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Effect of Channel Multipath Fading on VoIP QoS in WiMAX Networks

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Abstract: In wireless signal propagation, the biggest challenge is to overcome the effects of fading. The multipath nature of channel leads to ISI (Inter Symbol Interference) and the severity of ISI effects increases with bandwidth increase. The radio link between the Base Station and Service Station/Mobile Station can be a LOS or it can be a NLOS. The environmental objects and features like buildings, weather conditions can severely obstruct NLOS signal.

In this paper the effect of pedestrian multipath in WiMAX network is studied under different codecs schemes in order to evaluate the effect of multipath channel fading on the QoS parameters end to end delay, jitter, mean opinion score and throughput of a VoIP application. The obtained results showed that multipath fading has sever effect on throughput and MOS value for all studied codecs and on the other parameters the effect varies depending on the implemented codecs..

KeyWords : propagation, multipath**,** *jitter*, *throughput, VoIP,codecs, NLOS.*

I. Introduction

WiMAX stands for Worldwide Interoperability for Microwave Access. WiMAX embodies the IEEE802.16 family of standards that provide wireless broadband access to residential and commercial Internet subscribers [1].

Due to the growing demand for newer applications that require mobility features as well as the very rapid advancement in technology. The IEEE 802.16 workgroup presented the IEEE 802.16e standard version based on the IEEE 802.16-2004 standard (fixed version) in order to support such mobile wireless broadband access service which in turn provides high-speed information transmission through this proposed wireless broadband solution as well as supporting high speed mobility[2].

Mobile WiMAX performance is influenced by many external factors such as traffic type, network size, traffic load and node mobility and multipath fading[3]. QoS is the fundamental premise of the IEEE 802.16 MAC architecture . It defines a number of Service Flows which can map to DiffServ code points that enable end-to-end IP based QoS. In addition it provides a flexible mechanism for optimal scheduling of space, frequency and time resources over the air interface on a frame-by-frame basis using the sub-channelization schemes [4].

The performance of the VoIP calls which are mapped to the BE service class are analyzed and evaluated to investigate the effect and functions of QoS mapping in VoIP applications. Different trajectories were applied to the MS with the G.711 and G.729 encoders in order to identify which encoder gives the best performance to the VoIP application. It was concluded that the G.729 is better than G.711 in terms of QoS parameters and can support up to 80 mobile users [5].

In this paper performance of VoIP that are mapped to UGS service class are evaluated under different multipath environment for mobile and fixed nodes under different codecs schemes.

II. **Quality of service**.

Quality of Service (QoS) is the ability to communicate a type of traffic in good conditions, in terms of availability, throughput, transmission delay, jitter, packet loss, and rate…etc. It has become an important factor to support variety of applications that use network resources. These applications include multimedia services, Voice over IP…etc.

The traffic engineering term Quality of service refers to the probability of the telecommunication network meeting a given traffic contract, or the probability of a succeeding packet in the transition between two points in the network.[6].

In order to guarantee QoS multiple constraints need to be addressed by Mobile WiMAX such as the wireless nature of the channels, QoS requirements violation due to transmission errors, the negative effect by the mobility of users on the real time services and security level. Standardized mechanisms for supporting QoS are defined by Mobile WiMAX amendments but in the mean time have left many QoS functions unspecified so that researchers and constructors could design and adopt the mechanisms best suited to fulfilling particular requirements [7].

