ANALYSIS OF HANDOVER PERFORMANCE IN A MOBILE WiMAX NETWORK

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Abstract* – Mobile WiMAX is a fast growing broadband access technology that enables low-cost mobile Internet application. Data, voice and video streaming are the main application of the mobile WiMAX and the demand from the user is growing every day. The handover performance in mobile network is the most important factor that can influence the Quality of Service (QoS). The parameters such as throughput and packet delay are the main factors which affect the WiMAX network performance. This paper study the handover performance in term of throughput and packet delay for three different applications which are Voice over IP (VoIP), video conferencing and web browsing (HTTP).

***Keyword* – mobile WiMAX, handover, throughput, delay**

I. Introduction

WiMAX (Worldwide Interoperability for Microwave Access) is a digital next-generation communication technology that provides broadband wireless access for fixed, mobile subscriber, nomadic and portable in line of sight (LOS) and non light of sight (NLOS) environment with a base station (BS). WiMAX is based on Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard [1]. WiMAX supports broadband wireless internet access up to 50km distance for fixed and 5-15km distance for mobile subscribers [2]. Peak data rate of 72 Mbps can be reached for downlink, although in reality the transfer data rate will be at most around 15Mbps.

There are two commercial versions of WiMAX which are Fixed WiMAX and Moile WiMAX. Fixed WiMAX based on IEEE 802.16d and Mobile WiMAX based on IEEE 802.16e standards. Mobile WiMAX can be used in both fixed and mobile scenarios while Fixed WiMAX deos not support mobility features. Mobile WiMAX is the mainstream technology adopted by numerous wireless access service providers and supported by equipment vendors whereas the Fixed WiMAX standard has limited deployment and support within the larger WiMAX ecosystem.

Mobile WiMAX (IEEE 802.16e) is a fast growing broadband access technology that enable low-cost mobile internet application, and realizes the convergence of mobile and fixed broadband access in single air interface and network architecture. It was developed by WiMAX Forum and IEEE 802.16 Working Group. Mobile WiMAX was introduced for mobility feature. The amendment is for mobile broadband for vehicular speed in licence band of 2-6GHz and unlicensed band of 2-11GHz [2]. The system also enables roaming for portable client such as smart phone and portable pc within and between service areas. Figure 1 shows a Mobile WiMAX environment.

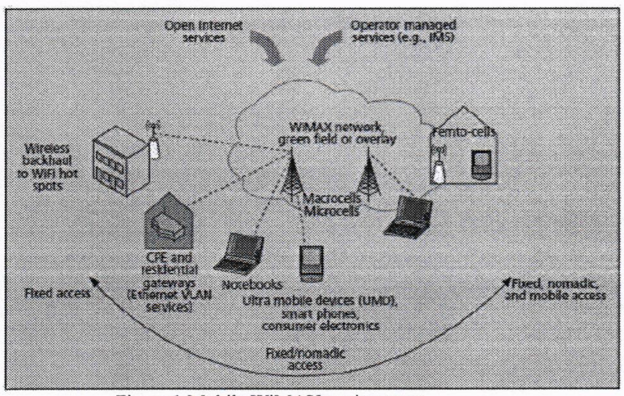


Figure 1 Mobile WiMAX environment

Mobile WiMAX is generally considered a fourth generation (4G) wireless access technology that provides significant advancement in throughput over existing wireless access technologies. The features of Mobile WiMAX include OFDMA, advance antenna system, scalable bandwidth in downlink and uplink, spatial multiplexing and flat-IP architecture. Mobile

WiMAX is based on all IP-platform with no legacy circuit-switched component as in 3G systems (where data is IP based and voice is circuit switched). The flat-IP architecture reduces the total cost of ownership of the network and reduces the deployment cycle to allow for faster time-to-market (or time-to-operation) of the network.

II. Handover in Mobile WiMAX

In communication industry today, the mobility use of devices is increasing rapidly and mobility is in trend. Many users want to have access to the same services as wired technology no matter where they happen to be. So we need a mobile device that provides seamless high speed broadband access to users, which is provided by mobile WiMAX.

