A SIP-based Method for Intra-Domain Handoffs

Dimitra Vali
OTE Research
Hellenic Telecommunications Organization - OTE S.A.
Athens, Greece
dvali@oteresearch.gr

Sarantis Paskalis, Alexandros Kaloxylos; Lazaros Merakos
Department of Informatics and Telecommunications
University of Athens
Athens, Greece
{paskalis, agk, merakos} @di.uoa.gr

Abstract- **SIP evolves as the multimedia call control protocol of choice in IP networks, making steady inroads in the network infrastructure. The concept of using SIP for mobility support appears promising in light of reusing the existing SIP network elements. Existing SIP mobility approaches exhibit however poor micro-mobility performance and lack TCP session support. To alleviate these shortcomings, we propose the introduction of the Hierarchical Mobile SIP (HMSIP) framework to efficiently handle the micro-mobility issues in SIP environments. HMSIP is a SIP-based solution that builds on existing IP mobility protocols, integrating their key concepts in an efficient manner. The proposed scheme aims at minimizing the handoff latency and the mobility-related backbone signaling overhead while supporting all types of traffic. Moreover, HMSIP can be further integrated with QoS-optimized micro-mobility solutions leading to a complete supporting architecture for QoS enabled mobile terminals.**

Keywords; SIP, micro-mobility, QoS.

I. INTRODUCTION AND RELATED WORK

IP networks face among others, the challenges of mobility support, Quality of Service (QoS) provision, and their combination. The Internet was initially conceived as a network for serving fixed hosts and no provision was made for supporting mobile users. Mobile IP (MIP) [] and Mobile IPv6 (MIPv6) [] were proposed lately for supporting terminal mobility at the network layer. In addition, various micro-mobility approaches (e.g. Cellular IP [], HAWAII [], HMIPv6 [], IDMP []) have also been developed for enhancing the Mobile IP performance in high mobility environments. Micro-mobility schemes enable fast intra-domain handoff by constraining mobility related signaling inside the boundaries of the domain.

There have also been efforts for supporting IP mobility at the application layer using the Session Initiation Protocol (SIP) [], as an alternative to network-layer mobility. For simplicity reasons, we will refer to these efforts as "Mobile SIP (MSIP)" (in accordance to "Mobile IP (MIP)"). Motivation and description of Mobile SIP functionality can be found in [2], [3] and [4]. The authors argue that SIP can be used to provide terminal mobility to Internet multimedia applications, proposing appropriate SIP extensions to the base SIP specification [1]. In short, the MH, after performing a hand-off, re-establishes an on-going SIP session by sending a SIP INVITE message to the Correspondent Host (CH). The INVITE contains the new IP address of the MH and an updated session description [9] for the on-going session. The CH responds to the MH with a 200 OK message and sends all subsequent data to the new IP address of the MH. For TCP flows, where SIP session establishment is not required, the MH should send its new IP address to the CH inside a SIP INFO message [4].

While using Mobile SIP for handling terminal mobility in SIP environments enables reuse of existing SIP infrastructure (i.e. SIP proxies, SIP registrars, etc.), deploying Mobile IP leads to some extent in a duplicated network functionality and stored user data (e.g. in MIP Home Agent and in SIP Home Registrar). In addition, the use of Mobile SIP could also compensate for the current lack of wide deployment of Mobile IP.

Mobile SIP however, as well as Mobile IP, is not optimized for fast handoffs. The communication re-establishment after a handoff requires end-to-end signaling exchange, which results in long update delays and high signaling overhead in the backbone network. Moreover, Mobile SIP (similarly to Mobile IP) exhibits major deficiencies when handling mobility of resource reserving QoS flows. The mobility related end-to-end signaling exchange results in end-to-end reservation re-establishment, long handoff delay and bandwidth waste through over-reservation. Therefore, micro-mobility schemes are also necessary in SIP environments to efficiently handle intra-domain handoff. As the application in SIP networks of the various network-layer micro-mobility approaches results in duplication of functionality and stored data (both SIP and the various micro-mobility protocols have their own mechanism for registration/location update and their own database for storing location info), enhancing the Mobile SIP approach so as to cater for micro-mobility seems to be the most efficient solution for enabling fast handoff in SIP networks. For this reason an RTP translator optimization for Mobile SIP is proposed in [], which caters however only for RTP flows and induces several modifications to the standard RTP discard behavior of the mobile terminal.

