Lightweight Handover Control Function (L-HCF) for Mobile Internet Protocol version Six (IPv6)

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Abstract

While shifting from one specific single access point to another point, the Mobile IP address permits a single mobile node for keeping an uninterrupted connection with the internet. Nevertheless, when handover occurs, the packets designed for the mobile nodes may have some delay or the risk of getting lost, because of the operations such as Mobile IP handover and link switching delay. This paper presented a novel control function that is called Lightweight Handover Control Function (L-HCF). The purpose of this control function is to improve of the handover performance in the perspective of Mobile IPv6 over wireless networks. The L-HCF functionality allows a router to choose which Access Router(AR)/Access Point (AP)/ address that the mobile node is associated with when movement is needed, by using available IP addresses in its database if the movement operation in side domain or by exchange messages between other routers if the movement alter domain. Thus the Mobile Nodes (MN) can use this address without engaging in the process of Stateless Address Auto-configuration or the procedure of Duplicate Address Detection. The function is implemented analytically then simulated in OPNET. The result shows that, the control function offer minimum latency, less packet loss compared with the standard function of the mobile IPv6.

Keywords: Handover Latency, IP6, IEEE 802.11/Wi-Fi, Lightweight Handover Control Function (L-HCF)

1. Introduction

Wireless networks are in full development because of the flexibility of their interfaces, which allow users to be easily connected to the Internet. Among various technologies of wireless networks, IEEE 802.11/Wi-Fi technology is becoming better known and more used to construct high speed wireless networks in areas with high concentration of users, such as airports, campuses or industrial sites. The passion for wireless networks and in particular for Wi-Fi networks has given rise to new uses of the Internet, such as moving in wireless networks while still being connected¹. In Wi-Fi networks, the user's movement may sometimes lead to a change of Access Points (APs) to the network. This fact is generally named the handover of layer 2 because this change involves only the first two layers of the OSI model. If the two APs are located in different networks, the change of AP would entail a change of network for the user. This situation is generally termed, the handover of layer 3, because the user should change his network and his IP address to maintain connection to the Internet. Therefore, this change intervenes with the OSI model's network layer¹².

The process of the handover of layer 2 is handled by the IEEE 802.11 standard and that of layer 3 is controlled by the Mobile IP protocol¹³. The Mobile IP protocol is

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a protocol standardized by IETF, which allows users to change network, while maintaining their actual connection to the Internet. Consequently, users can connect to the Internet, while keep moving in Wi-Fi networks in control of the IEEE 802.11 standards and the Mobile IP protocol¹⁴. However, the delay induced by these procedures of handover is too long. As such, this generally leads to the cut-off of current communications, hence impacting adversely on the qualitative requirements of real-time applications, i.e. video conferencing or VOIP (Voice Over Internet Protocol). Various proposals have been made to reduce the delay of handover procedures and to improve their performances. However, these proposals are either imperfect, or non-implementable because of their complexity. Based on the premise that Wi-Fi networks and access routers are already massively implanted in academia and in industry, we propose to add a new functionality, called L-HCF (Lightweight Handover Control Function) in routers, without modifying other network equipment's. A router equipped with this functionality is called an L-HCF router. To reduce the delay of handover procedures, the L-HCF functionality allows a router to generate a topology of APs by using the neighborhood graph theory and to maintain a pool of available IP addresses in its database.