In older version IEEE 802.16 was defined only fixed and nomadic access. Fixed access allows no movement while nomadic access provides movement among the cells but there is no handover support. IEEE 802.16e specifies handovers for portability, simple mobility and full mobility for users [3]. The IEEE 802.16e [4] standard defines three basic mechanisms for handover process which are hard handover, Fast Base Station Switching (FBSS) and Micro Diversity Handover (MDHO). In cellular communication, the term of handover refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another.

III. Types of Handover

1. Hard Handover

Hard handover is mandatory in mobile WiMAX network while the other two is optional [8]. During hard handover the mobile station communicates with only one base station in each time. Connection with the old base station is broken before the new connection is established. Handover is executed after the signal strength from the current cell as shown in. Figure 2. The dotted thick line at the boarder of the cells represents the place where hard handover happened. The hard handover is referred as break before make. The connectivity with old base station is aborted during handover.

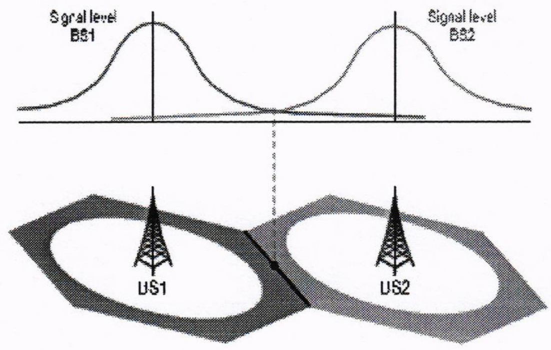


Figure 2 Hard handover

A very likely usage scenario could be a user travelling in a car which means that the communication and handover is needed to be supported even when the car is moving with high speed. Another consideration with mobile devices is limited power resources. Hard handover is also used by the systems which use time division multiple access (TDMA) and frequency division multiple access (FDMA) such as GSM and General Packet Radio Services (GPRS)[8].

2. Fast Base Station Switching

Soft handover is referred as make before break. The connectivity with old base station is maintained during handover. There are two methods of soft handover which are Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO) [7]. In Fast Base Station Switching, the mobile station and base station diversity set is maintained similar as in Macro Diversity Handover. Mobile station continuously monitors the base stations in the diversity set and defines as an "Anchor Base Station". Anchor Base Station is only one base station of the diversity set that the mobile station communicates with all uplink and downlink traffic including management messages as shown in Figure 3. The base station where mobile station is registered, synchronized, performs ranging and there is monitored downlink channel for control information. The anchor base station can changed from frame to frame depending on base station selection scheme. This means every frame can be sent via different base station in diversity set.

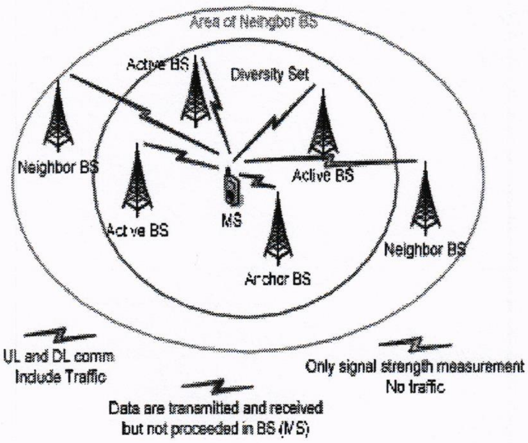


Figure 3 Fast Base Station Switching

3. Macro Diversity Handover

When Macro Diversity Handover is supported by mobile station and by base station, the "Diversity Set" is maintained by mobile station and base station. Diversity set is a list of the base station's, which are involved in the handover procedure. Diversity set is defined for each of mobile station in network. Mobile station communicates with all base station in the diversity set (Figure 4). For downlink in Macro Diversity Handover, two or more base station transmits data to mobile station such that diversity combining can be performed at the mobile station. For uplink in Macro Diversity Handover, mobile station transmission is received by multiple base stations where selection diversity of the received information is performed [7]. The base station, which can receive communication among mobile station and other base stations but the level of signal strength is not sufficient is noted as "Neighbor Base Station".

