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Review Article

Techniques for Enhancing Voice over Internet Protocol (VoIP) Quality of Service (QoS) Over Wireless LANs

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Abstract: The ground breaking impact of VoIP or IP Telephony in contemporary society's telecommunication is monumental, colossal, abysmal, enormous and massive. This work presents controversies, issues, and problems bordering on the deployment and management of voice over internet protocol (VoIP) quality of service (QoS) over wireless local area network (WLAN) and suggests very significant ways of addressing such issues. The methodology used in this work is quantitative. Review of related work was conducted through evaluation of scholarly works (books, journals, articles, etc.), of scholars in telecommunication VoIP raises a number of new possibilities to explore the telecommunication world. This exploration only requires a willingness to entertain new paradigms in telecommunication. Our commitment to growth in the telecommunication industry demands that we take this journey. Our homes and our businesses deserve nothing less.
Keywords: WLAN, LAN, QoS, VoIP.

INTRODUCTION

VoIP is an acronym for Voice over Internet Protocol. It is a cutting-edge technology that permits people to make calls over the Internet through Wireless Local Area Networks (WLANs). This means that, with a. high speed internet connection at home or office, one can get a phone service provided through the internet connection as an alternative of getting it through the local career (i.e. telecommunication companies such as MTN, GLO, AIRTEL, ETISALAT, etc). VoIP can be used both in the home, office and for business purposes. To access VoIP service, a user must connect to the internet via a WLAN.

VoIP can also be called Internet Telephony or IP Telephony. William, H. M. & Tim, K [1] stated that VoIP is a generic term that describing voice or fax carried over IP-based networks, such as the Internet. According to these scholars, the importance of IP telephony to include (1) In the short-term, it cuts the cost of calls, especially if routed over the public Internet (2). In the longer-term, telecoms carriers (telcos) are migrating their separate voice and data networks to converged IP-based networks. Their study revealed some examples of IP Telephony Service Providers to include Skype, Vonage, Net2Phone, BT, KPN, and Verizon. The study went further to explain the essential characteristics of VoIP to include: a disruptive technology, threatening traditional revenues from public voice services; it reduces costs dramatically for all services; it provides for the integration of services, i.e., convergence; it facilitates the application if IP services to a wide range of activities, e.g. E-commerce; and that its biggest users are incumbent telcos. The researchers restrain was that neither Quality of service (QoS) nor security can currently be controlled as reliably as on traditional POTS network services

The Emergence of VoIP over WLANs has witnessed the fastest evolution in World contemporary communication. WLAN is most promising technologies among wireless networks, which have smoothed high-rate voice services at very less cost and flexibility over IP-based networks as noted by Aad, *et al* [2]; Xiong, & Mao [3]; Zahedi & Pahlavan [4]; and Xiao [5]. The main source for such adaptation is that VoIP real-time application over WLANs is more flexible than traditional public switched telephone networks systems [6]. Also, VoIP can support multiple infrastructure environments IP-based-Phones, Soft-Phones and Traditional and mobile Phones.

VoIP provides mix mode communication with PC-to-PC, PC-to-IP-Phone and PC-to-Cell-Phone communication over WLANs. They are moving on campuses, hotels, airports, health care, commercial, education, and industries to provide voice traffic. WLAN also provide audio, voice and video conferences over IP-based networks [7, 8].

VoIP converts analog voice signals into digital data packets and supports real-time, two-way transmission of conversations using Internet Protocol (IP). VoIP calls are usually made on the Internet using a VoIP service provider and standard computer audio systems. Alternatively, some service providers support VoIP through ordinary telephones that use special adapters to connect to a home computer network. Many VoIP implementations are based on the H.323 technology standard and offers a substantial cost savings over traditional long distance telephone calls.

The main aim of this work is to survey the performance degradation issues in VoIP and how it can be improved upon for better service delivery. The study intend to achieve this aim by x-raying *deployment and performance issues and management of voice over internet protocol (VoIP) quality of service (QoS) over wireless local area network (WLAN), and suggests* ways of enhancing good QoS in VoIP calls over WLANs.

