

# HANDOVER PERFORMANCE ANALYSIS IN MOBILE IPv6

## *A Contribution to Fast Detection Movement*

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**Abstract:** Nowadays, mobile communications face new challenges in its evolution: The convergence of wireless cellular networking and TCP/IP architecture. In addition, Internet protocols do not support mobility, so different mechanisms to offer seamless mobility have been proposed. The fourth generation (4G) IP-based wireless networks have lead IP level the ideal candidate where mobility should be implemented. Mobile IP is the protocol proposed for mobility management at the IP layer. Handover management is one of the most critical phases of this protocol. The high delay of this phase is a limitation to seamless mobility. In this work a detailed analysis about handover process is presented. Moreover, movement detection is a very costly stage in handover mechanism so a new fast movement detection algorithm to improve this detection has been developed. It is called FDML3 (Fast Detection Movement Layer 3). As the handover analysis as the algorithm proposed has been carried out thanks to OMNeT++ simulator.

## 1 INTRODUCTION

In recent years mobile communications have changed the traditional way of Internet access. Convergence between TCP/IP and wireless networks is a challenge to achieve seamless mobility in heterogeneous networks (Makaya, 2007). In this sense, mobility management must be implemented in a common level. IP is the best candidate to offer this capacity (Abduljalil, 2007). However, IP operation does not allow a node to move between different networks without a connection disruption. To solve this situation, IETF (Internet Engineering Task Force) has designed Mobile IPv6 (hereafter MIPv6) (Johnson, 2004). One of the most critical phases in MIPv6 is the handover or handoff, produced when a node moves to a new IPv6 subnet while connection is still alive (Koodly, 2007).

In this work, we analyze the handover process and a new L3 detection movement algorithm has been developed (FDML3) to decrease the handover delay. This work belongs to a research project called Campus Ubicuo (Carmona-Murillo, 2007).

This article is organized as follows: Section 2 presents mobility problem in IP networks; section 3

is focused on handover analysis; the proposed FMDL3 algorithm is explained in section 4; next, simulation results are shown in section 5; finally, conclusions are presented in section 6.

## 2 MOBILITY IN IP NETWORKS

In general, a host in the Internet changes data with other nodes thanks to TCP/IP architecture. These protocols were designed for fixed hosts, which are identified by an IP address.

Convergence towards “All-IP” architectures next generation wireless networks has made Mobile IP (Figure 1) the main solution to offer seamless mobility in the Internet (Le, 2006). Some approaches to reduce movement detection latency are based on layer 2 information. These solutions are faster than L3 ones but have an important drawback because they restrict the movement among heterogeneous networks due to L2 access technology dependence.

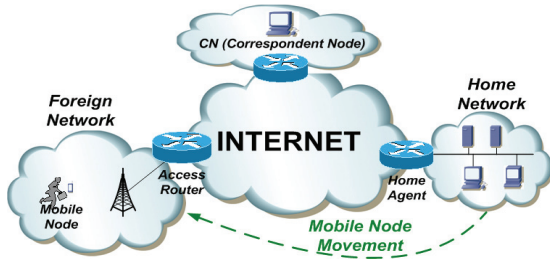


Figure 1: Mobile IPv6 entities.

### 3 PERFORMANCE EVALUATION OF MIPv6 HANDOVER

Mobility protocols are designed to solve overhead, packet loss and path recovery during handover. Handover latency is defined as the interval starting when the mobile node (MN) leaves the old access medium until the communication is resumed (Figure2). In this work a handover analysis has been carried out, contrasting it with similar research in this area (Cabellos-Aparicio, 2005).

Figure 2 shows handover latency components. T1 is the L2 handover and represents 12% of the total handover latency. T2 is the time spent by IPv6 to realize that it is attached to a new subnet and to obtain a new IP (87%). Finally, MIPv6 operation is carried out in T3 and is composed of the time that the MN needs to announce its new location (1%). Accordingly, the handover delay is given by (1):

$$T_{\text{handover}} = T_{L2\text{handover}} + T_{L3\text{handover}} \quad (1)$$

In this work, we focus our attention in L3 handover delay (2). In detail, this time results:

$$T_{L3\text{handover}} = T_{\text{IPv6}} + T_{\text{MIPv6}} \quad (2)$$

where  $T_{\text{IPv6}}$  (3) and  $T_{\text{MIPv6}}$  (4) are:

$$T_{\text{IPv6}} = T_{\text{MD}} + T_{\text{CoA}} \quad (3)$$

$$T_{\text{MIPv6}} = T_{\text{HARegistration}} + T_{\text{CNRRegistration}} \quad (4)$$

As Table 1 shows, T2 is the main responsible of the high latency in handover process, so most of the time (87%) is devoted to IPv6 tasks.

Table 1: Phases in MIPv6 handover.