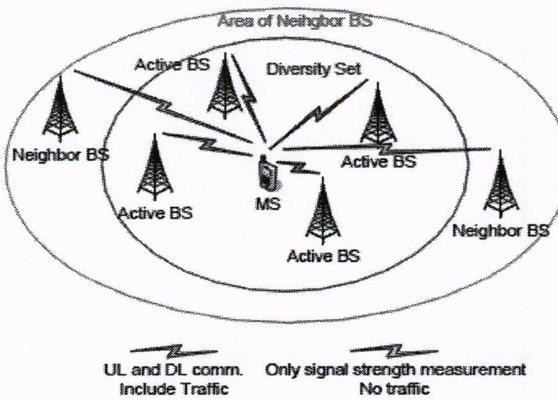


Figure 4 Macro Diversity Handover

IV. Handover process

The handover procedure in Mobile WiMAX network consist of following stages [1],

i. Network Topology Advertisement
ii. MS Neighbourhood Scanning
iii. Cell selection
iv. Handover Decision & Initiation
v. Network Entry
   a. Ranging
   b. Re-authorization
   c. Re-registration

Each state is provided with its own functions and if any of this not completed then that cell will be rejected which in turn rejects the target base station. The whole handover procedure is describes in Figure 5.

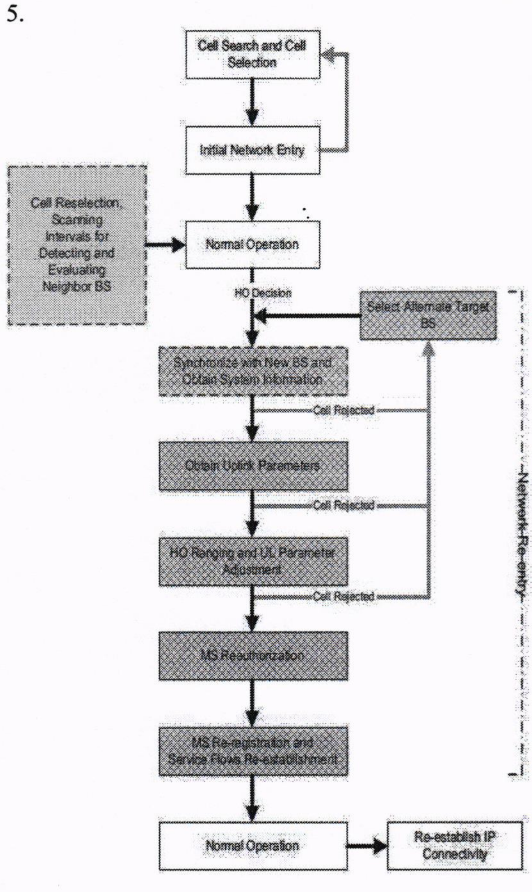


Figure 5 Handover procedure

V. Simulation model

This study uses OPNET 14.5 simulator to simulate the handover from one mobile station to base station. The simulator is used to analyse the performance of mobile WiMAX network and focusing on handover delay, throughput and delay for the application of Voice over IP(VoIP), HTTP and video conferencing in mobile WiMAX network. As shown in Figure 6, the simulation model consists of three base stations with cell radius of 2km, one mobile station and one server.

The BSs are aligned as Figure 4.1 so that they have 4 kilometers between each other and their coverage areas have a radius of 2 kilometers. At the start of the simulation the distance between the MS and the BS0 is 1 kilometer. The MS begin moving as in Figure 4.1, from BS0 to BS1 and its distance is 3.924 kilometers, then it moves entering the BS2 coverage with distance 2.589 kilometer and go back to BS0 with the distance of 4.957 kilometers and the total distance of MS moving is 11.470 kilometers. This value was selected in random and naturally it could be anything else too. However, the MS has to be in reach of the BS coverage.

