Seamless Multimedia Handoff for Hierarchical Mobile IPv6

Khaled Zeraoulia
Department of Computer Science.
University of Sciences and Technology Houari Boumediene (USTHB)
Algiers, Algeria
Khaled.zeraoulia@gmail.com

Nadjib Badache
Research Center on Scientific and Technical Information
CERIST
Algiers, Algeria
nbadache@Cerist.dz

***Abstract*—The majority of today's multimedia applications and content reside on the Internet. Since the Internet Protocol (IP) is the "glue" that holds the Internet together, there is enormous interest in extending IP to mobile multimedia networks. Handover is one of the most important factors that may degrade the performance of real-time applications in mobile multimedia networks. In this paper, we introduce a novel mobility management strategy for mobile IP networks, in which we develop a seamless handover scheme called SHMIPv6 (Seamless Multimedia handoff for hierarchical Mobile IPv6). By integrating MAC and Network layer handovers efficiently, SHMIPV6 can significantly reduce the system signaling cost and handover delay. Also, our performance study shows that SHMIPv6 achieves loss-free packet delivery using an anticipated buffering scheme.**

Keywords- Seamless handover; HMIPv6; multimedia applications.

I. INTRODUCTION

Mobile IP is the key protocol in providing mobile multimedia applications to mobile devices [1][2]. These applications concern all modern life aspects: peer-to-peer communications, video conferences, remote learning, etc. Several standard bodies such as the IETF [2] are working on the specifications of all IP wireless networks that allow roaming users to access integrated data, voice, and multimedia services. A wide variety of mobility management schemes have been proposed [5][9][12][14][15] working at different layers of the protocol stack. However, these schemes are not suitable for all types of applications. Thus, dedicated schemes capable of acting more semantically must be developed; e.g., in the case of HTTP or FTP applications, handoff latency is not of vital importance (waiting one or two seconds extra when downloading a web page is not critical). But for real-time media, latency and packet losses are extremely important and even a small disturbance can make a media stream unintelligible .The mobility requirements can be satisfied by handover solution based on integrating of MAC and Network layer mechanisms[3][12]. Although the mobile IPv6 offers mobility management capability, however, MIPv6 is not suitable for supporting streaming media with stringent delay and eliminates packet losses requirements [6][7]. Therefore, the MIPV6 handoff needs careful investigation to offer reasonable delays and packet loss for mobile multimedia application. The rest of this paper is structured as follows: handover, MIPv6 and HMIPv6 are analyzed in Section 2. Section 3 introduces the basic idea of the improved scheme SHMIPv6 in detail. Simulation setup and results of performance comparison are provided in Section 4. Finally, concluding remarks are presented in Section 5.

II. THEORETICAL BACKGROUND

A. Handover Management

The process by which a Mobile Node (MN) changes to a new subnet is called handover. Handover in packet networks is administratively costly due to the number of signaling messages involved and the change of state in participating nodes. Although Mobile IP is designed for mobility management in IP networks, it causes a high latency and signaling overhead during handover. Therefore, advanced mobility mechanisms improving Mobile IP are desirable to perform efficient handovers. Also, appropriate Quality of Service (QoS) support is needed for mobility-enhanced Internet Protocol (IP) in order to meet mobile user's expectations.

1) MAC Layer Handover (Handover Layer 2)

The handover preparation procedure begins when MN moves into the overlapping radio coverage area of two adjacent subnets, it needs to perform a Handover Layer 2 (MAC Layer) to bring to an end the association with the old Access Point and re-associate with new one [5]. This will require some steps such as detection, authentication and re-association with the new Access Point. Only, after these procedures will finish, higher layer protocols can proceed with their signaling procedure, such as layer 3 router advertisements. Once the MN finishes Handover Layer 2 and receives the router advertise from the Router, it should begin to obtain a new router address.

2) Anticipated Handover

Handover is initiated when either the MN or the previous Router have predictive information about the next point of attachment to which the MN will move to Neighbor Discovery for IP Version 6 (IPv6)[11]. Nodes (MN and Routers) use Neighbor Discovery (ND) protocol [11] to determine the link-layer addresses for neighbors known to reside on attached links. Nodes also use Neighbor Discovery to find neighboring routers that are willing to forward packets on their behalf. Finally, nodes use the

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protocol to actively keep track of which neighbors are reachable and which are not, and to detect changed link-layer addresses. If the MN has such information, or it chooses to force a handover to a new subnet, it sends a Router Solicitation for Proxy (RtSolPr) to the previous Router, and receives a Proxy Router Advertisement (PRtAdv) in response, providing the MN with the L2 (MAC Layer) information, such as the subnet prefix, link quality, measured bandwidth and available attachments status required for the MN to establish a new Care-of-Address (CoA) on the new subnet [12]. When previous Router receives an indication from L2 that the MN will be moving or RtSolPr indicating that the MN wants to move, the previous Router exchanges messages with new router in order to obtain or validate the new CoA for the MN. The previous Router sends a Handover Initiate (HI) message to the new router. The HI message contains the requested new CoA on the new subnet.

