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Inter-ASN Handover Using MSCTP Protocol in IEEE 802.16e Networks

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***Abstract*—We propose in this paper, to replace the two Layer 3 Handover mechanisms defined for the situation of macro mobility with IP address change in IEEE 802.16e: "Client-MIP and Proxy-MIP", by the new protocol created specially for the mobility without services interruptions: "MSCTP", which has the peculiarity to support several IP sessions at the same time.**
The purpose of this proposal is to reduce the latency and avoid the interruption of services during the IP address change procedure by the mobile station.
We compare simulation results, done with NS2 [1], between MSCTP, PMIP and CMIP protocols under the context of simple and full mobility.

Client-MIP, IEEE 802.16e,Inter-ASN, mobility, MSCTP, Proxy-MIP, QoS, video.

I. INTRODUCTION

A. Problematic

Currently, the field of wireless networks suffers from the problem of multimedia service continuation, and specifically the interruption during Layer 3 Handover (macro mobility with IP address change). In this context, and based on IEEE 802.16e networks, we try to prove through simulations, the effectiveness of MSCTP mechanism in such situation.

B. Mobile WiMAX (IEEE 802.16e)

The IEEE 802.16e [2] is a mobile extension of the standard IEEE 802.16 [3] which defines the specifications for metropolitan networks radio, offering broadband to achieve a high flow rate and using techniques to cover large areas.

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 Handover (HO) in the mobile WiMAX: Intra-ASN Handover (layer 2: no change of IP address) and Inter-ASN Handover (layer 3: IP address change) [4] [5].

IEEE 802.16e defines two mechanisms for the Inter-ASN Handover: Mobile IPv4, also known as Client-MIPv4; and Proxy-MIPv4 [4].

The architecture of mobile WiMAX is composed of mobile stations (MS), which communicate freely (radio link) with base stations (BS), which act as relays with the terrestrial infrastructure of IP network. The base stations themselves are connected to the network elements (gateways) called ASN GW which manages their connection with the IP network [4] [5].

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 architecture of mobile WiMAX is presented in the figure 1 [4] [5]:

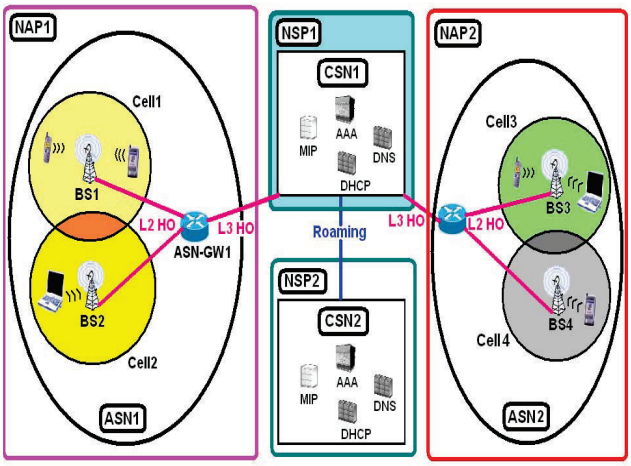


Figure 1. Architecture of IEEE 802.16e

II. INTER-ASN HO MECHANISMS IN IEEE 802.16E

IEEE 802.16e defines 2 types of Layer 3 HO [4] Mobile IPv4 (MIP) or Client-MIPv4 (CMIP) and Proxy MIPv4 (PMIP).

CMIP provides a set of extensions to the Interne protocol standards defined by the IETF. Its focus is to allo user to register on foreign networks and connect back t their home network via a combination of FA (Foreig Agent) and HA (Home Agent) [6]: When MS move t another network, a router of visited network supporting I (FA) which broadcasts packets periodically in network t detect newcomers adds it. After having acquired temporary IP address in the visited network, when the M contacts its corresponding server with its new IP addres the source address in the IP packet sent does not contain th current IP address of the MS, but the address of its Hom Agent (HA) attached to home network. The correspondin returns its response to the HA and, the HA creates a tunne and send the packet directly to the MS [7].

