Mugla Journal of Science and Technology, Vol 1, No 1, 2015, Pages 34-38

Mugla Journal of Science and Technology

THE ANALYSIS OF LAYER-2 HANDOVER PERFORMANCE FOR MOBILE IPV6 USING OMNeT++ SIMULATION TOOL

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Accepted: 06.04.2015
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Abstract

One of the important factors for Mobile IP version 6 (MIPv6) is to ensure a seamless handover while a Mobile Node (MN) maintain active communication. A seamless handover can be realized by reducing or finishing the latency times during movement detection, a new address configuration and binding update procedures which have been defined in MIPv6 protocol clearly. However, MIPv6 handover process is a very complex due to Layer 2 (L2) and Layer 3 (L3) operations, and this drawback can cause significant performance degradation in macro mobility or real-time communications mainly. L3 handover is the most important factor to MIPv6 handover process because a major proportion of the total handover latency occurs in this stage. On the other hand, L2 handover results in the less latency than L3 handover. However, the researches on L2 handover also has an important place in literature because the events during L2 handover can trigger L3 handover in advance. By this way, seamless handover techniques have been realized. L2 approach is faster than L3 based solutions. Nevertheless, these methods are also limited to L2 handover latency. In this paper, we analyzed the L2 latency in MIPv6 handover using OMNeT++ simulator. These analyses will show the each components of the L2 handover latency separately.
Keywords: Layer-2 handover, Mobile IPv6, OMNeT++

OMNeT++ BENZETİM ARACI KULLANILARAK MOBİL IPV6 KATMAN-2 HÜCRE GEÇİŞİ BAŞARIMININ ANALİZİ

Özet

Bir Mobil Düğüm (Mobile Node - MN) aktif iletişimi sürdürürken pürüzsüz bir hücre geçişi sağlamak Mobil IP sürüm 6 (MIPv6) için en önemli etkenlerden birisidir. Pürüzsüz bir hücre geçişi, MIPv6 protokolünde açıkça tanımlanan hareketliliğin tespit edilmesi, yeni bir adresin yapılandırılması ve bağlama güncellemesi işlemleri sırasındaki gecikme sürelerinin azaltılması ya da sonlandırılması ile gerçekleştirilebilir. Ancak, MIPv6 hücre geçişi süreci Katman-2 (Layer2- L2) ve Katman-3 (Layer 3 – L3) işlemleri nedeniyle oldukça karmaşıktır ve bu dezavantaj özellikle makro hareketlilikte ve gerçek zamanlı iletişimde performansta önemli derecede azalmaya neden olur. L3 hücre geçişi MIPv6 hücre geçişinin en önemli faktörüdür çünkü toplam hücre geçişi gecikmesinin büyük bir bölümü bu aşamada meydana gelir. Diğer taraftan, L2 hücre geçişişi L3 hücre geçişine göre çok daha az kayıp ile sonuçlanır. Ancak, L2 hücre geçişi üzerine yapılan çalışmalar da literatürde önemli yer tutmaktadır. Çünkü L2 hücre geçişi sırasında gerçekleşen olaylar L3 hücre geçişini önceden tetikleyebilmektedir. Bu sayede, pürüzsüz hücre geçişi teknikleri bu şekilde gerçekleştirilmektedir. L2 yaklaşımı L3 tabanlı çözümlere göre çok daha hızlıdır. Buna rağmen bu yöntemlerde L2 hücre geçişi gecikmesi kadar sınırlıdırlar. Bu makalede, biz MIPv6 hücre geçişindeki L2 gecikmelerini OMNeT++ benzetim ortamını kullanarak analiz ettik. Bu analizler, L2 hücre geçişi gecikmelerinin bileşenlerini ayrı ayrı gösterecektir.
Anahtar Kelimeler: Katman-2 hücre geçişi, Mobil Ipv6, OMNeT++

1 Introduction

The number of IP address that can be assigned to new users with IPv4 have become inadequate as a result of the expansion of internet in last few decade. IETF designed to IPv6 as a solution to the problems in IPv4 [1]. IETF also proposed MIPv6 for mobile users which have increased in recent years [2]. MIPv6 provides transparency in the routing of packets which are sent from correspondent nodes (CNs) to MN while a MN move from one network to another network (handover) by maintaining its home address [2]-[4].