In this paper, we introduce a SIP-based micro-mobility scheme named Hierarchical Mobile SIP (HMSIP) that efficiently handles micro-mobility in SIP environments. The proposed scheme caters for all kinds of traffic and assumes standard SIP behavior support from the CH.

The remainder of this paper is organized as follows:***

II. HMSIP

A. Overview

HMSIP aims at reducing handoff latency and minimizing signaling overhead in the backbone network, by restricting intra-domain handoff related signaling inside the roaming domain. HMSIP caters for all kinds of IP traffic, while it can be further combined with other efforts for micro-mobility of QoS flows, resulting in a complete solution for mobility of SIP sessions with QoS guarantees.

HMSIP caters for intra-domain mobility and relies on Mobile SIP for handling inter-domain mobility. HMSIP follows the general regional registration approach found in various proxy-agent micro-mobility schemes (e.g. MIP-RR, HMIPv6, IDMP) and builds on the SIP Hierarchical Registration proposed in []. Moreover, HMSIP introduces the concept of a SIP Mobility Agent (SIP MA), a domain border entity responsible for locally handling intra-domain mobility, enabling thus fast intra-domain handoffs. The SIP MA terminates the handoff related signaling inside the domain and performs fast data path redirection to the current location of the mobile.

Similarly to other micro-mobility approaches, HMSIP allocates two IP addresses to the MH, a Local Address (LA) and a global Domain Address (DA). The LA is an IP address that has only local significance inside the domain. It identifies the MH at subnet level and is allocated by the serving access router, based on the subnet prefix. A new LA is allocated to the MH each time it performs an intra-domain handoff. The DA is a globally routable IP address, that uniquely identifies the MH for the whole duration of its roaming inside the same access domain. Each mobile is allocated a different DA by the SIP MA, which has a pool of globally addressable IP addresses associated with it.

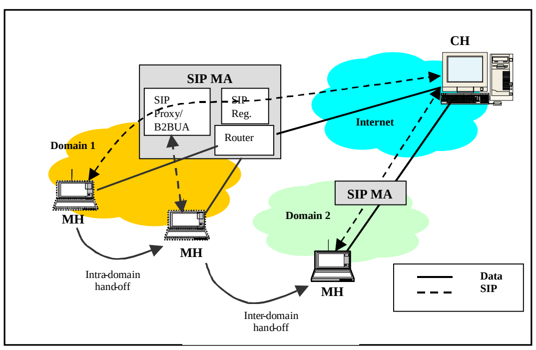


Figure 1. HMSIP architecture

The SIP MA (Figure **) is a domain border router, enhanced with the functionality of a SIP Proxy/B2BUA and a SIP Registrar. The SIP MA is responsible for maintaining and managing a database with soft state mappings between the SIP URI, the DA and the LA for each mobile that roams inside the domain. Soft states allow an allocated DA to a MH to be released when the MH visits another domain or goes down for a long time. In case that the SIP MA entities (SIP Proxy/B2BUA, SIP Registrar and Router) are not collocated, the SIP MA database can be distributed as follows: the SIP Proxy/B2BUA stores the SIP URI-to-DA mappings, the Local SIP Registrar stores the SIP URI-to-LA mappings and the Router stores the DA-to-LA mappings.

B. Mobility Procedures

1. Registration Procedure

When powering-on inside a visiting domain, the MH is allocated a LA from the serving access router, as well as a DA from the serving SIP MA. The new LA and DA should be registered with the MH's visited (Regional Registration) and home (Home Registration) network respectively.

The MH sends a SIP REGISTER message towards its SIP Home Registrar to register its new location (LA) with its home network. The Contact field of this message includes the LA. The SIP Proxy entity of the SIP MA, intercepts this REGISTER message and triggers the Regional and the Home Registration procedures.

