

## Performance Simulation and Analysis of Video Transmission over Proxy Mobile IPv6 in a Micro mobility domain

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**Abstract.** The phenomenal growth of Internet technology as well as the convergence in network communication technologies has improved the overall quality of ubiquitous communication significantly. In recent years, Network-based Localized Mobility Management (NETLMM) working group has proposed a protocol namely Proxy Mobile IPv6 (PMIPv6), which is actively receiving standardization by the Internet Engineering Task Force (IETF). PMIPv6 is an effective mobility management protocol for next generation wireless networks that has salient features and is expected to expedite the real deployment of IP mobility management. Even though PMIPv6 offers many advantages, it still suffers from handover latency. In order to reduce the handover latency, we propose a seamless handover integrated solution. The purpose of this paper is to simulate, analyze and evaluate the performance of video Transmission over PMIPv6 in a Micro mobility domain on link-layer and network layer. Through simulations, we analyzed the video transmission quality for our proposed protocol as compared to PMIPv6.

**Keywords:** PMIPv6, MIH, ND, Mobility Prediction, Video Streaming

### 1. Introduction

With the recent explosive growth in wireless and internet technologies, the number of mobile end-users has increased tremendously in recent years. With more and more mobile end-users, there is also an increased in demands for continuous network connection and improved Quality of Service (QoS) while on the move. Eventually, all mobile wireless networks will gradually have to evolve to support all-IP network architecture and real-time multimedia services. As compared to desktop users, mobile end-users can enjoy the freedom and flexibility to access Internet and services at any location. In order to access the Internet continuously while on the move, mobile host (MH) establishes new connection with base station (BS) when they move from one place to another. Based on the demand of mobile end-users, NETLMM [1] proposed a network-based localized mobility management protocol called Proxy Mobile IPv6 (PMIPv6) that defines a domain in which the MH can roam without being aware of any layer 3 ( $L_3$ ) movement since it will always receive the same network prefix in the Router Advertisement (RA).

However, since the PMIPv6 was only designed to provide local mobility management, it still suffers from a lengthy handover latency and packet loss during the handover process when MH moves to a new BS in high speed. This handover process causes long handover latency and packet loss which severely degrades the performance of video transmission over PMIPv6.

This paper focuses on improving the performance of video transmission over PMIPv6 in a micro mobility domain because user mobility is higher in this domain hence frequent handovers occur and cause service disruptions, especially when the MH moves from one BS to another. The remainder of this paper is organized as follows: Section 2 presents some related background about PMIPv6 and Media Independent Handover (MIH). Section 3 briefly explains our proposed solution scheme. Section 4 describes the simulation results and comparison of network-based mobility management protocols under different

parameters like handover delay, throughput, packet loss rate and peak signal noise ratio (PSNR). Finally, Section 5 concludes the remarks and provides future works.

## 2. Related Works

### 2.1. Proxy Mobile IPv6

PMIPv6 [2] was designed to provide an effective network-based mobility management protocol for next generation wireless networks that support a MH in a topologically localized domain. Thus, PMIPv6 extends Mobile IPv6 signaling messages and reuses the functionality of Home Agent (HA) to support mobility for MH without host involvement. In the network, mobility entities are introduced to track the movement of MH, initiate mobility signaling on behalf of MH and setup the routing state required. The core functional entities in PMIPv6 are the Mobile Access Gateway (MAG) and Local Mobility Anchor (LMA). Typically, MAG runs on the Access Router (AR). The main role of the MAG is to perform the detection of the MH's movements and initiate mobility-related signaling with the MH's LMA on behalf of the MH. In addition, the MAG establishes a tunnel with the LMA for forwarding the data packets destined to MH and emulates the MH's home network on the access network for each MH. On the other hand, LMA is similar to the HA. The main role of the LMA is to manage the location of a MH while it moves around within a PMIPv6 domain and it also includes a binding cache entry for each currently registered MH and also allocates a Home Network Prefix (HNP) to a MH.