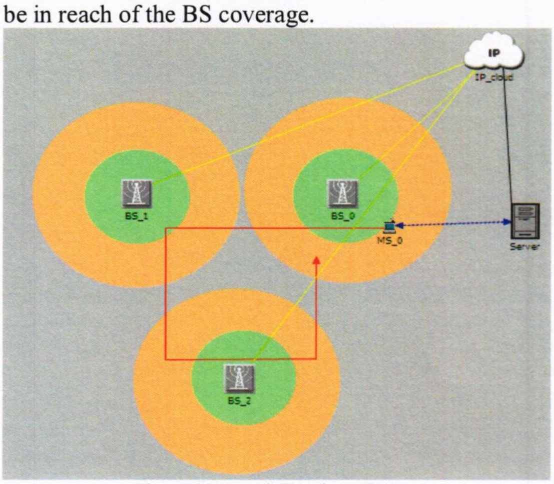


Figure 6 Network Topology Setup

Other parameter setup:

Parameter	Value
Network	IEEE 802.16e
Modulation technique	Adaptive
Bandwidth	10MHz
Multiple Access method	OFDMA
Frequency	2.3GHz
Path loss	Vehicular
Distance between BS	4000m
Antenna gain	15dBi
Antenna maximum transmission power	3.8W
MS maximum transmission power	2.0W
Simulation time	30 minutes
Cell radius	2km

VI. Simulation result

In this section, analysis of various types of application such as voice over IP (VoIP), video conferencing and web browsing (HTTP).

Table 1 Handover delay for VoIP, video conferencing and web browsing application

Application	Handover delay (ms)
Voice over IP (VoIP)	18.95
Video Conferencing	19.5
Web Browsing (HTTP)	25.18

Table 1 shows the handover delay for the three applications. Handover delay is computed from the time the MS sends a MOB_MSHO-REQ message starting the handover process until initial ranging with the new serving BS is successful.

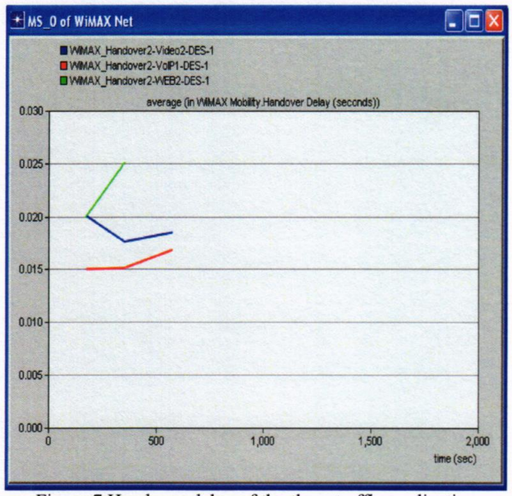


Figure 7 Handover delay of the three traffic application

Figure 8 shows the serving BS ID for the three applications in mobile WiMAX. From the graph we observed that the handover was happened among the BS while the MS moving.

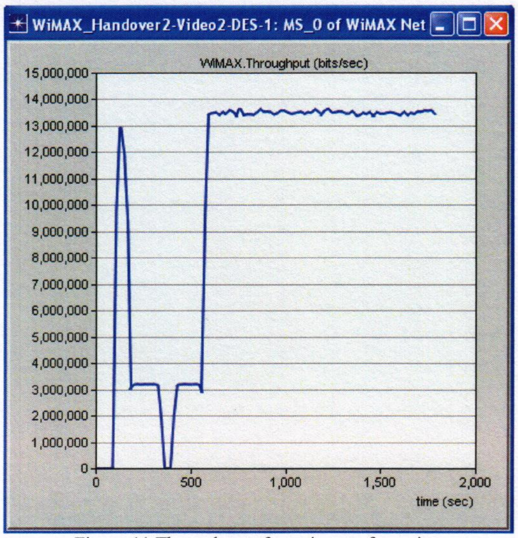


Figure 11 Throughputs for voice conferencing

C. Web browsing application

Figure 13 shows the average delay for web browsing and its shows that the delay was drop at one point before it become consistent at average time is 2.8ms. Delay represents the end to end delay of all the data packets that are successfully received by the WiMAX MAC and forwarded to the higher layer.