B. Mobile IPv6 overview

The IETF is in the midst of designing Mobile IPv6 [2]. The true goal of MIPv6 is to offer an end-to-end IPv6 operability between mobile devices. It should be mentioned here that there is a standard for Mobile IPv4 [10]. The basic principle for both MIPv4 and MIPv6 is that all mobile nodes have a permanent IP address on a "home" network. When a mobile node (MN) roams to another subnet, it must first acquire a temporary (CoA) on that network. The next step is to send a binding update (BU) back to a special router on the home network named the Home Agent (HA). A BU associates the CoA with the permanent IP address of the MN. When any other Correspondent Node (CN) sends an IP packet addressed to the permanent IP address of the MN, the HA intercepts the packet and, using the BU, tunnels the packet to the CoA of the MN. At this point, the MN knows the address of the CN by looking at the source address of the packet header. Therefore, the MN does not have to tunnel reply packets to the CN through the HA but can send them directly to the CNs destination address. The MN can elect to send a BU to the CN so that the CN can send optimally routed packets to the MN instead of having to go through the HA. How does MIPv6 discover that the MN has moved to a new subnet? The MIPv6 requirement is that a router supporting Neighbor Discovery [11] must be operational on the subnet. This router sends out a "beacon" packet of 32 bytes called a Router Advertisement [11]. The recommended intervals are from 20 to 1500 milliseconds between advertisements. The first time an MN receives an advertisement, it can examine it to find out what the subnet prefix is and when to expect the next advertisement. If the "old" advertisement is overdue or an advertisement with a "new" subnet prefix shows up then MIPv6 has discovered that it has moved to a new subnet.

C. Hierarchical MIPv6

Hierarchical mobility management for Mobile IPv6 is designed to reduce the amount of signaling between the MN, its CNs, and its HA [13]. HMIPv6 improves the handover management of basic MIPv6 by introducing a new protocol agent called Mobility Anchor Points (MAP) [7]. MAP splits the management of the handover process into macro-mobility and micro-mobility and deals with them separately. In HMIPv6, MN assigns two addresses, regional care of address (RCoA) and link care of address (LCoA). These two addresses are very useful managing mobility (figure 1). A MN that enters a foreign network first configures its LCoA by the IPv6 address auto-configuration scheme. The MN then sends a local BU message to the MAP. This local BU message includes the MN's RCoA in the Home Address Option field and the LCoA is used as the source address of the BU message. This BU message binds the MN's RCoA to its LCoA. The MAP then performs duplicated address detection (DAD) procedure for the MN's RCoA on its link and returns a Binding Acknowledgement (BAck) message to the MN.

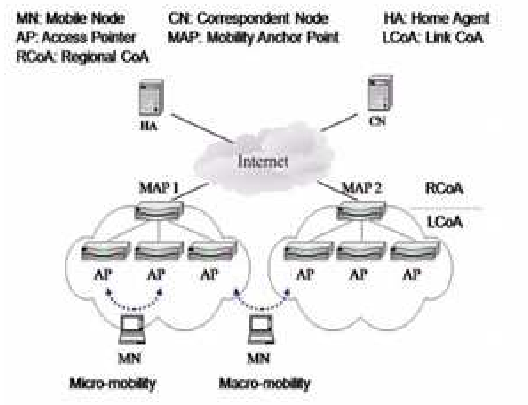

Figure 1. Hierarchical Mobile IPv6

III. SHMIPv6: Seamless hierarchical Mobile IPv6

In this section, we will discuss our proposed scheme (SHMIPv6). Our solution *tries to* provide good *QoS* performance support for *multimedia applications.* The fast handover mechanism using HMIPVv6 may guarantee seamless multimedia handover as long as the MN moves inter domain. But it is still not enough to support real time voice services. So we propose a fast buffering schema to reduce packet loss. The aim of SHMIPv6 can be described by the following three parameters:

A. Reduce signaling overhead

- Using Hierarchical Mobile IPv6 (HMIPv6) reduce signaling overhead and support seamless handoff in IP-based wireless/mobile networks.
- Using several MAPs: Using one MAP keeps large number of packets waiting before it receives or sends them, and this causes long delay and large number of lost packets. The domain is composed of multiple Mobility Anchor Points; each MAP in the domain is attached with an Access Router (AR). The mechanism shares the traffic information among the MAPs in the domain to make decision of MAP reassignment. The MAPs at the domain give the same RCoA.