The mobility in the MIPv6 only provides a good performance in the macro areas or non-real-time communication. However, there are undesirable packet losses in the micro areas or real-time applications during handover time. These packet losses cause degradation in Quality of Service (QoS) for various applications such as VoIP [4].

It can be considered that handover procedure consist of Link Layer (Layer 2 – L2) and Network Layer (Layer 3 – L3) typically. L2 handover is performed between connection points on the same network. In contrast to it, L3 is carried out on the different subnets and it requires the configuration of new IPv6 address to MN [5]. If we look in more detail, total handover time for MIPv6 comprises of L2 latency, movement detection latency, registration latency and Duplicate Address Detection (DAD) latency [6]. To diminish these latency times, countless works have been done by IETF and researchers in recent years. IETF has standardized Hierarchical MIPv6 (HMIPv6), Fast MIPv6 (FMIPv6) [7] and Proxy MIPv6 (PMIPv6). On the other hand, the authors of more recent studies have proposed some techniques which include the buffering packets in the handover time [8], estimating the handover [9], [10], signaling traffic reduction [11] and late tunneling [12] methods to decrease or remove packet losses completely.

Another solution to reduce total handover latency is the utilization of the L2 handover time. The L2 handover means that the MN establish a connection with a new AP very soon [13]. For this reason, L2 and L3 handover are carried out in some methods simultaneously such as FMIPv6 and Fast Proxy (FPMIPv6). Such methods eliminated the handover latency or are limited it to maximum L2 handover latency.

The aim of this article is the representation of performance evaluation results for MIPv6 protocol L2 handover latency. For this purpose, we simulated a MIPv6 network by using OMNeT++ to determine the L2 handover latency. Moreover, we presented to the time components of L2 handover latency with simulation results.

The rest of paper is structured as follows: MIPv6 protocol, its handover scheme, analytical model of total handover latency and L2 handover are described in section II. Then, L2 handover procedure is simulated in Section III, and its results is given. Concluding remarks of the paper are given in Section IV.

2 MIPv6

A MIPv6 network principally consists of a Mobile Node (MN), Correspondent Node (CN) and Home Agent (HA) as illustrated in Fig. 1. The MN is a mobile node, and it can be have Home address (HoA) and Care of Address (CoA). The MN is obtain HoA from HA, and it is identified with its HoA all the time in a MIPv6 network. HoA is a constant address to the MN. On the other hand, the MN can benefit from a configured CoA only when it moved to a new link. MN takes all tunneled datagrams with its CoA during handover. HA which is another component of MIPv6 network acts as a router, and it provides a home network service for a MN. It also sustains an association between HoA and CoA. By this means, a MN is always accessible with its own HA and HoA even if it change the attaching point in a network.

