

An IMS based Vehicular Service Platform

Iván Lequerica Roca¹, Antonio Jesús Ruiz Ruiz², Andrés Samuel García Ruiz²,
Antonio Fernando Gómez Skarmeta²

Abstract—This paper presents a innovative solution for the deployment and management of vehicular services based on IMS. We justify our proposal analysing the advantages of IMS applied in vehicular scenarios. For this purpose we have designed and experimentally developed a platform that consists in an IMS Core, advanced enablers and two IMS Clients. We demonstrate the potential of this solution by evaluating the performance of two vehicular services, explicitly tested in real conditions using our platform. We provide qualitative analysis and quantitative results, including performance metrics of the services using our solution through different access technologies.

Keywords: Vehicular Services, IMS, NGN, SIP, OSGi.

I. INTRODUCTION

Road network is one of the key factors in global economies. Road transport takes a significant percentage of GDP (Gross Domestic Product) and employs a large number of citizens around the world. Although transportation is one of the most relevant activities in the global economy, the costs due to energy, time and pollution are still high. Moreover, road accidents are one of the higher cause rates of mortality in over the world. The number of deaths and serious injuries has significantly decreased in the last few years as a result of recent actions taken by authorities in many countries but it is still a challenge to the society as a whole.

As a response of those challenges appears the *m:Vía* research project [1]. The main goal of *m:Vía* is to design, develop and deploy the technology required to improve the road transport, creating an Intelligent environment within the roads and the vehicles.

m:Vía and most of the vehicular communications related research projects aim to provide secure communications for exchanging information between vehicles (V2V), Road Side Units (RSUs) (V2R) and Internet servers (V2I). Over the communication systems a variety of services (regarding safety, mobility and infotainment) must work efficiently. Thus, a service platform should provide control mechanism to enable vehicular terminals to operate these services efficiently regardless the access technology, even over Vehicular Ad-hoc networks (VANETS). For this purpose, we designed a platform based on the IP Multimedia Subsystem (IMS) [2]. IMS is a subsystem, standardized by 3GPP that enable the provision and deployment of multimedia services to final users, enabling the convergence of voice, video and real time data over IPv4 and IPv6. The IP technologies in which IMS relies, such as SIP (Session Initiation Protocol) [3] for session control, allow fast

development services and reduces operation and infrastructure costs.

In this paper we present an innovative platform for the deployment of vehicular services based on IMS and advanced capabilities. The work has involved the design and experimental implementation of enriched enablers over an IMS Core and two IMS clients. Enablers provide efficient instant messaging and enriched presence functionalities to the services. We have designed an IMS client to use on board vehicles, under modular architecture based on Equinox [4], an OSGi [5] R4 core framework. The second IMS client is designed to work with servers, without the restrictive requirements of on board modules. In order to demonstrate the goodness of our solution, we have developed, deployed and tested two experimental services in real scenarios. After the analysis, we can conclude that our platform satisfies the challenging requirements of vehicular services, the good performance makes our approach ideal for the massive deployment of Intelligent Transport Systems (ITS).

In section II we detail the design of our solution, including IMS architecture and On-board modules, justifying the choice of IMS for our purpose. We describe the Core, the enablers and the *IMS Client*. In section III we explain the logic of the services developed for the validation of the platform, detailing how those services benefit from our solution. In Section IV we evaluate the performance of our solution in a real vehicular scenario, we provide some metrics regarding delays, overhead and capability. Finally we point out the conclusions of our work focusing on the importance of an IMS-based platform for achieving goals in vehicular environments.

II. SERVICE PLATFORM

A. On-board Architecture

Services in vehicular environments provide rich functionalities to users improving safety, traffic efficiency, logistic operations, and making the travels more enjoyable. With this purpose, we have established a comprehensive on board architecture depicted in Fig. 1.

The on board equipment consists in two main components; the Application Unit (AU) and the On-Board Unit (OBU).

