Performance Evaluation of VoIP Codecs over WiMAX/Wi-Fi Integrated Network

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ABSTRACT
In this paper, we evaluate the performance of different VoIP Codecs over WiMAX/Wi-Fi Integrated network. An integrated WiMAX/Wi-Fi network scenario is designed using QualNet 5.0.2 for VoIP application. This integrated network has a dual radio interface of WiMAX and Wi-Fi network. The network performance parameters such as Average one way Delay, Average Jitter, Average Mean Opinion Score (MOS), Packet loss have been used to evaluate the performance of VoIP Codecs. The simulation result is performed in QualNet 5.0.2 Simulator by varying the number of VoIP flows for different VoIP Codecs like G.711, G.726 and G.729 in this WiMAX/Wi-Fi Integrated network. Simulation result shows that the codec G.729 performs better than other two Codecs in terms of QoS performance parameters of VoIP.

General Terms
Wireless communication, Heterogeneous Networks, Voice over Internet Protocol, QualNet Simulator

Keywords
WiMAX, Wi-Fi, Integrated network, Performance Evaluation, VoIP, Codec, QoS, QualNet 5.0.2

1. INTRODUCTION
The next generation of networks is applied to bring together all heterogeneous wired and wireless systems under the same framework in an innovative way such that there will be a seamless connectivity anytime and anywhere using any available technology. Network convergence is one of the major challenges faced by next generation network technology. Therefore evolution of telecommunication technology leads to the integration of the computer and communication networks.

WiMAX and Wi-Fi are the two most prominent technologies that have been implemented by wireless service providers. Wi-Fi technology is commonly available in different offices, college campuses, coffee shops and other public places around the world to provide wireless Internet connectivity. The problem faced by Wi-Fi network is the lower coverage as it operates in public bands so that the wireless signals broadcasted by Wi-Fi hotspots are so weak to avoid interference. On the other hand, WiMAX provides data speed faster than current 3G wireless networks and over much longer distances than comparably fast Wi-Fi technology. Therefore WiMAX can be able to fill holes in Wi-Fi hotspots coverage and enable wireless connectivity on trains or buses.

With rising demand for mobile broadband multimedia services, operators are enforced to increase in bandwidth requirements. To keep in mind with this huge bandwidth demand, operators must think about new packet backhaul networks that fulfill the needs for increased capacity at lower cost and provide the necessary quality of service and service reliability that users expect. By offering integrated WiMAX/Wi-Fi services, users would benefit from efficient use of radio spectrum, enhanced radio coverage and seamless wireless data services. It could capitalize on the investment of various service providers, attract more number of users and ultimately facilitate the performance of high speed wireless data.

Voice over Internet Protocol (VoIP) is a modern emerging technology for voice communication and multimedia sessions over Internet protocol (IP) networks, such as Internet. VoIP enabled devices like desktop and mobile IP phones decrease the cost of communication, enhance existing features and provide new features of communication and data services. The term IP telephony in VoIP is used to replace the existing public switched telephone network (PSTN) using IP phones and IP-based transport, control and access networks.

A comparative analysis of bandwidth and delay requirements of different VoIP Codecs over WiMAX network is presented in [1]. In [2], a performance evaluation of WiMAX network under different operational conditions using QualNet is shown. Performance analysis of various VoIP Codecs on VoIP quality of service is presented in [3]. In [4] a simulation study is conducted to evaluate the performance of VoIP in WiMAX and UMTS. In [5] performance analysis of VoIP Codecs over best effort WiMAX network is presented. Effect of different VoIP Codecs on VoIP performance is presented in [6]. In [7] performance evaluation of VoIP using different Codecs over a UMTS network is presented. We have analyzed the performance of VoIP Codecs over WiMAX/Wi-Fi Integrated network using QualNet 5.0.2.

2. VOIP CODECS
VoIP Codecs are used for the conversion process of analog waveforms to digital information. It has a facility to compress the data stream and grant echo cancellation for VoIP application [1]. VoIP Codecs are sometime called "Vocoders", meaning voice encoders. There are mainly three operations performed by Vocoders namely encoding-decoding, compression-decompression, and least often, encryption-decryption [8]. There are different VoIP Codecs used for VoIP application. VoIP Codecs are varied to change the sound quality, bandwidth requirement, computational necessities for different VoIP applications. The main Vocoders are used today for VoIP application are G.711,

G.726 and G.729. Different characteristics of these three Codecs are listed in Table 1 below.