Figure 14 shows the throughputs for MS web browsing. For web browsing, the application on user is used the downlink interface. From the figure we can see that the throughput slightly increase to the maximum throughput provide by mobile WiMAX network. The maximum throughput is 80000bit/sec.

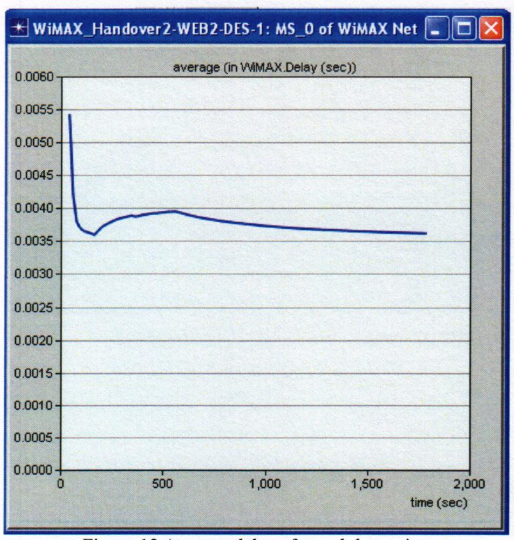
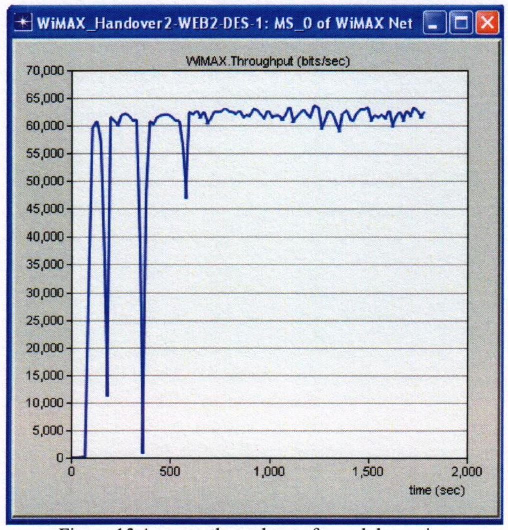


Figure 12 Average delays for web browsing



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Conclusion

The focus of the study is on the handover performance of the mobile WIMAX network. By using the OPNET 14.5 simulator, the performance is analysed in terms of handover delay, throughput and packet delay characteristic on the different traffic applications. It is observed that the different traffic application influenced the handover delay time from base station to base station while moving vehicular. Web browsing application had the higher handover delay time which is 25.8ms. For throughput, it can be concluded that each application have different value of throughput. For some application, the throughput is not consistent when handover process happened. In future, this work is being extended for analyse the handover performance by increasing the number of MS with multiple application in same coverage.

References

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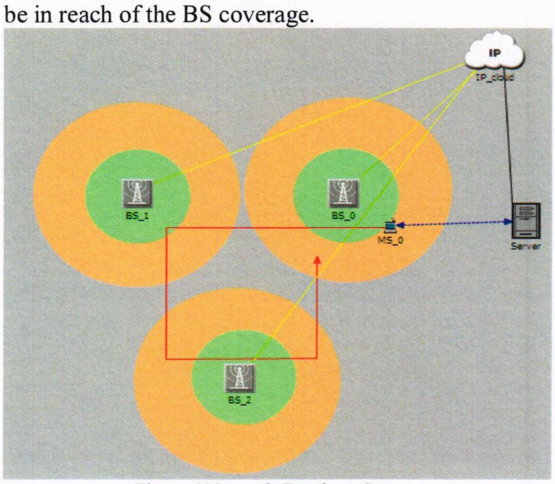

