Bringing Location Based Services to IP Multimedia Subsystem

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***Abstract*—As a result of the evolution of computer and networking technologies, the Third Generation Partnership Project (3GPP) has proposed the IP Multimedia Subsystem (IMS) as a key element in the UMTS architecture supporting multimedia services in the packet switched domain. Extending the IMS with support for location based services (LBS) will enable enhanced services and offer new revenues to the system. Connecting the IMS core network with a real positioning system providing support for LBS is an open issue. This paper addresses this issue and presents the design and implementation of an IMS Location Server (ILS) connecting the IMS with a positioning system. From the IMS perspective, ILS serves as a service enabler for LBS in the mentioned subsystem. 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 with the Ericsson Mobile Positioning System (MPS). This paper also gives the results of performance measurements including traffic load analysis and session establishment time.**

I. INTRODUCTION

In the move towards the next generation converged network, the IP Multimedia Subsystem (IMS) is the internationally recognized standard for providing end users with advanced multimedia services [1]. One key application area for IMS services that is believed to be of great end user interest is based on Location Based Services (LBS). This paper proposes the introduction of an IMS Location Server (ILS) located in the IMS network. 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 are described in the following section. Chapter II 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). Chapter III describes tests that were conducted to measure signaling performance.

A. *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 [5]. 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 benefits that the IMS is expected to provide 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 the type of services being used by a client. Based on a horizontally layered architecture, the IMS provides an open call/session control architecture with interfaces to the service and connectivity layers adopted in both wireless and wireline industries.

As shown on Figure 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.

The Service Layer comprises application and content servers to execute value-added services for the user. The IMS allows for generic and common functions

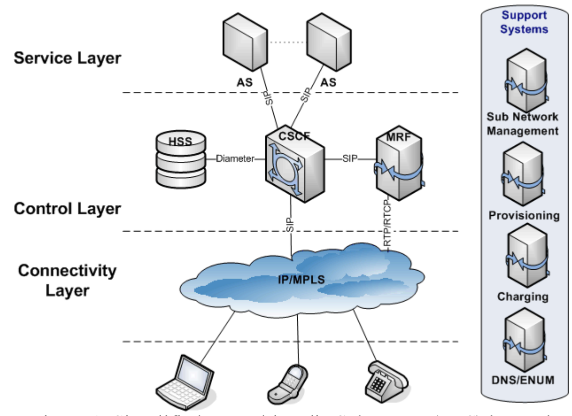

Figure 1. Simplified IP Multimedia Subsystem (IMS) layered architecture

(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 a simplified service creation and delivery process. In accordance with this concept, 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.

II. DESIGN AND IMPLEMENTATION OF ILS

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

A. 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. The Mobile Location Protocol (MLP) [3] provides the means of conveying such information. 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.

B. Mobile Positioning System (MPS)

The ILS was tested through integration with the MPS. The MPS is the name of Ericsson's solution for LBS. 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 main protocol between the ILS and MPS is Mobile Location Protocol (MLP). The MLP is an application-level protocol for obtaining the position of mobile stations (mobile phones, wireless personal digital assistants, etc.) independent of the underlying network technology. As mentioned, the MLP serves as the interface between a Location Server and a Location Services (LCS) Client.

MPS for GSM (MPS-G) consists of a Gateway Mobile Positioning Centre (GMPC), Serving Mobile Positioning Centre (SMPC), and features on Core and Radio Network nodes. Global Positioning System (GPS) reference receivers can also be used depending on the positioning method that is used.

MPS for UMTS (MPS-U) differs in comparison with MPS-G by including SMPC-like functionality in Core Network features and Radio Network features.

C. 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 MPS is shown in Figure 2. It consists of two new main components; LaPoC Application Server (LaPoC AS), and IMS Location Server (ILS).