The OBU is responsible for the external communications providing an access technology independent communication module. Although the communication modules within the OBU are out of the scope of this paper, we provide a brief description of the most relevant ones. The Intelligent Handover module manages vertical handovers and provides session maintenance. The API of the communication system is compliant with CALM [6] reference architecture. The main advantage of this approach is the possibility of adding new

¹Telefónica I+D, Madrid, 28043-Madrid, España, E-mail: ilr@tid.es

²Departamento de Ingeniería de la Información y las Comunicaciones, Universidad de Murcia, 30.100 Murcia, España, E-mail: [asgarcia, antonioruiz, skarmeta]@um.es

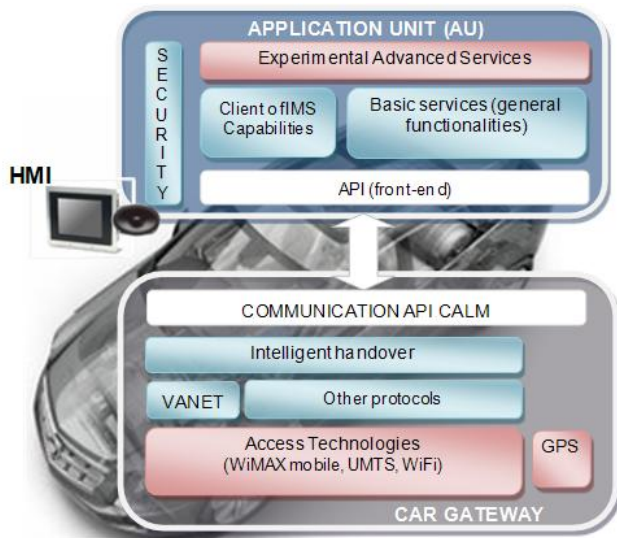


Fig. 1. On-board modules

communications technologies in a transparent way for the services.

The AU is the service environment container, including facilities and experimental services. One of the facilities within the AU is the *IMS Client* supporting IMS sessions establishment and access to the IMS enablers. The AU requests the OBU for communication provisioning through the CALM compliant API, specifying a set of communication parameters (i.e. QoS, delay-time, packet loss tolerance, jitter...). Once, the communication channel has been created, the experimental services can use the IMS facility for enriching their logic. Services show the relevant information through the HMI, which involves a touch screen and speech technologies for a secure and efficient use by the driver and passengers.

B. IMS in vehicular scenarios

In this section we justify the election of IMS as the basis of our service platform. We point out the advantages of the use of IMS for service provisioning in vehicular environments.

IMS enable the communication between vehicles in real time, establishing multimedia sessions with QoS parameters according to the network conditions and the service characteristics. Users also benefit from new integrated QoS-guaranteed multimedia services, accessing independently from their geographical location. IMS is access agnostic, so vehicles can dynamically use the most appropriate technology to transmit data (i.e. WAVE, Wifi, GPRS, UMTS, LTE, WiMAX, etc).

IMS provides maximum security through reliable authentication and authorization of users. This feature is critical and mandatory issue in vehicular services. It is based on well-known and widely used protocols as SIP, SDP, RTP and Diameter. The identities are managed through URIs (Universal Resource Identifier).

One of the most powerful advantages of our platform is the integration with advanced NGN enablers. These enablers provide centralized common functionalities to services, so they can reduce their logic and delegate critical operations

to a trusted reliable entity. Some examples of enablers are; Identity provisioning, authentication, authorization, location server, broadcast service, user profile, multi-conference, instant messaging and presence. [7] [8] [9].

These facts facilitate consistency and reliability in the creation of new services, promoting re-use, reducing development costs and improving usability. Thus, IMS becomes a very attractive framework for a strong growth in the service provisioning market in vehicular environments.

In the following subsections we present the design of the Vehicular Service Platform basic elements: The IMS Core, the two enablers; enriched presence and instant messaging and the IMS clients. The whole system is depicted in detail in Fig. 2

C. IMS Core

The heart of our solution is the IMS Core. The Core has been designed to enable operators to provide a wide range of real-time, packet-based services and to track their use allowing several types of charging. It also provides a framework for the deployment of both basic calling services and enhanced services. Our solution provides the basic entities needed for managing communications and for operation customization:

- P-CSCF (Proxy Call Session Control Function): It is the entry point to the IMS domain and serves as the outbound proxy server for clients.
- I-CSCF (Interrogating Call Session Control Function): It acts as an inbound SIP proxy server. During IMS registrations, the I-CSCF queries the HSS to select the appropriate S-CSCF which can serve users. The I-CSCF routes the incoming session requests to the S-CSCF of the called party.
- S-CSCF (Serving Call Session Control Function): It is the central brain. The S-CSCF is responsible for processing registrations to record the location of each user, user authentication, and call processing (including routing of calls to enablers). The operation of the S-CSCF is controlled by policy stored in the HSS.
- HSS (Home Subscriber Server). It is a database that holds configuration storage, identity management and user status.

