VoIP over WMN: Effect of packet aggregation

Khyati Marwah *(Author)*
Department of CSE & IT
B.B.S.B Engineering College
Fatehgarh Sahib, Punjab, India

Dr. Gurpal Singh *(Author)*
Department of CSE & IT
B.B.S.B Engineering College
Fatehgarh Sahib, Punjab, India

***Abstract*-VoIP services are getting more and more popular day by day. In order to meet the users demand for such services irrespective of users location requires wide area wireless coverage .To this extent, wireless mesh networks have been considered as practical and inexpensive solution .In order to improve the performance of VoIP services, techniques like packet aggregation are done . This paper focuses on finding the effect of packet aggregation on various parameters like aggregation delay, end to end delay and MOS etc. Results obtained through simulations done on Qualnet Simulator concludes that packet aggregation is justified upto a certain extent only as after that most of the users get dissatisfied.**

Keywords: WMN, VOIP, Aggregation Delay, end to End delay, MOS,R-Score, E-Model, Qualnet

I INTRODUCTION

Internet telephony or voice over Internet Protocol (VoIP) has emerged as an important application over Internet .But the wireless VOIP services like Skype requires ubiquitous WLAN coverage. IEEE 802.11 s based wireless mesh networks (WMN) caters this need of VoIP applications very well. WMN is an advanced form of wireless network in which every node is connected to other nodes on the network through hops. Some are connected through single hops and some may be connected with more than one hop. In a Wireless local Area Network (WLAN),the access point has to be wired to the infrastructure thus providing limited range of connectivity. Where as in case of WMN, the access points can be connected to the rest of network by wireless radio links .Moreover, WMN's are relatively cheaper and provide better data transfer rates than WLAN.
Basically wireless mesh network consist of two types of nodes:-

- Wireless mesh routers(MR): They provide strong switching ability, minimum mobility and ignorable battery restriction. They also form the mesh backbone
- Wireless mesh clients(MC): They could be designed with light architecture with the support for simplest routing ability and light-weighed communication protocols

This paper is organized into eight different sections. Section 2 discusses VOIP over WMN. Section 3 describes related work. Section 4 describes problem formulation and section 5 explains the proposed approach to the problem. Testbed Deployment and corresponding results have been shown in section 6 and section 7 respectively. Section 8 concludes the work.

II VOIP over WMN:

A typical VoIP application works as follows. First, a voice signal is sampled, digitized, and encoded using a given algorithm/ coder. The encoded data (called frames) is packetized and transmitted using Real Time Transport Protocol(RTP)/User Datagram Protocol(UDP)/Internet protocol(IP). At the receiver's side, data is de-packetized and forwarded to a playout buffer, which smoothes out the delay incurred in the network. Finally, the data is decoded and the voice signal is reconstructed. The quality of a VoIP [9] call is impacted by several parameters such as end to end delay, delay jitter, packet loss and so on. These parameters are determined by the performance of Codecs, echo control, buffering and network protocol. There are several technologies [17] like packet loss concealment ,silence suppression and frame aggregation which can be applied to VoIP calls to improve their performance in a communication network . Performance optimization of VOIP can also be done by Use of Dual Queue to give priority to VOIP, Packet Aggregation to increase Capacity, Header Compression, and Label Based Forwarding etc.

The quality of the reconstructed voice signal is subjective and therefore is measured by the mean opinion score (MOS). MOS is a subjective quality score that ranges from 1 (worst) to 5 (best) and is obtained by conducting subjective surveys. The MOS is generated by averaging the results of a set of standard, subjective tests where a number of listeners rate the heard audio quality. ITU-T G.107 [21] defines E-Model, a transmission planning tool which can assess the combined effect of varying transmission parameters on the voice quality. It defines R-factor (transmission rating factor) which depends on mouth to ear delay, loss rate and type of encoder. The R-factor [9] ranges from 0 to 100 and a score of more than 70 usually means a VoIP stream of decent quality. The output of E-model [8] is defined as follows:

$$R = Ro - Is - Id - Ie + A$$

where

Ro represents the basic signal-to-noise ratio,

Is represents the impairments occurring simultaneously with the voice signal,

Id represents the impairments caused by delay,

Ie represents the impairments caused by low bit rate voice coders. It also includes impairment due to packet losses of random distribution.

