Location conveyance in the IP Multimedia Subsystem

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Abstract. The 3rd Generation Partnership Project (3GPP) has proposed the IP Multimedia Subsystem (IMS) as a key element in the next-generation network (NGN) converged architecture supporting multimedia services. Extending the IMS towards provisioning support for location based services (LBS) will enable enhanced services and offer new revenues to the system. However, conveying location information in the IMS and connecting the IMS with a real positioning system are still open issues. This paper presents the design and implementation of an IMS Location Server (ILS) integrating IMS with a positioning system. From the IMS perspective, the ILS serves as a service enabler for LBS. Considerable work has been done by the IETF in the area of location information transport based on the Session Initiation Protocol (SIP). This paper proposes some improvements in this area. In order to demonstrate proof-of-concept in enhancing IMS-based services, a Location-aware Push-to-Talk (LaPoC) prototype service has been developed. The service has been integrated and tested with the Ericsson Mobile Positioning System (MPS). The paper also gives the results of performance measurements including traffic load analysis and session establishment time.

1 Introduction

Location awareness is an important issue affecting numerous human activities and even forcing the creation of a special scientific discipline called navigation in order to develop the means for location and travelling management. In recent years, location has acquired a completely new dimension through introduction of a special group of telecommunication services that explore location awareness. Location-based services (LBS) have become one of the most prosperous groups of emerging telecommunication services. In their essence, location-based services successfully integrate three basic building blocks [10]: positioning systems, (mobile) communication systems, and location content.

Positioning systems serve as the entities for determination of an end-user's position in a suitably chosen reference frame in space. Position determination is conducted by combining several positioning sensors' outputs (satellite positioning, network positioning, radio positioning, etc.) with required quality of positioning service [9], which is usually entitled positioning sensor fusion. Mobile communication systems provide reliable means for position reports and location content exchange between mobile units and the rest of the LBS system.

Location content refers to location-related information presented in various forms (charts and maps, numerical and textual content, multimedia, etc.) delivered either to the mobile unit or some third application (emergency call E112 service, for instance). Since location content is gradually shifting towards a multimedia form of presentation, it seems a natural step forward in LBS development to consider the utilization of the latest related communications technologies, such as the IP Multimedia Subsystem (IMS).

The IMS is the internationally recognized standard for providing end users with advanced multimedia services [1]. A wide range of location applications built around existing and emerging IMS services may be foreseen, including:

- presence and location (friend location visible in address book)
- users sending messages or initiating IMS sessions only with other users located at a defined distance
- context aware adaptation based on user location (e.g. user's communication preference is changed depending on whether the user is at work or at home)
- users sharing their location via shared maps
- location aware multimedia information broadcasting

With the provisioning of user location information considered as a generic and reusable network-provided enabling technology, this paper proposes the introduction of a service enabler called IMS Location Server (ILS) located in the IMS Service Layer. The ILS provides an interface towards a positioning system to retrieve user location information, thus providing the means of making this information available to other IMS application servers. The solution is independent of a particular service and is intended to support the enhancement of existing and emerging IMS-based services.

The basics of the IMS and SIP location conveyance are described in the following section. Section 3 presents the design and implementation of the proposed ILS. The solution is demonstrated with the development of a prototype service called Location-aware Push-to-talk (LaPoC) and through integration with the Ericsson Mobile Positioning System (MPS), as described in Section 4. Section 5 describes tests that were conducted to measure signaling performance.

2 Background

This section provides an introduction to the IMS and SIP. Furthermore, the status of standardization in the area of SIP location conveyance is described.

2.1 IP Multimedia Subsystem (IMS)

In the move towards a converged network architecture, the IMS represents a key element in the UMTS architecture supporting ubiquitous access to multimedia services. Originally specified by the Third Generation Partnership Project

(3GPP), IMS is considered to play a key role in merging the Internet and cellular worlds [8]. Eventually, it will work with any network with packet-switched functions (e.g. GPRS, UMTS, CDMA2000, WLAN, DSL, cable etc.), while interworking with legacy networks will be supported through gateways. Key IMS benefits include: Quality of Service (QoS) support securing enhanced service quality; service integration by defining a standard interfaces over an IP-based infrastructure; and support for flexible charging. Based on a horizontally layered architecture, the IMS provides open call/session control with interfaces to service and connectivity layers in both wireless and wireline industries.