Table 1. Characteristics of different VoIP Codecs

VoIP Codecs	Sampling Rate (KHz)	Bandwidth (Kbps)	Payload Size (ms)
G.711	8	64	20
G.726	8	16/24/32/40	20
G.729	8	8	20

3. METHODOLOGY

We consider a network model of integrated WiMAX/Wi-Fi network in Figure 1. In this model there is one WiMAX base station (BS) which provides radio connectivity to WiMAX subscriber stations and at the same time to the Wi-Fi access points or hotspots in its coverage area. Under each access point or hotspot, there are several Wi-Fi users. The WiMAX BS and each subscriber station are connected by a single link; on the other hand the link between WiMAX BS and access point is shared by multiple wireless access point nodes.

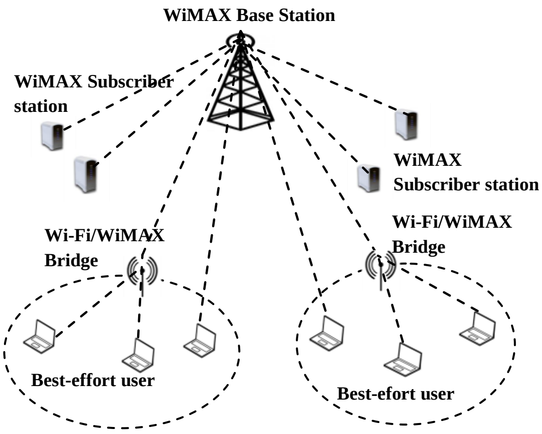

Fig 1: Network Model of WiMAX and Wi-Fi integration

We have designed an integrated WiMAX/Wi-Fi network scenario according to the above network model for VoIP application using QualNet Simulator as shown in Figure 2. In this integrated network, we consider one WiMAX Base Station and three Wi-Fi access points in different geographic locations to provide radio access coverage. WiMAX Subscriber stations are not directly connected to the WiMAX Base station in our designed network scenario. There is a dual radio interface of WiMAX and Wi-Fi network to support heterogeneous integrated networks .Under each access point, there is a mobile node for VoIP application.

We provide the mobility support for two nodes located at two different access points. Two static nodes are considered under third Access point. We have fixed the speed of the mobile node by setting the simulation time between two way points as we know the distance between two way points is 100 m when we set the two way points at the edge [9]. We have considered the speed of mobile node between two way points 2 m/s. The WiMAX Base Station is configured with 802.16 MAC and 802.11 MAC is configured to mobile node under each access point. We have increased the number of VoIP Flows from two to ten in this WiMAX/Wi-Fi integrated network to measure the performance of VoIP Codecs with respect to number of VoIP Flows. The modified WiMAX/Wi-Fi integrated network scenario with 10 VoIP Flows is shown in Figure 3. Network Simulation Parameters for this integrated network is shown in Table 2.

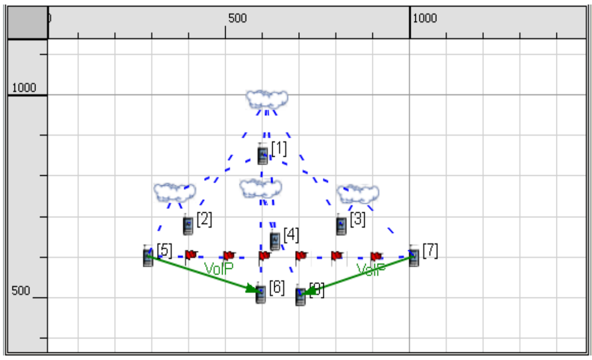

Fig 2: WiMAX/Wi-Fi integrated network with number of VoIP Flows=2

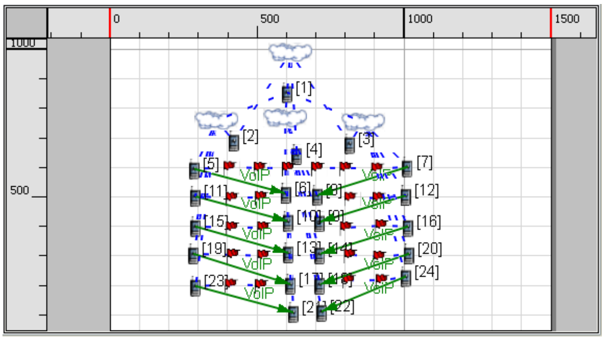

Fig 3: WiMAX/Wi-Fi integrated network with number of VoIP Flows=10

Table 2. Network Simulation Parameters

Description	Value
Number of Channels	4
Channel Frequencies	2.40, 2.41, 2.42, 2.43 GHz
Path Loss Model	Two Ray
Network Protocol	IPV4
Multimedia Signaling Protocol for Application Layer	SIP
VoIP Average Talking Time	20 Second
Packetization Interval	20 ms
Simulation Time	180 Second

4. SIMULATION RESULTS AND DISCUSSION

Average one way Delay by VoIP Initiator and VoIP Receiver with the number of VoIP flows is shown in Figure 4 and Figure 5 respectively. We see that as we increase the number of VoIP flows, Average one way Delay is increasing for all VoIP Codecs. But the G.711 Codec provides the higher Delay than G.726 and G.729 Codec for VoIP performance with respect to number of VoIP Flows in WiMAX/Wi-Fi Integrated network.

