A Multilevel Hierarchical topology of Duplication & Merging Agents for Mobile IPv6 Soft-Handover

Farouk Belghoul, Yan Moret, Christian Bonnet

Department of Mobile Communications, Institut Eurecom
2229 Route des Crêtes, BP 193, F-06904 Sophia Antipolis Cedex, France
{FirstName.Name}@eurecom.fr

Abstract

Mobile IPv6 soft handover is a new scheme that integrates soft handover management in mobile IPv6 in order, to provide better Quality of services (QoS) support of data communication, based on radio transmission between a mobile node (MN) with multiple radio interfaces or software-defined interfaces and an IPv6 internet network. This solution enables the reception of duplicated IPv6 flows by the MN from two or more Access Routers (AR) simultaneously. By merging those flows in IP layer at reception, the MN can simultaneously 1. Avoid connection disruption, packet loss and jitters introduced by wireless radio signal degradation. 2. Allows MN's session to progress without interruption when it moves from one radio cell to another regardless of its radio technology. To perform such thing this solution introduces "Duplication & Merging Agent" (DM) in IPv6 core network. It is a conventional router located at the core network which duplicates and merges IPv6 flows to and from the MN. By the introduction of multilevel hierarchical architecture of DM agents in soft handover, we aims to minimize the second connection establishment and registration latency, confine packets duplication and merging in the local network and reduce signaling messages to and from local network. In this paper we propose and evaluate a set of mechanisms that allows a soft handover to handle with multilevel hierarchical architecture of DM agents.

Keywords: *Soft Handover, Mobile IPv6, Hierarchical architecture, QoS*

Introduction

Internet Protocol is becoming the universal network-layer protocol over all radio access technologies, which makes the current trend today toward design of All-IP wireless and wireline networks, where radio cells are under the control of IP Access Routers for signalling and data transmission. Mobile IP [1] has long been considered as facto standard in providing IP mobility. However, as the demand of wireless mobile devices capable of executing real time applications increases, it has pushed for the development of better handover techniques for providing high Quality of services (QoS) support. Mobile IPv6 [2] is the natural evolution of Mobile IPv4. In mobile IPv6, each MN is able to create its own care of address (CoA) using IPv6 stateless auto-configuration mechanism [2], so Foreign Agent are not needed. Hierarchical Mobile IPv6 approach [3] aims to modify the network architecture to improve mobile IPv4 and mobile IPv6 fast handover [4] performance in case of local mobility. This is done by confining mobility management to the local level, which reduces local IP handover latency and decreases control information load in the network. IPv6-based soft handover [5] [6] for mobile IP-device is an efficient IP based micro mobility management based on the use of DM agents to duplicate and merge IPv6 flows. But the DM agent location issue still open. The question is how and where those DM agents will be disposed in the core of the network. In this paper, we present a short description of Mobile IPv6 soft handover; we then introduce a set of mechanisms to manage multilevel hierarchical topology of duplication and merging agents with soft handover. Early simulation results show that with hierarchical soft handover, we are able to provide a scalable solution that improves IP signalling latency, introduces less signalling overhead and less duplicated parquets in the core of a wide area network in case of frequents local mobile movements.

Basic IPv6 Soft handover mechanisms

Fast handover bicasting, enables data duplication through old and new ARs, but MN can not receive more than one IP data flow at the same time. Eurecom IPv6 Soft handover [7][8][9] improves that, it enables data reception from multiples Access Router simultaneously at IP layer, which allows MN's session to progress without interruption when it moves from one radio cell to another. This solution requires MN to have two WLAN radio interfaces, and. The IP Soft handover approach is based on four main processes. They allow duplication and merging of IP flows without the need to synchronise duplicated-flows transmission over the air [10].

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A. Mobile registration process: If we consider a special case of MN with data connection with two ARs in an IPv6 network, the sending device has to know all the addresses of the MN in all sub networks. Mobile IPv6 allows MN to have a primary CoA (PCoA) for the first time it connects to the network. It is registered within home agent and DM. Two additional local CoAs are used for packets transmission from DM agents to MN through the two ARs. Those LCoAs are obtained by MN using IPv6 stateless addresses auto-configuration mechanism [2] and registered within the DM agent. The registration is done using a Merging Solicitation message. This message allows MN to register its new LCoA and request DM to start the duplication and the merging process.

B. Duplication Process: In order to duplicate packets, the DM agent intercepts packets sent by CN, extracts from each packet the destination Address (PCoA) and finds all corresponding LCoAs. Using those LCoAs, the DM agent creates new IPv6 packets with same payload information, but with substitute LCoA as new destination address. A sequence number field is inserted in each IPv6 packets header, it is used to number all packets sent to the tunnel. Same duplicated packets will be identified by same sender, same receiver and same sequence number. Packets are then tunnelled through ARs to MN.

