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Performance of Soft Handover – FBSS Compared to Hard Handover in case of High Speed in IEEE 802.16e for Multimedia Traffic

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Abstract: This evaluation is intended to show through simulations, the performance of FBSS Handover mechanism compared to the Hard Handover mechanism in the case of high speed mobility with mobile WiMAX for multimedia traffic. The model we propose for the evaluation is composed to a highway in rural area between two cities and responsible of vehicles traveling in both directions with relatively high speeds and variable between 80 and 130 km/h. The passengers in vehicles are equipped with IEEE 802.16e terminals and exchange with other nodes VoIP and video traffics. The highway with 75 km length is covered by four base stations (BS) whose range is 10 Km radius, and every two BSs belong to the same Access Service Network (ASN). So, we will evaluate the QoS of this mobility model, using and comparing the Handover: Fast Base Station Switching (FBSS) mechanism with hard handover mechanism during the passage of vehicles between WiMAX cells, through the measures that we will obtain by simulations.

The simulations were conducted under the mobility module NIST of the NS2.29 simulator.

Key words: IEEE 802.16e, FBSS, Hard Handover, High-speed, L2 Handover, QoS, Soft Handover, video, VoIP.

INTRODUCTION

Services interruption during an important communication when the mobile makes a Handover passing from one cell to another of same technology with high speed, presents a real problem for users.

IEEE 802.16e is one of radio technologies well known and candidate for 4G validation, which suffer of this problem of service continuation during L2 (layer 2) or L3 (layer 3) Handover.

In this work we will try to solve a part of this problem in case of L2 Handover with high speed through the proposition of Soft handover – FBSS mechanism and its QoS simulation under NS2 simulator [NIS 06].

1. IEEE 802.16e (mobile WiMAX)

The mobile WiMAX [IEE 06] is a mobile extension of the standard IEEE 802.16 [IEE 04a]. IEEE 802.16 defines the specifications for

metropolitan networks radio or WMAN (Wireless Metropolitan Area Network), offering broadband to achieve a high flow rate and using techniques to cover large areas [IEE 04a].

The IEEE 802.16e is the version which adds specifications for mobile terminals as the standard GSM (2G) [ETS 95] and the standard UMTS (3G) [ETS 99], but with the specific use and the passage through the IP network.

The mobile WiMAX defines mechanisms of Handover (HO) [WIM 06] [ZDE 07]: Hard Handover for the simple mobility and Soft Handover for full mobility, to manage the passage of mobile WiMAX between cells. It also defines classes of services to manage QoS between terminals by classifying traffic according to its type [IEE 06].

The architecture of mobile WiMAX is composed of mobile stations (MS) who communicate freely (radio link) with base stations which act as relays with the terrestrial infrastructure of IP network. The base stations themselves are connected to the network

element (gateways) called ASN GW who manages their connection with the IP network.

The NAP (Network Access Provider) is an entity that provides the infrastructure for radio access to one or more providers of network services. It can control one or more ASN (Access Service Network) which is composed of one or more BS and one or more gateways.

The NSP (Network Service provider) is an entity that provides IP connectivity and network services to subscribers compatible with the level of service it establishes with subscribers. An NSP control one or more CSN (Connectivity Service Network) which is the core of the WiMAX network.

The IEEE 802.16e is suitable for any kind of traffic thanks to its flexibility justified by its 3 MAC layers [IEE 06] and its use of IP protocol. There are two kinds of HO in the mobile WiMAX: intra-ASN HO (level 2: no change of address IP) and inter-ASN HO (level 3: IP address change), the architecture of mobile WiMAX [MIC 06] [PAR 05] [WIM 07b] is presented in figure 1.

