An investigation of the use of VoIP system as an answer to the digital divide in Africa. A Case study of the blind and deaf people.

Abstract

The use of computers, phones and the Internet are on the increase in Africa, but not at the same pace as elsewhere in the world. Africa is far from providing real access to information and communication technologies (ICTs) to all. Disabled people face many challenges related to access, availability and accessibility of the technological resources. Consequently, this has caused problems such as the digital divide and the last mile which deprive them of the ability to communicate, receive education, have self esteem, contribute meaningfully to their community and have independence. In this respect, this study was carried out to find approaches to closing the digital divide for deaf and visually impaired people at the Jairos Jiri Association, Zimbabwe (JJAZim) first through a needs assessment and then by developing a VoIP system that converts speech to text and text to speech and thus removing the need for intermediary communication and lowering costs. A self-administered questionnaire and interviews were used on a sample of 10 deaf and 8 blind people to determine the challenges they faced in the use of ICTs. Descriptive statistics were used to describe and summarize these data. The responses from the sample indicated that the organization had few inaccessible and sometimes unavailable computers. Most documented material is not readily available in alternate formats such as Braille, large print and electronic text and as a result 75% of the respondents indicated that they read and interpret text and graphics through interpreters. After requirement gathering and analysis, Unified Modelling Language (UML) was used to design the VoIP system which was then coded using JAVA programming language to produce a VoIP system called Jairos Jiri VoIP (JJVoIP). This case study can serve as a model for the development of other software packages that help to bridge the digital divide amongst different sections of society.

Keywords and Phrases

ICT, Digital divide, accessibility, availability, access,

Introduction

While the digital revolution has extended its boundaries to the global village, the majority of the world has remained disengaged from this unfolding trend. For example, there is always time lag in the provision of services to the disabled whenever there is a new technology. It is only after the broader uses of new technologies have been explored that disabled people are considered. As a result, the political, economic and social lives of individuals, societies and governments have been negatively impacted.

Some countries have tried their best to make sure that access to ICTs is provided to disabled people. This has seen laws and regulations being passed in countries such as United States of America (USA). At the core of U.S. telecommunications policy is the goal of "universal service", (McConnaughey, Nila and Sloan, 1995). There is a universal service mission which ensures that the largest possible number of residents have access to basic telephone communication service regardless of income and geographical location. The Federal Communications Commission (FCC) has rules that were designed to give greater access to telecommunications technologies to the disabled. Also in the USA, the rules and policies, serving to implement the Telecommunications Act of 1996, compelled manufacturers of telecommunications equipment and providers of telecommunications services to accommodate the needs of the disabled whenever possible (Condado and Lobo, 2006). A part of the Workforce Investment Act— was also amended in 1998 to require that all electronic and information technology developed, procured, maintained or used by the federal government be accessible to employees and members of the public who have disabilities National collaborative on workforce and disability (2005). In addition, Title II of the Americans with Disabilities Act requires a public college to take appropriate steps to ensure that communications with persons with disabilities are as effective as communications with others (Waddell, 1999).

The USA also has organizations such the American Foundation for the Blind (AFB) that is responsible to make sure that people who are blind or visually impaired achieve equality of access and opportunity that will ensure freedom of choice in their lives. Despite these achievements, services for accessing the Internet like America Online are currently not good choices for consumers who are blind because of their non-standard controls (buttons and icons)

and the lack of keyboard commands (Waddell,1999). Welham (2006) reports that despite the barriers, there are more people with disabilities in the New Zealand labour market now than ever before. This is largely due to two major developments: the creation of an employment centre specifically for people with disabilities or special needs and the advances in IT. Other achievements made by developed countries include:

a) Telecommunications Relay Service (TRS, Relay Service, or IP-Relay, an operator service) that allows deaf, Hard-of-Hearing, Speech-Disabled persons to place calls to standard telephone users via TDD, personal computer or other assistive telephone device.
b) Voice Carry over (VCO) which allows the deaf or hard of hearing person to use his or her voice while receiving responses from a hearing person via text typed by the relay operator (communication assistant or relay agent).
c) Hearing Carry over (HCO) which is used by people with speaking problems, but have no difficulty in hearing and (d) Video Relay Service (Wikipedia).