Over these basic elements, the Core allows the deployment of IMS enablers (also known as capabilities). Enablers provide secure horizontal functionalities useful for the services as we described in previous sections. Capabilities export open and standardized interfaces using several protocols (HTTP, SOAP, SIP, etc).

D. Enriched Presence Enabler

The Enriched Presence (EP) enabler is an entity that accepts, stores and distributes presence information based on SIP messages [11]. We have based our design on [12], enriching the standardized enabler by attaching real time location information of the vehicle.

The EP enabler manages presence state (and location) publications from multiple vehicles. This includes refreshing or replacing existing presence information with newly-published

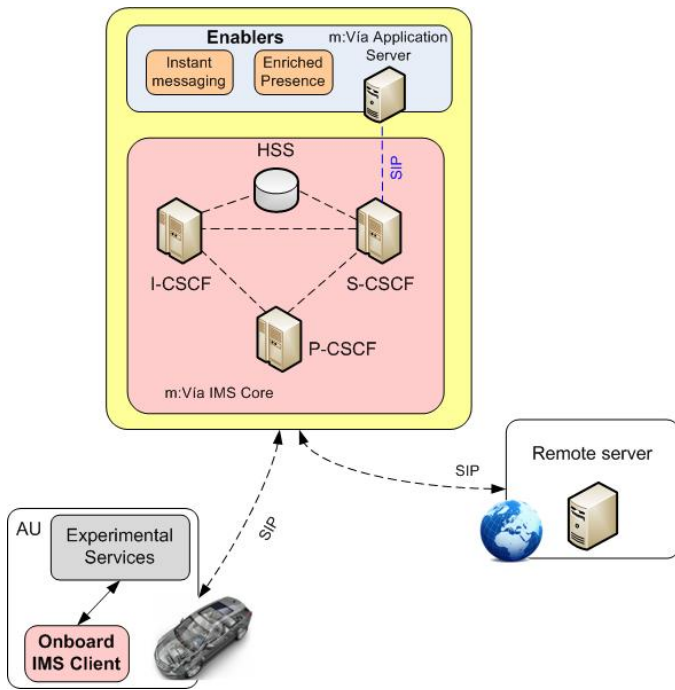


Fig. 2. IMS Scenario

information. It also manages subscriptions to the presence status (and location) of the vehicles, from authorized watchers, sending real time notifications when the status changes.

This enabler is fully compatible with the IMS Core. The integration of core and enabler has been made by the creation of specific trigger points. These triggers monitor the type of all the messages operated by the Core and progress presence events (REGISTER, SUBSCRIBE, PUBLISH and its responses) to the EP enabler.

E. Instant Messaging Enabler

The Instant Messaging (IM) enabler provides the mechanisms for the exchange of simple text messages in real time between vehicles and servers. Services can use IM for sending/receiving messages during a session, monitoring the delivery or managing a mailbox. The IETF specifications known as SIP for Instant Messaging and Presence Leveraging Extensions (SIMPLE) conforms the standardization framework for IM.

IM can work in two different modes: Pager and session. The pager mode is based in the method MESSAGE, an extension to SIP protocol. In this mode, messages are transmitted through the signalling channel. This mode can congest the IMS Core when many users or large messages are present in the system. The session mode is based on the Message Session Relay Protocol (MSRP), messages are exchanged within a SIP dialogue through a non-signalling channel. Our implementation of IM enabler works on session mode as it optimizes resources in vehicular scenarios involving many users.

The integration of this enabler within the system is transparent as our Core implementation supports MSRP.

F. IMS Client

Two different versions of the *IMS Client* has been developed, namely, the *On Board IMS Client* version, providing IMS capabilities to all services running on the *m:Via* platform, and the *IMS Standalone Client* version, for *m:Via* platform external utilization, i.e. as a server for receiving presence events from the platform. The *IMS Standalone Client* is a Java library, which can be used in any environment. Otherwise, the *On Board IMS Client* is based on a modular organization of OSGi compliant bundles enabling an agile and implementation-independent development and deployment. It also allow us the phased addition of new functionalities, creating an hierarchical structure of modules interacting with each other, but maintaining a low coupling level, thus will lead to an stable, reusable and adaptable for future needs *IMS Client*. Moreover, the communications API will give the client the ability to choose what will be the communication interface -whether Wifi, UMTS or WiMAX- to the outside.

