ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ
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Title
Telemedicine application for remote hearing evaluation and speech therapy for deaf people after cochlear implantation Предоставление медицинских услуг на расстоянии для дистанционной оценки слуха и логопедии глухим людям после кохклеарной имплантации.

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Contents

Abstract

In health and sciences providing telehealth and teleconsultations is not a new branch, but with an increase of world population now it's become very hard for doctors to cover all patient and to provide health and care services in remote areas according to health standards, but with the help of telehealth we can connect many patients with doctors remotely. In a future number of doctors will be less as compared to patients and will be very difficult to provide health and care services to everyone. Telemedicine is cost effective solution as compared to traditional approaches to provide health and care in remote areas, its saving patient, providers, consultants and player's money and time [13].

Internet not only revolutionized communication, Multimedia, Business, Education it also brings revolution in the field of Telehealth and Telerehabilitation. This time is evolution time of Tele-medicine, many scientist and companies are finding new ways of implementing telemedicine. Telepractice can connect patient to audiologist or SLP (Speech Language Pathologist) in other location. There are many similar words can be used for Telepractice e.g. (Telespeech, Teleaudiology, Teletherapy, Telehealth, and Telemedicine)[1].

Tele medicine is very vast field and covers many applications in the field of Audiology and it will take at least 3 years to collect results from real patients and make conclusion, I used simulations to simulate the telemedicine environment to make sure possibility of Telespeech therapy. Here I only focused on one topic Tele speech therapy which can be used as telemedicine. In other Teleaudiology research work, authors only focused on internet speed and used Purchased Licenses Software's for Conferencing and they can't modify any Audio / Video Codecs settings to optimize settings according to internet speed. If internet speed is good we can achieve best practice in Teleaudiology but it's not a correct approach because communication on the internet does not only rely on the speed of internet connection, many factors are involved which should be under consideration for taking the quality of experience.

In Telehealth services is not only connect consultant to consultant, consultant to patient or SLP to the patient it's about to provide excellent Quality of Experience at the time of exchanging information in form of Audio, Video or Files sharing.

This article presents a comprehensive remote Speech Therapy test system that integrates a speech test for CI implants patients which are directly connected with a computer with AUX or Bluetooth device. By using telehealth approach we can eliminate speech therapist or speech-language pathologist or may we can reduce the load on speech therapist.

Advantage of this work is to connect number of patients with one doctor or number of doctors like one to one or one to many or many to many to provide services in remote area to improve health care.

We can reduce patients load from speech therapist and audiologist and they can provide time to every patient and can give some medication prescription remotely.

By using this approach player and patient can save time and money both until unless doctors recommends in personal meeting.

With telemedicine approach it's possible to tune and calibrate Cochlear machine remotely and can ask response from patient.

Big disadvantage of this work is provide training to medical staff and patients how to use equipment correctly which settings they have to set and perform tests.

Age factor is involved in this telespeech therapy because infants and small children below age of 8 years they can't understand this system they need some assistant to use this service.

Less in personal meetings with doctor and there can be possibility of inaccurate reports in testing.

Future Work

We can lead this research to make standards for telemedicine for Russia for Tele Audiology and live care monitoring. This research have all simulated scenarios to determine hardware and software requirements to achieve good quality of experience.

We can evaluate speech processors to check how much speech processor are efficient and how patient is listening sounds.

We can connect speech processor part with internal surgery part through different wireless technologies to add different variants in connectivity like Wi-Fi, 5G, Bluetooth and NFC to provide good audio with big data rate and responses by using smartphone speech processor.

We can automate hospital machines that somebody can controls remotely and some test are possible to do remote use like x-ray machines , MRI machines, ECG machines and Ultrasound machine.

This Research have vast feature in the field of Medical Sciences in to provide medical services remotely and minimize the risk of deaths and other death diseases.

ACKOWNLEDGMENTS

My thesis work on "Telemedicine application for remote hearing evaluation and speech therapy for deaf people after cochlear implantation" has been a result of the contribution of many esteemed people and without their support the thesis work would not have been possible. It is only fair to sincerely acknowledge these vital contributions towards the completion and finishing of the report.

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1 Human Ear

In new technology era we are taking very precise outputs from artificial sensors but these sensors are not accurate every time they have error values that we neglect. For example Temperature Sensor, Proximity Sensor, Accelerometer, IR Sensor (Infrared Sensor), Pressure Sensor, Light Sensor, Ultrasonic Sensor, Smoke, Gas and Alcohol Sensor, Touch Sensor and Color sensor.

Same human body have many sensors organs to sense sounding environment like Eyes work like camera shown in Figure 1 taking inputs from surrounding and transfer to brain like images by using nerve cells, Ears works like Sound sensor takes sounds and vibrations from environments and send to inner haring cells then nerves to give signals to brain, Nose can smell air and surrounding environments and give signals to brain, Tongue works like taste sensor and send signal to brain. Skin is like temperature and humidity sensor and give signals to brain.

energy type #1 → transducer → energy type #2 (*a*)

light energy → transducer-- visual receptor → nerve impulses-electrochemical pulses (*b*)

sound waves-mechanical energy → transducer-- microphone → changing voltages (*c*)
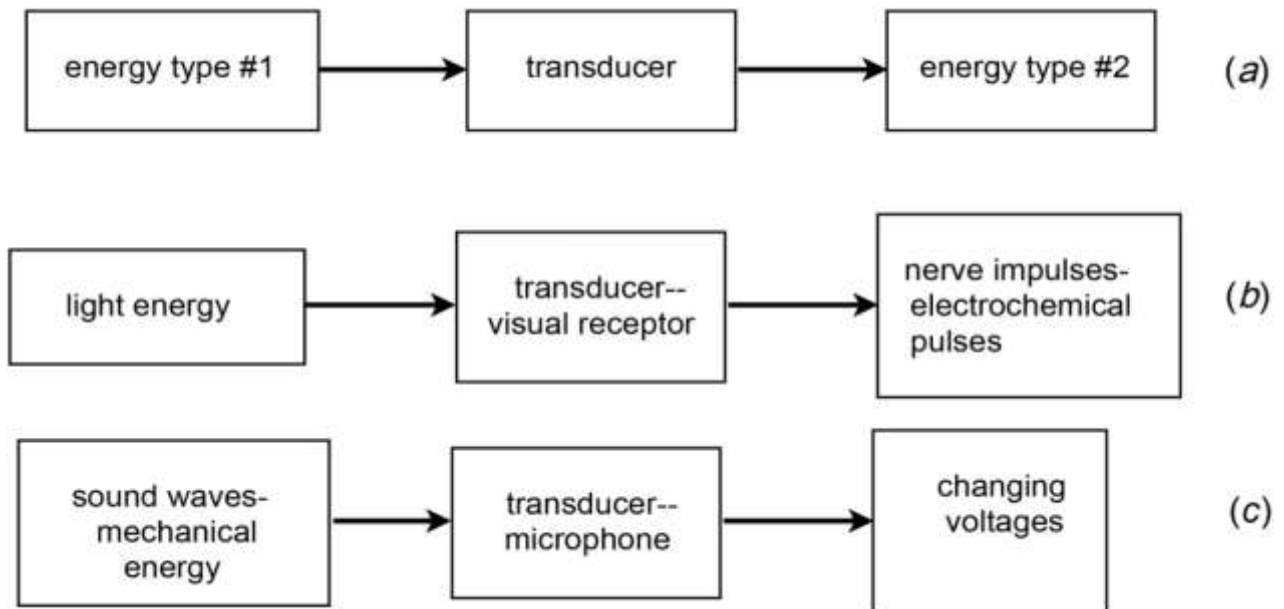
Figure 1: Conversion of Energy

1.1 Components of Human Ear

The three parts (as sown in Figure 2) of Human ear anatomy are the Outer ear, the middle ear and inner ear which is also called cochlea. The outer ear consists of the pinna, ear canal and eardrum, middle ear consists of the ossicles (malleus, incus, stapes) and ear drum and the inner ear consists of the cochlea, the auditory (hearing) nerve and the brain.
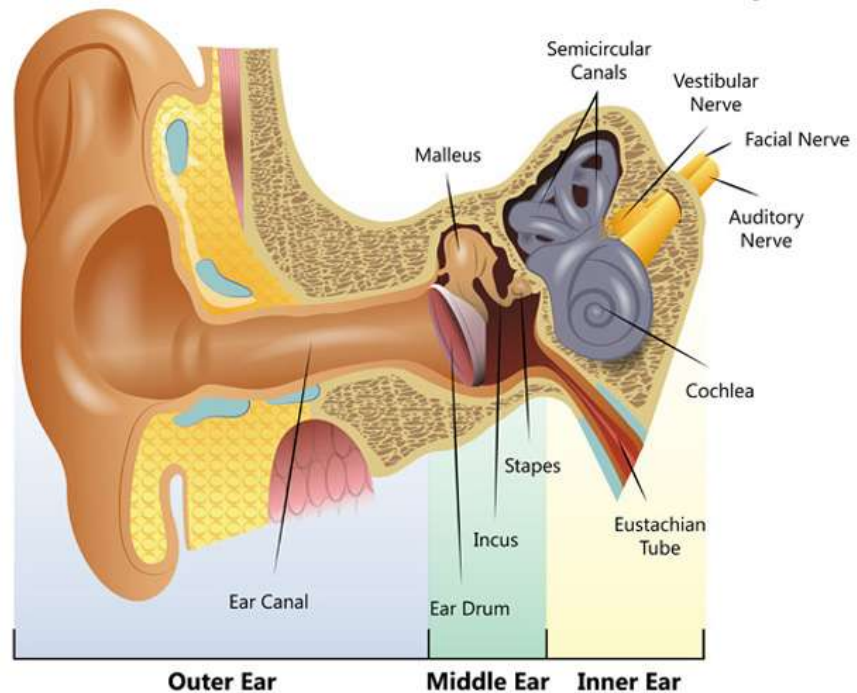
Figure 2: Ear Anatomy

- **Outer Ear:** external meaty piece of the ear, fundamentally, in essence, serves as a funnel for sound. It coordinates and limits sound (that is really why we have two ears-so you can decide the heading from where the sound is coming). That enables the sound to enter your ear waterway, so your cerebrum can settle on choices in view of the sounds you hear.

- **Middle Ear:** The eardrum acts as a natural boundary between the middle ear and the ear canal. Pressure in the middle ear is maintained through the Eustachian tubes (see Figure 3), which are closed when not in use. Each time a person swallows, the Eustachian tubes open and allow fresh air to enter into the tympanic cavity. This maintains a constant pressure gradient. Sometimes, this pressure is not equalized with the environment outside the head, and this is often the reason why some people experience discomfort in airplanes and at higher elevations.
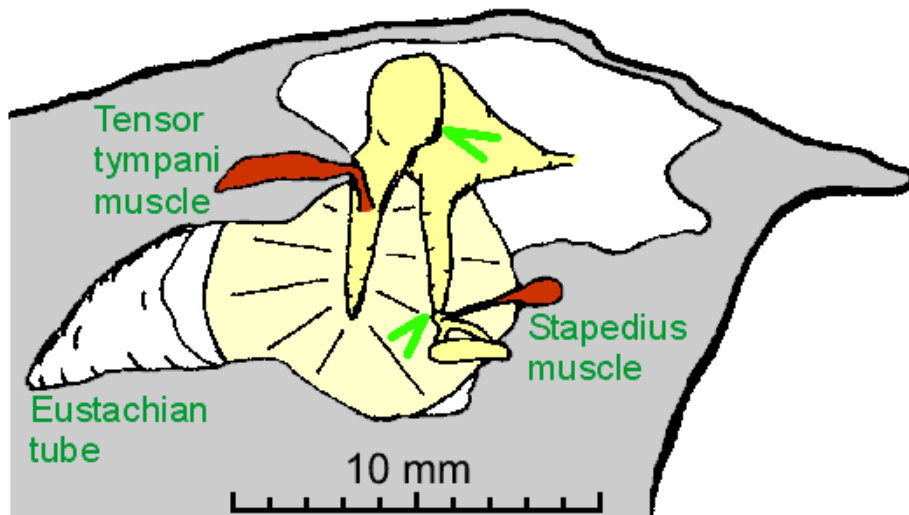
Figure 3: Middle Ear

- **Inner Ear** can be thought of as two organs: the semicircular canals which serve as the body's balance organ (shown in Figure 4) and the cochlea which serves as the body's microphone, converting sound pressure impulses from the outer ear into electrical impulses which are passed on to the brain via the auditory nerve.

Figure 4: Inner Ear

1.2 Problems with hearing

When your hearing is working normally, information is being passed through the different parts of the ear to the brain. The type of hearing problem (see Figure 5) you may have depends on which part of the ear is not responding well.

- Outer ear or middle ear problems lead to inefficient transfer of sound. The cochlea is still working but may not receive enough information. This type of hearing loss is called conductive hearing loss. The problem is that the sound is not being conducted (transferred) well enough.

- Conductive deafness can be caused by things such as an ear infection, a hole in the eardrum or otosclerosis.

- An inner ear (cochlear) problem means that sound arrives at the cochlea, but is then not fully passed on to the hearing nerve. Also it is possible that the hearing nerve itself is not passing on information well, or fails to pass on the sound at all. A cochlear or neural hearing loss is called a sensorineural hearing loss.

- Sensorineural hearing loss can be caused by things such as old age, Ménière's Disease or loud noise.

- It is possible to have a mixed hearing loss with both a conductive and sensorineural element.

Figure 5: Hearing Problem

2 General Purpose of Cochlear Implant

The first cochlear implant was invented by Dr. William House, in 1961.[18] In 1964, Blair Simmons and Robert J. White implanted a six channel electrode in a patient's cochlea at Stanford University.[19]

The modern multichannel cochlear implant was independently developed and commercialized by Graeme Clark from Australia and Ingeborg Hochmair and her future husband, Erwin Hochmair, with the Hochmairs' first implanted in a person in December 1977 and Clark's in August 1978.[20]

Cochlear Implant is surgical electronic device which converts analog audio signals into neural impulses and this device provide a sense of sound who is profoundly deaf or severely hard to listen. This device can be implanted to children who is birth deaf or sensorial hearing loss to improve hearing sense.

2.1 Cochlear Implant device parts

Cochlear implants sidestep most of the main auditory system parts which receives sound and converts that sound into movements of hair cells in the cochlea and transmit signal to brain.

The inside of basil membrane which contains hairs cells, these hair cells release potassium ions in response to the movement of the hairs, and the potassium in turn stimulates other cells to release the neurotransmitter, glutamate, which makes the cochlear nerve send signals to the brain, which creates the experience of sound.

Cochlear Implant device (see Figure 6) consist of two main parts External part consist on Mic, Speech processor and Transmitter and Inner part which can be implanted through surgery inside brain consist on receiver and electrode.
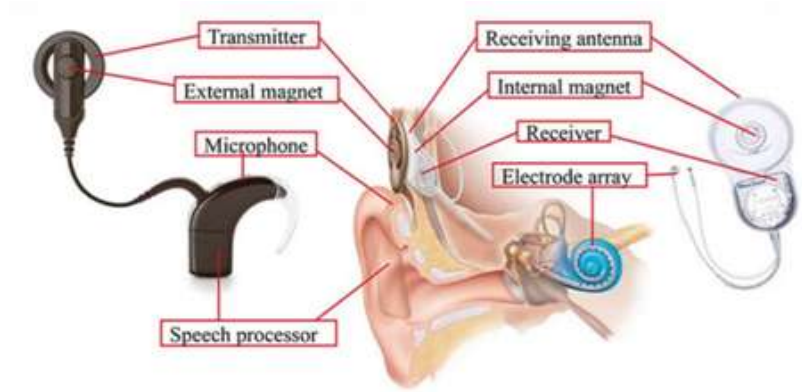
Figure 6: Basic Operation of Cochlear Implant

2.1.1 External Parts

Mic: Mic is first part of External part of Cochlear Implant device which takes audio signals from environment and delivered to speech processor or audio processor.

Speech Processor: Sound processor or speech processor gathers sound from environment by taking audio signals from Mic and performs sound processing, firstly analog to digital conversion with ADC converters, secondly using high band and low band pass filters for cutting high frequencies and low frequencies noises, thirdly performs FFT and change signal in to frequency domain in last transmitted signal to implant.

Transmitter: Transmitter is like ear drum which works between outer ear and inner ear. Transmitter takes signals from speech processor and delivered to internal part of cochlear implant device by using frequency modulation technique.

2.1.2 Internal Parts

Receiver: receiver implants inside of human skull which takes processed signal from outer part implant device and transmit signal to Cochlear Implant.

Cochlea Implant: cochlea implant device consist of electrodes array (see Figure 7). Specific frequency signal transmits to specific electrode for generating specific amount of voltage to stimulate nerves to transmit signal to brain this process is done by frequency mapping process.

(a) Peripheral auditory system.   (b) Frequency-to-place mapping of the cochlea.
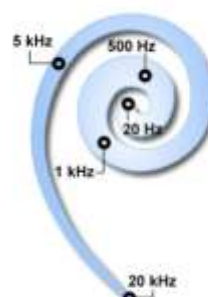
Figure 7: Inner part of Ear and cochlea

Typical Internal Circuit of Speech Processor is shown in Figure 8 for basic understanding.
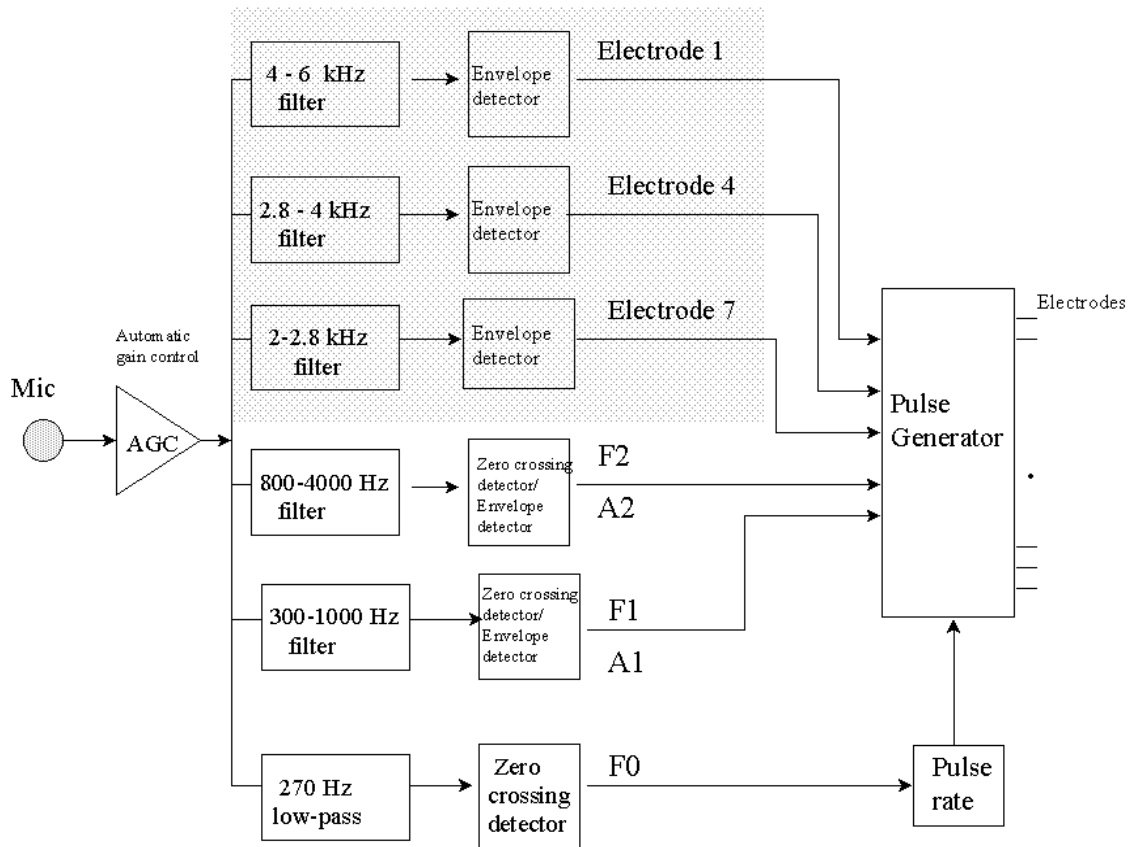
Figure 8: Internal Circuit of Cochlear Implant device

2.2 Audiology

The word audiology is Greek word which consist of two words: Audio and Logy. 'Audio' refers to 'hear' and 'logy' to 'the study of'. In essence, audiology is the study of hearing - as the inner ear is also required for balance, this is also included in the study. In medical terms it is the branch of science dedicated to the study of hearing, balance and their associated disorders [21].

2.2.1 Audiologist

Individuals who hone audiology are called audiologists. Audiologists are capable for diagnose and restoration of clutters related to hearing as well as adjust. Audiologists have a Doctorate in Audiology from an authorize college. They are arranged to observe over patients running from modern conceived children to elderly people.

2.2.2 Speech Pathologist

Speech pathologist also known as speech therapist, these people deals with peoples working in following fields which is not directly related with medical sciences audiology, optometry, occupational therapy, clinical psychology, physical therapy. These people is capable to trained people and diagnose

following problems communication disorders (speech disorders and language disorders), cognitive-communication disorders, voice disorders, and swallowing disorders.

The components of speech production include:

Phonation (producing sound)

Resonance

Fluency

Intonation

Pitch variance

Voice (including aeromechanical components of respiration)

The components of language include:

Phonology (manipulating sound according to the rules of a language)

Morphology (understanding components of words and how they can modify meaning)

Syntax (constructing sentences according to the grammatical rules of a target language)

Semantics (interpreting signs or symbols of communication such as words or signs to construct meaning)

Pragmatics (social aspects of communication).

3 History of Telemedicine

The progression of show day telemedicine begun with the creation of the broadcast communications system, counting the phone and transmit. At an advantageous time, telemedicine advancement was grasped for utilize in military circumstances in the midst of the Gracious War, for illustration, asking restorative supplies or helpful advises. Mishap and harm records were moreover passed on by implies of broadcast.