BACKGROUND ON WLAN

WLANs is a very familiar concept in networking. WLAN is an acronym for Wireless Local Area Networks.

A LAN is a computer network that span within a building or a small group of buildings. It usually connects computers, scanners, printers, for the purpose of sharing information and resources. Any communication network for connecting computers within a building or small group of buildings is called a Local Ares Network (LAN). A LAN may be configured as a bus topology, a ring topology, a star, topology or a mesh topology [9]. Even if only two computers are connected, they must follow rules, or protocols, to communicate. For example, one might signal ***"ready to send"*** and wait for the other to signal ***"ready to receive."*** When many computers share a network, the protocol might include a rule ***"talk only when it is your turn"*** or ***"do not talk when anyone else is talking."*** Protocols must also be designed to handle network errors.

When a wireless technology component (Router) is added to this LAN, so that computers don't need to be physically connected to share these information and resources (scanners, printers, etc.,) it becomes a WLAN. This addition of wireless technology component can be seen as upgrade to the LAN, which gives it additional capabilities to route packets even without being physically connected.

WLAN therefore, is a LAN that makes use of a wireless transmission medium such as microwave, infrared, etc. A WLAN does not make use of physical connection using cables. It can be classified as an unguided transmission model. Until relatively recently, WLAN implementation was quite erratic. The reasons for this included high costs, low data rates, occupational safety concerns, and licensing requirements. In recent times, these problems have been combated to a "*standstill*", the effect has manifested and it is ubiquitous in contemporary computing through the rapid development and growth of WLANs. In just the past few decades, WLANs have come to occupy a significant niche in the LANs. Increasingly, organisations are finding that WLANs are an indispensable adjunct to traditional wired LANs, to satisfy requirements for mobility, relocation, ad hoc networking, and coverage of locations that was difficult to wired LANs.

Bradley Mitchell [10] in his article entitled "WLAN" published in www.about.com, defined WLAN thus: WLAN provides wireless network communication over short distances using radio or infrared signals instead of traditional network cabling. A WLAN typically extends an existing wired area network. WLANs are built by attaching a device called the Access Point (AP) to the edge of the wired network. Clients communicate with the AP using a wireless network adapter similar in function to a traditional Ethernet adapter.

Pahlava, *et al.* [11] posits that "wireless LAN has four areas of application, namely, LAN extension, cross building interconnect, nomadic access and ad hoc networks". It is not in the scope of this study to provide an elaborate discussion on the application of WLANs.

Network security remains an important issue for WLANs. Random Access clients must usually be prohibited from joining the WLAN. Technologies like WEP raise the level of security on wireless networks to rival that of traditional wired networks.

On the requirements of WLAN, William, [12], said that A WLAN must satisfy certain conditions typical of any LAN. It has the same set of requirements as the wired LAN. These requirements include ability to cover short distances, broadcast capability, full connectivity among attached stations and high capacity. Again, there are a number of specific requirement for a wireless LAN environment that a wireless LAN must as a matter of standard, meet. These include: Transmission robustness and security; throughput; collated network operation; number of nodes; connection to backbone LAN; service area; battery power consumption; dynamic host configuration; handoff/roaming and licence-free operation".

In the past decades, an emerging technology called VoIP or IP telephony (where phone calls are made over the internet using and IP phones and a strong and reliable internet connection) has taken advantage of the WLANs to provide telephone services to clients. This technology is gradually taking over the PSTN. But one major problem of this technology is quality of service provided by the technology. Though quality of service is a very crucial issue even with the traditional PSTN, our major concern in this work is performance degradation of VoIP, that is, quality of service as it concerns VoIP.

WLAN Standards, Architectures and Technologies: An Appraisal

Generally, the entire WLAN concepts is basically categorised according to their transmission techniques. There fall into the following categories: Infrared (IR) LANs, Speed spectrum LANs and narrowband microwave. There is also what we call network gears, which are new technologies in the WLAN architectures. At this point, the study takes a critical looks on WLAN architectures.