In HMIPv6 DAD procedure, it takes at least 1000 ms to detect that there is no duplicate address in the link. The regional registration procedure proposed by HMIPv6 offers low handoff delay, but it remains too high for real time applications which require handoff delay to avoid service degradation. So, to reduce total handover latency, SHMIPv6 propose two mechanisms: anticipated handover and Predictive Address Reservation mechanism.

B. Low latency handover in SHMIPv6 : (Predictive Address Reservation mechanism)

With HMIPv6 allows not only reducing handoff delay but also signaling overhead. SHMIPv6 proposes to perform address allocation and registration procedures before the link layer handoff (L2) to reduce HMSIP handoff latency. This can be achieved by employing the movement detection scheme using link layer information (Figure 2). The base idea is to allocate a new IP address to the MN and allow him to re- REGISTER with its MAP (regional registration) using the link layer handoff triggering. In fact, address acquisition and HMIPv6 registration procedures are executed in parallel.

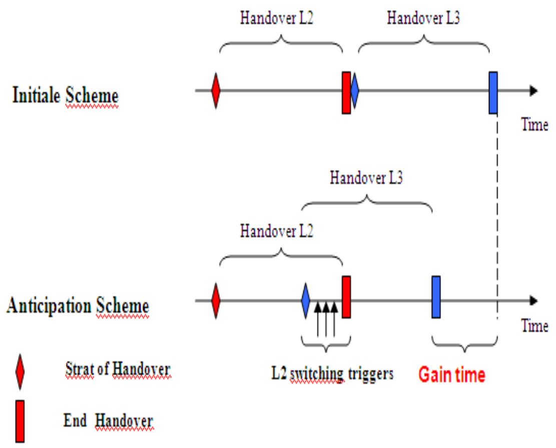

Figure 2. Anticipated Handover

C. Loss free packet: (Anticipated buffering process using security threshold)

To minimize loss packet during handover, SHMIPv6 propose an anticipate buffering process with conditional tunneling. This process enabling the temporary storage of the tunneled before the handover packets, thus eliminating packet loss occurred during the link layer handover period. To do this we define the two following metrics:

1) LT (Loss threshold): A packet may be considered as lost if it is received with signal strength (SS) less than LT (Loss threshold).

2) ST(Security threshold): This threshold may be useful to synchronize with the start of Buffering networks Handover (Handover L3): related to the initial idea was to start buffering with a broadcast message « Handoff Initiate». However, there may be packets loss before sending this message; we define the security threshold for anticipating the buffering before the signal level deteriorates. Soon as the mobile node receives the signal strength equal to the security threshold, it sends a message Application Control Buffer (RCB) to its old access router. This message acts as initiator of storing packets in the buffer. While the packets are being stored, the old access router sends a copy of these packets until there is a disconnection from the mobile node (reached the loss threshold). Note that the buffering continues until the connection with the new router is established and make a record with the new router.

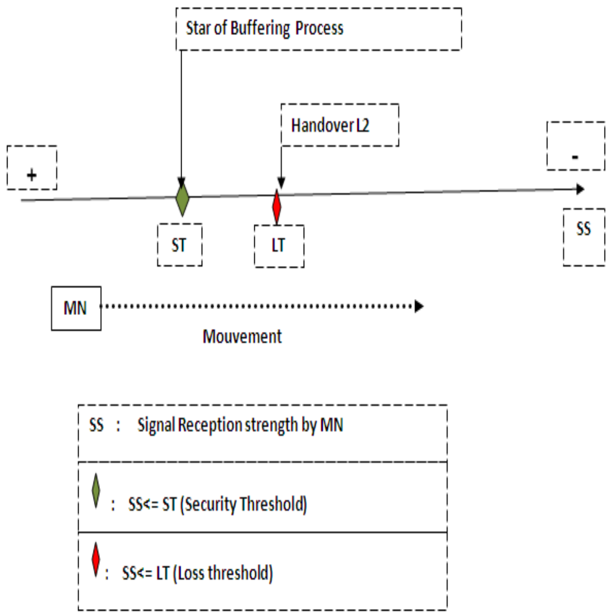

Figure 3. Anticipated Buffering Process

D. Enhanced Scheme

SHMIPV6 buffering scheme presented in figure4 can be summarized in five steps:

- *Step1:* Soon as the MN receives packets with: SS<= ST, it sends a RCB message to old access router. This message acts as initiator of storing packets in the buffer.

