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X-raying the trends in Voice over Internet Protocol Telecommunication Systems

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***Abstract*— Broadband technology offered by the Internet has increased the use of Over-The-Top (OTT) services in providing Voice over Internet Protocol (VoIP) calls used in making distant calls at cheap rate. Over the years telecommunication industries have sought for ways to satisfy their numerous customers. Voice call is one of the fastest ways of communicating due to its real time application. Telecom providers have undergone various platforms to render effective service to customers. This study has x-rayed how the Internet has affected the way people communicate, especially with the increase in broadband technology. An overview of how communication has evolved over the years from smoke signals to VoIP then to different generations of voice call to enhance effective communication have been highlighted.**

Keywords—Broadband Technology, Over-The-Top Services, Private Branch Exchange, Telecommunication, Voice over Internet Technology

I. INTRODUCTION

The advancement in communication technology has prompted the growing attempts to update the initial face-to-face communication to non-face-to-face using telecommunication systems. The early means of telecommunication date back to smoke signals and town Cryer, by community leaders. Telegraphy and telegraph system invented by Claude, Charles and William in the late eighteenth and early nineteenth centuries gave birth to another era. This was followed by the telephone using coaxial cable invented by Graham Bell, Lloyd & Herman, 1959 to make distant call across the Atlantic Ocean.

The rise in telecommunication technology over the past decades has changed the equipment, materials, ways and manner people communicate. In the bid to improve these changes, there has been trend in cables used from coaxial cables, then to microwave cables. In addition to these we have fiber optic telephone cables, digital network and satellite board band network. Combinations of these cables, materials and equipment also exist. These trends in telecommunication have revolutionized the means of telephone communication from analogue communication (as is the case with Private Branch Exchange (PBX)) to the use of Public Switched Telephone Network (PSTN). There has been a rapid drift from analogue to digital means of communication. The rapid growth of Internet usage has revolutionized telephony usage whereby voice is transmitted over the Internet known as Voice over Internet Protocol (VoIP). The metamorphosis of mobile network from 2G, 2.5G, 3G and 3G+ and still counting to 5G is due to increase in Wireless Fidelity (Wi-Fi) broadband[1] (Jain, Jain, Kurup,. & Gawade, 2014).

All these have transformed voice communication from what it was in Graham Bells time to what it is in our current day. Over The Top (OTT) service providers have leveraged on increased broadband to provide VoIP services to its customers. VoIP calls include voice calls made on WhatsApp, Viber, Skype, YouTube, Facebook messenger and iMessage.

Today people will prefer to use OTT services, which are services that are used over the Internet [2] (Ogidiaka & Ogwueleka, 2019). Such services such as Google Play Movies & TV, Amazon, Google Play Music, iTunes, YouTube TV, Netflix, and Hulu are offered with low or no cost, and without going through telephone service providers. People prefer to make calls and get the best service in terms of low cost, than to spend money to purchase air-time. The VoIP services offer voice calls which run over IP. [3]Daws, 2019 has this to say "With over 1.5 billion active users, WhatsApp is the world's most popular messaging app. Nowadays these services are becoming more popular due to the increase in broadband network, which has led to high frequency signals[4] (Ma & Jia, 2017). This makes it possible for people to leverage on this broadband advantage to offer voice call services.

II. II. OBJECTIVES OF THE STUDY

THE OBJECTIVES OF THIS STUDY ARE TO GIVE US AN OVERVIEW OF HOW TELEPHONY HAS METAMORPHOSED OVER THE YEARS TO WHAT WE HAVE CURRENTLY AS VOICE OVER THE INTERNET. THIS WILL ASSIST US TO APPRECIATE WHAT TELECOMMUNICATION PROVIDERS AND RESEARCHERS HAVE DONE TO ENSURE EFFECTIVE COMMUNICATION AT CHEAP RATE TO ENABLE CUSTOMERS COMMUNICATE AT MINIMUM COST. THE WORK WILL ALSO HELP US TO RESEARCH MORE ON HOW TO COMBAT CALL QUALITY ISSUES IN VOIP, WHICH DISCOURAGE TELECOM USERS FROM NOT USING IT, DESPITE, IT IS CHEAPER TO MAKE BOTH LONG AND CLOSE DISTANCE CALLS.