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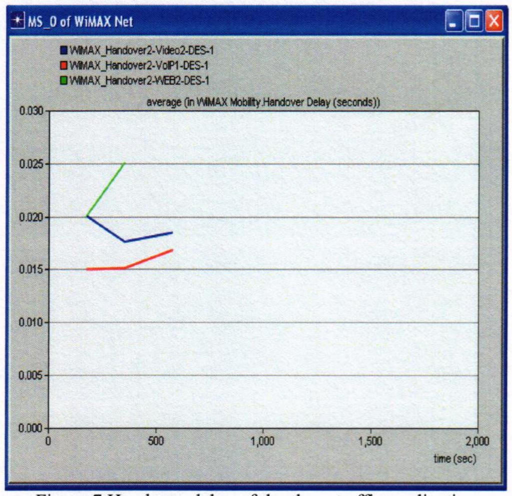

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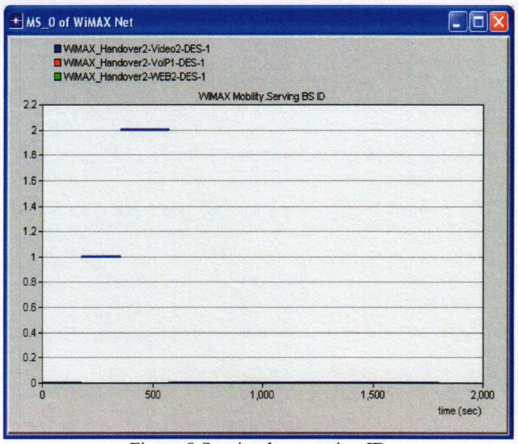


Figure 8 Serving base station ID

A. VoIP application

Figure 9 shows the average delay of VoIP in MS that through the three BS in Mobile WiMAX network. The figure shows that MS have the delay time about 2.3 msec. It is because at that time MS is moving from BS0 to BS2 before come back to BS0.

Figure 10 shows the throughput for MS. Through at MS is sustainable about 190kbit/sec but at certain time there have a drop because of the handover process. We can see that the handover type is soft handover. When the throughput is sustainable, the less interruption of data transmission occurred and the GoS would be achieved.

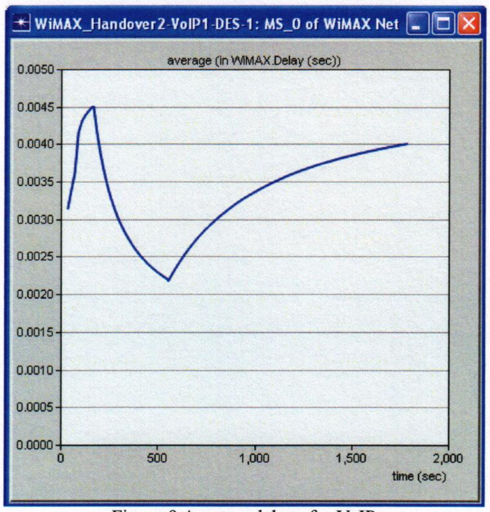


Figure 9 Average delays for VoIP

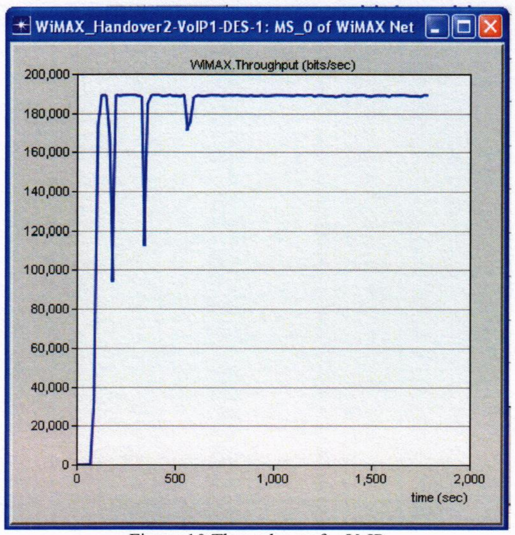
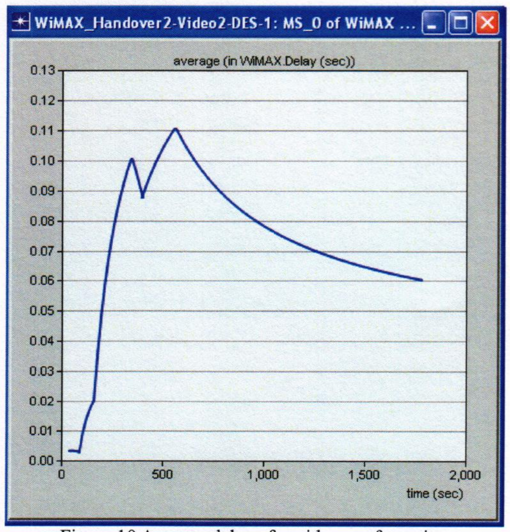


