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QoS in IEEE 802.16e for VoIP and Video with mechanism of Soft Handover – FBSS in Highway

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Abstract—This evaluation is intended to show through simulations, the performance of FBSS Handover mechanism in the case of high speed mobility with mobile WiMAX for multimedia. The model we propose for the evaluation, is close to a real case in life, where it is made up of a highway between two cities far from 145 km and responsible of vehicles traveling in both directions with relatively high speeds and variable between 70 and 130 km/h. The passengers in vehicles are equipped with terminals adapted to the IEEE 802.16e better known as the "mobile WiMAX". As a result we will suppose that the terminals exchange traffics such as VoIP and video with base stations for a real time of 100 minutes. The highway is covered by 6 base stations, whose range is a 14 km (radius) and every two base stations belong to the same ASN. So, we will evaluate the QoS of this mobility model, which uses the mechanism of Handover: Fast Base Station Switching (FBSS) 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 simulator NS2.29 [1].

FBSS mechanism, High speed, IEEE 802.16e, L2 Handover QoS, Soft Handover.

I. INTRODUCTION

A. Problematic

Currently, the field of wireless networks suffers from the problem of multimedia service continuation: specifically, the interruption during mobile change cell to another with high speed. In this context, and based on wireless network: IEEE 802.16e, we will try to prove through simulations in a real model, the effectiveness of Soft Handover mechanism: FBSS in such situation.

B. Mobile WiMAX (IEEE 802.16e)

The mobile WiMAX (IEEE 802.16e) [2] is a mobile extension of the standard IEEE 802.16 [3]. 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 [3].

The IEEE 802.16e is the version which adds specifications for mobile terminals as the standard GSM (2G) [4] and the standard UMTS (3G) [5], but with the specific use and the passage through the IP network.

The mobile WiMAX defines mechanisms of Handover (HO) [6] [12]: 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 [2].

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 [2] 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 [7] [10] is presented in figure 1.

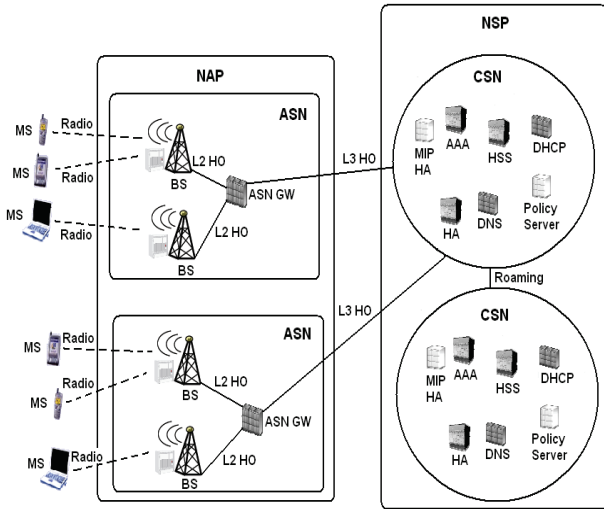


Figure 1. Architecture of IEEE 802.16e

II. HANDOVER MECHANISM APPLIED

In the IEEE 802.16e are 3 types of HO [6]: The Hard Handover which 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 messages management and signaling with only the Anchor BS. The mobile has the right to change Anchor BS when he wants as long as it is connected with.

In our simulations in the highway, vehicles move at high speed, so we will choose to implement the FBSS as Soft HO mechanism between cells [6].

A description of messages exchanged between BSs and mobile in case of MDHO and FBSS is represented in the figure 2 and 3 to show the difference between the two Soft HO mechanisms [8] [11]:

There is two reasons why we prefer to implement FBSS as HO mechanism in our simulations: the Hard Handover is not adapted to high speed, insofar as there will be too many losses which is not acceptable for multimedia traffic, and MDHO technique uses lots of radio resources because the mobile must communicate its traffic with all BS neighbors at the same time.

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

NBR-ADV: neighbor advertisement message.
 DL-MAP/UL-MAP: control messages.
 SCAN-REQ: scanning interval allocation request.
 SCAN-RSP: scanning interval allocation response.
 MSHO-REQ: MS HO request message.
 BSHO-RSP: BS HO response message.
 HO-IND: HO indication message.

