


Fig.4.9: Time series chart produced by KnowledgeSTUDIO for the Best Model.

At 95% confidence again, the 2nd model predicted that ETC will generate revenue of about Birr 313 million for year 1997 as indicated in the following table.

Year	Revenue in E	Revenue in	Revenue i	Revenue in	Exchange	Telepho	Waiting	Incoming r	Outgoing	Price
1981	???	0	???	51762954	162260	115843	90684	12248225	4722587	17
1982	???	0	???	69721398	171386	125398	108908	15085296	7313113	17
1983	108089422.8	9483447.1	-10748657	97340766	175653	133091	123140	17922367	8865471	17
1984	96316562.64	9483447.1	10383500	106700063	164273	127041	122066	20759438	10030634	17
1985	165774662.7	9483447.1	-10321317	155453346	169622	132478	141035	22880589	10915704	17
1986	166009627.8	9483447.1	16937836	182947464	172742	137731	160939	23172247	11472100	17
1987	273125701.3	9483447.1	21227590	294353291	179094	142452	178992	26154134	10499396	17
1988	335398103	9483447.1	-5089867	330308236	190177	148739	193499	32502997	10346291	17
1989	378302483.2	9483447.1	-11044366	367258117	196322	156538	206562	38140076	10690183	17
1990	412176223.8	9483447.1	-5988708	406187516	211108	164140	230225	38797299	11839351	17
1991	360154135.3	9483447.1	-273188.3	359880947	372885	194494	224788	38586910	12453411	17
1992	348902667.4	9483447.1	2568112	351470779	458247	231945	196883	36734936	13420355	17
1993	334370499.4	9483447.1	30767.63	334401267	511474	283683	155208	35632887	13415739	17
1994	347747672.1	9483447.1	-596916.1	347150756	600337	353816	139095	37541834	12882848	17
1995	364677768	9483447.1	952791	365630559	649593	404790	146062	54886817	14312370	15.3
1996	347027691.5	9483447.1	-188001.5	346839690	722548	484368	156963	133679022	17700238	10
1997	313259489.1	9483447.1	???	???	1022548	684368	146226	182424674	20118157	10

Table 4.2.3: The time series dataset of Best Model indicating the prediction for 1997 E.C.

This model produced a prediction that has smaller changes or deviations from the actual values when compared to that of the 1st model. The 1st model has learned early (showed better performance in earlier years) and become poorer for recent years. The best model, on the other hand, learnt late and showed much better results for the recent years. The deviation of predicted results of the two models from actual revenue is summarized in the following table.

Year	Actual Revenue in Birr	1 st model Revenue Prediction	%age change form actual	2 nd model Revenue Prediction	% change form actual
1981	51762954	???		???	
1982	69721398	69298865	0.61%	???	
1983	97340766	92878001	4.58%	108089423	-11.04%
1984	106700063	105704425	0.93%	96316563	9.73%
1985	155453346	152290068	2.03%	165774663	-6.64%
1986	182947464	208151729	-13.78%	166009628	9.26%
1987	294353291	281738391	4.29%	273125701	7.21%
1988	330308236	320991826	2.82%	335398103	-1.54%
1989	367258117	359969468	1.98%	378302483	-3.01%
1990	406187516	405334853	0.21%	412176224	-1.47%
1991	359880947	372642598	-3.55%	360154135	-0.08%
1992	351470779	340414953	3.15%	348902667	0.73%
1993	334401267	330955915	1.03%	334370499	0.01%
1994	347150756	354729271	-2.18%	347747672	-0.17%
1995	365630559	361958438	1.00%	364677768	0.26%
1996	346839690	344100170	0.79%	347027692	-0.05%
1997	???	300835316		313259489	

Table 4.2.4: Comparison of the two prediction models.

☞ Thus, according to KnowledgeSTUDIO-Time Series Model, the prediction of the best model which is Birr 313 million was taken as the revenue ETC is going to collect in 1997.

CHAPTER 5: FACTS AND FINDINGS

So far, we have analysed primary and secondary data and wide range of documents that support the research objective. This chapter deals with the findings from literature review and from primary and secondary data analysis.

5.1. VoIP Requirements and Existing PSTN Infrastructure

From the vast books, journals, and magazines, we have understood that large scale implementation of VoIP is not a simple thing. It needs to build proper mechanisms and meet standards to achieve the quality of voice, security, interoperability, scalability, and integration of VoIP with PSTN challenges. VoIP has such opportunities as effective network capacity utilization, reduced phone bills especially for international calls, simpler infrastructure, improved productivity, improved customer services, and additional service opportunities for generating new revenue. The cost of operating separate networks (for voice and data) will be saved for the operator and many companies are implementing VoIP and enjoying with its opportunities.

Although specific requirements of hardware and software can be determined based on company needs, any VoIP service for personal use needs to be connected to the Internet using PCs with necessary software, or IP stars or adopters, or IP enabled phones. However, fulfilling these requirements is not enough to provide VoIP service at a wider range. Telecom service providers need to have mechanisms that enable their existing PSTNs to be integrated. They need to use Internet gateways to connect their PSTNs with the Internet.

So, ETC can have its own gateways, but subscribing gateway services from service provider is a low cost option. And if its transit exchange is connected to the Internet through subscribed gateways, all the outgoing calls can be routed on the Internet to the gateways connected at the other end (destination country). The gateways at the receiving country handover the voice traffic to its international link/transit and the transit sends the

traffic to the local exchange the receiver is connected with. The whole scenario can be depicted on the following figure:

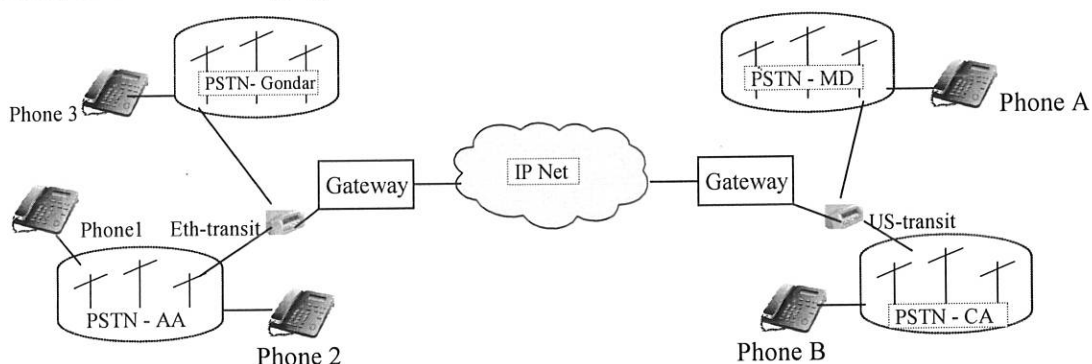


Figure 5: An architecture for implementing VoIP in Ethiopia

As the figure above shows, a call between Phone 1 and Phone 2 (within Addis Ababa) and between Phone 1 or 2 and Phone 3 (Addis Ababa – Gondar) will be conducted as usual. But a call from Phone 1 to Phone A or B (Ethiopia to US) will be transmitted on the Internet through gateways.

5.2. VoIP and Outgoing Traffic Volume

From tables 4.1.4, 4.1.5 and 4.1.6

- A user under PSTN makes on the average monthly international calls for 2.25 persons, 2.63 times for a person, and for 3.92 minutes per call.
- A user under VoIP on the other hand, makes international calls for 3.63 persons, 3.92 times for a person, for 6.5 minutes per call under VoIP system.

The effect of VoIP on international (outgoing) traffic can be found as follows:

Traffic = Persons X Calls X Minutes; where:

Traffic = average monthly traffic generated from a person;

Persons = average number of persons to dial for (2.25 for PSTN and 3.63 for VoIP);

Calls = average number of calls to a person per month (2.63 for PSTN and 3.92 for VoIP); and

Minutes = average duration of a call in minutes (3.92 for PSTN and 6.5 for VoIP).

Thus,

$$\text{Traffic}_{(\text{PSTN})} = 2.25 \times 2.63 \times 3.92 = 23.20 \text{ minutes; and}$$

$$\text{Traffic}_{(\text{VoIP})} = 3.63 \times 3.92 \times 6.5 = 92.49 \text{ minutes.}$$

Due to VoIP, therefore, the amount of international (outgoing) traffic (which was 23.20 minutes under PSTN) will show a percentage increase of:

$$(92.49 - 23.20) / 23.20$$

$$= 298.66\% \quad \text{..... (Outgoing traffic growth)}$$

When we project this result of the sample to the total outgoing traffic from Ethiopia, the outgoing traffic ETC is expecting to generate from its current (PSTN) operation in 1997 (20 million minutes) will show a 298.66% increase.

This means, the outgoing traffic from Ethiopia under VoIP will be:

$$20 \text{ million minutes} + (20 \text{ million minutes} \times 298.66/100)$$

$$= 79.7 \text{ million minutes} \quad \text{..... (Outgoing traffic forecast under VoIP)}$$

5.3. VoIP and ETC's Revenue

Telephone calls using VoIP do not account to international resettlement charges (for the difference between incoming and outgoing calls) unlike PSTN traffic. For this reason, both incoming and outgoing traffic will be treated as any data on the net and there will not be revenue from excess of incoming over outgoing traffic. The assumption here is ETC will transmit outgoing and receives incoming voice traffic on its own VoIP network or using Internet service providers' gateways. Thus the revenue of ETC under VoIP will be generated from international telephone users in Ethiopia.

ETC collects revenue from its customers of Birr 10 per minute for outgoing international calls under PSTN. But under VoIP, we will take the Birr 4 per minute price. ETC's revenue from international calls under VoIP operation is, therefore, given by the formula:

$$\text{Revenue} = \text{Birr } 4 \times \text{Outgoing traffic;}$$

$$= \text{Birr } 4 \times 79.7 \text{ million minutes;}$$

$$= \text{Birr } 318.8 \text{ million} \quad \text{..... (ETC's revenue estimate under VoIP)}$$

Compared to the revenue prediction for 1997 under PSTN operation (which was Birr 313 million), ETC gets additional revenue of Birr 5.8 million from the huge outgoing traffic to be generated due to VoIP's low price opportunity. On the other hand, ETC expects to get Birr 333 million from 192 million incoming minutes alone and Birr 195 from 19 million outgoing minutes in 1997 (a total of Birr **528 million**). This has a difference of Birr 210 million from VoIP and Birr 215 million from the PSTN revenue prediction of KnowledgeSTUDIO. This difference may be due to the fact that ETC's revenue plan is estimated manually (by multiplying the difference between incoming and outgoing minutes by the international resettlement rate of USD 0.22 per minute, multiplying the outgoing minutes by the Birr 10 per minute tariff rate, and adding the two multiplicity results). Since the international resettlement rate (USD 0.22 at the beginning of the year) is drooping frequently, (USD 0.20 now) a prediction at one settlement rate may not indicate what changes will there be throughout the year and can make a big difference between ETC's estimates and its actual earnings.

These facts indicate that VoIP will positively affect both international (outgoing) traffic and ETC's revenue from international calls. The 298.66% traffic growth is a very big change in the international transfer of information. Since communication is two way, it is possible to state, although not the exact figure, that the incoming traffic will also show a significant growth.

5.4. VoIP and Service Centers' Revenue and Government's Tax

Based on the information obtained from Table 4.1.18-19, the 15 persons making international calls with average duration of 2.8 minutes per call under the current PSTN system gives us the average monthly minutes per service center. The monthly international traffic through a tele-center is, therefore, **42 minutes** ($= 15 \times 2.8$).