IEEE 802.11

In 1997, the Institute of Electrical and Electronics Engineers (IEEE) created the first WLAN standard. They called it *802.11* after the name of the group formed to oversee its development. *802.11* is the generic name of a family of standards for wireless networking related to Wi-Fi. The numbering system for 802.11 comes from the IEEE, who uses "802" to designate many computer networking standards including Ethernet (802.3). 802.11 standards define rules for communication on WLANs. Each extension to the original 802.11 appends a unique letter to the end of the name. While 802.11g and 802.11n are the most interesting to the average consumer, many other extensions exist or are under development. Popular 802.11 standards include 802.11a, 802.11g, and 802.11n. 802.11 (with no letter suffix) was the original standard in this family, ratified in 1997. 802.11 defined WLANs that operate at ***a bandwidth of 1-2 Mbps.*** Unfortunately, 802.11 only supported a maximum ***network bandwidth of 2 Mbps*** - too slow for most applications. For this reason, ordinary 802.11 wireless products are no longer manufactured, the standard is obsolete today.

IEEE 802.11a

While 802.11b was in development, IEEE created a second extension to the original 802.11 standard called *802.11a*. Because 802.11b gained in popularity much faster than did 802.11a, some folks believe that 802.11a was created after 802.11b. In fact, 802.11a was created at the same time. Due to its higher cost, 802.11a is usually found on business networks whereas 802.11b better serves the home market. It supports ***bandwidth up to 54Mbps*** and signals in a regulated ***frequency spectrum around 5GHz***. This higher frequency compared to 802.11b shortens the range of 802.11a networks. The higher frequency also means 802.11a signals have more difficulty penetrating walls and other obstructions. Because 802.11a and 802.11b utilize different frequencies, the two technologies are incompatible with each other. Some vendors offer hybrid *802.11a/b* network gear, but these products merely implement the two standards side by side (each connected devices must use one or the other).

The strengths of 802.11a are: fast maximum speed; regulated frequencies prevent signal interference from other devices and its w**eaknesses are:** highest cost; shorter range signal that is more easily obstructed

IEEE 802.11b

IEEE expanded on the original 802.11 standard in July 1999, creating the *802.11b* specification. 802.11b supports ***bandwidth up to 11Mbps***, comparable to traditional Ethernet. It uses the same *unregulated* radio ***signalling frequency (2.4GHz)*** as the original 802.11 standard. Vendors often prefer using these frequencies to lower their production costs. Being unregulated, 802.11b gear can incur interference from microwave ovens, cordless phones, and other appliances using the same 2.4 GHz range. However, by installing 802.11b gear a reasonable distance from other appliances, interference can easily be avoided.

The Strengths **of 802.11b** are: lowest cost; signal range is good and not easily obstructed. The weaknesses are: slowest maximum speed; home appliances may interfere on the unregulated frequency band.

IEEE 802.11g

In 2002 and 2003, WLAN products supporting a newer standard called *802.11g*emerged on the market. 802.11g attempts to combine the best of both 802.11a and 802.11b. 802.11g supports ***bandwidth up to 54Mbps,*** and it uses the ***2.4Ghz frequency*** for greater range. 802.11g is backwards compatible with 802.11b, meaning that 802.11g access points will work with 802.11b wireless network adapters and vice versa.

The strengths of 802.11g are: fast maximum speed; signal range is good and not easily obstructed and its weaknesses are: costs more than 802.11b; appliances may interfere on the unregulated signal frequency

IEEE 802.11n

802.11n (also sometimes known as "Wireless N") was designed to improve on 802.11g in the amount of bandwidth supported by utilizing multiple wireless signals and antennas (called *MIMO* technology) instead of one. Industry standards groups ratified 802.11n in 2009 with specifications providing for up to ***300Mbps of network bandwidth.***802.11n also offers somewhat better range over earlier Wi-Fi standards due to its increased signal intensity, and it is backward-compatible with 802.11b/g gear.