As shown in Fig. 1, the IMS consists of 3 layers: Service Layer, Control Layer and Connectivity Layer. Of the most significant protocols used in the IMS, we point out the Session Initiation Protocol (SIP) chosen by 3GPP as the protocol for session establishment, modification, and release.

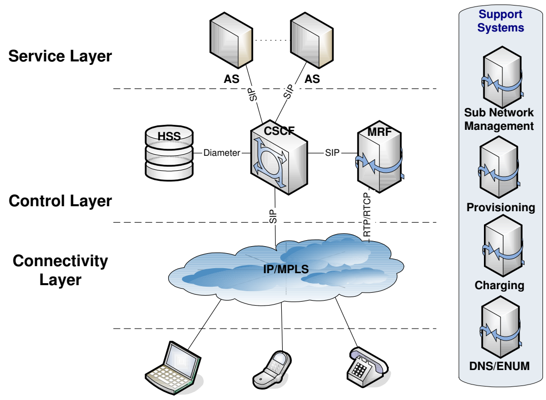

Fig. 1. Simplified IP Multimedia Subsystem (IMS) layered architecture.

The Service Layer comprises application and content servers to execute value-added services. The IMS allows for generic and common functions (implemented as services in SIP Application Servers) to be reused as building blocks for multiple applications and services. This implies the introduction of new services offering rich user experiences, with fast time-to-market and simplified service creation and delivery. Accordingly, the proposed ILS provides location services to other IMS Application Servers (AS) via a standard SIP interface.

The Control Layer comprises network control servers for managing call or session set-up, modification and release. The key IMS entity in the Control Layer is the Call Session Control Function (CSCF) which is responsible for session control and processing of signaling traffic. The Home Subscriber Server (HSS) is a user database, which maintains each end-user's profile. The Media Resource Function (MRF) is responsible for the manipulation of multimedia streams.

The Connectivity Layer comprises routers and switches, both for the backbone and the access network.

2.2 SIP location conveyance

The Session Initiation Protocol (SIP) [15] has emerged as part of the overall IETF multimedia architecture, providing advanced signaling and control functions for a wide range of multimedia services. SIP is defined as an application-layer control (signaling) protocol for creating, modifying and terminating sessions with one or more participants, and has been adopted by 3GPP as the key session establishment protocol in the IMS.

Conveying location information over SIP is a relatively new issue and is not completely standardized, although there are several Internet Drafts and RFCs [13][12][11], released by the IETF, dealing with this subject. Various SIP methods are applicable to carry location information, in the body or in the header of a message, but no method is pointed out as the preferred standard. More details on the framework and requirements for usage of SIP to convey user location information from one SIP entity to another SIP entity are given in [13].

The IETF proposes a protocol independent object format for conveying such location information [12], extending the XML-based Presence Information Data Format (PIDF) to allow the encapsulation of location information within a presence document. As the baseline location format in PIDF-LO objects, the Geography Markup Language (GML) 3.0 [5] was selected. Conveying static location in PIDF-LO bodies is straightforward. However, the difficult part about asynchronous notification of location information is that many forms of location are measured as a continuous gradient. Unlike notifications using discreet quantities, it is difficult to know when a location change is large enough to warrant notifications. Moreover, different applications require a variety of location resolutions.

Location filters are necessary to specify events that will trigger notifications to subscribers because location information is continuous and not discreet. We can not expect to flood the network (periodically or not) with responses carrying location information. Defined location filters [11] are XML documents which limit location notification to events which are of relevance to the subscriber.

3 Design and Implementation of ILS

The ILS functionality proposed in this work has been tested with the development of a prototype service.

3.1 IMS Location Server (ILS)

The ILS is designed as a generic SIP Application Server located in the IMS Service Layer. Methods for determining user positions are not implemented within ILS; rather, ILS is responsible for delegating the location request to the positioning system. Using the terminology proposed in [2], the ILS takes on the role of a Location Services (LCS) Client and obtains location information from an LCS Server. All other Application Servers (AS) requiring location data may send requests to the ILS via a SIP interface. Such a concept provides a central location in the IMS Service Layer that provides location data, rather than having each AS separately requesting data from a LCS Server.