Meanwhile, Africa has a different story to tell. It is argued that there are fewer phone lines in Africa than in New York City alone. According to estimations of (Nua Internet surveys, 2001) from November 2000, of 407 million Internet users, only 3 million of them were Africans. If these figures were compared with the world's population, a huge gap becomes evident between the developed countries (such as USA and Canada where there are more than 16 millions users) with developing or underdeveloped countries. The World Bank also highlights this issue by reporting that roughly 90 percent of Internet host computers are located in high-income countries that account for only 16 percent of world population (World Bank, 2000). According to Chisenga (2001), although Africa has about 13% of the world population, it only has 2% of the world's telephone lines. The continent's population of about 739 million shares only 14 million telephones lines. Africa's number of telephone lines per 100 (telephone density) of 7.1 is the lowest in the in the world. Chisenga (2001) also noted that from the figures extracted from the International Telecommunications Union's (ITU) 1998 world Internet Indicators statistics, Africa had about 5,027,000 personal computers, translated into 0.76 PCs per 100 inhabitants. The International Telecommunication Union (ITU), pointed out that while fixed broadband penetration is growing rapidly and has reached around 15 and 10 percent in Europe and the Americas, it stands at less than half a percent in Africa. Internet use, in general, remains low in

Africa especially, where only 5 percent of the population is online, compared to over 40 percent in Europe, the Americas, and Oceania.

The scarcity of Adaptive computing technology at Jairos Jiri Association of Zimbabwe (JJAZim) which is evidenced by, among others, very few computers and unavailability of adaptive software has created a barrier of communication for the deaf and the blind people. As a result, this has created a barrier not only deprives them of their right to communicate, but also to share information, acquire proper education, contribute meaningfully to their community and have self esteem. Their privacy and independence is usually compromised as they need assistance to carry out even the most basic operations, like typing documents. It is important to note that the deaf and hard of hearing have always had problems communicating over telephone networks, which are designed for people who can hear. While the telephone was invented in the late 1800s, the first device to allow a deaf person to communicate over the public telephone network was not invented until 1964. Even today, an international call is very difficult to make due to interoperability problems between so many textphone protocols (Daily Payload, 2004).

This study was carried out to improve the communication system for deaf and visually impaired people at JJAZim by assessing their communication needs and by developing a cheap VoIP system that converts speech to text and text to speech thus removing the need for intermediary communication.

Methods

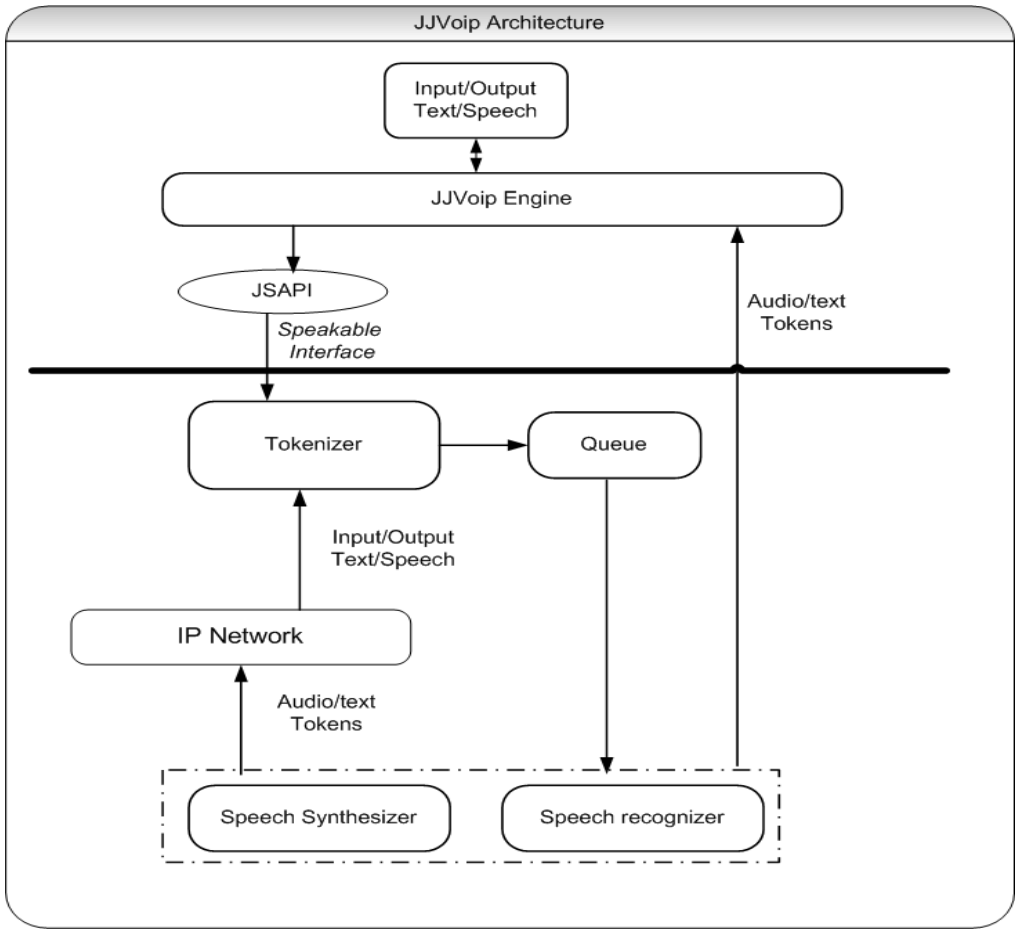
Stratified sampling was used to come up with a sample of 10 deaf and 8 blind people from a population of 30 and 20 respectively. A questionnaire was applied to ascertain the communication challenges faced by physically challenged people at the JJAZim. Semi structured interviews were later carried out with the people in the sample so as to probe further and give a deeper insight to their challenges. Descriptive statistics were used to analyse the data.