Push-to-talk over Cellular (PoC) [4] is one of the first IMS services provided by many operators. In this walkie-talkie type of service users must press and hold a button when they want to say something, and can start talking only when the terminal notifies them. By releasing the button, users signal the end of their speech. In regular full duplex voice calls all participants can talk at the same time. However, Push-to-talk is a half-duplex service, meaning 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", meaning 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).

As mentioned, PoC is a walkie-talkie type of service. With location awareness, the service is even more similar to walkie-talkie, since conversation is possible with other users that are at a certain distance from the originating user, such as in real walkie-talkie. The reason for implementing such a service is not only in enriching user experience, but also because such service poses location-based challenges for its implementation in IMS. The idea was to demonstrate the possibility of implementing any other kind of location based service in

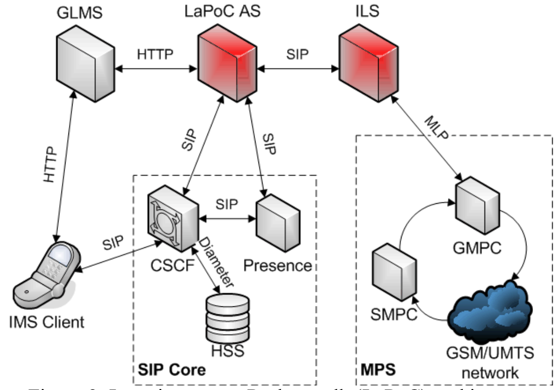

Figure 2. Location-aware Push-to-talk (LaPoC) architecture

IMS. For example, the simplest case is when one user wants to know position of another user. In this case a location response is sent back right away on received location request. These are so called immediate location requests [2]. The situation gets more complicated when we have so called deferred location requests, meaning a location request is sent to a server but the response is received when some condition, stated in the request, is fulfilled. For example, the user wants to be notified when other user enters a certain area such as a building or city. This means that the location server needs to monitor the user's location and send a notification when he is in that area. With the LaPoC service this is even more complicated since the designated area is not static, and a group of users is being monitored rather than just one user. For this reason, the dynamic location areas and sessions with groups of users, which are characteristic of the LaPoC service, make it a good case study for LBS in IMS.

D. Location filters

On one side, the ILS receives location requests through a SIP interface, and on the other, it delegates the request through MLP to MPS. One big difference between these location requests on different interfaces is that SIP location requests can also carry location filters [6]. 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 are XML documents which limit location notification to events which are of relevance to the subscriber. In [6] several such events that compose an initial list of Interesting Events are proposed. For the LaPoC prototype the most suitable is the so called "enterOrExit" filter that triggers notification when the resource enters or exits a named 2-dimensional or 3-dimensional region or list of regions.

A similar concept is going to be supported in the next version of the MPS with so called spatial triggers. However, due to lack of support for deferred location requests in the current version of MPS, 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 SIP notification to LaPoC AS. Location signalization between the LaPoC AS and ILS is in this way minimized, 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 movement speed of the user. 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 slightly improved the signalization amount between ILS and MPS. The results are presented in the next section.

E. LaPoC Application Server

The LaPoC AS represents an enhancement to the PoC Server. Besides implementing classic PoC functionalities, it 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.

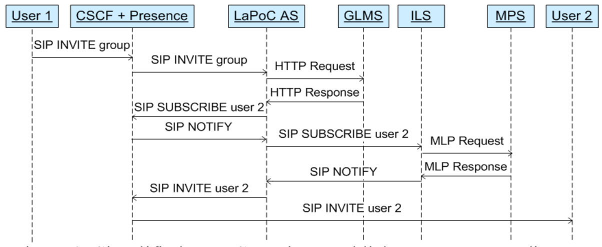

Figure 3. Simplified LaPoC session establishment sequence diagram

The simplified session establishment sequence diagram is shown in Figure 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. Then, for each member of the group the server checks their presence status by contacting the Presence Server, meaning checks whether they are online, offline, or busy. 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. However, conveying location information over SIP is not completely standardized, although there are several Internet Drafts and RFCs [6][7][8], released by the IETF, that are dealing with this subject. Communication between LaPoC AS and ILS is compliant to these recommendations.