Figure 10 Throughputs for VoIP

B. Video conferencing application

Figure 11 below shows the average delay for video conferencing. On this simulation, MS moving from one place to another while doing video conferencing there have some delay for that multimedia application. The delay is not consistent.

Figure 12 shows the throughput for MS video conferencing. The throughput was sustainable after 10 minutes simulation. The total traffic that forwarded from WiMAX layers are about 13.5Mbit/sec. From the graph, we can see that while MS moving from BS to BS the throughput is worse.



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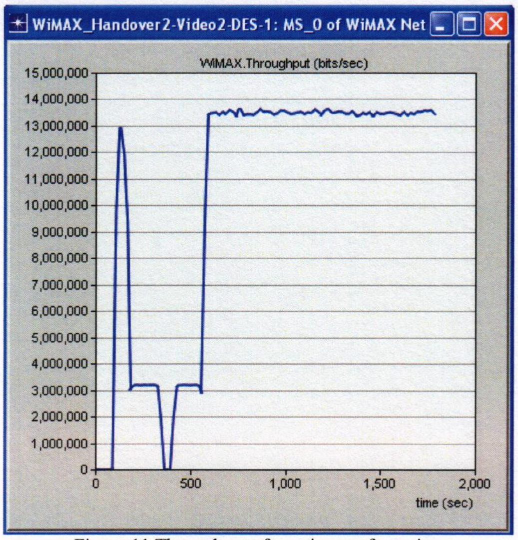

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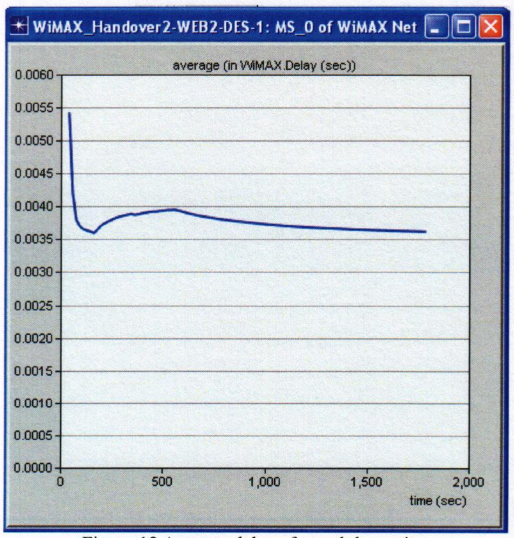
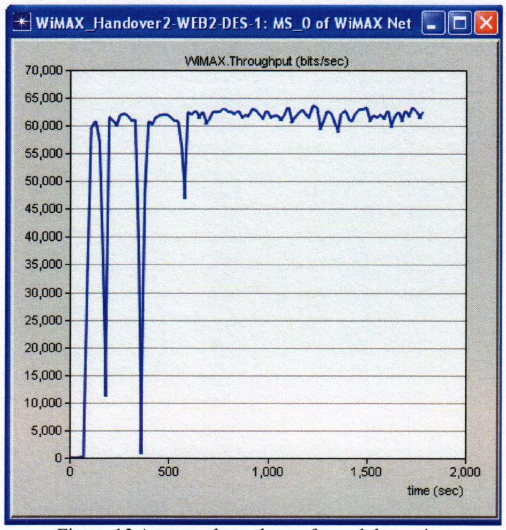


Figure 12 Average delays for web browsing



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