1) *Step 2*: in this step three tasks are performed:
   a) *Handover L2 is initiate (SS<=LT)*
   b) *Buffering process is executed in the PR*
   c) *Initialization of tunneling process.*
2) *Step 3:* in this step four tasks are performed:
   a) *Handover L2 is performed*
   b) *Handover L3 is initiate*
   c) *Running buffering process*
   d) *Tunneling parquets from PR to NR*
3) *step 4*: in this step, two tasks are executed
   a) *Handover L3 is performed*
   b) *Tunneling packets from PR to NR*

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4) step 5: in this last step, scheduling process is executed for packets received via tunnel (sent from the PR) and packets received from the NR

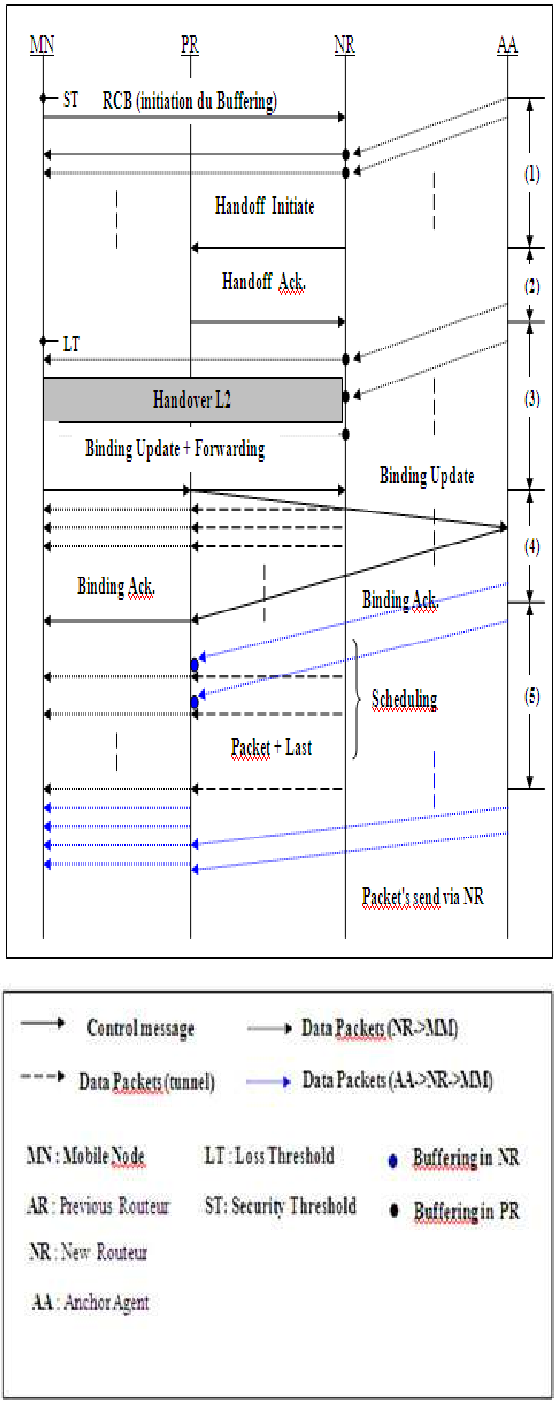

Figure 4. SHMIPv6

IV. SIMULATION RESULTS

Performance results will be provided in terms of handoff latency, packet loss, and jitter. We compare our algorithm against previous Mobile IPv6 propositions [5] [12] [14]

- *Simulation Prameters*
  - *Simulator:* *Ns-allinone-2.34*
  - *Network:* *600*600 and 1000*1000*
  - *Modulation:* *DSSS*
  - *Mobil node:* *7 and 12*
  - *Bandwidth:* *2 mbps*
  - *Traffic generator:* *Constant Bit Rate and Video*
  - *Packet rate:* *13 packet per second*
  - *Packet size:* *512 bytes*
  - *Loss Threshold:* *3.41828e-10 Watts*