In CMIP mechanism, the MIP standard exists in the MS therefore there is a lot of complexity in MS.

Also CMIP is incompatible with IP-sec based VPNs an with NAT gateways, while NAT (network address translator) and VPN (virtual private network) refers to a Network topology, in which Mobile IPv4 traffic has to traverse one or more NAT gateways followed by a VPN gateway in the path to its final destination [8].

To correct these problems, they have introduced a functional entity called Proxy Mobile IP to help MIP traversal across VPN or "NAT and VPN" gateways. The PMIP is in the path between MS and its corresponding HA, and acts as a surrogate MS and HA.

PMIP does not involve a change in the point of attachment address when the user moves and there is no need for the terminal to implement a client MIP stack [4]. And if we point to the stage where the HA creates a tunnel, it does not sent the packet directly to the mobile in the visited network, but send the packet to a FA which implement the protocol MIP standard and belong to the network visited by the mobile. At the end, FA delivers the packet to the mobile.

The exchange of messages for both techniques between different entities is illustrated in the two figures 2 [9]:

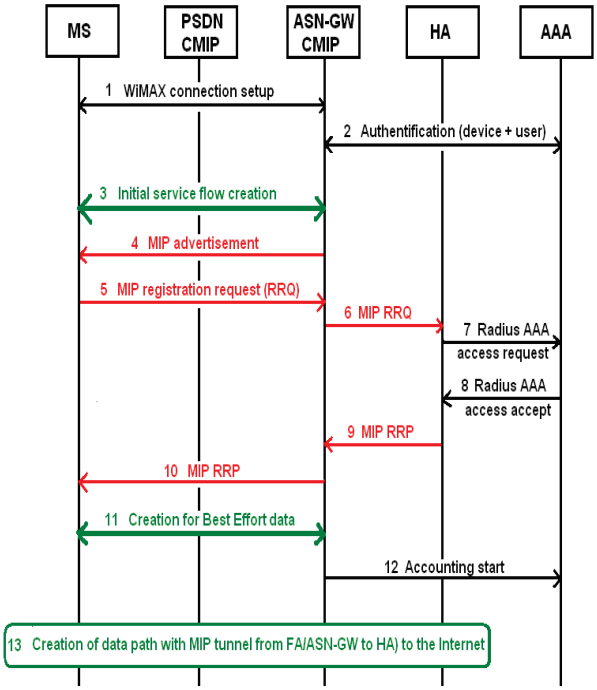


Figure 2. CMIP mechanism

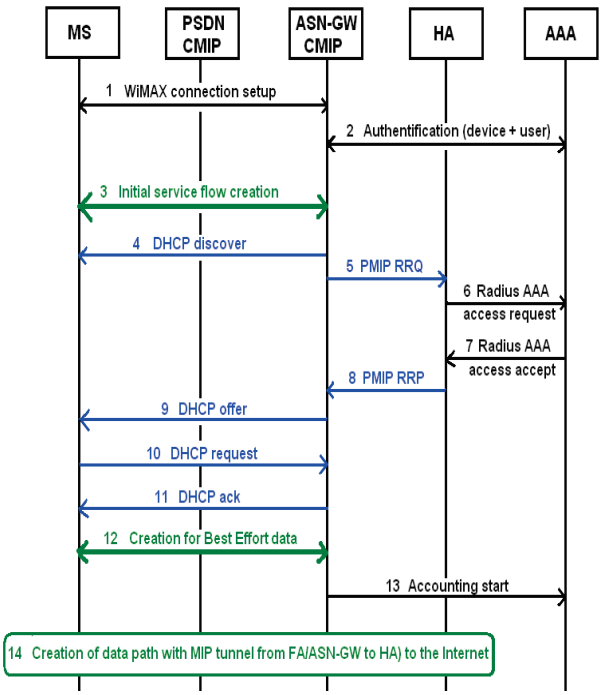


Figure 3. PMIP mechanism

III. MECHANISM PROPOSED FOR LAYER 3 HO: "MSCTP"

The mobility of transport layer is proposed as an alternative to the mobility of network layer to support integrated mobility. The management of mobility in the transport layer is made exclusively by Stream Control Transmission Protocol (SCTP) [10] and its extension: Dynamic Address Reconfiguration (DAR) [11]. SCTP extended with DAR constitute Mobile SCTP (MSCTP) [12] [13] [14].belong to a second ASN, and the last two BSs belong to a third ASN.

