A solution for designing 4G networks in urban areas

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ABSTRACT:
International Mobile Telecommunications-Advanced (IMT-Advanced) or 4th Generation (4G) Cellular Systems are mobile IP-based systems. This generation is expected to provide users with access to advanced IP-based services and applications, supported by mobile and fixed broadband networks which are packet-based.4G networks support a wide range of data rates with different quality of services requirement. WiMAX embodies the IEEE 802.16 family of standards that provide wireless broadband access. The IEEE 802.16e – 2005 or IEEE 802.16m promises to address the ever increasing demand for mobile high speed Wireless data in forth – generation (4G) network. This network provides wireless broadband and IP connectivity. In this paper we proposed a solution for designing 4G Networks by mobile WiMAX technology in urban with an intelligent Medium Access Control (MAC) that adapts with the Physical layer (PHY) to provides requirements 4G. In our scheme we present 24 scenarios with different parameters. The performance of proposed scheme is evaluated by simulation using Opnet.

KEYWORDS: IEEE 802.16e, IEEE 802.16m, MAC layer, PHY layer, OFDMA, Opnet, Mobile WiMAX, ARQ

1. INTRODUCTION

Wire-based access networks deliver the Applications only to the fixed points. So, a new technology that can deliver the contents to mobile users is needed. The IEEE 802.16 standard is a broadband wireless access technology. It is capable of delivering very high data rates. WiMAX systems must to deliver broadband access services. Worldwide Interoperability for Microwave Access (WiMAX) technology is based on IEEE-802.16–2004 and 802.16e–2005 standards for fixed and mobile wireless access in metropolitan area networks (MAN). It can provide delivery of Applications and support mobile users at vehicular speeds. Physical layer uses adaptive modulation that works on Orthogonal Frequency division multiplexing (OFDM) and orthogonal frequency division multiple accesses (OFDMA). Adaptive modulation is used to provide the highest data rate for a QoS. Modulation can be adjusted at very short time intervals, to achieve robust transmission links and high system capacity. The higher modulation constellations provide a larger throughput but all users don't receive adequate signal levels to reliably decode all modulation types. Some of Users that are close to the base station that have good propagation and interference characteristics are assigned with higher modulation constellations to minimize the use of system resources. While user doesn't have favorable areas use the lower order modulations for send/receive data at the expense of additional frequency/time slots for the same amount of throughput. This modulation based on the link conditions increases the overall capacity of the system. WiMAX- MAC-layer supports real time poling services (rtPS) that ensures required bandwidth and minimum latencies for different of services through quality of service (QoS). Physical-layer is resilient to multipath fading channels. So, it uses forward error correction (FEC) to improve service quality. Since WiMAX-PHY supports scalable frame sizes and varying bandwidth, WiMAX is a choice for new services. WiMAX is emerged as an all IP access network offering transparency for packet based core networks. Additionally, WiMAX radios are designed not to add any interference to the content delivery. Hence, WiMAX base stations (BSs), subscriber or mobile stations (SSs/MSs) are suited for the delivery of IP based services; (triple play) VoIP, IPTV, internet multimedia over wireless MAN. This makes WiMAX an ideal choice over traditional wire-based. WiMAX access networks will provide the much desired ubiquity for the contents. WiMAX Support two type of network topologies: point-to-multipoint and mesh. In point-to- multipoint, the link connection is only between BS and SS. This paper aims to discuss the performance and efficiency of WiMAX MAC-layer for point-to-multipoint topology for designing 4G networks. The influence of several parameters is examined. This paper is organized as follow in Section-2 WiMAX network architecture is introduced. Simulation is described in Section-3. Section-4 Simulation results are given. Finally the paper is concluded in Section-5.

2. WIMAX NETWORK ARCHITECTURE

Figure 1 presents the Network Reference Model (NRM), consisting of the following logical entities: MS, ASN, and CSN and clearly identified reference points for interconnection of the logical entities. The figure illustrates the key normative reference points R1-R5. Each of the entities, MS, ASN and CSN represent a grouping of functional entities. Each of these functions may be realized in a single physical device or may be distributed over multiple physical devices. The grouping and distribution of functions into physical devices within a functional entity (such as ASN) is an implementation choice; a provider may choose any physical implementation of functions, either individually or in combination, as long as the implementation meets the functional and interoperability requirements**.** The target of the NRM is to allow multiple implementation options for a given functional entity, and yet provide interoperability among different realizations of functional entities. Interoperability is based on the definition of communication protocols and data plane treatment between functional entities to achieve an overall end-to-end function, for example, security or mobility management. So, the functional entities on either side of a reference point represent a collection of control and bearer plane end-points.