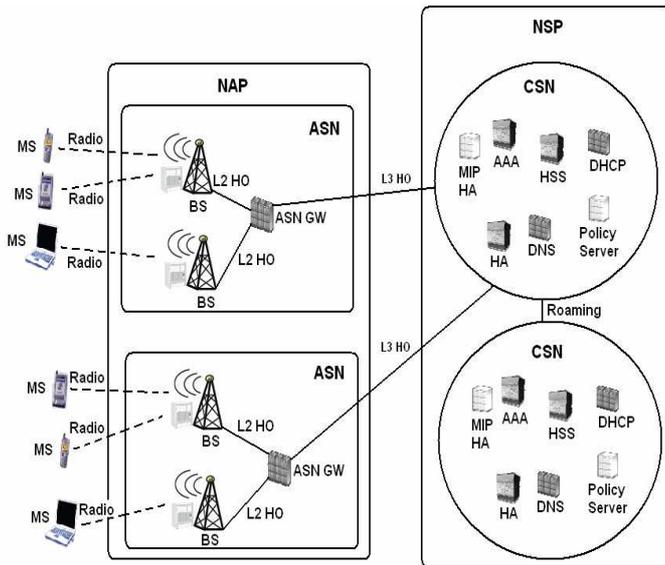


Figure 1. IEEE 802.16e architecture

2. Handover mechanism applied

In the IEEE 802.16e are 3 types of HO [MIC 06]: the Hard Handover that is applied in the case of a low speed, it uses the mechanism break-before-make (interruption connection with the old BS before the connection with the new BS), and in this case the mobile communicates with a single BS.

The Soft Handover - MDHO (Macro Diversity Handover) applied in the case of a high speed and use the make-before-break (establishment connection with the next BS before the break with the old BS), in this case the mobile communicates with several BSs at the same time.

The soft Handover - FBSS (Fast Base Station Switching) is like the MDHO, except that the mobile defines an Anchor BS among BSs which it is

connected to, and communicates all traffic including the management and signaling messages with only the Anchor BS. The mobile can changes its Anchor BS when he wants as long as it is connected with.

As already seen, in the Soft Handover there are two techniques. In our simulations we will use only FBSS technique as Soft Handover mechanism because it works exactly as MDHO technique except that it uses fewer resources with its choice of an Anchor BS.

Hard handover, FBSS and MDHO mechanisms are presented in 3 figures below [WIM 07b] [IEE 04b]:

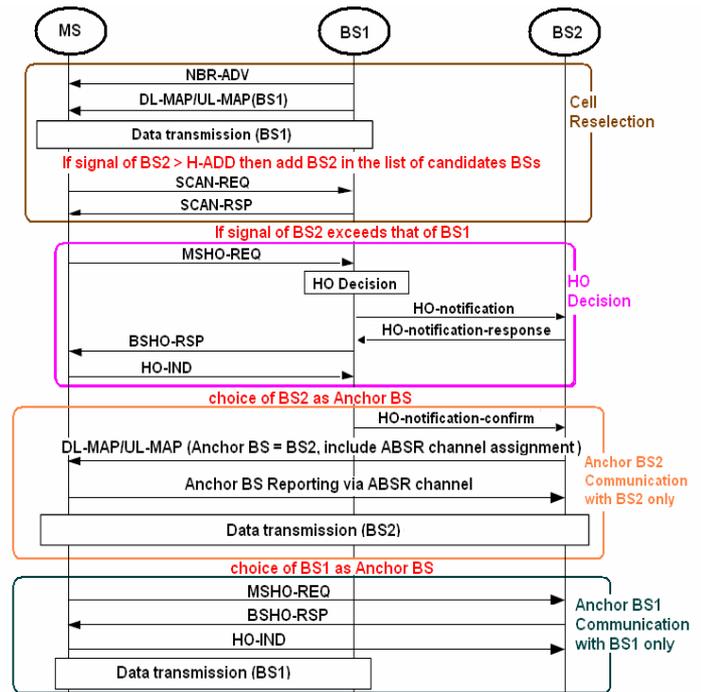


Figure 2. FBSS mechanism

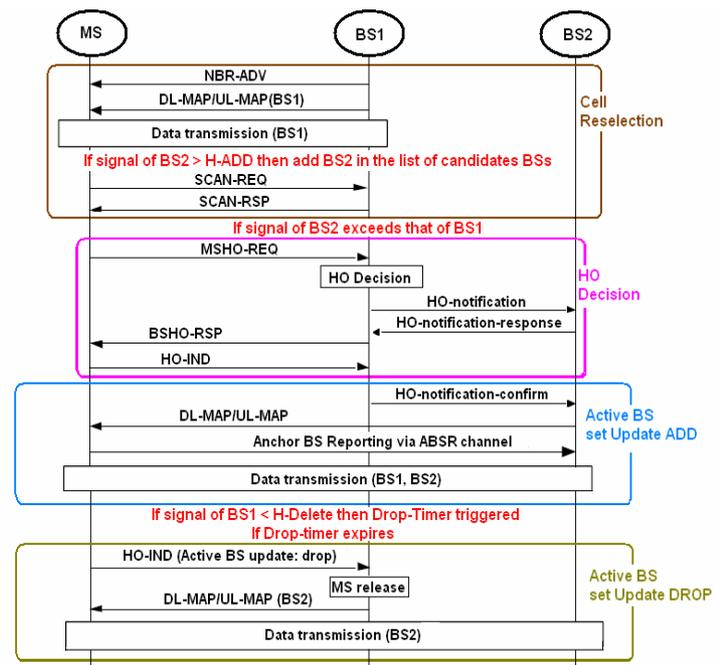


Figure 3. MDHO mechanism

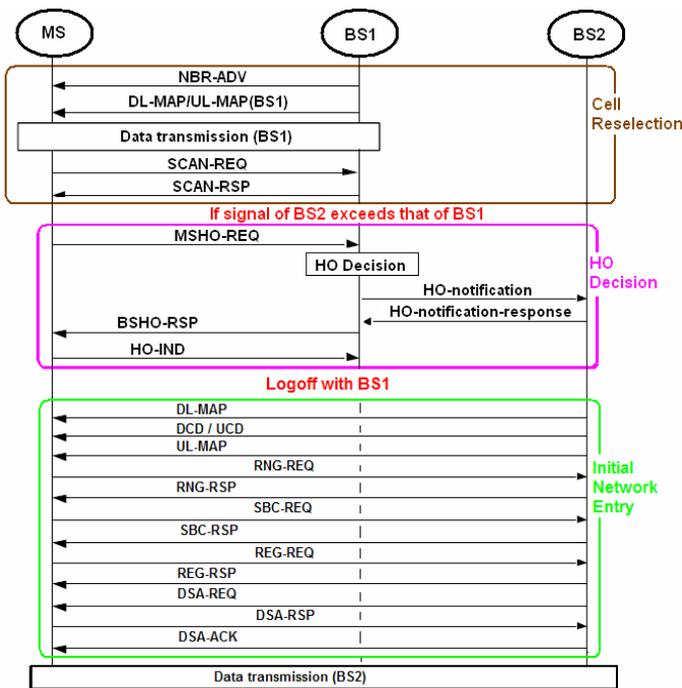


Figure 4. Hard handover mechanism

The description of messages exchanged in the figures 2, 3 and 4 is below [IEE 06]:

NBR-ADV: neighbor advertisement message.

DL-MAP / UL-MAP: downlink and uplink map messages (control messages).

SCAN-REQ / SCAN-RSP: scanning interval allocation request and response messages.

MSHO-REQ: mobile station HO request message.

BSHO-RSP: base station HO response message.

HO-IND: HO indication message.

DCD / UCD: downlink and uplink channel descriptor messages (control messages).

RNG-REQ / RNG-RSP: ranging request and response messages.

SBC-REQ / SBC-RSP: mobile station basic capability request and response messages.

REG-REQ / REG-RSP: registration request and response messages.

DSA-REQ / DSA-RSP / DSA-ACK: dynamic service addition request, response, acknowledges messages.

3. Simulation model and results

3.1. The simulation model

The simulation has been applied on a highway with distance of 75 km between two cities covered by four base stations (with range of 10 km for each BS). The diameter of HO zones (between cells) varies between 1 and 3 km. The first two BSs belong to the same ASN and the last two BSs belong to a second ASN.

The two ASN belong to the same CSN. Vehicles containing mobiles move in both directions at variable speeds between 80 and 130 km/h. The traffics exchanged between mobiles and BSs are VoIP and video, and the size of a video packet is fixed as 4960 byte and a rate as 100 packet/s, and for the VoIP, the size is fixed as 160 byte and a rate as 300 packet/s.