MSCTP was designed in order to avoid the connections disruptions observed with TCP or UDP during a change of IP address. It is a transport layer protocol similar to Transmission Control Protocol (TCP). It provides point-to-point communication oriented connection between applications running on different hosts. The major difference with TCP is the multi-homing; it allows by multi-homing to manage multiple IP addresses in terminal nodes by conserving the point-to-point connection intact [15].

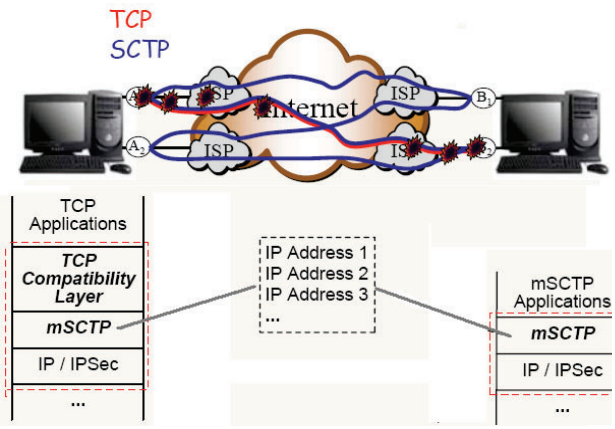


Figure 4. MSCTP VS TCP and protocol stack

In the mobile station implementing MSCTP protocol, one address is chosen as the primary address and is used as destination address for the normal transmission. The other addresses are used only for retransmissions. The DAR extension allows the terminal nodes to add, delete and change IP addresses during a SCTP session between two MS implementing MSCTP agent, without affecting the established connection by using address configuration messages.

During a communication with a distant server (DS), when the MS changes its home network to a foreign network passing by Handover Area (at the beginning of the coverage area of foreign network), the MS receives an IP address from the foreign network either by contacting a DHCP, or by automatic configuration of IPv4 address. The MS is now able to establish a liaison with the DS through this second IP address and is accessible via the home and the foreign networks. Then, the MS sends to the DS via its home network, its second IP address. It therefore adds the new IP address to the association identifying the connection to the DS. The DS, then, responds with an acquittal. After, when the MS leaves the coverage area of its home network, it notifies the DS to assign the new IP address as primary IP address, which the DS approves with an acquittal. The new primary IP address is now the address of MS destination for the communication. The DS sends at this moment all his messages to the new IP address of MS. Finally, the MS inform the DS to delete the first IP address of the association, which the DS confirms with an acquittal [12] [13] [14].

IV. DIFFERENCE BETWEEN THE THREE MECHANISMS

We present in this section a comparative table of the three mechanisms:

Protocol	CMIP/PMIP v4	MSCTP
Protocol layer	Network	Transport
Transport protocol	TCP/UDP	SCTP
Location management	Yes	No
Route optimization	No	Yes
Deployment	Two agents : HA & FA	No addition device
Association	Only one IP address	Several IP address
Technique used during Handover	Break-before-make	Make-before-break

V. SIMULATION MODEL AND RESULTS

A. *Simulation model and proposed scenario*

The proposed model is composed of two WiMAX cells with coverage of 3 Km radius for each BS and an area of 28 km² for each cell.

Each cell belongs to a different ASN, and the two BSs are connected with the same CSN via different ASN-GWs. The HO area is the common area between the two cells and has a surface near to 3 km²; and we have set a number of MSs moving randomly in each cell as 50.