### 2.2. Media Independent Handover

The working group of IEEE 802.21 developed a standard specification called Media Independent Handover (MIH) [3] which defines extensible media access independent mechanisms that facilitate handover optimization between IEEE 802 systems such as handover of IP sessions from one layer 2 ( $L_2$ ) access technologies to another. MIH introduces three different types of communications with different associated semantics, the so-called MIH services: Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS).

MIES introduces event services that provide event classification, event filtering and event reporting corresponding to dynamic changes in link characteristics, links status, and link quality. It also helps to notify the MIH users such as PMIPv6 about events happening at the lower layers like link down, link up, link going down, link parameters report and link detected etc and essentially work as  $L_2$  triggers.

MICS provides the command services that enable the MIH users to manage and control link behaviour relevant to handovers and mobility such as force change or handover of an interface. The commands generally carry the upper layers like  $L_3$  decisions to the lower layers  $L_2$  on the local device entity or at the remote entity. There are some examples of MICS commands such as MIH scan, MIH configure, MIH handover initiate, MIH Handover prepare and MIH handover complete etc.

MIH provides the information services through a MIIS which enables effective system access and effective handover decisions based on the information about all networks in a geographical area from any single  $L_2$  networks. MIIS provides registered MIH users with the knowledge base of the network and information elements and corresponding query-response mechanisms for the transfer of information. MIIS can be classified into three groups: (i) general or access network specific information, (ii) PoA (Point of Attachment) specific information and (iii) vendor specific information.

## 3. Proposed Integrated Solution Scheme

To overcome the problems of video transmission over PMIPv6, we proposed a seamless handover integrated solution that provides seamless handover using Media Independent Handover (MIH), Neighbor Discovery (ND) message of IPv6 and mobility prediction to reduce handover latency, packet loss and increase throughput on network layer and link layer at new MAG (n-MAG). The figure 1 below represents the seamless handover integration solution of PMIPv6 (PMIPv6-SH).

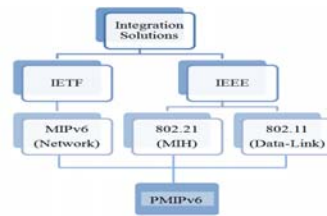


Fig. 1: Proposed Seamless Handover Integrated Solution

### 3.1. Overview of PMIPv6-SH

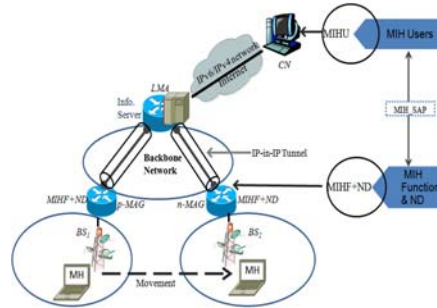


Fig. 2: Architecture of PMIPv6-SH

As shown in figure 2, the key functionality is provided by MIH which is communication among the various wireless layers and the IP layer. The working group of IEEE 802.21 introduces a Media Independent Handover Function (MIHF) that is located in the protocol stack between the lower layer wireless access technologies and IP at upper layer. It also provides the services to the L<sub>3</sub> and L<sub>2</sub> through well defined Service Access Points (SAPs) [3].

When a MH moves from one base station to another within same network using the same technology, the handover can usually be performed within that wireless technology itself without involving MIHF or IP. However if the handover is from one BS to another new network station, then MIH is required. The two BSs can communicate with each other at the link layer and network layer with high latency and packet loss, because they are, in general, on different IP subnets. When a MH moves away from one BS to new BS with high speed mobility, MIH may also assist the handover process by exchanging services among the Internet access technologies and IP.

### 3.2. Neighbor Discovery

Neighbor Discovery (ND) is a set of ICMPv6 messages and processes that determine the relationship by sending network information to the neighbor MAG before handover that can helps to eliminate the need for MAG to acquire the MH-profile from the policy server/AAA whenever a MH performs handover between two BSs in micro mobility domain. It avoids the packet loss of on-the-fly packet which is routed between the LMA and previous MAG (p-MAG). This network information could include information about MH-profile which contains the MH-Identifier, MH home network prefix, LMA address (LMAA), MIH handover messages etc. The module of ND is used to provide L<sub>3</sub> movement detection. In the network, BS sends RA messages periodically to inform the MH about the network prefix. In our simulation, the prefix is the address of the BS. If RA messages contain a new prefix and inform the interface manager, MH receives these RA messages and determines where ND agent located. A timer is associated with the lifetime of the prefix. The prefix expired and a notification is sent to the interface manager when the MH losses its connection with the BS. The implementation of ND Agent is based on the information of ND for IPv6 which is provided by RFC 2461 [4].