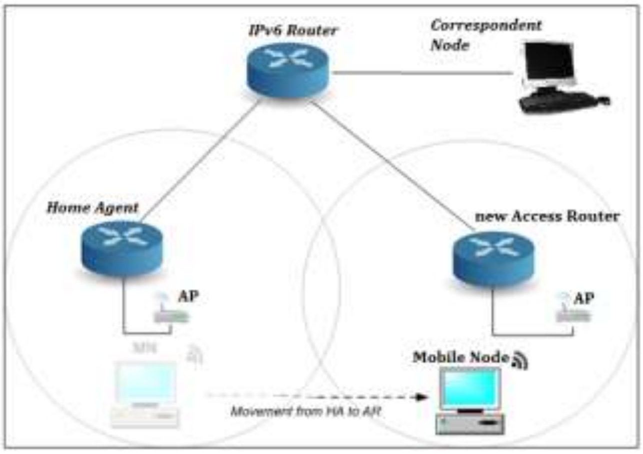


Figure 1. The structure of MIPv6 network

2.1 MIPv6 Handover Procedure

When a mobile node changes to its attachment point in a network, this node moves from its domain to a new domain. This mobility process is called as handover. Handover procedure in MIPv6 can be shown in fig.2. From the fig. 2 it is apparent that the MN is responsible for determining of the handover. When a MN moves into a new domain, it will obtain a RA (Router Advertisement) message from new AR as a result of sending a RS (Router Solicitation) message by MN. This stage is called as router discovery. Then, a new CoA is configured for MN. Address Configuration process can be stateless (prefix discovery) or stateful (DHCPv6) [14]. Furthermore, the uniqueness of the CoA in this network is guaranteed with Duplicate Address Detection (DAD) procedure.

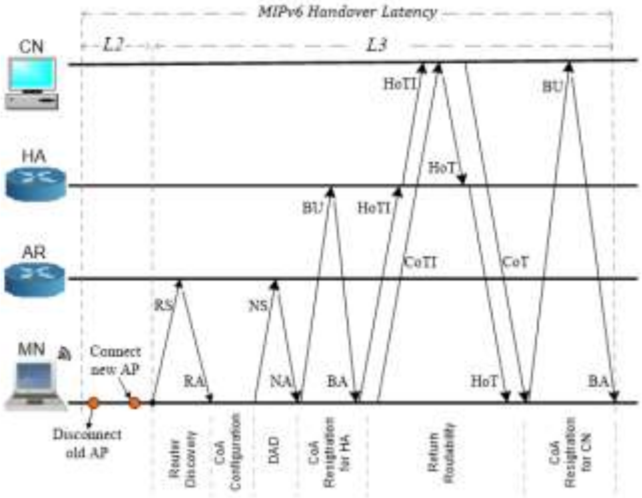


Figure 2. MIPv6 handover scheme

MIPv6 realizes the sustainability in service for MN by sending Binding Update (BU) messages. MN utilizes this message type to inform HA and CN about its new CoA. When a BU message is reached to HA, HA will respond with Binding Acknowledgment (BA) message, and it set up a tunnel between HoA and CoA. This tunnel is used for forwarding data packets to MN. In addition to BU procedure, Return Routability (RR) test is also carried out between MN and CN by using Home Test Init (HoT) and Care of Test (CoT) messages. After all these operations, handover is completed together with the taking of BA from CN [15].

2.2 Analysis of MIPv6 Handover Latency

A MN cannot send or receive any data packets for a certain time during handover. This certain time culminating in packet losses is named as handover latency. Fig.3 shows the total handover latency components to MIPv6.

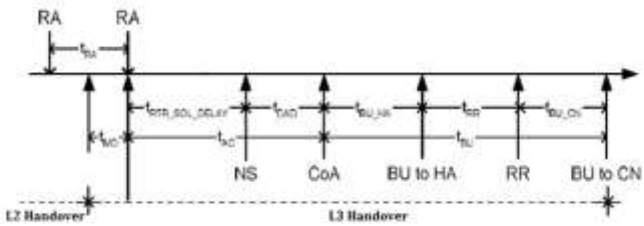


Figure 3. MIPv6 handover latencies

According to fig.2, we can describe to the total handover latency (T_H) as the sum of L2 (T_{L2}) and L3 (T_{L3}) latencies all in all. Accordingly, T_H is shown in Equation (1).

$$T_H = T_{L2} + T_{L3} \tag{1}$$

T_{L3} is given by Equation (2). It consists of T_{IPv6} and T_{MIPv6} latencies. T_{IPv6} is required for detecting a new network and configuring a unique CoA as shown in Equation (3). Movement detection is a crucial phase to T_{L3} because it decreases T_{L3} handover latency markedly. It relies on the taking of RA messages, thus it is highly depend on the frequency of broadcasted RAs [16]. T_{MIPv6} is a latency time that a MN needs to inform its new position. The time components of T_{MIPv6} are given in Equation (4).

$$T_{L3} = T_{IPv6} + T_{MIPv6} \tag{2}$$

$$T_{IPv6} = T_{MD} + T_{CoA} \quad (3)$$
$$T_{MIPv6} = T_{BU-HA} + T_{RR} + T_{BU-CN} \quad (4)$$