The ASN defines a logical limit and represents a suitable way to describe aggregation of functional entities and corresponding message flows associated with the access services. The ASN defines a boundary for functional interoperability with WiMAX clients, WiMAX connectivity service functions and aggregation of functions embodied by different providers. Mapping of functional entities to logical entities within ASNs as defined in the NRM may be performed in varying ways. The WiMAX Forum is in the process of network specifications in a manner that would allow a different of provider's implementations that are interoperable and suited for a wide diversity of deployment requirements.

Connectivity Service Network (CSN) is represented as a set of network functions that provide IP connectivity services to the WiMAX subscriber(s). A CSN may is consist network elements such as routers, AAA proxy/servers, user databases and Interworking gateway devices. A CSN may be spreader as part of a Greenfield WiMAX Network Service Provider (NSP) or as part of an incumbent WiMAX NSP.

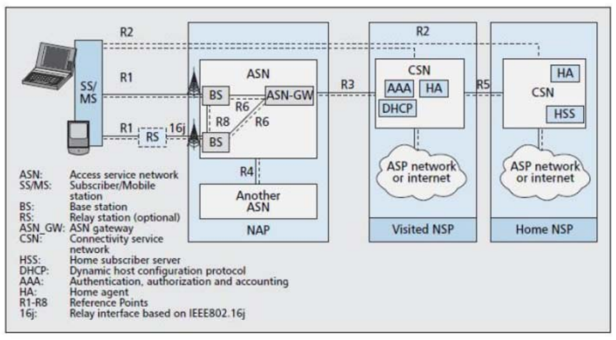


Fig. 1 WiMAX network architecture

3. SIMULATION

Figure 2 and 3 illustrates purposed network for designing 4G mobile system. In this proposal access network is created by six cells. In each cell, there are 10 MS which all of them have trajectory and can move in this network with 120 Km/H maximum speeds. This network is connected to core IP by OC_48 link. There are varying server such as VOD, VOIP, Applications and other servers that are requirement in 4G. Other parameters are presents in table 1.

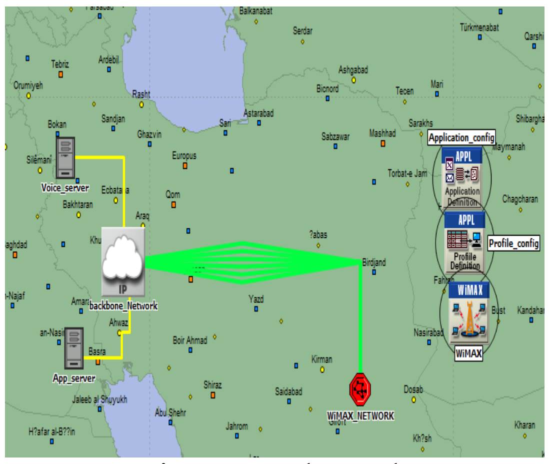


Fig. 2 purposed network

4. SIMULATION RESULTS

We develop 24 scenario using Opnet to analyze the Proposed Network. The simulation parameters For scenarios are shown in the below table 1. These Parameters present that environment is urban with real Conditions.

We created two kind of Traffic: a) VOIP b) IP uncast for 30 minutes contemporaneous and simulated each of scenarios in 15 minutes and collected results that it is presented in table 2. Some of results are presented in figures below. Results compared with calculate theories. We used Hata model for Path loss and throughput for QoS. We'll present some of Important calculates in this simulation.

