Eurecom IPv6 Soft Handover

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Abstract. The growing demand for high-speed wireless access to the Internet is the driving force behind the current trends to design All-IP wireless networks, whose Access Router and mobile stations use Internet Protocol for signaling and /or data transport. That will allow an ubiquitous IP-based access by mobile users, with special emphasis on the ability to use a wide variety of wireless and wired access technologies to access the common information infrastructure. The design of an All-IP wireless network requires an efficient and flexible handover management, independent of layer 2 protocol, which allows efficient mobile stations roaming between Access Routers. In this paper we propose new IPv6-based Soft-handover approach, which guarantee an efficient and flexible mobile handover between heterogeneous wireless networks.
Keywords. MobileIP, Handover, Wireless IP, Soft Handoff

1 Purpose and Scope

One of the most important metrics in IP-mobility protocols design is the IP handover performance. IP handover occurs when a mobile node changes its network attachment from an Old Access Router (OAR) to a New Access Router (NAR). If not performed efficiently, end-to-end transmission delay, jitters and packet loss directly impact and disrupt applications quality of services. With the Internet growth and heterogeneity, it becomes crucial to design efficient pure IP based handover protocol in order to handle mobility at network layer. This paper presents a novel method, *Eurecom IPv6 Soft Handover* [2], which object is to improve the quality of service of data communications, particularly for mobiles nodes communicating via radio transmission with point of attachment to the Internet Network. This approach is based on IPv6, which, compare to IPv4, provides additional features and new communication possibilities, such stateless auto-configuration address that facilitates the attachment of mobile node with IPv6 network

IPv6 defines also several kinds of extension headers, which allow easier handling with IPv6 packets routing, tunneling and communication securing. The defined IPv6 extension headers include destination Options headers, Hop-by-Hop Option header, Routing and Authentication headers. The solution does not impose any change to the Mobile IPv6 standard [3]. It's an extension to support an efficient Soft handover, and Mobile Node (MN) can use existing radio technologies without changes.

The underpinnings of Eurecom IPv6 Soft Handover are that it:

- Data Distribution: Separate copies of the same packet sent by a Correspondent Node (CN) are tunneled via multiple Access Router (AR) to the same MN.
- Handover process: The Mobile node can establish links with both OAR and NAR simultaneously when performing handover. It receives duplicated flows through the two AR. MN roaming from OAR to NAR can be totally transparency.
- Merging process: The introduction of Merging Agent structure to perform data distribution and duplication from CN to MN, and from MN to CN. Merging algorithm is described to merge duplicated streams in MN, without any modification in IPv6 address mechanisms.

This paper is organized as follows. The section 2 contains description of current main IP-based mobility protocols: Mobile IP, Mobile IPv6, Hierarchical, Smooth, Fast, BETH and some presented ideas about IPv4-based soft handover. Handover characteristics and their effect in TCP connections are studied in section 3, and in section 4, soft handover protocol based on IPv6 is described with redundant IP flow. Finally we discuss a number of open issues and present some concluding remarks.

2 Overview Of Soft handover

If Mobile IPv4 [2]introduces basic mobility management service in Internet Protocol, many proposals were done to enhance its basic performances. In order to minimize the packets losses and data delayed-delivery in Real-time wireless application (voice over-IP), a number of proposals such as Hierarchical Mobile IP[4], Fast Handover [7] and Bi-directional Edge Tunnel [8] are proposed with some common characteristics. Their key choice is to try to decrease delay of interruption time, between mobile disconnection at the OAR and data connection with network through the new point of attachment. Smooth handover [5][6] is another approach, It introduces packets buffering mechanisms in access router to recovers lost packets when mobile is disconnected.

Simulation work done in [9][10][11], shows us that it is very hard to avoid packet losses and degradation of TCP performances when MN moves from the OAR to the NAR using those handover mechanisms. Soft handover is another kind of approach that allows a mobile station's session to progress without interruption when a Mobile Node moves from one radio cell to another. These can be done, by allowing a MN to communicate with multiple AR. To perform such thing in our approach, Duplicating and Merging Agent (D&M) is being established within the IPv6 Network, and is used for the duplication and for the merging for IPv6 packets going to and arriving from the communications links.

3 Data Distribution

As we see in **Figure1** the proposed approach introduces a new component called "Duplication & Merging Agent". It's a conventional router located at the core network, between CN and AR.