III. ANALYSIS OF THE IMS-BASED VEHICULAR PLATFORM

In this section we analyse our IMS based platform by the implementation and evaluation of two experimental services over it: Access control to restricted areas and On-line lorry diagnosis. We qualitatively analyse the accomplishment of the services operation and quantitatively measure the message exchange between these services and the core IMS network.

For this purpose, we deployed a real scenario following the *m:Via* Architecture in the Andalusia Technology Park in Malaga (Spain). This scenario involves a full-equipped vehicle with OBU, AU, HMI and three communication technologies (WiFi, UMTS, WiMAX); two RSUs connected to the Internet and a WiMAX Base Station. Fig. 3 and Fig. 4 illustrate the deployment.



Fig. 3. Car equipped with the *m:Via* platform

A. Access control to restricted areas

This service allows authorities to control the access of vehicles to the restricted areas. When an authorized vehicle is close to a previously configured restricted area, the Traffic Control Centre (TCC) will open the access barrier. For this purpose the TCC and the OBU are registered in IMS and EP enabler, so that any variation on the location of the vehicle will be notified to the TCC when the vehicle is in "Emergency State".

The approaching vehicle will use the IMS EP enabler to dynamically publish the following data:



Fig. 4. *m:Vía* tests scenario

- The state; emergency or regular.
- The location of the restricted area where the vehicle is going to.
- The current location of the vehicle.

With this information, TCC can monitor the location of the emergency vehicles, the state of those vehicles and the restricted area they are approaching to. When the logic of the service, attending the presence events published by every authorized vehicle, realises that a vehicle is close to a restricted area, it automatically open the barrier. The trigger distance of the vehicle to the area can be configured by the TCC attending the situation of the area and the type of roads around it.

The use of our platform by this service, facilitates the access management of restricted areas enormously, as drivers only need to activate the "Emergency State" and the system will grant the access automatically without further hardware deployments on board or human interaction. During the tests we validated our approach in a real scenario, the performance of our platform, quantitatively detailed in Section IV, made this service efficient and reliable. After configuring an appropriate trigger distance, we obtained a rate close to the 100% of successful barrier openings. In these cases, vehicles also received information on time, before reaching its destination.

B. Remote Lorry Management

In this service, we have developed an advanced private communication network for professional users, very demanded by companies which want to manage, control and keep a communication thread with their professional vehicles. The service also monitors relevant information of the status of the lorries, obtained through on board sensors and transmitted through our IMS-based platform.

In this service, the lorries and a server of the company exchange messages through the IM enabler for reporting current status or for requesting information. With this functionality,

lorries can be notified with new routes to follow or company can obtain real-time problem reports.

In addition the service uses the EP enabler for automatically report the state of the lorry, e.g. on route, resting, refuelling, on a traffic jam or an accident. Furthermore, thanks to the on board sensors, it is possible to send extra information on the notification message for a better knowledge of the accident. Instant messages can be sent automatically, triggered by the detection of a fault in the lorry.

In the real scenario tests, we used the service for exchanging real time information between the vehicle and the company server, concluding that the use of both IM and EP enablers satisfies the challenging requirements for real time logistic services. Our platform provides the functionality needed to track the fleet efficiently and supports a secure data channel for the the dissemination of critical information.

IV. EVALUATION OF THE PLATFORM

In this section we describe the quantitative results obtained by testing the previous mentioned services over our platform in the real scenario. We have carried out tests measuring the times of registration messages, EP notification, and IM reception, using different access technologies. The results are depicted in Fig. 5 and Fig. 6.

In order to demonstrate the suitability of our IMS-based platform in real environments, we have run over 1000 tests for registration, presence and instant messaging, repeated for both Wifi and UMTS technologies.