The strengths of 802.11n are: fastest maximum speed and best signal range; more resistant to signal interference from outside sources and its weaknesses are: standard is not yet finalized; costs more than 802.11g; the use of multiple signals may greatly interfere with nearby 802.11b/g based networks.

IEEE 802.11ac

The newest generation of Wi-Fi signalling in popular use, 802.11ac utilizes dual band wireless technology, supporting simultaneous connections on both the 2.4GHz and 5GHz Wi-Fi bands. 802.11ac offers backward compatibility to 802.11b/g/n and ***bandwidth rated up to 1300 Mbps*** on the ***5GHz*** band plus up to ***450Mbps on 2.4GHz***.Itis a next-generation standard for Wi-Fi wireless networking that extends the previous generation 802.11n standard. Counting back to the little-known original version of 802.11 defined back in 1997, 802.11ac represents the 5th generation of Wi-Fi technology.

Nadeem, [13] in his article titled "Comparing the Suitability of LTE, WiMAX, 3G, Wi-Fi and GSM for Mobile VoIP" was of the view that VoIP is the best alternatives for making cheap international calls. He made his position clear in the following lines:

Mobile VoIP is imposing itself as a means of making phone calls for much cheaper than what it actually costs over GSM and roaming networks. The benefits of mobile VoIP are even more pronounced when the calls are made to international destinations. But which of the existing wireless network standards is best suited for making phone calls for free and cheap, using VoIP technology, on one's mobile device?...While there are, among the existing mobile standards, some best suited than others, the answer to which is best depends greatly on a number of factors, including commercial support, manufacturer adoption and simply the place where the calls are placed. But the most important consideration is how much it allows you to really save on the calls.

Nadeem, U. [14] went further to compare the suitability of the various wireless technologies (the LTE, WiMAX, 3G, Wi-Fi and GSM wireless standards) for cheap VoIP calls in the light of their cost benefits, accessibility, hardware support and speed.

GSM (General Services for Mobile Communication)

GSM (the standard for cellular networks) isn't really the type of standard for VoIP. In fact, VoIP services tend to provide products that allow mobile communicators to rid themselves of the high GSM call costs. There are however a handful of VoIP services that work through a SIM card – the first and last parts of a call are channelled over GSM networks and the rest on IP networks and the Internet. GSM enjoys the advantage of nearly full coverage and that of network and hardware support. You can have GSM signals nearly anywhere under the sky with even the cheapest of mobile phones. But since the network isn't primarily IP-based, it is not for VoIP.

Wi-Fi (WIRELESS FIDELITY)

Wi-Fi would be nearly perfect had it not had the coverage limitation. It offers tremendous speed and has reasonable hardware support on laptops, handhelds and mobile devices, but it just cannot reach far enough. In a Wi-Fi hotspot, you can't get the signal beyond a dozen meters or two. Wi-Fi is free, that is, once you invest on the Wi-Fi-enabled hardware and a router for the hotspot, you use the service with your ADSL line. Thus, you could use VoIP and make free or very cheap local or international phone calls on your mobile device using the Wi-Fi connection, with good call quality. But while being wireless, Wi-Fi isn't really mobile, as it drops you once you move away from home or the office.

The popularity of Wi-Fi has grown steadily. Wi-Fi allows local area networks (LANs) to operate without cables and wiring, making it a popular choice for home and business networks. Wi-Fi can also be used to provide wireless broadband Internet access for many modern devices, such as laptops, cellular phones, PDAs, and electronic gaming consoles. Wireless-enabled devices are able to connect to the Internet when they are near areas that have Wi-Fi access, called "hot spots." Hot spots have become common, with many public places such as airports, hotels, bookstores, and coffee shops offering Wi-Fi access [15].

3G (Third Generation)

3G came as the champion of mobility, at a time when being connected to the Internet and being able to communicate over IP networks anywhere under the sky were still features of sci-fi movies. 3G offers the possibility of remaining connected through your mobile device on the road, at the seaside, in the bus, in the car, at school, you name the place.