2. Methodology

The handover operation comprises two types of different stages: Link Layer handover and Network Layer handover. In Link Layer handover there are three phases: first one is Discovery phase (which works by scanning of the channels to find out if there any Access Point), second one is called Authentication phase, and the third one is, Re-association phase. On the other hand, Network Layer handover has four phases: Router Discovery phase, Detection Address Duplication (DAD) phase, Binding Update phase and Binding Acknowledgement phase¹⁵. The maximum estimated value for the typical MIPv6 handover latency is 1290 ms². In the real time applications i.e. audio and video this long value of the latency cannot be applicable. In Figure 1 (Router Discovery, DAD, Binding Update and Binding Acknowledgement), it can be noted by analyzing the phases of the network layer handover that DAD latency takes away just about 1000 ms and in the global handover latency, it carries a heavy weight^{3,10}. Thus, to make the total handover latency as low as possible, a novel technique is created for the avoidance of any kinds of DAD operation while the handover is occurring. A new-found local intelligent entity is developed called L-HCF. The attached MNs, the Aps and the ARs should be controlled properly by this control function. Connected directly to its access routers, each Lightweight Handover Control Function router keeps beforehand a collection of every available addresses of local IP. Another list that comprises the used addresses of ARs/APs/IP is also created and maintained periodically by the L-HCF router. Now, with the help of these two lists, one possible identical collision IP address can be found by the L-HCF router, in this domain. At that point, this specific L-HCF router may withdraw this particular possible identical address of the IP or it may request an attached sub-node to alter its address of the IP. Thus, without the Detection Address Duplication, a single and distinctive IP address is provided to the MN by the L-HCF router. Additionally, the L-HCF router has the ability to interchange some local info with its attached ARs/APs/MNs and it also can exchange some external info with the other L-HCF routers.

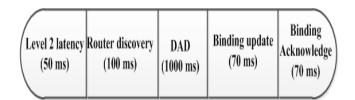


Figure 1. Standard delay time of the handover.

To realize L-HCF method several new messages are suggested: MNReq (Mobile Node Request), MNRep (Mobile Node Reply), HCFReq (Handover Control Function Request), HCFRep (Handover Control Function Reply), CEInf (Connection Established Information) and HFCon (Handover Finished Confirmation) messages¹⁵.

- LEHCF: Total handover latency with the L-HCF approach.
- Lscan: The Latency because of the mobile node's authentic scanning of its information of the adjacent AR/AP.
- LMNReq: The Latency of the mobile node while sending MNReq message to its original L-HCF router.
- Ldec: Essential latency of the L-HCF router while deciding which AR or AP the mobile node is suitable to be attached (with short delays used

both for sending and receiving the HCFRep message).

- LMNRep: The Latency needed for the L-HCF router to direct the MNRep message to the mobile node.
- LCNinf: Essential latency of the mobile node while performing automatic configurations of its new CoA.
- Lconf: The latency while the L-HCF router is sending the buffered packets and an HFCon message.
- LBU = BA: The latency which called Binding Update or Binding Acknowledgement.

3. Proposed L-HCF Procedure

All L-HCF routers' database must be recorded and maintained at regular intervals. While the handover is occurring, with the intension of adapting for the mobile node activities, in absence of the DAD phase, this database aids to find a distinctive and new configuration of IP address. The steps of this procedure (as shown in Figure 2) are as follows:

- While moving inside the same network, if the maximum threshold value of the receiving signal is exceeded, the mobile node starts to acquire the neighbor AR/AP's information such as access point's BSSIDs, signal strength, IP addresses, interface addresses of the access router and prefix of the sub-network. After that, the mobile node directs the MNReq message towards its original L-HCF router (through its attached AR/AP) for the reporting of this information.
- The access router halts forwarding the packets to the mobile nodes after receiving the MNReq message. To escape from the packet loss, the AR starts forwarding them towards the original L-HCF router in the procedure of the handover.
- The original L-HCF router selects the eligible AR/AP the mobile nodes needed to be associated with, after getting a MNReq message. The selection can be done in two different criteria: on the basis of the database acquired with the help of periodic exchange messages as of the EHCF router to another (massages i.e. HCFReq, HCFRep etc.) or from the ARs/APs/MNs. As an example, if one particular access router or

access point reaches at the limit with total number of the registered mobile nodes, the original L-HCF router would not assign any other mobile node(s) to that particular overloaded AR/AP. After performing this prior decision, the original L-HCF router directs a MNRep message towards mobile nodes that contains a new IP address, a new BSSID of the AP, a sub-network prefix and an address of the AR interface.