In the beginning of telemedicine, wellbeing experts utilized the prospering innovation as an approach to achieve patients living in country zones. Notwithstanding, the innovation immediately ventured into urban zones, particularly those that experienced human services deficiencies. In 1967, doctors at the University of Miami School of Medicine and Miami's Fire Department transmitted electrocardiographic rhythms over existing voice radio channels from flame safeguard units to the city's Jackson Memorial Hospital.

3.1 Types of Telemedicine

Telemedicine refers to the delivery of clinical services at a distance. The practice of telemedicine largely breaks down into three types of solutions, store-and-forward, remote patient monitoring, and real-time encounters [22].

- **Store and Forward**: Store-and-forward telemedicine is also called "asynchronous telemedicine." It is a method by which healthcare providers share patient medical information like lab reports, imaging studies, videos, and other records with a physician, radiologist, or specialist at another location (see Figure 9). Store-and-forward is particularly popular for diagnoses and treatment with certain specialties including dermatology, ophthalmology, and radiology.

Figure 9 Store and Forward Telemedicine type

- **Remote Patient Monitoring:** Remote patient monitoring, or "telemonitoring" is a method that allows healthcare professionals to track a patient's vital signs and activities at a distance. This

type of monitoring (See Figure 10) is often used for the management of high-risk patients, like those with heart conditions and people who have recently been released from the hospital.

Figure 10: Remote Monitoring type of Telemedicine

- **Real-time telemedicine:** When you think of telemedicine, it is likely real-time video visits that comes to mind. During a real-time telemedicine encounter, patients and providers use video conferencing software (see Fig. 11) to hear and see each other. While the other types of telemedicine are used to enhance traditional in-person visits, real-time telemedicine can be used in lieu of a trip to the doctor's office in certain situations. It is popular for primary care, urgent care, follow-up visits, and the management of medications and chronic illness.

Figure 11: Real Time Telemedicine

3.2 Related Work on Telemedicine

There is a number of applications in which telepractice are involved, many medical problem investigators conduct many investigations by using telepractice. Richard et al., 2013 used studied telepractice procedures were used in the assessment or treatment of individuals with aphasia were reviewed [2]. Speech-language pathologist used telepractice and they assist with the delivery of services to participants with aphasia by their caretakers or clinicians. In this paper, through telepractice, they performed an appraisal, diagnostic assessments, interventions, and consultation services and by using Skype for conferencing.

Yongbo Wan Et al., 2009 [3] used web service to realize remote pure tone hearing assessments. In this paper, they used web-based browser server architecture to connect patient and audiology specialist for conducting pure tone assessments. For software, they used they used 3 tier approach which makes the system stable for conducting pure tone test. This developed system reduced a load of hardware and software's on audiologist computer and used regular internet for getting good service.

Jianchu (Jason) Yao et al., 2015[4] used Web application server, an embedded smart Internet-Bluetooth and Bluetooth-enabled audiometer to perform pure tone audio test and speech test and compare results with traditional face to face approach. In conclusion, they recommend this browser-server–based comprehensive tele-audiology can be expanded side by side with trained clinicians and eliminate the traditional hearing system.

Craig Locatis et al..,2012 [5] used to store and forward type of telemedicine to study elepsychiatry and teleneurology applications and tele dermatology. Store and forward is the one type of telemedicine in with consultants gives instructions to clinical staff how to perform tests and save this information and sent to a specialist who is sitting remote place to examine reports. This research is simply carried out by high definition cameras for an impersonal interview after getting reports and tested is these possible with telemedicince or not.

Abigail M. Fellows et al.., 2013 [6] performed pure tone audio assessment with in ear monitoring of noise levels. To carried out this assessment they simply developed IBM laptop system and used Audiometry software mic and ear plugs to reduce passive surrounding environment noise. In conclusion, they suggest if the ear is not covered appropriately then noise level will exceed with according to permissible level so it should be plugged in ear correctly in teleaudiolgy.

Theresa H. Chisolm et al.., 2015[7] discussed the importance of telemedicine and how we can take best results from telemedicine. For proceeding good telepractice and taking results they recommend training clinical staff how to use equipment's and also trained patients how to response, because telemedicine depends on the degree of human interaction in diagnostic assessments. Furthermore designed and hierarchy of application must be according to standard.

Marilyn F. Dille et al.., [8] discussed they store and forward technology in teleaudiology to promote Solution to Promote Efficient Screenings for Ototoxicity during Cisplatin Cancer Treatment. For achieving this practice they developed identification device (OtoID), this device connects remote patients for hearing monitoring for chemotherapy treatment. For results they used logistic regression model analysis of the probability of an ASHA shift identified by the automated OtoID was conducted. They recommend using OtoID automated test because this test provides significant personnel efficiencies.

Matthew L. Bush et al.., [9] discussed only advantages of teleaudiology because its very difficult to provide audiology services in remote areas which is physically difficult to e.g (Appalachia areas with mountains). He points out some important factors Multiple barriers including education, distance, accessibility, socioeconomic factors can affect timely diagnosis and treatment of congenital hearing loss for children residing in rural areas. Educational and telemedicine programs may benefit parents in Appalachia, as well as parents in other rural areas.

Michelle L. Hughes et al.., 2012[10] performed a comparison to measure all electrode-specific and statically they don't find any difference between remote and traditional conditions. Speech perception was not significantly proper in the remote condition, which was likely due to the lack of a sound booth. They connected remote sites by using Dell latitude E6400 with encrypted hard drive and using widows XP.

Laptops were loaded with the following specialized CI software: Custom Sound and Custom Sound EP (v. 2.0 with upgrade to 3.2 during this study; Cochlear Americas, Centennial, CO), Nucleus Implant Communicator (NIC v. 2) subroutines (Cochlear Ltd., Lane Cove, New South Wales, Australia), SoundWave (v. 1.4.77 with upgrade to 2.0 during this study; AB, Valencia, CA), and the Bionic Ear Data Collection System (BEDCS v. 1.18.295; AB, Sylmar, CA). The following speech-processor interfaces and corresponding programming cables were also provided: programming pod (for Nucleus Freedom or CP810 speech processors), portable programming system (PPS, for 3G speech processors), and clinical programming interface (CPI II, for all AB processors). The PPS and CPI II were attached to the laptop's USB port via a serial-to-USB adaptor (IOGEAR USB to Serial Adapter, Model GUC232A, Irvine, CA). Laptops were connected to the internet via a local Ethernet connection. They used video conferencing with 20Mpbs and 1Gbps connection for telemedicine, before starting this session they instruct patients and technicians how to use device and setup to get accurate results.

Christin Bexelius et al.., 2008 [11] discussed hearing impairment is most accurately measured by a clinical puretone audiogram. They described this method of hearing assessments is not good for large scale purpose patient must need to visit the hospital because in hospital clinicians are trained and they know how to check patient accurately for diagnosing and for treatment. For conducting this research they

prepared a questionnaire and prepare 6 tones audiogram between 500 to 8000Hz. Tones were presented between 0 and 60dB. And they conclude after getting results and they recommend that clinical testing is much important and better than teleaudiology. Teleaudiology is a valid and useful screening tool for hearing testing in a large population carried out at a low cost.

Maine Botasso et al.., 2014[12] discussed efficacy and feasibility of telemedicine in audiology, and they recommend to use teleaudiology for remote places because its cost effective and reliable to provide health care in remote areas. For building teleaudiometry procedure was performed using specific software installed on a notebook computer (HP PavilionH dv4000) with a 2.0 GHz IntelH Centrino, 1024 MB memory, 100 GB hard drive, SoundMAX Integrated Digital AudioH sound card processor and a 15.4" screen. TDH 39 headphones were used with a P10-P2 connector adapter.

3.3 Advantages of Telemedicine

Access of medical facilities remotely

There are several advantages of Telemedicine. You can discuss your medical history with doctor and your health problem without visiting hospital and doctor can provide your remote consolations.

No charges for Transportations

If you are living very remote area where it's very hard to provide medical facilities you can have access with doctor and you can use any type of Telemedicine like store and forward for your old medical report results and take new medical consultations.

No need to take leave from Job

You can save your Time by using Telephonic or Videoconference consultations with Doctor which can save time and money for both doctor and player and you don't need to visit doctor separately.

Monitoring in Real Time

In latest approaches of Telemedicine like Real Time method you can be under observation 24/7 by using different sensors and provide your Medical health status in Real Time.

Provide 100 percent of Privacy

Telemedicine can provide you 100 percent privacy with doctor and you can discuss your health issues by using Encrypted communication and nobody can access your health secrets.

On Demand choice of Doctor

With the help of Telemedicine you can choose any doctor or physician that you like to communicate without wastage of time and no need to sit in queue.

Better Health

With the Help of Telemedicine you can have access with your concern doctor every time without in personal meeting and you can be updated with your health issues and you can be save from many chronicle health issues.

3.4 Disadvantages of Telemedicine

Additional Training Required

For this additional training is required for medical staff and patient to use this type of health care for example how you can use medical equipment's and medical machines in the absence of medical specialist.

Lack of In Personal Visits

Some people don't have psychological satisfaction because they don't want to accept new technologies and they believe on visit doctor in personal and discuss their health issues.

Virtual Clinic

Virtual clinic decrease the human interaction while treatment which can be cause of in accuracy in results and diagnose the problem correctly.

Legal Regulations

Telemedicine system requires tough legal regulation to prevent unauthorized and illegal service providers in this sector.

Trade with Technology Issues

Technology plays main role in Telemedicine filed you must have at least latest equipment's which can support internet protocols to connect with internet and you must have at least sufficient internet speed connectivity to exchange medical information between doctor and patient with minimum delay.

Traffic shaping issues for medical traffic

Because of high use of internet application for education, multimedia, business, banking, advertisements, government traffic and other interactive applications traffic is hard to provide Quality of

Service for medical applications. For medical applications they have to priorities medical network traffic but it's very difficult tasks for ISP Internet service providers to connect many remote sites.

3.5 Actuality of Work

Just after finishing my literature review on telemedicine and i found nobody carry out researches in the field of improving speech therapy by using telemedicine for cochlear implants patients. The goal of this research activities is to be to assist in the early detection of potential health problems for deaf people because you can teach them using distant learning education and diagnose the level of deafness of patients and to provide telespeech therapy in remote areas.

4 Structural Implementation of Telemedicine

In this work, we highlight the importance of quality of audio for cochlear implant people while using telemedicine and use of telemedicine for telespeech therapy. Audio processing inside cochlear implant device is not so much clear due to the limitation of electrodes array and not enough filtering of sounds in result deaf people can't enjoy the quality of sound as compared to natural sound, normal people can't understand processed sound as well. If we use telespeech therapy service we have big challenges to provide good audio quality on the internet over a big distance. Because there is two big challenges one audio quality loss because of cholera speech processor and secondly because of delay on the internet. In this research we will use different audio codecs and QoS model to measure quality of experience for deaf people and then output signal gives to "Cochlear Implant Simulation" version 2.0 for converting audio files in to cochlear sound and compare converted audio files with reference original signal to see how much audio is degraded over internet and how the sound is perceived by a subject who has received a cochlear implant.

Present work is only focusing on speech processing algorithms and hardware base enhancement research for making good speech processors and playing with a number of electrodes arrays/virtual electrodes to achieve all frequency responses, My research task is to improve and monitor audio quality over the internet for Tele speech therapy for cochlea implant patients.

For Telemedicine I used my own model which is showed in Figure12. I divided my work in following steps to carry out this work. I also explained work methodology.
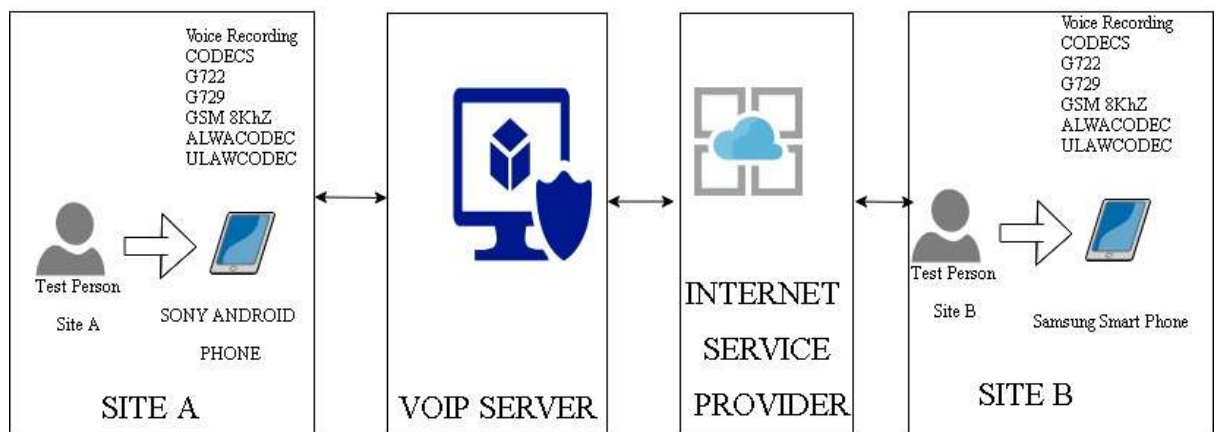
Model Used For Telemedicine

Figure 12: Telemedicine Work methodology

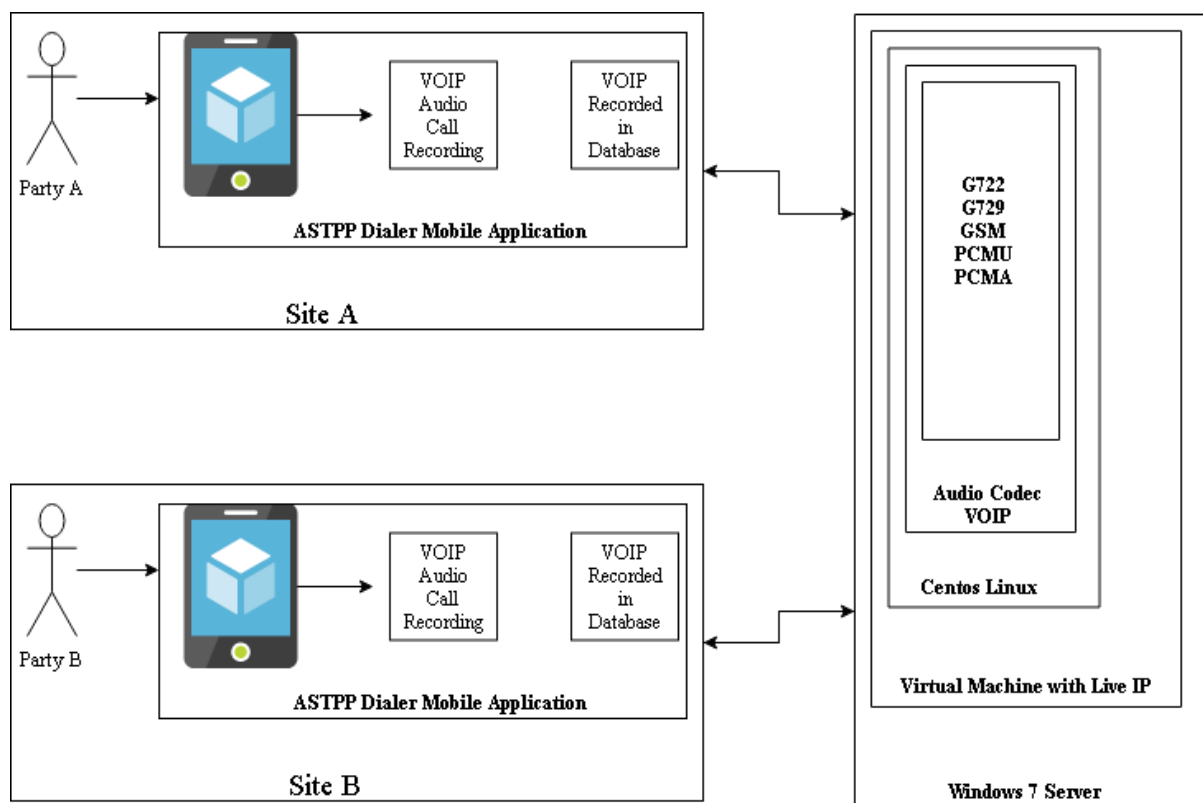For Further details I used graphical method to understand working scheme which is shown in Figure13.

Figure13: Detailed Telemedicine Model

Step by step instruction detail are shown in Figure 14.

Step 1: Input Audio Signal is obtained to through MIC device and recorded through smartphone device through mobile application and saved in to database, recorded signal is provided to Cochlear Implant Simulator input and output audio signal is save into the Database and it will be the reference signal for the second step.

Step 2: Record Voice Signal which is passed through VOIP Server and over Internet cloud on Site B with same application but different hand held device and save in to Database.

Step 3: Comparison of A and B signal on Matlab to calculate and compare SNR, Signal Sampling, Finding correct signal frequency for recover signal again after FFT, Signal, Signal segmentation, FFT of Signal and Filtering by Using FFT Filter.

Step4: Again follow the same steps and change the Audio Codecs and record the samples in Database for comparisons.
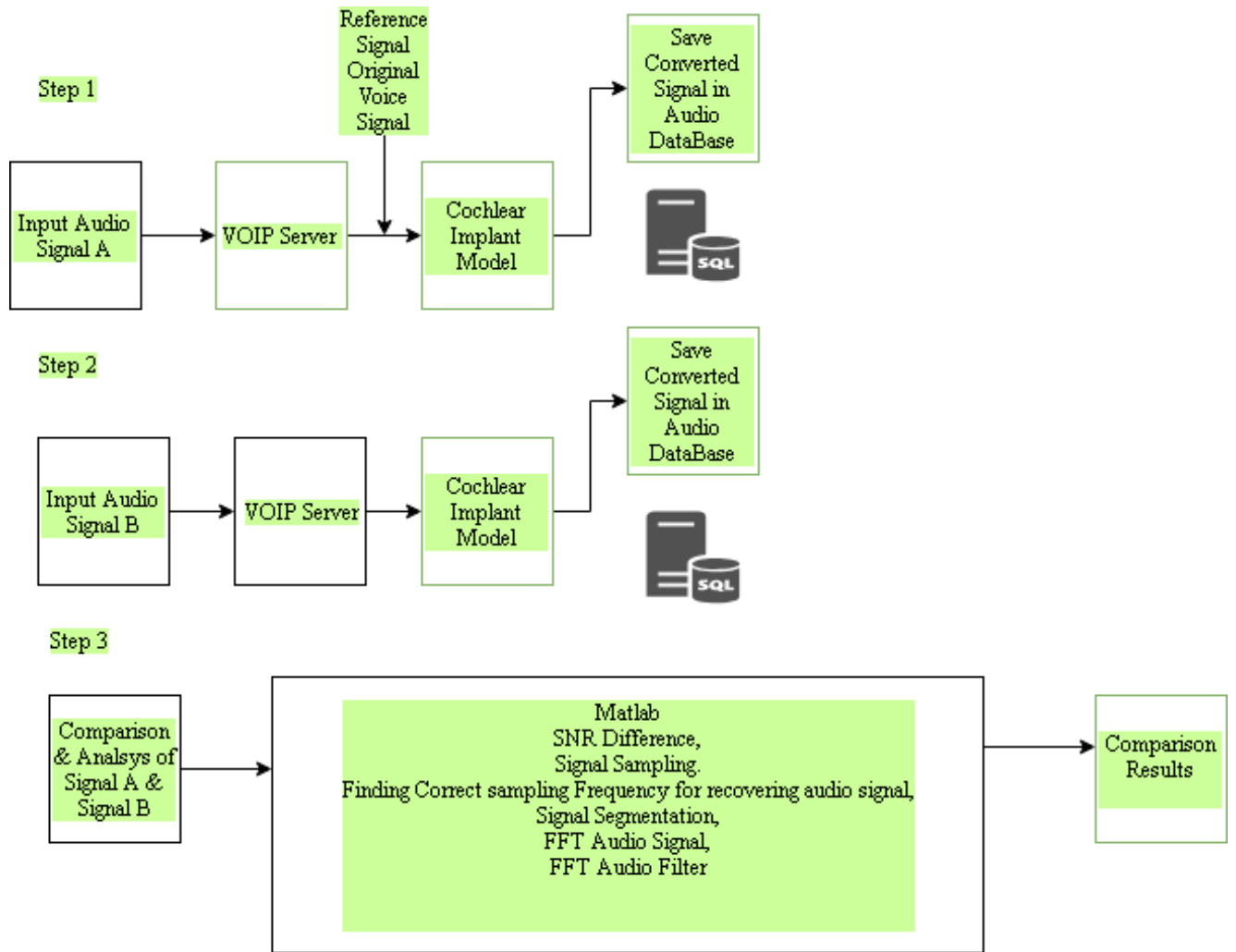
Figure 14: Step by step details for signal analysis

4.1 Device, Methods, & Installations

4.1.1 Software Descriptions

•   To make connectivity between different endpoint on internet we need Session Initiation Protocol (SIP) RFC 3261.

There are number of protocols are available to carry out real-time multimedia sessions such as Video, Data, Audio and Messages.

•   Virtual PBX13.5.0 which can create virtual environment same like traditional ISDN or PSTN network for relaying calls and multimedia traffic. Virtual PBX is a budget-friendly form of hosted VoIP (Voice over Internet Protocol) that usually only handles inbound calls. A virtual PBX is typically intended for small business VoIP customers with fewer than 10 employees and low-volume telephone traffic.

•   Linux Red hat Server / Ubuntu Server is like base platform for installation and developing all system for Communication.

• VoIP Client Software is used to make, disconnect Audio and Video call. Line software is used for this purpose.

• Matlab 2017 for Simulation of audio Signals and analysis of signals checking SNR, FFT, Signal sampling and segmentation, For FFT Filter, Spectrogram and finding correct frequency of Signal.

• Cochlear Implant Simulator for simulating audio signals in to cochlear speech.

• OPNET14.5 Simulator is used to simulate real World scenario Main Site located in Tomsk Region and 2nd site located in Moscow, 3rd site located in St. Petersburg, 4th site is located in Omsk and last site located in Vladivostok.

4.1.1.1 SIP Protocol

SIP is an application-layer control protocol that can establish, modify, and terminate multimedia sessions (conferences) such as Internet telephony calls [26]. SIP can also invite participants to already existing sessions, such as multicast conferences. Media can be added to (and removed from) an existing session. SIP transparently supports name mapping and redirection services, which supports personal mobility users can maintain a single externally visible identifier regardless of their network location. SIP call follows is shown in Figure 15.