III. Multipath fading

In mobile communication systems, the RF signal propagates from the transmitter to the receiver via multiple different paths due to the obstacles and reflectors existing in the wireless channel. The environmental objects and features like buildings, weather conditions can severely obstruct NLOS signal . Due to the freedom of mobility of users as well as the frequent changes of location with respect to base station in wireless communication environment, received signal strength is affected by three major fading phenomena: Diffraction, Scattering and Reflection as a result of this relative motion. When the mobile unit is considerably far from the base station, the LOS signal path does not exist and reception occurs mainly from the indirect signal paths. These multiple paths have different propagation lengths, and thus will cause amplitude and phase fluctuations and time delay in the received signal. Therefore, the main effect of multipath propagation can be described in terms of fading and delay spread [8] . WiMAX technology has developed advanced techniques for overcoming critical problems arising from NLOS conditions. WiMAX can transmit data in NLOS conditions without losing a significant number of packets and without much delay by using advanced features such as OFDM, Sub-channelization empowers transmission of sub-channels to reach further distances, Adaptive Modulation Coding (AMC) adjusts the code rate while modulation is based on each sub-channel`s condition. MIMO are also used in WiMAX to make it perform better in NLOS conditions and helps to improve signal strength and throughput [9].

IV. Voice over IP

VoIP (voice over internet protocol) is a way to utilize a data network IP to carry voice calls. VoIP carries voice signals as digital packetized signal by converting the original analog voice signal into digitized packets.

This process is called encoding and the reverse of this process is called decoding. Both of the processes are done by voice codecs[10]. Voice over Internet Protocol (VoIP) brings new challenges along with the benefits. Since VoIP has an extreme sensitivity to delay and packet loss in comparison to other network applications such as web and e-mail services , a basic understanding of VoIP traffic and of the quality metrics provided by VoIP monitoring tools will help to keep VoIP network running smoothly[11].

A VoIP codec is an algorithm used to encode and decode the voice stream. Different algorithms are used for different codecs to compress and decompress the voice stream. The main difference between the various codecs is the type of modulation and demodulation scheme being adopted[12]. Voice Codecs are used on the client side to convert the analog voice signal to digital signal and vice versa. There are many types of codecs depending on the selected data rate, sampling rate, and compression algorithm being implemented.

In order to locate the bandwidth requirements of VoIP connections, common VoIP Codecs are employed such as G711, G729 and G723[13].

V. Simulation and Results

To test the effect of node trajectory on QoS under different codec schemes when using VoIP as testing application the topology in fig(1) is used. As can be seen it consists of 5 fixed subscriber stations (SS) , five mobile stations (MS). one base station (BS), one server and cloud. The application implemented in this scenario is VoIP in order to test QoS of this WiMAX network. For the VoIP application, the "Application Config" node is used to specify applications using available application types. or to create new applications where a name for the new application can be specified and the corresponding description of the application.. the "Profile Config" node is used to create user profiles. These user profiles can then be specified on different nodes in the network to generate application layer traffic. The application defined in the "Application Config" objects are used by this object to configure profiles. Therefore, applications must be created using the "Application Config" object before using this object. The service class used for all the scenarios is the unsolicited grant service (UGS) since as per the IEEE802.16 standard is the recommended class for

VoIP. Six scenarios are run in this test, three of which use the codecs G711, G729A and G723 without applying multipath model to the mobile nodes. The other three scenarios use the same codecs but this time a multipath channel model type ITU Pedestrian B and the path loss for (MS) is Pedestrian and for (SS) is Terrain B (Suburban Fixed) as can be seen in fig(2) and fig (3), applied to the mobile nodes to check the effect on the QoS parameters, which are the jitter, end to end delay , mean opinion score (MOS), packet delay variation and throughput.