The average revenue per month of a service center from international calls will become:

Traffic in minutes per month X the Birr 12 rate,

$= 42 \times 12 = \mathbf{504 \text{ Birr from international calls under PSTN.}}$

Under the VoIP system, on the other hand, the 34 international telephone users per month with 5.06 minutes per call (Table 4.1.18-19) gives us the average monthly minutes per service center:

$$= 34 \times 5.06 = 172.04 \text{ minutes per month.}$$

The average revenue per month of service centers from international calls **under VoIP** will become:

minutes per month X the Birr 4 per minute rate;

$$= 172.04 \times 4 = \mathbf{688.16 \text{ Birr from international calls under VoIP.}}$$

Comparing this amount with the **Birr 504** revenue under PSTN, the percentage increase:

$$= (688.16 - 504) / 504 = 36.54\%$$

Thus, resellers will get additional 36.54% in VoIP than what they are getting now from the PSTN system. This positive impact of VoIP also indicates that the government's collection of tax from tele-centers will also grow by 36.54%.

5.5. Findings on other Challenges and Opportunities of VoIP

Quality of Voice Challenge not a problem in Ethiopia:

Quality of VoIP is not a concern in Ethiopia as the quality of the existing PSTN telephone service is not good. Among the 19.64% respondents who showed no interest in VoIP (Q1P5q6-7), quality is not even mentioned as a problem. Rather, most of them mentioned the restriction of VoIP by law, the inability to have VoIP equipment, and absence of awareness of benefits of VoIP (training requirement) as problems to lose interest in VoIP. Only 1.88% of the respondents (Q1P5q5.7 and Q2P4q10) objected the implementation of VoIP stating that it will reduce ETC's revenue and this in turn will affect the regular telephone service. Note here also that the objection is not related to quality of VoIP. Thus, quality is not identified as a challenge to implement VoIP in Ethiopia. This can contradict findings in the developed countries that have identified quality of voice degradation as a major barrier for the deployment of VoIP (Lee, 2004).

Challenges of Monopolized Telecom Sector:

While 51.88% of the respondents preferred to cease ETC's monopoly if VoIP is implemented in Ethiopia, 28.57% totally avoided ETC from being their choice of VoIP service provider as indicated in the table below.

Preferred service provider	Response	%
ETC alone	52	19.55%
ETC and Others	138	51.88%
Others alone	76	28.57%
Total	266	100%

(From Q1P5q8 and Q2P4q11)

Table 5.1: Customers' preference of VoIP service provider in Ethiopia.

This challenge is emanated from the poor quality of service ETC has been providing. Through out its 110 years of operation, the telecom sector in Ethiopia, although seems better than other sectors in some aspects, could not make its services to be of quality and abundant. Customers in their responses to open indeed questions said that ETC has been weighted in the balance of service provision for plenty of years and found incapable of being good service provider.

Preference of VoIP by Customers (Unutilized Market Opportunity):

Measured against such parameters as price, congestion, security of message, interference of unwanted voice, delay, echo, and communication interruption, VoIP scored the highest preference rate for its cheap price opportunity (92.64%) and relatively small rates for security (53.39%) and communication interruption (53.06%). VoIP is generally preferred to PSTN by 66.61% of the respondents as indicated in the following table.

Criteria for comparison	PSTN	VoIP	Total
Price of International calls	7.36%	92.64%	100.00%
Congestion	42.57%	57.43%	100.00%
Security of messages	46.61%	53.39%	100.00%
Interference of unwanted voice	27.39%	72.61%	100.00%
Delay	27.05%	72.95%	100.00%
Echo	36.63%	63.37%	100.00%
Communication interruption	46.94%	53.06%	100.00%
Average (overall preference)	33.39%	66.61%	100.00%

(From table 4.1.7 and 4.1.17)

Table 5.2: Customers' preference from VoIP & PSTN telephony systems.

Generally, only 30.74% users have high satisfaction in PSTN and 63.08% of respondents expressed their high satisfaction with VoIP. The percentage of high, medium, and low satisfaction rates are presented below:

Telephony	High	Medium	Low	Total
PSTN	30.74%	45.56%	23.70%	100%
VoIP	63.08%	32.71%	4.21%	100%

(From Table 4.1.3 and 4.1.17)

Table 5.3: Customers' satisfaction from PSTN & VoIP telephony systems.

Although VoIP is not yet provided legally in Ethiopia, there is a positive attitude towards VoIP as it is expected by more than 60% of the respondents to give high satisfaction. This can be attributed to the fact that more than 69% of users of the existing PSTN telephony system are not highly satisfied. This attitude towards VoIP is a great opportunity to get sufficient market in the country. Getting VoIP market is one of the challenges in developed countries as they have better capability to pay for quality. But, the cheap cost VoIP is preferred in Ethiopia as there is neither a reliable quality of PSTN nor the capacity to pay. Let it be of poor quality VoIP in Ethiopia; it will be a matter of comparing two poor quality telephone services with a big difference of cost. The users expressed to benefit from the low cost VoIP opportunity as they are not already getting high quality PSTN telephony service.

Besides, ETC has potential customers (hundreds of thousands are waiting for telephone service). The fact that Ethiopia has over 70 million populations (the 3rd largest population in Africa) is a great market opportunity. Added to the users' interest to use VoIP, ETC will not face market problems unlike telecom providers in saturated markets.

Opportunity of Good Perception of Management:

In the interview to ETC and ETA officials, there is a promising attitude towards VoIP. Although there is a general fear of losing revenue from international calls, they are not against the technology. This can be considered as an opportunity for implementing VoIP. But the fact that they neither have started any thing in practice nor have clear plans may hinder the implementation of VoIP.

ETA officials, on the other hand, seem that they will always stand in ETC's side to protect its revenue rather than regulating the sector for adoption of new technologies (such as VoIP) to the benefit of the people. This is because of the fact that both parties have common commitments to the government. Had there been free market, ETA could have played its role of regulating the service rather than providing protection service for operators. So ETA is waiting for ETC's "go-ahead" to legalize VoIP. Even if ETC lets VoIP to be legally used now, ETA has not clearly specified standards and preparing this may take time.

However, from the global pressures on ETC to use the technology and the world trends as mentioned in the interview, it can be concluded that VoIP will be implemented in Ethiopia in the coming few years as ETC officials showed readiness to begin to work on VoIP and as they cannot go longer against global interests in using VoIP technology.