SIP supports five facets of establishing and terminating multimedia Communications:

User location: determination of the end system to be used for communication.

User availability: determination of the willingness of the called party to engage in communications.

User capabilities: determination of the media and media parameters to be used;

Session setup: "ringing", establishment of session parameters at both called and calling party.

Session management: including transfer and termination of sessions, modifying session parameters, and invoking services.
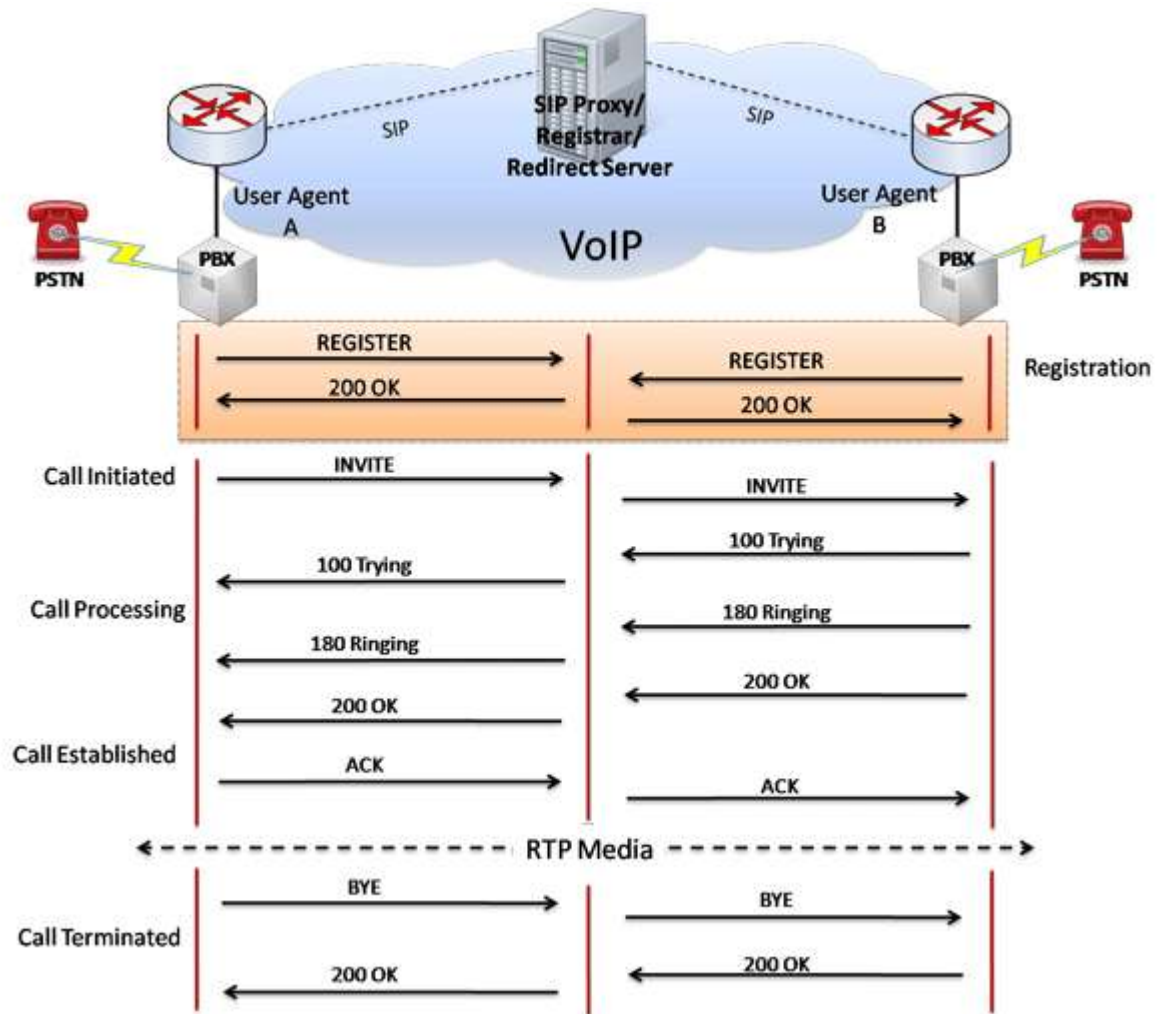
Figure 15: Call follow of VOIP call between A and B party

4.1.1.2 Virtual FreePBX

For installation Free PBX follow this link [35]

https://wiki.freepbx.org/display/FOP/Installing+FreePBX+14+on+CentOS+7.

4.1.1.3 SIP CLIENT

Linphone is an open source Voice Over IP phone (or SIP phone) that makes possible to communicate freely with people over the internet, with voice, video, and text instant messaging. Interface of application shown in figure 16.

Linphone makes use of the SIP protocol (an open standard for internet telephony) and can be used with any SIP VoIP operator, including our free SIP audio/video service. Audio codecs shown in Figure 17.
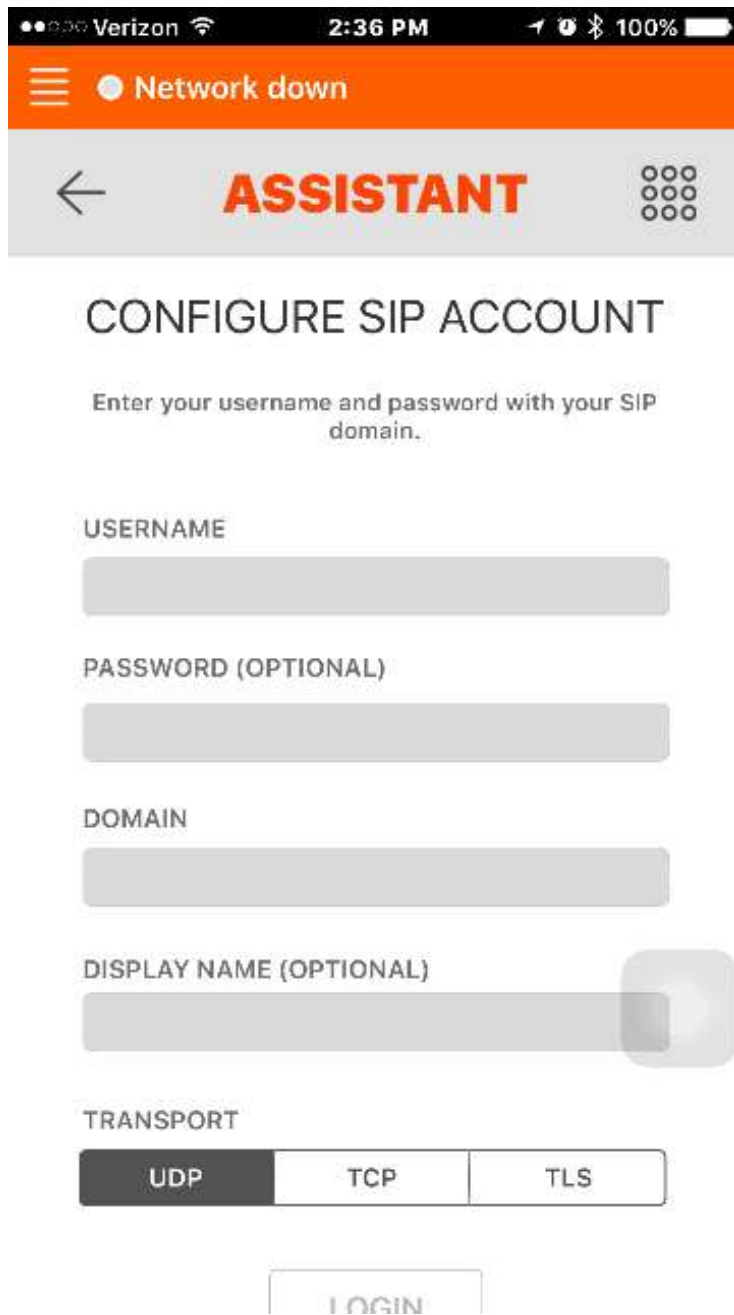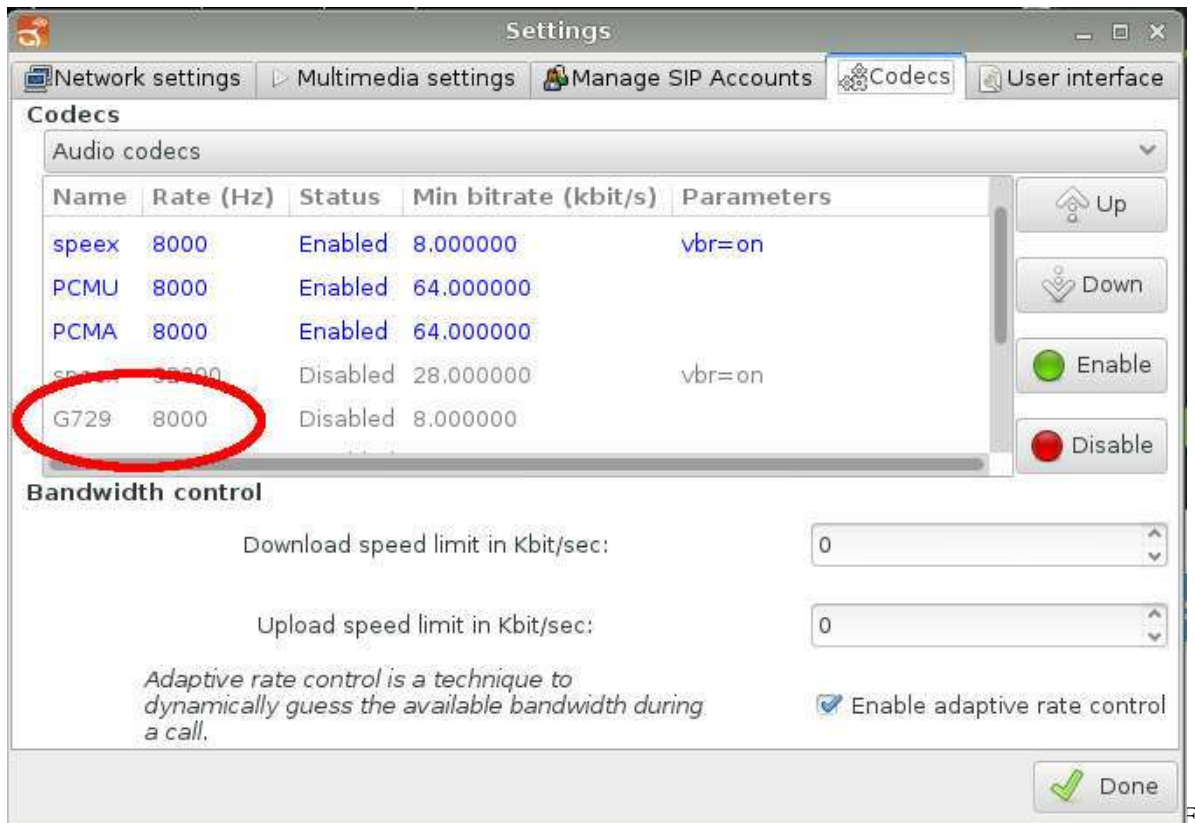
Figure 16: SIP application account page

Figure 17: Audio codecs setting

4.1.1.3 Creating SIP Accounts

Configuring chan_sip

```
[general]
transport=udp


[friends_internal](!)
type=friend
host=dynamic
context=from-internal
disallow=all
allow=ulaw


[demo-alice](friends_internal)
secret=verysecretpassword ; put a strong, unique password here instead


[demo-bob](friends_internal)
secret=othersecretpassword ; put a strong, unique password here instead
```

Configuring chan_pjsip

```
[transport-udp]
type=transport
protocol=udp
bind=0.0.0.0

;Templates for the necessary config sections

[endpoint_internal](!)
type=endpoint
context=from-internal
disallow=all
allow=ulaw

[auth_userpass](!)
type=auth
auth_type=userpass

[aor_dynamic](!)
type=aor
max_contacts=1
```

Definitions for our phones, using the templates above

```
[demo-alice](endpoint_internal)
auth=demo-alice
aors=demo-alice
[demo-alice](auth_userpass)
password=unsecurepassword ; put a strong, unique password here instead
username=demo-alice
[demo-alice](aor_dynamic)
[demo-bob](endpoint_internal)
auth=demo-bob
```

aors=demo-bob

[demo-bob](auth_userpass)

password=unsecurepassword ; put a strong, unique password here instead

username=demo-bob

[demo-bob](aor_dynamic)

After Adding Accounts you can see Account of patients in Figure 18.

	Extension	Name	CW	DND	FM/FM	CF	CFB	CFU	Type	Actions
	100	100	✓	☐	☐	☐	☐	☐	sip	✎ 🗑
	200	200	✓	☐	☐	☐	☐	☐	sip	✎ 🗑
	300	300	✓	☐	☐	☐	☐	☐	sip	✎ 🗑
	500	500	✓	☐	☐	☐	☐	☐	sip	✎ 🗑

Showing 1 to 4 of 4 rows

Figure 18: Account Add page

Audio Codecs List

This is the default Codec setting for new Trunks and Extensions.

ilbc

ulaw

alaw

gsm

g726

g722

g723

g729

speex

speex16

Fig. 19 Audio Codes List installed in PBX for communication

Video Codecs
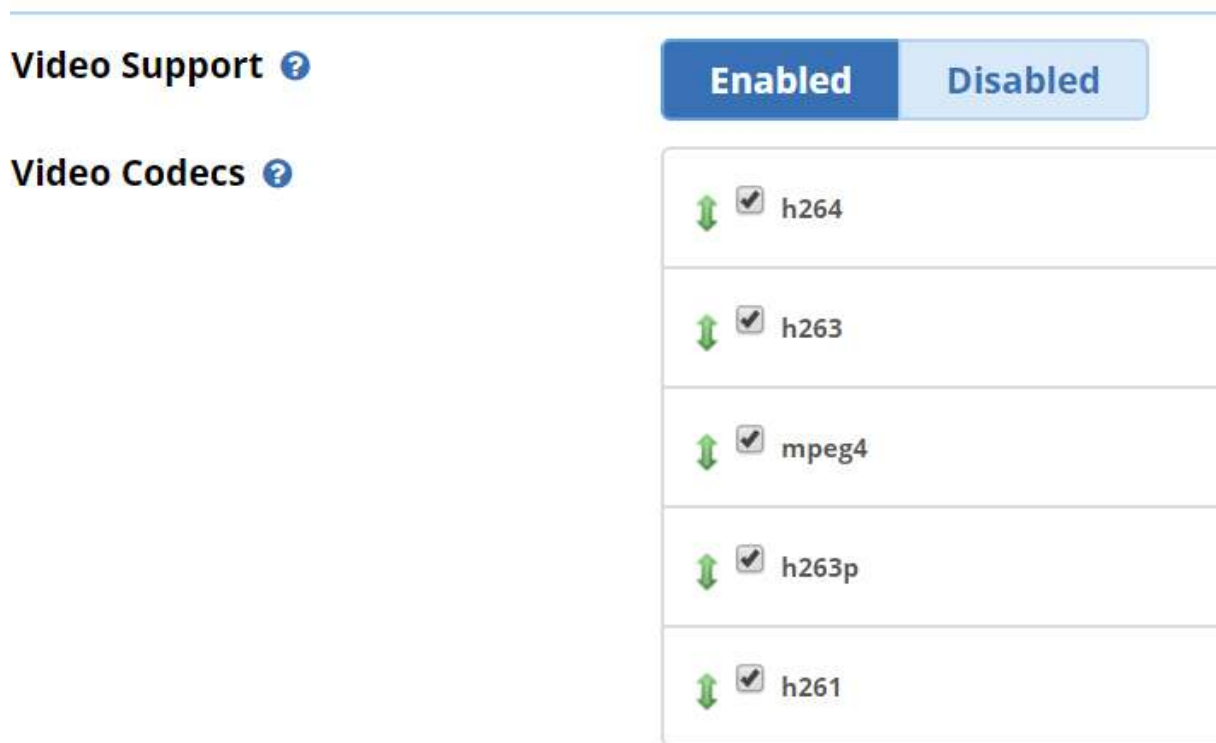
Fig. 20 Video Codecs

4.1.1.4 Installation of Matlab

For installation of Matlab please follow the following steps [27].

https://www.mathworks.com/help/install/ug/install-mathworks-software.html

4.1.1.5 Installation of Linux Red Hat

For installation of Red hat Linux please follow below link [28].

https://access.redhat.com/documentation/enus/red_hat_enterprise_linux/6/html/installation_guide

/index

4.1.1.6 Installation OPNET 14.5

For installation of OPNET simulator please follow this link [29].

https://www.scribd.com/doc/53640582/OPNET-14-5-Installation-for-Windows

4.1.1.7 Installation of VirtualBox

For installation of VirtualBox please follow the below Link [30]

https://www.virtualbox.org/manual/ch01.html

4.2 Simulation of Telemedicine Network with real world scenario

This research and results conducted by Network Simulation with OPNET14.5 simulator. Scenario is used in simulation is real world scenario and sites are connected with PP DS3 lines and each router is connected with other sites and Ripping Routing Protocol with IPv6 which is similar with ISP networks to calculate delay and end to end traffic delivery are show in Figure 21.

Main Site is located in Tomsk and other cities all over the Russia is connected through internet cloud to build setup communication between sites shown in Figure 21.
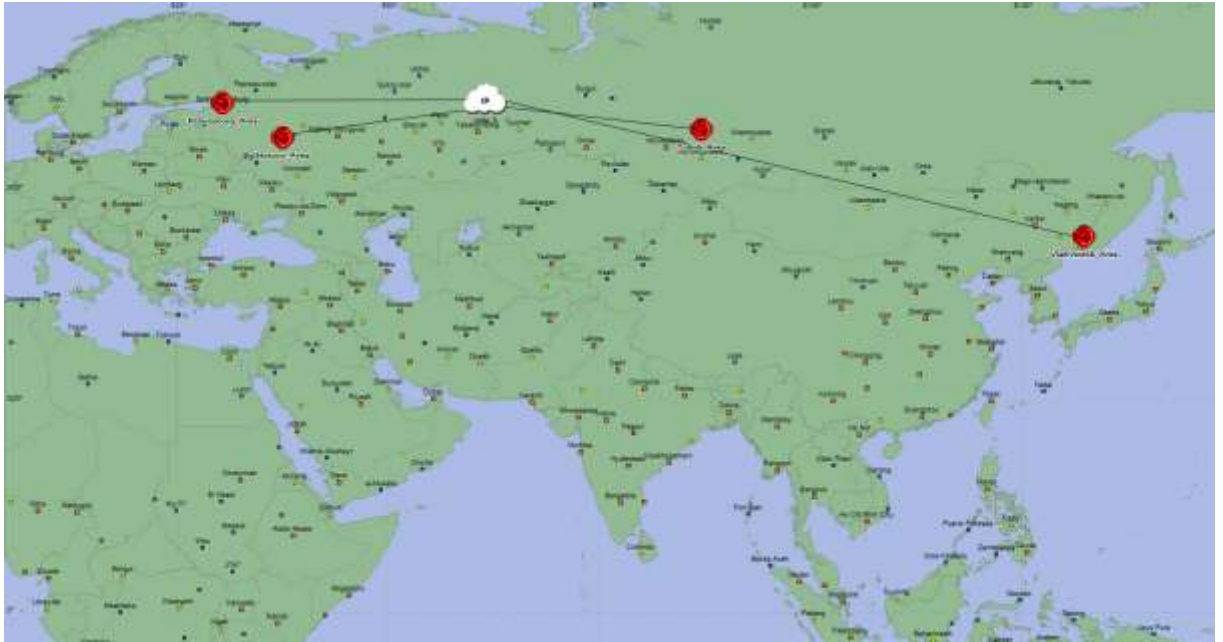
Figure 21: Real World Scenario

To build Main site one Application Server is placed for running FTP, VOIP, HTTP and Database Services which is directly connected with router in Tomsk Site. Each site contains 8 Personal computers with Audio and Video conferencing facility. One main router is used in every site to connect other city sites and one switch is used to connect router and Personal computers with 1000 Base X Duplex connection, Router and Switch is shown in Figure 22a.
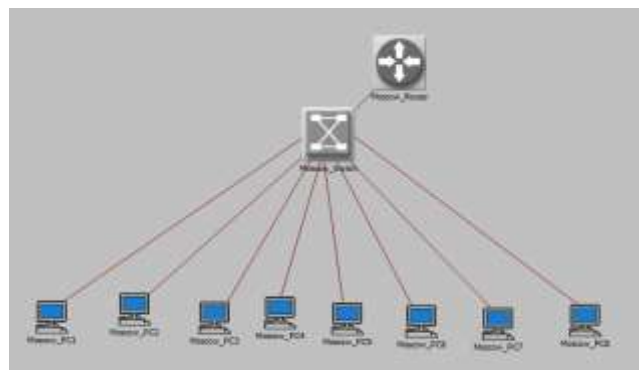
Figure 22a: Moscow Site is shown
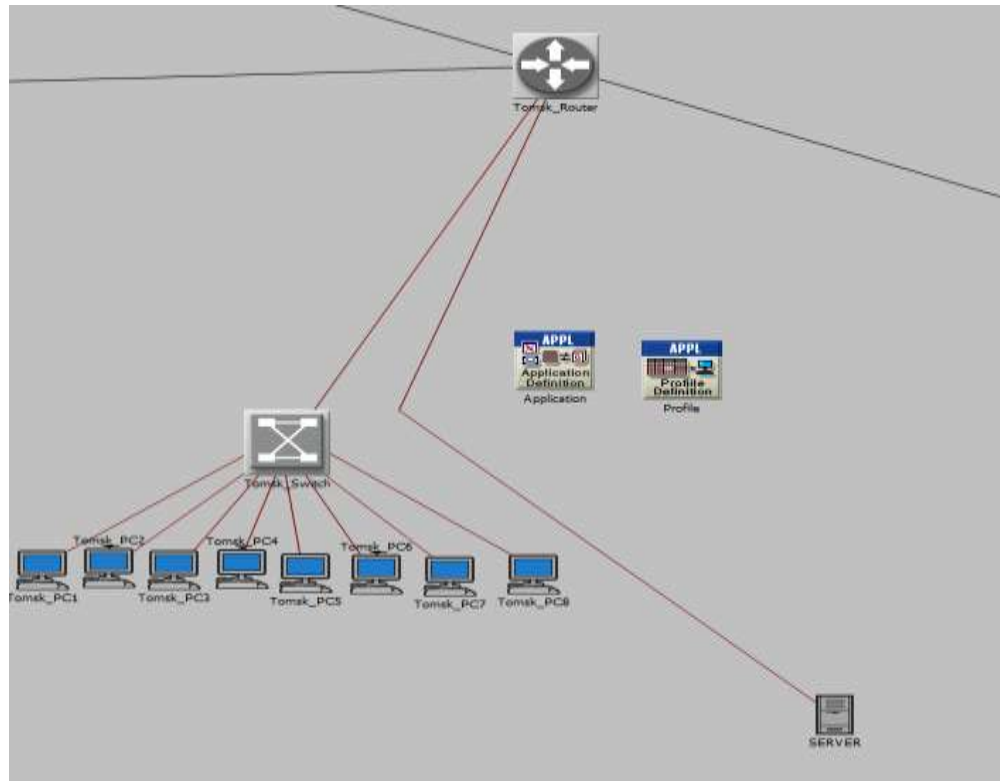
Figure 22b: Shows Tomsk Main Site

Tomsk Site is back bone network site where we implemented all polices and controlling traffic.