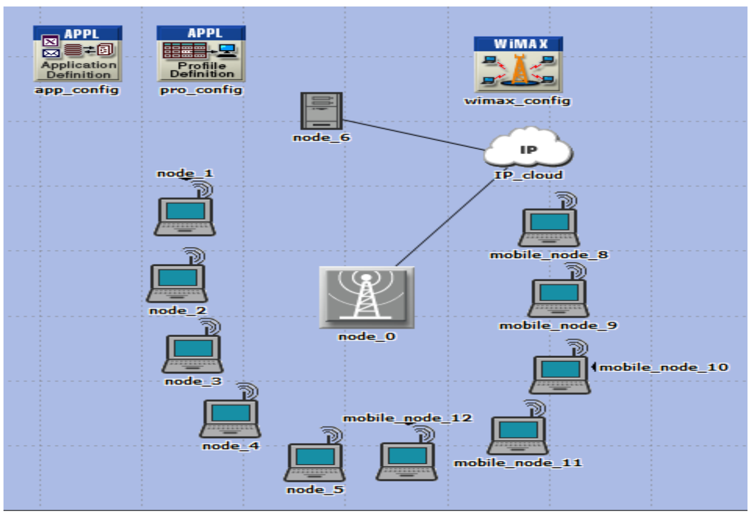

Fig. 1 Network topology with multipath

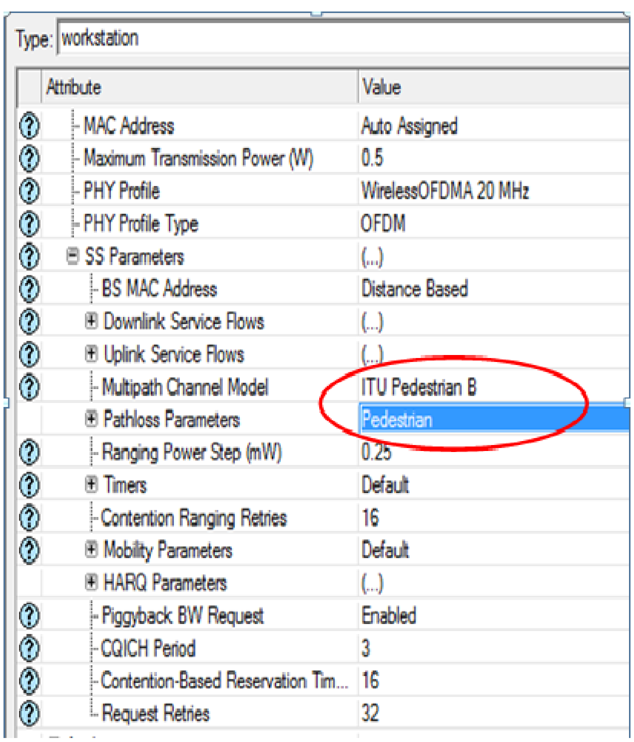

Fig (2) Mobile station Multipath model attributes

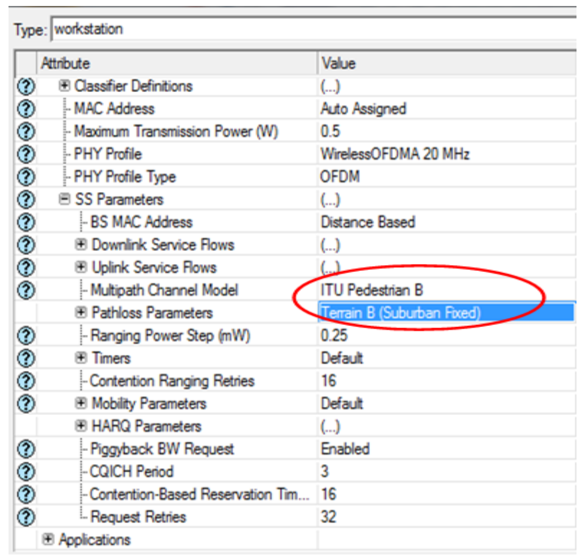

Fig (3) Fixed station Multipath model attributes

Parameter	Value
Scheduling class	UGS
Codecs	G711, G729A, G723
Max. latency millisecond	30
Efficiency mode	Mobility and Ranging
Profile	OFDMA 20 MHz
Frame duration millisecond	5
Symbol duration millisecond	102.86
Number of subcarriers	2048
Duplexing mode	TDD
Multipath channel model	ITU Pedestrian B
Path loss model	Pedestrian

Table(1) details the parameters of the WiMAX that have been used for the test.

Table(1) WiMAX configuration parameters

The following set of graphs show the effect of the multipath environment on the mobile and fixed nodes on QoS of the test WiMAX network topology under different codecs schemes. The parameters that have been chosen for comparison are those once that effect QoS of the running application on the tested network platform which are end to end delay, jitter, packet loss variation and MOS as well as throughput for the WiMAX network.