### 3.3. Mobility Prediction

In our proposed Integrated Solution scheme, we also include Mobility Prediction. Overall, Mobility Prediction is defined as estimating the future position of the MHs and assists by predicting the handover of

MH from one BS to another and can be used to reserve resources and speed up the handover process. In an effective meaning, mobility prediction is to minimize the effect of performance degradation resulting from high handover latency and packet loss rate during high speed movement of MH. Mobility Prediction is to predict the next BS through the mobile user will connect to the network which is based on the concept of movement history is being generated by MH on daily, weekly or monthly [5]. The general definition of mobility prediction can be expressed as follows:

$$\text{Prediction: BS}_{\text{previous, current}} \rightarrow \text{BS}_{\text{next}}$$

### 3.4. Analytical Analysis

Seamless Handover requires user-acceptable quality of services and experience during handover. To meet this requirement, we proposed a seamless handover integrated solution of PMIPv6 (PMIPv6-SH) in order to reduce packet loss and handover latency as well as increase throughput and quality of video streamed with is measured by PSNR. The overall handover latency consists of the  $L_2$  and  $L_3$  operations. The handover latency is consequent on the processing time which involved in each step of handover procedure on each layer. The handover latency ( $L_{\text{seamless}}$ ) can be expressed as:

$$L_{\text{seamless}} = L_{L_3} + L_{L_2} \dots (1)$$

On  $L_3$ , PMIPv6 does not require time of CoA (care-of-address) configuration ( $T_{\text{config}}$ ) and Duplicate Address Detection ( $T_{\text{DAD}}$ ) except when MH first enters in PMIPv6 domain. PMIPv6 requires only the time of registration ( $T_{\text{reg}}$ ) and movement detection ( $T_{\text{MD}}$ ) on  $L_3$ . Based on our proposed PMIPv6-SH, we will consider the registration time of PBU (proxy binding update) and movement detection time of RA because n-MAG gets all necessary information through the ND message. The transmission time of RS (router solicitation) message is considered to be non-appreciable because of the specification of PMIPv6. The time required to obtain mobility-related signaling message exchange during pre-registration may not be considered as this negotiation is established before MH attachment. Since the MH is already pre-registered and all the necessary information is send to n-MAG through ND message before handover, therefore the last PBA message sent from the LMA may not be considered. The overall time for seamless handover latency on  $L_3$  for PMIPv6-SH can be expressed as:

$$L_{3\text{PMIPv6-SH}} = T_{\text{PBU}} + T_{\text{RA}} \dots (2)$$

On  $L_2$ , p-MAG has already authenticated the MH and sends MH's profile which contains MH-Identifier to the n-MAG through the ND message. This is due to the fact that the MH is already in the PMIPv6 domain and receiving as well as sending information to CN before the handover. Therefore, the time of authentication, authorization and accounting ( $T_{\text{AAA}}$ ) may not be considered at n-MAG. Moreover, since we also already have all the necessary information about the next BS by using mobility prediction, therefore the earlier connection with new BS can be established before the actual handover take place. The moving pattern obtained will be very useful in determining the next cell that the MH would be moving to. Therefore, by applying the mobility prediction in PMIPv6-SH, the overall packet loss and latency can be reduced by reducing the time of scanning ( $T_{\text{scan}}$ ) and re-association ( $T_{\text{re-ass}}$ ). As a result, the equation of seamless handover latency on  $L_2$  can be expressed as:

$$L_{2\text{PMIPv6-SH}} = T_{\text{scan}} + T_{\text{re-ass}} \dots (3)$$

The Seamless Handover Latency of PMIPv6-SH on  $L_3$  and  $L_2$  can be expressed as:

$$L_{\text{seamlessPMIPv6-SH}} = T_{\text{PBU}} + T_{\text{RA}} + T_{\text{scan}} + T_{\text{re-ass}}$$