This site is directly connected with Moscow, St. Petersburg and Vladivostok sites shown Figure 22b.

Full network showcase shown in Figure 23.
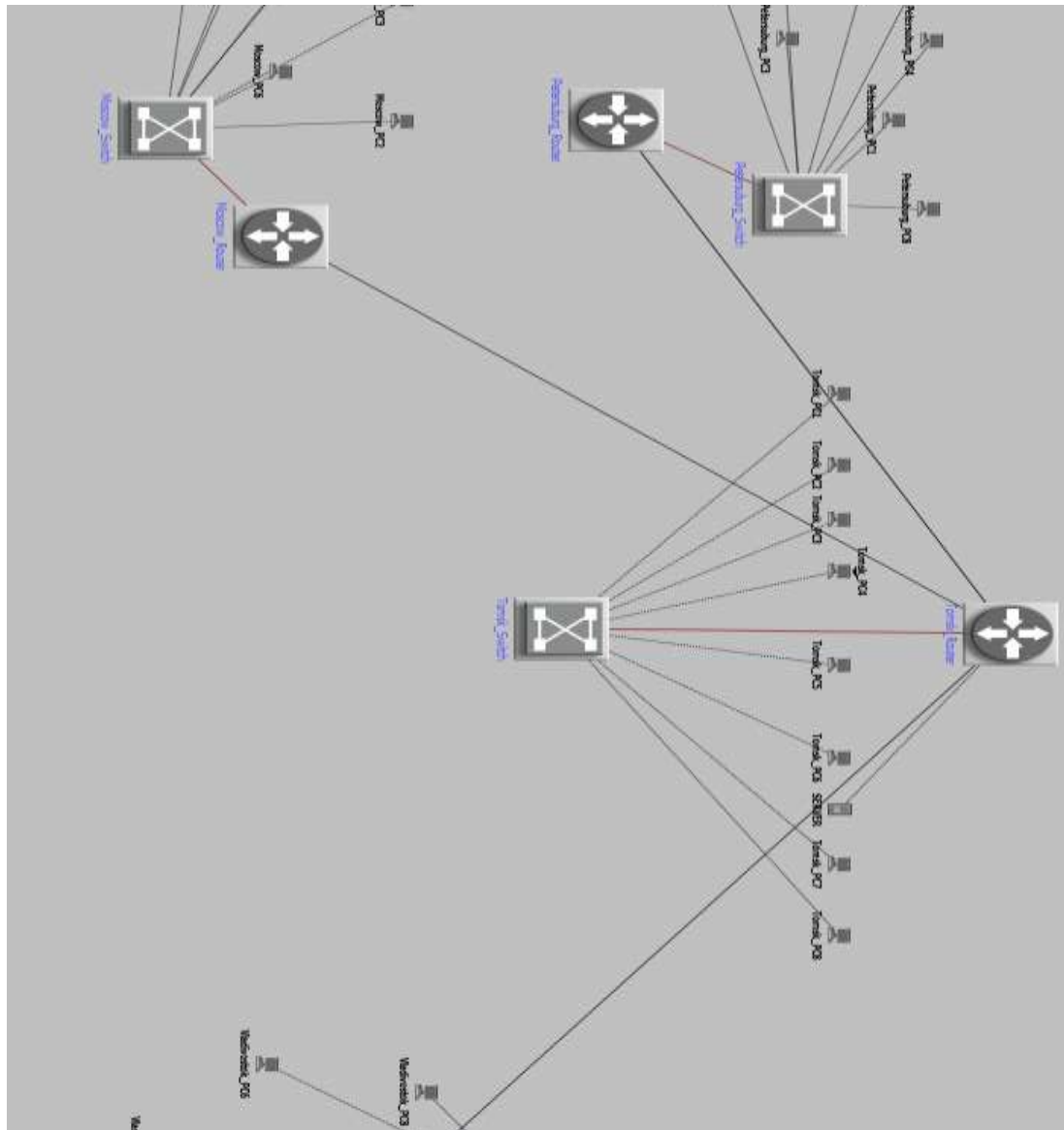
Figure 23: Shows Network Showcase

4.2.1 Simulation Characteristics

Simulation have different parameters to build Real-world scenario which is shown Inventory Table 1.

Element	Type	Count
Devices	Total	45
	Route r	4
	Switc hes	4
	Work Stations	32

	Serve r	1
Physical Links	Total	40
PP DS3	Serial	3
1000 base X	Ether net	37

Table 1 shows Network Inventory

Different Traffic Type use in simulation to calculate different network parameters shown in Table 2 below like Delay, Jitters, End to End Delay, Throughput, Network Utilization

Application Definition	Characteristics
FTP File Transfer Protocol	Heavy File Sharing between all Computers
HTTP	Heavy Surfing of HTTP for images
VOIP Voice over IP	Video Conferencing in HD
Voice follows	Full Rate (FR or GSM-FR or GSM 06.10 or sometimes simply GSM) , G711, G723, Half Rate (HR or GSM-HR or GSM 06.20)
Database	Database queries for accessing data

Table 2 shows Application Definitions

Simulation Parameters are shown in Table 3

Simulation Tool	OPNET 14.5
Simulation Area	Real World Scenario
Simulation Time	15 Minutes
Simulation Kernel	Optimized
Simulation IP's	IPv6 on all nodes

Table 3 Shows simulation parameters

After running simulation for 15 minutes you can see voice flows over the network, these voice flows in Figure 24. All computer connected with full mesh network and call are generated with each other and you can count number flows with permutation formula.
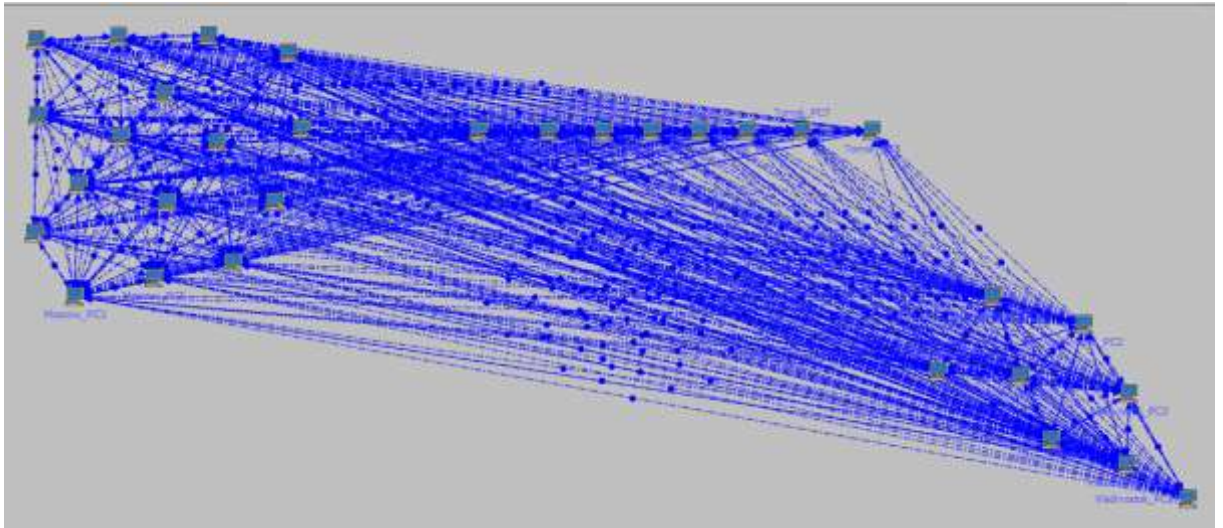
Figure 24 shows Voice Flows between Mesh Network

5 Testing and Results

5.1 Testing & Results

After simulating scenarios with different audio codecs and video conference we got different results of video and voice characteristics which shows different usage of network bandwidth but voice quality inversely proportional with bandwidth, traffic shaping and type of application but not so much degraded that Cochlear Implant persons can understand over the internet.

Video Conference Results
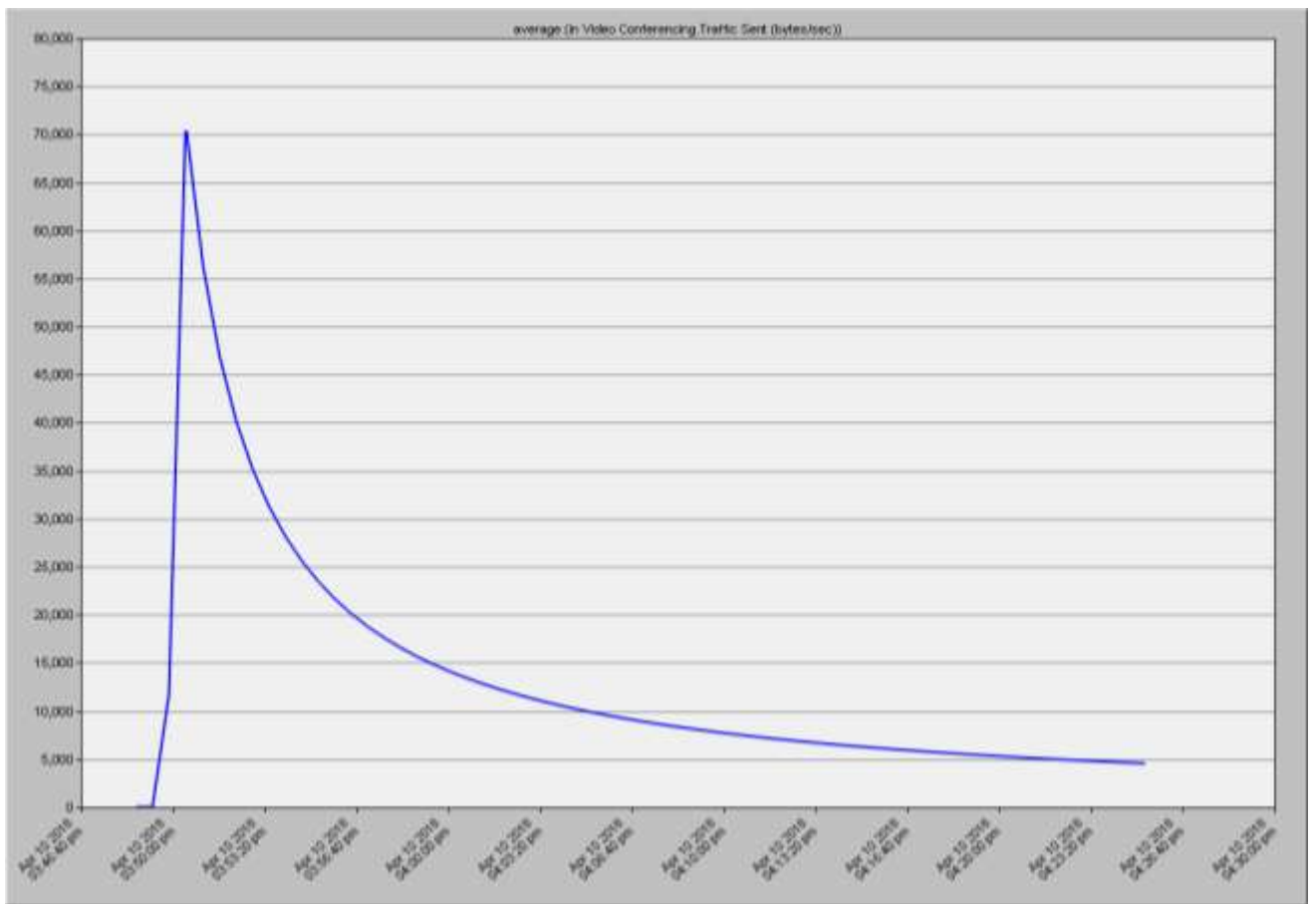
Figure 25: Shows Traffic sent bytes/sec in Video Conf.
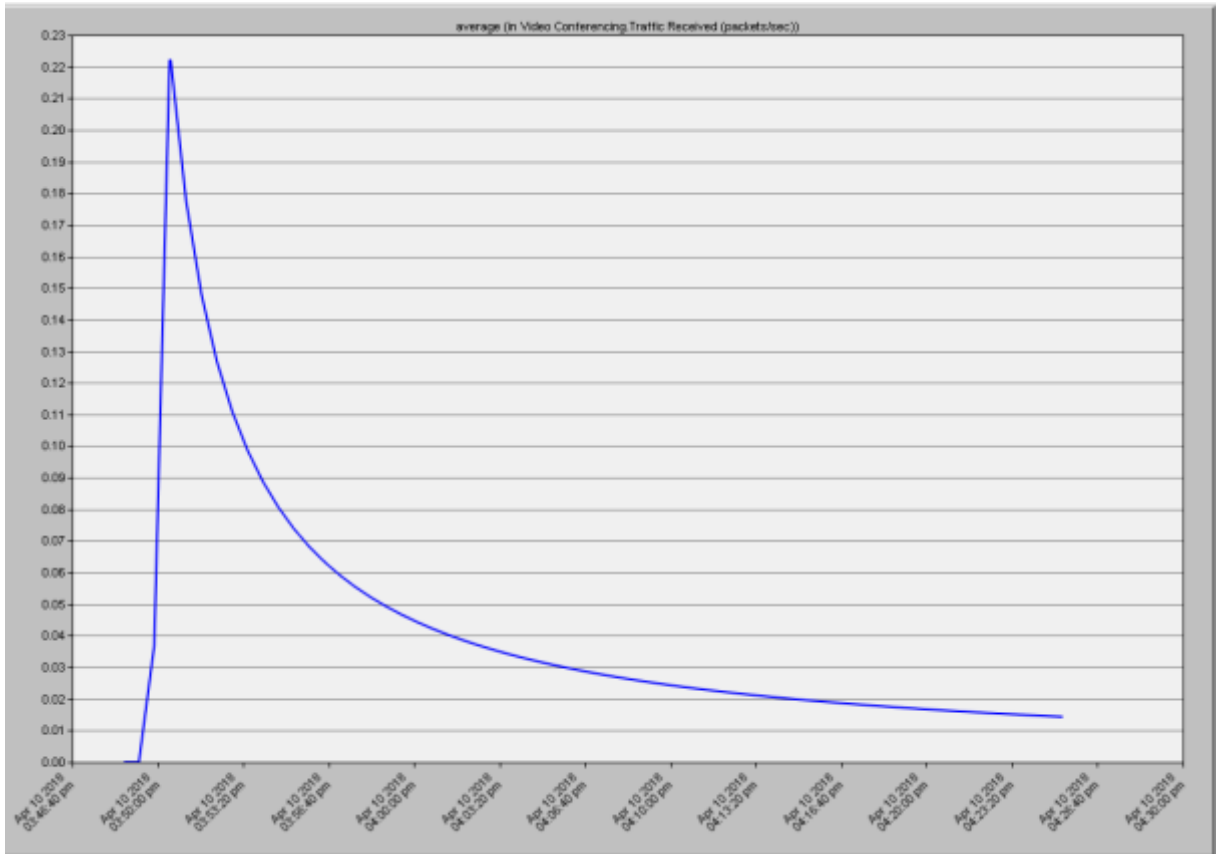
Figure 26: Shows Traffic Received Packets/Sec in Video Conf.

These results shows Traffic Sent and received in form of packets and bytes and results falls in satisfactory side which shows we can deliver remote Tele health services over VoIP network with Best effort model on existing network which is used in Figure 25 and Figure 26. Now a days we have many challenges to take Best Quality of Service it's not only problem for users its more headache for big ISP Internet Service Providers. There are many factors are involved to get good throughput over the internet for example which Routing Protocols you choose, Which communication media you choose, which hardware you choose, which class of service you choose, which application you are running, which computer server you choose and in the last how administrator prepare policies for different traffic types.
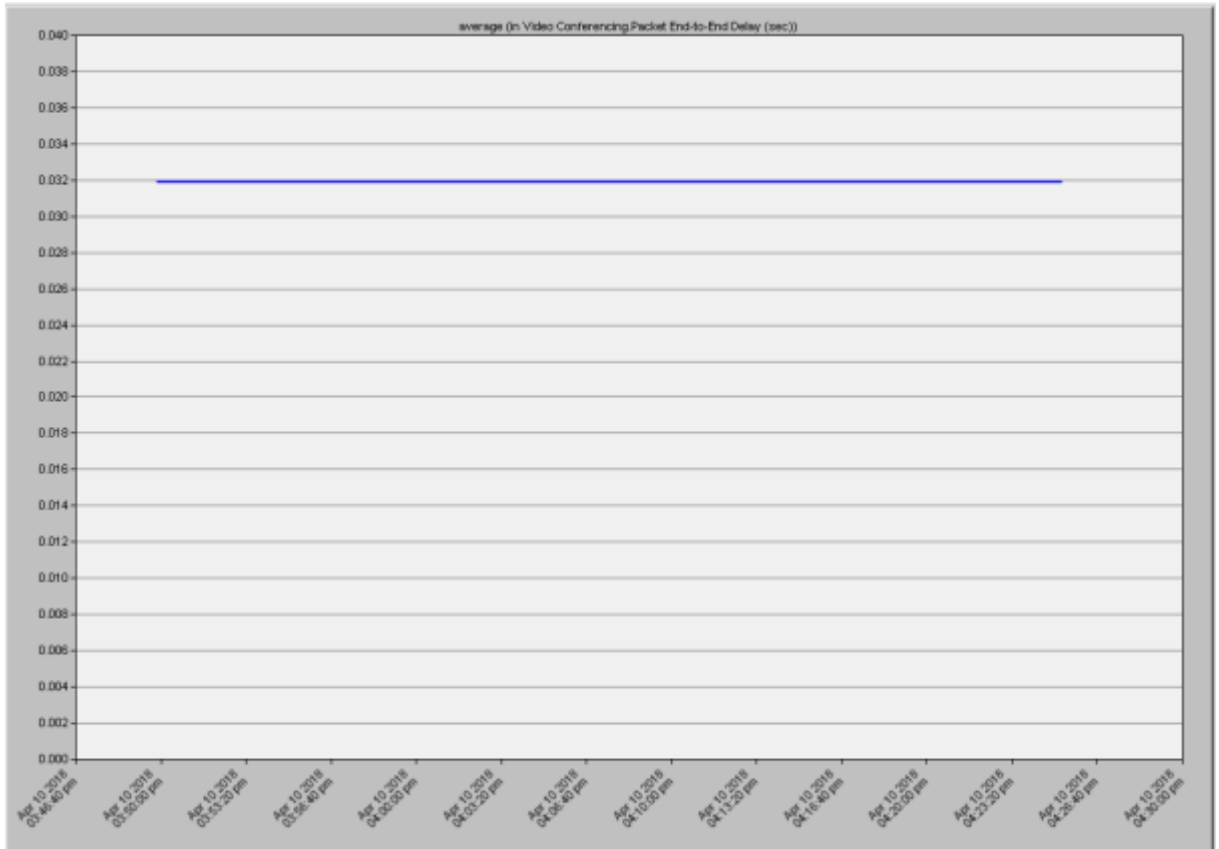
Figure 27: Shows Packet End to End Delay / Sec in Video Conference

In simulation End to End delay for High Definition traffic was constant shown in Figure 27 without any up's and down's which is acceptable for video conferencing and very suitable for Telemedicine with PP DS3 lines with normal network equipment's.

Audio Conferencing Results

Audio Conference information Table 4 shows Audio Conference Results Total Volume on Flows, Average Volume per Flows, Total Volume and Flow Average.

Total Volume on flows	Average Volume Per Flow	Total Volume	Flow Average	Codec Name
0.982 TB	1.412 GB	0.982 TB	3.333 B	**G723**
5.893 TB	8.475 GB	5.893 TB	20.000 B	**G711**
1.780 TB	2.560 GB	1.780 TB	6.042 B	**GSM FR**
2.445 TB	3.531 GB	2.455 TB	8.3 B	**G729**
1.473 TB	2.119 GB	1.473 TB	5.000 B	**GSM HR**

Table 4 Shows Audio Conference Results

Audio conferencing results shows different Audio codecs used different Data Bandwidth which is depends on voice quality and data rate transfer. Normally G711 shows highest bandwidth usage and highest Total volume flows and highest flow average among other audio codecs, while in other hands G729 codec shows 2nd highest Total volume flows and Flow Average GSM FR [33] codecs show 3rd highest Total volume flows and Flow Average. GSM HR [34] show 4th highest Total Volume on flows and Flow Average and last one is G723 Codec which shows lowest Total volume and Average Flows this codec is with very compressed audio and suitable for internet telephony if bandwidth is very small and you want to connect with other party.

Mean opinion score (MOS) is a test that has been used for decades in telephony networks to obtain the human user's experience of the quality of a phone call [31].