A is an advantage factor than can be used for some compensation

III RELATED WORK

In recent years, many researchers have done research on wireless mesh networks. Till date few research works has been also carried out to investigate the effect of VOIP over wireless Mesh Networks. Following are the various articles highlighting research on various facts on WMN and voice in Wireless Mesh Network.

According to [1], WMN can be considered as a type of wireless ad-hoc network because nodes can automatically establish network and maintain the connectivity in an ad-hoc manner. In addition, the WMN can also be dynamically self-organized and self-configured.

According to [2], Wireless Mesh Network is based on low cost commodity hardware and has a great potential for public safety and disaster recovery applications. The key characteristics of WMNs like robustness, fault tolerance along with the rapid deployment and self-configuration capability are crucial features for PSDR communications.

In [3], Testbed for the deployment of a real wireless multi-hop network utilizing WMN technology based on Microsoft MCL has been created .Various experiments are performed to access the functioning of testbed and to evaluate the performance of heterogeneous flows over it. Experiments say that time to download the file increase linearly with the number of hops the flow has to traverse.

In [4] ,an initial variant of a 802.11s simulation model for the QualNet simulator is described. The tool builds on the existing QualNet 802.11 model by adding capabilities suitable for mesh networking.

In [5], an IEEE 802.11-based wireless mesh network testbed was developed in order to evaluate the performance of wireless mesh networks in a real environment. A multimedia service test using a multimedia application is performed. It supports many audio and video codecs, and is interoperable with other SIP compliant software and Microsoft NetMeeting.

In [6] Ye Yan, HuaCai and Seung-Woo Seo worked on analytical traceable stochastic models to characterize the average delay and throughput performance in wireless mesh Network. The analytical model takes into account the mesh router density, the random packet arrival process, the degree of locality of traffic and the collision avoidance mechanism of the IEEE802.11.

According to the work in [7] Security is the vital problem in the design of Wireless Mesh Network. Appropriate measures should be taken to avoid security threats. Various possible attack types which can affect networks are Tempering, Pretending, Forging, Resource depletion attack, wormhole attack, black hole attack and Rushing attack.

The article in [8] presents a voice quality measurement tool based on the ITU-T E-Model. Some methods for measuring voice not only takes in account transport delay and network packet loss, but also considers the voice application characteristics, like the codec quality, codec robustness against packet loss. The resulting score is the transmission rating factor(R-factor), a scalar measure that ranges from 0 (poor) to 100 (excellent). *R* factor values below 60 are not recommended.

According to [9], the R factor is related to Mean Opinion Score (MOS) as follows

R-Value	MOS	User satisfaction
90	4.34	Very satisfied
80	4.03	satisfied
70	3.60	Some users dissatisfied
60	3.10	Many users dissatisfied
50	2.58	Nearly all dissatisfied

Table1:Relation of R-factor to MOS

In [10], S. Ganguly proposed various techniques like packet Aggregation, Header Compression and Label Based Forwarding to enhance the performance of voice .Also S.Ganguly has given various Performance Metrics.

In [11], H. Y. Wei, K. Kim, A. Kashyap and S. Ganguly measured the quality of a call,using a metric which takes into account mouth to ear delay, loss rate, and the type of the encoder. Quality is defined by the R score, which should provide a value above 70, for medium quality in wireless mesh network.

Literature survey reveals that still there is lot of scope for further investigations in various aspects of voice over Wireless Mesh Network.

