Emergency Services in IMS

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Abstract. There is an increasing demand of multimedia and location aware services when an accurate and immediate response is needed, for example in the case of emergency services. In parallel, the technology has evolved from Circuit Switch (CS) to Packet Switch (PS) networks requiring backwards compatibility. As a result the emergency services support for NGNs, in particular for IMS, is being standardized by 3GPP, NENA, ETSI. In this paper we present architecture for Emergency Services support in IMS, starting from the one from 3GPP. We have implemented this architecture as the Emergency Branch of the open-source project Open IMS Core. The available methods for personalizing the testbed and validation scenarios are described here. More important, the management of resource allocation and prioritization of emergency calls is also discussed in the context of the emerging EPC.

Keywords: IMS, emergency services, location aware, LOCSIP, LoST, SIPp.

1 Introduction

Telecommunications play a major role in speeding response and minimizing loss of life and property. Communications systems can help, for instance, when making a daily emergency call to police, ambulance and fire brigade. For example, if the location of the caller is determined the call can be forwarded by the network to the nearest Public Safety Answering Point (PSAP), including mobile rescue teams, eliminating the delay for a central call center to transfer the call. At the same time the PSAP can be instantly informed about the accurate location of the caller leading to reduced necessary call duration and problems related to pronunciation or human error. When the caller is moving, the PSAP can monitor the current caller location.

IP Multimedia Subsystem (IMS) [0] is the result of the standardization effort of 3GPP for a platform offering Voice over IP (VoIP) and other multimedia services supporting multiple access network technologies from Public Switched Telephone Network (PSTN) to 3G mobile. Other standardization bodies, like ETSI, are also

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defining interfaces towards IMS. Next Generation Networks (NGNs), in particular IMS, are certainly the future replacement of the current telecommunication networks; therefore the current emergency systems need to be upgraded in order to fulfill the NGNs requirements.

The need for Emergency Services support in the emerging platforms has been recognized also by 3GPP that initiated the standardization of context aware emergency services architecture in IMS. In order to validate the specifications and to find the possible breaches, there is a need for a testbed. This is the reason we have developed one that enables not only the industry to have a testbed for emergency services, a standardization starting point or an evaluation testbed for potential commercial solutions, but also the academia in the path for future research.

The open-source Open IMS Core project [3] was released in 2006 by the Fraunhofer FOKUS Institute and has been recognized as a reference implementation and testbed for IMS. The emergency branch of the project [2] can be used as emergency services in IMS testbed. It has been developed during the collaboration with Telefonica Research and Development (TID) under the umbrella of the project IP-based Emergency Application and serviCes for nExt generation networks (PEACE) [4] partly financed by the European Commission.

The central functionality of the testbed, dispatching a call to the nearest required service center, has a more general appliance in the field of context aware services: it can be used for other services than emergency ones like taxis, pharmacies, restaurants or gas and electric stations.

In this paper we present the implemented testbed. The document is divided as follows: section 2 for the state of the art in the emergency services support for IMS and some of the protocols related to location information defined by IETF, section 3 for the design and implementation of the testbed as well as the general functionality and methods for personalizing it, section 4 for the most representative validation scenarios are presented and section 5 for the roadmap of the solution and conclutions.

2 State of the Art

In this section we describe the architecture for emergency services support, as specified by 3GPP and the IETF standardization effort for emergency services, including: the emergency URNs that a caller can use when generating an emergency call and some of the current formats and protocols related to location information.

2.1 3GPP Architecture of the IMS

The IMS framework [Fig. 1] is the result of the 3GPP standardization group and includes three layers: the *Access Layer*, the *Control Layer and* the *Service Layer*.

The *access layer* consists of IP routers and legacy PSTN switches that provide access to the IMS network both from contemporary IP telephony devices and older circuit switched devices respectively. IP devices compatible with IMS incorporate a SIP user agent that can be used, for example, to place voice or video calls toward the network.

The *control layer* of the IMS network manages (amongst others): the subscriber authentication and call establishment and release using components with Call Session Control Function (CSCF): Proxy (P-CSCF), Interrogating (I-CSCF) and Serving (S-CSCF) and the subscriber profile and the interface to the service layer at the Home Subscriber Server (HSS).

The applications are hosted in the *service layer*. This layer provides the end user service logic and consists of SIP Application Servers (AS). An AS executes IMS applications and services by manipulating SIP signaling and interfacing with other systems.