The MOS is assigned by a group of listeners using the following values:

Excellent	**5**
Good	**4**
Fair	**3**
Poor	**2**
Bad	**1**

According to MOS table G711 codec have highest MOS 4.1 but through simulation this codec used highest network bandwidth and G723 used lowest network bandwidth and have 3.8 MOS which is not big difference as compared to G711 but there is big difference in Network utilization and Bandwidth

Utilization.G729 Codec used 2nd highest bandwidth and 3.92 MOS but used half of Network Bandwidth and use small amount of Network, GSM FR used 3rd highest bandwidth and have 3.6 MOS which is lower than G711 and G729. GSM HR on 4th place which is used small amount of Network Bandwidth but have lowest MOS which is bad as compared to bandwidth usage. MOS table shows different Codecs MOS in Figure 28.

Codec	Bitrate (kb/s)	Frame (ms)	Bits per frame	Algorithmic delay[a] (ms)	Codec delay[b] (ms)	Compression type	Complexity (MIPS)[c]	MOS
Narrowband codecs								
G.711	64	0.125	8	0.125	0.25	PCM	≪1	4.1[d]
G.723.1	6.3	30	189	37.5	67.5	MP-MLQ	≤18	3.8
G.723.1	5.3	30	159	37.5	67.5	ACELP	≤18	3.6
G.726	16	0.125	2	0.125	0.25	ADPCM	≈1	–
G.726	24	0.125	3	0.125	0.25	ADPCM	≈1	3.5
G.726	32	0.125	4	0.125	0.25	ADPCM	≈1	4.1
G.728	16	0.625	10	0.625	1.25	LD-CELP	≈30	3.61
G.729	8	10	80	15	25	CS-ACELP	≤20	3.92
G.729A	8	10	80	15	25	CS-ACELP	≤11	3.7
G.729D	6.4	10	64	15	25	CS-ACELP	<20	3.8
G.729E	11.8	10	118	15	25	CS-ACELP LPC	<30	4
GSM-FR	13	20	260	20	40	RPE-LTP	≈4.5	3.6
GSM-HR	5.6	20	112	24.4	44.4	VSELP	≈30	3.5
GSM-EFR	12.2	20	244	20	40	ACELP	≈20	4.1
AMR-NB	4.75–12.2	20	95–244	25	45	ACELP	15–20	3.5–4.1
iLBC	13.33	30	400	40	60	LPC	18	3.8
iLBC	15.2	20	304	25	40	LPC	15	3.9
Speex (NB)	2.15–24.6	20	43–492	30	50	CELP	8–25	2.8–4.2
BV16	16	5	80	5	10	TSNFC	12	4
Broadband codecs								
G.722	48, 56, 64	0.0625	3–4	1.5	1.5625	SB-ADPCM	5	~4.1
G.722.1	24,32	20	480, 640	40	60	MLT	<15	~4
AMR-WB (G.722.2)	6.6-23.85	20	132–477	25	45	ACELP	≈38	Various
Speex (WB)	4-44.2	20	80-884	34	50	CELP	8-25	Various
iSAC	Variable 10–32	Adaptive 30–60 ms	Adaptive-variable	Frame + 3 ms	Adaptive 63–123	Transform coding	6–10	Various[e]
BV32	32	5	160	5	10	TSNFC	17.5	~4.1

Figure 28 Shows MOS of different audio codecs

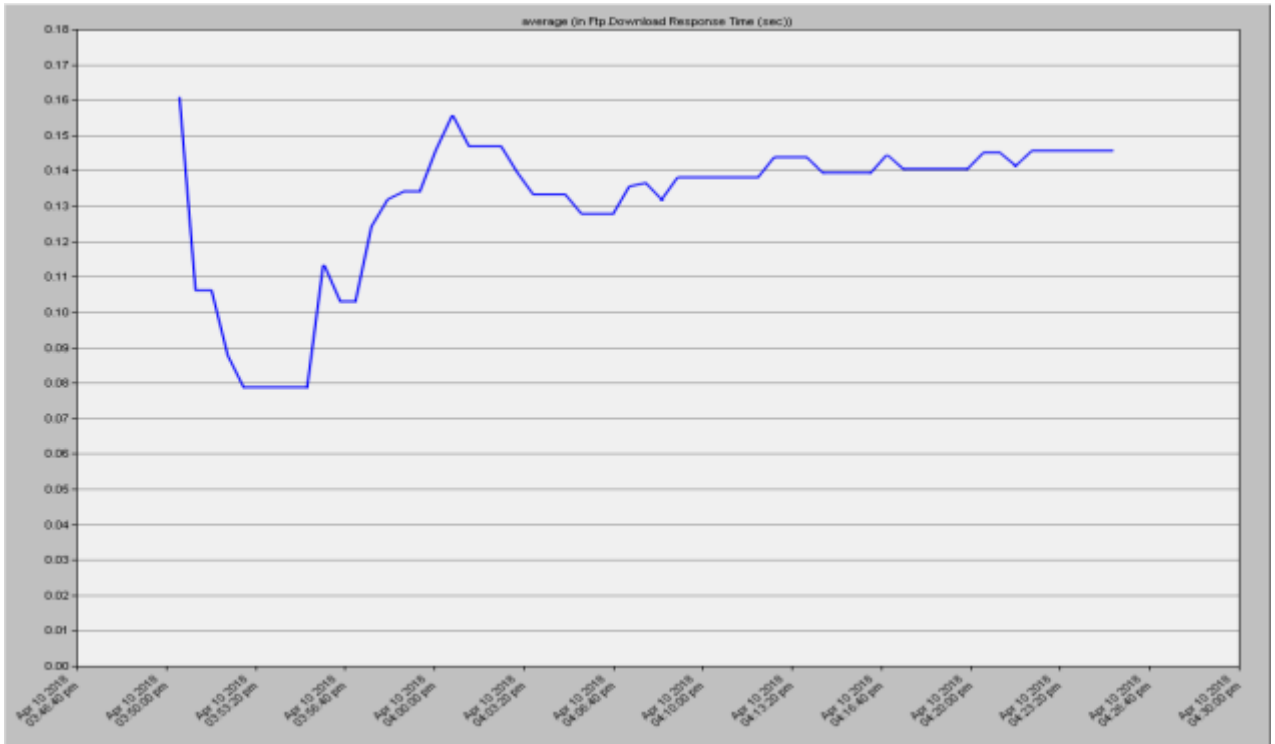## FTP Traffic Results for Medical Images sharing

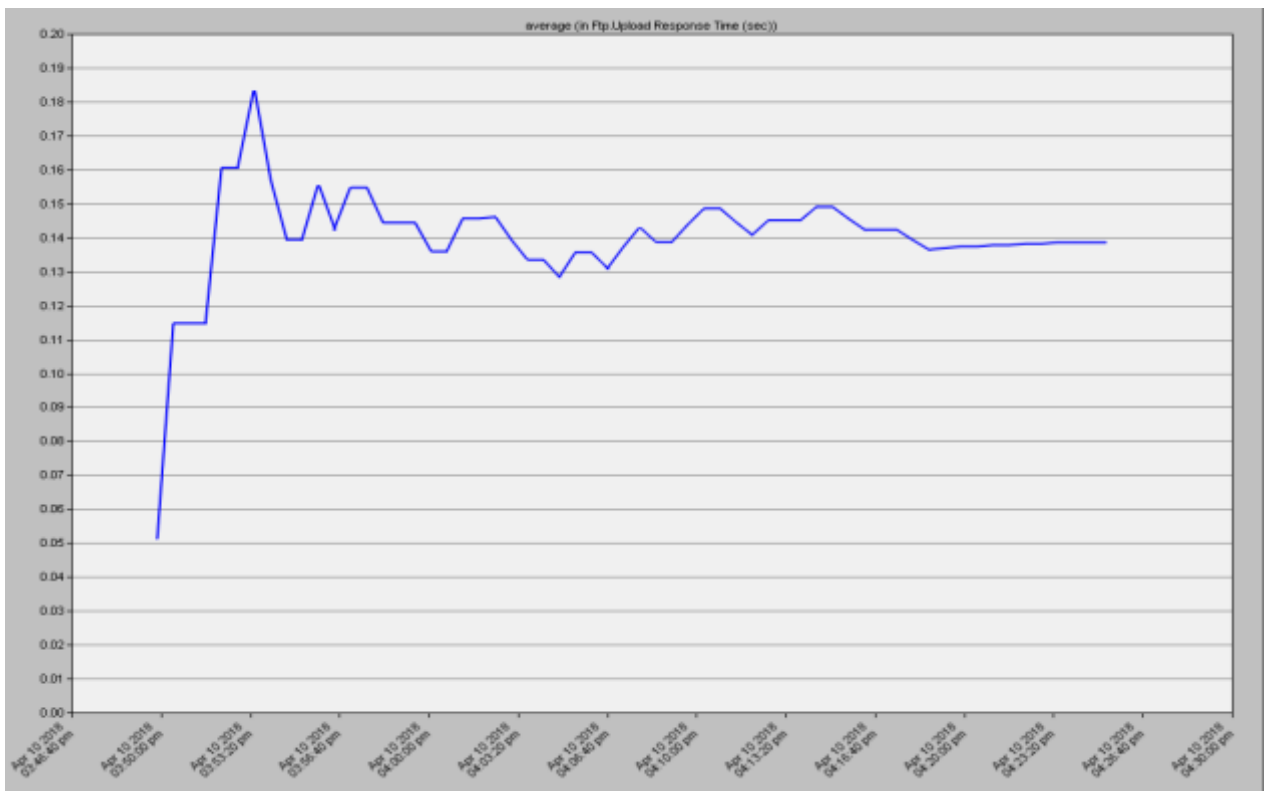Figure 29: Shows Average Time of Download Response Time (SEC)

Figure 30 Shows Average FTP upload Time (sec)

Anita Xiao-min Kuang et al.., 2014[32] discussed the different delays of traffic for medical applications after running simulation on OPNET simulator. Table 5 is given below for reference and our results are reliable and its feasible to provide services remotely. For FTP Heavy Image Traffic Image Download response is 160 microsecond and download time 190 microseconds shown in Figure 29 and Figure 30.

	Bandwidth	**Delay**	**Packet Drop**	**Reliability**	**Ubiquity**	**Sec urity**
Life-critical applications	Relatively low bandwidth is required. 10-100kb/s	Relatively low delays are required. 10-150 msec	Zero fault tolerance is expected	Very high reliability requiremen t	High ubiquity requiremen t	Authenticat ion and confidentia lity are expected
Non critical Multimedia applications	Voice: low requiremen t 10kb/s Video: high requiremen t 100kb/s	Low to moderate delays <300 msec	Low data loss is expected <0.0001	High reliability is expected	High ubiquity requiremen t	Authenticat ion and confidentia lity are expected
Office-oriented applications	Relatively high bandwidth is required. 1-1Mb/s	Moderate to high delays <1 sec	Some recoverable data loss are tolerated <0.01	High reliability is expected	High ubiquity requiremen t	Authenticat ion, integrity and confidentia lity are expected
Distant Control applications	<1 kb/s	Low delays <3-5 sec	Zero fault tolerance is expected	Very high reliability requiremen t	Not required	Integrity is required

Table 5 shows acceptable delays of Different Medical Traffic

G729 Codec Scenario Comparison Results with Matlab

Recording, working steps and Comparison step are shown in Figure 31 which is very briefly described for understanding.
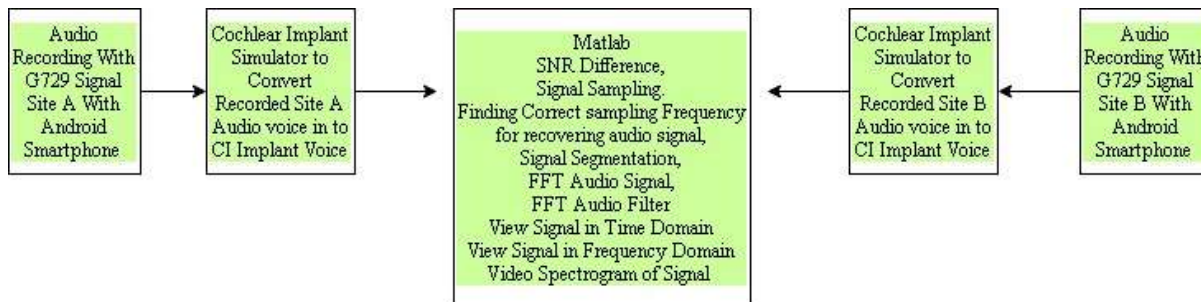
Figure 31: Shows G729 Scenario

Recorded Audio Signal on Site A before passing Cochlear Implant simulator

First Graph shows Site A recorded G729 audio signal in Time domain. 2nd graph shows signal frame from different points and 3rd graph shows samples of audio signal and determine frequency of signal. Audio Signal Time domain shown in Figure 32. Samples * Frequency

89 * 179.77 = 15931 approximate 16000Hz of recorded signal on Site A.
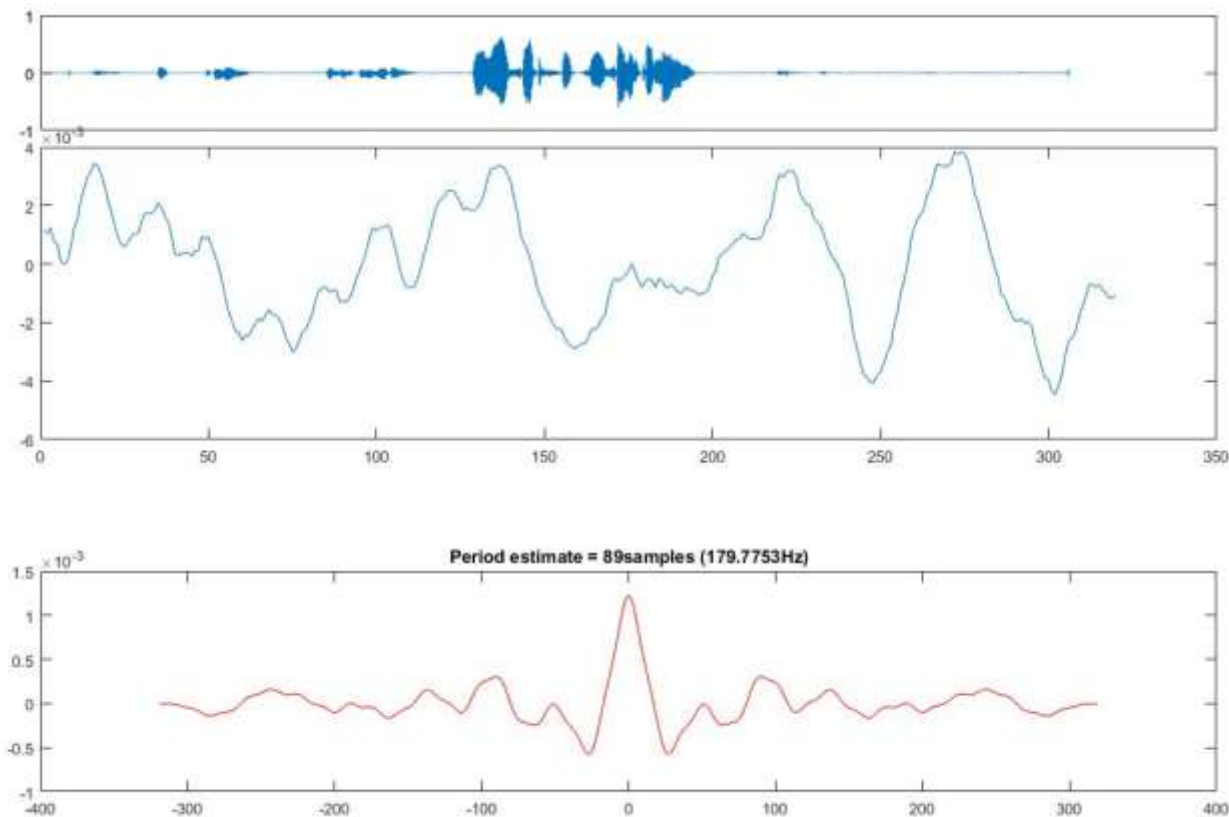
Figure 32: Audio Signal, Peaks of Signal and shows sampling of signals

Noise in recorded signal you can see Figure 33 by zoom, signal clearly shows high peaks of frequency and voice data in signal, background distortion of signal and different sample are taken of audio signal to verify sampling frequency.

Samples * Frequency

117 * 136.752 = 15931 approximate 16000Hz of recorded signal on Site A.
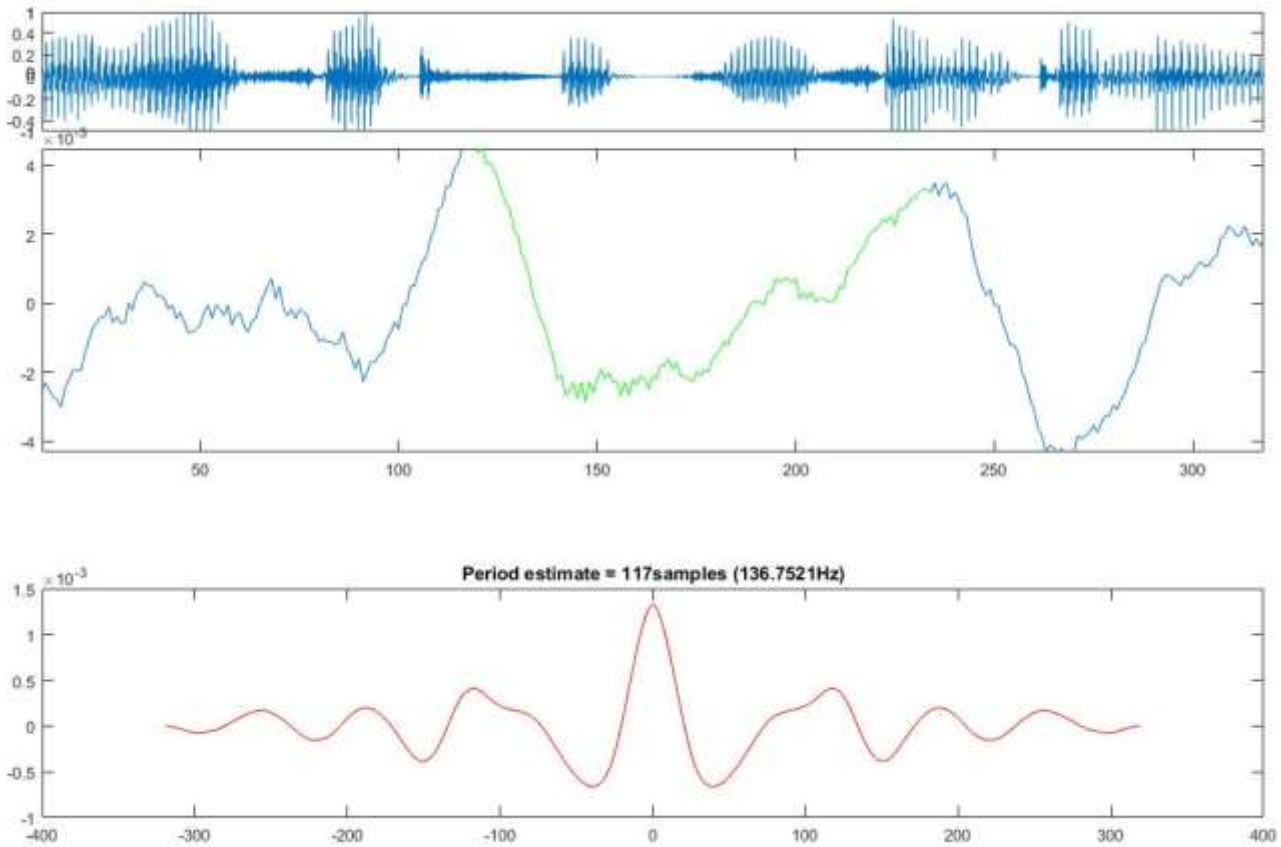
Figure 33: Audio Signal, Peaks of Signal and shows sampling of signals

Noise in signal shown audio Signal shown in Figure 34
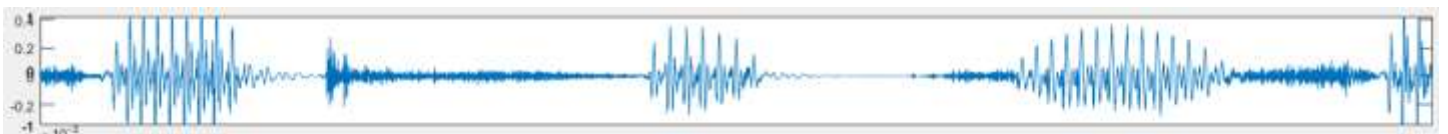
Figure 34: Shown Noise in Signal

Recorded Audio Signal on Site A after passing Cochlear Implant simulation

Graph A shows in Figure 35 Recorded Audio communication between Site A and Site B With noise that shows audio signal get degraded after passing internet and delay and change in frequency. First Samples * Frequency

36 * 555.55555 = 19999.9998 approximate 20000Hz of recorded signal on Site A.