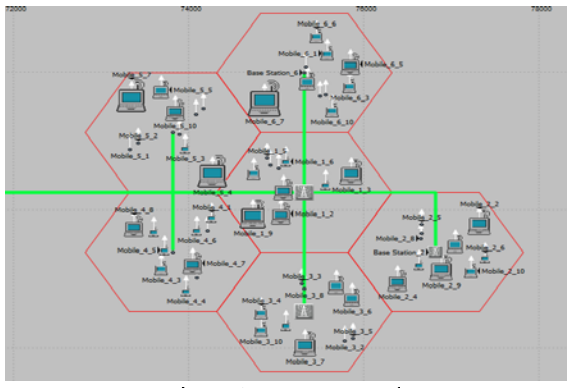


Fig. 3 Access Network

Table 1 the Key Simulation Parameters

Parameters	Value
Number Of BSs	6
Number Of Ms	10 for each BS=60
Inter BS distance	800m
Channel Frequencies	2.4 – 2.45 GHz
PHY 802.16-FFT-Size	512, 1024, 2048
MAC Propagation Delay	1ms
Simulation Time	15 minutes
Traffic	VOIP & IP
Channel Bandwidth(MHz)	5, 7, 10
Frame Duration(ms)	5, 20
TMM propagation	CCIR
Path loss Model	Vehicular
Altitude(m)	1600
Trajectory	Random
h_{BS}(m)	40
h_{MS}(cm)	180

4.1. Calculates

Path loss Analyze*:* path loss for the Hata model is given by:

$$P_L(dB) = (44.9 - 6.55\log_{10}(h_{BS})(\log_{10}(\frac{d}{1000}) + 45.5 + (35.46 - 1.1h_{MS})\log(f_c) - 13.82\log_{10}(h_{BS}) + 0.7(h_{MS}) + c \quad (1)$$

So path loss for each node is 188.5dB that simulation result presents it such as figure 4 for one node.

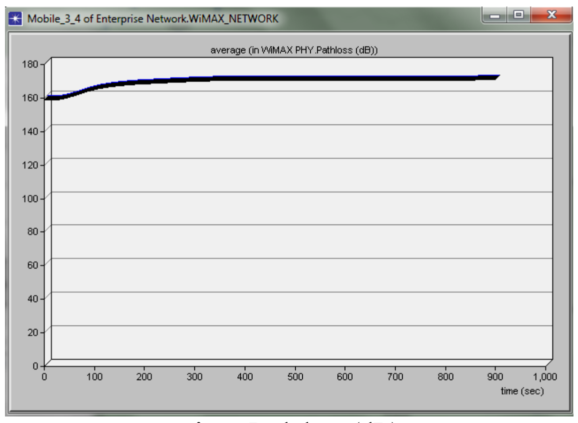
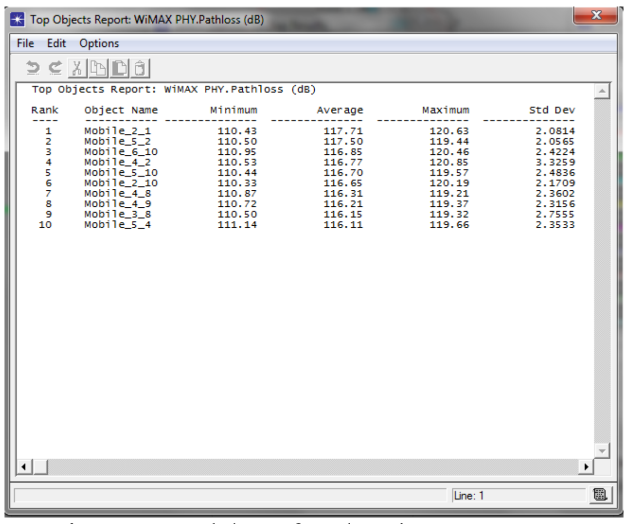


Fig. 4 Path loss (dB)

In simulation results is better than calculates because MSs are closer to BSs.

There are other parameters to decrease P_L such as Multiple -Input Multiple - Output (MIMO) and advanced Antenna Systems (AAS). We used these technologies in simulation.


Top Objects Report: WiMAX PHY.Pathloss (dB)

Rank	Object Name	Minimum	Average	Maximum	Std Dev
1	Mobile_2_1	110.43	117.71	120.63	2.0814
2	Mobile_5_2	110.50	117.50	119.44	2.0565
3	Mobile_6_10	110.95	116.85	120.46	2.4224
4	Mobile_4_2	110.53	116.77	120.85	3.3259
5	Mobile_5_10	110.44	116.70	119.57	2.4836
6	Mobile_2_10	110.33	116.65	120.19	2.1709
7	Mobile_4_8	110.87	116.31	119.21	2.3602
8	Mobile_4_9	110.72	116.21	119.37	2.3156
9	Mobile_3_8	110.50	116.15	119.32	2.7555
10	Mobile_5_4	111.14	116.11	119.66	2.3533