- The mobile node can be automatically conFig.d with the help of the MNRep message and a new CoA is also can be obtained. The new attachment can be confirmed when the CEInf message is sent from MN to its original L-HCF router.
- When a CEInf message is received, the original L-HCF router handovers the packets (buffered) to the new CoA of the MN. After that, the original L-HCF router transmits the HFCon message for ending the procedure of handover.
- After finishing the above stated procedures the mobile node now will have the ability to share and communicate with the home agent and its associating nodes via massages such that BU and BA. As illustrated inside L-HCF procedure, a mobile node can acquire a new CoA prior to the attachment with the next AR/AP. Additionally, any kind of latency which involves DAD operation and close to 1000 ms, will be avoided. Hence, with the help of L-HCF approach the minimization of both conventional packet loss and the handover latency can be performed. Comparing

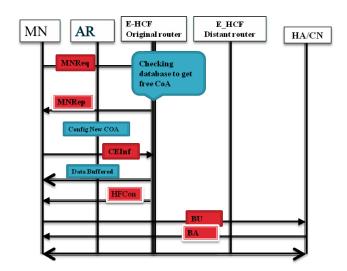


Figure 2. L-HCF procedure.

with the conventional method, the performance of the handover process is optimized in this way.

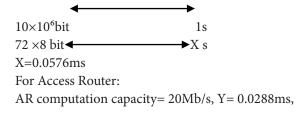
4. Simulation and Analysis

TL-HCF method is simulated using Opnet and Matlab, two handover scenarios are implemented for both intra and inter domain handover cases. Table 1 show the simulation parameter setup for the simulated network.

Table 1.	Parameter	setup
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Parameter	Value	Comment
Channel scan time	50 ms	MIPv6 standard
BU/BA latency	140 ms	MIPv6 standard
Wireless link bandwidth	5.5 Mb/s	IEEE 802.11b
Wireless link bandwidth	9 kb/s	GSM
AR computation capacity	20 Mb/s	general router
MN computation capacity	10 Mb/s	PC computation capacity
MNReq message size	72 byte	E-HCF approach
MNRep message size	45 byte	E-HCF approach
HCFReq message size	45 byte	E-HCF approach
HCFReq message size	45 byte	E-HCF approach
CEInf message size	45 byte	E-HCF approach
HFCon message size	24 byte	E-HCF approach

To generate MNReq message by MN: MN computation capacity= 10Mb/s



To put on WiFi Network: Wireless link bandwidth =5.5 Mb

Z=0.1047ms
Latency=0.1914ms
MNRep: latency=0.119ms
HCFReq: latency=0.083ms
HCFRep: latency=0.083ms
CEInf: latency=0.119ms
HCFon: latency=0.0638ms
Total latency for messages=0.6588ms
$LEHCF = L_{scan} + L_{MNReq} + L_{HCFReq} + L_{HCFReq} + L_{MNRep} + L_{conf}$
$+ L_{(BU+BA)} = 190.7312 \text{ ms}$

(1)

Therefore, the total latency for Wi-fi network is 190.7312 ms, for UMTS network 191.4352 ms and for GSM network 435.6645 ms. By comparing the latency in Wi-Fi network, UMTS network and GSM network using mat lab simulation code this result is obtained and shown in Figure 3. The Figure 3 shows two types of latency based on MIPv6 handover: one of them is the standard (1290 ms) (7-10,15) the other one is the L-HCF handover latency which is on the basis of the GSM link bandwidths, UMTS and WiFi. It can be noted that if the rates of the link bit changes between 150kbps to 5.5 kbps, there is a very little variation in different L-HCF latencies. On the other hand, there is a rise in the latency value (up to 435ms) when the link bit rate comes down to 9 kb/s (for the GSM). Therefore, the bandwidth of the wireless

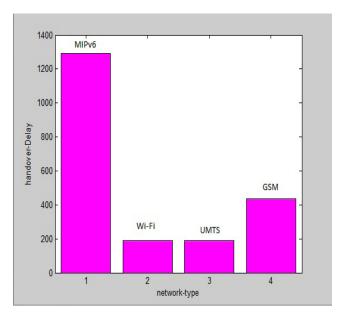


Figure 3. L-HCF handover latencies as a function of wireless link bandwidths.

link has a very significant influence on the overall procedure of the handover. Here, the main focus is given about L-HCF latency which associated with the wireless networks of IEEE 802.11b standard.