After passing signal through Cochlear implant simulator we found increase in frequency and rest of signal is same and we calculate samples frequency.
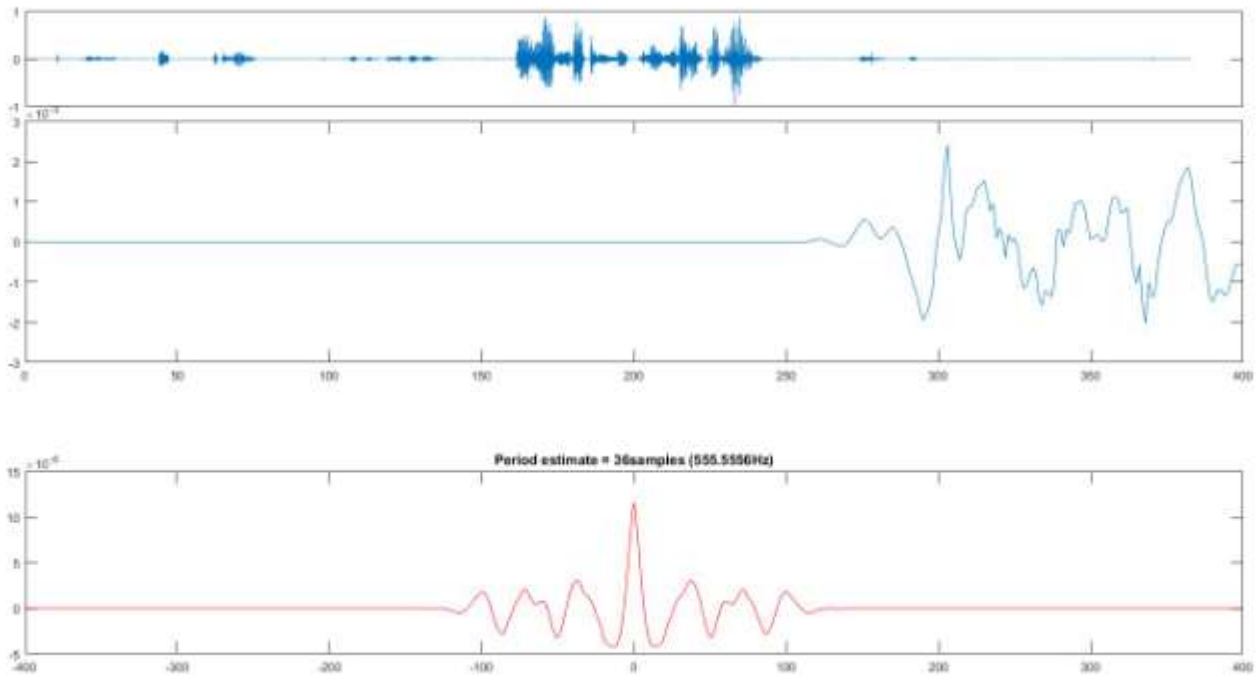
Figure 35: Shows Recorded Audio Signal after passing CI Simulation

Recorded Audio Signal on Site B passed over internet and before passing Cochlear Implant simulator.

Graph A shows in Figure 36 Recorded Audio communication between Site A and Site B With noise that shows audio signal get degraded after passing internet and delay and change in frequency. First Samples * Frequency

50 * 320 = 16000 Hz approximate recorded signal on Site B.
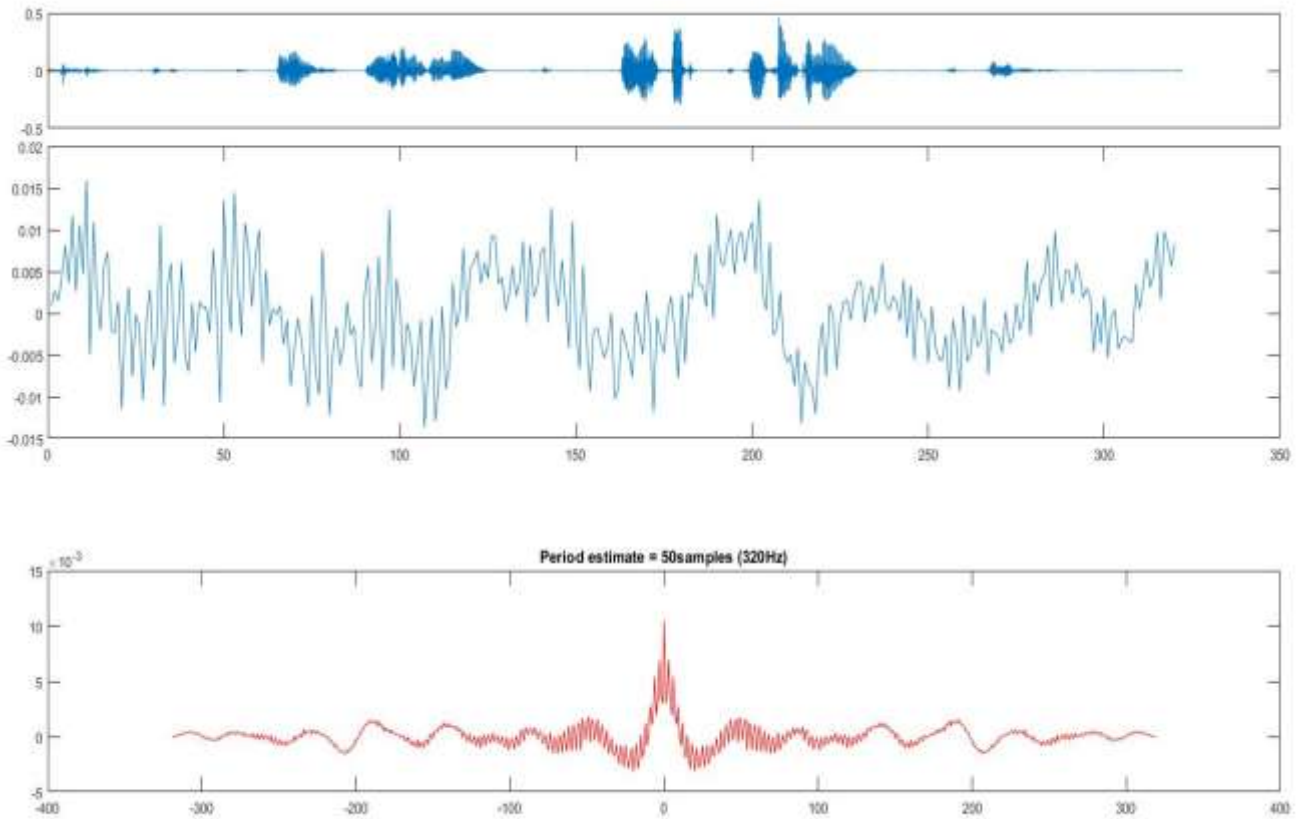
Figure 36 Shows Graphs of Recorded signal on Site B

Figure 37 shows Noise in audio signal and peaks of signals which degrades the audio signal on Site B because of internet and background noises and different modulation techniques applied on signal because of internet.

Figure 37: Shows Noise in Signal after Zooming

Figure 38 shows different signal samples frames with respect different samples points.

First Samples * Frequency

86 * 186.0456 = 15999.9216 Hz approximate 16000 HZ recorded signal on Site B.
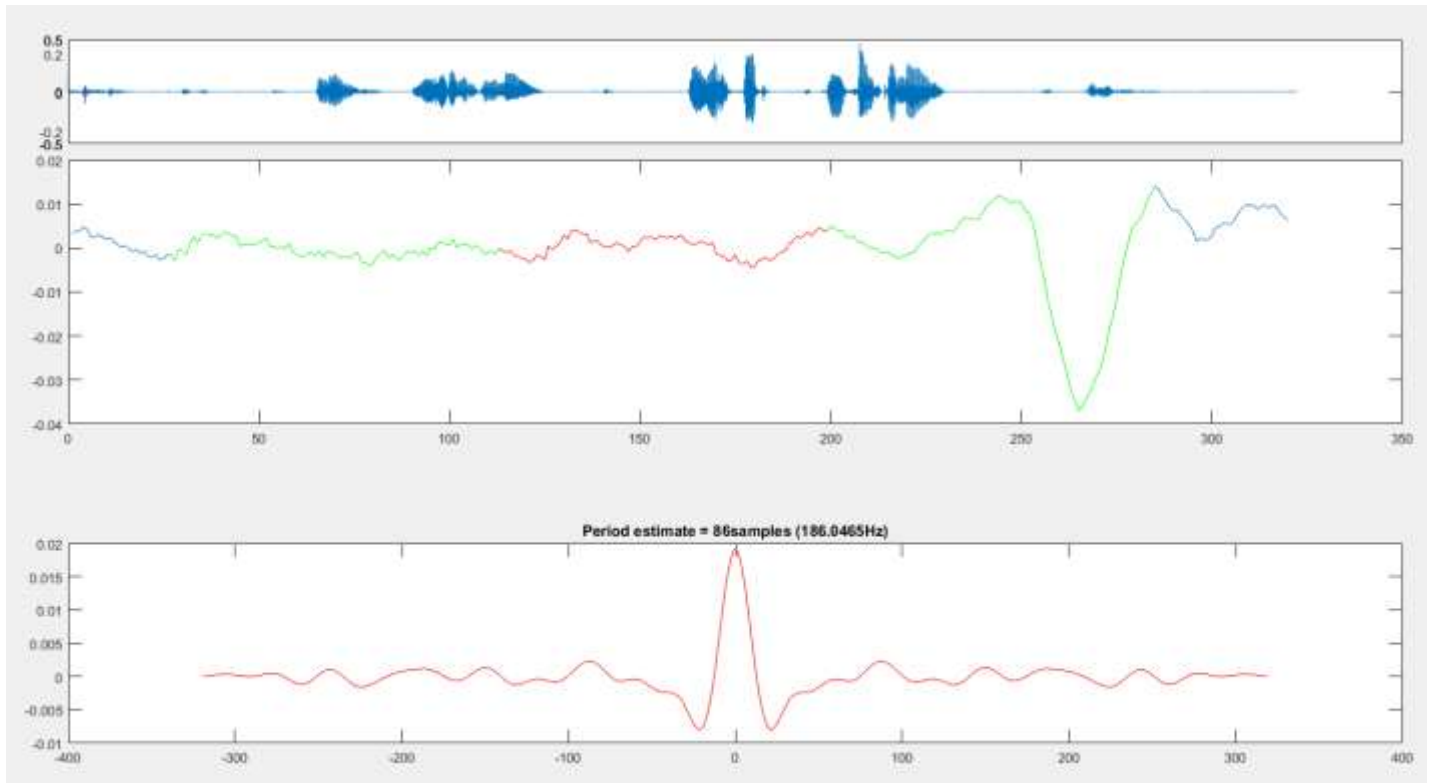
Figure 38: Shows different samples places and sampling of signals

Recorded Audio Signal on Site B passed over internet and after passing Cochlear Implant simulator.

1st graph shows recorded signal shown in Fig. 40 which is received from Internet which is passed through CI Implant Simulator and saved in to database. 2nd graph shows the certain points of basic speech data which identify the frequency of basic signal. The basic speech system is not lenient system according to Time domain, So the implementation of LTI for sampling and then applied the FFT to change is basic signal to periodic signal. The algorithm shows the frequency of basic audio signal. The algorithms chose any time domain convert in to periodic signal and shows the frequency.

You can see Noise and change in frequency in Figure 39 because of internet modulations attenuations of signals and CI implant speech processing algorithm.

Figure 39: Shows Noise in Signal and peaks of frequency
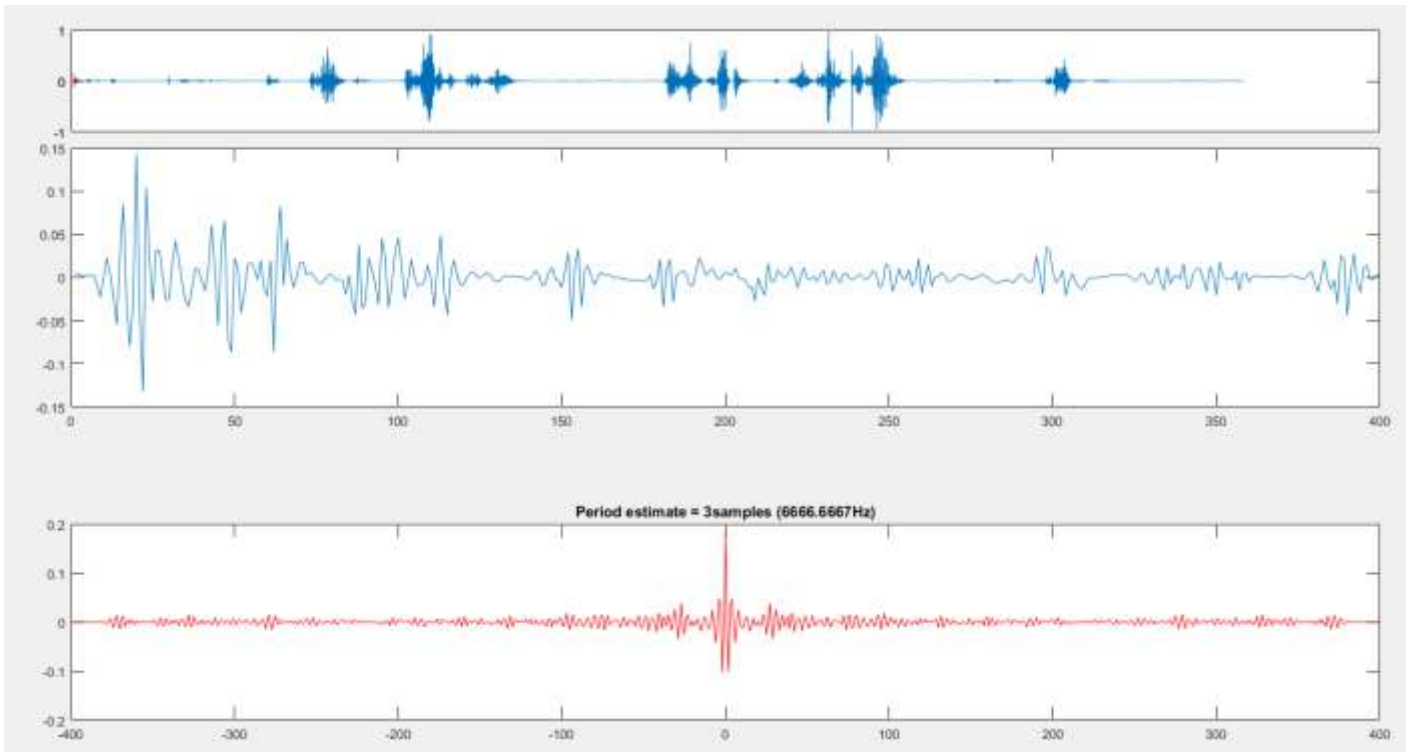
Figure 40: Recorded Signal Received through internet and passed through CI Simulator.

Recorded G729 Audio Signal FFT on Site A before passing Cochlear Implant simulator.

Figure 41 shows 4 graphs. Graph A Shows unfiltered sound Time domain presentation without filtration, Graph 2nd shows audio signal in Frequency domain without filters. Graph 3rd shows Time Domain Representation with filtration of audio Signal 4th graph shows frequency domain of audio signal after filters.

By applying FFT we can minimize noises of signal and its dominant in graphs after applying FFT of signals.
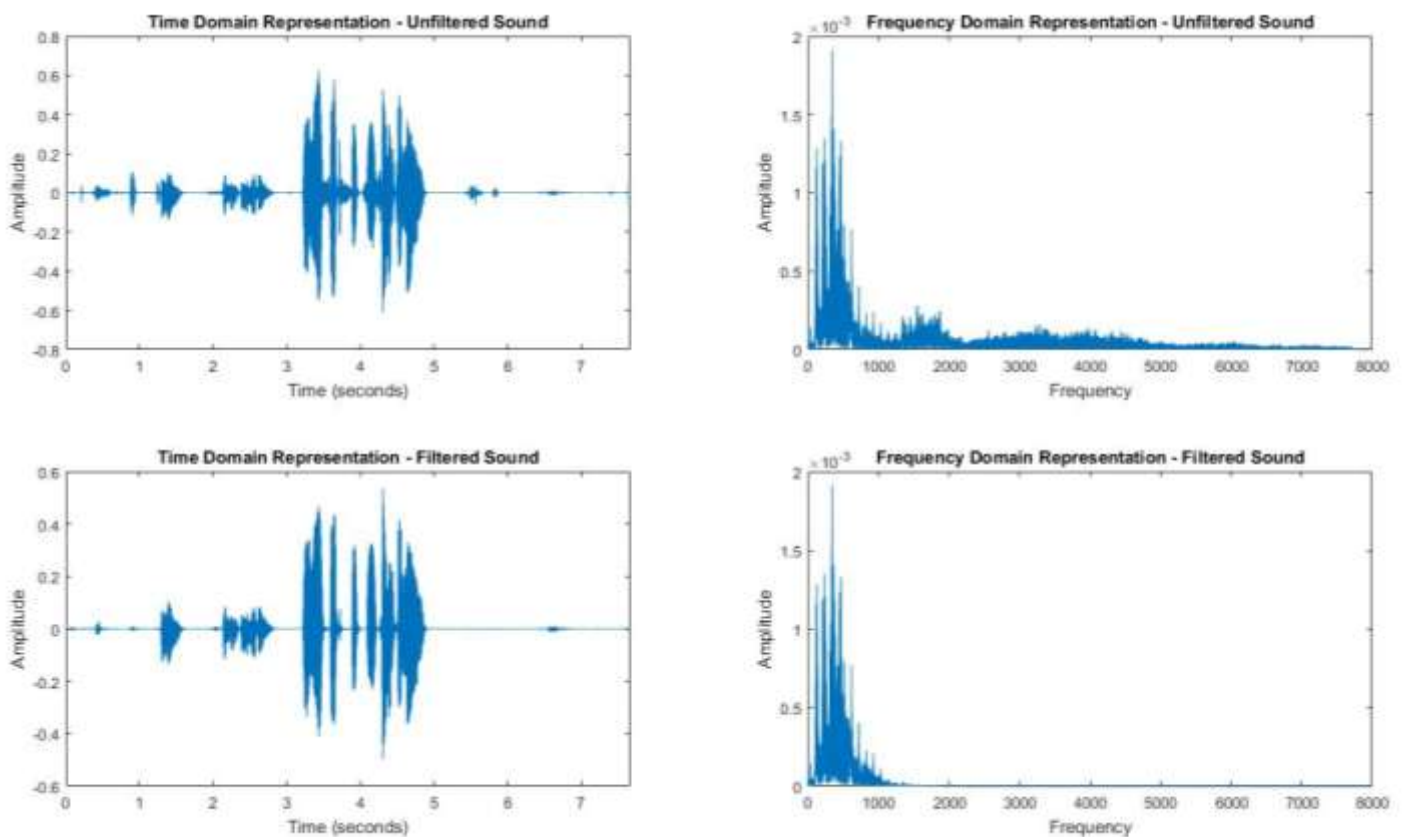
Figure 41: Shows Time Domain and Frequency Domain Comparison

Recorded G729 Audio Signal FFT on Site A after passing Cochlear Implant simulator.

Frequency domains representation of recorded G729 shown in Figure 42 Audio signal which is passed through CI Implant Simulator and applied FFT of audio signal. Graph A shows Time domain of audio file and then transferred in to Frequency domain and then same 3rd graph shows Time domain Representation of Filtered sound and 4th graph shows frequency domain of filtered sound.

These graphs shows that voice through CI simulator which added noise and change in frequency, by applying filter we can reduce noise and we can achieve good quality of sound.
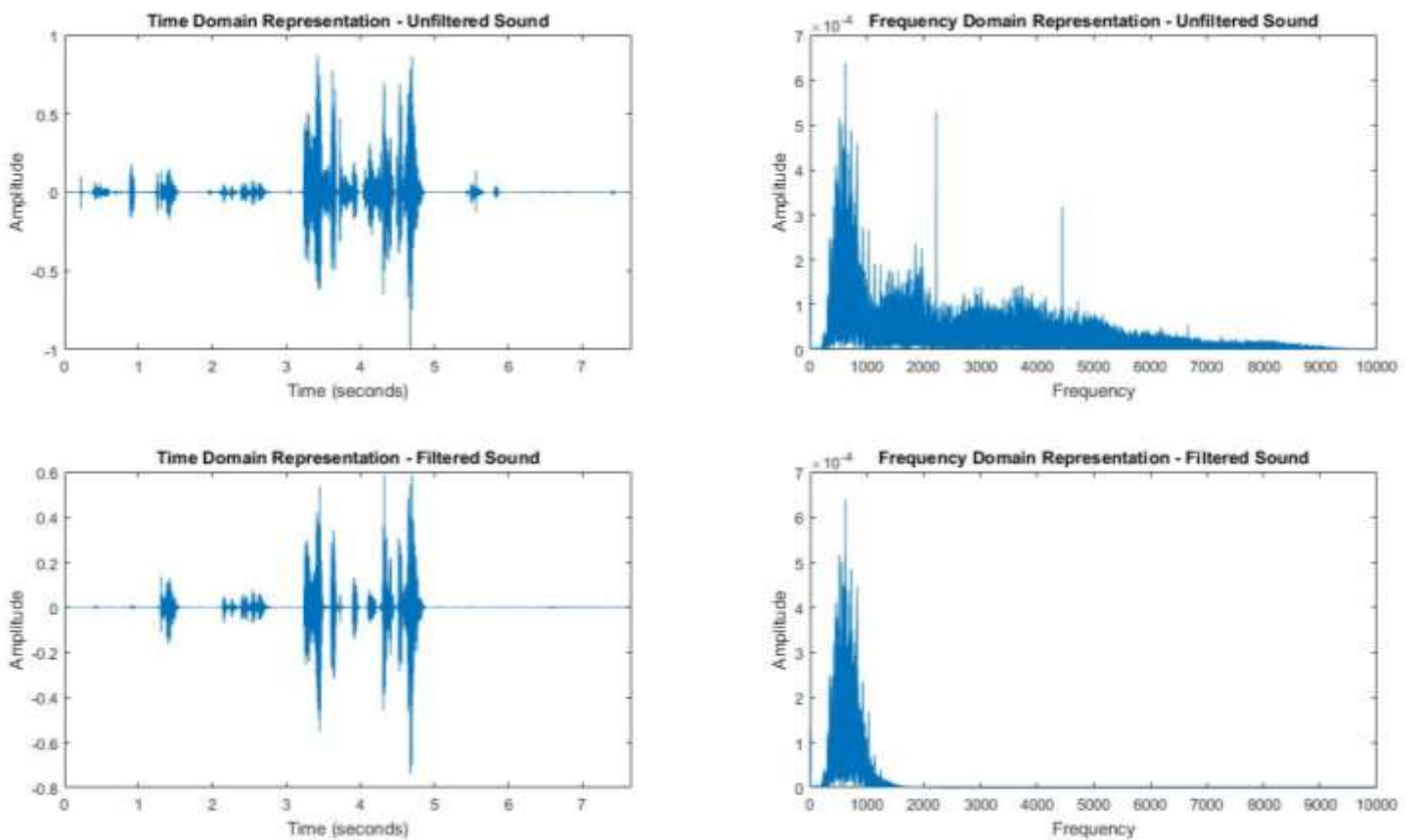
Figure 42: Shows Time domain and Frequency domain of audio signal

Recorded G729 Audio Signal FFT on Site B before passing Cochlear Implant simulator.

Time domain and Frequency domain of signal shown in Figure 43. This signal passed through internet and recorded on Site B and performed FFT of this signal after and before Filtering audio signal.