If D_{X-Y} represents a transmission latency between X and Y and it is assumed that D_{X-Y} is equal toD_{Y-X}, Equation (5), (6) and (7) can be expressed as [17]

$$T_{BU-HA} = D_{MN-HA} + D_{HA-MN} \quad (5)$$
$$T_{BU-HA} = 2 \times D_{MN-HA}$$
$$T_{RR} = max[(D_{MN-HA} + D_{HA-CN}), D_{MN-CN}] + max[(D_{CN-HA} + D_{HA-MN}), D_{CN-MN}] \quad (6)$$

by assuming of

$$D_{MN-HA} + D_{HA-CN} > D_{MN-CN}$$
$$T_{RR} = D_{MN-HA} + D_{HA-CN} + D_{CN-HA} + D_{HA-MN}$$
$$T_{RR} = 2 \times (D_{MN-HA} + D_{HA-CN})$$

and

$$T_{BU-CN} = D_{MN-CN} + D_{CN-MN} \quad (7)$$
$$T_{BU-CN} = 2 \times D_{MN-CN}$$

Accordingly, the T_{MIPv6} latency can be rewritten as in Equation (8).

$$T_{MIPv6} = 2 \times (2 \times D_{MN-HA} + D_{HA-CN} + D_{MN-CN}) \quad (8)$$

T_{L2} is essential to a new association. It is utilized by the physical interface, and it is independent from network topology [16]. Some studies [17] have shown that T_{L2} represents 12% of the total handover latency. The L2 latency can be elaborated as shown in Equation (9) [5].

$$T_{L2} = T_{PRB} + T_{AUTH} + T_{RASS} \quad (9)$$

Where: T_{PRB} is probe latency, T_{AUTH} is authentication latency and T_{RASS} is association latency.

2.3 L2 Handover

L2 handover or Link Layer handover is called for the connection that the MN performs with a new AP. In the IEEE 802.11 networks, L2 handover is composed of three distinct stages as shown in fig.4:

- *Scanning:* This stage can be occur in passive or active mode. In the passive mode, a MN listens beacon messages which are sent by APs periodically whereas the MN executes the scanning mechanism by sending Probe frames to discover all potential APs in the active mode [5]. In the active mode, a MN moves from one channel to another channel until it receives a Probe Response message during MinChannelTime. If the MN gets a Probe Response from an AP at any rate, it maintains scanning for the same channel to find all APs on this channel. This process occupy until a MaxChannelTime [16]. Scanning results gives some information such as ESSID, MAC addresses and signal strength of each AP, and so the MN choses an appropriate AP according to these information (signal strength is usually used). Scanning stage ends by finding an AP.
- *Authentication:* This stage is rely on the security mechanism which are used in the mobile node and new AP. Authentication mechanism is not required in an open system because it is sufficient that empty authentication frames is only exchanged between the two sides. If a WEP encryption procedure is used between the MN and new AP, a WEP key or a challenge text is exchanged [16].
- *Re-association:* The mobile node will attempt to perform re-associate procedure by sending a re-association request message for new AP after a successful authentication phase. The AP replies this message with a re-association reply message. It includes the results of re-association [5].

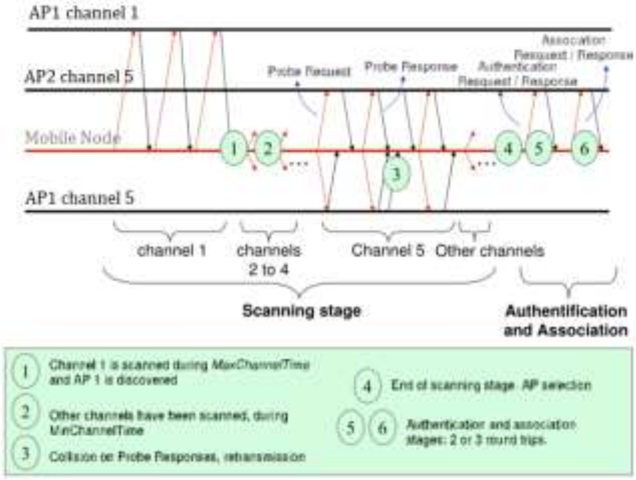


Figure 4. IEEE 802.11 standard L2 handover stages [16]