A detailed background study of VoIP was carried out because of the nature of the problem and needs of the users. An Incremental development model was used as a Software Model. This model was used because with it, deliverables are produced early (in each iteration) in the

Software Development Life Cycle and it is flexible and easy to manage. The researcher analyzed the gathered requirements and drew up a broad architectural design - a large scale view of the final system. This was later broken down into the main functional areas or modules which were then developed and tested in parallel. These modules or cycles were divided up into smaller, easily managed iterations which passed through the requirements, design, implementation and testing phases.

For this research, the inclusion of the architectural diagram (figure 1) means that there was an overall view or understanding of the functionality of the VoIP system. Note that, the diagram is divided into two sections, one of which signifies our JJVoIP user on one end and another signifying another JJVoIP system user over the IP Network.

Figure 1: JJVoIP UML Architectural Diagram.



As can be noted from figure 1 the system's functional requirements are as follows.

1. Capture text from the computer system – This facility was to be used by the deaf (who have the capability to see and write) to send messages to their counterparts who could be blind. The typed text is sent to the JJVoIP engine for processing.
2. Text conversion – the JJVoIP engine, (through the use of libraries that facilitate conversions from speech to text and vice versa), converts the text typed.
3. Through Java Speech Application Programming Interface (JSAPI), an interface called Speakable is implemented. This Speakable interface helps JJVoIP engine in enabling the speech synthesizers and recognizers available.
4. The text input is tokenized and later queued for further processing.
5. Through the speech synthesizer, the queued tokens are converted to speech output that is sent to the intended recipients (over the IP network or loop back to JJVoIP).

Note: Apart from typing, text can also be received from the IP network, through sockets.

On the other hand, if it is speech to text, the following stages take place.