## 4. Simulation Results

In order to evaluate the performance of our proposed Integrated Solution for video transmission we conducted simulation using Network Simulator, ns-2 [6]. Through simulations conducted, we simulate, analyze and evaluate our proposed seamless handover integration solution of PMIPv6 (PMIPv6-SH) as well as compared with MIH and ND assisted PMIPv6 (PMIPv6-MIH+ND) and MIH assisted PMIPv6 (PMIPv6-MIH) in a micro mobility domain. For the simulations, we measured four important performance indicators:

(i) packet loss rate, (ii) throughput for packet delivery, (iii) handover latency and (iv) PSNR. For PSNR measurements, we utilized the tools provided by Chih-Heng Ke [7] to simulate video transmission simulation over wireless network in ns-2. For our simulations, we used H.263-coded video stream that is similar to H.261 with some improvements and changes to improve performance and error recovery and also MPEG-1 and MPEG-2 standards. There are two format sizes, CIF (352 x 288) and QCIF (176 x 144). The difference of them is video frame size. For our simulations, we converted a video clip file named “Transformers 2” in CIF format. We measured the performance for network-based mobility management protocols in a micro mobility domain with high speed movement of the MH. The simulation results of video transmission over PMIPv6-SH and other protocols were obtained and as shown in figure 3, 4, 5 & 6:

**A. Packet Loss Rate:**

As soon as simulation is started, video start to be transmitted from CN to MH. After video has been received by MH, we can get how many packets and frames have been sent or lost. The results are as follows:

In PMIPv6-MIH:

Packet sent: p→nA:6662, p→nI:1025, p→nP:1854, p→nB:3782  
 Packet lost: p→lA:464, p→lI:86, p→lP:138, p→lB:240  
 Frame sent: f→nA:1404, f→nI:157, f→nP:312, f→nB:934  
 Frame lost: f→lA:132, f→lI:14, f→lP:34, f→lB:84

In PMIPv6-MIH+ND:

Packet sent: p→nA:6662, p→nI:1025, p→nP:1854, p→nB:3782  
 Packet lost: p→lA:221, p→lI:38, p→lP:73, p→lB:110  
 Frame sent: f→nA:1404, f→nI:157, f→nP:312, f→nB:934  
 Frame lost: f→lA:77, f→lI:9, f→lP:21, f→lB:47

In PMIPv6-SH:

Packet sent: p→nA:6662, p→nI:1025, p→nP:1854, p→nB:3782  
 Packet lost: p→lA:194, p→lI:29, p→lP:67, p→lB:98  
 Frame sent: f→nA:1404, f→nI:157, f→nP:312, f→nB:934  
 Frame lost: f→lA:71, f→lI:8, f→lP:20, f→lB:43

where A stands for numbers of packets or frames sent in all, while I, P, B stand for the three different types of frames of H.263.