By removing noise from the signal we can listen sound of signal and its shows dominant difference in both signals in graphs B shows FFT of signal and we can see noise in sound. Graph D shows FFT of signal after applying Filter.
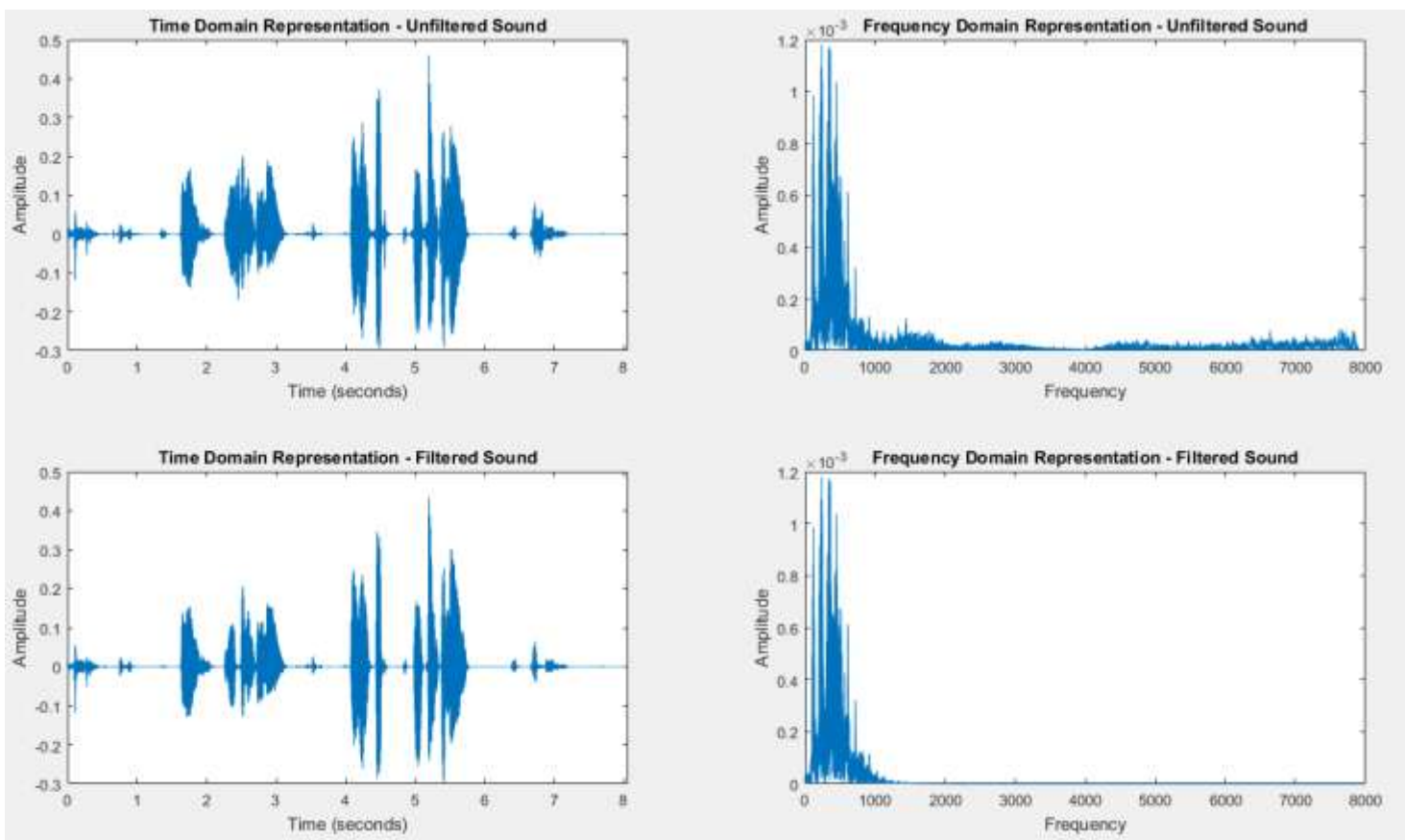
Figure 43: Shows Time domain and Frequency domain of signal Received on Site B

Recorded G729 Audio Signal FFT and FFT Filtration on Site B after passing Cochlear Implant simulator.

Time domain and Frequency domain of signal shown in Figure 44. This signal passed through internet and recorded on Site B then passed through CI Simulator and performed FFT of this signal after and before Filtering audio signal.

By removing noise from the signal we can listen sound of signal and its shows dominant difference in both signals in graphs B shows FFT of signal and we can see noise in sound. Graph D shows FFT of signal after applying Filter.
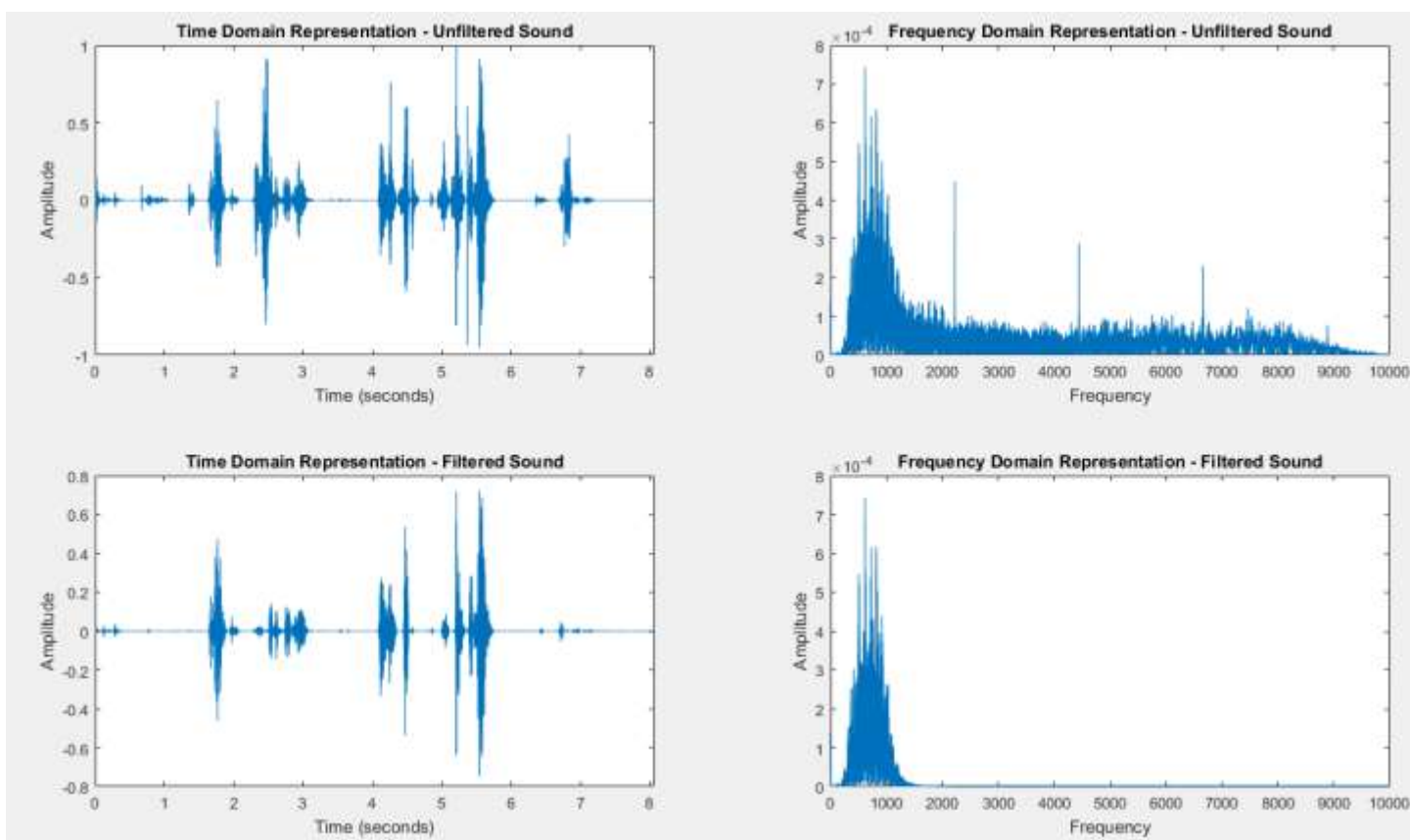
Figure 44: Shows Time domain and Frequency domain of signal received on Site B and passed through CI Simulator

Recorded G729 Audio Signal SNR Calculation on Site A before passing Cochlear Implant simulation.

Signal to Noise Ratio of Receded Signal on Site A shown in Figure 45. Total SNR of Signal is -17.34 dB.
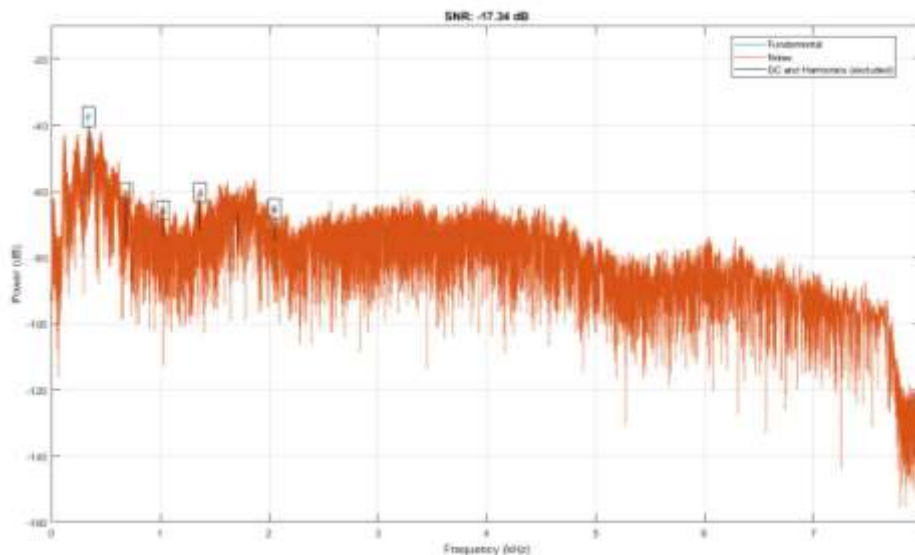
Figure 45: Shows Signal to Noise Ratio of Receded Signal on Site A

Recorded G729 Audio Signal SNR Calculation on Site A before passing Cochlear Implant simulation.

Signal to Noise Ratio of Receded Signal on Site A shown in Figure 46. Total SNR of Signal is -22.82 dB.
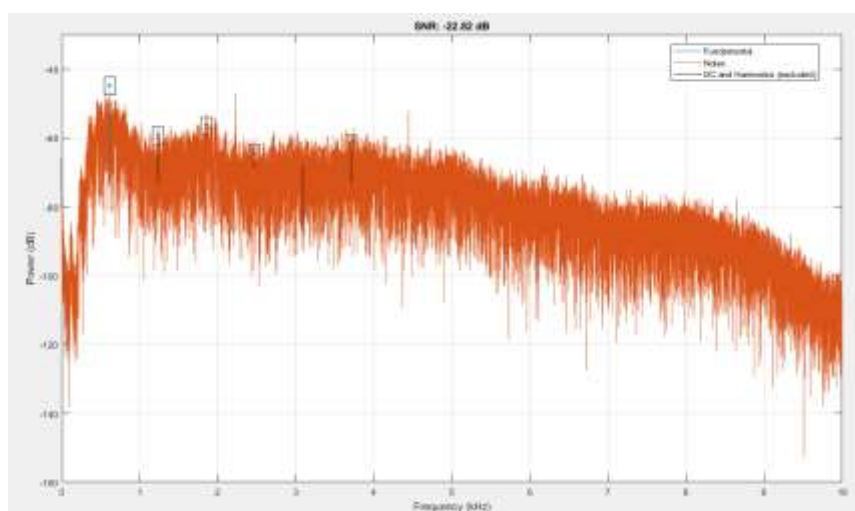
Figure 46: Shows Signal to Noise Ratio of Receded Signal on Site A after passing CI Simulator

Recorded G729 Audio SNR Calculation on Site B before passing Cochlear Implant simulation.

Signal to Noise Ratio of Receded Signal on Site B shown in Figure 47. Total SNR of Signal is -15.15 dB.
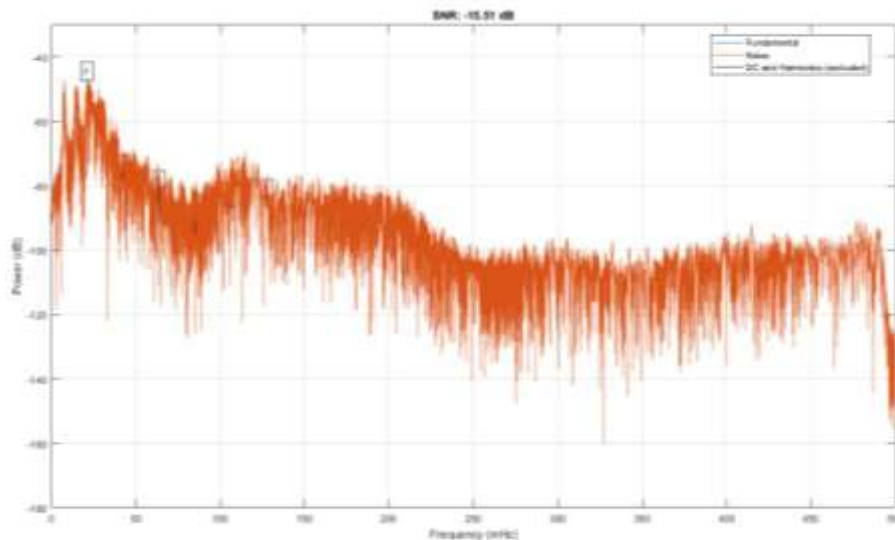
Figure 47 shows Signal to Noise Ratio of Receded Signal on Site B

Recorded G729 Audio Signal SNR Calculation on Site B after passing Cochlear Implant simulation.

Signal to Noise Ratio of Receded Signal on Site B shown in (Figure 48) after passing audio signal from CI simulator. Total SNR of Signal is -18.47 dB.
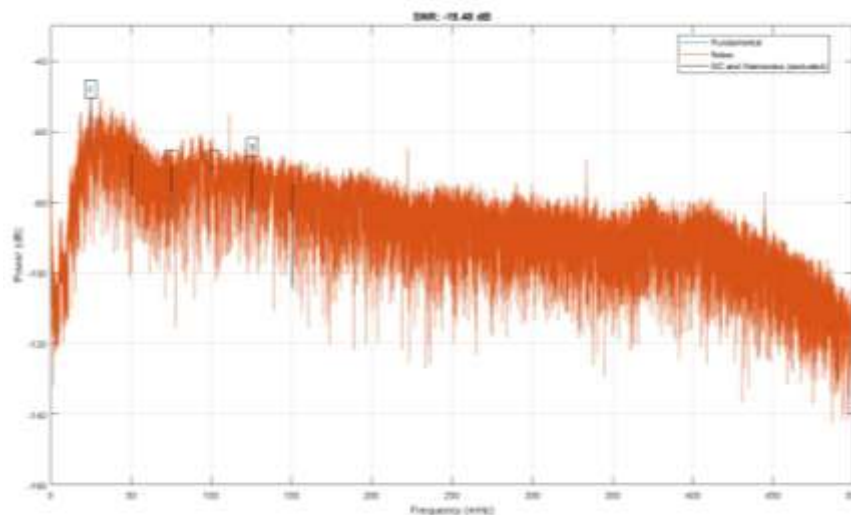
Figure 48: Shows Signal to Noise Ratio of Receded Signal on Site B after CI Simulator

G729 Codec Site A and Site B Signal differentiation through graphical representation of signal before CI Simulation

Difference between A and B site (Shown in Figure 49) signals and in different colors Purple color shows signal received on Site B and Light Blue color shows Signal on Site A.
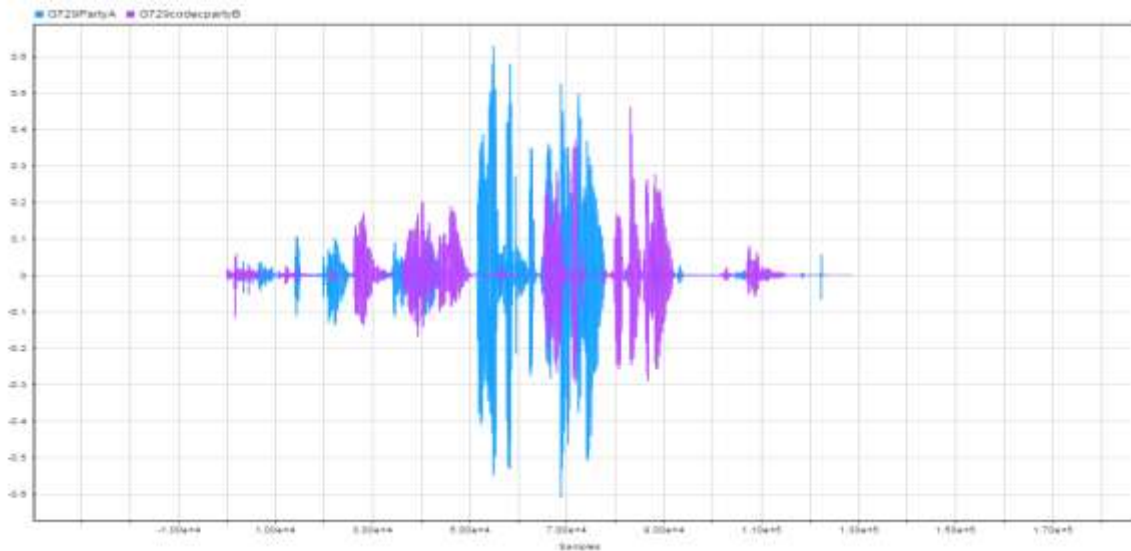
Figure 49: Shows Difference between A and B site signals

G729 Codec Site A and Site B Signal differentiation through graphical representation of signal after CI Simulation

Difference between A CI Simulated and B CI Simulated sites (Shown in Figure 50) signals and in different colors Green color shows signal received on Site B and Orange color shows Signal on Site A.
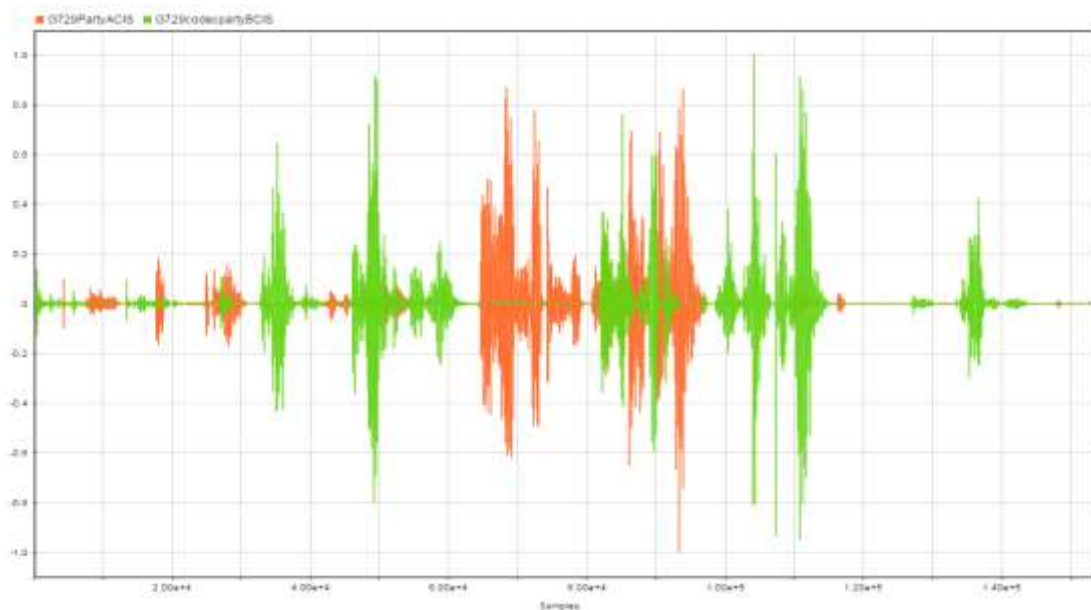
Figure.50: Shows Difference between A CI Simulated and B CI Simulated sites signals

Power Spectrum of Signals (Shown in Figure 51) in Combined view and their differences between signals.
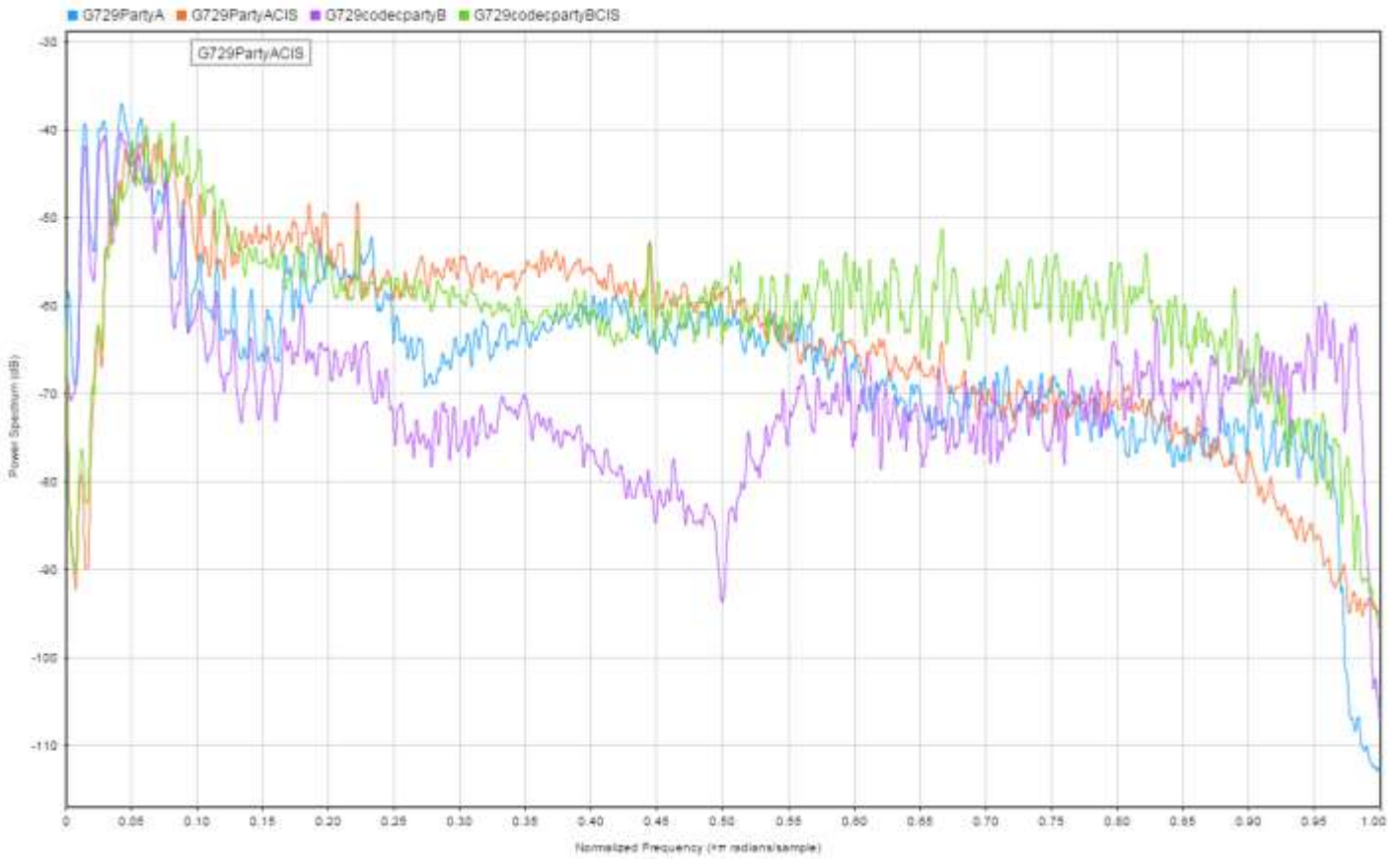
Figure 51: Shows Power Spectrum of Signals in Combined view