The SIP MA performs the Regional Registration for the MH by creating a mapping of the MH's SIP URI and LA inside the SIP MA's database.

Following a successful Regional Registration, the SIP MA queries its database about any association of the user's SIP URI and an already allocated DA. When no relative mapping is found, the SIP MA allocates a DA to the MH. Then the serving SIP MA triggers the Home Registration procedure to register the DA with the MH's home network. The SIP MA forwards the intercepted REGISTER message to the SIP Home Registrar, inserting in the Contact field the DA allocated to the MH. As a result, the respective SIP URI-to-DA mapping is created in the SIP-HR database. SIP calls towards the MH can now be routed to the DA. Finally, the SIP MA communicates to the MH its allocated DA, by including it inside the payload of a SIP INFO message.

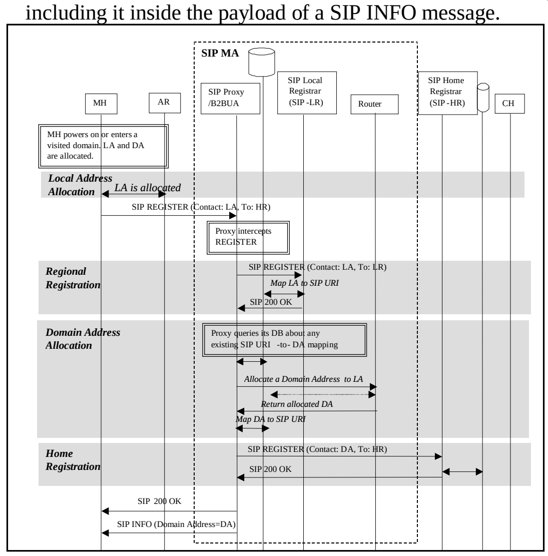


Figure 2. Regional and Home Registration

2. *Intra-domain hand-off procedure*

When performing an intra-domain handoff, a MH is allocated a new LA while its globally known DA remains the same for as long as the mobile host roams inside the domain. The allocated LA must be registered with the roaming domain, so Regional Registration is triggered. Home Registration does not take place since the globally known DA of the MH does not change.

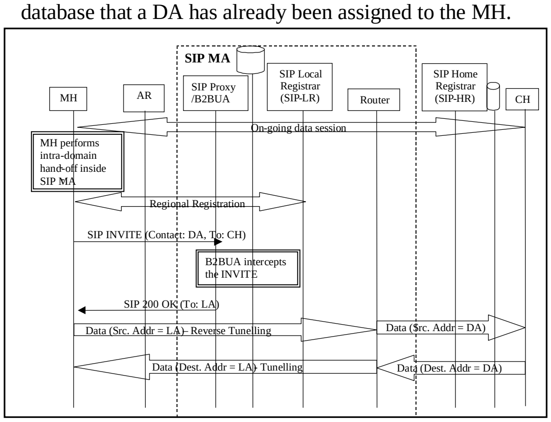
SIP session re-establishment takes place (when necessary) only inside the roaming domain. The SIP MA is responsible for terminating the SIP INVITE message sent by the MH, ensuring that all mobility related signaling remains constrained inside the domain. Moreover, the SIP MA properly redirects data to the current LA of the MH.

As far as TCP flows are concerned, SIP session re-establishment is not required after an intra-domain hand-off. The SIP MA is being kept informed about the current LA of the MH via the Regional Registration procedure and is therefore able to properly redirect the flows to the new location of the MH.

In what follows, we describe the HMSIP mobility procedures related to intra-domain hand-off, considering two separate scenarios: the intra-domain intra-SIP MA hand-off and the intra-domain inter-SIP MA hand-off. In the first scenario, the serving SIP MA before and after the intra-domain hand-off is the same, whereas in the second scenario they are different network elements.

a) *Intra-SIP MA hand-off*

In this case, no DA is allocated by the serving SIP MA to the MH after hand-off, since the serving SIP MA finds in its database that a DA has already been assigned to the MH.