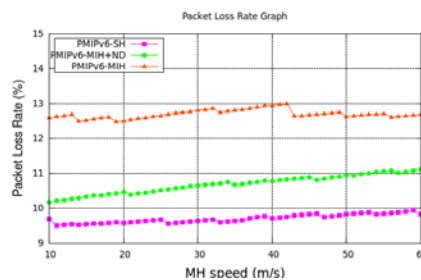


Fig. 3: Packet Loss Rate of Network-based Mobility Management protocols

**B. Throughput:**

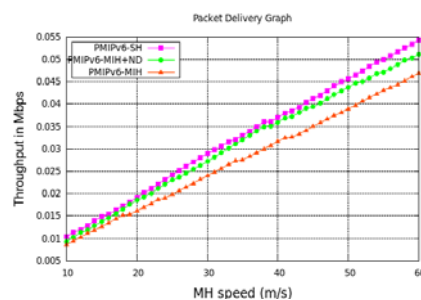


Fig. 4: Throughput of Network-based Mobility Management protocols

### C. Latency:

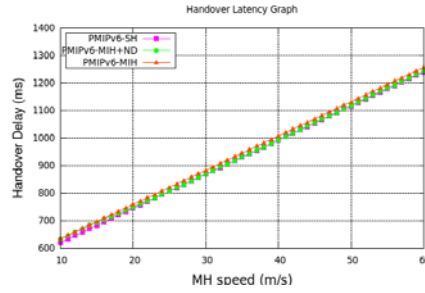


Fig. 5: Latency of Network-based Mobility Management protocols

### D. PSNR:

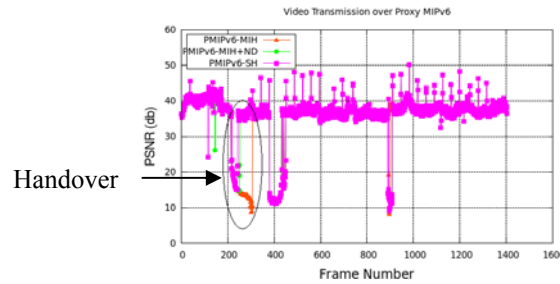


Fig. 6: PSNR over Network-based Mobility Management protocols

In Figure 6, we can see at the time when the 2100<sup>th</sup> packet is being transmitted, the PSNR falls, which is due to the time that handover is taking place during the high speed movement of MH. As can be seen from the result, at that time the quality of video transmission of our proposed PMIPv6-SH is much better than other network-based mobility management protocols.

## 5. Conclusion

In summary, the reason of high packet loss, increase handover delay and less transmission throughput is due to the increment in movement speed of MH. During the handover process, high numbers of packets are being transmitted to the p-MAG and this causes loss many packets. To solve the crucial problem, the use of our proposed PMIPv6-SH is expected to reduce handover latency, lower down the packet loss, increase the throughput and PSNR since the connection to the n-MAG is established before the MH arrived. The n-MAG gets all necessary information of MH by using ND message on network layer and also already predicts the next BS before MH handover. Thus, there would be no break connection problem during the high speed condition of MH where CN can continue to communicate with the MH as usual. The use of mobility prediction in wireless network makes great help to minimize or eliminate the high packet loss.

In this paper, we have conducted simulations to evaluate the network-based localized mobility management protocols in a micro mobility domain. The analytical analysis and simulation results showed that the proposed seamless handover integration solution of PMIPv6 (PMIPv6-SH), as a network-based mobility management protocol, performs better than PMIPv6-MIH and PMIPv6-MIH+ND. For our future work, we would like to improve the packet loss, handover latency and also improve the performance of our proposed PMIPv6-SH for real-time applications in a macro mobility domain.

## 6. References

- [1] J. Kempf. Goals for Network-Based Localized Mobility Management (NETLMM). April 2007, [http://www.rfc-archive.org/getrfc.php?rfc=4831&tag=Goals-for-Network-Based-Localized-Mobility-Management-\(NETLMM\)](http://www.rfc-archive.org/getrfc.php?rfc=4831&tag=Goals-for-Network-Based-Localized-Mobility-Management-(NETLMM))
- [2] K. Kong, W. Lee, Y. Han, M. Shin and H. You. Mobility management for all-IP mobile networks: mobile IPv6 vs. proxy mobile IPv6. In: K. Kong, et al (eds.). *Proc. of International Conference on Wireless Communications*. 2008, pp. 36-45.

- [3] K. Taniuchi, Y. Ohba, V. Fajardo. IEEE 802.21: media independent handover: features, applicability, and realization. *IEEE Communications Magazine*. 2009, vol. 47, no. 1, pp. 112–120.
- [4] T. Narten, E. Nordmark and W. Simpson. Neighbor Discovery for IP Version 6 (IPv6). December 1998, <http://www.ietf.org/rfc/rfc2461.txt>
- [5] S. Kwon, H. Park and K. Lee. A Novel Mobility Prediction Algorithm based on User Movement History in Wireless Network. In: H. Park, et al (eds.). *Proc of Berlin Heidelberg*. 2005, pp.419-428.
- [6] NS-2 home page, <http://www.isi.edu/nsnam/ns>
- [7] Chih-Heng Ke, An example of multimedia transmission over a wireless network. <http://140.116.72.80Hhlin5/ns2/ns2.htm>