IV PROBLEM FORMULATION

Research on investigating the performance of VoIP over WMN is not all and many challenging issues in this area remains to be resolved .VoIP packets are usually very small in size .The packets generates a constant bit rate with size of packet and packet rate governed by CODEC. For example ,G.729 a popular voice encoder sends 50 packets per second of 20 bytes each .Small sizes of packets reduce the network utilization causing high overhead as most of the time spent by the 802.11 MAC is for sending headers and acknowledgments, waiting for separation of DIFS and SIFS, and contending for the medium. If the packets are sent over the network one by one then the protocol overhead will waste a large percentage of bandwidth . In order to increase data throughput, number of packets sharing a single header can be aggregated.

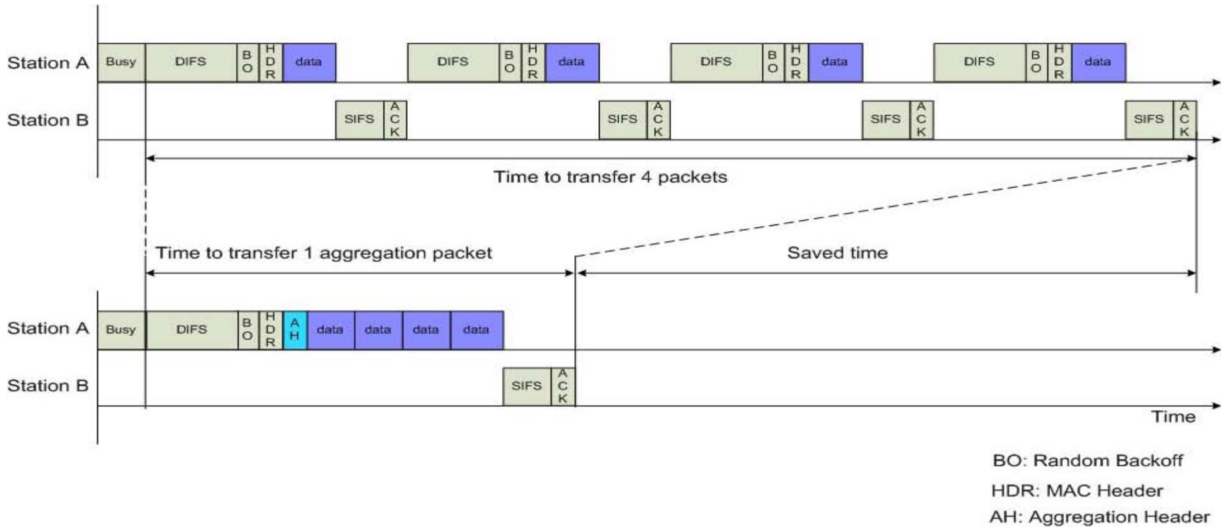

Fig 1. Packet Aggregation

Aggregation Delay

In case of packet aggregation, the terminal does not attempt to transmit packet immediately upon its arrival, thus aggregation delay is the waiting time of first arrival packet staying in the buffer. This aggregation delay can be a disadvantage for time critical VOIP packets. If not checked, it can further degrade the voice quality

However, the literature survey reveals that little work has been done in this direction. This provided motivation for the current work as it is worth investigating the effect of packet aggregation on various parameters affecting the voice quality like end to end delay, aggregation delay and R-Score

V PROPOSED METHOD

To analyze the effect of packet aggregation in case of VOIP traffic over 802.11s based Wireless Mesh Network, simulations based on the well known QualNet Simulator will be used. QualNet [4] provides a comprehensive environment for designing protocols, creating and animating experiments, and analyzing the results of those experiments. The simulations will help us to find the effect of packet aggregation on End to End delay and MOS .

In this work,we also propose an extension to the E-Model by including the parameter A_d (aggregation delay)that represent impairments due to aggregation in the equation of R-factor.