In certain regions and for certain 3G service providers, coverage could be a problem in certain remote areas, but with the increased number of antennas, 3G coverage isn't a big problem. 3G bandwidth, while not giving lightning speed, isn't bad. With 384 Kbps, you can talk, chat, check email, and even video-conference and watch TV on your mobile phone or smart phone. However, with the growing number of users over 3G networks, saturation will start being an issue in the near future.

The true problem with 3G is its cost. First, you need to have the hardware, which is a non-negligible upfront investment. Take the iPad as example and compare the price between the 3G version and the non-3G one. There is as such no unlimited plan for 3G. You have flat rates that are expensive, with a traffic threshold. Once this threshold is passed, each megabyte of data can cost the eyes of the head.3G is therefore not interesting for making VoIP calls, because, added to the call cost, there is the cost of the 3G data plan. Unless you already are using 3G on your mobile device for other purposes, or unless you are a heavy VoIP-communicator, VoIP over 3G isn't going to make you save a lot. The discussion on VoIP over 3G goes on there.

WiMAX

And then came WiMAX, a 4G wireless standard. It could be described as the WAN version of Wi-Fi. It offers wireless connectivity over large areas, with the convenience of Wi-Fi and the coverage of 3G, but without the financial weight of the latter. With WiMAX, you can have a flat rate without threshold, so the price is much better than with 3G. However, WiMAX suffers lack of support, both in terms of network deployment and device compatibility. There aren't enough WiMAX service providers to make the technology that successful, and there are very few mobile devices equipped with WiMAX support. As a result, many believe in the technology for boosting VoIP benefits on mobile phone calls, as do I, but all are waiting for its maturity and global support.

LTE

LTE comes as an unexpected but pleasant guest. It is an improvement over WiMAX and 3G. It gives peak download rates of 100 Mbps and half that amount for upload. It also offers an improvement on latency. One of the most interesting things about LTE is that, it is capable of working on existing technology. This will give it a high penetrating power, higher than that of 3G, WiMAX and Wi-Fi, which all suffer from restricted hardware deployment. At the time I am writing this, LTE is still in its early stages of development. A handful of leading service providers have invested on it, which is an indication of sure support and popularity.

VoIP QoS Over WLANs

QoS is defined as an instrument for resource reservation and control, which has ability to differentiate this data into different types and also rank each type of data according to network requirement.

Nadeem, U. [16] in his work "VoIP Cons - VoIP Problems and Pitfalls", defined Quality of Service (QoS) in VoIP as "the level of 'quality' obtainable from the VoIP service to make calls conveniently without interference". (http://voip.about.com/od/voipbasics/a/voipproblems.htm). This culminates to mean that, users can only say that the QoS for VoIP is good if they can make voice calls without suffering from interference, delays, weird sounds, noise and echo. VoIP QoS depends on so many factors: viz broadband connection, your hardware, the service provided by your provider, the destination of your call etc.

QoS addresses several real-life problems with VoIP which include traffic shaping (high bandwidth applications which hog shared bandwidth can be controlled/limited), Avoiding Congestion (implement heuristic algorithms such as Weighted Random Early Detection (WRED) (where the packet Queue is dynamically adjusted by analysing traffic priority and allocating more space for higher priority packets) and similar. Proper QoS management is critical for deployment of VoIP in large scale networks where first hop bandwidth is restricted, such as modern deployments of 3GPP cellular networks.

In our contemporary society, quality of service is a much talked about problem space for data communication and networks, internet telephony, manufacturing industries, health care delivery, etc. Every part of the economy tries to enforce compliance to quality of service. Quality of service in VoIP or put simply, quality of service in internet telephony is not left out.