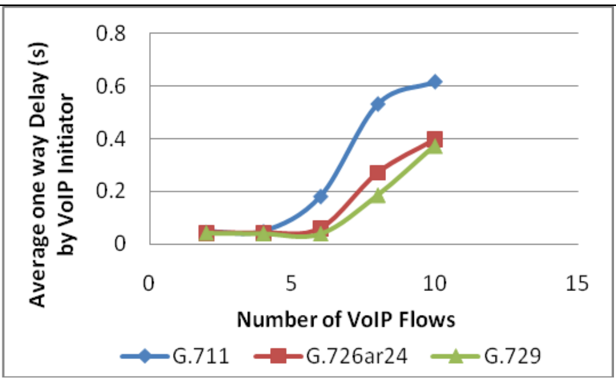

Fig 4: Average one way Delay (s) by VoIP Initiator

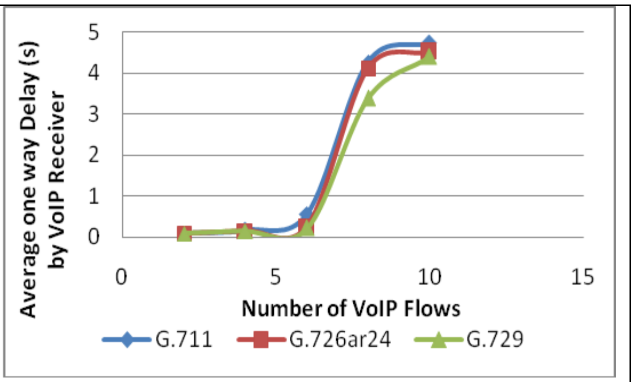

Fig 5: Average one way Delay (s) by VoIP Receiver

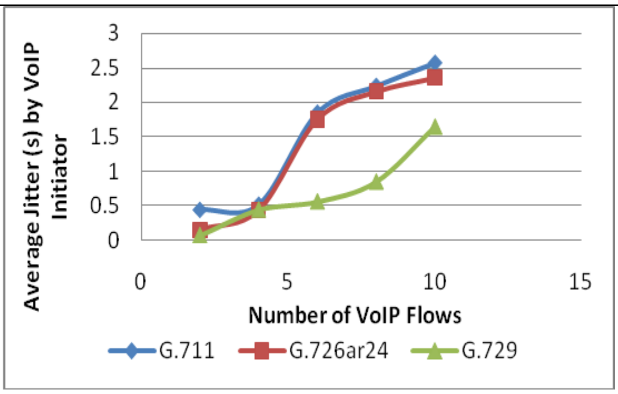

Fig 6: Average Jitter (s) by VoIP Initiator

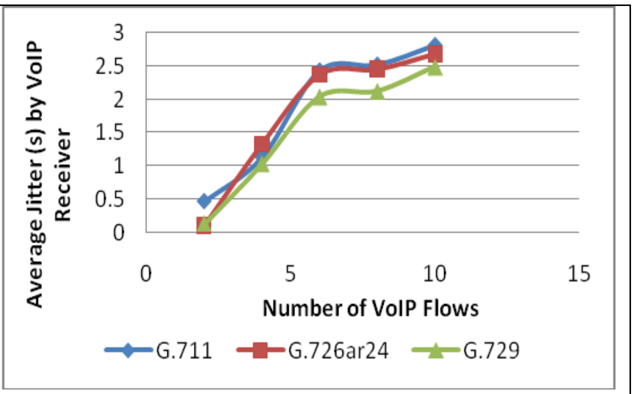

Fig 7: Average Jitter (s) by VoIP Receiver

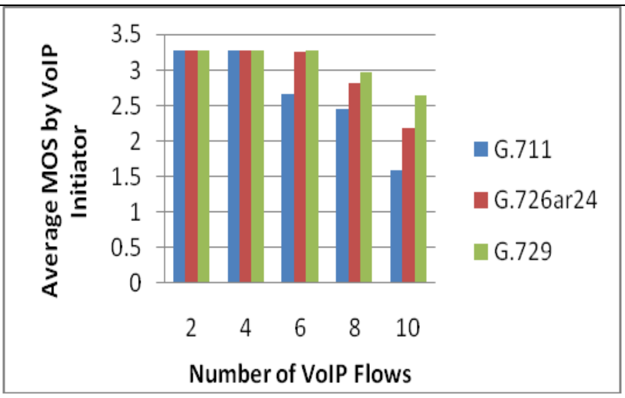

Fig 8: Average MOS by VoIP Initiator

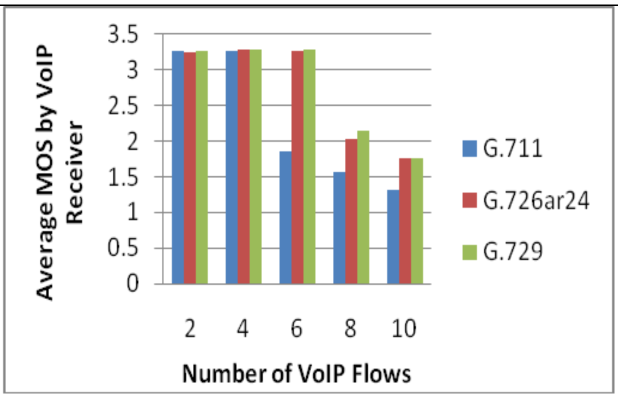

Fig 9: Average MOS by VoIP Receiver

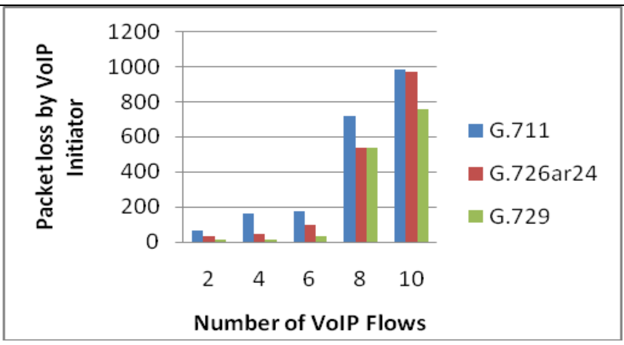

Fig 10: Packet loss by VoIP Initiator

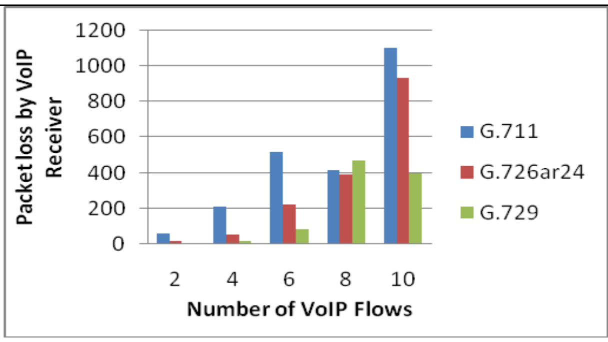

Fig 11: Packet loss by VoIP Receiver

Figure 6 and Figure 7 show the Average Jitter for VoIP Initiator and VoIP Receiver respectively. Average Jitter is increasing when we increase the number of VoIP Flows for VoIP Initiator and VoIP Receiver in this integrated WiMAX/Wi-Fi network. As we increase the number of VoIP Flows in this integrated network, the load of this network is also increasing. Therefore the Average Jitter for VoIP Initiator and VoIP Receiver is increasing for the entire network. From these graphs we see that the Codec G.729 performs well under heavy load of the network than the Codec G.726 and G.711.

Average MOS by VoIP Initiator and VoIP Receiver with respect to number of VoIP Flows is shown in Figure 8 and Figure 9 respectively. MOS depends on average end-to-end delay and packet loss. From these bar graphs we conclude that as we increase the number of VoIP Flows, Average MOS is decreasing for each VoIP Codec for VoIP Initiator and Receiver. G.711 Codec performs less for VoIP application in terms of Average MOS than G.726 and G.729 Codec.

Figure 10 and Figure 11 show the Packet loss by VoIP Initiator and VoIP Receiver with the number of VoIP Flows in this integrated WiMAX/Wi-Fi network. From these bar plots we see that Packet loss is increasing with the increase in number of VoIP Flows for each VoIP Codec in the above integrated network. Under heavy networking load the Packet loss for G.711 Codec is higher than G.726 and G.729 Codec for VoIP application.

5. CONCLUSION

We evaluated the performance of VoIP Codecs over WiMAX/Wi-Fi integrated network by performing the simulation experiments using QualNet 5.0.2 Simulation tool. We have analyzed several important critical Quality of Service parameters of VoIP such as Average one way Delay, Average Jitter, MOS and packet loss for different VoIP Codecs like G.711, G.726, and G.729 with respect to number of VoIP Flows in this WiMAX/Wi-Fi Integrated network. Simulation results show that G.729 Codec performs better than G.726 and G.711 Codec under heavy load in respect of Delay, Jitter, MOS and Packet Loss in WiMAX/Wi-Fi integrated network. As there is a less bandwidth requirement for G.729 Codec, therefore this Codec is mostly used in VoIP applications where bandwidth must be conserved.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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