$R = Ro - Is - Id - Ie + A - \mathbf{A_d}$

Arriving packets are stored in infinite buffer until they are transmitted to destined peer Let n denote the threshold of the number of packets to be aggregated ,the terminal will transmit when it has at least n packets in the buffer. Thus the aggregation delay [22] is the waiting time of the first arrival packet staying in the buffer and is given by

$A_d = 0$ when $n=1$……………………………………………………………………[22]

$A_d = \tau \lceil \{(n-1) / \lambda\tau\} \rceil$ when $n \geq 2$……………………………………………………………………[22]

Where

λ is the packet arrival rate per time τ

τ is the frame period and it includes one uplink subframe and downlink subframe

n is the number of packets to be aggregated

$\lceil\ \rceil$ is the ceiling function

Thus the current work will help us to find effect of packet aggregation on various parameters like End to End delay, Aggregation Delay, and MOS analytically and experimentally

VI TESTBED DEPLOYMENT

This section describes the experimental testbed that has been set up to evaluate the effect of packet aggregation on end to end delay and R-Score in case of VOIP traffic over Wireless Mesh Network. WMN test bed has been developed using Qualnet simulator. Qualnet has several core components as well as add-on-components. It is state of art simulator for large ,heterogeneous networks and the distributed applications that execute on that. To implement the 802.11s based WMN functionalities, we have created 2 Mesh Points(MP), 2 Mesh Access Points(MAP), 4Mesh Clients as shown in figure 2.

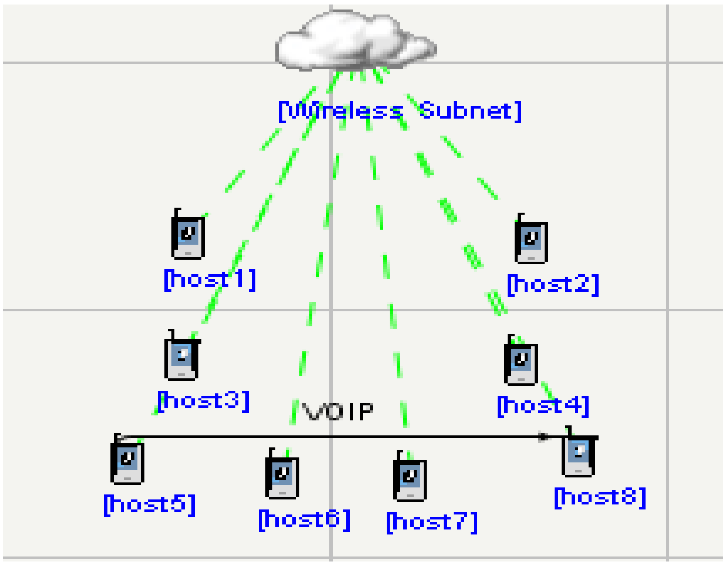

Fig-2:Simulation scenario

All MPs and MAPs have been connected in adhoc mode, whereas Mesh clients are connected to mesh access points in infrastructure mode. In this scenario, we are sending the VoIP traffic from node 5 to node 8. To send a 10 byte VoIP payload, a 50 byte packet is assembled from 20 bytes IP header, 12 bytes RTP header, and 8 bytes UDP header. Here, we will keep the source node and destination node same for all the simulations . To implement packet aggregation we will aggregate payload of number of packets while making them share single header. We will see the effect of packet aggregation for different codecs. The various simulation parameters are as follows:

Source	5
Destination	8
Average Talking Time	20S
Start Time *	5S
End Time *	90S

Table2:Simulation Parameters

The following screenshot shows the VoIP traffic flow from node 5 to node 8, over wireless mesh network. This scenario is run for different codecs and for different payload sizes