The remaining paper is organized into subsections; the first section is advancement in telephony devices, the second section gives a general overview of IP telephony and mobile technology, this is followed by section three, which deals about historical perspective of telecommunication technologies. The fourth section is on generations and

advancements of mobile telephone network, the fifth section deals on broadband features, the sixth is on broad voice router and Networking/Broadband VoIP. Section seven is an evaluation of TCP versus UDP in VoIP. Finally conclusion and recommendations for future researchers

III. Advancement in Telephony Devices

In order to overcome the shortcomings and deficiencies of existing hand held devices, the advance in microchip technology in the 21st century no longer speaks of mainframe computers. The power of operating systems has made it possible to incorporate millions of applications into sizable and unified hand-held devices, such as the hand-phones, interactive Personal Application Devices (iPads) and other small devices which can easily be carried about and used by billions of people. Smart phones or tablets have made communication popular and easy. Users want to settle for the best communication quality, hence the need for improving service delivery. VoIP was one of the ways in which the cost of calling over long distances was reduced, particularly for international calls [5] (Jung, Mo & Park, 2017). Since the first reported use of VoIP in 1995, as reported by [6] Chakraborty, Misra, Prasad, (2019), VoIP technology has become the next level of technology, due to cheap calls especially over long distance. In addition, people want to settle for cheap and better call quality. Notwithstanding the advantages and benefits associated with VoIP technology, it is not without challenges. These includes packet loss, jitter, noise, echo and delay [7] [8] [6] [91 (Adewale et al., 2017; Bora1, Bora, Singh, & Arsalan, 2014; Chakraborty, Misra & Prasad 2019 and Ismail, 2013). The penetration rate of mobile broadband is driving the shift to Internet Protocol (IP) services. Phones have grown to be multidimensional devices that can be used as other means of communication and not just devices for receiving and making calls. Forty seven (47) years ago, the first mobile phone was launched by Martin Cooper [11] (Goodwin, 2017). Recently, mobile devices have been part of everyday human activities and it appears as though life cannot be complete without these devices. Another important role which the mobile devices have played is to bridge the communication gap between people. Voice over Internet Protocol (VoIP) is one of those techniques which use mobile devices as a means of communicating. VoIP is used to improve the traditional Public Switched Telephone Network (PSTN) telephone network. A PSTN routes calls through a dedicated circuit-switched connection between two points, whereas the VoIP routes calls through the Internet Protocol (IP) in packets. According to [12] Skouby, William and Gyamfi, (2017), the Internet has revolutionized how information travels through computers.

III. General Overview of IP Telephony and Mobile Technology

Audio traffic has risen considerably in recent years with the widespread use of mobile devices because of the development of wireless network technologies. Recent research has shown that voice traffic accounts for the highest on the internet [7] (Adewale, Matthews, Agboje, Adelakun & Okosun, 2017). According to [13] Mueller and Grindal (2019), the approximate percentage of data that flowed through the internet was 66.5%. However, the same source has it that a large amount of all telecommunications network data dominated the Internet. Communication is considered a vital tool in any society's developmental process [14] (Rizky & Hakim, 2019). The above position becomes important because effective communication brings every member of a given society together on what, how, when and where things will be done. Information is easily disseminated among members when there is good communication network [15] (Friday & Olikiabo, 2015). The invention of the Internet has brought a radical change to how people communicate in today's world. The Internet has virtually permeated every facet of life and mobile devices are not left out.