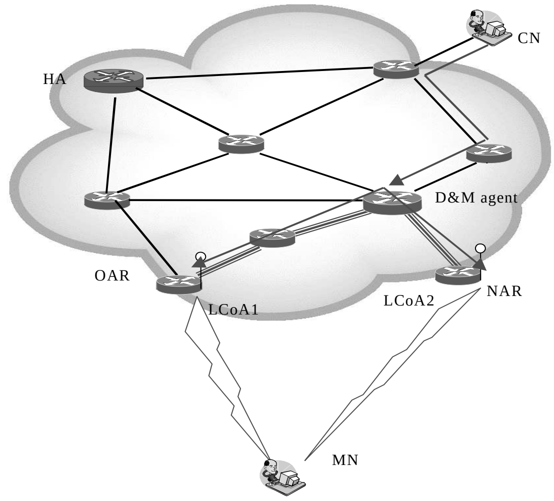

Figure 1. Data distribution

D&M agent intercepts packets sent to MN and duplicates them to create two or more copies of the same packet, tunnel them via multiple AR to the MN. The number of streams between the MN and D&M agent depends of system resource and wireless connection quality.

Consider the special case of MN with data connection with two AR in IPv6 network, when a CN wants to send it an IP packet, the sending device will have to determine all the addresses of MN in all sub networks. To avoid that kind of problems, two substitutes CoA (figure2) (or more if more than two different Access Routers are used simultaneously), are used for the transmission of the packets from the CN to the MN. The primary CoA (PCoA) is the temporary address (MIPv6), obtained by MN for the first time it connects to the network. It is registered within home agent and D&M agent in the reference link of MN and it's the Address used by the different CN, which are likely to communicate with mobile node. Each Local CoA (LcoA) identifies a connection of MN with an AR. If the MN is connected with two AR, it will have first substitute LCoA with first AR and second substitute LCoA with second AR, and both them are registered with D&M agent. To duplicates packets, the D&M agent receives packet arriving from CN and stores them in its internal memory, extracts from each packet the destination Address (PCoA) and accesses its duplication control table to find all corresponding LCoA. With those LCoA, D&M agent creates new IPv6 packets with the same payload information, but with substitute LCoA as new destination address, Those packets are tunneled to MN via corresponding AR.

Inversely, the MN can duplicates the uplink stream. It duplicates all packets and sends them to the D&M agent via the two AR.

4 Handover Process

When MN first starts communication with an AR (OAR), it obtains a PCoA and first substitute LCoA using IPv6 address auto configuration. After this, MN can send Merging Solicitation Message to D&M agent, to solicit resource. If the D&M agent accepts this request, it initializes a duplication and merging table, open a tunnel with the MN via the OAR, and respond with a merging advertisement message. MN can then perform binding update to register its PCoA with HA and all CN. When the MN detects a new AR (NAR), it obtains another substitute LCoA and registers it with D&M agents. More than two different links for a single MN could be arranged, the limit depend only of resource availability and number of AR.

The duplication and Merging process will, as described in 4.2.2, use PCoA and others LCoA to intercept MN-destined IPv6 Packets, duplicate packets and forward them via the different AR.

So when the MN wants to moves from one AR to another, the handover process happens in multiple steps. First the MN establishes a new link with the NAR as described bellows. So, it can receive data from the OAR and NAR simultaneously, which performs better quality of service. As the MN continues to move, eventually the signal strength from the OAR will be weak and not useful any longer. Again, the MN will inform the D&M agents of this fact, which will close IPv6 tunnel between D&M agent and OAR, so the MN can shut down its link with OAR and keep connected only throughout NAR. Thus, the MN transition between OAR and OAR will be totally transparent with no packet loss and no handover delays. **Figure 2** describes mobile handover process

