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A solution for transparent mobility with route optimization in the IP multimedia subsystem

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ABSTRACT

This paper presents TRIM+, an architecture for transparent mobility management with route optimization in IMS based networks. The design of our architecture is based on a previous work referred to as TRIM. TRIM was originally devised to provide transparent mobility support in the IMS, although transparency came at the cost of using a suboptimal data path between communicating end points. TRIM+ maintains transparency as a design criterium, and thus end-user applications, running at the mobile node and its correspondent communication peers, are unaware of mobility management procedures. Additionally, the proposed design defines a set of route optimization procedures, allowing compliant devices to use the optimal data path for media communications. Furthermore, TRIM+ addresses packet loss management in scenarios where the media path cannot be maintained during the handover of the MN. To this end, our architecture enables the MN to request buffering capacity in its home network to temporarily store incoming media traffic during the handover, which would otherwise be dropped. This mechanism, as well as route optimization procedures, are executed transparently to the end-user applications running at the communicating end points. As a proof-of-concept, we have implemented a software prototype of the TRIM+ architecture, deploying it over a real IMS testbed. By means of a set of experiments, we have validated the mechanisms proposed in this paper, considering both UDP and TCP user traffic.

1. Introduction

Convergence and mobility are the two main trends in the current evolution of communication networks. Convergence means that services traditionally offered through circuit switched networks, such as telephony, are being moved to packet based networks, specifically to IP-based networks. Telecommunication operators see the IP Multimedia Subsystem (IMS) [1] as the key enabler to support convergence, providing access control and session signaling, functionalities that are needed to offer traditional services of circuit switched networks through IP-based networks.

Nevertheless, providing mobility on these converged IP based networks is not a trivial task. Although there are several solutions developed to enable mobility support at the IP layer, their integration in an IMS network poses several challenges that have to be considered. Other solutions, which do not have an impact in the IMS, are also available, but they have some limitations such as offering mobility support only within an administrative domain or within a restricted geographical scope, or affecting the applications that have to be adapted to deal with changes produced by mobility. In Section 2, we give an overview of the different approaches for mobility support in IP networks with IMS, and their limitations.

In order to address the challenges of providing IP mobility in an IMS based network, in [2] we proposed TRIM, a solution to support mobility in IP networks with IMS, making mobility transparent to applications and to communication peers of mobile nodes. TRIM overcomes the limitations of previous alternatives for mobility support in IP networks with IMS. Nevertheless, this solution is limited on performance, because transparency comes with the cost of utilizing a suboptimal path to exchange data between end-user applications.

This paper presents TRIM+, an architecture for transparent mobility management with route optimization in IMS based networks. As in TRIM, our solution can be easily integrated into the IMS infrastructure, and preserves transparency as a design criterium. However, TRIM+ defines a set of route optimization procedures, which allow configuring the optimal data path for the exchange of media between compliant user equipment. In addition, TRIM+ addresses packet loss management in scenarios where the media path cannot be maintained during the handover of the MN (hard handovers). Finally, TRIM+ is compatible with legacy terminals, so a TRIM+ terminal can communicate with a standard 3GPP terminal or other terminal without TRIM+ functionality,

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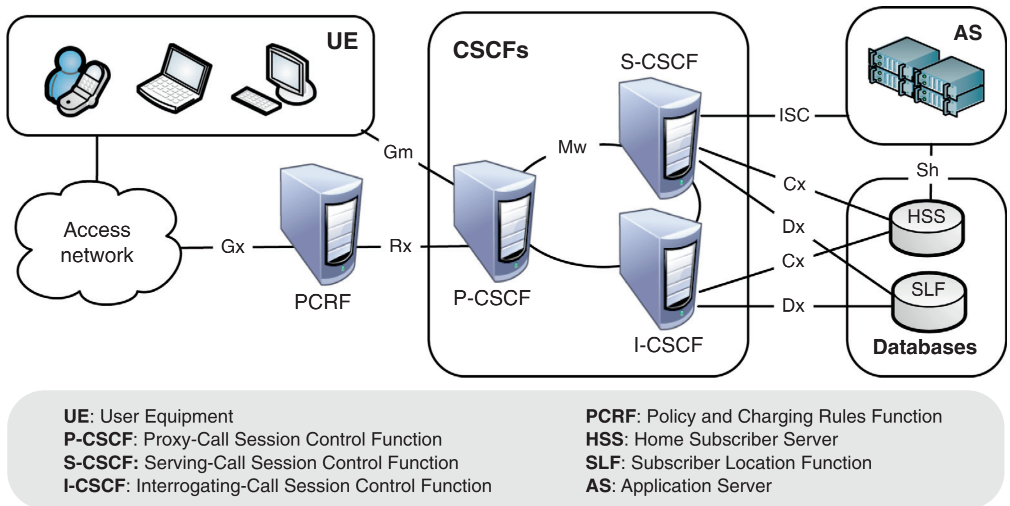