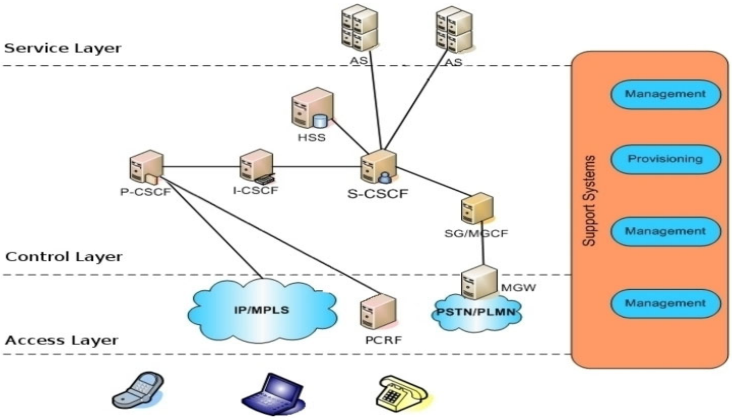

Fig. 1. IMS Architecture

The 3GPP architecture for the Emergency Services support in IMS is defined in TS 23.167 [5]. For routing the emergency call (E-Call) to the nearest PSAP, e.g. Police station new components have been added in the *Control layer*.

The *Emergency-CSCF (E-CSCF)* – retrieves the PSAP URI for the E-Call from the LRF and forwards the call accordingly. If the PSAP URI is a TEL URI [6] the call will be sent to the gateway towards the PSTN. In the case that the URI is an Internet protocol URI, .e.g. SIP [7], the call will be routed using the interface to the Internet.

The *Location Retrieval Function (LRF)* – receives the caller location from the E-CSCF if this information is present in the initial request of the E-Call. Otherwise it will query the network about the caller location. It maps an E-Call to the nearest PSAP of the required service by having an interface with or including the *Routing Decision Function (RDF).*

The *emergency registration* (E-Reg) was introduced in TS 23.167 [5]. It can be used by the user when roaming or not yet registered to its home network; otherwise the existing non-emergency registration to its home network is enough for making an E-Call. The E-Reg is used to allocate the network resources to the subscriber, independently of its home network by ignoring the roaming restrictions (see TS 29.228 [8]). At the SIP level, the E-Reg is a registration where the REGISTER request contains a “sos” URI parameter in the Contact header as defined in [9].

The P-CSCF recognizes *emergency calls* (E-Call) as the calls of which the initial INVITE request contains a request URI that matches one of the emergency numbers or an emergency services URN (see subsection 2.2). When the caller does not have enough credentials to authenticate, e.g. no available SIM, based on local policies the caller can still make emergency calls, known as *"anonymous" E-Calls.*

2.2 IETF Standardization Effort for Emergency Services

Currently the operator recognizes as emergency calls the calls addressed to emergency numbers from the country the caller is located or emergency numbers from networks that have roaming agreements with the operator.

Some of the countries even have a unified emergency number, e.g. 112, for multiple emergency services. One advantage of using a single emergency number is that it is easier for the citizens to remember it. The disadvantage is that a call taker has to identify which services (e.g. Police or Ambulance) are required in every case and forward the call accordingly. This operation implies a delay which can be critical in most of the situations, especially when there is congestion at the call center.

In order to unify the emergency number based on the type of service and independently of the country, *emergency URNs* were defined in [9], e.g. *"urn:service:sos.police"* for referring to the Police Department. They enable the caller to make E-Calls independent of its roaming state. For example, emergency URNs would be the solution for a roaming caller that does not know the emergency number from the attached network and the emergency number from its country/home network is not recognized by the attached one or, even worse, it has a different meaning leading to the call being redirected to a different service.

Location information can be conveyed directly, in a "location-by-value" format or indirectly, in a "location-by-reference" one. The recipient of a location by reference has to "dereference" it by interrogating a location server using the data from the reference thus obtaining a location by value [11].

Presence Information Data Format (PIDF) objects [12] consist of XML encapsulated information that can be carried in the payload of the protocols meeting the requirements from [12]. SIP is one of these protocols and at the same time can be used to establish a multimedia session. Based on the requirements regarding location objects [13], the **PIDF-Location Objects** (**PIDF-LO**) were defined as an extension of PIDF objects for "location-by-value" in [15]. SIP messages convey PIDF-LOs as body parts with the Content-Type "application/pdf+xml". A PIDF-LO can encode *geodetic* as well as *civic* location information, timestamps, and privacy requirements [16, 17] and can be used for routing the call to an appropriate service instance by context aware systems.