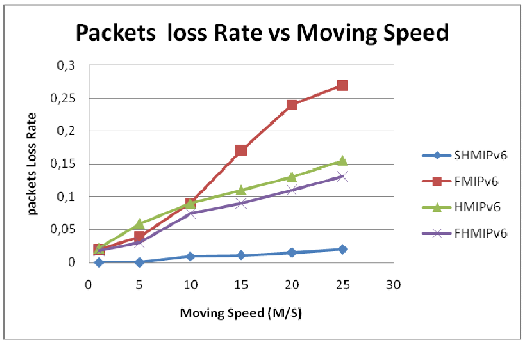

Figure 5. Packet loss rate vs. Moving Speed

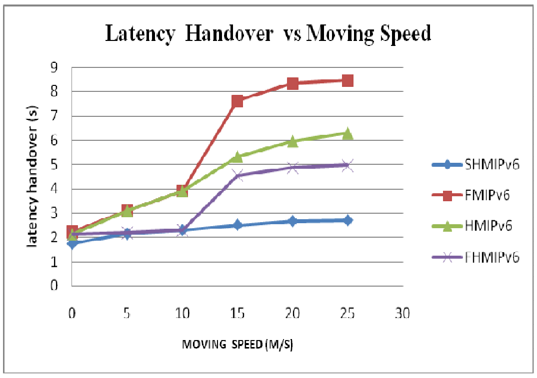

Figure 6. Latency Handover vs. Moving Speed

As we analyzed the performance of our proposed scheme we proved that SHMIPv6 transmits message faster and efficient than FMIPv6, FHMIPv6 and HMIPv6.

Figures 5, 6 show the increase in the handover latency and the packet loss due to an increase in moving speed of MNs. As can be seen, SHMIPV6 approach performs better than FHMIPV6, HMIPv6 and FMIPV6 in terms of the handover latency and packet loss. Although the SHMIPv6 (*with the integration of thresholds: ST-LT, Using several MAPs, Predictive Address Reservation*) is designed to minimize the packet loss and the latency during a handover, a worse performance is observed with respect to FMIPv6

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and MIPv6. In contrast, SHMPIv6 provide a low latency handover (1.75s and 2.7s). This is due to the fundamental difference between handover registrations and anticipation Procedures in SHMIPv6 and other procedures.

Furthermore, the number of packets lost depends on the moving speed of MN. As seen in the figure 6, SHMIPv6 packets lost rate is between (0 and 0.02).This means that the packet loss can totally eliminated if we use an anticipated buffering scheme.

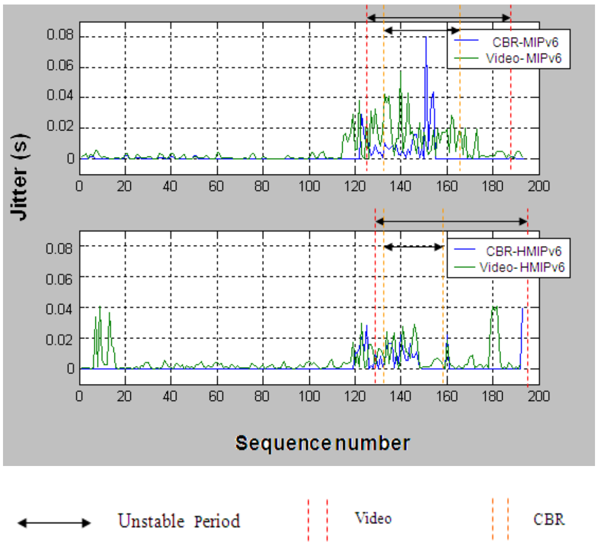

Figure 7. Jitter vs. Sequence number generated

Figure 7 shows the jitter comparison under CBR and video sequence generated. The mean jitter for CBR traffic is 0.08s and 0.038s in MIPV6 and SHMIPV6 correspondingly. In the other hand the mean jitter for video traffic is 0.058 and 0.04 s in MIPV6 and SHMIPV6 correspondingly. Furthermore, we can see that when the payload is light, there is no loss in both two kinds of protocols and for all type of traffic (CBR or video). We can see also, that there is a difference between MIPv6 and the SHMIPv6 under heavy background payload; Payload affects more to the performance of MIPV6 than SHMIPVt6. When there is heavy background payload, the loss rate of MIPv6 is bigger than that of SHMIPV6.

V. CONCLUSION

Both Hierarchical Mobile IPv6 and Predictive Address Reservation schemes have been proposed to reduce the handoff latency in their own ways. The Hierarchical Mobile IPv6 allows reducing handoff latency and overhead. On the other hand, the Predictive Address Reservation and anticipated handover use link layer information for earlier movement Detection and address configuration for the new point of Attachment so as to minimize the disruption of the services during the handoff process. The integration of anticipated buffering reduces significantly the handoff packet losses during the handover process, but its integration with the HMIPv6 environment provides better handoff performance.

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