In this paper, only one mobility scenario is proposed for simulation with two different speeds: simple mobility with 50 km/h and full mobility with 100 km/h.

A mobile station is localized at the beginning in the coverage area of the first cell, and it is in communication with a distant server localized in a foreign network. During communication, the traffic passes via BS1, ASN-GW1, CSN and at the end Internet until it reaches the distant server. The proposed traffic in our simulations is video traffic.

After, the MS starts to move towards the second cell, continuing its communication with the server. During the MS moving, and passing by the HO area, we establish a comparison by applying the two Layer 3 Handover mechanisms proposed by the IEEE 802.16e standard: CMIP and PMIP, which can use only one IP address; and the proposed mechanism: MSCTP which uses the Multi-Homing technique which allows to mobile to maintain multiple IP sessions.

At the end, the MS leaves definitely the Handover area and the coverage area of the first cell to join the second cell, there, the communication passes by BS2 and ASN-GW2 instead of BS1 and ASN-GW1.

During Layer 3 Handover, with CMIP mechanism, the mobile implement the MIP module; with PMIP, the ASN-GW implement the MIP module; and with MSCTP mechanism, we apply the Multi-Homing technique by opening two IP sessions to communicate with BS1 and BS2 together at the same time.

The proposed model and the scenario of mobility are illustrated in the figure below.

Also the scenario using MSCTP is presented in the same figure here in blue.

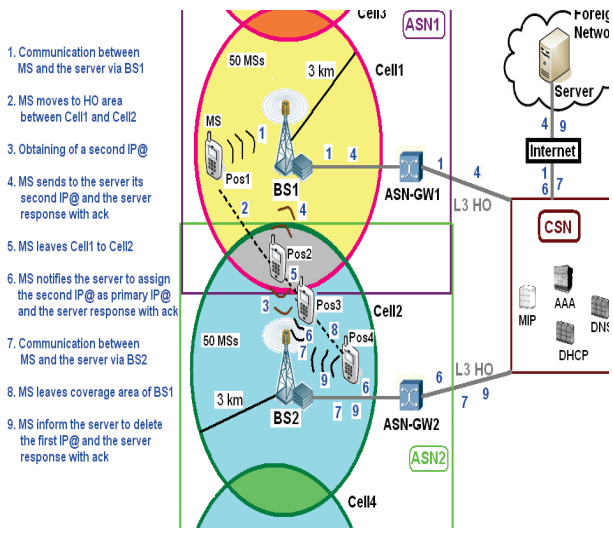


Figure 5. Simulation model, scenario and MSCTP operation

B. *Simulation parameters*

For the two IEEE 802.16e cells, the simulation parameters are illustrated in the table below:

	IEEE 802.16e
Transmission Power (Pt_)	15 W
Receiving Threshold (RXThresh_)	9.375-13 W
Carrier Sending Threshold (CSThresh_)	1.34219e-14 W
Coverage Radius (Distance D)	3 km
Radio Propagation Model	Two-Ray Ground [17] $P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L}$
Transmit Antenna Gain (Gt_)	1 dB
Receive Antenna Gain (Gr_)	1 dB
System Loss (L_)	1 dB
Transmit Antenna Height (ht_)	1.5 m
Receive Antenna Height (hr_)	1.5 m
Modulation	OFDMA
Frequency (Freq_)	3.5 Mhz

The performance criteria listed in our simulations to establish a comparison between Client-MIP, Proxy-MIP, and MSCTP mechanisms are: End-to-end delay, jitter, packets loss ratio and throughput.

D. *Simulation results*

The simulation duration was set to 250 seconds, and the results are calculated every 20 seconds out of Handover and every 5 seconds during Handover. The types of traffic used are CBR / TCP for Client-MIP and Proxy-MIP mechanisms, and CBR / SCTP for MSCTP mechanism. The size of a video packet is fixed to 4960 byte and the CBR is equal to 100 packet/s.