Following the same principle of presence services using SIP, Open Mobile Alliance (OMA) [18] has defined the protocol Location in SIP/IP Core (**LOCSIP**) [19] that can be used for retrieving the location of a certain target identified by the SIP URI, IP, IMSI or other characteristics. The protocol consists of a SIP subscription [20] to the new introduced event package "location". If the information is available, the notifications will include the location information for the corresponding target in the PIDF-LO format. This protocol also supports subscription filters [21] to request automatic generated notifications when a parameter of the subscription's target has changed, in our case when the user's location is modified, useful for monitoring a moving target.

The Location to Service Translation protocol (**LoST**) [22] is an XML-based protocol which can be used for mapping a tuple (location, service URN) to a service URI responsible for that type of service in an area that includes the given location. The LoST payload can use protocols such as HTTP or HTTPS as carriers. In particular, it can be used to decide which PSAP is the one in charge of a specific emergency service in an area.

3 Open IMS Core Emergency Services Testbed

Open IMS Core Emergency Testbed implements a set of standard compliant components, easily adapted to further evolution of the standards and other research topics. Following the emergency services architecture from TS 23.167 also described in the section 2.1 of this paper, the components E-CSCF and LRF have been added to the original Open IMS Core project. The architecture can be seen in Fig. 2.

The P-CSCF is the first node in the SIP signaling path from the IMS network. It recognizes E-Calls and forwards them to the E-CSCF. The latter will query the LRF for the PSAP URI. In the query the E-CSCF will insert the requested service URN and, if present, the location information of the caller from the SIP INVITE request.

When the query includes location information, the LRF can proceed immediately with mapping the pair (location, type of service) to a PSAP URI using the interface to the RDF. We have designed the *RDF as a LoST server*, because the LoST protocol suites the role of the RDF. Another reason was that both SIP and LoST use the PIDF-LO format for encoding location information eliminating the delay introduced by a format translation when creating a LoST request.

In order to support *E-Call without location information* we have designed the interface between the LRF and the network based on the LOCSIP protocol. The reason for choosing this protocol was that it is SIP-based and is using the same location information format as the initial INVITE request of the E-Call. This means that LRF will process the location information received from both the E-CSCF and the LOCSIP server without any format translation. The LRF has to inform the E-CSCF about the acquired location data. The E-CSCF includes the location information received from the LRF in the initial request and forwards it to the PSAP URI, without any translation of the location format.

The specification of the interface between E-CSCF and LRF is still an open issue as Release 9 of IMS [24] does not state which protocol, type of messages and how their content should be encoded. The design has to support callback and location update, which have an impact on the information stored in the E-CSCF and LRF components and depend on: the registration state of the caller and the type of PSAP to which the call was forwarded: VoIP-based or legacy one (PSTN telephones).

We have identified two types of messages that the interface between the E-CSCF and LRF should support:

1. **Mapping Request.** when a new E-Call is about to be established, sent from the E-CSCF to the LRF for mapping a location, if available, and service type to a PSAP URI. The reply contains the PSAP URI and the retrieved location information, if not included in the initial INVITE request.
2. **Release Request.** when an E-Call is released: the E-CSCF alerts the LRF that it should free any resource allocated to the emergency call. This is important as it keeps the LRF clean and able to better use its resources.