Poor PSTN infrastructure and new investment on it:

The existing PSTN telephone infrastructure is poor in quality and supply. It needs huge maintenance costs and ETC is investing to improve the performance by transferring the old network to new one. ETC's officials have made clear that they will not migrate to VoIP before they get a return from the existing PSTN infrastructure that equates to the investment. This may lengthen the time for VoIP to be implemented. In order to make the transition from PSTN to VoIP seamless, ETC has to begin to invest and work on VoIP now. But the technology has an opportunity that the existing PSTN network can be used for VoIP purpose by making the connection at international transit level by purchasing gateway services at lower costs than having own gateway as indicated in **figure 5**.

5.6. Facts Supporting the Findings

The Impact of International Tariff Reduction of ETC's Revenue and Outgoing Traffic

ETC has made a 41% price reduction for international calls (from Birr 17 to 10 for minute) as of from March 2003. If VoIP is to be implemented in Ethiopia, the international tariff rate will be reduced farther to Birr 4 and even less. Assessing the impact of the first tariff

reduction on international revenue and traffic volume may enable us to see the impact of the second tariff reduction as a result of VoIP.

The following tables show the revenue from international outgoing calls and the traffic volume before and after price reduction:

Year/Quarter	Revenue in Birr	% change	Outgoing calls in minutes	% change
1993/1	47,905,000		3,230,461	
1993/2	49,862,000	4.09%	3,507,247	8.57%
1993/3	49,862,000	0.00%	3,347,889	-4.54%
1993/4	54,643,000	9.59%	3,327,289	-0.62%
1994/1	46,088,000	-15.66%	3,142,150	-5.56%
1994/2	47,106,000	2.21%	3,231,513	2.84%
1994/3	44,809,000	-4.88%	3,174,271	-1.77%
1994/4	56,134,000	25.27%	3,332,355	4.98%
1995/1	43,599,000	-22.33%	3,265,407	-2.01%
1995/2	42,964,000	-1.46%	3,469,304	6.24%
1995/3	43,920,000	2.23%	3,626,244	4.52%
1995/4	37,526,000	-14.56%	3,892,324	7.34%
1996/1	37,717,000	0.51%	4,126,640	6.02%
1996/2	38,782,000	2.82%	4,342,878	5.24%
1996/3	39,425,000	1.66%	4,373,041	0.69%
1996/4	49,752,000	26.19%	4,801,239	9.79%

Source: ETC

Table 5.4: International outgoing and incoming traffic before and after price reduction

Revenue from international outgoing calls registered the greatest reduction (22.33%) in 1995/1. The period immediately after price reduction was 1995/4 which showed the medium reduction (third to the greatest and smallest reduction). Thus, it is impossible to account the revenue reduction in 1995/4 for the tariff reduction as revenue has registered even greater reduction in periods where there was no tariff reduction. Besides, the revenue showed improvements after this first quarter loss.

Traffic on the other hand, was showing improvements constantly in the subsequent quarters.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

This research targeted to investigate the opportunities and challenges of VoIP in view of suggesting decisions to be made regarding its implementation in Ethiopia. Assessment of the status of VoIP world wide and in Ethiopia, investigation of the impacts of implementing VoIP in Ethiopia on ETC's revenue, on information transfer, on tele-centers' revenue, on government tax, and on existing infrastructure, and assessment of the conditions for implementing VoIP in Ethiopia were set as specific objectives.

For this effect, vast books, journals, and Internet sources were reviewed. Primary data and secondary data were collected and analyzed using statistical methods and KnowledgeSTUDIO.

Findings of the research revealed that Internet telephony (VoIP) has got the recognition as *next generation technology* world wide. Most telecom operators of the developed countries are aggressively working on it. VoIP supports PC-to-PC, PC-to-PSTN or vise versa, PSTN-to-PSTN, and IP phone-to-PC/PSTN or vise versa connection formats when compared to PSTN-to-PSTN format of the traditional telephony technology. Other opportunities associated with VoIP (such as low cost international calls, simplified network management, improved productivity and customer services, and new services) have attracted many countries even in Africa. It was found that in Africa (including Ethiopia), at least 10% of the outgoing international traffic was made through "illegal" VoIP providers.

However, having these opportunities does not mean that VoIP has no problems. Since it involves the transmission of digitized voice packets over IP networks, it suffers from problems associated with networking, such as packet delay and loss. Implementing VoIP demands to meet secured and good quality of service standards. More importantly, VoIP challenge such as integration with PSTN, interoperability, and scalability should be addressed in an implementation schedule. Overall, telecom operators are enjoying from VoIP and the technology has got the recognition as the next generation technology.

Interview with ETA and ETC officials showed that they are not fully successful in controlling such operations as the technology is very dynamic. It was perceived that the deployment of broadband Internet in Ethiopia will worsen the controlling activity and the actions being taken on “illegal” operation will not protect ETC from losing revenue and the “illegal” operators from generating non-taxed income. Legalizing VoIP avoids this loss as the “illegal” operators can now be legally licensed. The probable loss of ETC’s revenue from international calls, although found non-realistic, is among the big threats of ETC and ETA officials on VoIP. This had made them to stick to the PSTN technology, invest on it, and resist to not letting VoIP until a reasonable return is obtained.

This research has achieved its general objective and specific objectives by assessing the possible impacts of implementing VoIP using primary and secondary data. In so doing, the research has found out the following facts if VoIP is to be implemented in Ethiopia:

1. VoIP has no negative effect on ETC’s revenue from international calls. The prediction, of ETC’s revenue under the existing PSTN operation for the E.F.Y. 1997, using KnowledgeSTUDIO – Time Series model, was found to be Birr 313 million. It was found through the survey that ETC’s revenue under VoIP will be Birr 318.8 million, showing a 1.85% increase from the revenue under PSTN).
2. The greatest positive impact of VoIP was observed on international traffic or information transmission (an increase of outgoing minutes by 298%). This was an encouraging result that people in Ethiopia will have that much contact with the international community; meaning, Ethiopians will not be far from the global information society.
3. VoIP also affects telephone resellers’ revenue and government’s tax collection positively by 36.54%.

