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Introduction

Handover optimization is one of the areas of growing scientific interest concerning mobility in communication networks. The duration of service disruption and the amount of packet loss during handover periods directly impacts on communication performance and are critical to applications in which QoS is an essential factor.

In order to avoid the side effects of the handover, communication layers affected by the handover process should perform a handover procedure based on appropriate techniques to detect the movement of the terminal between networks and to execute the necessary adaptations of their communication control functions to avoid loosing the ongoing communication sessions.

There are handover procedure proposals targeted to each of the different TCP/IP architectural layers. For the application layer, for example, we could mention the Reliable Sockets (RSOCKS) [17] and the MSOCKS [18]; in the transport layer, an example is the TCP Migrate [19]; finally, in the network layer the most prominent examples are MIP [7], HMIP [8], FMIP [9] and HIP[20].

Because of the communication dependency between layers, upper layers can only react to handover after lower layers have restored their connectivity. Therefore, the higher is the layer responsible for the handover procedure, the longer will be the latency of the handover. On the other hand the lower is the layer responsible for the handover procedure, the lower will be the impact on the functioning of the upper layers.

This work aims to define a *Global Mobility Architecture* (GMA) for the TCP/IP architecture that provides a better Layer-3 (L3) handover procedure when compared to traditional and enhanced IP mobility architectures. Section 1.1 presents our motivation to propose a new L3 handover process and section 1.2 presents the organization of this thesis.

1.1 Motivation

Mobile IP [7] is intended to enable nodes to move from one IP subnet to another. Although achieving its purpose, the process associated to node transition between IP subnets that changes the point of attachment, known as *L3 handoff* or *L3 handover*, presents two factors that disturb real-time, interactive or delay sensitive applications. The first factor is the high latency of the process, that may generate long periods in which nodes are prevented from sending or receiving packets that may, in turn, cause the service disruption. The second one refers to the high number of packets that may be dropped or delayed due to the change of the point of attachment. As presented in [1], HMIPv6 [8] and FMIP6 [9] respectively define a hierarchical architecture and a fast handover procedure in order to achieve an effective gain on L3 handover latency.

As discussed in [2], HMIPv6 and FMIPv6 are not enough to handle QoS context transfer to the new point of attachment in an acceptable time. In fact, traditional resource reservation protocols like RSVP [6] do not operate efficiently in mobile environments. This deficiency and the evolution of mobile networks determined the elaboration of innumerous proposals to enhance RSVP with new controls to provide QoS guarantees in Mobile IP environments. Some of these proposals were discussed in [2] and all suggest the need for standard methods to exchange information between the network (L3) and the link (L2) layers in order to make it possible to obtain anticipated notifications about L2 events related to handover.

Some standard bodies working on an individual standard, such as IEEE 802.11 and 3GPP have incorporated mechanisms for handover with other technologies. However, with the emergence of multiple standards, such as WiMAX, Mobile-Fi and IEEE 802.15, it has become necessary to define a new interworking standard designed to facilitate handover among any wireless access technologies [14]. The IEEE 802 committee responded with the proposal for a new standard to provide this kind of support to heterogeneous handover (vertical handover): the IEEE 802.21 – Media Independent Handover (MIH) [5]. The IEEE 802.21 standard defines a MIH Function (MIHF) which is located in the protocol stack between IP at Layer 3 and wireless link technologies at Layer 2, acting as what can be called a *Generic Link Layer* (GLL) interface [4].

As discussed in [3], MIH contributes to reduce handover latency and packet loss when used in conjunction with FMIPv6 mainly because: (i) it eliminates the need of some control messages and (ii) it increases the probability of an anticipated and predictive mode of operation. In fact, in order to effectively benefit from MIH, higher layer protocols are expected to use the services provided by the MIHF to: (i) anticipate and predict the change of the point of attachment of MNs in order to start, as soon as possible, the handover control procedures and (ii) reduce the amount of control messages related to mobility. In order to achieve these goals, two strategies can be followed: (i) to propose changes or adaptations to current standardized mobility protocols; or (ii) to propose a new mobility architecture with new mobility control protocol.

This work proposes the *Global Mobility Architecture (GMA),* introducing its functional entities and mobility support operations by means of the *GMA Mobility Protocol* (GMP). The main advantages, performance evaluation and result analysis of the GMA compared to the above-mentioned mobility architectures are also presented.

1.2 Organization

This thesis was elaborated after a long bibliographical review related to mobility architectures. The result was organized into three research reports ([1], [2], and [3]) that form the background to this work. As a result, this document presents a more condensed background and related work section and focus its pesentation on the proposed architecture and performance evaluation. To achieve this goal, this work is organized as follows.

Chapter 2 briefly presents some of the relevant related work that propose handover mechanisms on various TCP/IP architectural layers, such as: MSOCKS [17], RSOCKS [18], TCP Migrate [19], HIP [20], MIP [7], HMIP [8] and FMIP

[9]. Some considerations that justify the use of the L3 (Layer 3) handover by the GMA are also discussed.

Chapter 3 presents the background to the proposed architecture. First, it details the basic operation and main techniques (route optimization, hierarchical approach, buffering and forwarding mechanisms) of the L3 handover procedure of the standard and enhanced IP mobility architectures (MIP [7], HMIP [8] and FMIP [9]). Then, it presents the MIH Function of the IEEE 802.21 standard [5], whose Event Service (MIES) is a requisite to the GMA.

Chapter 4 introduces the proposed *Global Mobility Architecture* (GMA). First, it depicts the GMA features and functional entities. Then, it details the operation of the *GMA Mobility Protocol* (GMP). Finally, it presents the four main advantages of the GMA when compared to MIP, HMIP and FMIP, which are: (i) simplification of the signaling protocol on the mobile node; (ii) optimization of the binding update procedure; (iii) optimization of the registration procedure; and (iv) optimization of the L3 handover. Details about the GMP, such as the handlers of the mobility manager entity, the GMP message format and the types of PDU, are documented in the appendixes.

Chapter 5 presents a performance comparison of the mobility architectures above-mentioned and the GMA based on the following factors: (i) packet loss during a session; (ii) average handover latency to restore the downstream flow during a session; (iii) average handover latency to restore the upstream flow during a session; and (iv) buffer size requirement for buffering and forwarding mechanisms. Finally, this chapter presents the result analysis of the performance evaluation.

To conclude, Chapter 6 depicts the four main advantages of the GMA when compared to MIP, HMIP and FMIP, justify the benefits of the proposed architecture based on the performance evaluation and result analysis, and presents some ideas for future works.