1. End to end delay

From fig.4 it can be seen that the node multipath has a very minimal effect on the end to end delay for the VoIP application under the three implemented codecs schemes, where for the G711 and G729A there is no effect at all but for the G723 , the multipath has improved the delay.

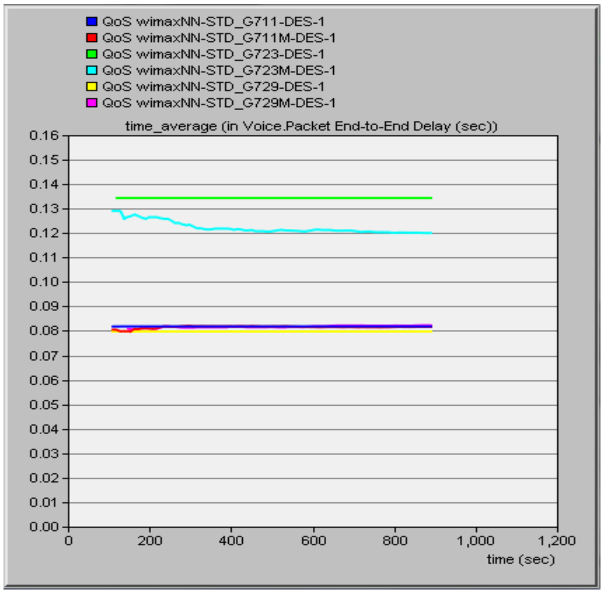

Fig. 4 End to end delay

2. Jitter

Fig. 5 Jitter

It is quite clear form fig.5 the effect of multipath as far as voice jitter's concerned is not significant except for the G711 codec where jitter starts with high negative value the it settles and G723where towards end simulation time it increases and fluctuate due to channel fading.

3. Mean Opinion Score

For this parameter it can be noted from fig. 6 that all the codecs performed poorly because of the multipath channel fading, where the MOS value dropped very sharply.ue worse.