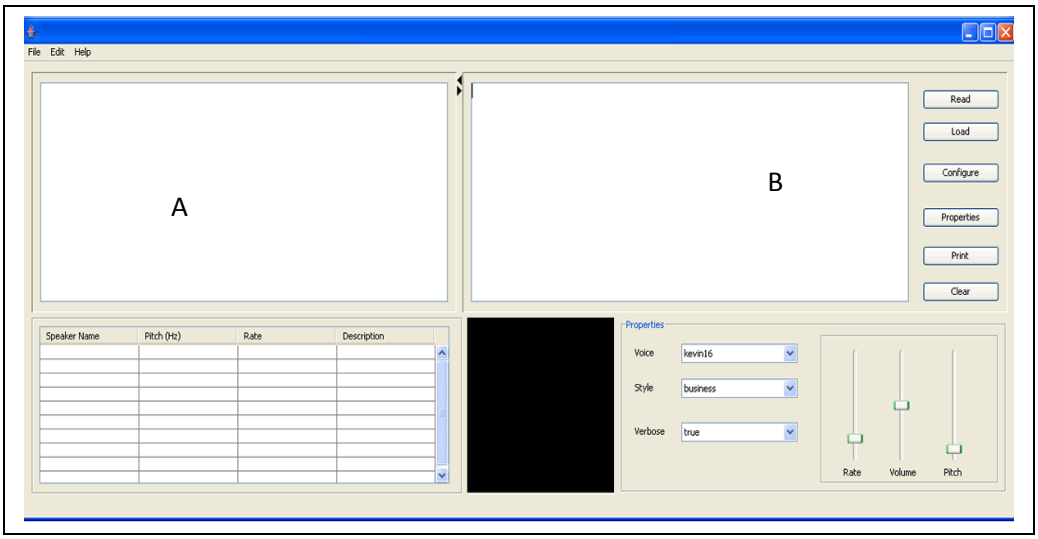
6. Capture speech from the computer system – This facility was to be used by the blind (who have the capability to hear) in sending messages to their counterparts who could be deaf. The inputted voice is sent to the JJVoIP engine for processing.
7. Speech conversion – the JJVoIP engine, (through the use of libraries that facilitate conversions from speech to text and vice versa), converts the inputted speech
8. Through Java Speech Application Programming Interface (JSAPI), an interface called Speakable is implemented. This Speakable interface helps JJVoIP engine in enabling the speech synthesizers and recognizers available.
9. The speech input is tokenized and later queued for further processing.
10. Through the speech recognizer, the queued tokens are converted to text output that is sent to the intended recipients (over the IP network or loop back to JJVoIP).

Implementation Language

Java was used as the implementation language because third party libraries like Free TTS (used for speech synthesis) can easily be incorporated to it. Moreover, it is platform independent, thus applications developed in Java can be run on any known platform and it is a potable language so there are no implementation-dependent aspects of the specification.

The screen shot on figure 2 shows how the system interacts with its users. A text editor labeled B is used to type text. Instead of the blind person looking for someone else to revise their document after typing, they can click on the read button and hear everything that has been typed through the speakers.

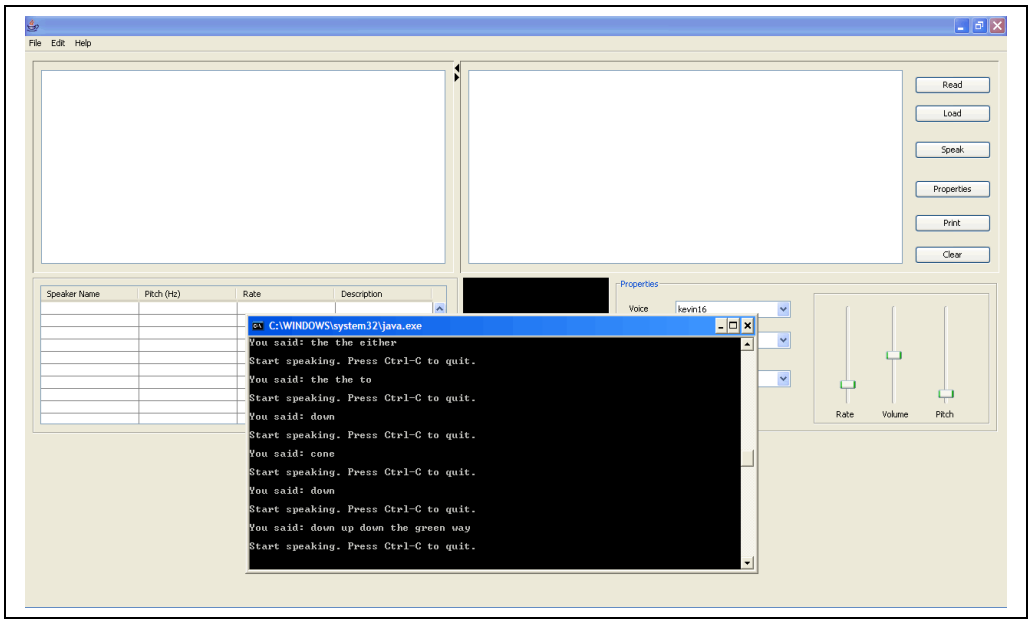
Figure 2: JJVoIP Interface Window



When the blind person wants to read a document, they need to click on the button captioned "*load*" and the document is loaded on the text area labelled A. It should be noted that for all the components on the form; tool tip messages and speech will be generated (as the mouse cursor hovers over the components) to guide the user in using the system.