3.2 Location-aware Push-to-talk (LaPoC) service

The proposed solution was demonstrated based on development of a prototype service called Location-aware Push-to-talk (LaPoC). The architecture of the LaPoC system integrated in IMS and connected with a generic Positioning System is shown in Fig. 2. It consists of two new components; the LaPoC Application Server (LaPoC AS), and the IMS Location Server (ILS).

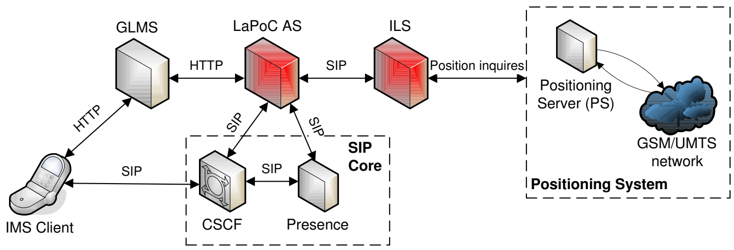

Fig. 2. Location-aware Push-to-talk (LaPoC) architecture.

Push-to-talk over Cellular (PoC) [3] is one of the first IMS services provided by numerous network operators. In this walkie-talkie type of service, the user must press and hold a button when he/she wants to communicate, and can start talking only when the terminal notifies them. By releasing the button, users signal the end of their speech. Because Push-to-talk is a half-duplex service, only one user can speak at a time. In the IMS network, a PoC Server is responsible for session control functionality.

The LaPoC service implemented in this work extends the functionality of the PoC service to make it location aware. This means that the PoC Server is enhanced to establish and modify PoC sessions in the IMS system taking into account end-user location information. The new proof-of-concept service demonstrates how to establish and modify a group PoC session only with users that are at a certain designated distance from the originating user (e.g. 1 km).

With location awareness, the service is even more similar to walkie-talkie. The difference in comparison with the classic walkie-talkie solution is the possibility for the user to define the coverage area. In LaPoC, this area can range practically indefinitely, while in the classic walkie-talkie the coverage area is limited by propagation characteristics of radio waves. Example use cases for such a service include a person wishing to establish a PoC session only with selected colleagues located within company premises; or a security officer speaking to officials securing the grounds at a soccer stadium.

The general aim of the latest interdisciplinary activities is to provide a generic model for successful implementation of a variety of location services within the IMS. One can find the simplest case in the service of another user location provision to the initiator of the service. Called the immediate location request, this service asks for location response to be delivered immediately after the location request is received [2].

In another case, a location request is sent to a server, but a response is received only when a certain condition stated in the request is fulfilled. Such a service is called a deferred location request. An example is a service initiator requesting to be notified when another user enters a certain area, such as a building or a city. Practical implementation of this service requires the location server to monitor the users' locations. Requirements become even more challenging in the LaPoC service because the designated area is not static, and a group of users is to be monitored instead of a single user.

3.3 LaPoC Application Server

The LaPoC AS represents a PoC Server enhancement. Besides implementing classic PoC functionalities, the LaPoC AS is responsible for contacting the ILS to obtain information about which users in the group are inside the designated radius from the originating user, and which are not. It is also responsible for modifying the session in accordance with the location of session members. This means if one user moves outside of range from the originating user, the LaPoC AS will receive a notification from ILS and will terminate the session. In the same way, when one user from the group enters the designated area, ILS sends notification to LaPoC AS which then includes him in the session.

The simplified session establishment sequence diagram is shown in Fig. 3. After receiving a SIP request for a group session, the LaPoC AS contacts the Group List Management Server (GLMS) to retrieve the group member list. For each member of the group the server checks their presence status, whether they are online, offline, or busy, by contacting the Presence Server. Finally, the LaPoC Server retrieves location information from the ILS for available users, to determine whether they are within range from the session originator. Most interfaces of the LaPoC AS are based on SIP, including communication with the ILS.