Economical Part

Expenses of the Resources

DSL Internet at least 2Mb Upload and Download: 2000- 5000 Rubles

2*PC Server: 2*60000 Rubles

2*Mic and 2*HD Camera: 2*7000 Rubles

Mat lab : 940$

Cochlear Implant with Aux and Bluetooth Technology: 2*20000$

SWOT Analysis:

Strengths:

- Advantage of this work is to connect number of patients with one doctor or number of doctors like one to one or one to many or many to many to provide services in remote area to improve health care.
- In latest approaches of Telemedicine like Real Time method you can be under observation 24/7 by using different sensors and provide your Medical health status in Real Time.
- We can reduce patients load from speech therapist and audiologist and they can provide time to every patient and can give some medication prescription remotely.
- By using this approach player and patient can save time and money both until unless doctors recommends in personal meeting.
- With telemedicine approach it's possible to tune and calibrate Cochlear machine remotely and can ask response from patient.
- With the help of Telemedicine you can choose any doctor or physician that you like to communicate without wastage of time and no need to sit in queue.
- Telemedicine can provide you 100 percent privacy with doctor and you can discuss your health issues by using Encrypted communication and nobody can access your health secrets.
- With the Help of Telemedicine you can have access with your concern doctor every time without in personal meeting and you can be updated with your health issues and you can be save from many chronicle health issues.
- You can save your Time by using Telephonic or Videoconference consultations with Doctor which can save time and money for both doctor and player and you don't need to visit doctor separately.

This project is perfect for big countries where it's difficult to provide health and care services because of worst weather conditions and distances and limitation of doctors as compared to patients.

This idea is to provide medical health services with maximum number of automation of medical machines and less involvement of human interaction with patients and machines.

Weaknesses:

- For this additional training is required for medical staff and patient to use this type of health care for example how you can use medical equipment's and medical machines in the absence of medical specialist.
- Some people don't have psychological satisfaction because they don't want to accept new technologies and they believe on visit doctor in personal and discuss their health issues.
- Virtual clinic decrease the human interaction while treatment which can be cause of in accuracy in results and diagnose the problem correctly.
- Telemedicine system requires tough legal regulation to prevent unauthorized and illegal service providers in this sector.
- Medical data protection of information exchange through internet all over the world.
- Traffic shaping issue because of bulk of internet traffic on the internet.
- Big disadvantage of this work is provide training to medical staff and patients how to use equipment correctly which settings they have to set and perform tests.
- Age factor is involved in this telespeech therapy because infants and small children below age of 8 years they can't understand this system they need some assistant to use this service.

This project have some weakness which can be improved with the passage of time because this technology will takes time to introduce with patients and doctors. It's necessary that doctor must know everything about technology and they can take patient in confidence that this technology is much enough trust worthy to diagnose easily and patient can use it easily in home or anywhere by connect each other over the internet. But this work will take much time to instruct surgeons, doctors and patients. Age factors of patient and doctor is main key some people wants to accept technology some people do not want to accept technology easily.

Threats

- Errors in report because of human errors.
- Protection of data over the internet.
- Patients and Doctor must familiar with technologies

  - Ethical Challenges.
  - Limited Awareness/ Unrealistic Expectations.
- Build of trust on the doctor and patients.

It's very hard to introduce this trend because patients are still thinking if doctor will check you in personal meeting its mean patient is satisfied otherwise patient have no any trust on doctor consultation.

When this trend will built all medical health will be revolutionized, people will take advantage in very remote areas for initial test and doctor consultations without going anywhere.

Secondly internet is back bone of this project. Internet service up time should be 99.9999999% without any link down because under this technology we can be performed critical surgery or critical other diagnose where internet connectivity is important like electricity.

Opportunities

● We can lead this research to make standards for telemedicine for Russia for Tele Audiology and live care monitoring.

● This research have all simulated scenarios to determine hardware and software requirements to achieve good quality of experience.

● We can automate hospital machines that somebody can controls remotely and some test are possible to do remote use like x-ray machines , MRI machines, ECG machines and Ultrasound machine.

● This Research have vast feature in the field of Medical Sciences in to provide medical services remotely and minimize the risk of deaths and other death diseases.

● We can evaluate speech processors to check how much speech processor are efficient and how patient is listening sounds.

● We can connect speech processor part with internal surgery part through different wireless technologies to add different variants in connectivity like Wi-Fi, 5G, Bluetooth and NFC to provide good audio with big data rate and responses.

● Telerehabilitation, TelePractice, TeleSpeech Therapy, Tele Medicine.

Social Responsibility

Occupational safety

The goals of occupational safety and health programs include to foster a safe and healthy work environment's may also protect co-workers, family members, employers, customers, and many others who might be affected by the workplace environment.

Identification and analysis of workplace hazards, which the research object can create for people

For making workplace hazards its varies from kind of research or industries, for example in oil and gas companies plants , nuclear power station, gas stations are common places where you must provide extreme level of health and safety to protect people from big hazards and then assets.

For making analysis you have to learn all process of plants to identify the problems and then you to right down all process and what kind of hazards can be possible.

Dangers and hazard factors coming about because of the workplace and working conditions ought to be surveyed methodically in the working environment. On the off chance that the dangers can't be killed totally, their importance to the wellbeing and security of specialists (=magnitude of the hazard) ought to be surveyed and measures gone out on a limb to a reasonable level or to dispense with it by and large [36].

Identification and analysis of workplace hazards, which may influence a researcher during the research process

The magnitude of the risk is made up of the likelihood of the hazard occurring and how big an impact the hazard would have on people's health and safety.

Factors affecting the impact of the hazard

- Nature of the hazard, mild/severe
- Extent of the consequences, how many people are hurt or injured
- Recurrence/non-recurrence of the hazard
- Duration of adverse effects, short-term/long-term.

Factors affecting the likelihood of the hazard occurring

- Frequency of occurrence of the adverse event
- Duration of the adverse event
- Possibilities to predict the occurrence of the adverse event
- Possibilities to prevent the adverse event.

Protection methods to mitigate the potential damage

Risk management measures

The measures taken to reduce risks are assessed according to the following criteria:

Fulfilment of requirements, if the measure can be used to remedy shortcomings in the fulfilment of goals set by the legislation, interest groups or oneself, the measure will be implemented.

Increased level of safety, the more effective the measure is in reducing the largest risks, the better it is.

Extent of the impact, the more risks and more people's safety the measure affects, the better it is.

Smoother operations, if the measure causes work to go smoother, it should be implemented.

Monitoring and reporting

Open communication and reporting on the implementation of the risk assessment and the measures taken on the basis of the assessment are all important factors in getting the entire staff to commit to the development of a safe and healthy workplace.

The management and supervisors need reports that they can use to monitor the development of occupational safety and well-being at work.

When monitoring risk assessment, it is important to assess the magnitude of the risks that the measures have had an impact on and to ensure that the planned effect has been achieved with the measures.

The information obtained from the risk assessment is utilized in the following issues:

- work guidance and orientation
- work and operating instructions
- occupational safety and health policy
- occupational safety and health action plans
- planning of occupational health care services
- planning of reports on the work environment and work atmosphere
- changing of workspaces and work processes.

Environmental safety

Environmental safety has become a high priority issue within the United States and among other countries around the world. Ensuring the safety of an environment is key to productivity and function in a work or research setting.

Environmental safety is the practice of policies and procedures that ensure that a surrounding environment, including work areas, laboratories or facilities, is free of dangers that could cause harm to a person working in those areas. A safe place to work is the key element of environmental safety [37].

Impact analysis of research object on environment

We know about the natural corruption happens because of real improvement ventures, development and so forth. At the point when a development venture is proposed and composed, that undertaking may influence the earth, including impacts on water or air quality, monetary interruption for a group, or even effects on social communications. These potential outcomes should be assessed with the goal that negative impacts can be limited or compensated for by one means or another through different roads.

This is the reason ecological Effect Evaluation is essential. A domain affect appraisal depends on an interdisciplinary procedure to illuminate people in general and chiefs of likely results of a proposed activity keeping in mind the end goal to stay away from or relieve environmental corruption. It is fundamental that anticipated effects are assessed with a specific end goal to protect the earth and the personal satisfaction for people and life forms.

The earth affect appraisal investigates both positive and negative effects. It even investigates conceivable outcomes for upgrading nature, for example, enhancing wetland territories as a major aspect of the undertaking and improving financial open doors in the region. Maybe in particular, it distinguishes conceivable negative effects and recommends approaches to limit them.

Impact analysis of research process on environment

Potential ecological effects could emerge amid development and task periods of the undertaking. The positive effects of the blossom cultivate venture incorporate producing high-pay charge, making openings for work, presenting current innovation, supporting the close-by schools and wellbeing focuses. The negative effects could emerge fundamentally amid the activity period of the undertaking. In this way, in light of the nature and size of tasks and highlights of the undertaking's condition the accompanying issues have been recognized and examined in order to distinguish the basic issues and to make the venture manageable.

Effects on human wellbeing Farming manures and pesticides are risky, in specific conditions, to human wellbeing particularly on the individuals who are occupied with the application. The impact of

composts incorporates clean introduction and ingesting nitrate which causes gastric and bladder esophageal tumor. The impacts of pesticides on people are a cerebral pain, irritability, tipsiness, loss of hunger, sickness, muscle jerking, writhing and loss of cognizance, cancer-causing impacts, neurobehavioral impact, conceptive impacts, and diabetes. The adjacent ranchers rely upon ground water from wells for their everyday life.

Protection methods to mitigate the potential damage

There are many actions you can take to reduce the environmental impacts of your energy use.

Be more energy efficient

Energy efficiency means delivering the same (or more) services while using less energy. So how can you make a difference through energy efficiency? EPA's ENERGY STAR program is the best place to start for guidance on how to save energy, save money, and protect the environment. Behind each blue ENERGY STAR label is a product, building, or home that is independently certified to use less energy and cause fewer of the emissions that contribute to climate change. Today, ENERGY STAR is the most widely recognized symbol for energy efficiency in the world, helping families and businesses save $300 billion on utility bills, while reducing carbon pollution by two billion metric tons [38].

Switch to cleaner energy resources

Clean energy generally means energy generated using renewable energy sources that emit no or negligible air emissions—solar and wind, for example—as well as clean distributed generation, such as combined heat and power.

As the price of wind and solar energy continues to fall, more and more people are choosing to purchase renewable energy. Many businesses are also choosing to install renewable energy and combined heat and power at their buildings to save them money, reduce their environmental impact, and provide greater control of their energy use.

Safety in emergency

Identification and analysis of emergency situations, which may occur during the research process

Emergencies present hazards that need to be recognized and understood. Nonroutine or infrequent tasks, including maintenance and startup/shutdown activities, also present potential hazards. Plans and procedures need to be developed for responding appropriately and safely to hazards associated with foreseeable emergency scenarios and nonroutine situations [39].

How to accomplish it

Identify foreseeable emergency scenarios and nonroutine tasks, taking into account the types of material and equipment in use and the location within the facility. Scenarios such as the following may be foreseeable:

- Fires and explosions
- Chemical releases
- Hazardous material spills
- Startups after planned or unplanned equipment shutdowns
- Nonroutine tasks, such as infrequently performed maintenance activities
- Structural collapse
- Disease outbreaks
- Weather emergencies and natural disasters
- Medical emergencies
- Workplace violence

Protection methods to mitigate the potential damage

Regularly review your systems of work to ensure that they still reduce or minimize risk and revise as necessary. Safe systems of Work can reduce or eliminate exposure to hazards but they must be strictly followed.

Safe Systems of Work

1. Know about space & equipment

- Know your building:-
- Exit routes
- Areas of rescue assistance
- Shelter in place locations
- Assembly location

  2. Know your gear:-

- First aid supplies
- Emergency Procedures poster

- Keep a Go Bag (flashlight, emergency contacts, etc.)

  3. Hearing about an emergency

- Siren
- Fire alarm
- Social media
- Alerted by a colleague
- Call from a friend
- Witness the event

  4. Getting help:-

- For any type of emergency call police or administrator
- Give your name, address, and the nature of the emergency
- Stay on the line until you are told you may hang up
- Remain calm and answer questions as clearly as possible

  5. Deciding what to do - evaluation

- Gather information Watch and listen for instructions
- Follow instructions
- Shelter in Place = Stay
- Evacuate = Go Sometimes you just have to use your best judgment

Workplace design (workplace ergonomics)

Work environment configuration is utilized to survey how assignments or the whole occupation is composed inside the   work condition, and after that guarantee these are all around coordinated to the properties of the employee. While the two terms, work plan and work environment configuration are utilized conversely, workplace configuration has an attention on those managerial changes that are required to improve working conditions, with work configuration having a more sober minded approach and addressing those modifications that might be required to workstations, instruments, and body positions to enable the specialist to work all the more viably

Conclusion

We tested G729 Audio Codec with 2 scenarios voice data after passing internet cloud and before passing internet cloud via Open source Linux VoIP server and record the audio voice with noise active cancelation smartphone MIC for comparisons of signals applied on cochlear implant simulator.

Firstly sampled the audio signal G729 for change to estimated periodic signal to find out the frequency of voice data. Examined result shows sample of desire signal is directly proportional to samples.

We conclude difference in time domain, Frequency domain and Harmonic Noise factor is concerned with SNR Values, Because of pauses in speech harmonic noise includes in voice data. Generally used to exclude the noise from the signal by High Pass and Low Filters, But we developed algorithm of FFT to identification of both voice data signals without any filters Because of filters the voice data is discard.

We analyzed the spectrogram of signal by using single sided magnitude spectrum frequency in radian per sample and double sided magnitude spectrum showing positive frequency of FFT.

By segmentation addition of 2 voice signals is possible, and we added reference audio signal with CI applied signal there is difference in signal frequencies because in simulator cut of frequency, Rate of Signal, Frequency of Signal and length of signal depends on SNR Value, because of all above mentioned factors its increases the SNR of Signal as compared to reference signal. And this system have 0.9411 error factor and its minor error. Because of less error in SNR values which depends on power spectrum of signal its mean the electrical circuit of that device will consume low power. But we merged in Matlab to get desired signal. With desired signal we can make device for real-time implementation.

References

[1] http://www.asha.org/academic/accreditation/caa_app.

[2] Hall, Nerissa, and Boisvert, Michelle and Steele, Richard Telepractice in the assessment and treatment of individuals with aphasia.

[3] USING WEB SERVICES TO REALIZE REMOTE HEARING ASSESSMENT

Jianchu Yao, Ph.D., Yongbo Wan, MS and Gregg D. Givens, Ph.D.

[4] A Browser-Server–Based Tele-audiology System That Supports Multiple Hearing Test Modalities Jianchu (Jason) Yao, PhD,1 Daoyuan Yao, PhD, and Gregg Givens, PhD.

[5] Three Principles for Determining the Relevancy of Store-and-Forward and Live Interactive Telemedicine: Reinterpreting Two Telemedicine Research Reviews and Other Research Craig Locatis, PhD, and Michael Ackerman, PhD.

[6] Pure-tone audiometric threshold assessment with in-ear monitoring of noise levels, Int J Audiol. 2013 November. Jay C. Buckey1, Abigail M. Fellows1, Benjamin G. Jastrzembski2, Isaac I. Maro3, Ndeserua Moshi4, Marvee Turk1, Odile H. Clavier5, and Robert J. Kline-Schoder51Geisel.

[7] Connected Audiological Rehabilitation: 21st Century Innovations, Gabrielle H. Saunders and Theresa H. Chisolm. J Am Acad Audiol. 2015 October ; 26(9): 768–776. doi:10.3766/jaaa.14062.

[8] A Store-and-Forward Tele-Audiology Solution to Promote Efficient Screenings for Ototoxicity during Cisplatin Cancer Treatment, Marilyn F. Dille, Garnett P. McMillan, Wendy J. Helt, Dawn Konrad-Martin and Peter Jacob, J Am Acad Audiol. 2015 October.

[9] Rural Barriers to Early Diagnosis and Treatment of Infant Hearing Loss in Appalachia,Matthew L. Bush, M.D.1, Bryan Hardin, B.S.2, Christopher Rayle, B.A.1, Cathy Lester, MSSW3, Christina R. Studts, Ph.D.4, and Jennifer B. Shinn, Ph.D. Otol Neurotol. 2015 January ; 36(1): 93–98. doi:10.1097/MAO.0000000000000636.

[10] Use of Telehealth for Research and Clinical Measures in Cochlear Implant Recipients: A Validation Study Michelle L. Hughes, Jenny L. Goehring, Jacquelyn L. Baudhuin, Gina R. Diaz, Todd Sanford, Roger Harpster, and Daniel L. Valente

J Speech Lang Hear Res. 2012 August ; 55(4): 1112–1127. doi:10.1044/1092-4388(2011/11-0237).

[11] Evaluation of an InternetBased Hearing Test—Comparison with Established Methods for Detection of Hearing Loss, Christin Bexelius, Louise Honeth, MD, Alexandra Ekman, PhD, Mikael Eriksson, Sven Sandin, Dan BaggerSjöbäck, MD, PhD, and JanEric Litton, Published online 2008 Oct 21. doi: 10.2196/jmir.1065.

[12] Teleaudiometry as a screening method in school children Maine Botasso,I Seisse Gabriela Gandolfi Sanches,I Ricardo Ferreira Bento,II Alessandra Giannella Samelli.

[13] Telemedicine's Impact on Healthcare Cost and Quality April 2015, American telemedicine Association.

[14] Cochlear Implant Simulation version 2.0, The version 2.0 has been concluded in the University of Granada, Spain, December 2004.

[15] https://advancedbionics.com/us/en/home/products/solution-finder/phone-solutions.html

[16] http://mininet.org/.

[17] http://searchsdn.techtarget.com/tip/SDN-and-Openflow-Is-the-protocol-dead.

[18] Martin, Douglas (December 15, 2012). "Dr. William F. House, Inventor of Pioneering Ear-Implant Device, Dies at 89". New York Times.

[19] Mudry, A; Mills, M (May 2013). "The early history of the cochlear implant: a retrospective". JAMA otolaryngology-- head & neck surgery. 139 (5): 446–53. PMID 23681026.

[20] "2013 Lasker~DeBakey Clinical Medical Research Award: Modern cochlear implant". The Lasker Foundation. Retrieved 14 July 2017.

[21] Gelfand, Stanley A. (2009). Essentials of Audiology (3 ed.). New York: Thieme Medical Publishers, Inc. p. ix. ISBN 978-1-60406-044-7.

[22] https://chironhealth.com/definitive-guide-to-telemedicine/about-telemedicine/types-of-telemedicine/

[23]https://www.voip-info.org/wiki/view/Asterisk+config+extensions.conf

[24] https://www.tecmint.com/red-hat-enterprise-linux-rhel-6-installation-guide-with-screenshots/

[25] https://asterisk-pbx.ru/wiki/asterisk_install/asterisk14-ubuntu16

[26] https://tools.ietf.org/html/rfc3261

[27] https://www.mathworks.com/help/install/ug/install-mathworks-software.html

[28]https://access.redhat.com/documentation/enus/red_hat_enterprise_linux/6/html/installation_guide/index

[29] https://www.scribd.com/doc/53640582/OPNET-14-5-Installation-for-Windows

[30] https://www.virtualbox.org/manual/ch01.html

[31] http://www.teledynamic.com/blog/bid/178260/SIP-Trunking-For-Dummies-Which-Codec-Should-You-Use

[32] Performance Studies of Integrated Network Scenarios in a Hospital Environment

June 2014 DOI 10.4018/ijicthd.2014010103 Nurul I Sarkar, Anita Xiao-min Kuang ,Kashif Nasir, Angela Amphawan.

[33] https://en.wikipedia.org/wiki/Full_Rate.

[34] https://en.wikipedia.org/wiki/Half_Rate.

[35] https://wiki.freepbx.org/display/FOP/Installing+FreePBX+14+on+CentOS+7.

[36] https://ttk.fi/en/well-being_at_work_and_occupational_health_and_safety/occupational_health_and_safety_work_in_the_workplace/responsibilities_and_obligations/analysis_and_assessment_of_risks_at_work

[37] http://environmentalsafety123.blogspot.com/p/definition-of-environmental-safety.html

[38] https://www.epa.gov/energy/reduce-environmental-impact-your-energy-use.

[39] https://www.osha.gov/shpguidelines/hazard-Identification.html#ai5