Furthermore, upsurge in the popularity of mobile telecommunication devices such as laptops, IP phones or VoIP phones, PDA, etc, have started a new era of improved wireless communication. WLANs are acting as very good supporting agents for easy communication between these devices. The key points of this technology are its simplicity, cost effectiveness and flexibility. In other words IEEE 802.11 protocol has taken wireless communication at new level. Because of the ever increasing popularity and commercial success of IEEE 802.11, considerations of multimedia traffic over WLANs have accelerated in past few years. The most vital among them is VoIP.

Currently IEEE 802.11b, IEEE 802.11g, and IEEE 802.11b are the most commonly used protocol in many different environments such as university campuses, homes, churches, schools, and offices. IEEE 802.11b/g standard treats all heterogeneous traffics such as data, voice, and video in an identical manner. This equal treatment, become obstacle for guaranteed service for voice over WLANs. IEEE 802.11e working group has tried to overcome this problem by suggesting new standard in form of IEEE 802.11e. IEEE 802.11e is an approved amendment to the IEEE 802.11, which focuses on quality of service improvements for WLANs through reforms in Media Access Control Layer.

The main disadvantage of VoIP is a superior potential for dropped calls and degraded voice quality when the underlying network links are over loaded. As we know, performance degradation in computer networking is a function of QoS in every system. QoS have manifold limitations. These limitations are ubiquitous from, implementation to deployment, and even when the VoIP becomes operational. The introduction of WiFi related technologies for the first hop access for VoIP phones, noise and interference become momentous issues that can cause serious degradation to the overall user experience and proper QoS allocation schemes can help reduce these problems.

The number of VoIP calls that existing VoWLAN products can support on an IEEE 802.11 WLAN channel is disappointingly small [17, 18], because of lack of QoS support and unproductive WLAN frame transmission.

In this work, I will analyze QoS on the basis of delay, throughput, jitter, packet loss, and availability bearing in mind that, the existing data obtainable from networks are heterogeneous in its nature.

Delay: When a packet takes more than expected time to reach their destination, it causes disruption in quality of service for traffic. This difference between the expected time to reach the destination and actual time required to reach destination is called Delay. Various components of delay are: queuing delay; packetization delay; and propagation delay.

Throughput: It is the rate at which a network can send or receive data successfully through a channel. In this project we have calculated throughput in terms of packet/seconds.

Jitter: It is not necessary that the packet delay will remain same throughout the packet transmission from source to destination. Jitter is basically a difference between two consecutive delays. It is the variation between packets arriving time caused by network congestion, changes in route direction etc.

Packet Loss: Due to network conditions, collisions in network causes number packets getting dropped before reaching their final destination. This is known as packet loss. It is a ratio of number of packets being dropped and total number of packets transmitted.

Availability: It is the time for which the network is available for communication or data transmission.

In this light, I have segregated QoS in two parts:

1) QoS within a WLAN [Between voice, data, video stations and Access Point]

2) End to End QoS [RSVP, SIP/SDP, H323]

Problems of VoIP QoS Over WLANs

VoIP is replete with several issues. A cursory glance reveals problems like jitter, poor internet connection, bad configuration, inadequate routers, latency, propagation delay, queuing delay, handling delay, etc. I wish to further discuss them in the preceding section.

The Jitter Problem

Behrouh, A. Forouzan [19] defined Jitter as the variation in the packet arrival time. He went further to elaborate that it is the uneven delay in the delivery of audio or video packets. He cited an example, using video packets. If video packets are sent every 3Dms, and some of the packets arrive with 3D-ms delay and others with 4D-ms delay, an uneven quality in the video is the result.

Jitter is a common problem of the connectionless networks or packet switched networks. Because the information (voice packets) is divided into packets, each packet can travel by a different path from the sender to the receiver. When packets arrive at their intended destination in a different order than they were originally sent, the result is a call with poor or scrambled audio. Jitter is technically the measure of the variability over time of the latency across a network. Jitter is one of the most common VoIP call quality problems.