3.4 ILS SIP interface

As mentioned earlier, the IETF is working towards standardization of SIP location conveyance. The usage of Presence-based GEOPRIV Location Objects (PIDF-LO) [12] carried in the body of a SIP message is proposed. Several SIP methods are applicable to carry the PIDF-LO but none are pointed out as preferred [13]. In the LaPoC prototype, location conveyance using SUBSCRIBE and NOTIFY SIP methods is selected since this model is used for specific event notification in SIP [14].

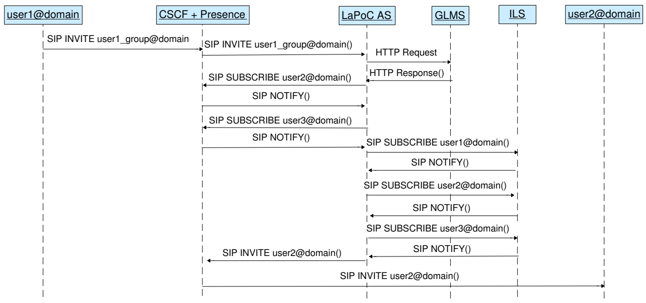

Fig. 3. Simplified LaPoC session establishment with *enterOrExit* filters.

Furthermore, the usage of location filters to specify events that will trigger notifications to subscribers is also proposed. Several such events and corresponding filters are defined [11], of which the *enterOrExit* filter is most suitable for the LaPoC prototype. The *enterOrExit* filter triggers notification when one of the LaPoC session participants enters or exits a named 2-dimensional or 3-dimensional region or list of regions corresponding to a GML feature.

The problem with this filter definition is that an area is static and that such a filter can be sent for one user only. In the LaPoC service, there is a group of users that needs to be monitored for one dynamically changing location area. If we would like to apply this filter definition, we would first have to send an inquiry for the position of the originating user to form an *enterOrExit* filter and then send a subscription carrying filter for each user in the group (Figure 3). Furthermore, during the session lifetime if or when the originating user changes their position, a new *enterOrExit* filter needs to be formed and again sent for each user in the group. This does not necessarily mean that any of the users have changed their state (entered or exited the defined area). Thereby, in order to reduce signaling between the ILS and LaPoC AS, we propose a new filter definition called *groupInRange*.

3.5 *groupInRange* filter

The idea of a *groupInRange* filter is to encapsulate the solutions of the two main disadvantages of *enterOrExit* filter. First, to avoid re-sending the same filter for each group member, the whole list of users is sent together with one filter definition to the ILS. This principle could be applied for any type of filter and that could significantly reduce initial signaling. Secondly, since the *enterOrExit* filter defines a static area and results in redundant signalization when the originating user changes position, a new event has been defined. This event describes the situation when one resource (user) falls in or out of range from an originating user. This corresponding filter is defined with resource (user) identification and range length only.

The *groupInRange* filter enables the LaPoC AS to send the whole list of users and range length in one SIP message to the ILS and receive back a list of users with information regarding a particular user being in or out of range from the originating user (Fig. 4). Each time a user leaves or enters the range, a notification is sent to the LaPoC AS. A traffic analysis and comparison of these two events is given in Section 5.

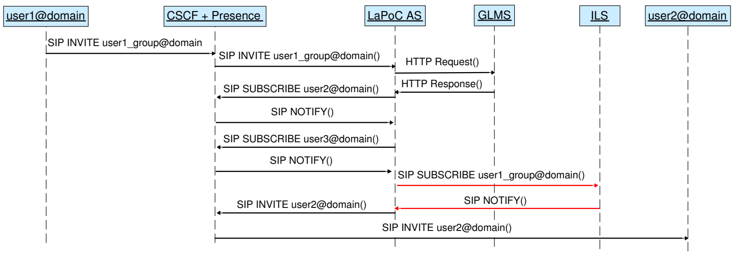

Fig. 4. Simplified LaPoC session establishment with *groupInRange* filters.

4 Case Study

In this section we describe the integration of ILS with a real positioning system, namely the Ericsson Mobile Positioning System (MPS).