Figure 5 shows the simulation model:

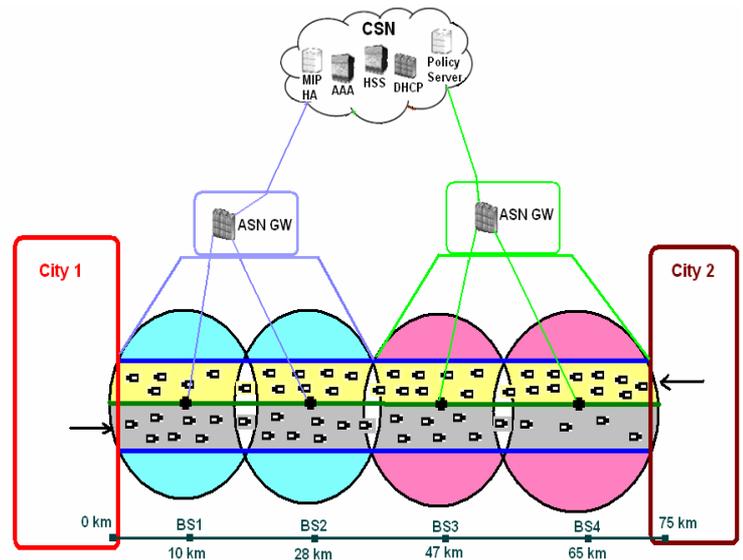


Figure 5. Simulation model

3.2. Scenario

The scenario simulated in this work begins with a fixed number of mobiles (70) distributed on the two lanes of the highway (40 and 30) and moving in both directions with other vehicles containing mobiles entering the highway during simulation in both directions. The number of mobiles entering to the highway per minute is random and bounded between one and three mobiles in the first way, and between one and two mobiles in the second way.

The choice of this scenario is intended to show the difference of QoS depending on the mobiles charge.

3.3. Simulation parameters

Simulations parameters of IEEE 802.16e architecture are illustrated below:

Transmission range: (transmission power = 15W, receiving threshold = 7.59375e-15, carrier sending threshold = 2.13841e-16), distance (coverage radius) = 10 Km, radio propagation model = TwoRayGround, transmit antenna gain = 1 dB, receive antenna gain = 1 dB, system loss = 1 dB, transmit antenna height = 1.5 m, receive antenna height = 1.5m, modulation = OFDMA, frequency = 3.5 Mhz, frequency bandwidth = 5 Mhz, multiplexage = TDD.

3.4. Performance criteria

The simulation metrics for both types of traffic

during 100 minutes are:

Average end-to-end delay, average jitter, average throughput, packet loss ratio, the total number of intra-ASN HO (L2 Handover) and the total number of inter-ASN HO (L3 Handover).

And the results obtained for two techniques, will be compared to those already defined by the standard for QoS required for multimedia traffic [WIM 07a].

3.5. Simulation results

The simulation duration was set to 60 minutes, and the results for both handover mechanisms: FBSS and Hard Handover are calculated every 5 minutes. The type of traffic used is the CBR / UDP for video and VoIP, packet size is variable for VoIP and video traffic, but the size of a video packet is higher than that of the VoIP packet.

The number of mobiles in each way varies as follows according to the time of simulation and depends on the input – output of vehicles in the highway.

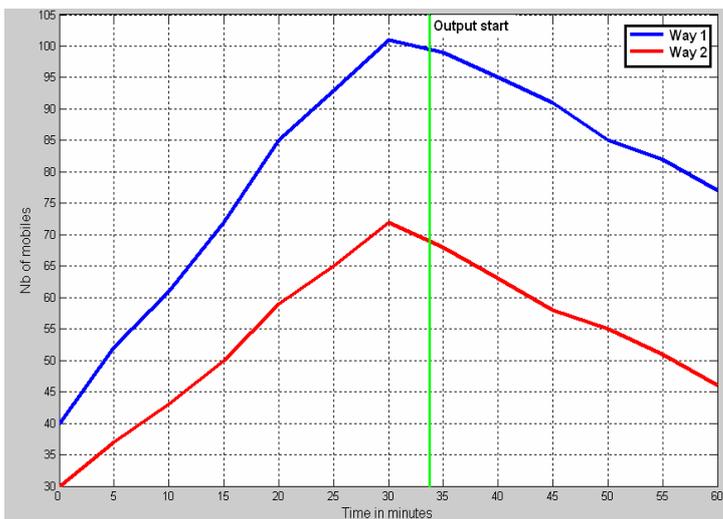


Figure 6. Total number of mobiles in highway

The number of mobiles in highway varies between 30 and 102 mobiles.