Fig. 5. top Path loss after changing parameters

Capacity Analyze: For this work we used the following equations:

$$C_{max} = B\log_2(1 + SNR) \quad (2)$$

$$p_b \le 0.2e^{-1.5\gamma/(M-1)} \quad (3)$$

$$PER \le 1 - (1 - p_b)^L \quad (4)$$

$$C = C_{max}(1 - BLER) \quad (5)$$

Where: C is capacity- P_b is Probability of bit error rate(BER) – M is order of QAM – L is packet length- PER is packet error rate = Block Error rate (BLER) that we offer L=48 bit P_b=10^{-5} and SNR=20dB so :

$$PER \le 1 - (1 - 10^{-5})^{48} = 0.0004 \quad (6)$$

For FFT=2048 and SNR=20dB=100w C is given by:

C=125.26MHz for All BSs so:
C= 20.88MHz for each BS

Figure 6 Presents BLER uplink and Downlink for one Node.

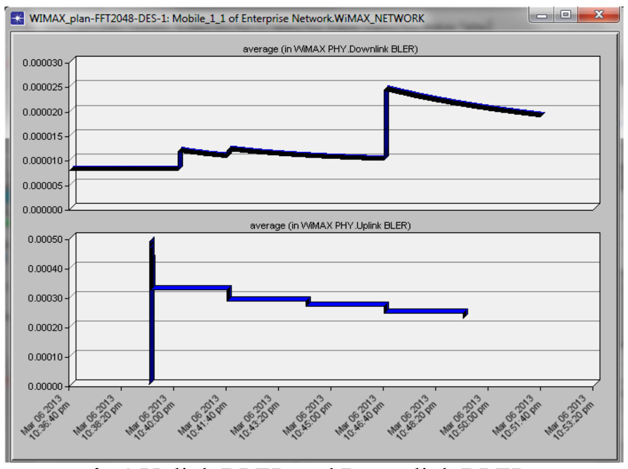


Fig.6 Uplink BLER and Down link BLER

Figure 7 presents SNR (Uplink and Downlink) For 10 Node with 2048 FFT Scenario.

SNR Downlink

Top Objects Report: WiMAX PHY.Downlink SNR (dB)

Rank	Object Name	Minimum	Average	Maximum	Std Dev
1	Mobile_2_6	0.326	26.199	28.966	5.889
2	Mobile_4_10	10.721	26.025	28.662	4.476
3	Mobile_4_5	18.484	25.918	31.583	3.416
4	Mobile_3_7	-1.662	25.415	30.284	6.137
5	Mobile_2_7	14.445	25.074	29.944	3.728
6	Mobile_3_6	-7.733	24.196	27.761	6.276
7	Mobile_6_1	-10.272	24.193	31.442	7.655
8	Mobile_3_1	-2.491	24.009	30.974	6.815
9	Mobile_1_8	-11.391	22.663	31.334	8.926
10	Mobile_2_9	13.318	22.250	28.936	4.031

SNR Uplink

Top Objects Report: WiMAX PHY.Uplink SNR (dB)

Rank	Object Name	Minimum	Average	Maximum	Std Dev
1	Mobile_3_1	-1.975	27.134	29.725	7.081
2	Mobile_1_1	-0.817	25.875	33.847	9.827
3	Mobile_1_9	-14.284	24.263	33.534	8.658
4	Base Station_3	-6.557	24.181	32.408	7.484
5	Mobile_1_5	-4.736	24.086	32.954	8.448
6	Mobile_3_3	-6.557	23.856	32.408	7.300
7	Mobile_1_4	-18.525	21.279	32.714	10.168
8	Mobile_1_7	-3.929	21.070	34.173	9.394
9	Mobile_1_2	-8.673	20.981	29.707	9.460
10	Mobile_1_10	-13.150	20.248	31.966	8.435

Fig.7 SNR (Downlink and Uplink) in 2048 FFT

5. CONCLUSION

WiMAX is a technology for wireless broadband and core technique for the fourth generation (4G) wireless mobile communications. The important points of WiMAX network architecture and the PHY and MAC layer along with key characteristics are summarized and features are discussed. We simulated 4G network by Opnet and changed some of important parameters in 24 scenarios. Results present mobile WiMAX can handle this network by best choices such as Number of Subcarrier (FFT) and schedule Algorithm for type of service and Multiple -Input Multiple - Output(MIMO) and advanced Antenna Systems (AAS).

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