VoIP technology makes use of packets just as any transfer of data over an IP network to convey voice communication. The analog voice is digitally transformed into packets which are returned to the end customer via the network in analog signals. VoIP is not restricted to audio communication alone. Other forms of multimedia objects such as data, video, images can be communicated via this innovation. However for the purpose of this work only audio in form of voice call is considered VoIP makes use of codecs which are algorithms that compress the data so as to allow for transfer over IP network. VoIP uses preexisting network architecture, protocols, and components. Other IP based network connections experience packet delay, jitters, packet loss and echo over the network.

Planning, effective communication, and team work can be achieved with VoIP services due to its cost effectiveness. An organization can move to the next level if its members are on the same page information wise. The members will know what to do and cue into the goals and vision easily without spending much money trying to involve its members. The globe is now a web-based worldwide town with the use of the Internet [16] (Koopman & Hay, 2019). Distance, time and space are no longer hindrances because with the click of a button, one can be in the bedroom and reach out to the entire world through the internet.

IV. Historical Perspective of Telecommunication Technologies

After God created man, He gave them the capacity to relate with each other, and this connection is called communication. The Holy Bible says in Genesis Chapter 11, verses 6 to 9 that man had one reason and spoke in one dialect. We can correlate this one dialect to a pre-call amount and which number allows the caller to reach the recipient prior to interaction. The confusion of language at the tower of Babel made man to device several means of communication, a situation that has continued till date through the invention and use of various telecommunication systems. Table 1 is a summary of telecommunication inventions history.

Table 1: History of Inventions in Telecommunication Technologies

S/N	Technology	Year	Inventors	Function	Limitation
1.	Smoke Signal, Drum Beats	Early Era before 1700	Community Leader's used to disseminate information	Drums and smoke signal were used for announcement/communication.	Messages was limited to an environment
2.	First visual Telegraphy	1792	Claude Chappe	The system involved pulleys rotating beams of wood.	Weather and line of sight limited.
3.	Telegraph System	1844	Charles Wheatstone and William Fothergill C.	It needs many cables and only able to reach a near distance.	It is a slow data transmission method.
4.	Telephone	1876	Alexander Graham Bell	1878 and 1879 gave both to the first commercial telephone where calls were made across the Atlantic oceans	There was no Trans-Atlantic voice communication
5.	Coaxial cable microwave link	1929	Lloyd Espenschied and Herman Affel	Broadband communications were possible which led to high frequency signal.	Only voice signal was used; no image.
6.	Cellular (Mobile) System	1973	Martin Cooper	The technology used police was adopted. The phone was connected without the assistance of a mobile operation.	Only few simultaneous telephone calls
7.	Cable TV, Digital Tech, Internet, Internet Telephone	Back in 1984		It is a mixture of radio and telephone technology	Poor voice call quality

Sources: [17] [18] [19] Dan, (2014); Verulkar and Limkar, (2012); Winston, (2002)

The wireless internet used the technology of a *Universal Serial Bus* (USB) modem plugged into a laptop [20] (Pyers, Wiley, Willkie, Steele, Nahata & Kaliannan, 2013). Nowadays, with the growth of the internet, people are no longer satisfied with notebook and USB modem. Smart phones such as Blackberry, iPhone, and Android cell phones are popularly used. Beside smart phones, other tablet technologies such as iPad and Samsung Galaxy which are light and user friendly are in vogue.

V. Generations and Advancements of Mobile Telephone Network

The advancements in wireless Telephone systems have led to the most appropriate technology chosen to meet the demands and the best quality of service required at a specified place and time. Different generations use different technologies which differentiate them from the previous generations as shown in Table 2. The 1970s saw the start of mobile technology. Analog wireless was the first generation (1 G) that gave birth to mobile voices. The Second generation (2G) introduced wider exposure signals, which had the digital communication technology such as GSM, GPRS, TDMA and CDMA. The 3 G technology objective was to increase the data rate, improve QoS and provide MM services such as audio and TV services. Excessive broadband internet access, such as Wi-Fi, WiMAX and LTE, has been created by 4G (4th generation). In the Fifth generation (5G) mobile network concept, the user has been given the prime and top most priority compared to the operator [21] (Mehta, Patel, Joshi and Modi, 2014).