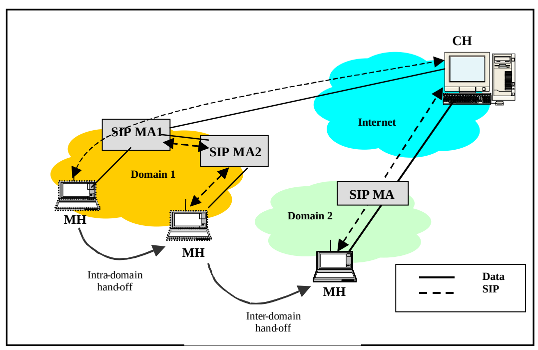
A SIP REGISTER message containing the new LA is sent by the MH towards the CH, which is intercepted by the SIP MA. The SIP MA triggers the Regional Registration procedure, which is depicted in detail in Figure **. Following successful Regional Registration, the MH re-establishes (when necessary) any existing SIP on-going sessions inside the domain. Session re-establishment requires that the MH send a SIP INVITE message to the CH, with the DA included both in the Contact field and the SDP [] part of the INVITE (Figure ***). The SIP B2BUA entity of the SIP MA intercepts this message and terminates it by responding to the MH with a SIP 200 OK. We note that, as a result of the Regional Registration procedure, the database of the SIP MA is up to date with the new LA. Thus, the SIP MA is able to intercept all signaling and data packets destined to the MH's DA and encapsulate them towards the respective LA. In the uplink direction, reverse tunneling takes place inside the access domain.

b) *Inter-SIP MA hand-off*

In the case where a single domain is supported by numerous SIP MAs (Figure ***), an intra-domain hand-off can result to a change of the serving SIP MA for the MH. In this case, the MH, apart from being allocated a new LA, is allocated a new DA by the serving SIP MA.

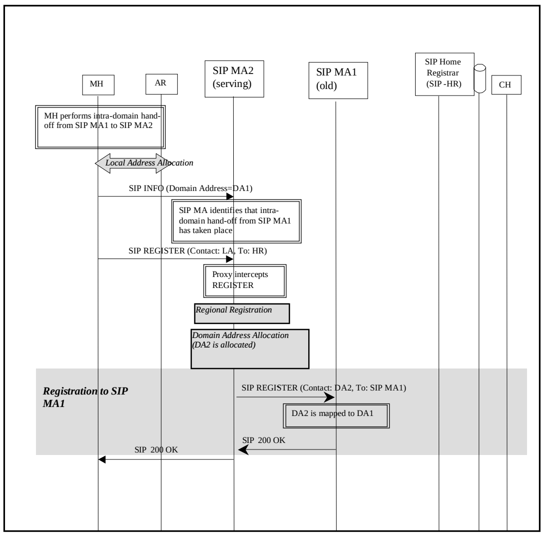
However, the globally known DA for the MH shall not change and the exit point for all signaling and traffic of the MH towards outside the domain shall not change either. For as long as the MH roams inside the same domain, the globally known DA shall be the first DA allocated to the MH inside this domain and the respective SIP MA that allocated it shall be the gateway to the outside world for this MH.

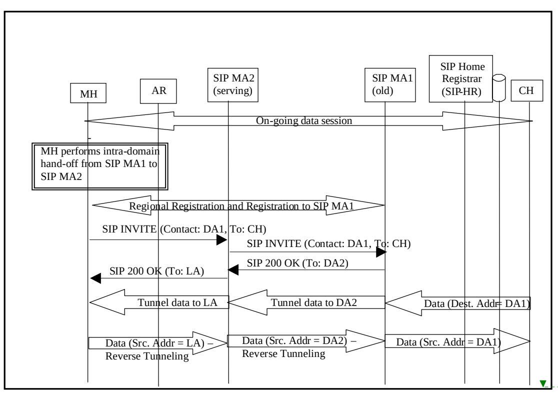
To ensure the above, we mandate that the DA allocated to the MH by the serving SIP MA is made known neither outside the domain or to the MH itself (the SIP INFO message containing its new DA will not be sent to the MH).