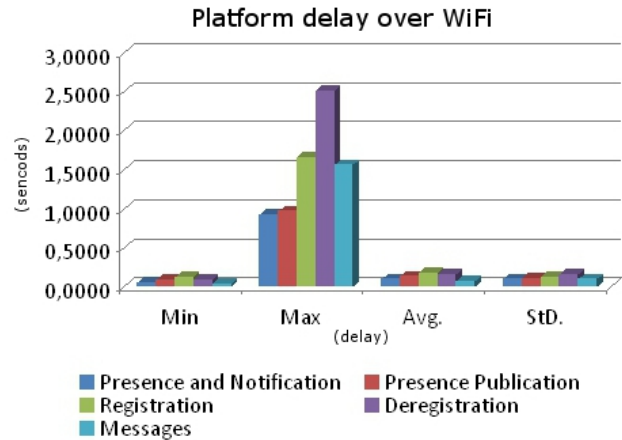


Fig. 5. Platform delay over WiFi

Analysing the obtained data, we observe that in the worst case, the time it takes to transmit a message is 1.906 seconds. These delay times are reasonable as we do not use the platform for critical safety services which restrictive time needs. In addition, the standard deviation indicates that the values obtained in the tests are very close to the average, confirming that there are not big differences in the delay of communications regardless the network circumstances. The technology with a higher delay is UMTS. If we focus on the values of the tests, we can see that the results are reasonable for both technologies. The average latency over WiFi for

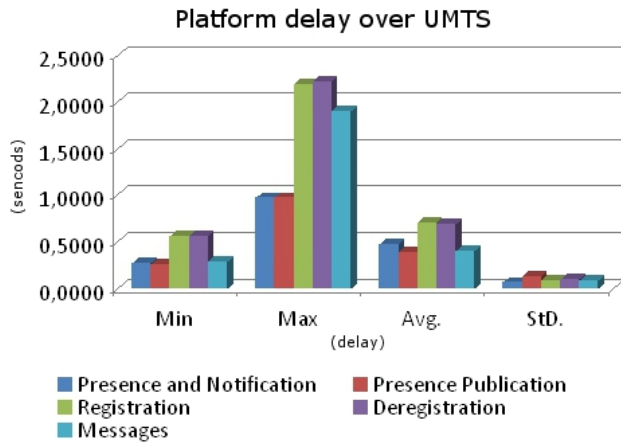


Fig. 6. Platform delay over UMTS

all the tests carried out is 129.06 milliseconds, and 525.48 milliseconds over UMTS. These results are coherent with the analysis made in [13].

In addition, we have measured the number of losses during the tests, regarding registration, presence and instant messages. The obtained results are promising in terms of service reliability. Although IMS signaling is transported over UDP, the number of packet retransmissions have been very low. The percentage of IMS notifications lost is, in any case, lower than 1%. Moreover, the number of instant messages lost during all the test, even for an UMTS connection with several handovers, is less than 0.1%.

In order to estimate the capacity of our IM enabler, successful tests have been carried out with more than 4,000 characters in IMS instant messages.

We must notice that the EP enabler generates significant load on the network as it reports the location of the vehicle periodically. However, this load can be balanced implementing multiple IMS Core entities.

V. CONCLUSIONS AND FUTURE WORK

In this paper we have presented an IMS based platform for the deployment of services in vehicular scenarios. This platform is composed by an IMS Core, two advanced enablers and two types of Clients. Our analysis points out many advantages of the use of an IMS based platform for the provisioning of services in these scenarios.

Our solution natively covers the challenging requirements related to security and mobility of vehicular services. The deployment of advanced functionalities for vehicular services such as voice communication, video-conference, location, accounting or any other value-added service can be done with no extra costs for service providers or telco operators. Thus, the IMS-based platform not only enriches significantly the logic of services, it also becomes a very attractive framework for a strong growth in the provisioning market in vehicular environments.

Our experiments in real scenarios, demonstrates the great performance of our platform dealing with vehicular services

in terms of delay and capacity. The scalability of the system is assured, due to the distributed design of the IMS core. Moreover, the development and integration of advanced enablers with other architectures opens many research possibilities in the vehicular context. In future works, we will analyse how current NGN enablers can be adapted in order to fulfill open issues in vehicular communications.

Regarding the performance of the platform, we will continue the work testing more services in a wider context; including interurban scenarios, involving more vehicles and using other access technologies. Although we deployed a WiMAX infrastructure in our scenario, we could not provide quantitative results over this technology due to time constrains within the project. Real measures of services over a variety of access technologies (including vertical handovers among them) will help to find out the appropriate balance between deployment costs and performance in vehicular environments.

VI. THANKS

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