4.1 Mobile Positioning System (MPS)

Ericsson Mobile Positioning System (MPS) [7] comprises the functionalities of two entities of a 3G network: Gateway Mobile Positioning Centre (GMPC) and Serving Mobile Positioning Centre (SMPC). It collects all available location-related information from the mobile communication network and performs the fusion of two main positioning services when they are available: satellite positioning methods, and network positioning methods (Cell-ID, E-OTD). By combining position mechanisms with location-specific information, MPS can offer customized personal communication services through the mobile phone or other mobile devices. The system is fully scalable and it supports both GSM (MPS-G) and UMTS (MPS-U). The MPS utilizes the Mobile Location Protocol (MLP) for data exchange with the Location Services (LCS) Client [4] (Fig. 5).

The reason for connecting ILS with MPS is interesting because the MPS Software Development Kit (SDK) that was used to emulate MPS functionalities

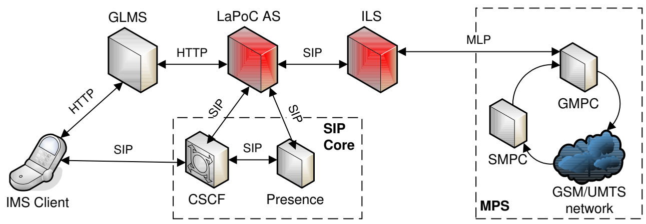

Fig. 5. LaPoC with MPS architecture.

does not support deferred location requests in its currently available version. On one side, the ILS receives location requests through a SIP interface, and on the other, it delegates the request through MLP to the MPS emulator. One major difference between these location requests on different interfaces is that SIP location requests can also carry location filters [11], hence the ILS SIP interface does have support for deferred location requests. A similar concept is going to be supported in the next version of the MPS SDK with so called spatial triggers. However, due to lack of support for deferred location requests in the currently available version of MPS SDK, the ILS sends location requests for each user periodically to MPS. When the ILS detects that one user has entered or exited the area defined by a location filter, it sends a SIP notification to LaPoC AS. Location signalization between the LaPoC AS and ILS is minimized, as described in the previous section, but periodic signalization with MPS presents a problem. In order to decrease this signalization, we implemented ILS in a way that the time between location requests to MPS depends on the user's velocity. For example, if a user stands still, the location inquiry period is maximized, but as the user starts to move, the period decreases. With this we have slightly improved the signalization amount between ILS and MPS.

5 Measurements

This section describes traffic and performance measurements for the developed LaPoC service. Several sets of measurements were conducted. First, measurements were conducted to compare the session establishment time of LaPoC with the classic PoC service for different group sizes. The second set of measurements was performed to compare signalization load between the LaPoC AS and ILS for the LaPoC service implemented with different location filter types, namely *enterOrExit* according to IETF and our proposed *groupInRange* filter. Finally, a comparison of the traffic load between the ILS and MPS implemented with periodic and improved non-periodic location querying was made.

The measurements were performed in the Ericsson Nikola Tesla (ETK) Research & Development Center research lab. The IMS Client, SIP Core and GLMS functionalities were realized with Ericsson PoC Reference Test Suite [6], while the MPS Emulator from the Ericsson MPS SDK was used to emulate MPS func-

Table 1. Hardware and software configuration

COMPUTER	HARDWARE	SOFTWARE
rlabsrv	Pentium 4, 1.3 GHz, 40 GB HDD, 512 MB RAM	Windows 2000 Server, IMS Clients
rlab2, rlab3, rlab5	Pentium 3, 800 MHz, 10 GB HDD, 512 MB RAM	Windows 2000 Server, IMS Clients
rlab4	Pentium 3, 800 MHz, 40 GB HDD, 512 MB RAM	Windows 2000 Server, LaPoC Server
rlab6	Pentium 3, 866 MHz, 20 GB HDD, 512 MB RAM	Windows 2000 Server, SIP Core Server, MPS emulator
rlab7	Pentium 3, 866 MHz, 20 GB HDD, 512 MB RAM	Windows 2000 Server, GLMS, IMS Location Server (ILS)
rlab8	Pentium 4, 3 GHz, 80 GB HDD, 1 GB RAM	Windows 2000 Server, IMS Clients
rlab9	Pentium 4, 1.3 GHz, 40GB HDD, 256 RAM	Windows Server 2003, IMS Clients
rlab10	Pentium 4, 1.5 GHz, 20GB HDD, 512 RAM	Windows Server 2003, IMS Clients
rlab11	Pentium 4, 1.3 GHz, 80GB HDD, 512 RAM	Windows Server 2003, IMS Clients

tionalities. The whole system was deployed on eleven computers, connected with a 100 Mbit/s Ethernet network switch (Table 1).