3 Evaluation

We used OMNet++, which is an extensible, modular and component-based C++ simulation library and framework [18], as a simulation tool in our study. Moreover, xMIPv6 (Extensible Mobile IPv6) implementation in OMNeT++ is used to simulate MIPv6 handover protocol. It was strictly designed in accordance with IETF's official specification for MIPv6 protocol that was standardized in RFC 3775 [19].

In this section, we have analyzed the L2 handover latency and the factors concerned with L2 handover in terms of MIPv6 simulation.

3.1 Test Environment

In this study, a MIPv6 network environment (see Figure 5) based on IEEE 802.11 protocol was established by using OMNeT++ network simulator. This simulation supplies the basic configuration to the L2 handover. In the simulation, the MN1 that is one of the main nodes on the network model is connected with AP1. However, it performs the handover procedure by moving AP2 domain in time. In the handover time, the MN decide whether the default AP is accessible or not, and then, it realizes standard IEEE 802.11 handover procedure. On the other hand, the CN1 is a node that communicating with MN1 on this network simulation. CN1 is continuously sending data packets to the MN1 with 0.5s interval. Furthermore simulation network is consist of IPv6 routers and a HA.

In the simulation, the beacon interval value was adjusted to 100ms. It is sufficient to send beacons by AP1 and AP2 successfully. This is important because very frequently sending beacons may lead to considerable overhead. Moreover, RA intervals was set to 0.03-0.07 which are the minimum range identified in RFC 3775. The mean time between unsolicited multicast RAs is 50ms with a smaller MinRtrInterval value and MaxRtrAdvInterval in this case. Therefore, it allows sending of unsolicited RAs more often [20].

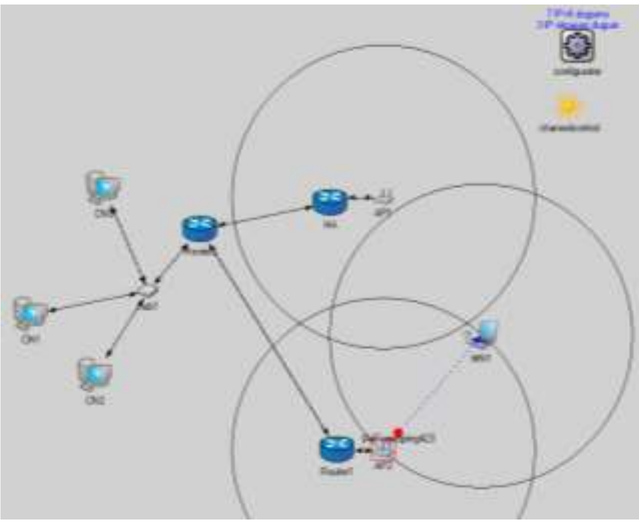


Figure 5. MIPv6 handover procedure test network

3.2 Performance Evaluation

L2 handover latency and packet losses were measured by using the simulation results. The measurement of L2 handover latency resulted in 0,6549s based on the default values of RAs (MinRtrAdvInternal = 0.03s, MaxRtrAdvInternal =0.07s).

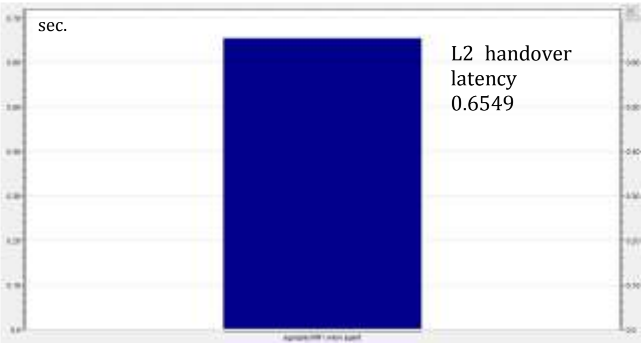


Figure 6. MIPv6 handover L2 latency

L2 handover latency is the sum of scanning latency, authentication latency and re-association latency as previously shown in Equation (9). According to simulation results, the L2 handover components were extracted as follows:

Scanning Latency= 0.65

Authentication Latency = 0.00334

Re-association Latency = 0.00157

As can be seen in Figure 7, scanning stage is the significant part of the total L2 handover latency because more than 90% of the total latency occurred in this stage.