Handover phases	Time
$T1 = T_{L2\text{Handover}}$	12%
$T2 = T_{\text{IPv6}}$	87%
$T3 = T_{\text{MIPv6}}$	1%

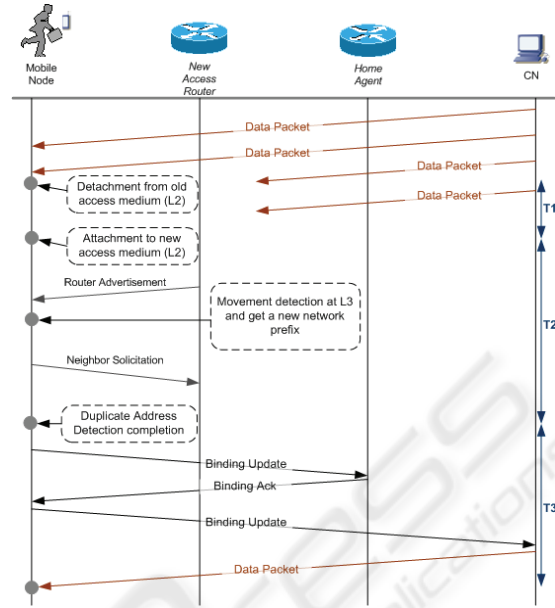


Figure 2: Handover latency components.

### 4 FDML3: A FAST DETECTION MOVEMENT PROPOSAL

Movement detection (MD) is a crucial task in MIPv6 handover and is based on IPv6 Neighbour Discovery (ND) (Narten, 1998). MD in MIPv6 is too costly in spite of modifications performed by MIPv6 in ND process. The most important modification is to allow sending Router Advertisements (RA) more frequently than the 3 second established in standard. MinRtrAdvInterval and MaxRtrAdvInterval can be set up till 0,03 and 0,07 seconds. Some studies have provided a mathematical analysis of MD in MIPv6 (Young-Hee, 2006), (Lee, 2004). In this work, we propose a L3 fast detection movement mechanism called FDML3. This algorithm starts from the research developed in (Blefari-Melazzi, 2005). The algorithm flowchart (Figure 3) is explained next.

1. A MN detects that an unsolicited RA has been lost. This situation is known because of the absence of a new unsolicited RA in an interval equal to the interval option configured.
2. MN sends a Router Solicitation to the access router to check the bidirectional reachability.
3. If a RS is not received in an interval between 0 and MAX\_RTR\_SOLICITATION\_DELAY (1 second), is possible to suppose that the lost has been caused due to a mobile node movement.
4. The MN tries to connect to a new access router to complete the handover, listening RA messages sent by routers periodically. The

network prefix obtained in a RA is used to configure the new CoA. This new IP address is registered in the Home Agent (HA) and CN.

## 5 RESULTS

OMNET++ simulation scene (Figure 4) is composed of nine routers, one of them is the Home Agent; nine wireless access points; a MN (client1); and a CN. The node moves in a circular path across the nine access points (generating eight L3 handovers).

The three tests that appear in this section are:

1. L2 vs. L3 handovers in MIPv6
2. Influence of unsolicited RA interval, given by MaxRtrAdvInterval and MinRtrAdvInterval.
3. Comparison of MIPv6 handover depending on MD algorithm used (FMDL3 evaluation).

For each test, the following information is presented:

- Overall MIPv6 handover time (sec.).
- Data lost percentage in transmission (%).

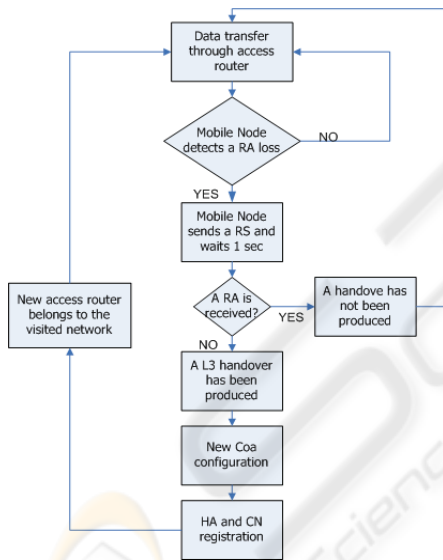


Figure 3: FDML3 flow chart.

### 5.1 Link-layer Triggers

Although our proposal consider network-layer the place where implement mobility, is important to compare the behaviour when link-layer information is used. As we can see in Figure 5 and in Table 2, the difference between both times is very large. Nowadays, handovers use L2 information to achieve a high performance. In this test, L2 handover time is 75% less than the L3 one. This test proves the necessity of L3 handover delay improvement to achieve mobility in heterogeneous networks.

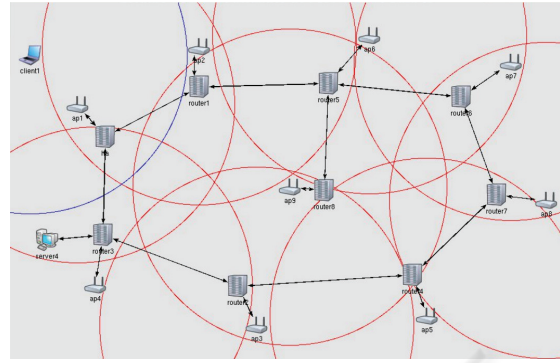


Figure 4: Simulation scene.