We compute know total number of intra-ASN HO and inter-ASN HO for all mobiles during their mobility, and the results obtained are shown below:

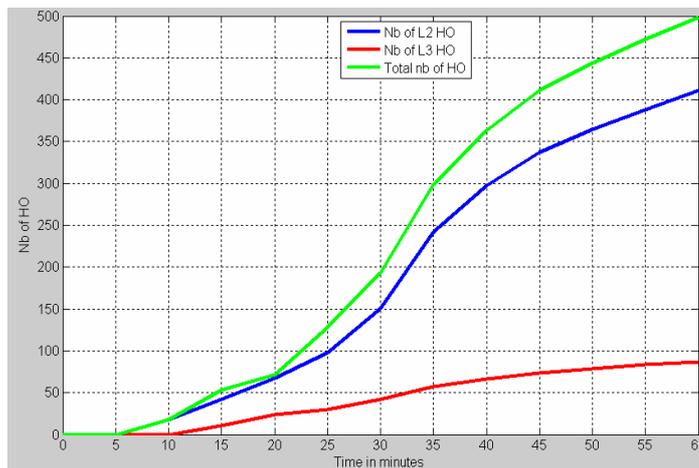


Figure 7. Total number of HO

In our simulation model, the number of intra-ASN HO areas is 2, and the number of inter-ASN HO area is 1 (fig 5). Therefore the number of intra-ASN HO is always higher than that of inter-ASN HO over time. The maximum number of HO here is near to 500 in 60 minutes.

We present in figure 8, the average end to end delay for all mobiles in 4 cells on the highway during simulation for two Handover mechanisms:

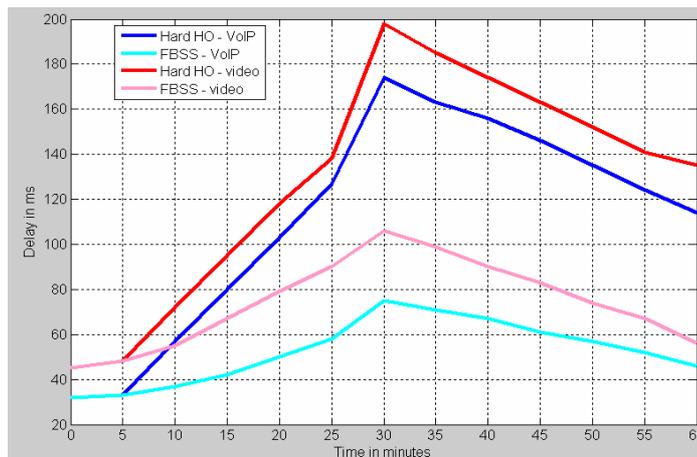


Figure 8. Average end-to-end delay

Watching this figure, we see that the FBSS Handover mechanism decreases significantly end-to-end packets delay compared to Hard handover mechanism for two traffics: video and VoIP, because there are no services interruption during handover.

FBSS is the only mechanism which respects the threshold fixed [WIM 07a] as 100 ms and defined for the QoS of video and VoIP traffics.

The maximum delay obtained for video traffic with FBSS is 104 ms and with Hard handover is 198 ms; and for VoIP traffic: with FBSS when the highway is in maximum loaded, the maximum delay is 76 ms and with Hard handover: 174 ms.

Then, delays obtained with FBSS for both traffics are satisfactory, unlike with Hard handover.

Now we introduce measures obtained for the average jitter (variation of delay):

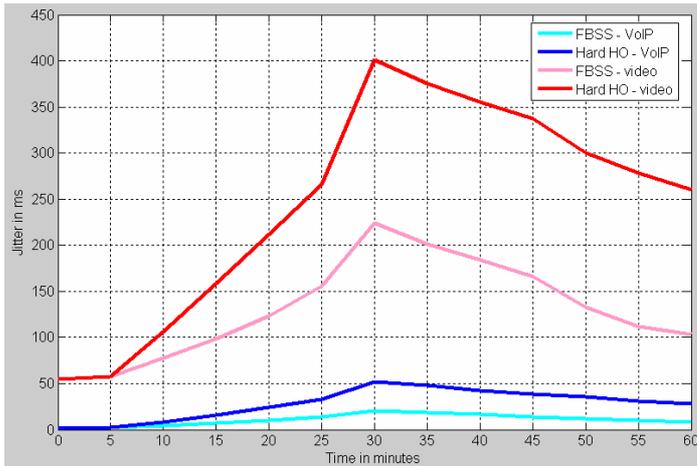


Figure 9. Average jitter

Concerning Jitter (variation of delay), for VoIP traffic, only FBSS respects the threshold fixed as 20 ms [WIM 07a], unlike Hard handover where delays exceed the threshold between 20 and 60 minutes, when the highway is very loaded and vehicle speed is high.