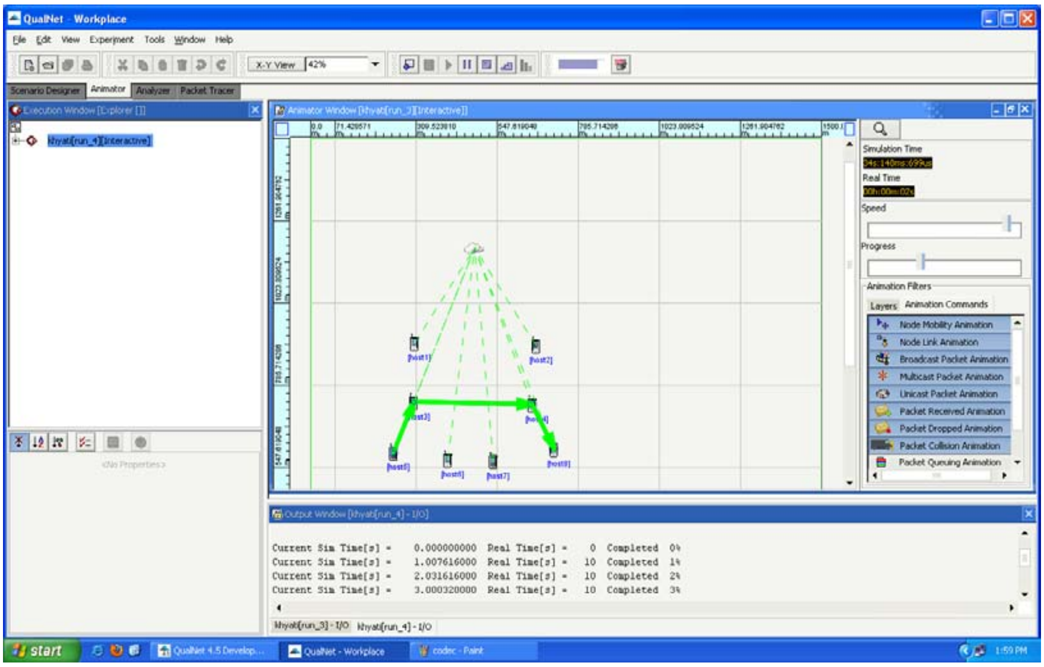

Fig-3:Scenario in running mode

VII RESULTS:

The VoIP traffic is CBR (Constant Bit Rate) with packet rate and packet size governed by codec. In order to increase data throughput, no. of packets sharing a single header are aggregated On running the designed scenario ,we were able to find the effect of packet aggregation on end to end delay, aggregation delay and the consequent effect on Mean Opinion Score. The results obtained for different codec's are as follows:

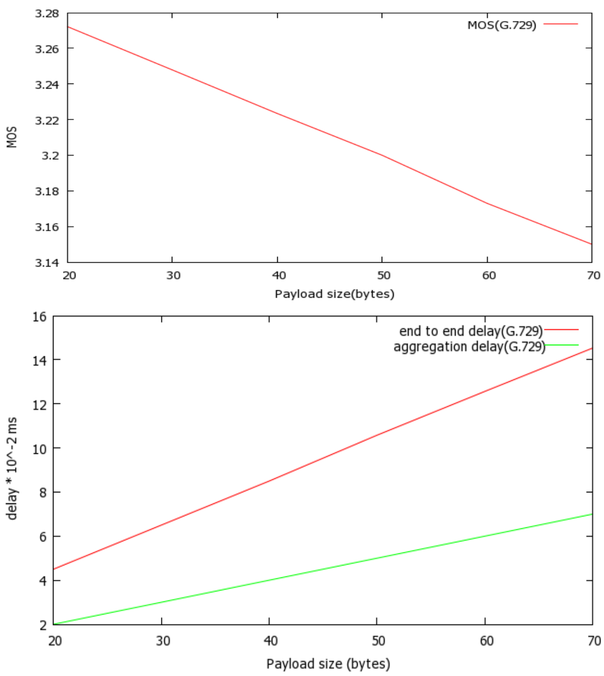

Fig-4:Effect of packet aggregation on (A)MOS and (B)aggregation delay and end to end delay in case of G.729 codec