To enable the serving SIP MA to detect that a MH has handed-off from a SIP MA inside the domain, we assume that after the hand-off the MH sends a SIP INFO message to the serving SIP MA containing its globally known DA. The serving SIP MA should be able to detect that the globally known DA belongs to the domain and to identify the SIP MA inside the domain that has allocated it. The serving SIP MA creates then a mapping between the globally known DA of the MH and the new allocated DA, which enables it to redirect all traffic coming from the MH to the gateway SIP MA.

During the registration phase, the LA of the MH should be registered with the serving SIP MA and the DA allocated to the MH by the serving SIP MA should be registered with the gateway SIP MA. The latter is necessary, since the communication path between the MH and the CH continues to pass through the old SIP MA for as long as the MH roams inside the same domain. Thus, a SIP REGISTER message containing the LA is sent by the MH towards the CH, as usually. This message is intercepted by the serving SIP MA that initiates the Regional Registration procedure as depicted in Figure **. Then the serving SIP MA, sends a SIP REGISTER message to the gateway SIP MA to register the MH's newly allocated DA. A mapping between the MH's globally known and newly allocated DA is then created inside the old SIP MA. The procedure above is depicted in Figure ***.





Following successful registration with the serving and the gateway SIP MA, the MH re-establishes (when necessary) any existing SIP on-going sessions inside the domain. Session re-establishment requires that the MH send a SIP INVITE message to the CH, with the globally known DA included both in the Contact field and the SDP [] part of the INVITE (Figure ***). The serving SIP MA intercepts this message and forwards it to the gateway SIP MA. The gateway SIP MA terminates it by responding back to the serving SIP MA with a SIP 200 OK, which is forwarded back to the MH.

The CH continues to send all data destined for the MH to the global DA. The gateway SIP MA encapsulates data towards the serving SIP MA, where packets are encapsulated towards the current location of the MH. In the reverse direction, traffic is routed to the CH via crossing both serving and gateway SIP MAs, using reverse tunneling.

III. CONCLUSIONS AND FUTURE WORK

In this paper, we introduce Hierarchical Mobile SIP (HMSIP), an efficient micro-mobility management scheme for SIP networks. HMSIP minimizes intra-domain hand-off latency by restricting mobility related signaling inside the roaming domain, while taking advantage of information stored in existing SIP network entities. Moreover, HMSIP supports intra-domain mobility for all types of traffic and sets no specific requirements to the far end-system, apart from exhibiting standard SIP behavior.

To locally handle intra-domain mobility HMSIP introduces a SIP-based domain border entity, named SIP Mobility Agent (SIP MA). The SIP MA terminates the handoff related signaling inside the domain and performs fast data path redirection to the current location of the mobile.

In this paper, the HMSIP mobility procedures following an intra-domain hand-off are described in detail. Message flows are given describing the mobile host registration procedure, the re-establishment of on-going SIP sessions and the proper re-direction of the data path to the current location of the mobile host after intra-domain hand-off. The special case where a single domain is supported by numerous SIP MAs is also covered, describing the HMSIP procedures for intra-domain hand-off of a mobile host to a different SIP MA of the same domain.

It is important to note that HMSIP can be effectively combined with hierarchical QoS micro-mobility schemes, enabling efficient micro-mobility support for SIP sessions with reserved resources.

Future work will focus on validating HMSIP's enhanced performance via comparison with Mobile SIP, as well as with other micro-mobility approaches.

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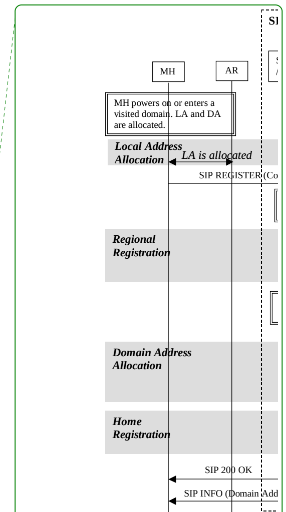

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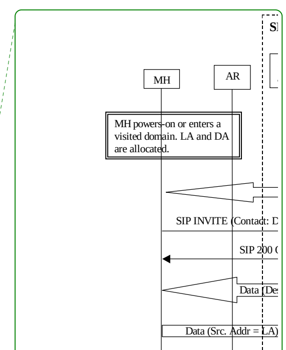

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