Table 2: Summaries of Generations of Mobile Technologies from 1G to 5G

Generations	1G	2G	3G	4G	5G
Starts from	1970 – 1984	1990 – 2003	2001	2010	2015
Frequency	800 - 900 Mhz	850-1900 Mhz(GSM) 825-849 Mhz(CDMA)	1.6-2.5GHZ	2-8GHZ	3 TO 300 GHZ
Data Capacity	2KBPS	10KBPS	384KBPS	200Mbps-TO-1GBPS	Higher than 1Gbps
Technology	Analog Wireless	Digital Wireless	Broadband/IP Technology, FDD,TDD	LTE, WIMAX	IPV6
Standard	AMPS	CDMA, TDMA, GSM	CDMA/WCDMA /UMTS/CDMA2000	IP-Broadband LAN/WAN /PAN	IP-Broadband LAN/ WAN/ PAN & WWW
Multiplexing	FDMA	CDMA, TDMA	CDMA	MC-CDMA, OFAM	CDMA , BDMA
Switching	Circuit	Circuit, packet	circuit, packet	Packet	all packet
Services	voice only	voice data	high speed voice/data/		
Main network	PSTN	PSTN	Packet network	Internal	Internet
Hand off	Horizontal	Horizontal	Horizontal	Horizontal and vertical	Horizontal and vertical
Core network	PSTN	PSTN	Packet N/w	Internet	Internet

[21] [22] [23] [24] [25] Source: Jain et al, (2014), Meraj and Kumar, (2015), Sharma, (2013), Gawas, (2015) Mondal, Sinha and Routh, J. (nd)

Note: Acronyms in use in Table 2 are explained in Appendix 1.

VI. Broadband Features

According to [4] Ma and Jia (2017), the IEEE 802.11 standard Wireless Local Area Network (WLAN), as well as the present third, fourth and fifth generations of cellular systems are the kinds of systems that are most commonly used in providing broadband access. The rise in broadband technology has led to high usage of the Internet. Hence users have leveraged on this to provide services that run on the internet to make free calls or calls at a cheaper rate compared to the traditional telephony system. This has led to over-the-top services (OTTs) which simply means services that are used over the network of service providers. OTTs are matters that are delivered over the internet without passing through several operator systems to regulate or scrutinize its content. The signals from OTT is received on devices like PC, phone, app, tablets as long as it is connected to a network or the internet Table 3 shows

the evolution of Wi-Fi technologies which are used for VoIP.

VII. BROAD VOICE ROUTER AND NETWORKING/BROADBAND VOIP

Broad Voice Router: This is used to connect the mobile devices to the internet. It is also used to support a wide range of frequencies. With the router, the best route for the data packets is chosen so that the packets can be received quickly. VoIP sends packets from one party to another through packet switched network. It calls for cautious management of resources. Circuit switch (CS) has been used in previous years for voice and packet switch (PS) for information. However VoIP is currently used to send packets of voice over the internet. Calls are being transmitted on first-come-first-served bases. With VoIP, calls can be made without a telephone set.

Table 3 Comparing TCP/IP, OSI Models and VoIP Protocols & functions

TCP/IP	OSI	Description	VoIP Protocols & functions
	Application Layer	Provides end-user applications	NetMeeting/Application
	Presentation Layer	Gives data transmission formats and codes	Codecs
	Session Layer	Supports telecommunications session	H.323/Media Gateway Control Protocol (MGCP)/SIP
Layer 4 Transport Layer	Transport Layer	Supports organization and data transfer between nodes on a network	Real-time Transport Protocol (RTP)/Transmission Control Protocol (TCP)/Use Datagram Protocol (UDP)
Layer 3 Internet Protocol	Network Layer	Gives routing and connection between network nodes	IP
Layer 2 Network Interface	Data Link layer	Supports accurate transmission of data within network	Frame Relay, ATM, Ethernet, Point-to-Point Protocol (PPP), Multilayer Perceptron (MLP) and more
Layer 1 Physical Layer	Physical Layer	Provides physical transmission of data using telecommunications media on the network	

[26] Source: Mundra and Taeib, (2015).