### 5.2 Interval between Unsolicited RAs

Routers send unsolicited RAs to advertise its presence to other nodes in an interval defined by MaxRtrAdvInterval and MinRtrAdvInterval. MIPv6 modify the default values of these parameters to allow fast movement detection in network layer.

Figure 6 shows L3 handover delay in four configurations, where these two parameters change its values. Obtained data are also shown in Table 3. If routers send unsolicited RAs fast, the time needed to detect the movement is shorter. However, a low configuration of these parameters causes an extra overload in the network. As in test before, packet loss is lower according to the time of the process.

Table 2: Simulation data. L2 triggers.

	L2 handover	L3 handover
Hand. Time	0,58	2,3
Packet loss	1,71	2,77

Table 3: Simulation data. Unsolicited RA interval.

	0,5-1,5	0,3-0,1	0,25-0,75	0,1-0,3	0,03-0,07
Hand. time	2,30	1,32	0,96	0,18	0,15
Packet loss	2,76	2,20	1,87	1,47	1,21

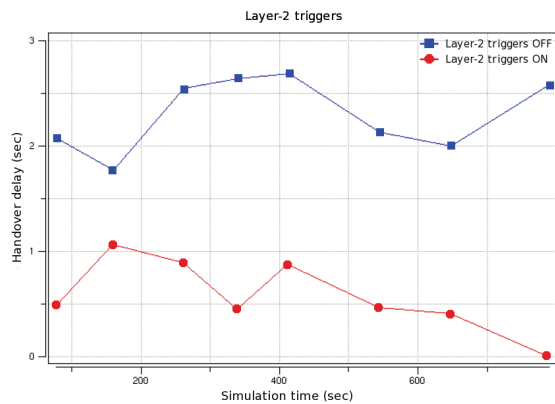


Figure 5: Handover delay with and without L2 triggers.

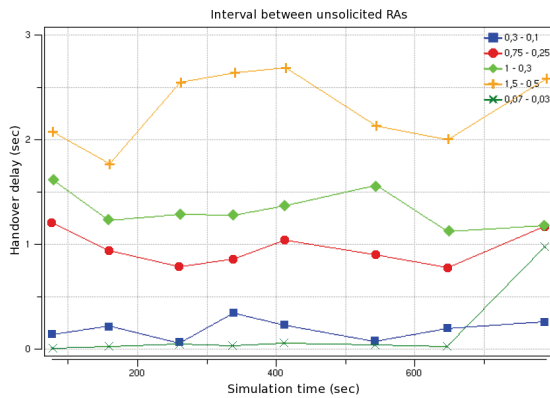


Figure 6: Handover delay. Unsolicited RA interval.

### 5.3 FMDL3 Evaluation

This proof checks the behaviour of the proposed FMDL3 algorithm comparing it versus the defined in (Johnson, 2004). Figure 7 and Table 4 shows the simulation results. When FDML3 is used, handover delay is reduced in an average of 25,6 %.

With this new mechanism, if unsolicited RA interval established is low, the handover delay improvement is not so high; however a configuration like this provokes a high amount of signalling traffic in the network, so this configuration will not be chosen usually. This means that FDML3 algorithm will improve the delay of the overall handover process in MIPv6 protocol, minimizing connection disruption while the mobile node moves among heterogeneous networks.

Table 4: Simulation data. FDML3 algorithm.

	With FDML3	Without FDML3
Hand. time	1,63	2,19
Packet loss	3,62	4,04

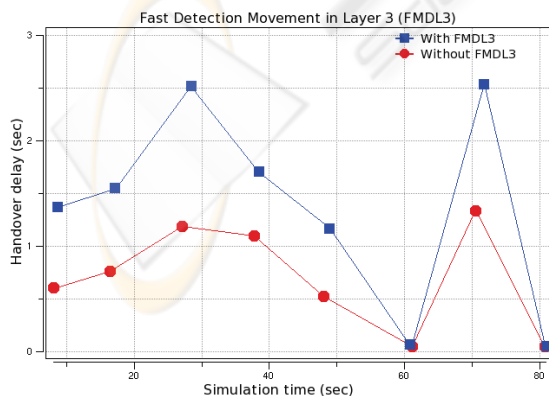


Figure 7: Handover delay improvement with FDML3.

## 6 CONCLUSIONS

In this work a MIPv6 handover evaluation is presented, checking each phase of the process. This analysis has been carried out using OMNeT++ simulator. Obtained data shows that there is a phase very costly in time terms (87% of the process). In this stage movement detection is performed, so it is a critical part of the process. Due to this limitation, a new fast movement detection algorithm has been developed: FDML3. With this algorithm, the overall delay is improved up to 25%.

Although this research work reduces the handover delay, there are other important sources of delay in MIPv6 handover: Router advertisement, duplicated address detection (DAD) and Binding Update RTT. The study and improvement of these topics is presented as future work.

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