To conclude, VoIP has positive answers to our research questions with its potential of increasing international traffic (information transfer) and revenue for ETC, the resellers, and the government; it can be used to narrow down the digital divide by enabling people in developing countries to communicate with the global world and share information at a very cheap rate; and there are required facilities in Ethiopia, such as broadband, that enable the people to use VoIP technology.

6.2. Recommendations

After conducting this research, the findings supported that VoIP has no negative effect in Ethiopia. Rather, it has all-round positive effect for building the informed society in the country.

Most of us believe ETC is a committed telecom provider that is trying to connect Ethiopia to the future. We also believe that ETA, as a regulator, is committed to facilitate the people to benefit from telecom services and technologies. Therefore, the following recommendations are forwarded to ETC and ETA:

1. As VoIP is the next generation technology, it is only with this technology that ETC can connect the people to the future. ETC has to start working and investing to implement VoIP today rather than tomorrow. It has to rethink on investing more to build the next generation network, as what is done on broadband, than to reach the society by the traditional telephony system. Other wise, its vision of providing modern, world-class telecom services will remain unfulfilled.
2. Knowledge of the VoIP technology by officials, although encouraging, is meaningless by itself unless the knowledge is practiced. ETC in this regard has to make use of the knowledge in the minds of its officials and other professionals. Graduate students at its graduate school and/or at Addis Ababa University should be encouraged to work in the area. The graduate school has to prepare seminars to discuss with ICT professionals, Internet service providers, and companies owning private networks on how to use VoIP for the best of the country. ETC has to consider the VoIP issue as a hot agenda to be addressed as soon as possible.
3. To be an accepted and even preferred service provider by its “choice-less” customers, ETC has to compare the different possibilities for providing VoIP even with the existing infrastructure and choose the best option that enables to exploit the opportunities of VoIP fully. An appendix (*Appendix 1*) is attached as a start up guide for the implementation of VoIP.
4. To protect ETC from losing revenue, ETA has to set criteria and give license to Internet telephony operators. As VoIP is uncontrollable, it will be better to initiate

ETC to join the technology. Otherwise, the broadband technology is there to spread the “illegal” operation throughout the country. Protecting ETC by trying to control the unstoppable operation is not an achievable strategy, but may make ETC to slowly grow to die out from the modern telecom industry.

Finally, future research works can extend this work by developing alternatives for implementing VoIP and modeling their costs, related technical issue such as voice quality, security, and other challenges of VoIP, and intra and inter company VoIP implementation architectures.

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Appendix 1: A Proposed VoIP Implementation Guide in Ethiopia

The implementation of VoIP in Ethiopia can follow similar steps as those that are followed during any project development and implementation. ETC can form a project team under a technical representative. The team must utilize the knowledge resource of graduate students of Telecommunications Engineering at the GSTIT, that of the Engineering Faculty at Addis Ababa University, and other ICT professionals. Thus, expecting the detail implementation plan to be designed by the proposed team, a high level view of the implementation plan is presented here with 4 steps.

Step 1: Evaluation of Alternatives

To implement VoIP in Ethiopia, ETC has at least three options:

1. IT can partially (phase-by-phase) implement VoIP as suggested by the officials during the interview and even let the “illegal” VoIP providers to be licensed. This is an easy start (that can be done overnight) but will endanger ETC’s revenue and have a price discrimination effect between company owners (and their employees) and the people at large unless ETC decreases the existing tariff rate significantly (by grater than 60%). This tariff reduction can keep its customers to stay with ETC than going to the service centers. ETC will get equal or even greater revenue from the huge traffic to be generated at such a cheaper rate. ETC has to decide if this tariff reduction is possible. But, even if possible, this option may require new billing system for those who are allowed to use VoIP and this should be considered. Besides, this option requires the users to have PCs or IP stars, or IP phones, or special adopters to make a connection to the Internet. Central control of the traffic is not possible here.
2. Providing VoIP services with the new broadband Internet and developing its own IP infrastructure is also an option. As the broadband Internet recently implemented supports VoIP operation to those who have Internet connection, ETC can provide the service for the public use who have Internet connection. But the number of Internet subscribers are too small (around 15 thousand), indicating that the people at

large will not be beneficial. This option, like the first option, is discriminatory (only Internet subscribers are beneficial) and ETC will lose revenue unless the tariff reduction is made. Besides, although building the future generation network (IP) is inevitable, it demands to invest a lot and is impossible too do so within a short period of time. The loss of central control and the need for new billing system also appear here.

3. It can connect its existing PSTN switches at its international gateway to the Internet through gateway service providers. ETC's connection at its PSTN gateway to hub providers is currently through satellite, microwave, or sub-marine cable. It is possible to connect our PSTN with the Internet through VoIP gateways of the same hub providers (most of the hub providers are also VoIP gateway providers). This option has no discriminatory nature as there will no different rates, all traffic passes through centralized manner, and there is no need of new billing system. More over, there is no need of having PCs or IP stars, or IP phones, or special adopters as the existing telephones get VoIP capability through their switches (all switches are to be connected to the global Internet through VoIP gateway at the international transit level).

Thus, it seems that the third one is the best option to start enjoying with the benefits of VIP in the shortest possible time. It is easier to manage for ETC as the traffic is centrally controlled and there is no need of new billing system. The architecture of this option is indicated in Figure 5.

It is important to note here that most of the current hub providers to Ethiopia are also VoIP gateway providers, but at a very cheap rate (US\$0.03 per minute) than the hub rate (US\$0.2 per minute). As they are increasingly employing VoIP using gateways to connect the PSTN of many countries with IP, and as the competition between these service providers is becoming stronger and stronger, we might have been using VOIP without our knowledge. Our international PSTN gateway could have been receiving VoIP calls through the hub providers. It is also possible that the hub service provider could have been transmitting our

international calls through their VoIP technology while we are paying for the hub service at a higher rate. We know that we are paying for their hub services at higher rates than VoIP service rates, but we do not know whether the incoming and outgoing traffic is transmitted through the Internet or not. Thus, paying for the cheaper technology is better and, hence, connecting our international transit gateway with IP through VoIP gateways seems the best option.