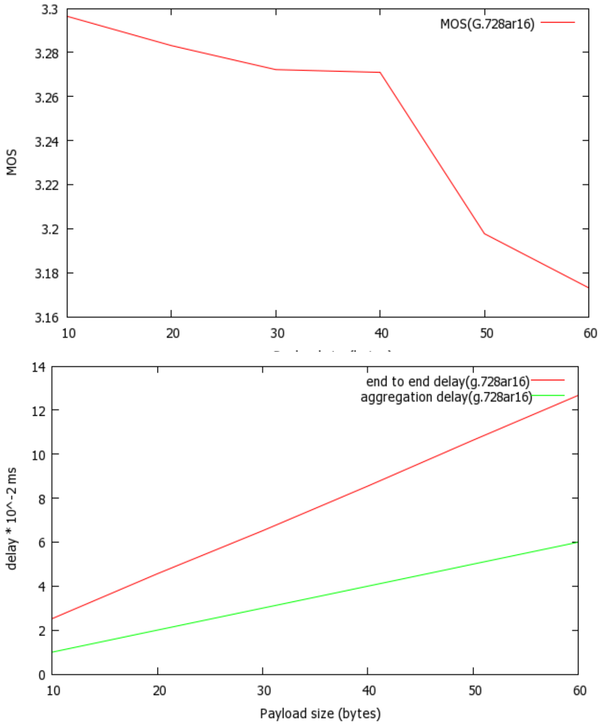

Fig-5:Effect of packet aggregation on (A)MOS and (B)aggregation delay and end to end delay in case of G.728ar16 codec

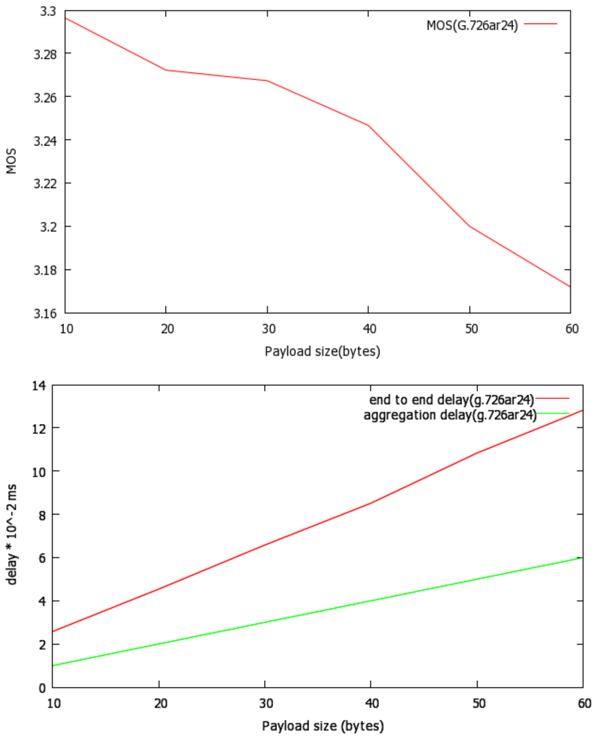

Fig-6:Effect of packet aggregation on (A)MOS and (B)aggregation delay and end to end delay in case of G.726 ar 24codec

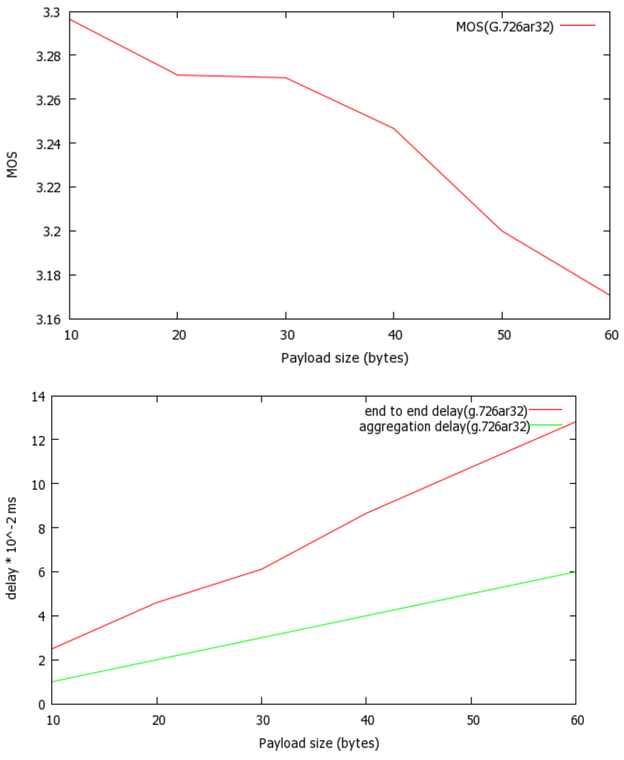

Fig-7:Effect of packet aggregation on (A)MOS and (B)aggregation delay and end to end delay in case of G.726 ar32 codec