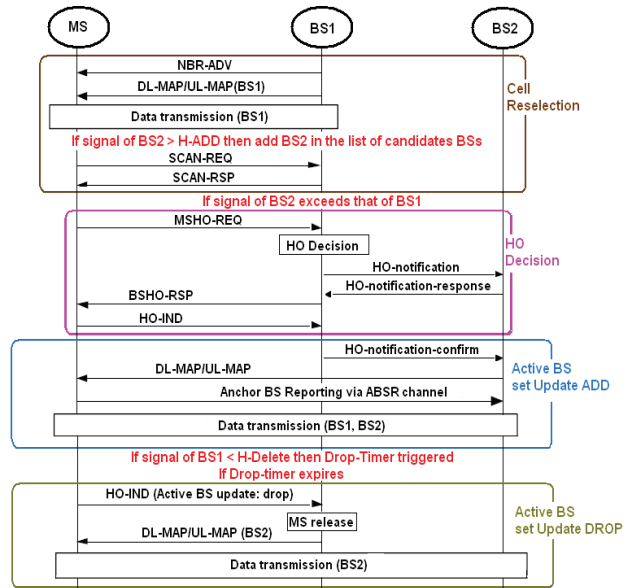


Figure 2. MDHO mechanism

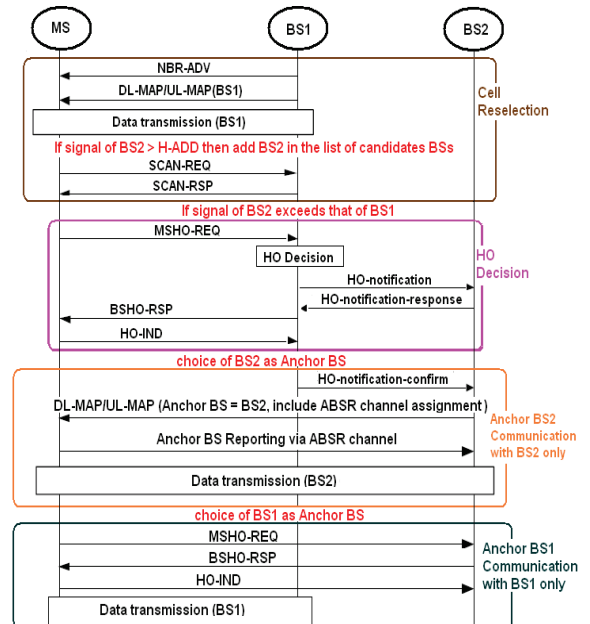


Figure 3. FBSS mechanism

III. ARCHITECTURE OF SIMULATED MODEL AND RESULTS

A. Simulation model

The simulation has been applied on a highway with distance of 145 km between two cities covered by six base stations (with range of 14 km for each BS). Areas of HO zones (between cells) vary between 1 and 3 km. The first two BSs belong to the same ASN, the following two BSs belong to a second ASN, and the last two BSs belong to a third ASN.

The three ASN belong to the same CSN. Vehicles containing mobiles move in both directions at variable speeds between 70 and 130 km/h. The traffics exchanged between mobiles and BSs are VoIP and video. 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 4 shows the simulation model:

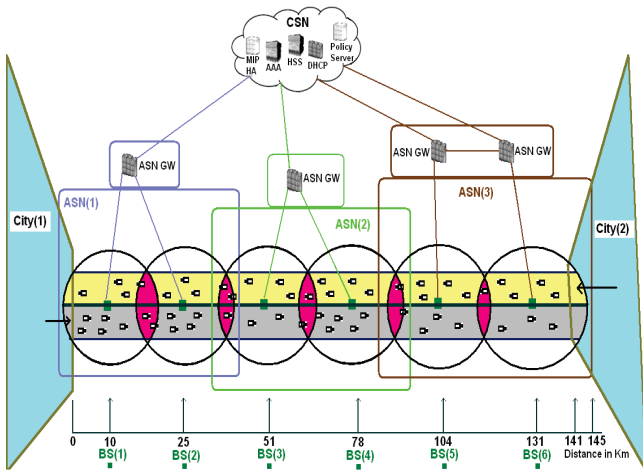


Figure 4. Simulation Model

B. Scenarios

Two scenarios were simulated in this work:

We use in the first scenario a fixed number of mobiles (123) distributed on the two lanes of the highway and moving in both directions.

The second scenario begins with the same number of mobiles, but with vehicles 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 these two scenarios is intended to show the difference of QoS depending on the mobiles charge.

C. 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, will be compared to those already defined by the standard for QoS required by video and VoIP traffic [9].

D. Simulation results

The simulation duration was set to 100 minutes, and the results are calculated every 8 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.

At the beginning of the simulation, the 123 mobiles distributed in cells throughout the highway as indicated below in figure 5.