The Latency or Delay Problem

Behrouh A. F. [19] defines latency or delay as how long it takes an entire message to completely arrive at the destination from the time the first bit is sent out from the source. We can say that latency is made of four components: propagation time, transmission time, queuing time and processing delay. This can be represented thus:

L = PT + TT + QT + PD
Where L = Latency
PT = Propagation Time
TT = Transmission Time
PD = Processing Delay
QT = Queuing time

VoIP delay or latency is characterized as the amount of time it takes for speech to exit the speaker's mouth and reach the listener's ear. Latency sounds like an echo. There are 3 types of delay commonly found in today's VoIP networks:

a. Propagation Delay

Light travels through a vacuum at a speed of 186,000 miles per second, and electrons travel through copper or fiber at approximately 125, 000 miles per second. A fiber network stretching halfway around the world (13, 000 miles) induces a one-way delay of about 70 milliseconds (70ms). Although this delay is almost imperceptible to the human ear, propagation delays in conjunction with handling delays can cause noticeable speech degradation.

b. Handling Delay

Devices that forward the frame through the network causes handling delay. Handling delays can impact traditional phone networks, but these delays are a larger issue in packetized environments.

c. Queuing Delay

When packets are held in a queue because of congestion on an outbound interface, the result is queuing delay. Queuing delay occurs when more packets are sent out than the interface can handle at a given interval.

The Problem of Poor Internet Connection

In the market today, we have many Internet Service Providers (ISPs). Originally, many of them were not designed for VoIP benefits, but were designed with a specific objective of surfing the web. Furthermore, most clients are not aware that conveying voice packets is different and requires an additional set of internet protocols that your ISP may not be providing.

The Problem of Inadequate Routers

The internet is a collection of different networks and millions of routers are connected together. A router is a three-layer device that routes packets based on their logical addresses (host-to-host addressing). A router normally connects LANs and WANs in the Internet and has a routing table that is used for making decisions about the route. The routing tables are normally dynamic and are updated using routing protocols. In very large networks, very good and high speed routers are required. When routers are bad, network suffers.

The Problem of Internal Network Improperly Configured

VoIP is less than 10-years old. Many companies do not consider the higher quality demands of VoIP communications. If your company decides to route both voice and data over the same network without properly configuring your network for VoIP traffic, you can expect to have call quality issues.

The Problem of Service Set

A crucial decision facing IP network deployment is the service set and design to be supported, which can be either minimal set, full scale PSTN equivalence or advance services for operators and carriers wishing to replace their current infrastructure with a new converged network for all subscribers.

The Problem of Security

PSTN became resistant to security attacks with the advent of SS7 out-of-band signalling. IP nets are more susceptible to attacks to address 3-issues:

a. Invasion of Privacy - Callers in VoIP expect calls are private with no third party eavesdrop. VoIP achieves this via a physical security mechanism (wire from a user's home is only connected to local exchange or digital loop carrier and cannot easily accessed). Whereas, IP network uses different encryption measure to cater for such security issues via its cable/wireless media. E.gA5 cipher used in GSM or CDMA.

b. Denial of Services attack prevents a legitimate user access to the network feats and services. Though rare and extremely difficult in VoIP; But, are common in IP networks. Example includes sending false signalling message so that a call agent is fooled and bombarded with pings from a soft phone or other packets so frequently that it has no spare processing power to process legitimate request. A consequence of this is that sometimes, the soft-phone(s) can no longer pull data from the IP network. Also, hacking a subscriber gateway to send ftp or other data traffic as high priority voice traffic.

c. Theft of Service – is aimed at Service Providers, where the attacker simply wants to use a service without paying for it. Its most common form in PSTN is called subscriber fraud – where a user sets up an account with a service provider (SP) using false billing data such as stolen credit card. Other forms are more technical that utilizes black boxes or similar to fool the network into providing free service. With VoIP, bandwidth is still a limited resource even with low packet loss and jitters required for good voice quality.

FINDINGS, DISCUSSIONS AND RECOMMENDED TECHNIQUES FOR RESOLVING VOIP QOS OVER WLANS

In solving the jitter problem, a Jitter buffer must be introduced to the entire VoIP system. The function of this jitter buffer is to momentarily stores arriving packets in order to minimize delay variations. If packets arrive too late then they are discarded. This solution is supported by Haniyeh *et al* [20].