Figure 3 shows a screen that provides the facility for speech to be converted from the IPNetwork to text.

Figure 3 JJVoIP Interface Window_2



Meanwhile, a deaf person can reply by typing on the text editor labeled B and sending text which is to be converted into speech back to the person on the other end of the IPNetwork. It is important to note that, the blind person can also change the type of voice, style, and verbose.

Results

The JJAZim only has four available computers. They use the dial up system to access the internet. This system is so slow that one has to wait for about five minutes to open a single Web page. As a result, their monthly telephone bills are always high. Moreover, the electronic information obtained is often available in formats that are not easily accessible to the disabled community.

Availability and use of Internet

As can be observed from table 2, only one person from the group of the blind indicated that he was aware of the existence and use of the internet. The rest were not aware because they were never introduced to it; one of their responses was that since they do not see, no one has ever introduced it to them, and they also did not bother to find out about its existence and how to use it. It is important to note that there is only one blind person who indicated that he can use the internet. However his major concern was the changes of the Internet from a text-based medium to a multi-media environment, which to him had created another digital divide. Previously, he

could access the Internet with the use of a screen reader which could audibly read aloud the text on a web page, but nowadays, most graphical web pages are a barrier as they do not incorporate accessible web design.

Table 1. Response of the study group on the availability and use of the Internet

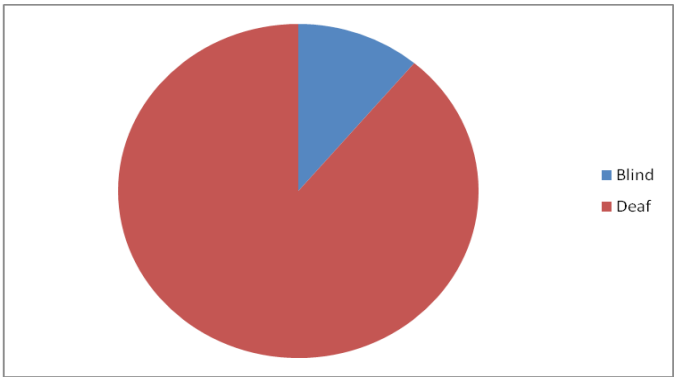
Disabled person	**Response**		**% Response for yes**
	Yes	NO	
Blind	1	7	13
Deaf	8	2	80
Total	9	9	

On the other hand, the majority of the deaf (80%) indicate that they were aware of the existence of the internet and knew how use it. Further probing revealed that the ability to see gave them an advantage over their blind counterparts. Meanwhile, those who responded by saying yes, affirmed that although the Internet is there, there is no guarantee of access, availability and accessibility. The research showed that because of electrical power cuts the four computers are always off and when power is available, many people will scramble to use the few (four) and slow computers.

Interpretation of text, graphics on-screen.

Most (89%) of the people who could read and interpret text, graphics etc from an output device such as monitor were the deaf (figure 4). On the other hand, the majority of the blind indicated that they read and interpret text, graphics etc through the help of others who act as a go between by narrating or translating what ever they hear or see depending on the disability.

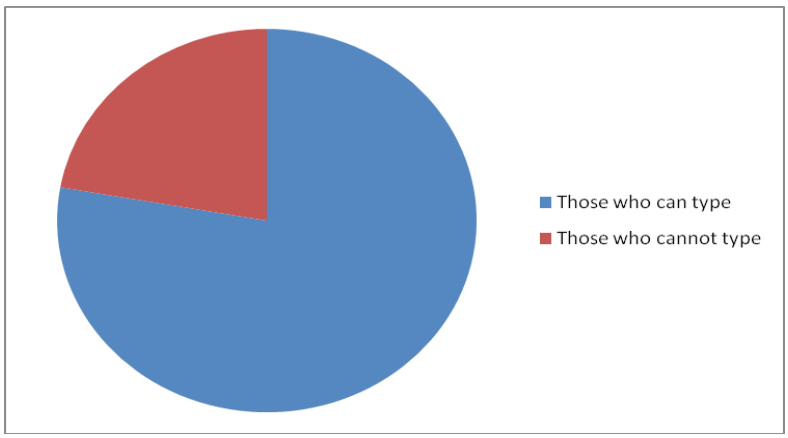
Figure 4. Interpretation of text, graphics and other visual content on-screen.