VIII. AN EVALUATION OF TCP VS UDP IN VOIP

[27] Wheeb (2015) is of the view that the transmission of information is achieved via the Internet Protocol (IP) using the User Datagram (UDP) or Transmission Control Protocol (TCP). However, when velocity is critical, TCP ensures reliability and UDP is not needed for error control. TCP has a higher segment overhead, uses more bandwidth and more packet overhead, which increases call setup times. Whereas UDP uses less bandwidth, reduces call setup time, is connectionless and depends on SIP to maintain reliability.

Table 4 Comparison of UDP and TCP

Features	UDP	TCP
Explanation	Straightforward High-speed low functionality that interface applications to the network layer.	Transport protocol that permits transmission of reliably data.
Protocol connection setup	Sending of less data	Connection-oriented.
Data interface to application	The application sends massages in packages.	The application sends massage in no particular structure.
Reliability and Acknowledgements	Delivery is unreliable and without acknowledgements	Delivery is reliable and with acknowledgements
Retransmissions	Lost data are not automatically retransmit except it is needed	Lost data is retransmitted automatically
Data flow features	None	Sliding windows control flow, congestion avoidance algorithms
Overhead	Low	Very Low
Transmission speed	High	Very High
Data quality suitability	Moderate amounts of data	Very large amounts of data
Sequence	Sequenced	Un-sequenced
Circuit	Virtual Circuit	Low overhead

Source: [27] Wheeb (2015).

IX CONCLUSION

This work is geared towards x-raying the different trends in communication from primitive age to the 21st century. This work shows how people over the years have tried to improve the ways they communicate and make use of the broadband technology offered by Internet providers to make calls at cheaper rate or at minimum cost especially when making distance calls by leveraging on Voice over the Internet technology offered by Over-The-Top service providers. The study recommends that more research should be done to improve call quality issues associated with VoIP calls which hinder customers from using it for voice call.

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Appendix 1

Abbreviations

AMPS`	-	Advanced Mobile Phone System
ATM	-	Asynchronous Transfer Mode
BDMA	-	Beam Division Multiple Access
CDMA	-	Code Division Multiple
FDD	-	Frequency Division Duplex
FDMA	-	Frequency Division Multiple Access
GBPS	-	Gigabit per Second
GSM	-	Global Service Mobile Communication
HSDPA	-	High Speed Downlink Packet Access
HSPA	-	High Speed Packet Access
HSUPA	-	High Speed Uplink Packet Access
IETF	-	Internet Engineering Task Force
IMTS	-	Improved Mobile Telephone System
IMTS	-	Improved Mobile telephone system
MGCP	-	Media Gateway Control Protocol
MIMO	-	Multiple Input/Multiple Output
MPLS	-	Multi-protocol Label Switching
OSI	-	Open Systems Interconnection
PAN	-	Private Area Network
PBX	-	Public Branch Exchange
PSTN	-	Public Switched Telephone Network
SIP	-	Session Initiation Protocol
TDD	-	Division Duplex
TDMA	-	Time Division Multiple
TCP	-	Transmission Control Protocol

UMTS System	-	Universal Mobile Telecommunications	WCDMA-		Wireless- Code Division Multiple Access
UDP	-	User Datagram Protocol	Wi-Fi	-	Wireless Fidelity
VoIP	-	Voice over IP	WLAN	-	Wireless Local Area Network
WFQ	-	Weighted Fair Queuing	WWW	-	World Wide Web
WAN	-	Wide Area Network			
WAP	-	Wireless Application Protocol			