Step 2: Determining the specification of VoIP gateways and other required hardware and software to be used.

ETC needs at least VoIP gateway services and software to link its international PSTN gateway with VoIP gateways. Since there are various types of gateways that have different capacities, the proposed team has to set company-specific requirements first and determine the VoIP hardware and software specification. Once clear specifications are determined, it could be easy to select which VoIP gateway services are to be used. The proposed project team can have different groups and, of which, one group can compare and evaluate the appropriate hardware and software requirements based on ETC's needs.

Step 3: Selecting the best VoIP gateway service providers

ETC's existing PSTN gateway has different links to different countries. There are cases that having a direct link with a country could be better than reaching that country through the hub providers. For example, the connection to Djibouti through the existing direct link is cheaper than getting this country through the least price hub provider. This indicates the need to evaluate with which countries shall the direct link continue and with which countries shall the VoIP link be operational. Another group of the team can work on this area.

Besides, in addition to the price and other criteria, service providers should be evaluated in terms of their service coverage. Selecting a service provider working in larger number of countries that have greater amount of traffic flow with Ethiopia means that the interoperability problems are minimized. More importantly, the selected VoIP gateway service provider can be used as network partners in the future (when Ethiopia is in a

position to build the IP infrastructure for large scale utilization) should have the best experience in providing VoIP services.

Step 4: Side-by-side operation of both the existing and VoIP links

In order to make the transition from PSTN links (satellite, microwave, and sub-marine cable) to the VoIP link seamless, ETC shall not disconnect the existing links at once. Side-by-side operation is required until some time to compare the results of both operations and improve VoIP quality problem in case it faces. Evaluating the performance and improving the quality of VoIP operation can be done by other groups of the proposed team.

Appendix 2: Questionnaire for International Telephone Users

Addis Ababa University Faculty of Informatics Department of Information Science

A Questionnaire for International Telephone Users to Study the Impact of VoIP if Implemented in Ethiopia

Part 1: Introduction

Internet Telephony or Voice over IP is being implemented in Africa and all over the world especially due to its cheap price for international calls. In Ethiopia (especially in Addis Ababa) too, VoIP has been in use since 2002/3 although not legally. As VoIP is uncontrollable, such services are still being provided underground for Birr four or three per minute of international calls.

This questionnaire is designed specially to assess what advantages and disadvantages will VoIP have and especially its impact on international telephone utilization of the customers and on the telephone resellers' revenue if it is legalized and implemented in Ethiopia by ETC or other legal providers.

Therefore, since your kind responses to the questions are of immense use for my research work regarding the implementation of Internet telephony in Ethiopia. Even though your responses remain secret, you are not required to mention your name or identity.

Thank you very much for your great assistance in this research by vesting your precious time in giving open and faithful responses.

Part 2: General Information

1. Town _____
2. The type of you subscription from ETC: ☐ Fixed ☐ Mobile ☐ Internet
3. Your telephone subscription category
☐ Resident ☐ Own office ☐ NGO ☐ Government office
4. Your source of income
☐ Salary ☐ Pension ☐ Own work ☐ Other (mention_____)
5. Your monthly income in Birr
☐ 500 or less ☐ 501-1000 ☐ 1001-1500 ☐ 1501-2000
☐ 2001-2500 ☐ 2501-3000 ☐ above 3000 (mention_____)
6. Are you a computer user? ☐ Yes ☐ No
7. If "Yes" to Q.6 above, where do you use computer?
☐ Home ☐ Office ☐ Computer centers ☐ School
8. Are you an Internet user? ☐ Yes ☐ No
9. If "Yes" to Q.8 above, where do you use Internet?
☐ Home ☐ Office ☐ Computer centers ☐ School

10. If "Yes" to Q.6 above, for what purpose do you use the Internet?
☐ e-mail ☐ voice transmission ☐ research ☐ others (mention_____)

Part 3: About the quality of telephone service you are getting now from ETC:

1. The tariff rate for international calls (Birr 10 per minute) when compared to the service you are getting is:
☐ Very cheap ☐ Cheap ☐ Fair ☐ Expensive ☐ Very expensive

For Q.2 to 8, rate the frequency of occurrence of the following problems in your international telephone usage:

Q.No.	Problems	Frequently	Sometimes	Never occurred
2	Problem of congestion			
3	Problem related to security of messages during conversation.			
4	Interference of unwanted voice during conversation (cross talk)			
5	Delay of partner's voice			
6	Reflection of own voice during conversation (echo)			
7	Interruption of communication			
8	Exaggeration of bills for international calls			

9. General level of satisfaction with international telephone service you are getting from ETC
☐ High ☐ Medium ☐ Low

Part 4: About your actual average monthly international telephone consumption under the current tariff rate (Birr 10 per minute)

1. For how many persons do you make an international call monthly?
☐ 1 person ☐ 4 persons ☐ 7 persons ☐ 10 persons
☐ 2 persons ☐ 5 persons ☐ 8 persons ☐ more than 10 persons
☐ 3 persons ☐ 6 persons ☐ 9 persons (specify_____)
2. What is the average frequency of international call you make for a person monthly?
☐ 1 ☐ 2-3 ☐ 4-5 ☐ 6-7 ☐ 8-9 ☐ 10 or more (specify_____)
3. What is your average duration of international calls in minutes?
☐ 1-3 minutes ☐ 7-9 minutes ☐ 12-15 minutes
☐ 4-6 minutes ☐ 10-12 minutes ☐ more than 15 minutes
(specify_____)

Part 5: About Internet Telephony

1. Assume that you are provided with Internet telephony service in which you will be charged Birr 4 per minute for your international calls.