The use of input devices like mouse and keyboard

The majority of those who can type came from the deaf people. Although some blind people at the centre can use typewriters to type their letters or notes, it has always been a challenge to revise them (notes, memos etc) after typing because they can not see. For example, one participant commented that there are cases when they are interrupted whilst typing they need someone else to read the previously typed work in order for them to resume. They highlighted the need for a way to type without the need for a go-between.

Figure 5. Respondents' ability to type



Telephone usage

While a person without disabilities can easily make phone calls, because of prohibitive costs, unavailability, unreliability, access difficulties and unfamiliarity with electronic technology, some disabled people are unable to so. For example, this study revealed that only two blind people can use telephone as a means of communication. This is because, to a blind person

telephone buttons can be difficult to distinguish and some of them can be difficult to hold without accidentally pressing other keys. The two blind people have been using the same type of phones for a long-time, so they were now used to the buttons and their tones. Changing the handset, would bring about challenges to them again. None of the deaf people indicated that they can use a telephone because they cannot hear. In most cases, they (deaf people) depend on a friend, a family member, or a colleague, to communicate with a telephone

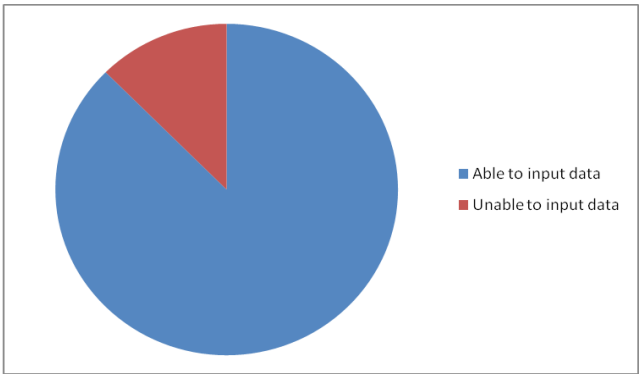
The organization (JJAZim) did not have definite policies and procedures for people with disabilities that assure access to printed materials and computers. Most (90%) of the respondents pointed out that most printed software and hardware documentation and other publications were unavailable in alternate formats such as Braille, large print and electronic text. The study also found out that 75% of the staff members do not know how to respond to requests for disability-related accommodations such as sign language interpreter.

Application of JJVoIP

Ability to input data

When JJVoIP was implemented, 86% of the blind people were able to input data through the keyboard, because of a combination of JJVoIP and narrator (resources available in Windows XP), an opportunity that they did not have before. All deaf people had no problems with entering text through a keyboard. The main reason was the fact they could see so they did not have any challenges with the keys of the keyboard.

Figure 6: Showing a number of blind people who could (not) use a keyboard to input data.



All the blind people managed to use the microphone to enter data (as voice) which was later converted to text and sent over the network. Their ability to talk made using a microphone easier. All of the deaf people could also use the microphone, since they could talk. Moreover, unlike their blind counterpart, they had another option of inputting their data via text.

Ability to use output devices (monitor)

It was a challenge for blind people to use monitors. Fortunately, the JJVoIP enabled them to hear (as output) what has been sent from the other end though speakers. They could adjust volume and sound quality so as to meet their needs. On the other hand, the hearing-impaired people could not use the speakers. However, the existence of JJVoIP helped them to read text which had been converted from voice from the other end of the network.

Limitations of JJVoIP

The system, however, does not currently provide a proper interface for the deaf who cannot read, since there are no pictures or videos or animations that can be used as a communicative tool. There are also challenges faced when speech is to be converted to and from text; at times the system fails to interpret spoken words and ends up outputting wrong information. Sometimes it does not even show the information on the screen; thus creating a digital divide again.

Discussion

The findings from the study indicated that JJAZim needs adaptive technology which is able to cater for deaf and the blind people. This will enable them to be independent from a go between who can read or revise whatever has been written for a blind person. The same goes with the deaf; conversation of voice to and from text will mean that he will not need someone to translate for him. The findings of the research revealed that although there are computers at the institution, there are many problems related to access, availability and accessibility. Consequently both the blind and the deaf are denied their right to communicate. This deprives them of chances of sharing information, contribute meaningfully to their community, share their experiences and have a sense of independence. Literature has shown that that networking can be a fundamental vehicle for successful business; that networking can be enhanced by the use of ICTs, sadly, those who do not use computers have little means to drive market demands for computer applications

in their language (Ryder, 2004).