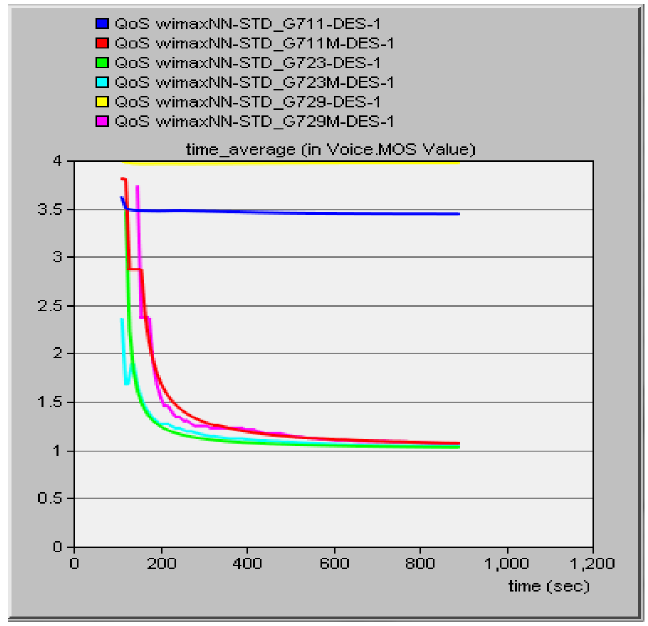

Fig 6 MOS value

4. Throughput

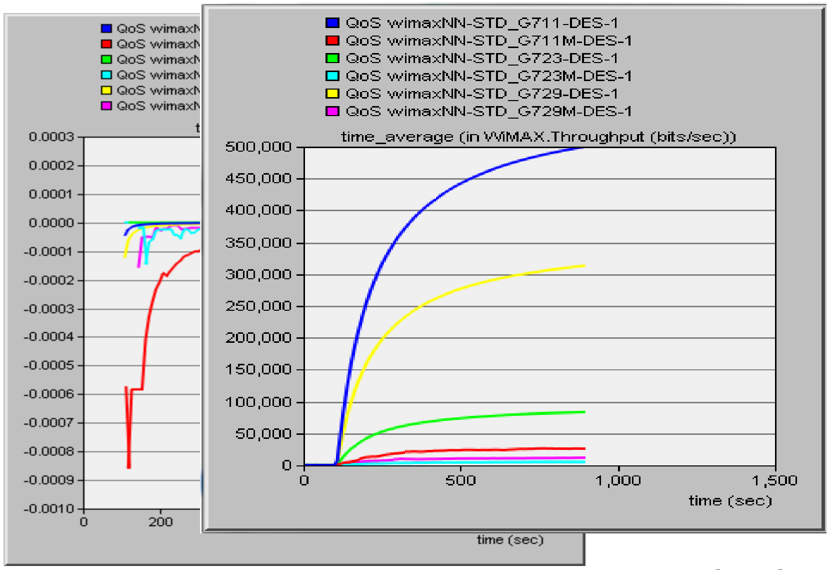

Fig. 7 throughput

From fig. 7 the multipath channel fading caused a very large drop on the network throughput in all the codecs hence the multipath has a significant effect on the network throughput.

5. Packet Delay Variation

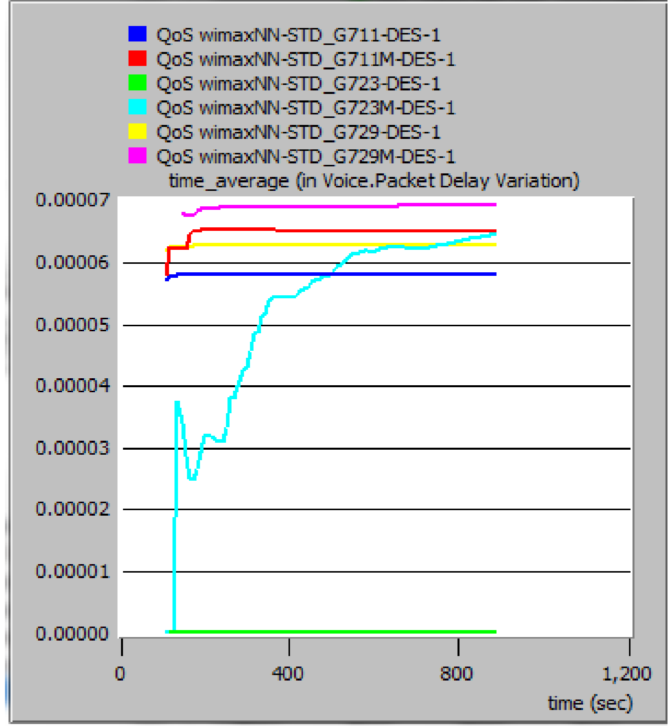

Fig. 8 Packet Delay Variation

Fig. 8 shows that in the case G723 codecs delay variation value increases sharply whereas the G729A has the highest delay variation . In the case of G729A the effect of multipath fading was not significant.

IV. Conclusion

In this paper the OPNET simulation tool was used to test the effect of multipath pedestrian channel fading on QoS for three VoIP codecs G711, G729A and G723 for a WiMAX network when a VoIP application is implemented in the network. Six scenarios were executed and some results were collected to check the effect of channel multipath on QoS parameters, end to end delay, jitter, MOS, packet delay variation and throughput.

From the obtained results it can be concluded that the effect of pedestrian channel fading depends on the type of codec being implemented since as it was shown from the results that end to end delay is improved for G723 codec but has no effect on the other two codecs. Multipath fading increased jitter for G723 but it is within the acceptable limit of 30ms for VoIP. MOS is very severely affect by multipath fading for all of the three codecs and this is also true for the network throughput. As of packet delay variation the most affected codec is the G723 while the other two get affect with lesser extent. Therefore pedestrian multipath fading has a great effect on throughput and MOS value for all the codecs but as far as the other QoS parameters' concerned the effect varies as per the implement codec. One way to improve performance degradation due to multipath is to implement MIMO technology.

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