The first set of measurements includes a comparison of session establishment time for the LaPoC and PoC services for different group sizes (Fig. 6). The session establishment time prolongation for the LaPoC service is expected and is relatively small if we consider the value added to the PoC service. Furthermore, results illustrate improvements in session establishment time that were made with definition of the *groupInRange* filter (Section III). The reason for this time improvement lies in reduced traffic load between the LaPoC AS and ILS for the LaPoC service for *groupInRange* location filters. Fig. 7 shows that *groupInRange* significantly reduces the amount of signaling in comparison to the *enterOrExit* filter implemented according to IETF recommendations.

The third set of measurements compares traffic load between ILS and MPS implemented with periodic and improved non-periodic location querying. The first test was done to measure the quantity of signalization for various group sizes, where the location of all users was requested periodically every ten seconds. The

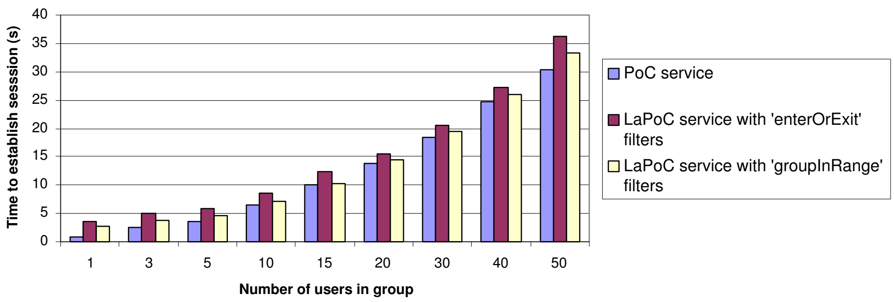

Fig. 6. Comparison of PoC , LaPoC with *enterOrExit* filters and LaPoC with *groupInRange* filters service session establishment time.

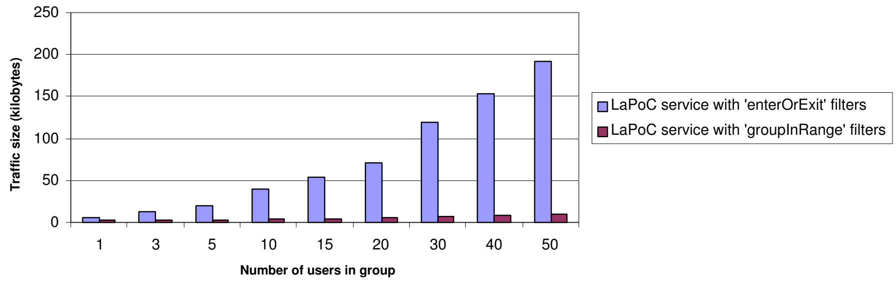

Fig. 7. Traffic load between LaPoC AS and ILS at session establishment.

second test was done to measure the quantity of signalization for various group sizes, where all users were static. In this case, location requests were sent non-periodically. Finally, the last test was done to measure quantity of signalization for various group sizes, where about 30-40% of users (phone routes) were static and the rest changed their position. In this case, location requests were also sent non-periodically. It is clear that aggregated traffic load between ILS and MPS increases with time. The results presented in Fig. 8 show the total sum of signalization for a one minute time period, dependant on the number of users in the group. For non-periodic testing where all users were static, the amount of signalization is at its minimum. As the number of users that are randomly changing their movement speed increases, the traffic load increases. In our case, where 30-40% of users remain static, the traffic is still considerably lower than in periodic testing. If all the users in a group are moving with maximum speed, then the traffic load in the case with using non-periodic testing is equal to the worst case scenario when the location of all users is requested periodically.