The solution to latency and delay problem is prioritizing VoIP traffic over the network. This technique yields latency and jitter improvements. There are a lot of other techniques but I will like to mention a few: Multi-Protocol Label Switching (MPLS), bandwidth reservation, Policy based network management, Type of Service, and Class of Service, are all widely used techniques for prioritizing VoIP traffic. A quality VoIP router can solve many of these issues and will result in business quality VoIP phone service.

The solution to poor internet connection is to get a business class high speed. Fortunately, most of the ISP's, including cable and DSL high speed internet providers offer business class high speed internet service that is acceptable.

The solution to the problem of inadequate router is to install a specialized VoIP Router. Inadequate specialised VoIP routers is one of the most common causes of call quality issues. Many small businesses use their internet connection for both voice and data. This is perfectly fine as long as your router has the ability to prioritize VoIP traffic. Without a router that is configured for packet prioritization, call quality can be impacted by the other users on your network. For example, if during a call, another user on your network downloads a large file, without packet prioritization, your call quality could be degraded. A VoIP router prevents this from happening by giving priority to voice traffic on your network.

The Solution to Network Configuration is just to get a business VoIP capable router that is properly configured. It will generally solve the problem. By all standards, this is one of the easiest and least expensive problems to correct.

The Solution to Security Problem is to enforce security strategies such as encryption, to prevent the various form of data modification, repudiation and theft. Example, A5 cipher. This is supported by Behrouh [19].

Anand *et al* [21] in their experiments discovered two methods of enhancing VoIP QoS over WLANs. These methods are: VoIP packet aggregation and header compression. The basic idea of aggregation is to combine together several small packets that arrive at the ingress node and forward them with one IP, MAC, and physical (PHY) header across the air. Because 802.11 networks incur a high overhead to transfer one packet, therefore small sizes of packets reduce the network utilization. Applying VoIP packet aggregation can significantly reduce the overhead and increase the number of supported calls. This method still have issues in mesh networks. They proposed the *accretion aggregation algorithm a (hybrid of the two naïve algorithms used in aggregation) which* provides low delay variation, and larger aggregation packets.

Header Compression is a complementary scheme related to aggregation and also, packet headers with redundancy may be reduced through compression techniques as has been done with great success for cRTP or ROHC. The usage for header compression is motivated by the fact that:

1) the VoIP payload is typically compressed at the application layer, which means another compression does not help reduce the payload size;
2) the headers occupies a large portion of the packet; and
3) the headers have significant redundancy.

They further explained that the compressor and the decompressor as a matter of standard, operate in synchronization, either implicitly (optimistic mode) or explicitly (acknowledged mode). In addition to the compression logic, they propose *zero-length header compression* (ZHC) algorithm for redundant header elimination algorithm that leverages the VoIP packet aggregation mechanism. It is to be noted that ZHC does not require context synchronization between two nodes. The compressed headers from the compressor are needed to restore the original packet headers from them, as the index, at the decompressor. However, if the header compression method is used with the aggregation mechanism, there is no need of the headers from the second packet until the last packet, with the fresh header of the first packet from the same flow. The decompressor has enough information to restore all headers from the first fresh header, which does not depend on synchronization of the compressor/decompressor. Loss of one aggregation packet is isolated to packets lost in aggregation packet without requiring any extra information to restore the decompression.

CONCLUSION

The Latin maxim “QUIDQUID INITIUM HABET FINEM HABET” means “WHATEVER HAS A BEGINNING HAS AN END”. This work is in its concluding stage.

We assume the internet to be the *“information super highway”*, yet the voice that is supposed to flow, free of interference and encumbrances still suffer, even with cutting-edge technologies that have been implemented on the internet over the years. In this work, I have suggested measures that will solve the problem of interference of information, whether deliberately or as a result of poor equipment or poor configurations.

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