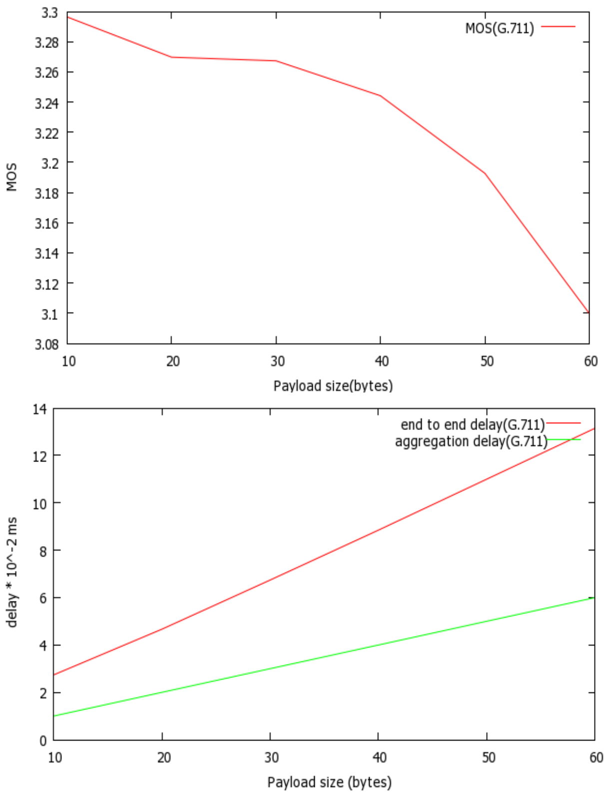

Fig-8:Effect of packet aggregation on (A)MOS and (B)aggregation delay and end to end delay in case of G.711 codec

VIII CONCLUSION:

Results have shown that on increasing the payload size for different codecs ,the end to end delay as well as aggregation delay increases.As we know that delay has significant effect on transmission rating factor(R-factor), it should be checked for VoIP services.Moreover R-score must be above 70 in order to provide a decent quality VoIP stream. Correspondingly Mean opinion score should be above 3.60 for good voice quality.But the results have shown that ,if packet aggregation continues-upto aggregation of 5 packets in row then MOS value reaches to3.10 which implies that most of the users are dissatisfied(As in table1). Thus the results have shown that packet aggregation is justified upto a certain limit only so as to avoid poor quality of VoIP services. So, packet aggregation must be checked for transmission of time critical VOIP applications

IX REFERENCES:

[1] Akyildiz, I.F.; Xudong Wang,” A Survey on Wireless Mesh Networks” Communications Magazine, IEEE Volume: 43, Publication Year: 2005, Page(s): S23 - S30.

[2] Marius Portmann, Asad Amir Pirzada “Wireless Mesh Networks for Public Safety and Disaster Recovery Communications”.

[3] Ali Hamidian, Claudio E. Palazzi, Tin Y. Chong, Juan M. Navarro, Ulf Körner, Mario Gerla, "Deployment and Evaluation of a Wireless Mesh Network," mesh, pp.66-72, 2009 Second International Conference on Advances in Mesh Networks, 2009.

[4] I. Alocci, S. Murphy, A. Nafaa, J. Murphy, “Development of an IEEE 802.11s Simulation Model for QualNet” M conference In Riva del Garda, Italy on 25th-28th of September 2008.

[5] Heecheol Song; Bong Chan Kim; Jae Young Lee; Hwang Soo Lee, “IEEE 802.11-based Wireless Mesh Network Testbed” Mobile and Wireless Communications Summit, 2007. 16th IST Publication Year: 2007 , Page(s): 1 – 5

[6] Ye Yan; HuaCai; Seung-Woo Seo, “Performance analysis of IEEE 802.11 Wireless Mesh Network” Communications, 2008. ICC '08. IEEE International Conference on Communications, 2008. ICC '08. Publication Year: 2008 , Page(s): 2547 – 2551.