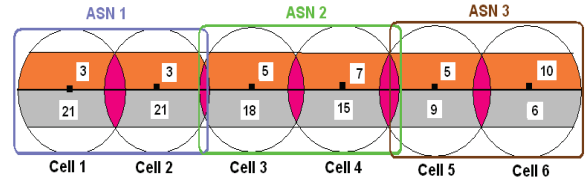


Figure 5. Number of mobiles in Cells

The number of mobiles varies as follows according to the time of simulation for both scenarios

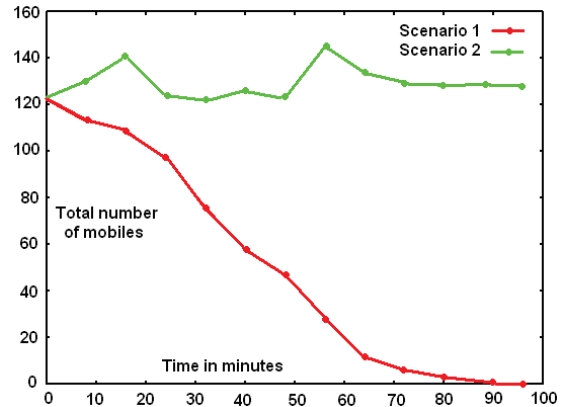


Figure 6. Total number of mobiles in cells

In the first scenario, the number of vehicles decreases until becoming null at the end of simulation because there are no new vehicles entering the highway and existing vehicles leaving the highway.

In return, in the second scenario, the number of mobiles varies between 122 and 145 over time because new vehicles enter the highway every minute and existing vehicles leaving the highway.

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

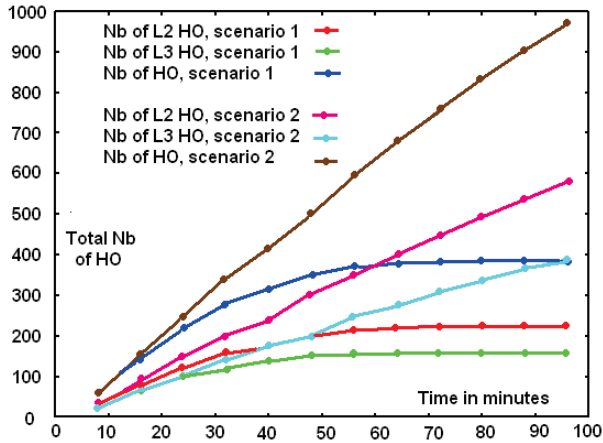


Figure 7. Number of HO intra/inter - ASN

In our simulation model, the number of intra-ASN HO zones is 3, and the number of inter-ASN HO zones is 2 (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 973 in 100 minutes.

We present in figure 8, the average end to end delay for all mobiles in 6 cells on the highway during simulation.

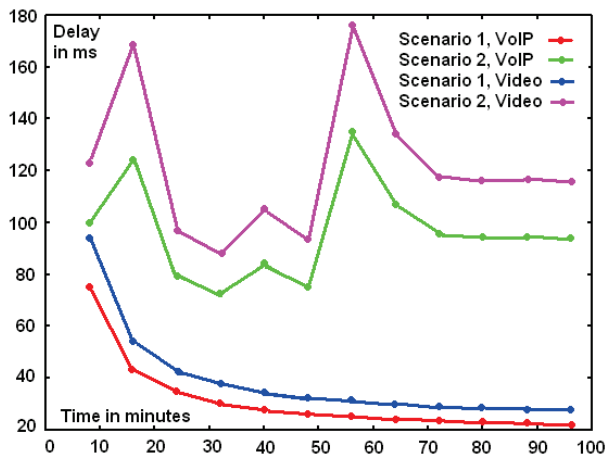


Figure 8. Average Delay

The maximum delay obtained is 176 ms for video and 135 ms for VoIP and the average delay obtained for both types of traffic is about 100 ms, knowing that the QoS standard requires maximum a delay of 100 ms for both types of traffic [9]. The two peaks in the curves express the high number of mobiles traveling at high speed in these periods of simulation on highway. So, we can see that these periods depend on the highway traffic load and vehicles speed.

Then, delays obtained are satisfactory, as we get an acceptable quality of voice and video with our model and with FBSS mechanism.