We plot figures representing end to end delay, jitter, packets loss ratio and throughput for the three Layer 3 Handover mechanisms with the two mobile speeds. We use the same thresholds like in [16] which are defined for video traffic.

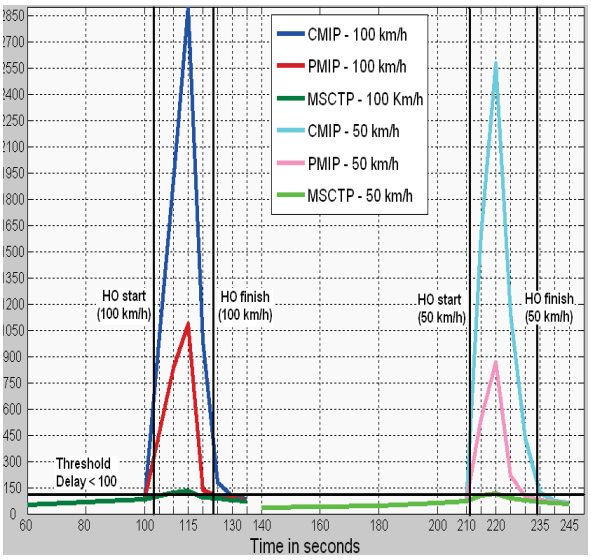
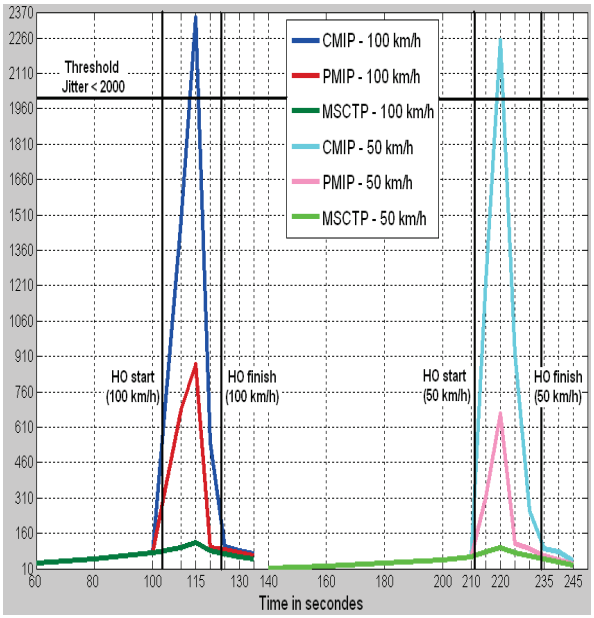


Figure 6. Delay

We see in this figure that, the only mechanism which respects the fixed threshold [16] for the video traffic delay during Handover is MSCTP. Thanks to the Multi-homing technique, MSCTP provides better results than CMIP or PMIP. It also notes that CMIP and PMIP exceed widely the fixed threshold but PMIP gives better results than CMIP. With a mobile speed of 100 km/h, and with MSCTP, delays during Handover exceed slightly the fixed threshold, while with a mobile speed of 50 km/h the results are better.



Concerning Jitter (variation of delay), we see in this figure that only the two mechanisms MSCTP and PMIP respect the fixed threshold for video traffic. MSCTP results are better then those obtained with PMIP.

The jitter values obtained during the Handover with CMIP are not acceptable, because they exceed the threshold. It also notes that the results obtained with simple mobility are better than those obtained with full mobility.