But for video traffic, the fixed threshold [WIM 07a] as 2 sec is respected by both techniques; this is justified by the classification of services by WiMAX.

Than, FBSS mechanism is effective in this case.

In figure 10, we will present the average packets loss ratio:

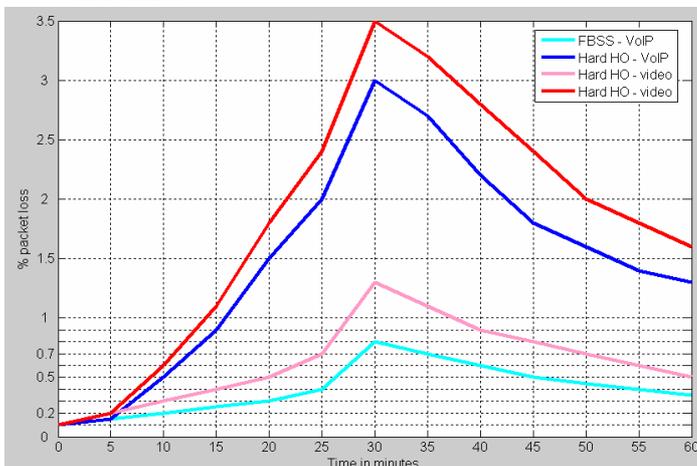


Figure 10. Average packet loss ratio

Maximum losses in these curves for video are 1.3% with FBSS and 3.5% with Hard handover. For VoIP, maximum losses are 0.8% with FBSS and 3% with Hard handover.

In this figure, only FBSS does not exceed the threshold fixed as 1% [WIM 07a] for packet loss ratio in the case of VoIP traffic.

Finally, we present in figure 11 the throughput results:

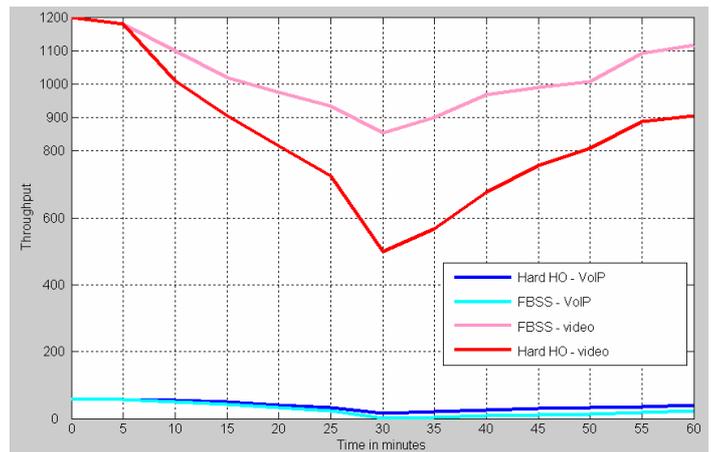


Figure 11. Average throughput

The throughput allocated for the video is roughly between 850 and 1200 kb/s with FBSS and between 510 and 1200 kb/s with Hard handover. And it is between 16 and 60 kb/s for VoIP with FBSS and between 2 and 60 kb/s with Hard handover, knowing that the QoS standard requires [WIM 07a] minimum 1000 kb/s for video and requires between 4 and 64 kb/s for VoIP traffic [WIM 07a].

4. Conclusion

The main purpose of this work is to show effectiveness of Handover mechanism FBSS compared to Hard handover for multimedia traffic in the case where the mobiles WiMAX move in high speed.

And based on the comparison of simulation results obtained for delay, jitter, packets loss and throughput with those defined in the standard of QoS [WIM 07a], FBSS has proven its effectiveness in such environment (highway) with vehicles traveling with high speed.

We must report that the performance criteria deteriorate depending on the charge of road traffic and vehicles speed. The more the highway traffic load is greater and the speed is higher the more the QoS deteriorates. Nevertheless, we notice that video requires more bandwidth than VoIP.

The implementation of this model with its two ASN and four BS gave satisfactory results, but these results necessarily depend on the number of mobiles in cells and their speed.

In the end, we can say that trough these simulations, it was able to prove the effectiveness of FBSS mechanism for high-speed in mobile WiMAX with the context already presented in comparison with the values set by the standards.

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