Suggestions for further work using VoIP

The researcher is planning to include lip reading on the system to cater for those who can neither read nor write. When further developing the system, users should be more involved so as to come up with an ideal solution. Further research need to be done on VoIP traffic models and improvement of Quality of service.

Conclusion

There is no doubt that ICT is perceived as a catalyst for economic growth as it involves a set of activities that facilitate by electronic means the processing, transmission and display of information). In fact, an accessible and readily available information infrastructure is very important as it enables the connection of people and gives them opportunities to interact with businesses, government agencies, entertainment sources, and social networks. Internet is now being used as a primary communications channel; for emailing, e-commerce, e-voting etc and those without access or adequate skills are excluded. Disabled people are considerably disadvantaged as communication becomes more reliant on technology. The deaf or blind people have no reliable, cost effective, and convenient communication network. Their lower internet usage and inaccessible communication devices mean less e-mails and website use; hence, isolating them from socio-economic and political circles. Although the developed JJVoIP enabled some of the disabled people to communicate, a lot still needs to be done. The challenge to society is therefore to ensure access to communication and information resources for every member, regardless of age, physical ability, race or ethnicity, education, ability, cognitive style, or economic level, thus bridging the digital divide.

References

Chisenga J, (2001), Facing the Digital Divide: Ensuring Access to Digital Information in Sub-Saharan Africa. Available at: http:// home.imaginet.co.za/liasa/CHISENGA2001.doc [Accessed 20 May 2007**]**

Condado, P. (2006). Breaking barriers for people with voice disabilities. http://arxiv.org/abs/cs.CY/0606088, [Accessed 5 June 2007].

Daily Payload. (2004) VoIP: A Step Forward for the Deaf. www.dailypayload.com/2004/0503.html, [Accessed 20 May 2007].

Estavillo, Maricel E. (2004) Study seeks clearer definition of ICT projects for dev't in

RP. IT Matters. Available at: http://itmatters.com.ph/news/news_08312004e.html

[Accessed 19 December 2004].

Humanics Ergonomics. Disabled accessibility**. http://www.humanics-es.com/accessibility.htm**. **[Accessed** 20 May 2007]

International Telecommunication Union (ITU), http://www.itu.int/ITU-D/ict/statistics/ict/index.html [Accessed 20 May 2007**]**

McConnaughey, J., Nila, C. A., & Sloan, T. (1995). Falling through the net: A survey of the "have nots" in rural and urban America. Washington, DC: U.S. Department of Commerce. http://www.ntia.doc.gov/ntiahome/fallingthru.html. [Accessed 20 May 2007].

National collaborative on workforce and disability (2005) Breaking Down Technological Barriers. Info Brief, Issue 14. Available at www.ncwd-youth.info/assets/info_briefs/infobrief_issue14.pdf, 2004, [Accessed 20 May 2007].

NUA Internet Surveys. (2001). How Many Online? Available: http://www.nua.ie/surveys/how_many_online/index.html.

Peters, T. (2003), Bridging the digital divide. Available at: http://usinfo.state.gov/journals/itgic/1103/ijge/gj08.htm [Accessed 7 March 2007].

Ryder M (2004), The Digital Divide. Available at:

http://carbon.ucdenver.edu/~mryder/dig_div_este.html

UNESCO. (1999). *World information and communication report 1999-2000*. Paris: UNESCO. Retrieved January 11, 2001 from the World Wide Web:

http://www.unesco.org/webworld/wcir/en/report.html) [Accessed 20 May 2007**]**

Waddell,C J.D.(1999) The growing digital divide in access for people with disabilities: Overcoming barriers to participation in the digital economy. www.icdri.org/CynthiaW/the_digital_divide.htm, [Accessed 20 May 2007**]**

Welham, J (2007). www.med.govt.nz/templates/MultipageDocumentTOC____16733.aspx , (2006) http://www.med.govt.nz/templates/MultipageDocumentTOC____16733.aspx [Accessed 20 May 2007**]**

Wikipedia. (2007) Encyclopedia, http://en.wikipedia.org/wiki/Digital_divide [Accessed 7 March 2007].