III. MEASUREMENTS

This chapter describes traffic and performance measurements for the developed LaPoC service. The goal of the measurements was to compare the session establishment time of LaPoC with the classic PoC service for different group sizes. Additionally, 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 Centre research lab. The IMS Client, SIP Core and GLMS functionalities were realized with Ericsson PoC Reference Test Suite, and we used the MPS Emulator from the Ericsson MPS SDK to emulate MPS functionalities. The whole system was deployed on eleven computers, connected with a 100 Mbit/s Ethernet network switch. Each computer hardware and software configuration is shown in Table 1.

The first set of measurements included comparison of session establishment time for the LaPoC and PoC services for different group sizes. The results are shown in Figure 4. 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.

The second set of measurements compared traffic load between ILS and MPS implemented with periodic

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	Pentium 3, 800 MHz, 10 GB HDD, 512 MB RAM	Windows 2000 Server IMS Clients
rlab3	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
rlab5	Pentium 3, 800 MHz, 10 GB HDD, 512 MB RAM	Windows 2000 Server IMS Clients
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 2003 Server IMS Clients
rlab10	Pentium 4, 1.5 GHz, 20GB HDD, 512 RAM	Windows 2003 Server IMS Clients
rlab11	Pentium 4, 1.3 GHz, 80GB HDD, 512 RAM	Windows 2003 Server IMS Clients

and improved non-periodic location querying. There were three different tests performed. 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 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 traffic load between ILS and MPS increases with time. The results presented in Figure 5 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 quantity of signalization is the minimum possible. As we increase the number of users that are randomly changing their movement speed, the traffic load gets higher. 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.

IV. 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 provide a basis for performance measurements related to signaling. The emphasis was on location signalization with positioning system that does not have the support for deferred location requests, and on improvements that were done in order to reduce that signalization load.

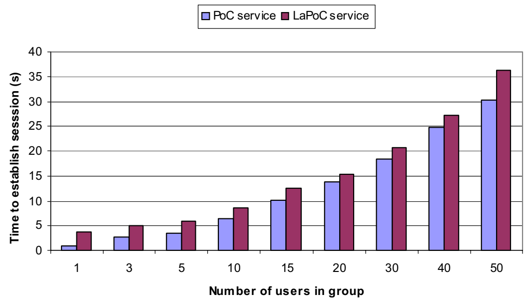

Figure 4. Comparison of PoC and LaPoC service session establishment time

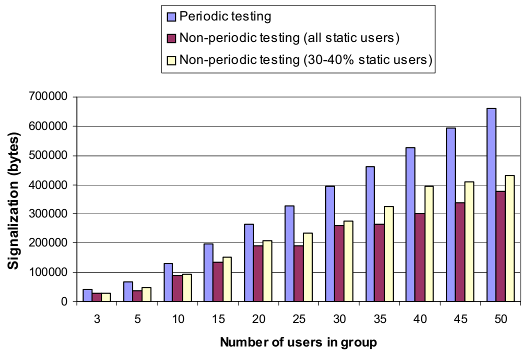

Figure 5. Traffic load between IMS Location Server (ILS) and Mobile Positioning System (MPS)

In our future work we will consider the integration of ILS with several different positioning systems. If one user's position can be determined by more positioning systems connected with ILS, it would be interesting to investigate how to delegate location inquires considering signalization load vs. accuracy tradeoffs. Secondly, with the current "enterOrExit" filters, implemented according to IETF recommendations, one filter is sent for each user in a group. Furthermore, if originator moves, the filter must be updated and resent to the users. It is clear that such SIP location conveyance can be optimized by defining different location filters. These improvements will be considered in future work.

V. References

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