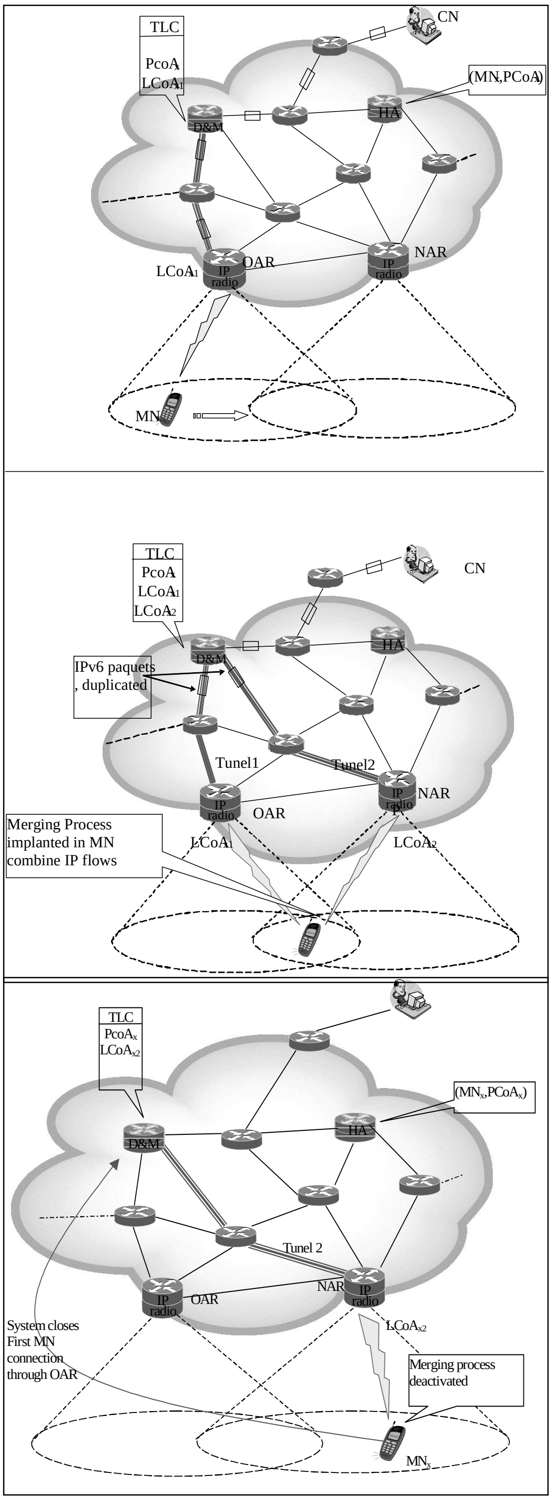

Figure 2. Handover process

5 Merging process

The use of D&M agent (respectively MN) duplication process to sent separates copies of the same data via multiple AR to the MN (respectively D&M agent), can guarantee data transmission quality of service and allows MN to perform an efficient and transparent handover process without packet losses. To perform efficiently such thing, MN or D&M agent needs to match those multiples streams of the same data sent through multiple AR.

When duplicating IPv6 packets, D&M agent or the MN uses a Destination Identifier Option (DIO) to insert merging and control information. A particular field of the destination option defines the parameter X, which is an integer used for numbering the different packets that are sent to the tunnel between the MN and the D&M agent. All duplicated packets will have the same value X.

MN and D&M agent incorporate a set of table, particularly a merging control table (MCT), which defines for each registered LCoA the parameter e and a list of X_i. e is the highest value X of all received packets plus one. X_i corresponding to packets which are been transmitted through the tunnel, but which are not yet received. Those values correspond to packets that are still missing.

In response to the reception of one packet, the process checks if the DIO is included in the IP packet. If not option is present, that's means that packet was not duplicated and the process route normally payload information.

If the DIO is included in the packet and the source address has an entry in MCT, this means that the packet has been duplicated. Thus the value of parameter X within the DIO is read, to determine whether it's inferior to the expected value e of the MCT. If X shows to be inferior to e, and the value X is not listed as missed packet in MCT, the packet is discarded (the packet has already been received). Else if X is included in the table, this means that the received packet corresponds to one packet which is still missing, the payload is routed and the value X suppressed from the table. If the value X shows to be superior to the expected value e, e is set to X+1, and the intermediate values between the old value of e and X are inserted in the MCT. The merging process is described in **Figure 3**.

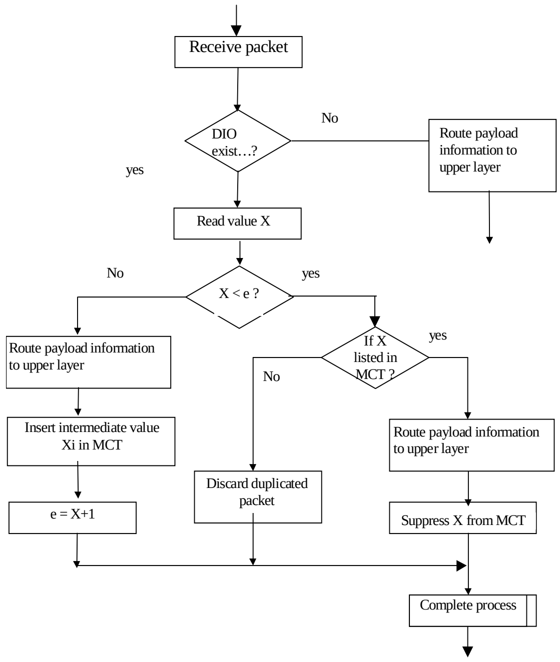

Figure 3. Merging process

6 Summary and Open Issues

We have presented a novel method, Eurecom IPv6 Soft handover, which is a pure IP solution for handover management. This process is completely transparent, doesn't let any additional packet losses, and doesn't introduce end–to-end latency in packet transmission. Unlike current Soft handover schemes, in this solution there is no need to synchronize distributed copies of data, MN route first received duplicated packets and simply ignore the others. No changes to the Mobile IPv6 standard are needed and Mobile Node (MN) can use existing radio technologies without changes.

Among the open issues that needs further study are:

- The performance - complexity of this approach and its comparison with other IP based handover mechanisms.
- Radio Resource management for duplicated link and Quality of Service management.

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