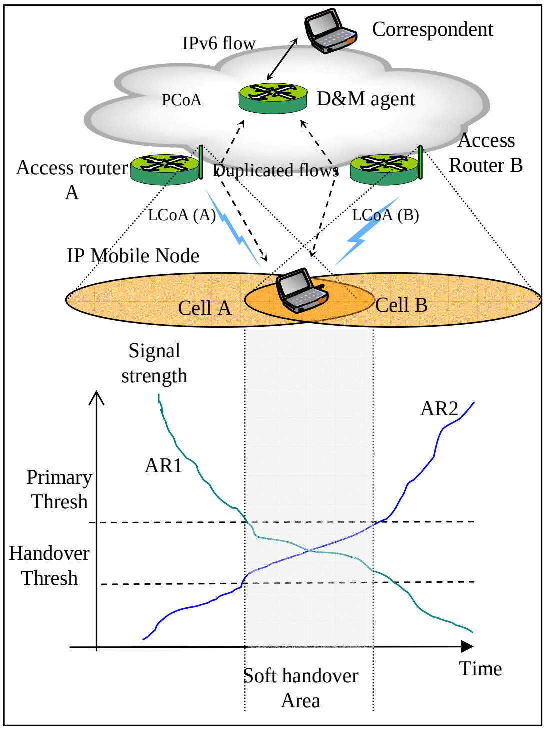

Figure1: IPv6 flow duplication and merging

C. Merging process: The use of duplication process to send separate copies of same data via multiple ARs to the MN, introduces the need to filter the duplicated packets. Merging process checks if the sequence number is included in the IP packet. If there is no sequence number, process will route normally the payload information. Otherwise, if the packet sequence number exist and already listed as received packet, IP packet will be discarded (it has already been received).

D. Handover Process: We suppose a mobile with two interfaces primary and secondary, the interfaces priority choice is dynamic; we assume that the primary interface is always the interface with better connexion quality. The mobile must be kept connected through its primary interface. The secondary interface is used to perform the handover and avoid signal strength degradation if possible. The aim of this handover strategy is to efficiently exploit all available resources in order to avoid packet loss and the introduction additional end-to-end delays during mobile roaming from an AR to another one. Two signal strength thresholds are defined, handover threshold (H_SH), which is the threshold used in Mobile IPv6 to initiate the handover. Primary threshold (P_SH) is used in soft handover to initiate secondary interface connection process. Figure 1. We assume a mobile connected on its primary interface with AR1, it has its PCoA and LCoA1, and both of them are registered with in DM agent. When mobile discovers AR2, and if quality of primary connection is less then P_SH, secondary interface connection is established with AR2, LCoA2 is registered within DM, duplication and merging process will be UP. In this case: 1. Interface with better connection quality will be assigned dynamically to be the primary one. 2. If signal strength of secondary connection became worst then H_SH, the secondary connection is closed and active scanning is initiated to connect it to new AR. 3. When the Signal strength quality of primary connection became better then P_SH (very good connection quality), mobile closes secondary connection, shut down duplication and merging process.

Hierarchical DM agents Architecture

Our proposal use several levels of hierarchy per site, a site can be split into several levels of hierarchy. A DM agent is then deployed in each level of hierarchy of the site. The DM agent that manages duplication and merging for hole the site is in the top of the tree, followed by the DM of the lower hierarchy level and so on, until the lowest level. (Figure 2).