1.1. For how many persons will you make an international call monthly?

- ☐ 1 person ☐ 4 persons ☐ 7 persons ☐ 10 persons
☐ 2 persons ☐ 5 persons ☐ 8 persons ☐ more than 10 persons
☐ 3 persons ☐ 6 persons ☐ 9 persons (specify____)

1.2. What is the average frequency of international call you make for a person monthly?

- ☐ 1 ☐ 2-3 ☐ 4-5 ☐ 6-7 ☐ 8-9 ☐ 10 or more (specify____)

1.3. What is your average duration of international calls in minutes?

- ☐ 1-3 minutes ☐ 7-9 minutes ☐ 12-15 minutes
☐ 4-6 minutes ☐ 10-12 minutes ☐ more than 15 (sprcify____)

2. A tariff rate of Birr 4 per minute for international calls using Internet telephony service, compared to the service you are going to get, is:

- ☐ Very cheap ☐ Cheap ☐ Fair ☐ Expensive ☐ Very expensive

3. Have you heard previously about the Internet telephony that it enables to make international calls at cheap price? (If "No", go to Q.6) ☐ Yes ☐ No

For Q.4 to 5.4: If you are allowed to give telephony service with Internet telephony, how frequently will the following problems occur in using it for making international calls?

Q.No.	Problems	Frequently	Sometimes	Will not occur
4	Problem related to security of messages during conversation.			
5.1	Interference of unwanted voice during conversation (cross talk)			
5.2	Delay of partner's voice			
5.3	Reflection of own voice during conversation (echo)			
5.4	Interruption of communication			

5.5. General level of satisfaction with international telephone service you may get in using Internet telephony.

- ☐ High ☐ Medium ☐ Low

5.6. Comparing the existing telephone (PSTN) and Internet telephony with the following parameters, which telephony system do you prefer for making international calls?

QoS Measurements	Your preference	
Price of International calls	☐ PSTN	☐ Internet telephony
Congestion	☐ PSTN	☐ Internet telephony
Security of messages	☐ PSTN	☐ Internet telephony
Interference of unwanted voice	☐ PSTN	☐ Internet telephony
Delay	☐ PSTN	☐ Internet telephony
Echo	☐ PSTN	☐ Internet telephony
Communication interruption	☐ PSTN	☐ Internet telephony
Overall preference	☐ PSTN	☐ Internet telephony

5.7. *Shall VoIP be implemented in Ethiopia?*

☐ Yes;

Reason: _____
_____.

☐ No;

Reason: _____
_____.

6. If you have the chance to use Internet telephony for making international calls at a cheaper price, will you prefer to use it? ☐ Yes ☐ No

7. If your answer to Q.6 is "No", your reason for not to use Internet telephony is:

☐ Do not know benefits

☐ Do not know the requirements

☐ Do not have the capacity to have the requirements

☐ Hearing that it is illegal

☐ Other reasons (mention _____)

8. If Internet telephony is implemented in Ethiopia, from whom do you prefer to get the service?

☐ ETC alone; reasons:

_____.

☐ ETC and others together; reason:

_____.

☐ Others alone; reason:

_____.

9. Do you have anything else to say/comment about Internet telephony?

_____.

The attached post is prepaid post and thank you for returning this questionnaire in post or to the data collector who will contact you.

Appendix 3: Questionnaire for Tele-centers and Internet Cafes

Addis Ababa University Faculty of Informatics Department of Information Science

A Questionnaire for Tele-centers and Internet cafes to Study the Impact of VoIP if Implemented in Ethiopia

Part 1: Introduction

Internet Telephony or Voice over IP is being implemented in Africa and all over the world especially due to its cheap price for international calls. In Ethiopia (especially in Addis Ababa) too, VoIP has been in use since 2002/3 although not legally. As VoIP is uncontrollable, such services are still being provided underground for Birr four or three per minute of international calls.

This questionnaire is designed specially to assess what advantages and disadvantages will VoIP have and especially its impact on international telephone utilization of the customers and on the revenue of service centers if it is legalized and implemented in Ethiopia by ETC or other legal providers.

Therefore, since your kind responses to the questions are of immense use for my research work regarding the implementation of Internet telephony in Ethiopia. Even though your responses remain secret, you are not required to mention your name or identity.

Thank you very much for your great assistance in this research by vesting your precious time in giving open and faithful responses.

Part: General Information

1. Town _____

2. The service type you offer and the year you begin the service

Type of service	Number of lines for the service	Year you begin the service
Telephone		
Internet		

3. You give services for _____ number of days per week and for _____ number of hours per day.

4. If you provide telephone service (4.1 - 4.3):

4.1. Type and number of telephone lines used for the service:

☐ fixed phone ☐ wireless ☐ mobile phone

4.2. The average monthly telephone consumption (bill) you are paying in Birr to ETC for the telephones with which you give service:

☐ 1-250 ☐ 251-500 ☐ 501-750 ☐ 751-1000 ☐ 1001-1250
☐ 1251-1500 ☐ 1501-1750 ☐ 1751-2000 ☐ more than 2000(specify_____)

4.3. From the average monthly payment mentioned in Q.4.2, the amount of payment in Birr that appeared on bill for international calls is Birr _____.

5. If you provide Internet service (5.1 - 5.4):
- 5.1. Number of computers for the service _____.
- 5.2. The type of Internet subscription for the service: ☐ Dial up ☐ Leased line
- 5.3. The average monthly payment in Birr you are requested by ETC for the Internet you use for the service:
- ☐ 1-200 ☐ 201-400 ☐ 401-600 ☐ 800-1000 ☐ 601-800
- ☐ 1201-1400 ☐ 1001-1200 ☐ 1401-1600 ☐ more than 1600 (specify_____)
- 5.4. The average monthly payment in Birr you are requested by ETC for the telephone you are using for your Internet connection:
- ☐ 1-150 ☐ 151-300 ☐ 301-450 ☐ 451-600 ☐ 601-750
- ☐ 751-900 ☐ 901-1050 ☐ 1051-1200 ☐ more than 1201 (specify_____)
6. If you are providing only telephone service (not including Internet service), what is the reason that you do not provide Internet service? (You can give more than one reason.)
- ☐ I do not have enough space to include the service
- ☐ I am not capable of buying computers for the service
- ☐ I do not have the knowledge of how to provide the service
- ☐ The initial subscription rate is expensive
- ☐ I do not know the benefits
- ☐ Other reason (mention_____)
7. If you are providing only Internet service (not including telephone service), what is the reason for not providing telephone service? (You can give more than one reason.)
- ☐ I do not have enough space to include the service
- ☐ I am not capable of buying computers for the service
- ☐ I do not have the knowledge of how to provide the service
- ☐ The initial subscription rate is expensive
- ☐ Other reason (mention_____)