[7] Ping Yi; Tianhao Tong; Ning Liu; Yue Wu; Jianqing Ma; “Security in Wireless Mesh Networks: Challenges and Solutions” Sixth International Conference on Information Technology: New Generations, 2009 ITNG '09.. Publication Year: 2009, Page(s): 423 – 428

[8] Institute of Technology Atlanta, GA. Leandro Carvalho, EdjairMota, RegeaneAguiar Anderson Barreto, “An E-Model Implementation for Speech Quality Evaluation in VoIP Systems”.IEEE Symposium on Computers and Communications (ISCC 2005) 1530-1346 IEEE, 2005.

[9] L. Ding and R.A. Goubran, “Speech quality prediction in VoIP using the extended E-model,” IEEE GLOBECOM 2003, pp. 3974-3978.

[10] S. Garg and M. Kappes, “Can I add a VoIP call?,” in IEEE International Conference on Communications(ICC), (Anchorage, Alaska), 2003

[11] H.Y. Wei, K. Kim, A. Kashyap, and S. Ganguly, “On Admission of VoIP Calls over wireless Mesh Network,” in Proceedings of IEEE ICC, 2006

[12] K. Kyungtae and H. Sangjin, "VoMESH: voice over wireless mesh networks," in Proc.of IEEE Wireless Communications and Networking Conference, Las Vegas, NV, USA, 2006, pp.1938

[13] S. Ganguly et al., “Performance Optimizations for Deploying VoIP Services in Mesh Networks”, in IEEE Journal on Selected Areas in Communications (JSAC), 2006. p.2147-2158.

[14] KarishmaBabu, Luis Miguel Cortés-Peña, Prateek Shah, ShivaranjaniSankara Krishnan, “ Wireless Mesh Network Implementation” School of Electrical and Computer Engineering Georgia

[15] ITU-T, “The emodel: A computational model for use in transmission planning,” ITU-T Recommendation G.107, Dec. 1998.

[16] J. Kassler, M. C. Castro, and P. Dely, “Voip packet aggregation based on link quality metric for multihop wireless mesh networks,” In Proceedings of the Future Telecommunication Conference, Beijing, China, October 2007.

[17] Xuedong Wang et al. ,”VOIP over Wireless Mesh Networks: Challenges and Approaches “In proceedings of WINCON ’06 in Boston 2006

[18] Vinay Sridhara,Jonghyun Kim,Stephan Bohacek, “Performance of Urban Mesh Networks” *MSWiM’05*, October 10–13, 2005, Montreal, Quebec, Canada.

[19] Bur Goode, “Voice over Internet Protocal(VOIP)”,:PROCEEDINGS OF THE IEEE, VOL. 90, NO. 9, SEPTEMBER 2002

[20] R. Bruno, M. Conti, and E. Gregori, “Mesh Networks: Commodity Multihop Ad Hoc Networks,” IEEE Comm. Mag., vol. 37, pp. 123–131, March 2005.

[21] ITU-T, “The emodel: A computational model for use in transmission planning,” ITU-T Recommendation G.107, Dec. 1998

[22] Qi Zhang, Villy B.Iversen, Frank H.P. Fitzek, “Throughput and delay performance Analysis of Packet Aggregation Scheme for PRMA”, In proceedings of WCNC 2008, pp. 1380-1384

[23] Jing Ha Hong and Khosrow Sohraby, “On Modeling and Analysis, and Optimization of Packet Aggregation Systems” , In proceedings of IEEE transaction on communications, Vol-58, No 2, Feb 2010, pp. 660-668

[24] Yoanes Bandung et al., “Optimizing Voice over Internet Protocol(VoIP) Networks Based on Extended E-Model”, In proceedings of CIS 2008, pp. 801-805.