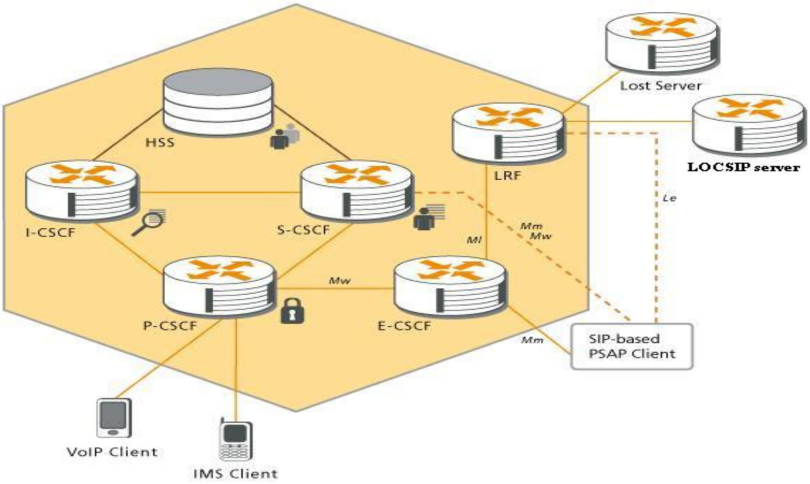

Fig. 2. Architecture of the Emergency Services Support of the Open IMS Core

We have designed this interface *based on SIP*, as this protocol can be used to carry the location information of the caller, is easily extensible and, according to our design, a SIP stack is already included in the implementation of the two involved components: E-CSCF and LRF.

The next step was defining which SIP messages to use between the E-CSCF and the LRF. We have considered using the OPTIONS request to for the *mapping request* and its response to transport the PSAP SIP URI and the caller location information if returned from the LOCSIP server. An OPTIONS request with a marker for terminating the processing of the emergency call would also cover the *release request*.

The implementation of our testbed is based on TS 23.167 [5], TS 29.228 [8] and TS 24.229 [22]. Open IMS Core has a module dedicated for each component.

The support for emergency registrations was added by enhancing the modules pcscf, icscf and scscf.

Then the *engine for routing the emergency calls* was implemented. The **pcscf module** was enhanced to recognize E-Calls. For an easily personalization of the list of the supported emergency numbers an XML file with *(emergency numbers, emergency URNs) associations* is loaded when the pcscf module starts.

The **ecscf module** and the **lrf module** were added as instances of SIP Express Router (SER) [25] written in the C language, just like the other CSCFs.

The interface between the P-CSCF and E-CSCF has been *secured* using the Path header to eliminate one of the possible methods for a third party to impersonate the PSAP. More details about the possible attack and the solution can be found in [26].

When processing the E-Call, the location information included by the caller or acquired by the LRF is considered to be "Location-by-value" as defined in [16, 17]. Both E-CSCF and LRF expect the PIDF-LO in the civic or geodetic formats mentioned in subsection 2.2. Otherwise the E-CSCF will reply with a 424 (Bad Location Information) error message as defined in [11]. The support for the PIDF-LO formats was implemented in a *pidflo library* based on the library *libxml* [28], shared by both modules.

When no caller location information was provided by the E-CSCF but the caller contact address is known, the lrf module will try to retrieve acting as a *LOCSIP client.* The *LOCSIP server acts as* ***a Global Location Enabler*** that can access several location databases, based on the type of the access network technology and the received information about the caller, e.g. PSTN number, IP. For mapping the emergency call to an appropriate PSAP, the module can also act as a *LoST client* using HTTP as transport for the LoST payload. For this purpose a *lost library* was developed based on *libcurl library* [27] for HTTP messages handling.

4 Validation Scenarios

For confirming the capabilities of our emergency services testbed support for multiple scenarios was added, from which the following were selected as the most representative. All the scenarios describe the case when the user makes a call to the Police Department, but the method or status of the caller location retrieval is different. The first one covers the case of *Location acquired by the user or caller device* and the second one *Location acquired by the LRF*. These are presented here as validation scenarios in order to prove the practical importance of the current implementation.

To generate the scenarios an enhanced Monster the IMS client [31] able to store location information and recognize and generate emergency calls. It has dedicated buttons for calling the Police Department, the Fire Brigade and Ambulance. For backwards compatibility the user can also dial emergency numbers, e.g.112. For testing GPS location, a GPS-enabled Location Agent was developed that connects to the IMS client using the NMEA0183 protocol. Two modes of operation exist: stand-alone GPS or Assisted-GPS (to speed up position acquisition) over OMA Secure User Plane Protocol (SUPL) [32].

Location acquired by the user or caller device. The first scenario represents the case when the calling IMS client is capable of determining the current location (geodetic or civic) (Fig. 3). Alice is registered to her home network using the SIP URI sip:alice@open-ims.test. She sets the IP and port of the of the NMEA server running on the GPS-Location Agent terminal. The location Germany, Berlin is acquired and the user is alerted about it. Then Alice calls the Police Department. The LRF has data for the area that includes Alice's location and type of service and maps it to the PSAP URI sip:police_berlin@open-ims.test. The call is forwarded by the E-CSCF accordingly. The PSAP can extract the location of the caller from the received INVITE request and show it on a map.