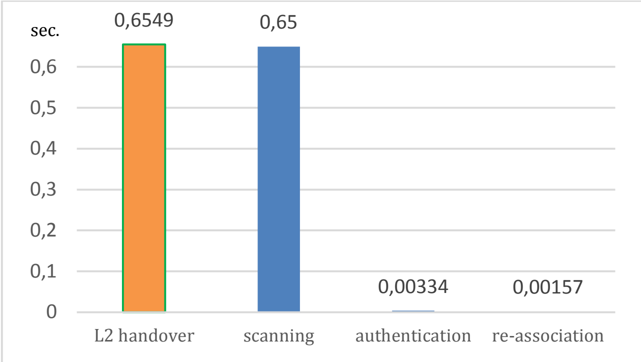
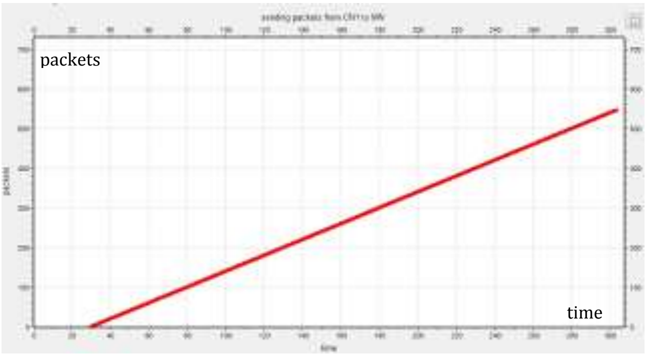
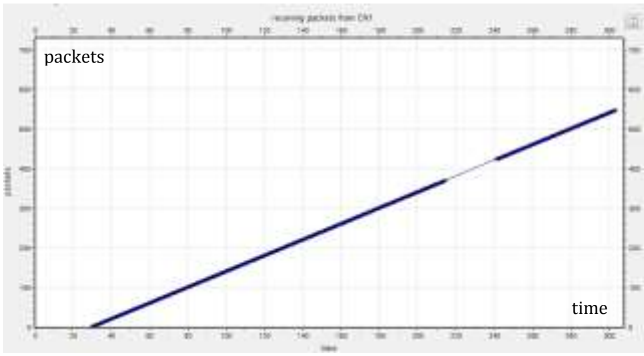


Figure 7. The time components of L2 handover

Figure 8 shows the sending and receiving data packets graphically. 549 data packet were sent by CN1 according to Figure 8 (a) but 496 data packets were received by MN1 according to Figure 8 (b). Accordingly, 9.67% of the data packets which were sent from CN1 to MN1 was dropped during L2 handover for *MinRtrAdvInternal* = 0.03s and *MaxRtrAdvInternal* =0.07s.



(a)



(b)

Figure 8. (a) Sending packets from CN1 to MN, (b) Receiving packets from CN1

4 Conclusion

Although MIPv6 will take place in the near future, handover management is still a major problem. Many researcher have focused L3 handover. However, it is seen that L2 approach is faster than L3 based solutions. The L2 handover means that the MN establish a connection with a new AP very soon.

In this study, we examine the L2 handover latency of MIPv6 by testing each phase of the process with the aim of produce a more complete understanding of L2 handover. The simulation result show that L2 handover latency is consist of scanning latency, authentication latency and re-association latency.

Channel scanning phase of the process have a remarkable value (more than 90%) in comparison to other L2 handover components. Therefore, a large portion of data losses occurs in this phase.

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