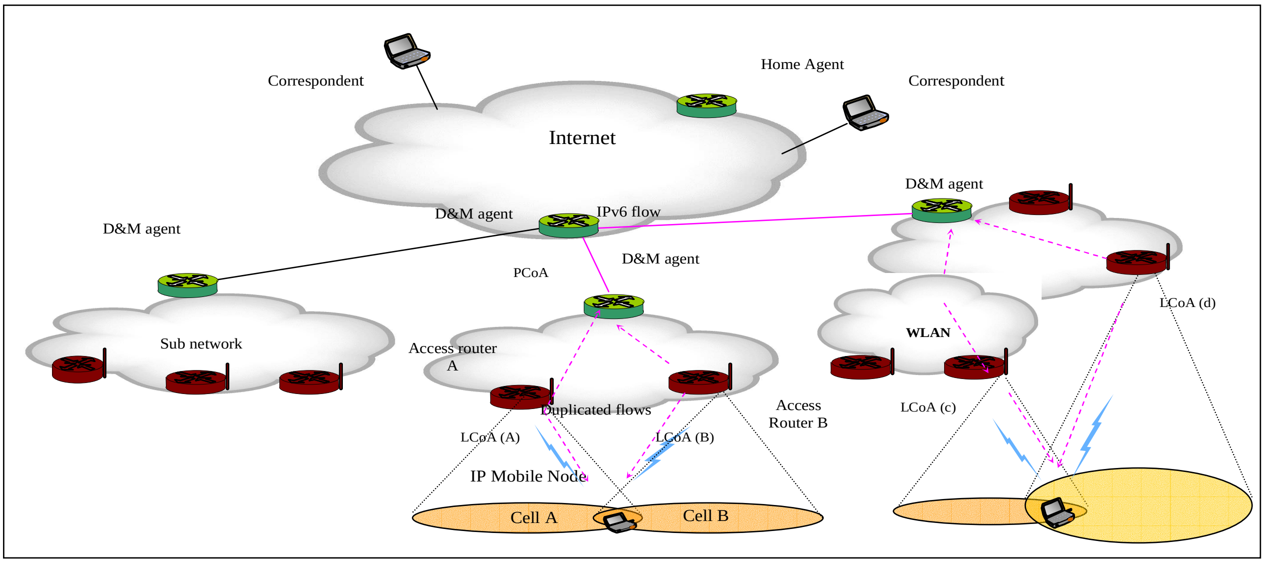

Figure2 . Hierarchical DM agent's architecture

When using a hierarchical DM architecture, to manage the second connection of the mobile, we separate mobility into micro mobility (within local network) and macro mobility (inter-site mobility). In micro mobility, the mobile node has to establish the second connection within the same sub-network with its first connection; in this case, the DM agent assigned to the MN will be automatically the lowest DM in the branch from MN current location to the top DM. The MN then performs the same process as described in (2.A). It sends merging request with its new LCoA to the lowest DM. this DM duplicate packets to the MN new LCoAs.

In case of macro mobility the MN performs the following operations:

1. It gets a new Local CoA from its new AR.
2. It gets new PCoA in each DM agents from DM1 to DMn (we note DMi, the DM of rank "i" in the branch from the MN to the top DM agents), using Merging request / Merging advertisement messages.
3. DMn is the first common DM agent between the primary MN connection and the new secondary connection.
4. This DM has to duplicate packets to the two MN connections.
5. The result is that the duplication process will be as near as possible to the MN.

Performance evaluation

Gemini2 simulator was used for the evaluation of the advantages of hierarchical DM architecture in soft handover compare to a single DM agent. Gemini2 is a discrete time simulator developed in Eurecom. It provides support for simple, open and efficient conception of a network topology to simulate complete wireless networks. 802.11b at 11mb/s is used as radio protocol. The goal of those early simulations was to examine the effect of a hierarchical architecture in wide area networks in an end-to-end UDP communication sessions. In particular we want to examine duplicated packets, signalling load in each part of our simulation network. We will see the effect of DM agent position in the soft handover delays using can sending UDP packets at 0.5 Mb/s to a MN moving across simulation network topology as described in Figure 3, 4.

The two figures show the same network topology, an Internet connected to three local networks, in each local network we have a set of IP Access Routers uniformly reparteed. Those AR give MN optimal radio coverage for about 1000m. In first network topology, we use only one DM agent and in the second topology, we introduce two levels of hierarchy. A local DM agent is used in each local network and global DM agent in internet is used to mange MN global mobility.