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

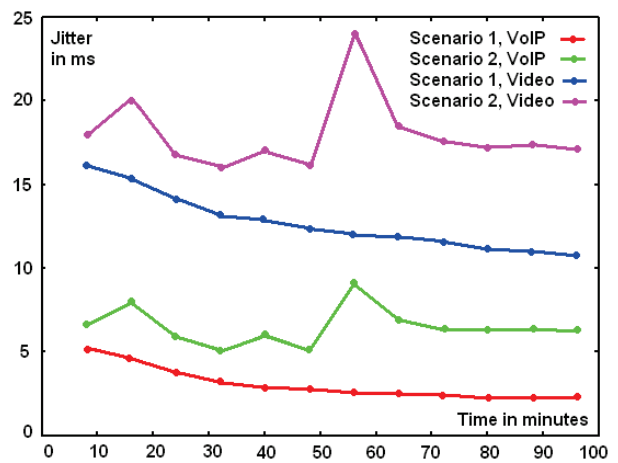


Figure 9. Average Jitter

Jitter also depends on the highway traffic load, so when the number of mobiles is maximal, jitter is maximal. In the results obtained, the maximum jitter for video does not exceed 25 ms and the one for VoIP does not exceed 10 ms, knowing that, the QoS standard requires maximum 20 ms of jitter with VoIP traffic and 2 sec with video traffic, so the jitter is of good quality according to the standard [9].

Then, FBSS mechanism is effective in this case.

In figure 10, we present the average packet loss ratio:

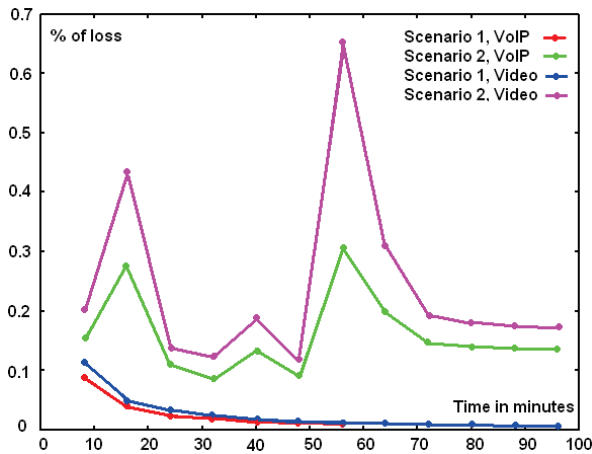


Figure 10. Average Packet loss ratio

Maximum losses in these curves are 0.66% for video and 0.3% for VoIP and average losses with video are 0.2% and with VoIP are 0.15%. For VoIP, these results are acceptable for a good quality, but for video it is different because it requires less loss, so we can judge this quality medium [9].

The reason behind this difference in packets loss between the two types of traffic: is that WIMAX makes service differentiation according to their priority and available radio resources. In our case here where the number of mobiles is too large and radio resources are not sufficient, the VoIP does not tolerate packets losses unlike the video which accepts some packets losses. The WIMAX network makes its choice award available resources so video lose more packets than VoIP.

Finally, we present in figure 11 the throughput results:

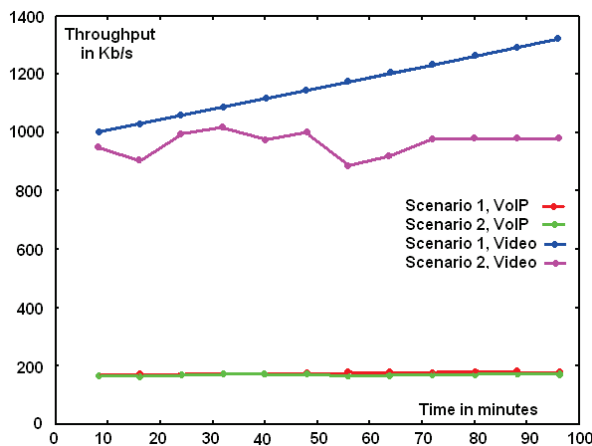


Figure 11. Average Throughput

The throughput allocated for the video is roughly between 900 and 1300 kb/s and it is around 180 kb/s for VoIP, knowing that the QoS standard requires minimum 1000 kb/s for video and requires between 4 and 64 kb/s [9]. Here, the throughput increases for less traffic.

We notice in this figure those throughputs encountered in first scenario are better than those in second scenario because the highway traffic is more loaded in the second scenario.

IV. CONCLUSION

The main purpose of this work is to show effectiveness of Handover mechanism FBSS for multimedia traffic in the case where the WiMAX mobiles 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 [9], 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 three ASN and six 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 [9].

In this work we began to work on QoS in highway with full mobility, future work will focus simulations in an urban area (city) with a variable speed (simple and full mobility), integrating another mechanism of HO to compare their performance and other types of traffic.

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