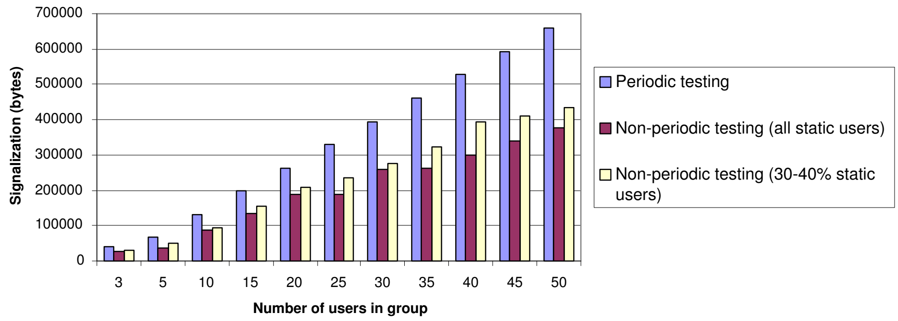

Fig. 8. Traffic load between ILS and MPS.

6 Conclusions and future work

This paper proposes the introduction of an IMS Location Server (ILS) in the IMS network responsible for retrieving user location information, thus providing the means of making this information available to other IMS application servers. A novel service was developed and integrated with the Ericsson MPS to demonstrate proof-of-concept and to provide a basis for performance measurements related to signaling. Improved SIP location conveyance is presented through definition of a new type of location filter. The emphasis was on location signalization with a positioning system that does not have support for deferred location requests, and on improvements to reduce signalization load.

Instead of using a laboratory environment, in our future work we will consider performing the same measurements in a real 3G network deploying IMS and a real positioning system. Furthermore, privacy related issues that have not been particularly discussed in this article will be also studied in the future.

References

1. 3GPP TS 23.228: IP Multimedia Subsystem (IMS); Stage 2. Rel. 7, 2005-06 (2005)
2. 3GPP TS 23.271: Functional stage 2 description of Location Services (LCS). Release 7, 2005-03 (2005)
3. -, Open Mobile Alliance OMA-AD_PoC-V1_0-20051104-C: Push to talk over Cellular (PoC) - Architecture. Candidate Version 1.0 , November (2005).
4. -, Open Mobile Alliance OMA-LIF-MLP-V3_1-20040316-C: Mobile Location Protocol (MLP). Candidate Version 3.1, March (2004).
5. OpenGIS: Open Geography Markup Language (GML) Implementation Specification. OGC 02-023r4, January 2003, http://www.opengis.org/techno/implementation.htm (2003)
6. Ericsson Corp: About IMS and Push-to-talk over Cellular. Accessed at: `http://www.ericsson.com/mobilityworld/sub/open/index.html`, Jan. (2006)
7. Ericsson Corp: Mobile Positioning System. Accessed at: `http://www.ericsson.com/mobilityworld/sub/open/index.html`, Jan. (2006)
8. G. Camarillo, M. Garcia-Martin: The 3G IP Multimedia Subsystem: Merging the Internet and the Cellular Worlds. John Wiley and Sons, Ltd., England (2004)
9. R. Filjar, D. Huljenic, S. Desic: Distributed Positioning: A Network-based Method for Satellite Positioning Performance Improvement. Journal of Navigation, vol. 55, no. 3, pp. 477-484 (2002)
10. R. Filjar, S. Desic, K. Trzec: LBS Reference Model. Proc. of NAV04 Conference (on CD-ROM), Westminster, London, UK (2004)
11. R. Mahy: A Document Format for Filtering and Reporting Location Notications in PIDF-LO. draft-mahy-geopriv-loc-filters-00.txt, Internet Draft, October 2005, work in progress (2005)
12. J. Peterson: A Presence-based GEOPRIV Location Object Format. IETF RFC 4119, December (2005)
13. J. M. Polk, B. Rosen: Session Initiation Protocol Location Conveyance. draft-ietf-sip-location-conveyance-01.txt, Internet Draft, July 2005, work in progress (2005)
14. A. B. Roach: Session Initiation Protocol (SIP)-Specific Event Notification. IETF RFC 3265, June (2002)
15. J.Rosenberg et al.: SIP: Session Initiation Protocol. IETF RFC 3261, June (2002)