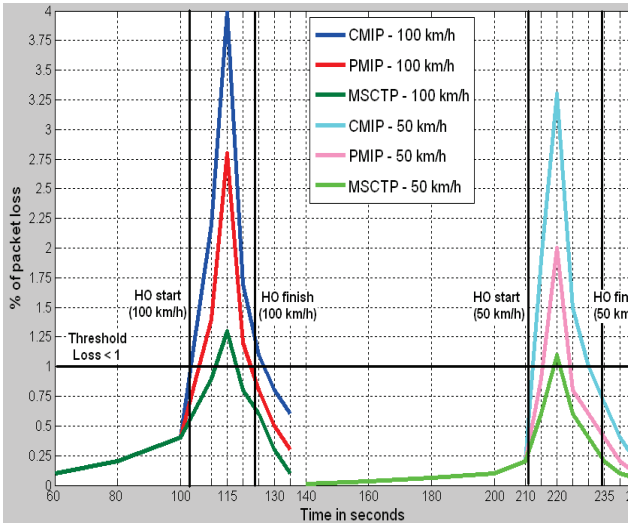


Figure 8. Packets loss

In this figure, only the MSCTP mechanism, in the context of simple mobility does not exceed the threshold for packet loss ratio in the case of video traffic. With full mobility, and with MSCTP, the results exceed slightly the threshold. The results obtained with CMIP and PMIP are not acceptable based on threshold.

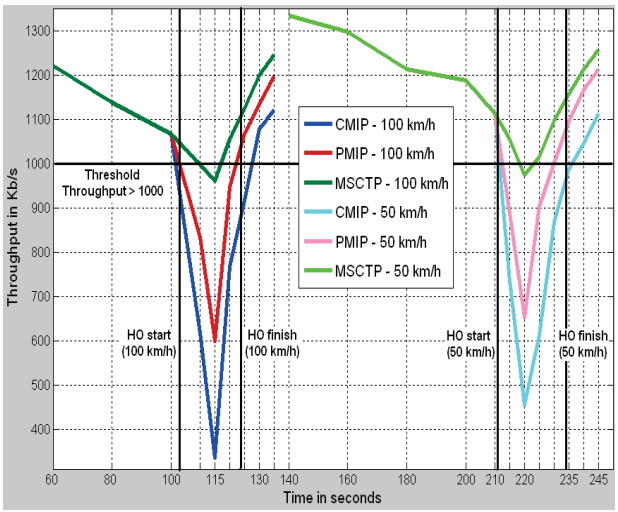


Fig. 9. Throughput

MSCTP in the context of simple mobility is perfect for video traffic, although with full mobility, the results exceed slightly the threshold fixed for video throughput. CMIP and PMIP provide results which are not acceptable for video traffic during Handover.

VI. CONCLUSION

In the wireless networks, the mobility from one network to another is an important issue, CMIP and PMIP show limitations when multimedia applications are sensitive to delay, because the triangular routing adds time, and the overhead of tunneling adds bytes to the headers of packets. To help mobile move from an IP network to another without interruption of the current association, the MSCTP protocol is implemented to benefit from its multi-homing technique. MSCTP is proposed in this paper as alternative of CMIP and PMIP for IEEE 802.16e with multimedia traffic, in order to classify WiMAX mobile as 4G technology which doesn't interrupt services during handover.

During the Handover, the endpoint using MSCTP protocol utilizes two network interface adapters. When one adapter is down, another adapter is still in the association to make a new path with peer endpoint. This "make-before-break" Handover can reduce handover latency heavily, thereby increasing the quality of the network. In additional, MSCTP is based on SCTP application, which is more powerful than UDP and TCP and, indeed, is designed to replace TCP and UDP. Also, MSCTP does not need any additional devices. The only requirement of MSCTP is that both the endpoints should support MSCTP which make MSCTP less costly and much easier to implement.

At the end, watching the simulation results obtained during Handover for the delay, gigue, loss packets and throughput, and with the two mobile speeds; it is clear that, the only technique able to generate good quality for video traffic is MSCTP. It is the only mechanism in the simulations that respects the thresholds required by the video traffic, which proves the performance of MSCTP compared to Client-MIPv4 or Proxy-MIPv4 for Layer 3 Handover with multimedia traffic.

Last comment: it has been proven through simulations the performance of MSCTP in case of L3 Handover, but in view of current software implementations using TCP and UDP, the choice of SCTP will require a reconfiguration of software.

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