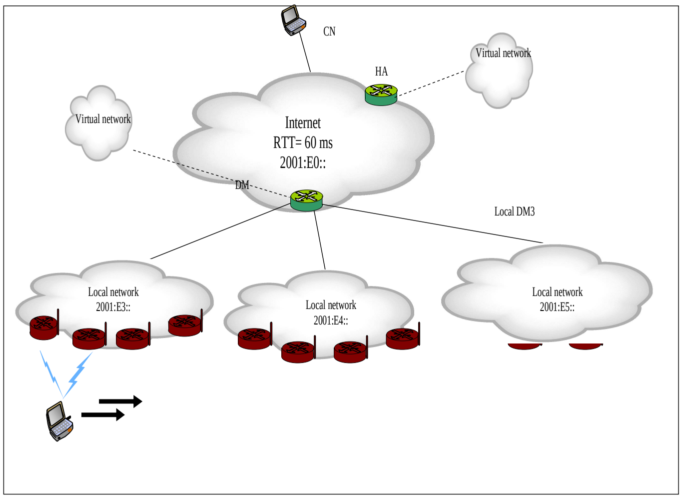

Figure 3: network topology with single DM agent

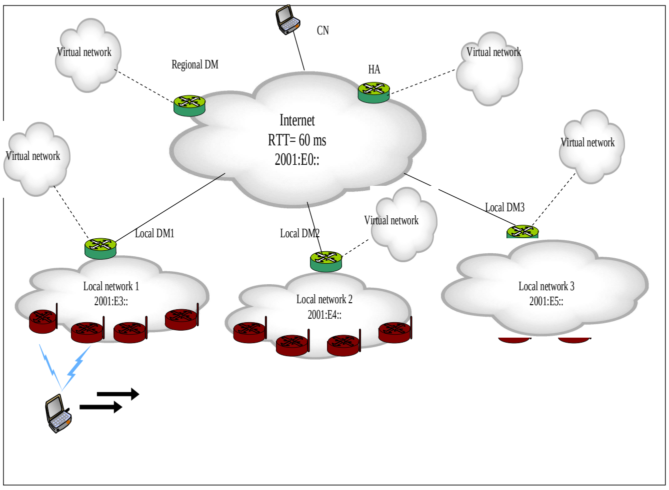

Figure4: Network topology with Hierarchical DM

A. Handover delay. For Soft handover, when the primary threshold connection became weak, the MN has to initiate the secondary connection as faster as possible to be able to receive duplicated packets. We notice second connection establishment and registration latency by (SCD). CSD = Layer2 roaming latency+ delay to receive Router ADVertisement + New COA configuration+ Round Trip Time (MN, DM agent).

In our simulation average Layer 2 roaming latency is 200 ms, the delays between two Router ADVertisement is set to 500 ms. We note RADV the average delay for to the MN to receive router advertisement from its new AR, after performing layer 2 handover. If we use a single DM as in network topology 1. The RTT (MN, DN) will be 120 ms. That will make SCD = 200+RADV+120 ms. The use of hierarchical DM agent as shown in network topology 2, introduces two formula to determine SCD. In local handover, RTT (MN, LDM) is near to 1 ms which means that the SCD =201+RADV

In global handover, SCD= L2 latency+ Router ADVertisement + New address configuration+ RTT (MN, LDM) .+ RTT(MN,GDM).

SCD =200+RADV+61. How much the frequency of MN local handover is higher than MN global handover, that illustrates that the use of local DM reduces sensibly he MN soft handover delays.

B Signalling load in the network. This simulation set tries to determine and compare load control information generated in each sub network as direct results of soft handover. The MN moves across the two networks using soft handover and performs both local handover and global handover. The MN speed is set to 5 m/s and mobility rate is set to 0.05 handover/s. Simulation results are shown in table1.

	Internet	LAN1	LAN2	LAN3
Hierarchical DM	1792	1024	1024	1024
Single DM	3584	-	-	-

Table1: Signalling load (byte)

Using a single DM in the network, for each handover, the MN has to send the binding update (merging request) to its DM agent and request for duplication and merging process. The results are that the entire signalling messages have to be routed through the Internet to the DM. In case of local Mobility in hierarchical DM architecture, the MN send its binding update only to the local DM which reduces sensibly the signalling load in internet and confines it only to the local level.

C. Duplicated packets in the networks.

	Internet	LAN1	LAN2	LAN3
Duplicated packets	1358	2974	5021	4473

Table2: Sum of duplicated packets

One of the most important issues in soft handover is the duplicated data overhead introduced in the core of the network. Using a hierarchical architecture of DM agents as shown in table 2 allows the local duplication of packets when MN performs local handover. The duplicated packets will be routed through Internet only when the MN performs a global mobility between sub networks. The table 2 shows the sum of duplicated data packets sent from CN to the MN when the MN moves across network topology 2 with mobility rate =0.005. its performs both local handover and global handover.

Local soft handovers in LAN1 introduce 2974 IPv6 duplicated data packets, in LAN2 they introduce 5021 and in LAN3 4473. Global MN handovers between each sub networks are managed through global DM agent. They generate 1358 duplicated packets in the Internet.

Conclusion

Mobile IPv6 soft handover is a promising IPv6 solution to manage soft handover across heterogeneous networks. This solution coexists with mobile IPv6 and can provide data transmission continuity and quality for delayed constrained application such as real time video playback. On the other hand this approach requires the introduction of DM agents in the network to duplicate IPv6 packets in the network through the old and the new Access router during the handover.

This paper presents an early simulation work regarding the impact of the use of a multilevel hierarchical architecture of DM agents. We show that the uses of local DM agents, In wide area networks reduces the delay needed by the MN to register its secondary LCoA and allows DM agents to start merging & duplication process as soon as MN registers a degradation of primary signal strength. We show also that the use of multilevel hierarchical DM reduces duplicated packet load, and signaling load and the core of the WAN. Local MN movements are managed by local DM agents, the handover signaling and packet duplication are generated only in local networks. Further simulation works are needed to valuate the impact of a hierarchical DM architecture when a large number of MN performs soft handover in a Wide Area Network.

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