Fig. 1. Simplified overview of the IMS reference architecture.

and still have mobility support. The architecture and operation of TRIM+ is detailed in Section 3. A thorough evaluation of the behavior of TRIM+ considering both TCP and UDP traffic, is presented in Section 4, where we also compared its performance with that of the 3GPP IMS Service Continuity. Finally, in Section 5 we summarize the conclusions of our work.

2. Mobility management in the IMS

Communication networks are converging towards packet switched IP-based technologies. To be able to accommodate traditional voice and video services over a packet network, operators have pushed the introduction of the IP Multimedia Subsystem (IMS) that provides access control and session control, according to a specific profile for the Session Initiation Protocol (SIP) [3] and the Session Description Protocol (SDP) [4] defined by the 3GPP in [5]. IMS was initially proposed by the 3GPP,[1] but currently it is being developed in conjunction with ETSI-TISPAN to ensure that IMS works with any type of access network. A simplified view of the IMS architecture is presented in Fig. 1.

Mobility support is also an essential feature in communication networks nowadays. Users expect network access everywhere and while moving. The IETF[2] has developed several solutions for mobility support based on the IP layer of the protocol stack, being significant examples: Mobile IPv4 [6] and Mobile IPv6 [7]. These two protocols account for the traditional approaches for solving the general problem of IP mobility in the Internet. Mobile IP uses two IP addresses, one that is permanent and does not change with mobility, and another one that is temporal and changes for each visited access network. The permanent address, called Home Address, is the one seen by applications, while the temporal address, called Care-of Address, is used to direct traffic to the current location of the MN. Mobile IP has been in place for a long time and it seems a good approach to solve the problem of mobility management in the IMS. Unfortunately the integration of Mobile IP and related solutions with IMS is not straightforward due to the two different addresses that Mobile IP manages but that IMS does not expect. The challenges in the integration are explained in detail in [8–11], and summarized next. IMS performs resource reservation and authorization within the network (part of the policy and charging control architecture), based on firewall-like rules which allow flows in the network if they match a certain template. This template is based on the IP addresses used by the flow that, in the case of using Mobile IP, in the terminal side correspond to the Care-of Address. The filtering rules are setup during the signaling exchange between the IMS core and the user terminal to request the session. The problem appears since the IP address used by the control application at the terminal (SIP-based) can only see the Home Address assigned to it, being unaware of the temporal Care-of address the terminal is currently using. Hence there is a mismatch between what the control signaling indicates and the actual IP addresses used. This mismatch cannot be solved without modifications in IMS and/or the policy and charging control architecture of 3GPP to make it aware of Mobile IP.

Therefore several works can be found in the literature trying to integrate different architectures through the use of modified Mobile IP and IMS approaches. Examples of these works can be found in [10,12–15]. Basically all of these approaches which try to tightly integrate the different WiMAX/WLAN/UMTS architectures, relay on Mobile IP mechanisms for managing the mobility between heterogeneous accesses. Some of these works just ignore the problems identified above for the interworking between IMS and Mobile IP, while others provide a variety of solutions, from the modification of the actual signaling used for the handover, the inclusion of new features in Mobile IP or even using some other specifications such as IEEE 802.21 to perform hybrid signaling mechanisms. Summarizing, all these approaches require modifications to standard protocols and procedures, in particular in the IMS infrastructure, in order to provide Mobile IP based mobility with IMS to the user.

There are some other works that look at the IP mobility management issue through a different perspective. These works understand mobility as a particular case of IP multi-homing, in which the terminal uses several IP addresses in one or several interfaces and is able to control which IP address is used for each flow. Examples of these approaches can be found using the Shim6 [16] and Mobile SCTP [17] protocols. In [18], authors try to provide a framework for service continuity for IMS-based networks using the Shim6 layer to provide IP mobility support. Although these approach has some benefits as the lack of modifications to the network side and mobility transparency at the IMS layer, it has a major drawback, since it requires all UEs to implement the Shim6 protocol and communication with legacy nodes is not possible.

Another work, which shares the same core ideas with the previous one, can be found in [19]. This work uses mSCTP instead of

[1] The 3rd generation partnership project: http://www.3gpp.org.
[2] Internet engineering task force: http://www.ietf.org.

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