Part 3: About the quality of telephone service you are getting now from ETC:

1. The tariff rate for international calls (Birr 10 per minute) when compared to the service you are getting is:
- ☐ Very cheap ☐ Cheap ☐ Fair ☐ Expensive ☐ Very expensive

For Q.2 to 8, rate the frequency of occurrence of the following problems while you give international telephone service:

Q.No.	Problems	Frequently	Sometimes	Never occurred
2	Problem of congestion			
3	Problem related to security of messages during conversation.			
4	Interference of unwanted voice during conversation (cross talk)			
5	Delay of partner's voice			
6	Reflection of own voice during conversation (echo)			
7	Interruption of communication			
8	Exaggeration of bills for international calls			

9. General level of satisfaction with international telephone service you are getting from ETC:
☐ High ☐ Medium ☐ Low
10. On the average, how many persons make international calls at your service center?
☐ 1-10 ☐ 21-30 ☐ 41-50 ☐ 61-70
☐ 11-20 ☐ 31-40 ☐ 51-60 ☐ more than 70 (specify_____)
11. What is your average duration of international calls in minutes?
☐ 1-3 minutes ☐ 7-9 minutes ☐ 12-15 minutes
☐ 4-6 minutes ☐ 10-12 minutes ☐ more than 15 minutes (specify_____)

Part 4: About Internet Telephony

1. Do you think that the Internet, in addition to data transmission, can also be used for transmitting voice like any telephone? ☐ Yes ☐ No
2. A tariff rate of Birr 4 per minute for international calls using Internet telephony service, compared to the service you are going to get, is:
☐ Very cheap ☐ Cheap ☐ Fair ☐ Expensive ☐ Very expensive
3. Have you heard previously about the Internet telephony that it enables to make international calls at cheap price? (If "No", go to Q.6) ☐ Yes ☐ No
4. If you are allowed to give telephony service with Internet telephony, how frequently will the following problems occur in using it for making international calls? For (4.1 to 4.5)

Q.No.	Problems	Frequently	Sometimes	Will not occur
4.1	Problem related to congestion.			
4.2	Problem related to security of messages.			
4.3	Interference of unwanted voice during conversation (cross talk).			
4.4	Delay of partner's voice			
4.5	Reflection of own voice during conversation (echo)			
4.6	Interruption of communication			

- 4.7. General level of satisfaction with international telephone service you may get in using Internet telephony.
☐ High ☐ Medium ☐ Low
5. If you have got the chance to use Internet telephony for making international calls at a cheaper price, will you prefer to use it? ☐ Yes ☐ No
6. If your answer to Q.5 is "No", your reason for not to use Internet telephony is:
☐ Do not know benefits
☐ Do not know the requirements
☐ Do not have the capacity to have the requirements
☐ Hearing that it is illegal
☐ Other reasons (mention_____)

7. If your answer to Q.5 is "Yes", at what price per minute (in Birr) will you give international telephone service to the following contents? (7.1-7.4)
 7.1. North America ____ 7.2. Europe ____ 7.3. Latin America ____ 7.4. Africa ____.

8. If Internet telephony is legally allowed to be in use in Ethiopia and if you are able to provide international telephone service at the price you set in Q.7 (8.1 - 8.6):

8.1. Can you estimate the average number of persons to be served at your service center for international calls per month?

☐ 1-10 ☐ 21-30 ☐ 41-50 ☐ 61-70
☐ 11-20 ☐ 31-40 ☐ 51-60 ☐ more than 70 (specify ____)

8.2. Can you estimate the average duration of international calls in minutes that are to be made at your service?

☐ 1-3 minutes ☐ 7-9 minutes ☐ 12-15 minutes
☐ 4-6 minutes ☐ 10-12 minutes ☐ more than 15 minutes
(specify ____)

8.3. For how many days per week will you give service? ____ days.

8.4. For how many hours per day will you give service? ____ hours.

8.5. Will you subscribe additional telephone lines for your service center? ☐ Yes ☐ No

8.6. If your answer to Q. 8.5 is "Yes", how many additional lines will you subscribe?
☐ fixed phone ☐ wireless ☐ mobile phone

9. Comparing the existing telephone (PSTN) and Internet telephony with the following parameters, which telephony system do you prefer for making international calls?

Q.No.	QoS Measurements	Your preference	
9.1	Price of International calls	☐ PSTN	☐ Internet telephony
9.2	Congestion	☐ PSTN	☐ Internet telephony
9.3	Security of messages	☐ PSTN	☐ Internet telephony
9.4	Interference of unwanted voice	☐ PSTN	☐ Internet telephony
9.5	Delay	☐ PSTN	☐ Internet telephony
9.6	Echo	☐ PSTN	☐ Internet telephony
9.7	Communication interruption	☐ PSTN	☐ Internet telephony
9.8	Overall preference	☐ PSTN	☐ Internet telephony

10. Shall VoIP be implemented in Ethiopia?

☐ Yes;

Reason: _____

 _____.

☐ No;

Reason: _____

 _____.

DECLARATION

This thesis is my original work, has not been presented for a degree in any another university and all sources of materials used for the thesis have been duly acknowledged.

Mariye Yigzaw

June, 2005

This thesis has been submitted for examination with our approval as university advisors.

Dr. Daneal Fekresillassie (Advisor)

June, 2005

Dr. B.Rama Krishna Rao (C-advisor)

June, 2005