The estimation of L-HCF performance is calculated with respect to the packet loss and the total handover latency in association with the architecture of the network, shown in Figure 4. The model enables the comparison between the L-HCF and standard handover of the MIPv6 protocol^{4–6,9,10}.

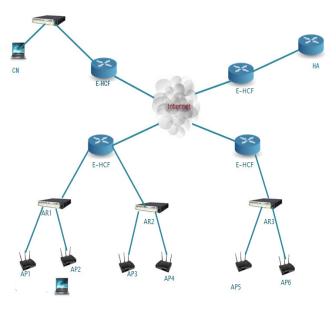


Figure 4. Network architecture.

The handover procedures are simulated in the Opnet simulator using two different types of applications – FTP/ TCP and VoIP/UDP. The simulation scenario is shown in Figure 5.

The L-HCF Latency Analysis with respect to the handover procedure. The total latency of the L-HCF handover (LEHCF) can be calculated by the following equation 2:

 $LEHCF = L_{MNReq} + L_{MNRep} + L_{BU} + L_{scan} + L_{dec} + L_{conf} + L_{CNinf} = BA$ (2)

If a comparison is made with the help of the equation (2) between the EHCF and standard handover latency, it can be seen that the average value is around 200ms for the L-HCF handover latency, and this specific value of the latency will be validated by the results of the OPNET. Although there is significant reduction of the latency value from 1290 ms to 200 ms, but the reduced value (200ms) is

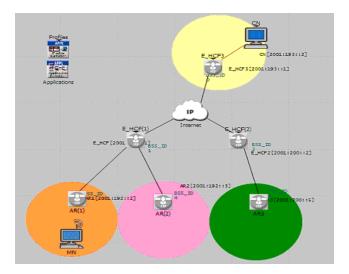


Figure 5(a). Simulation Scenario.

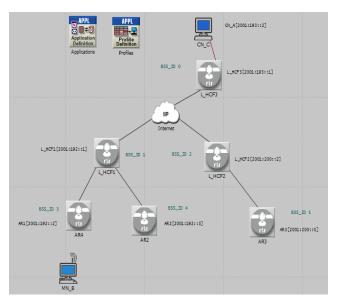


Figure 5(b). Simulation Scenario in Opnet.

still very long that it cannot be used in real time wireless networks' applications and this happens only because of the number of scans of the channel. By storing the packets into a buffer while the handover is occurring, the loss of the packet can be reduced in the L-HCF approach.

4.1 HCF Performance Estimation

Some applications are used that generate a stream of constant flow to observe the interruption of the receiving data stream of MN and packet loss. With respect to the handover in wireless network applications, it can be classified according to their mode of transport as follows:

The reliable mode with TCP.

An unreliable mode with UDP.

4.1.1 Case Study 1: TCP-based

Applications that require reliable transfer of data streams generally use the TCP protocol such as in the case of Email, instant messaging, Secure Shell (SSH), the Web application, File Transfer Protocol (FTP), etc. Figure 6 illustrates packet transmission in the case of FTP protocol.

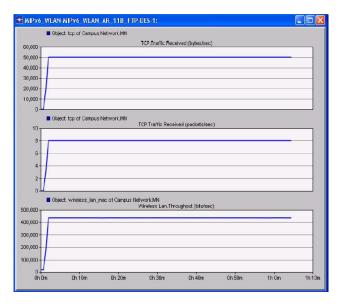


Figure 6. FTP Data.

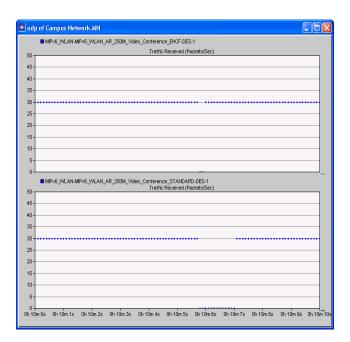


Figure 7. Comparison between packet lose in L-HCF and statured TCP Data Received.