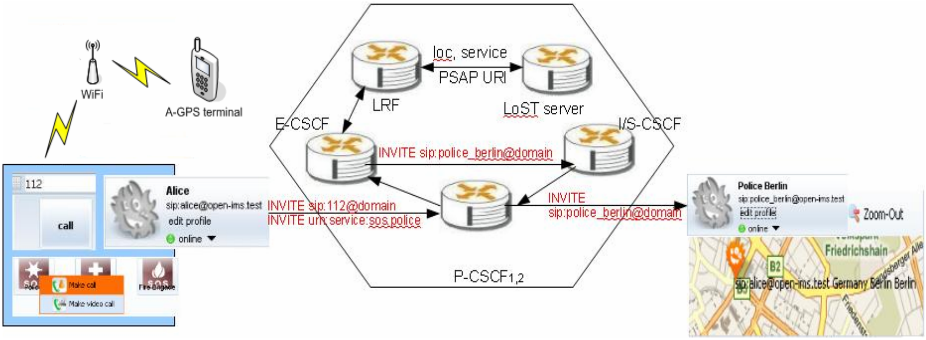

Fig. 3. Emergency call when the caller or caller's devide is able to acquire the lcoation information

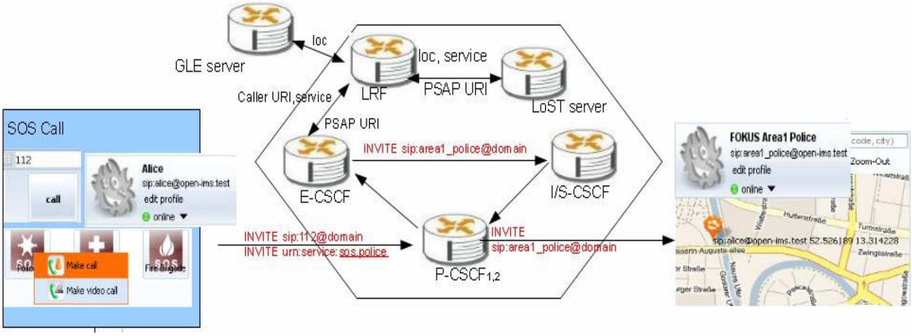

Fig. 4. Emergency call when the caller or caller's devide is not able to acquire the lcoation information and the LRF succsessfully retrieves it from the GLE

Location acquired by the LRF. The second scenario represents the case when the caller device is not able to acquire the current location and Alice make a call to the Police Department and this time no location information is included in the INVITE request (see Fig. 4). If the GLE is aware of the caller location, geodetic or civic, the LRF will be able to retrieve it. We consider also that the LoST server has data about the Police Department in an area that includes the caller location. The LRF maps the call to PSAP SIP URI “sip:area1_police@open-ims.test”. As a result the E-CSCF will forward the call to the designated PSAP after including the location information in the body of the INVITE request. In this case, the PSAP can extract and show the caller location on a map.

The scenarios have been presented as validation scenarios to the European Commission during the First Year Review of the PEACE project.

We have also created SIPp [33] scripts as a lightweight and public method for emulating: the caller, the PSAP and optionally the LOCSIP server.

5 Conclusions and Further Work

In the present paper we have presented an emergency services testbed implemented following the standards from 3GPP and developed as an extension of the Open IMS Core project.

One of the features not exploited yet in our implementation is a cross-layer prioritization of the emergency calls over the non-emergency ones. We mean by cross-layer prioritization a mechanism for prioritizing both the signaling and the data flow. The prioritization can be very important especially if we have a real situation where the network resources are limited or the network is congested. We intend to develop an algorithm for the P-CSCF to prioritize the signaling flow of emergency services over the one of non-emergency services. With the emerging Evolved Packet System (EPS) [34], which is being standardized by 3GPP as a policy based framework between multiple access network technologies and managed multimedia services, we intend to interface our emergency services IMS testbed with an EPC testbed as can be seen in [35].

Another useful feature is to enable the PSAP to update the caller location information, optionally using time and boundary filters. This can be achieved using the Le interface between the PSAP and the LRF, which needs further specification. The privacy and security issues related to this field are also an important research topic for our team. Following this goal, the testbed will be enhanced with a security framework for validating the location of the user and as well one for protecting the privacy of the user.

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