TCP stream is managed by the principle of "sliding window". So, after sending the packet, a MN expects an acknowledgment CN before sending the next packet. This flow causes the management number of received packets. Figure 7 Illustrates packets lose in FTP/TCP case.

4.1.2 Case Study 2: UDP-based

With UDP, applications can simply encapsulate IP data grams and send without connecting. So, UDP is suitable for real-time applications i.e. Voice over IP, video conferencing etc. Actually, multimedia applications consist of multiple streams: audio, video, text and possibly other streams. To transport the media stream over IP networks, it is necessary to use not only the UDP protocol but also Real- Time Transport Protocol - The Protocol for Real-Time Transmission (RTP). RTP implies that a transport protocol which is implemented in the application layer. As UDP, RTP receives no flow control or error control or acknowledgment, or retransmission request mechanism, but it can multiplex multiple data streams in real time by a UDP packet stream which is then sent via the UDP protocol. Figure 8 illustrates packet transmission in the case of VoIP application. When the MN and CN launch an application that uses UDP, then the MN and CN send UDP packets hoping that the other side is able to receive and there is no guarantee that UDP packets are delivered to the destination. If the network connection is interrupted, the packets will be lost. The results of the simulations are presented by using the VoIP application in the following paragraphs.

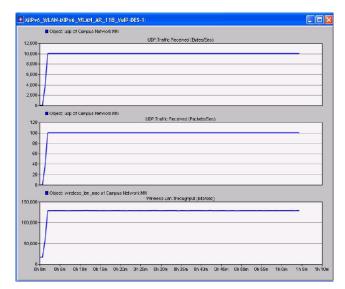


Figure 8. Illustration of VoIP Data.

Figure 9 shows comparison between the Standard¹² and L-HCF method for the application reception (number of packets received per second) packet to the MN during simulation. The Figure 9 shows a comparison of the standard method with the E-HCF method for packets received by the MN for 600 and 610 seconds. The procedure of handover occurred at 605.8 seconds. It can be seen that, in this Figure. a power reception of the data stream in the standard method and a low flow received by the MN in the method L-HCF. In fact, the VoIP application sends 10 packets for 100 ms. The OPNET measures for a period of 100 ms and generates a statistic value during the simulation. Since the duration of handover procedures managed by the L-HCF method is only about 140 ms, so it can be assumed that the handover is often begins and ends in the middle of a measurement period. Therefore, it can be seen that, a drop in flow is received, but a break in the receipt of data flow is not seen in the E -HCF method. This method can reduce packet loss and ensures an acceptable timeframe. Also, it has been found that the interruption of the reception stream is much smaller in the L-HCF method than the standard method. A visible result is obtained for the applications that use TCP and UDP. For future work, it can be recommended to enhance the performance of the handover process in network layer and link layer by decreasing the router discovery time and mechanism to decrease Binding Update and Binding Acknowledgement times.

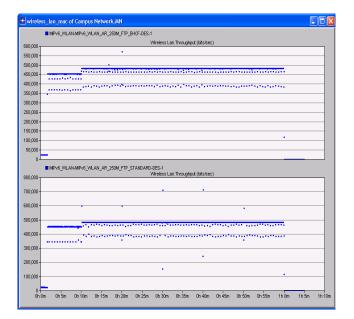


Figure 9. Comparison between packet lose in L-HCF and statured UDP Data Received.

5. Conclusion

For the improvement of the handover performance of the MIPv6, L-HCF approach permits collecting and storing of some link and networking data. The main problems of the handover of level 2 and level 3 handover from the fact that the time of handover procedures is too important for many applications, especially for real-time applications. The delay causes both communication interruptions and loss of packets visible to users. In regard to the classical MIPv6 handover performance, the results of the proposed method shows that the L-HCF approach significantly decreases the overall handover latency. As it has been described, this method reduces the handover delay of 272 ms. For the reduction of the packet loss due to the handover procedures, one proposal is made to amend the Mobile IPv6 protocol. The MN terminates the association with its home address and its care-of address with the home agent and matching nodes before the handover procedure. Therefore, the home agent can be used to intercept and redirect packets matching nodes or MN to the new MN address or to the addresses of nodes correspondents respectively during phase updating association.

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